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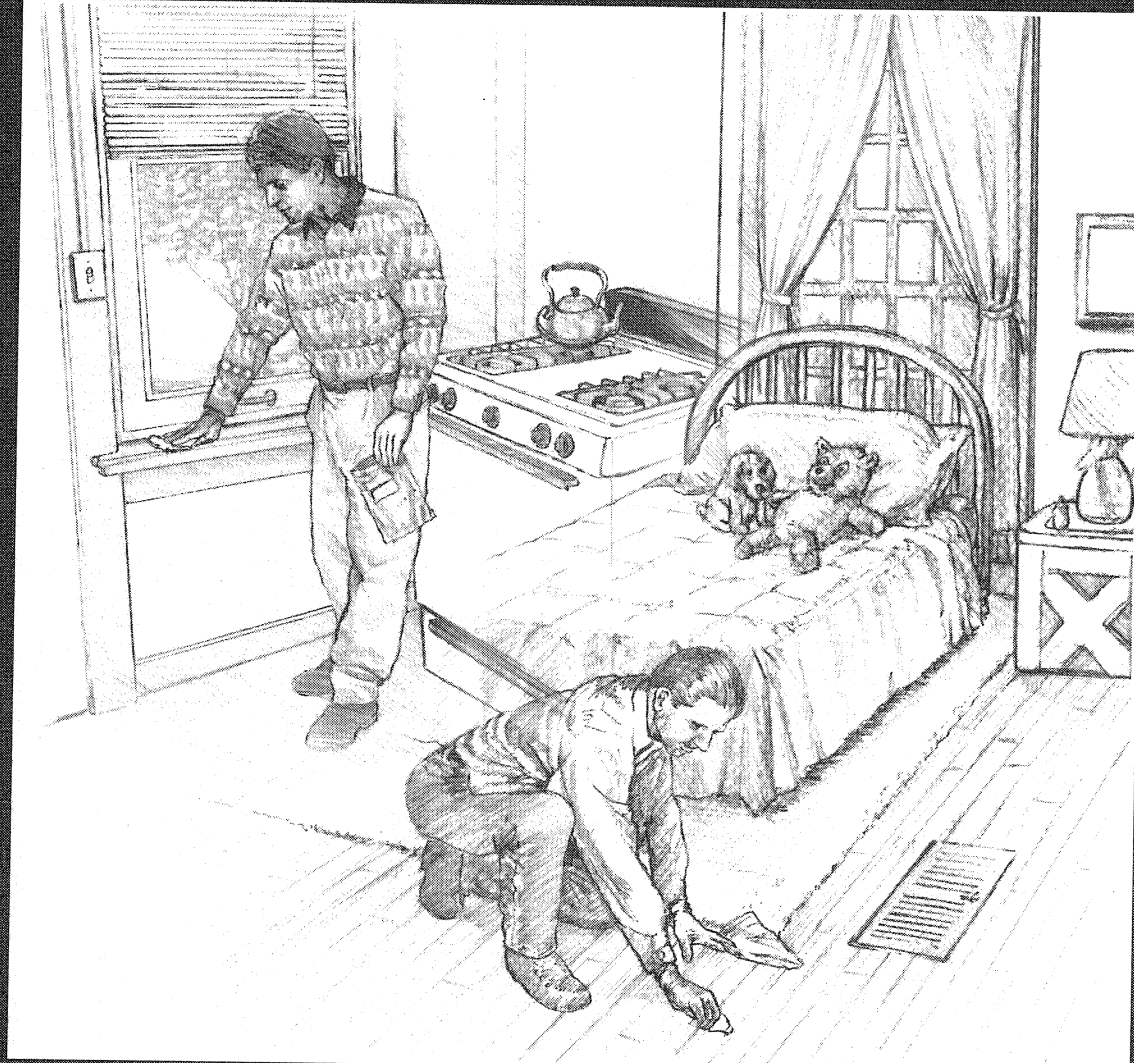

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EVALUATION OF SECTION 402 RISK ANALYSIS PROTOCOLS

Technical Branch
National Program Chemicals Division
Office of Pollution Prevention and Toxics
U.S. Environmental Protection Agency
Washington, D.C. 20460

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AUTHORS AND CONTRIBUTORS

The study that led to this report was funded and managed by the U.S. Environmental Protection Agency. The study was conducted by Battelle Memorial Institute. Each organization's responsibilities are listed below.

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Battelle was responsible for the data management, the development of the statistical models, the statistical analysis, and the writing of this report.

U.S. Environmental Protection Agency (EPA)

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EXECUTIVE SUMMARY

The Residential Lead-Based Paint Hazard Reduction Act of 1992 (Title X) required EPA "to ensure the availability of a trained and qualified workforce to identify and address lead-based paint hazards, and to protect the general public from exposure to lead hazards" [5]. As required by Title X, the U.S. Environmental Protection Agency (EPA) published a final rule for Section 402 of the Toxic Substances Control Act (TSCA) [4], in August 1996, which detailed the requirements for conducting lead-based paint activities. This rule requires that a risk assessment, lead hazard screen, inspection, and risk assessment/inspection be performed by certified individuals. While many aspects of the sampling and inspection are prescribed for the risk assessor, in other areas the certified individual has the freedom to use personal judgement to specify the extent of sampling during a risk assessment, including the location and number of samples taken.

The purpose of this task was to characterize the probability of a certified risk assessor correctly identifying a lead-based paint hazard in single family housing units when choices allowed by the Section 402 regulations are made. Specifically, the choices assessed were the number of rooms in which dust samples are collected and specific rooms in which dust is sampled. In addition, the method used to characterize the dust and soil samples was assessed by evaluating the ability of three statistics (geometric mean, arithmetic mean, and maximum value) to characterize the dust and soil levels found in the home. The task had three specific objectives:

1. Characterize the way different sampling protocols affect a) the probability of correctly concluding that an environmental lead hazard exists (defined for the purposes of this analysis as the presence of a child with a blood-lead concentration greater than or equal to 10 µg/dL) in single family housing (performance characteristic analysis) and b) the cost of the assessment (cost analysis). Also characterize differences between the 403 Interim Guidance and the 403 Proposed Rule in the probability of correctly identifying a health hazard in single-family housing (performance characteristic analysis).

2. Characterize for a risk assessment and lead hazard screen a) how well different estimators and sampling protocols estimate the true average lead levels in a single family home and b) the error probabilities associated with concluding that a home is above or below a given media standard for different estimators and sampling protocols (error probabilities analysis).

3. Assess which sampling locations risk assessors may want to target in order to assure that they are best evaluating the potential lead hazard to a child (pathways analysis).

Objective 1 was fulfilled using two sets of information. The first set was the risk assessment cost information collected from nine risk assessors in nine States. The second set was calculated information on four performance characteristics: sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Briefly,

a) *Sensitivity* is the probability that lead-based paint hazards have been found in the home given that there is a child with an elevated blood-lead concentration in the home

b) *Specificity* is the probability that no lead-based paint hazards have been found in the home given that there is a child with a low blood-lead concentration in the home

c) *PPV* is the probability that the child in the home has an elevated blood-lead concentration given that lead-based paint hazards have been found in the home

d) *NPV* is the probability that the child in the home has a low blood-lead concentration given that no lead-based paint hazards have been found in the home.

Objective 2 was fulfilled using two types of error probabilities: Type I (false positive) error and Type II (false negative) error. Each is briefly defined as follows:

a) *A Type I (false positive) error* is the probability of a risk assessment concluding that a home *has* lead-based paint hazards when the home does *not*.

b) *A Type II (false negative) error* is the probability of a risk assessment concluding that a home has no lead-based paint hazards when the home *does* in fact have lead-based paint hazards.

Finally, Objective 3 was fulfilled using Pearson correlation coefficients and structural equation models (pathways models).

The Objective 1 and 2 analyses used the media (dust and soil) and component (floors, window sills, and window wells) standards listed in EPA's 403 Interim Guidance and EPA's 403 Proposed Rule, and shown in Table ES-1, to calculate performance characteristics and error probabilities. At the time of this report, the guidance for the Section 402 activities was the Section 403 Interim Guidance and the HUD Guidelines. When the Section 403 Proposed Rule becomes final, the guidance in the Proposed Rule will supersede the Section 403 Interim Guidance. Therefore, the analyses assessed the impact that the standards in the Proposed Rule may have on the outcome of risk assessments, compared to the outcomes observed under the Interim Guidance standards.

Table ES-1. Environmental Standards Used in the Analyses.

Media		Hazard Standards for Comparison	
		EPA Interim 403 Guidance	EPA Proposed 403 Rule
Dust Wipe	Floors	≥100 μg/ft²*	≥50 μg/ft²*
	Window Sills	≥500 μg/ft²	≥250 μg/ft²
	Window Wells (Troughs)	≥800 μg/ft²	None
Soil (Bare)		≥5,000 ppm	≥2,000 ppm
Painted components with areas of deteriorated lead-based paint**		Any deterioration present	1) ≥2ft² deteriorated for large interior components; 2) ≥10 ft² deteriorated for large exterior components; or 3) ≥10% of the (interior or exterior) surface deteriorated for small components

* Floor dust wipe samples from uncarpeted floors only.
** The statutory definition of lead-based paint is paint with ≥1.0 mg/cm² lead or ≥0.5% lead by weight.

Data from the Rochester Lead-In-Dust Study [8], the Comprehensive Abatement Performance (CAP) Study [21, 22], the Rhode Island Health Department[1], and nine risk assessors were used in one or more of the analyses.

For Objective 1, only the Rochester study data were used in the performance characteristic analysis. The cost information from the surveyed risk assessors was used to evaluate the cost of risk assessments and lead hazard screens. Note that special emphasis was given to the sensitivity and NPV in the performance characteristic analysis. The sensitivity focuses on the home media failure rate when the child is known to have an elevated blood-lead concentration, while the NPV focuses on the probability of a child having a low blood-lead

[1] Data from the Rhode Island Health Department was not collected as part of a study, but as part of the lead program in the State of Rhode Island.

concentration when it is known that the media samples have passed the standards. The results indicated the following:

- The estimated cost of a risk assessment in areas where they are commonly performed was $435, while the average cost for a lead hazard screen was $169.

- Dust samples collected from the interior entryway and kitchen did not significantly add to information obtained from dust samples collected from the bedroom and play area.

- Under the Interim Guidance standards, the maximum value of the dust and soil samples yielded the highest sensitivity and NPV, while under the Proposed Rule the arithmetic mean of the dust and soil samples had the highest sensitivity and NPV.

- The exclusion of a window well (trough) standard in the Proposed Rule did not affect the ability of the risk assessment to identify health hazards. The exclusion could impact the outcome of a lead hazard screen. Section 402 only prescribes that "windows" be sampled for a lead hazard screen. The 1995 HUD Guidelines interpreted "windows" as sampling only the window wells (troughs) and not the window sills. Different interpretations and standards allow several scenarios under which a lead hazard screen may be performed including potentially not sampling any windows. Under the Interim Guidance, a lead hazard screen that samples only window sills is less effective in identifying potential health hazards than the full risk assessment. When both the window sills and window wells (troughs) are sampled, the lead hazard screen is as effective as the risk assessment. Under the Proposed Rule, the lead hazard screen is as effective as the full risk assessment when window sills are sampled.

- The combination of using the arithmetic mean to characterize the dust and soil samples and the lower standards, under the Proposed Rule, seem to provide for an assessment that maintains the ability to identify health hazards while failing fewer homes than that would have failed under the Interim Guidance standards.

The Rochester study data, CAP Study data, and Rhode Island Department of Health data were used in the Objective 2 analysis. The results showed that:

- Type I (false positive) error rates were highest when the maximum value was used to characterize the true medium average lead level and lowest when the geometric mean was used. The opposite was true for the Type II (false negative) error rates. The arithmetic mean error rates were always between the maximum value and geometric mean error rates.

- The Type I (false positive) and Type II (false negative) error rates were usually over 25% for all three statistics—geometric mean, arithmetic mean, and maximum value – when the true medium lead levels were within 20% of the medium standard. This indicates a large area where incorrect decisions may be made, regardless of the method used to characterize the dust and soil samples.

- The Type I (false positive) error probabilities increased as the number of samples collected for dust and soil increased when the maximum value was used to characterize the dust and soil samples. The Type I (false positive) error probabilities were much less dependent on the number of samples collected for the arithmetic mean and geometric mean.

- The combination of lowering the dust and soil standards and using the arithmetic mean to characterize these samples, as written in the Proposed Rule, seems to have improved the discrimination of the risk assessment conducted under the Interim Guidance by reducing the Type I (false positive) and Type II (false negative) error probabilities.

Only the Rochester study data were used in the Objective 3 analysis. This analysis showed:

- The log-transformed blood-lead concentrations were positively correlated with the log-transformed dust-lead loadings on the floors, window sills, and window wells (troughs) in the bedroom, kitchen, and play area.

- The log-transformed kitchen and play area window well (trough) dust-lead loadings, interior entryway and the kitchen floor dust-lead loadings, and play area and bedroom floors dust-lead loadings were significantly correlated.

- The play area floor dust was the only statistically significant pathway of environmental lead to the child's blood. This finding applies to the Rochester Study, but may or may not be the case for other studies. The reason for the significance of the play area floor dust in this analysis may be because, in the Rochester study, the play area floor was the pathway the children were most often in contact. The conclusion indicates that the risk assessor may want to collect samples from the child's play area floor to best assess a potential lead hazard to the child.

- The window well (trough) dust lead was a statistically significant pathway of lead to the window sill dust in both the bedroom and play area. This indicates that sampling either the window well (trough) or window sill may provide enough information about the lead hazard from the windows.

In summary, dust samples obtained from interior entryways and kitchens did not significantly add to information obtained from dust samples collected from bedrooms and play areas; increasing the number of dust samples collected only affected the outcome of a risk assessment when the maximum value was used to characterize the dust samples; sampling play area floors provided the best indication of the lead hazard to a child in the Rochester study (this may or may not be the case for other studies); removing the window wells (troughs) from the risk assessment did not affect the ability of the assessment to identify lead hazards; and the combination of the lower soil and dust standards and the use of the arithmetic mean to characterize these samples, as described in the Proposed Rule, resulted in an assessment that provided the same protection as the Interim Guidance, but failed fewer homes.

1.0 INTRODUCTION

Although the average blood-lead concentration of children has dropped dramatically over the last twenty years, an estimated 890,000 children aged 1 to 5 years still have blood-lead concentrations greater than or equal to 10 µg/dL [9]. Lead in dust, soil, and paint in their residences is considered the primary source of lead exposure for these children. The Residential Lead-Based Paint Hazard Reduction Act of 1992 (Title X) amended the Toxic Substances Control Act (TSCA) by adding Title IV, "Lead Exposure Reduction." Section 403 of TSCA requires EPA to promulgate regulations that identify lead-based paint hazards, lead-contaminated dust, and lead-contaminated soil [4]. Section 402 of TSCA requires EPA to finalize a federal regulation "to ensure the availability of a trained and qualified workforce to identify and address lead-based paint hazards, and to protect the general public from exposure to lead hazards" [5]. In addition, the rule was established "to ensure that individuals and firms conducting lead-based paint activities in target housing and child-occupied facilities will do so in a way that safeguards the environment and protects the health of building occupants, especially children aged 6 years and under" [5].

In September 1995, while in the process of developing the Section 403 regulations, EPA issued a notice that contained "information designed to serve as guidance [Interim Guidance] until the promulgation of the final rule" [4]. This information contained media and component standards by which those addressing lead-based paint concerns could conduct their activities. In particular the Interim Guidance provided standards for sampling floor dust, window sill dust, window well dust, soil, and paint samples.

In August 1996, EPA issued a final regulation for Section 402 requiring that a risk assessment, lead hazard screen, inspection, and risk assessment/inspection be performed by a certified risk assessor. The Section 402 rule did not dictate one set of methods or standards for carrying out the activities, but listed documents that contained methods/standards appropriate for conducting the activities [5]:

- U.S. Department of Housing and Urban Development (HUD) Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing [HUD Guidelines]
- EPA Guidance on Residential Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil [403 Interim Guidance]

- EPA Residential Sampling for Lead: Protocols for Dust and Soil Sampling; Regulations, guidance, methods or protocols issued by States and Indian Tribes that have been authorized by EPA

- Other equivalent methods and guidelines.

Section 402 provides general guidance for conducting risk assessment activities and references the HUD Guidelines and the Section 403 Interim Guidance as providing more specifics on conducting risk assessment activities. The HUD Guidelines provide specific methods for conducting risk assessments and provide standards against which the media samples collected are to be compared. The 403 Interim Guidance provides some detail on how to conduct risk assessments and provides standards against which the media samples collected are to be compared. Differences and distinctions between Section 402, the HUD Guidelines, and the Section 403 Interim Guidance are as follows:

1. Section 402 makes no distinction between window well[2] and window sill sampling for a lead hazard screen, only requiring that dust samples be collected from "windows." The HUD Guidelines distinguishes between sampling from window wells and window sills, and both the HUD Guidelines and the Section 403 Interim Guidance provide individual standards for the window sills and the window wells.

2. For both risk assessment and lead hazard screens, Section 402 makes no distinction between sampling dust from carpeted and uncarpeted floors, only requiring that dust samples be collected from "floors." The HUD Guidelines distinguishes between sampling from carpeted and uncarpeted floors and provides standards for both types of floors. The Section 403 Interim Guidance recommends that floor dust sampling occur on uncarpeted floors and only provides a standard for uncarpeted floors.

In June 1998, EPA issued a Proposed Rule for Section 403 [20]. The Proposed Rule differs from the 403 Interim Guidance in the following ways:

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[2] Throughout the document, the terms "window sill" and window well" will be used. For clarity, the definition of each term is given below:

<u>Window Sill</u>: The portion of the horizontal window ledge that protrudes into the interior of the room, adjacent to the window sash when the window is closed [23]. Also referred to as "window stool."

<u>Window Well</u>: The portion of the horizontal window sill that receives the window sash when the window is closed, often located between the storm window and the interior window sash [23]. Also referred to as a "window trough" or "window channel."

1. While the Interim Guidance made no distinction between carpeted and uncarpeted floors, the Proposed Rule provides a standard for uncarpeted floors but states that EPA has not made a decision on a standard for carpeted floors

2. The Proposed Rule halves the uncarpeted floor and window sill standards listed in the Interim Guidance and does not provide a standard for window wells

3. The soil standard was decreased from 5,000 ppm in the Interim Guidance to 2,000 ppm in the Proposed Rule

4. In the Proposed Rule, the arithmetic average from uncarpeted floor dust-lead loading, window sill dust-lead loading, and dripline and mid-yard soil-lead concentration was compared to the corresponding standard, whereas in the Interim Guidance, each individual sample result was compared to the relevant standard.

The purpose of this task was to characterize the probability that a certified risk assessor correctly identifies a lead-based paint hazard in single family housing units when using various options allowed by the protocols specified in Section 402 regulations and when using the standards and methods prescribed in both the 403 Interim Guidance and Section 403 Proposed Rule. Table 1-1 lists the standards.

Table 1-1. Environmental Standards Used in the Analyses.

Media		Hazard Standards for Comparison	
		EPA Interim 403 Guidance	**EPA Proposed 403 Rule**
Dust Wipe	Floors	≥100 $\mu g/ft^2$*	≥50 $\mu g/ft^2$*
	Window Sills	≥500 $\mu g/ft^2$	≥250 $\mu g/ft^2$
	Window Wells (Troughs)	≥800 $\mu g/ft^2$	None
Soil (Bare)		≥5,000 ppm	≥2,000 ppm
Painted components with areas of deteriorated lead-based paint**		Any deterioration present	1) ≥2ft² deteriorated for large interior components; 2) ≥10 ft² deteriorated for large exterior components; or 3) ≥10% of the (interior or exterior) surface deteriorated for small components

* Floor dust wipe samples from uncarpeted floors only.
** The statutory definition of lead-based paint is paint with ≥1.0 mg/cm² lead or ≥0.5% lead by weight.

In particular, the probability of correctly identifying a lead-based paint hazard was evaluated both from the perspective of a health hazard as characterized by a resident child with blood lead concentration greater than or equal to 10 µg/dL, and from the perspective of environmental lead levels being above a given standard. The choice of sampling options included the number of rooms, the location of samples to be collected, and whether to conduct a lead hazard screen or a full risk assessment. In addition, the type of estimator used to characterize the lead hazard in a home (arithmetic mean, geometric mean, and the maximum value across samples within a home) was assessed.

Although a certified risk assessor may perform several activities, the focus of the analysis was on the risk assessment and the lead hazard screen.

The costs for each of the activities were solicited from several contractors around the country and were provided for descriptive purposes only.

Comparisons involving the Interim Guidance and the Proposed Rule followed their respective protocols with one exception. For both sets of protocols, data for carpeted floors were also included in the analysis. Neither the Interim Guidance nor the Proposed Rule provides a standard for carpeted floors; in fact, the Proposed Rule explicitly states that a standard for carpeted floors was not included. Data for carpeted floors were included in the analysis to assess sampling that may be conducted under the HUD Guidelines.

1.1 OBJECTIVES

The overall objective of the analyses discussed in this report were to evaluate some of the choices a risk assessor may make when identifying lead hazards in a single family home and to evaluate the differences between the 403 Proposed Rule and the 403 Interim Guidance. This includes evaluating 1) the sampling choices a risk assessor may make during a risk assessment and 2) the choice between performing a risk assessment or a lead hazard screen.

The statistical analysis objectives in this study are the following:

1. Characterize the way different sampling protocols affect a) the probability of correctly concluding that an environmental lead hazard exists (defined for purposes of this analysis as the presence of a child with a blood-lead concentration greater than or equal to 10 µg/dL) in single family housing (<u>performance characteristic analysis</u>) and b) the cost of the assessment (<u>cost analysis</u>). Also characterize differences between the 403 Interim Guidance and the 403 Proposed Rule in the probability of

correctly identifying a health hazard in single family housing (performance characteristic analysis).

2. Characterize for a risk assessment and lead hazard screen a) how well different estimators and sampling protocols estimate the true average lead levels in a single family home and b) the error probabilities associated with concluding that a home is above or below a given media standard for different estimators and sampling protocols (error probabilities analysis).

3. Assess which sampling locations risk assessors may want to target in order to best evaluate the potential lead hazard to a child (pathways analysis).

Performance characteristics (sensitivity, specificity, negative predictive value, and positive predictive value), their associated 95% confidence intervals, and cost data obtained from risk assessors around the country were used to fulfill Objective 1. Within-home variance estimates and probability estimates of 1) a risk assessment concluding that a home has lead-based paint hazards when the home does not (Type 1, or false positive, error) and 2) a risk assessment concluding that a home has no lead-based paint hazards when the home, in fact, does (Type II, or false negative, error) were used to fulfill Objective 2. Correlation and structural equation modeling (pathways modeling) were used to fulfill Objective 3.

1.2 STRUCTURE OF THE REPORT

Data from the Rochester Lead-In-Dust Study [8] were used for all analyses in this report. Cost information collected from risk assessors around the country was also used in the Objective 1 analysis, while data from the Comprehensive Abatement Performance (CAP) Study [21, 22] and the Rhode Island Department of Health were also used in the Objective 2 analyses. Section 2 presents the conclusions drawn from the three sets of analyses. Section 3 presents quality assurance information for the data used in this analysis. Background information specific to the Rochester Lead-In-Dust Study data, the Rhode Island Department of Health data, and the Risk Assessor Cost Survey is provided in Section 4. The data and statistical methodology used in the analyses are discussed in Section 5. Results are presented in Section 6. A discussion of the results and conclusions is provided in Section 7, and references are provided in Section 8. Supporting documents and information are presented in the appendices.

1.3 PEER REVIEW

Prior to publication, this report was reviewed by four individuals with knowledge and expertise in the subject matter of the report but who were not involved in the development of the report. Reviewers conducted their assessments independently of each other. Following is a summary of reviewer comments that had an important impact on the report and the responses made to these comments.

Adding Additional Analysis

One reviewer suggested that additional analyses could be performed on the Department of Housing and Urban Development (HUD) Lead-Based Paint Hazard Control Grant Program (HUD Evaluation Study) data. Though this was recognized as a very good suggestion, at the time that this report was written, the data availability was not adequate to ensure suitability for inclusion in the analysis.

The performance characteristic analysis in this report was run using a blood lead level of 10 μg/dL, the elevated blood lead level at which no environmental intervention is recommended by the Centers for Disease control (CDC). One reviewer suggested that the performance characteristics analysis should also be run using a blood-lead level of 15 μg/dL because this is the environmental intervention blood-lead level used by CDC and HUD. Though this is a good suggestion, budget and time constraints prevented running this analysis for this report.

Adding Additional Information

One reviewer suggested including the article, "The Contribution of Lead-Contaminated House Dust and Residential Soil to Children's Blood Lead Levels," by Lanphear, et al. [24], as a reference. This article assessed 12 epidemiological studies of childhood lead exposure to determine the contribution of lead-contaminated house dust and residential soil to children's blood-lead levels. A pooled analysis was used to confirm that lead-contaminated house dust (i.e., interior household floor dust-lead loadings) is a major source of lead exposure for children. Because this analysis did not examine the contribution of floor dust in different rooms, it is hard to compare the results in this article with the results of the pathways analysis in this report. The pathways analysis found play area floor dust lead to be a significant pathway of lead exposure for children when only floor dust lead was considered to be a source of lead exposure for children. Nevertheless, the Lanphear article was added as a reference for this report.

Clarification of Terms

One reviewer asked what "gray areas" were when included in the discussion of the Type I (false positive) and Type II (false negative) error probability analysis. Gray areas are the ranges of observed levels for which there is a high probability of making an incorrect decision. For instance, the floor dust standard is 100 $\mu g/ft^2$. A gray area around this standard could ± 20%, i.e., 80 $\mu g/ft^2$ to 120 $\mu g/ft^2$. If the Type I (false positive) error rate is high in this area, then there is a good chance that an incorrect decision about the existence of a lead hazard could be made. "Gray areas" are described in the text.

Questions About Results or Interpretations

One reviewer disagreed with one of the conclusions of the report—i.e., that the arithmetic mean, under the Proposed 403 Rule guidance, provides an assessment that had the same protection as the maximum value under the Interim Guidance Rule, but failed fewer homes. The reviewer suggested that the use of the arithmetic mean masked the location of the specific area that may be causing the home to fail, thus causing the homeowner to spend more money removing lead hazards. Though the arithmetic mean may be used to determine whether a lead hazard exists in a home for any one medium, the lead levels in the individual samples are available from the laboratory analysis and can be assessed by the risk assessor to pinpoint the areas that may have to be cleaned. Therefore, use of the arithmetic mean does not mask the location, but is used as a reporting mechanism for determining the existence of a lead hazard in the home.

The same reviewer felt that too many homes may pass a risk assessment when they should have failed, if the arithmetic mean is used. It is true that more homes will fail a risk assessment when the maximum value is used, but the positive and negative predictive values in the performance characteristic analysis indicate that when the maximum value is used 1) more homes that should have passed the risk assessment fail and 2) more homes that should have failed, pass. The error probabilities analysis showed that the use of the arithmetic mean under the Proposed Rule guidance improved the discrimination of the risk assessment by reducing the

Type I (false positive) and Type II (false negative) errors when compared to the maximum value. Also the discrimination of the maximum value was shown to be dependent on the number of samples collected; i.e., better discrimination as the number of samples collected increases, while the arithmetic mean is less dependent on the number of samples collected.

A key assumption of the error probability analysis—no room in a home was more indicative of the dust-lead hazard available to a child than any other room in a home—was questioned by two reviewers. This assumption was made to permit assessing the impact of any one room on the dust-lead hazard to a child without introducing any constraints. In different parts of the country, different constraints may be placed on the room that has more impact on the child's blood-lead concentration. For instance, one reviewer pointed out that in California and other Western states, a child's primary play area may consist of a porch, patio, or balcony, while in the Rochester Study, the primary play area may be the child's bedroom.

One reviewer, familiar with the Rochester data, questioned the performance characteristic analysis of 2, 3, or 4 rooms. The reviewer felt that when adding entryways and kitchens, few additional window sill or window well samples were included in the analysis. This is true. In the 83 homes included in this analysis, few window sill or window well samples were collected in interior entryways and kitchens. In many of these homes, though, floor samples were collected in these rooms. Since the focus of the analysis was on the impact of overall sampling in additional rooms, and not on specific components, the fact that window sill and window well samples were not collected was not considered a hindrance in the analysis. Ideally, each additional room would have had a floor, window sill, and window well dust sample taken; but since the data were not collected specifically for this analysis, the best available information was used.

A reviewer pointed out that, when identifying paint-lead health hazards in the performance characteristic and error probability analysis, the distribution of the paint-lead concentration, as well as the distribution of the paint deterioration percentage, would better quantify differences. The report was not aimed at analyzing paint-lead concentrations, and there was no possibility of assessing paint deterioration distributions since the Rochester data were only reported as a categorical variable (1=0% to <5% deteriorated painted surface, 2 = ≥5% to ≤15% deteriorated painted surface, and 3 = >15% deteriorated painted surface). Another reviewer asked for an analysis using the Proposed Rule paint deterioration standard of >10%; but, again, because of the limitations of the data, this was not possible.

In the summary of the phone survey of risk assessors in the United States, one reviewer pointed out that some of the risk assessors reported collecting fewer samples than may be legitimate for a risk assessment. The numbers reported are the numbers collected in the phone survey and reflect what the risk assessors contacted were doing, on average, at the time of the call. Another reviewer questioned why only nine risk assessors were called. This was a result of time and budget constraints. Due to these constraints, it was thought that some information from around the country was better than no information. It is recognized throughout the discussion of the phone survey that the information presented is not statistically representative of the population of risk assessors in the United States.

Other Comments

Other changes to the report based on the reviewers' comments included the following:

- Added footnotes to several tables in Chapter 6 and Appendix G indicating sample sizes in the analysis.
- Added a footnote explaining that the Rhode Island data were not collected as part of a study, but were collected as part of the lead program in the State of Rhode Island.
- Discussed the potential differences in recovery rates between actual composite samples and the simulated composite samples used in the performance characteristic analysis.
- Discussed the fact that limited data were available that met the data requirements of the analysis.

2.0 CONCLUSIONS

This section presents overall conclusions drawn from analyses using the Rochester Lead-In-Dust Study data, the Comprehensive Abatement Performance (CAP) Study data, data from the Rhode Island Department of Health, and cost information collected from nine risk assessors around the United States.

2.1 OBJECTIVE 1: PROBABILITY OF CORRECTLY IDENTIFYING A LEAD-BASED PAINT HEALTH HAZARD IN SINGLE FAMILY HOUSING AND THE COSTS ASSOCIATED WITH THE RISK ASSESSMENT

2.1.1 Risk Assessor Costs

Caution: *The results and conclusions presented below are based on responses from nine contractors in phone interviews conducted in May 1997 and follow-up interviews conducted in April 1998 with seven of the original nine contractors. Because of the small sample size and changing markets for risk assessments and sample analyses, caution should be exercised when interpreting these results.*

- The estimated cost of a risk assessment in areas where they are most commonly performed was \$435, while the average cost for a lead hazard screen was \$169.

- There was tremendous variability among contractors in the total estimated costs for risk assessments, inspections, lead hazard screens, and risk assessments/inspections. Total costs ranged from \$90 for a lead hazard screen by a contractor in the northeast to \$2,825 for a risk assessment/inspection by a contractor in the south. Some possible reasons for the differences may include the demand for the service or the number of contractors in the area. One contractor in the south thought his prices were higher because he performed fewer risk assessment activities in his area of the country than may be performed in other areas of the country.

- Generally the cost per sample included both the collection and analysis costs, though some contractors did charge analysis fees separately and included the collection cost in the base fee.

- The average total cost per sample (collection plus analysis costs) was highest for composite dust samples (\$20) and lowest for water samples (\$13).

- The average the total cost per composite dust sample (\$20) was only slightly higher than the average total cost per single dust sample (\$19). (Note that the number of samples in the composite was not reported, and only three contractors reported costs for the composite dust sample compared to nine for the single dust samples.)

- Paint chip total costs per sample were not reported, even for those contractors that used paint chip samples in their assessments. For those assessors that performed paint chip analysis, the costs for the sampling tended to be included in the base fee for the environmental sampling.

- The average number of samples collected during an activity depended on how contractors collected the samples as well as the media sampled.

2.1.2 Performance Characteristic Analysis

Using only the Rochester study data, four performance characteristics were used in this analysis to assess various sampling protocols and standards. The four characteristics were sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Briefly,

a) *Sensitivity* is the probability that <u>lead-based paint hazards</u> have been found in the home given that there is a child with an <u>elevated blood-lead</u> concentration in the home

b) *Specificity* is the probability that <u>no lead-based paint hazards</u> have been found in the home given that there is a child with a <u>low blood-lead</u> concentration in the home

c) *PPV* is the probability that the child in the home has an <u>elevated blood-lead</u> concentration given that <u>lead-based paint hazards</u> have been found in the home

d) *NPV* is the probability that the child in the home has a <u>low blood-lead</u> concentration given that <u>no lead-based paint hazards</u> have been found in the home.

For all four characteristics, a higher probability reflects a more accurate assessment. The following are the conclusions drawn from the results of the performance characteristic analysis:

- Application of the 403 Proposed Rule found fewer homes with lead-based paint hazards than the 403 Interim Guidance standards without sacrificing the ability to determine whether a health hazard exists. The NPV, specificity, and PPV were higher for the 403 Proposed Rule standards than for the 403 Interim Guidance standards, while the sensitivity was the same for both sets of standards. This occurs despite the exclusion of a window well dust standard in the Proposed Rule.

- The Proposed Rule's use of the arithmetic mean of dust and soil samples, combined with the lower media standards, provides a slightly more discriminating, though not statistically significant, assessment than the Interim Guidance, which uses the maximum value of the dust and soil samples to compare to higher media standards.

The sensitivity and NPV for a risk assessment under the Proposed Rule is 91.7% and 92.6%, respectively, and 91.7% and 87.5% under the Interim Guidance.

- In the assessment of the number of rooms from which to collect dust samples during a risk assessment, collecting dust wipe samples from four rooms (i.e., the bedroom, play area, interior entryway, and kitchen) did not significantly improve the performance characteristics when compared to collecting dust wipe samples from only two rooms (i.e., the bedroom and play area). Table 2-1 presents the performance characteristics when dust samples are collected from two and four rooms when the Interim Guidance and Proposed Rule standards are applied.

Table 2-1. Summary of the Performance Characteristics when Dust Samples are Obtained from Four Rooms and Two Rooms in a Home.

	Four Rooms (Bedroom, Play Area, Entryway, Kitchen)		Two Rooms (Bedroom and Play Area)	
Performance Characteristic	Interim Guidance	Proposed Rule	Interim Guidance	Proposed Rule
Sensitivity	88.2%	64.7%	88.2%	58.8%
Specificity	19.7%	74.2%	21.2%	77.3%
PPV	22.1%	39.3%	22.4%	40.0%
NPV	86.7%	89.1%	87.5%	87.9%

Within the respective guidance standards, the differences between the performance characteristics shown in Table 2-1 were not statistically significant.

- In terms of sensitivity and NPV, under the Interim Guidance standards, using the maximum value to characterize the house dust and soil lead levels resulted in a slightly better detection of a lead health hazard when compared to either the arithmetic or geometric mean. Under the Proposed Rule standards, the arithmetic mean does a slightly better job of detecting a lead health hazard when compared to the geometric mean or maximum value.

- There was no quantitative difference in identifying lead health hazards through a risk assessment using paint samples from surfaces with greater than 15% deteriorated paint as opposed to using paint samples from surfaces with greater than 5% deteriorated paint. The performance characteristics were not statistically different.

- Under the Interim Guidance, a lead hazard screen that samples only window sills or only window wells was less effective (in terms of sensitivity and NPV) in identifying potential health hazards than the full risk assessment. When both window sill and window wells were sampled, the hazard screen (sensitivity = 91.7% and NPV = 89.5%) was as effective as the risk assessment (sensitivity = 91.7% and NPV =

87.5%). Under the Proposed Rule, when the window sills were sampled, the lead hazard screen was as effective as the full risk assessment, sensitivity was 91.7% and 91.7% and the NPV was 91.7% and 92.6%, respectively. When no windows were sampled, the Proposed Rule lead hazard screen was not as effective. Note that the results may be difficult to interpret since the Rochester study homes would generally have not met the criteria for choosing a lead hazard screen over a risk assessment (i.e., 95% of all the homes were built before 1970).

2.2 OBJECTIVE 2: ABILITY OF ESTIMATORS AND SAMPLING PROTOCOLS TO DETERMINE "TRUE" AVERAGE LEAD LEVELS

Data from the Rochester study, the CAP Study, and the Rhode Island Department of Health were used to calculate within-house components of variation for two types of error probabilities: Type I (false positive) error and Type II (false negative) error. Briefly,

a) A *Type I (false positive) error* is the probability of a risk assessment concluding that a home *has* lead-based paint hazards when the home does *not*

b) A *Type II (false negative) error* is the probability of a risk assessment concluding that a home has no lead-based paint hazards when the home in fact *does*.

The error probabilities were calculated for three statistics: geometric mean, arithmetic mean, and maximum value. Each statistic's ability to characterize the "true" lead levels in a house were assessed individually for different sampling protocols, different media (dust and soil), different sampling components (floors, window sills, and window wells), and different standards (Interim Guidance and Proposed Rule).

The within-house variability estimates that were used to calculate error probabilities were from the Rochester Study floor, window sill, and window well dust wipe samples; the CAP study foundation and boundary soil samples; and the Rhode Island Department of Health floor, window sill, and window well dust wipe samples and side of house/foundations soil samples. The following general conclusions were drawn from the error probability analysis for each set of data.

- The maximum value had the highest Type I (false positive) and lowest Type II (false negative) error rates for each medium, the geometric mean had the lowest Type I and highest Type II error rates, and the arithmetic mean Type I and Type II error rates always were between the maximum value and geometric mean error rates.

- Both Type I (false positive) and Type II (false negative) error rates were high (usually over 25%) for all three statistics when the true media lead level was assumed to be within 20% of the media standard. The high error rates in a fairly large window imply that there is a very large "gray" area around the standard where there is a high probability of a "wrong" decision.

- The Type II (false negative) error probabilities decreased as the number of samples collected for dust and soil increased from two to four samples, when the maximum value was used. The Type II (false negative) error probabilities were less dependent on the number of samples collected when the arithmetic mean and geometric mean were used to characterize the dust and soil. This implies that the level of protection in a risk assessment is dependent on the number of dust and soil samples collected, especially if the maximum value is used to characterize the dust and soil samples.

- The combination of lowering the dust and soil standards and using the arithmetic mean as the characterization of floor dust lead, window sill dust lead, and soil lead in the home, as written in the Proposed Rule, seemed to have improved the discrimination of the risk assessment from the 403 Interim Guidance by reducing the Type I (false positive) and Type II (false negative) error probabilities.

2.3 OBJECTIVE 3: SAMPLING LOCATIONS RISK ASSESSORS MAY WANT TO TARGET TO EVALUATE POTENTIAL LEAD HAZARDS

A risk assessor has a choice of rooms and components to sample during a risk assessment. To inform a risk assessor on which rooms and components to sample, this analysis assessed the rooms and components that significantly impacted the blood-lead concentration of children in the Rochester Study. Below are the conclusions drawn from this analysis.

- There was statistically significant and positive bivariate correlation between the log-transformed blood-lead concentration and the log-transformed floor, window sill, and window well dust wipe lead loadings from the bedroom, play area, and kitchen. This indicated that the pathways of lead from the floor, window sill, and window well in the bedroom, play area, and kitchen to the blood should be assessed in the structural equation modeling (SEM) analysis.

- The most statistically significant correlation among the log-transformed dust wipe lead loadings occurred between 1) the kitchen and play area window wells, 2) the interior entryway and the kitchen floors, and 3) the play area and bedroom floors. This indicated that the pathways of lead from the kitchen to play area window wells, play area to kitchen window wells, interior entryway to kitchen floors, and play area to bedroom and bedroom to play area floors should be assessed in the SEM analysis.

- The SEM analysis showed the play area floor dust to be the only statistically significant direct pathway of lead exposure to the child's blood. There were no statistically significant indirect pathways of lead exposure. This implies that the risk assessor may want to sample dust from the child's play area floors to best assess the lead hazard available to the child.

- The pathways of lead from the window well to the window sill in the bedroom and play area were statistically significant. This indicates that sampling both the window well and window sill may be unnecessary.

3.0 QUALITY ASSURANCE

Four sources of data were used for the analyses in this report: the Rochester Lead-In-Dust Study data, the Comprehensive Abatement Performance (CAP) Study data, data from the Rhode Island Department of Health, and data from phone interviews of risk assessors throughout the United States. The Rochester study, CAP Study, and Rhode Island Department of Health data were not collected specifically for these analyses. Therefore, the quality of the data is dependent on the data collection methods employed by original data collectors. In contrast, the risk assessor information was collected specifically for these analyses. Below are brief descriptions of the data collection methods employed for each source of data to ensure the integrity of the data for analysis.

The data from the Rochester study and the CAP Study have already been subjected to quality assurance checks by the respective study coordinators. For each study, the data analyses have been presented in peer-reviewed study reports [8, 21, 22] and several refereed journal articles [10, 11, 12]. Each data set was available for this analysis as a SAS® data set. The accuracy of each data set was verified by calculating summary statistics and comparing the results to summary tables in the study reports [8, 22]. Any differences were noted and resolved.

The Rhode Island Department of Health data were collected by health department officials as part of the lead prevention program in Providence, Rhode Island. The data were not collected with the intent of being part of a study and thus did not require the same level of quality control. Blood and environmental data were received on 3.5" diskettes as ASCII files. The ASCII files were converted to SAS® data sets. The blood-lead and environmental-lead data were matched by a unique child identifier, and data summaries were calculated. Results of the summaries were discussed with a program official. Discrepancies were noted and resolved by the program official by checking the original records for accuracy. Upon approval from the program official, changes were made to the SAS® data sets to reflect the correct information. Several iterations of performing data validation, talking with the program official, and revising the SAS® data set produced final versions of the SAS® data sets suitable for statistical analysis. A data dictionary was created detailing the information in the final SAS® data sets.

Cost information from the risk assessors was collected through use of a questionnaire executed over the telephone. After the phone interviews were complete, the recorded data were double entered into a Microsoft Access® data base (i.e., entered twice into the data base on two separate days). During the data entry, data were verified. After all data were entered twice, both sets of data were compared, any discrepancies were resolved, and the final data base was converted to SAS® using DBMSCOPY®. Additional data verification was conducted in SAS® by running frequencies and summary statistics. The data in SAS® were also compared to the hardcopy questionnaires. Through the entire process, any discrepancies were noted and resolved immediately.

For all sets of data, as the statistical analyses were performed, the analysis data were periodically verified using frequency counts and summary statistics. All programs used to conduct the statistical analysis and to prepare tables and graphs were validated through visual inspection. When possible, direct processing from SAS® output to WordPerfect tables or figures was employed to reduce any chances of transcription error.

4.0 DATA SOURCES

Two types of data were needed for evaluating of the Section 402 regulations. The first type centered around pre-intervention child blood-lead data and associated pre-intervention environmental-lead data. The second type of data consisted of costs associated with performing the activities recommended in the Section 402 regulations.

Two general sources of environmental-lead and blood-lead data were identified: 1) formal lead studies with published results, and 2) state and local health departments that have lead programs that collect environmental and blood information for cases of lead poisoning. The lead studies that were identified as possible data sources included the

- Comprehensive Abatement Performance (CAP) Study
- Baltimore Repair and Maintenance Study (R&M)
- Three-City Lead Demonstration Projects: the Baltimore Soil-Lead Abatement Demonstration Project, the Boston Lead-In-Soil/Lead-Free Kids Demonstration Project, and the Cincinnati Soil-Lead Abatement Demonstration Project
- Milwaukee Low-Cost Intervention Study
- HUD Abatement Demonstration
- HUD National Survey
- Rochester Lead-In-Dust Study.

Health departments across the United States were canvassed for environmental-lead and blood-lead data. Seven agencies responded by sending data:

- Pinellas County Health Department, St. Petersburg, Florida
- Nebraska Health and Human Services System, Lincoln, Nebraska
- Vermont Department of Health, Burlington, Vermont
- Ohio Department of Health, Columbus, Ohio
- Rhode Island Department of Health, Providence, Rhode Island
- Missouri Department of Health, Jefferson City, Missouri
- Bureau for Public Health, Charleston, West Virginia.

For each source of data, a set of minimum requirements needed to be met for the data to be included in the analysis. Appendix F provides the criteria used to evaluate the appropriateness of each data source. Of all the data that were available for evaluation, only data from the Rochester Lead-In-Dust study and the Rhode Island Department of Health met the criteria.

It should be noted that limited data were available for the analyses in this report, particularly data meeting the criteria set forth in Appendix F. The collection of such data through additional environmental studies or local health programs would provide valuable data for the evaluation of risk analysis protocols.

To obtain cost information associated with Section 402 activities, a phone interview of risk assessors across the United States was performed. Cost data from nine risk assessment contractors in nine States were logged for analysis.

This section provides a description of the data and the process by which the data were collected. Section 4.1 describes the Rochester Lead-In-Dust study, including a description of the purpose of the study and the data collected in the study. Section 4.2 discusses the Rhode Island data included in the analysis and the difficulties in locating usable data from non-study environments. Finally, Section 4.3 provides a brief discussion of the data obtained from the risk assessors through the cost interview.

4.1 ROCHESTER LEAD-IN-DUST STUDY

The Rochester Lead-In-Dust Study was designed to address several objectives: "to determine whether dust-lead loading (µg/ft²) or dust-lead concentration (µg/g) is a better predictor of children's blood lead levels; to investigate whether dust sampling using vacuum methods or a wipe method is more predictive of children's blood lead levels; to identify which interior household surface(s) should routinely be sampled for dust lead measurements; and to estimate the probability of a child having an elevated blood lead level on the basis of a known level of lead in house dust, controlling for other potential exposures [8]."

Children 12 to 30 months of age who lived in the city of Rochester and had no known history of an elevated blood-lead concentration were eligible for the study. In addition to the age of the child, the location of a child's residence, and the blood-lead history of the child, other eligibility criteria were applied to control for the possibility of non-residential, non-typical sources of lead affecting blood-lead concentrations [1, 3, 8]. Two hundred five children were enrolled into the study. To summarize the homes in the study, Table 4-1 shows the distribution of the year in which a home was built and the age of the child at blood collection.

Table 4-1. Distribution of the Year Homes were Built and Children's Ages for the Rochester Lead-In-Dust Study.

	N	Percent of Population
Year in which home was built		
Pre-1940	172	84%
1940 – 1969	22	11%
1970 – 1979	1	1%
Post-1979	10	5%
Age of children at time of blood collection		
12 – 18 months	90	44%
18 – 24 months	57	28%
24 – 30 months	58	28%

This table shows that 84% of the homes in the study were built prior to 1940 and that all of the children in the study were between 12 months and 30 months of age.

Collection of questionnaire data, blood-lead samples, and environmental-lead samples occurred between August and November 1993. Venous blood samples were obtained by a certified pediatric phlebotomist during a home visit using lead-free containers provided by the New York State Department of Health Clinical Laboratory Evaluation Program. Three dust collection methods were used to sample settled house dust: wipe sampling, dust vacuum method (DVM) sampling, and Baltimore repair and maintenance (BRM) vacuum sampling [8].

Dust samples were collected from the window well, interior window sill, and floor in the child's bedroom; the window well and floor in the kitchen; the window well, interior window sill, and floor in the child's principal play area; the interior window sill and floor in the living room; the interior entryway floor; and the exterior porch floor. Dust samples from carpeted and uncarpeted floors were collected over a 1 ft^2 area. Dust samples from window wells and interior window sills were collected over one-third of the available surface area. Soil core samples, taken at a depth of ½ inch, were collected in two distinct areas: the perimeter of the foundation and the child's principal outside play area. There were a significant number of homes for which play area soil was not collected. Three core soil samples were taken on each side of the house around the perimeter of the foundation where bare soil was present and combined for a composite foundation sample (in general there were 12 core samples). The soil samples were separated into fine and coarse samples for laboratory analysis. Two water samples were taken at each home. One sample was a first draw after an 8-hour stagnation period. The other was collected after a 1-minute flush. Three XRF paint-lead measurements were taken from areas such as the window well, sill, and sash; the floor and the door in the kitchen; the child's bedroom; the principal play area; the entryway; the living room; and any deteriorated surface. The three XRF measurements on each surface were averaged. Laboratory paint chip analysis (atomic absorption or inductively-coupled plasma emission spectroscopy) was used only when XRF could not be used due to an inaccessible surface, an ornate or severely curved surface, or when the painted surface was too small to measure. XRF readings were not substrate corrected or confirmed by laboratory analysis for this study [8]. Only XRF paint-lead measurements were discussed in this report. A visual inspection of each surface was also performed, and the paint condition was rated as poor, fair, or good.

For the analysis, soil-lead concentrations were estimated by calculating an arithmetic average of lead concentrations in fine and coarse soil fractions.

4.2 HEALTH DEPARTMENT DATA SOURCES

Additional sources of data were sought to complement and contrast with the information found in the environmental lead studies. To find these additional sources, staff at the CDC provided a list of 40 health departments in the United States currently participating in its Childhood Lead Poisoning Prevention Grant Program. A brief questionnaire was developed to collect information from these departments on the population size of the data base, agencies funding the program, the availability of the data, the age of children in the program, whether blood or environmental (soil, dust, paint, and water) samples were obtained, and the format of the data.

Following this first survey, a list of 24 health departments with potentially useful data was developed. A more detailed questionnaire, "Data Set Assessment," was developed requesting information from these departments about the data. A copy of this second questionnaire is included as Example K-1 in Appendix K. Included in this second questionnaire were questions concerning the format of the data, specific information about blood sampling of children, specific information about environmental sampling, and whether a unique identifier was available to link the environmental data and the blood data. A second telephone interview was conducted.

As a follow-up to the phone call, a letter was sent to the 24 health departments requesting their participation in the data collection effort for the Environmental Protection Agency (EPA) and explaining how the data would be used in this study. (A copy of the letter and information sent to each agency is provided as Example K-2 of Appendix K). Follow-up calls were made three weeks later. As a result of this effort, data were obtained from health department agencies in Columbus, Ohio; Providence, Rhode Island; Omaha, Nebraska; St. Petersburg, Florida; Burlington, Vermont; Charleston, West Virginia; and Jefferson City, Missouri. These data were entered into SAS® data sets and evaluated as to their applicability according to the criteria listed in Appendix F. Table K-1 of Appendix K provides a summary of the data collected from each health department. The last column in the table gives a brief description of the advantages and disadvantages of using the data sources. Only the data provided by the Rhode Island Department of Health met the necessary requirements for analysis.

Rhode Island Department of Health Data

As part of its ongoing lead program, The Rhode Island Department of Health has logged the occurrences of elevated blood-leads. When necessary, the health department requested that environmental sampling occur and has logged that information. Though the Rhode Island Department of Health has been collecting blood and environmental information for several years, only data collected in 1995 and 1996 was used in this analysis to ensure that the data could be reviewed and corrected, as necessary, in time to be included.

As shown in Table K-1 of Appendix K, blood, dust, soil, paint, and water samples were collected and recorded. Two hundred eighty-five children aged 6 months to 9 years and 4 months had blood samples available for analysis, and between 129 and 325 homes had the appropriate environmental samples needed for the analysis. Table 4-2 provides the distribution of children's ages. Eighty-five percent of the children were between 6 months and 48 months at the time of blood sampling. The location of the blood sampling was not available. There were a number of homes in which multiple blood samples were logged for one or more children. For homes in which multiple children were sampled, only the youngest child in the home was included in the analysis. Generally, a fingerstick blood sample was obtained for comparison against the action level of 25 µg/dL. (Note, at the time the data were obtained for the analysis, the action level for blood lead was moving toward 20 µg/dL, but 25 µg/dL was the standard for comparison at the time of sampling.) If the fingerstick blood-lead concentration was greater than 25 µg/dL, then generally a venous sample was obtained for confirmation, generating a second blood sample for the child. When available, a venous blood sample result was used in the analysis; otherwise, the fingerstick blood sample result was included.

Table 4-2. Distribution of Children's Ages in the Rhode Island Department of Health Data.

Age of children at the time of blood collection	N	Percent of Population
6 - 18 months	47	16.5%
18 - 24 months	61	21.4%
24 - 36 months	73	25.6%
36 - 48 months	61	21.4%
48 - 60 months	23	8.1%
60 - 72 months	12	4.2%
72 - 112 months	8	2.8%

Environmental samples were collected by a contractor for the Health Department to locate the lead problems in the child's environment. Dust wipe and vacuum samples were taken in 129 homes from a 1 ft^2 area on carpeted and uncarpeted floors, window wells, and window sills in the bedroom, dining room, hallway, kitchen, living room, and play room. Of the 129 homes, 109 homes had dust wipe samples taken. Seven hundred and sixty-six soil samples were taken from 264 homes from the top 2 cm of soil from the side of the home at the foundation. Paint chips of at least 2 in^2 in size were collected from the interior and exterior of the home including doors, trim, baseboards, ceilings, casings, walls, jambs, sills, wells, and furniture for 265 homes. The condition of the painted surface was not reported.

When the data were subset to include all the information needed for the Objectives 1 and 3 analyses, it was found that only 73 homes could be included in the analysis, with these homes having only between 1 and 10 samples per home. Note that 95% of the homes had a total of 5 or fewer dust samples collected.

Caution should be exercised when viewing the results obtained from the Rhode Island Department of Health data. These data were not collected under a controlled setting as were the Rochester study data. In the Rhode Island data, an elevated blood-lead concentration motivates the collection of environmental samples, not a statistical study design. As a result, the Rhode Island data generally represent children with blood-lead concentrations ranging from 1 μg/dL to 104 μg/dL with 90% of the children having blood-lead concentrations of 20 μg/dL or greater. This is a different population from the one assessed using the Rochester study data, where the blood-lead concentrations ranged from 1.4 μg/dL to 31.7 μg/dL, with only 3% of children having blood-lead concentrations of 20 μg/dL or more. In addition, background information such as type of housing, length of time at the residence, pica habits, etc. are not available. One advantage to the Rhode Island dataset is that it does reflect the environmental sampling choices a risk assessor makes, as opposed to the designed sampling scheme found in the Rochester study data.

As illustrated with the lead study and health department data, obtaining enough data from secondary sources to meet the requirements for analysis is difficult. Because of the varying study designs in the lead studies and the lack of a standard format used among the health departments, only the Rochester study and Rhode Island data met the necessary requirements.

4.3 RISK ASSESSOR COST INFORMATION

Data on risk assessment and lead hazard screen costs were collected by interviewing certified risk assessors in the United States. To identify certified risk assessors, the Governor's Legislative Conference supplied a list of states throughout the country with certification programs in lead risk assessment. From this list, several States were contacted to obtain lists of individuals who had been through the certification process and were actively involved in conducting lead risk assessments. A questionnaire was developed to be used in a telephone interview to obtain cost information for lead risk assessment, hazard screen, inspection, and risk assessment/inspection. This cost questionnaire was pilot tested in a telephone interview of six risk assessment contractors in Columbus, Ohio. The data were compiled from the pilot, and modifications to the questionnaire were made based upon the initial interviews. The final cost questionnaire was administered by telephone to nine contractors in different parts of the United States: the northeast, south, and west. Note that the contractors were not randomly selected.

The interviewer began at the top of the calling list and proceeded down until a successful interview was obtained. Eleven contractors were contacted, and no contractor refused to be interviewed. The two contractors that did not provide information were willing to participate, but were too busy at the time of the call to provide information.

The interviewer asked about the costs associated with four activities that a risk assessor can perform: a risk assessment, lead hazard screen, inspection, and risk assessment/inspection. Within each of these activities, the respondent was asked whether a basic fee was charged for the activity or whether separate fees were charged for specific components of the activity. For instance, within a risk assessment, separate fees could be charged for the visual assessment, the environmental sampling, or the risk assessment report. In addition, detailed questions on the particulars of the environmental sampling were asked. The questions included:

- What are the collection costs, analysis costs, and total costs per dust, soil, and paint samples?
- How many of these samples are typically collected?

All this information was recorded on a questionnaire. Appendix C contains a copy of the actual questionnaire used in the telephone interview and provides a summary of each of the responses. As seen in Appendix C, not all the questions were answered by the contractors. About one year after the initial phone call, in April 1998, a follow-up phone call was made to each contractor to obtain updated information.

5.0 STATISTICAL METHODS

The methods used in the data analysis and preparation of the data are discussed in this section. To characterize the probability of a certified risk assessor correctly identifying a lead-based paint hazard, three statistical objectives were defined. They are

1. Characterize how different sampling protocols affect a) the probability of correctly identifying a health hazard (defined for purposes of this analysis as the presence of a child with a blood-lead concentration greater than or equal to 10 µg/dL) in single family housing (performance characteristic analysis) and b) the cost of the assessment (cost analysis). Also characterize differences between the 403 Interim Guidance and the 403 Proposed Rule in the probability of correctly identifying a health hazard in single family housing (performance characteristic analysis).

2. Characterize for a risk assessment and lead hazard screen a) how well different estimators and sampling protocols estimate the true average lead levels in a single family home and b) the error probabilities associated with concluding that a home is above or below a given media standard for different estimators and sampling protocols (error probabilities analysis).

3. Assess which sampling locations a risk assessor may want to target in order to best evaluate the potential lead hazard to a child (pathways analysis).

The methods used to address the first statistical analysis objective included the calculation of four measurements (performance characteristics): sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). These measurements were used to characterize the performance of a lead hazard screen and several specific risk assessment protocols in terms of how well each protocol was able to identify a home with a child with a blood-lead concentration greater than or equal to 10 µg/dL. Confidence intervals about the individual performance characteristics were calculated. The cost estimates obtained via telephone interview from risk assessors across the country were summarized and used to calculate estimated costs for each of the risk assessment protocols and the lead hazard screen for which performance characteristics were calculated.

The second statistical analysis objective used variability estimates and distributional assumptions to estimate error probabilities associated with concluding that the true average lead level in a home is above or below a standard. Correlation and pathways analyses were used to evaluate the third statistical objective.

Section 5.1 discusses the Objective 1 analysis of cost information obtained from risk assessors around the country and the Objective 1 and 2 performance characteristics. The Objective 2 error probability calculations are detailed in Section 5.2, and Section 5.3 provides details on the Objective 3 correlation and pathways analyses.

Note, at the time of this report, Section 402 did not dictate one set of methods for carrying out activities outlined under Section 402, but listed documents that have appropriate methods. Two documents contained the prevalent method: the HUD Guidelines and the 403 Interim Guidance. These documents listed nearly the same methods with only a few differences. In addition, in June 1998, EPA issued its 403 Proposed Rule, which differs on several points from the 403 Interim Guidance. Both sets of differences, as well as the list of documents, are discussed in Section 1.

Throughout the analyses described in this report, the Interim Guidance and the Proposed Rule standards listed in Table 1-1 will be used for comparisons. One exception to the comparisons using the both the Interim Guidance and Proposed Rule standards is related to the use of samples from carpeted floors. Carpeted floor samples were included in the application of the Interim Guidance and Proposed Rule to assess sampling that may be conducted under the HUD Guidelines. The Section 403 Interim Guidance was recommended as a Section 402 guidance document at the time these analyses were conducted. When the Section 403 Proposed Rule becomes final, the guidance in the Proposed Rule will supersede the Interim Guidance as it applies to Section 402.

5.1 OBJECTIVE 1: PROBABILITY OF CORRECTLY IDENTIFYING A LEAD-BASED PAINT HEALTH HAZARD IN SINGLE FAMILY HOUSING AND THE COSTS ASSOCIATED WITH THE RISK ASSESSMENT

5.1.1 Risk Assessor Cost Information

Bar charts, pie charts, and tables are used to present, in Section 6, the summary statistics calculated for the risk assessor cost information. Appendix C contains a copy of the questionnaire used to gather the cost information; details of how the risk assessor interviews were conducted are discussed in Section 4.3. As discussed in Section 4.3, nine contractors in nine States were contacted and interviewed in May 1997. The sample of contractors was not a statistically representative sample. The information obtained from these contractors, though, did provide an indication of the costs that are associated with the activities of a risk assessor. Due to the voluntary nature of the interviews, some respondents did not answer all the questions posed. Follow-up calls were made in April 1998 to fill in the information gaps. The follow-up calls yielded some additional information, but not enough to warrant producing summaries for the follow-up calls only. Therefore, all the summaries presented are for the May 1997 calls, with additional discussion of the information gathered from the April 1998 interviews provided where appropriate.

To summarize the data, several questions in the questionnaire were combined. Below is a discussion of how the answers for several questions were combined to estimate costs per environmental sample, number of environmental samples collected, and costs for risk assessments and lead hazard screens, as well as a discussion of the naming scheme used to provide confidentiality for the contractors.

5.1.1.1 Naming Convention for the Contractors

Nine contractors from across the country provided risk assessor cost information. To preserve confidentiality, the contractors were categorized into three regions of the country; and, within each category, randomly assigned an ID number. The three regions were the northeast (NE), south (S), and west (W). Four contractors were in the northeast region, three contractors in the south region, and two contractors in the west region. Within each region, the IDs were assigned as NE-1, NE-2, NE-3, and NE-4 for the northeast, S-1, S-2, and S-3 for the south, and W-1 and W-2 for the west.

5.1.1.2 Risk Assessment, Lead Hazard Screen, Inspection, and Risk Assessment/inspection Costs

Contractors allocated costs for an activity in two ways:

a) A basic fee for the whole activity
b) Separate fees for each component of the activity.

When a basic fee was charged for the activity, the contractor generally fixed a maximum number of samples that could be collected for the fee. If additional environmental sampling was required, the contractor charged additional fees. Some contractors opted to charge separate fees for each component of the activity performed: a visual assessment, typical environmental sampling, and a report. The contractor set a fee for the visual assessment, environmental sampling, and report and fixed the maximum number of samples to be collected during the environmental sampling. Similar to the basic fee structure, if additional environmental samples above those covered in the typical environmental sampling were needed, additional fees were charged on a per sample basis. The basic fee structure and separate fee structure were both used to estimate the costs of the risk assessments and lead hazard screens evaluated during the performance characteristic analysis.

5.1.1.3 Costs Per Environmental Sample

The average total cost per sample was calculated based on the information in questions B8, B9, B13, and B15 for a risk assessment, C8, C9, C13, and C15 for a lead hazard screen, D8, D9, D13, and D15 for an inspection, and E9, E10, E14, and E16 for a risk assessment/inspection (see Appendix C). The collection and analysis costs per sample were reported, and the total cost per sample was the sum of these two responses. If either response was not available, then the total cost was either the collection cost or the analysis cost, whichever was reported. Note that some contractors reported the range of costs for the collection or analysis costs, rather than a specific cost. In cases such as this, the lowest cost in the range was assigned to a minimum cost variable, the highest cost in the range was assigned to a maximum cost variable, and the midpoint of the reported cost range was recorded in the average cost variable. When only an average cost was reported, the minimum, average, and maximum variables were set equal to the reported average cost. To calculate the minimum, mean, and maximum collection, analysis, and total costs per sample, the minimum of the minimum cost variable was equal to the minimum cost, the mean of the average cost variable was equal to the average cost, and the maximum of the maximum cost variable was equal to the maximum cost. This allowed all reported information to be used.

5.1.1.4 Number of Environmental Samples Collected

The responses to questions B6, B9, B13, C6, C9, C13, D6, D9, D13, E7, E10, E14 were used to estimate the average number of environmental samples collected for a risk assessment, lead hazard screen, inspection, and risk assessment/inspection, respectively. When ranges were reported for the number of samples collected, the same strategy as discussed for the cost per sample was employed.

5.1.2 Performance Characteristics

Four measurements (performance characteristics) (sensitivity, specificity, PPV, and NPV) were used to characterize the performance of the risk assessment protocols and to assess how well each protocol identified a lead-based paint health hazard. Each of the performance characteristics is defined in Table 5-1 below.

Table 5-1. Definitions of Performance Characteristics

		Media Standard	
		Below (<) Media Standard	Above (≥) Media Standard
Target Blood Lead Concentration	≥10 µg/dL	a	b
	<10 µg/dL	c	d

In the above table, the letter 'a' represents the number of children that have a blood-lead concentration above a given target and the media lead level (soil-lead concentration, etc.) below the selected standard. Letters 'b,' 'c,' and 'd' represent similar counts. From these counts the following performance characteristics are calculated:

Performance Characteristic	Definition	Calculation
Sensitivity (or True Positive Rate)	Probability that lead-based paint hazards are found in the home given that there is a resident child with an elevated blood-lead concentration.	b/(a+b)
Specificity (or True Negative Rate)	Probability that no lead-based paint hazards are found in the home given that a resident child has a low blood-lead concentration.	c/(c+d)
Positive Predictive Value (PPV)	Probability of a resident child having an elevated blood-lead concentration given that lead-based paint hazards are found in the home.	b/(b+d)
Negative Predictive Value (NPV)	Probability of a resident child having a low blood-lead concentration given that no lead-based paint hazards are found in the home.	c/(a+c)

5.1.2.1 <u>Performance Characteristic Calculations</u>

Ideally all four performance characteristics would equal 100%. Figure 5-1 presents an example of this ideal situation in which a foundation soil standard of 400 ppm is used to calculate the measures. In reality, achieving 100% for all four performance characteristics is generally not possible; Figure 5-2 illustrates an example when 100% is not achieved for positive predictive value and specificity. Because 100% cannot always be achieved for the performance characteristics, the different risk assessment/lead hazard screen sampling protocols were evaluated based primarily on sensitivity and NPV measures. The sensitivity focuses on the probability of finding lead-based paint hazards when the child is known to have an elevated blood-lead concentration, while the NPV focuses on the probability of a child having a low blood-lead concentration when no lead-based paint hazards have been found.

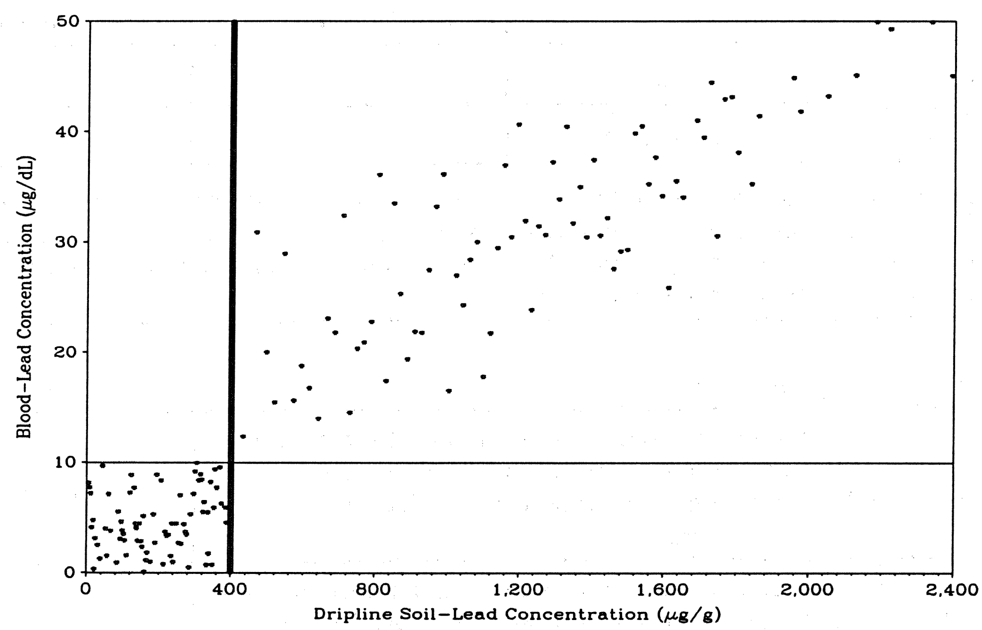


Figure 5-1. Example of an Ideal Situation When 100% is Achieved For All Four Performance Characteristics.

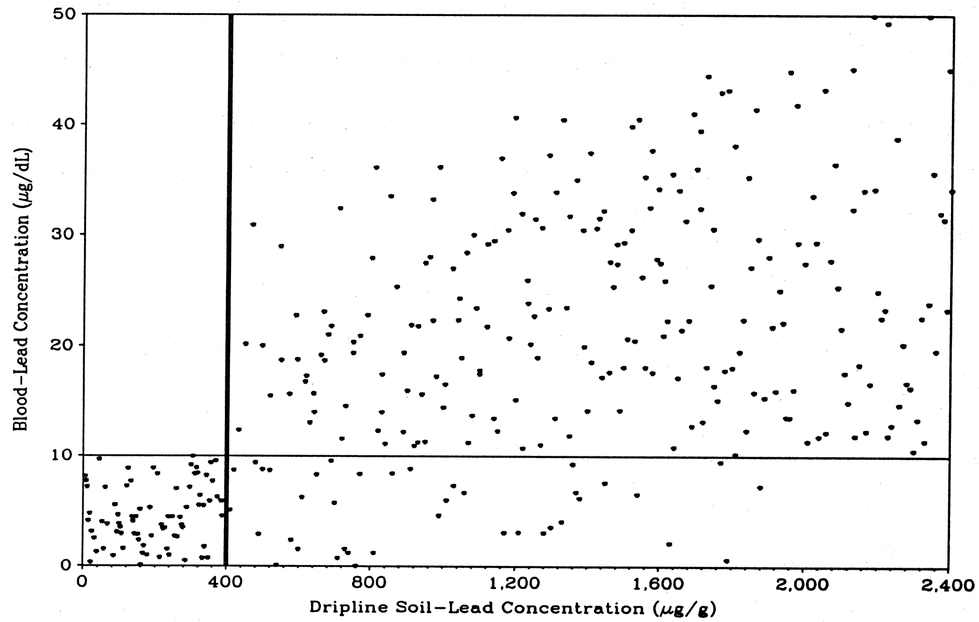


Figure 5-2. Example of a Situation Where the Negative Predictive Value and Sensitivity Equal 100%, but the Positive Predictive Value and Specificity are Less than 100%.

In addition to calculating the performance characteristic point estimates, confidence intervals about the different performance characteristics were calculated using an F-distribution approximation to a binomial proportion [2]. Using the variables defined in Table 5-1, the confidence limits were calculated as follows:

$$\textit{Lower Confidence Limit: } P_L^{\alpha}(n,\, B) \;=\; \frac{B}{B \,+\, (n-B+1)\times f_{\alpha/2,2(n-B+1),2B}}$$

$$\textit{Upper Confidence Limit: } P_U^{\alpha}(n,\, B) \;=\; 1 \,-\, P_L^{\alpha}(n,\, n\,-\,B)$$

where

B the numerator of the performance measure calculation (i.e., *b* for sensitivity and PPV and *c* for specificity and NPV)

n the denominator of the performance measure calculation (i.e., *a*+*b* for sensitivity, *c*+*d* for specificity, *b*+*d* for PPV, and *a*+*c* for NPV)

$f_{\gamma,\eta 1,\eta 2}$ the upper γth percentile for the F distribution with η_1 numerator degrees of freedom and η_2 denominator degrees of freedom.

For example, in the case of sensitivity, B is the number of homes that have a child with an elevated blood-lead concentration and have environmental media samples that are above the given environmental media standards, while n is the number of homes that have a child with an elevated blood-lead concentration. Note, no adjustment was made to the confidence intervals for the joint assessment of multiple confidence intervals.

For this analysis, identification of a lead-based paint hazard (i.e., failure or passage of a unit through a risk assessment or lead hazard screen) and evaluation of the performance characteristics defined above were based on the evaluation of floor dust, window sill dust, window well dust, soil, and paint simultaneously.

5.1.2.2 Data Used in the Analysis

As described in Appendix D, there are several options available to a risk assessor when collecting dust-lead loading samples. The purpose of this analysis was to assess the impact these choices may have on the outcome of a risk assessment or lead hazard screen. Several data sources were examined as to the applicability of assessing any one of these choices (see Section 4.0). The data sources were required to have collected dust wipe samples, since the Interim Guidance and Proposed Rule dust standards are for dust wipe samples only. Only the Rochester Lead-In-Dust Study data provided dust wipe sampling and enough additional information (such as room location of the dust samples, individual dust samples from several locations within a home, and condition of painted surfaces) to be included in this analysis. Specifics of the Rochester study data are provided in Section 4.1.

In this analysis, the proposed 403 Rule is used, paint standard is greater than 10% deteriorated lead-based paint, and no differentiation is made between interior and exterior painted components. In the Rochester study data, the condition of the paint was reported as good (from 0% to less than 5% deteriorated paint), fair (5% to 15% deteriorated paint on the surface), and poor (greater than 15% deteriorated paint on the surface). To best assess the effect of the assumed paint standard, two sets of analyses were run, where exclusively poor and fair conditioned surfaces are sampled (≥5% deteriorated paint on the surface) and where poor conditioned surfaces are sampled (>15% deteriorated paint on the surface).

The Proposed Rule does not present a standard for carpeted floors. In this analysis, average carpeted and average uncarpeted floor dust lead loadings are compared separately to the standard presented for uncarpeted floors.

In addition, the soil standard in the Proposed Rule is compared to a yard-wide average soil-lead concentration where the yard-wide average is calculated as the average of the dripline and mid-yard soil-lead. The Rochester study data represented foundation and play area soil. Therefore, for this analysis, the yard-wide average will be calculated as the average of the play area and foundation soil-lead concentration.

5.1.2.3 Protocols Evaluated

Because of the data limitations, not all choices available to a risk assessor could be examined. The following are the choices that were evaluated using the Rochester data:

1. Assessment of the number of rooms and types of rooms sampled for dust (shown in Table 5-2). This assessment addresses the benefits of reducing variability versus sampling rooms that may contribute little to a child's lead exposure.

2. Assessment of the effects of using the arithmetic mean dust wipe, a geometric mean dust wipe, and the maximum dust wipe (shown in Table 5-3).

3. Assessment of the deteriorated paint condition levels in the HUD Guidelines versus other options for deteriorated paint condition levels.

4. Assessment of the choice of conducting a lead hazard screen versus conducting a full risk assessment (shown in Table 5-4). (Since a lead hazard screen requires the use of composite samples, simulated composite samples were used when only single sample data were available.)

These options were evaluated for each medium individually and for all media standards (i.e., dust, soil, and paint) simultaneously.

Note that Section 402 recommends, for a lead hazard screen, comparing composite floor dust, window dust samples, and samples from deteriorated painted surfaces to their respective standards. Section 402 does not make a distinction among the types of floors or window components that should be sampled. The 1995 HUD Guidelines present a method for the lead hazard screen that collects floor samples from both uncarpeted floors and carpeted floors, composites them separately into an uncarpeted floor sample and a carpeted floor sample, and then compares them to their own standards. In addition, the HUD Guidelines recommend sampling the window well for the lead hazard screen, not the window sills. The Section 403 Interim Guidelines and Proposed Rule do not provide a method for sampling from a specific component. For windows, the HUD Guidelines and the Interim Guidance provide hazard standards for both the window well and window sill, while the Proposed rule only provides a standard for window wells. In the HUD Guidelines, standards for both carpeted and uncarpeted floors are given, while the Interim Guidance and Proposed Rule only provide a floor standard for uncarpeted floors. The different interpretations and standards allow several scenarios under which the lead hazard screen could be performed.

The protocols to be assessed using the Rochester study data are listed in Tables 5-2, 5-3, and 5-4. Composite samples were not collected in the Rochester study, so to perform the assessment in 4. above, the arithmetic mean of the uncarpeted and carpeted floor dust samples, window sill dust samples, window well dust samples, and paint samples were used as surrogate composite samples to compare to the lead hazard screen standards, depending on the scenario chosen. A composite sample is different from a single-surface sample in that samples are collected from common components in different rooms and analyzed as one sample. As a result, there may be potential differences in lead recovery rates for composite samples compared to surrogate composite samples. The Proposed Rule also recommends that dripline and mid-yard soil be sampled. The Rochester study data only distinguished between dripline and play area, not dripline and mid-yard. Therefore, for this analysis, the play area soil was used as a surrogate for the mid-yard soil.

Concurrent analyses were conducted for each sampling protocol and set of standards (Interim Guidance and Proposed Rule) to compare the results of the assessments when different standards for comparison are put into practice.

Though the performance characteristics and the risk assessor cost estimates for each protocol within a standard of comparison were the focus of this analysis, additional statistics were calculated to provide further characterization of the protocols. Table 5-5 lists the statistics included in the analysis and provides a brief explanation of how the statistics were calculated.

Table 5-2. Sampling Protocol Group A: Assessing the Impact of Dust Sampling from Specific Rooms Included in a Risk Assessment.

Sampling Protocol Group A	Room Location of Single Wipe Samples			Soil	Paint
	Floor Dust	Window Sill Dust	Window Well Dust		
A-1 4 rooms	Bedroom, Play Area, Entryway, Kitchen			Dripline & Play Area	>15% or ≥5% of the painted surface is deteriorated
A-2 3 rooms	Bedroom, Play Area, Entryway			Dripline & Play Area	>15% or ≥5% of the painted surface is deteriorated
A-3 2 rooms	Bedroom, Play Area			Dripline & Play Area	>15% or ≥5% of the painted surface is deteriorated

Definitions of the condition of the paint:
Poor: More than 15% of the paint film is peeling, chalking, flaking, blistering, or otherwise separate from the substrate.
Fair: The paint film is largely intact, but is cracked, worn, or chipped (approximately 5% – 15% deteriorated).
Good: The paint film appears intact and does not chalk, flake, or peel. Less than 5% of the surface is deteriorated or defective.

Table 5-3. Sampling Protocol Group B: Assessing the Impact of Using Different Summary Measures to Characterize Dust Samples for a Risk Assessment.

Sampling Protocol Group B	Summary Measure of All Available Samples (Wipe) taken in the Bedroom, Play Area, Entryway, Kitchen			Soil	Paint
	Floor Dust	Window Sill Dust	Window Well Dust		
B-1 Geometric Mean	Geometric Mean			Dripline & Play Area	>15% or ≥5% of the painted surface is deteriorated
B-2 Arithmetic Mean	Arithmetic Mean			Dripline & Play Area	>15% or ≥5% of the painted surface is deteriorated
B-3 Maximum Value	Maximum Value			Dripline & Play Area	>15% or ≥5% of the painted surface is deteriorated

Definitions of the condition of the paint:
Poor: More than 15% of the paint film is peeling, chalking, flaking, blistering, or otherwise separate from the substrate.
Fair: The paint film is largely intact, but is cracked, worn, or chipped (approximately 5% – 15% deteriorated).
Good: The paint film appears intact and does not chalk, flake, or peel. Less than 5% of the surface is deteriorated or defective.

Table 5-4. Sampling Protocol Group C: Assessing the Outcome of a Lead Hazard Screen Versus a Risk Assessment.

Sampling Protocol Group C	Room Location of Composite Wipe Samples			Soil	Paint
	Floor Dust	Window Sill Dust	Window Well Dust		
C-1 Full Risk Assessment – individual samples	Bedroom, Play Area, Entryway, Kitchen	Bedroom, Play Area, Entryway, Kitchen	Bedroom, Play Area, Entryway, Kitchen	Dripline and Play Area	>15% or ≥5% of the painted surface is deteriorated
C-2 Lead Hazard Screen	Bedroom, Play Area, Entryway, Kitchen	Bedroom, Play Area, Entryway, Kitchen	Bedroom, Play Area, Entryway, Kitchen	NA	>15% or ≥5% of the painted surface is deteriorated

Definitions of the condition of the paint:

Poor: More than 15% of the paint film is peeling, chalking, flaking, blistering, or otherwise separate from the substrate.

Fair: The paint film is largely intact, but is cracked, worn, or chipped (approximately 5% – 15% deteriorated).

Good: The paint film appears intact and does not chalk, flake, or peel. Less than 5% of the surface is deteriorated or defective.

Table 5-5. Summary of the Statistics Calculated to Characterize the Protocols.

Statistic to Characterize the Protocol		Description of the Calculation
Number of Homes Included in the Analysis		Homes were included in the analysis if the dust samples necessary for the analysis were available.
% of Homes in which Lead-Based Paint Hazards were Found		Given the media being evaluated in the protocol, this is the percent of homes that have at least one media sample that does not pass its associated standard.
% of Blood Samples ≥10 μg/dL		For all homes, this is the percent of children in the homes that had a blood-lead concentration greater than or equal to 10 μg/dL.
% of Homes in Which Lead-Based Paint Hazards Were Found Based on One Medium Assessed Individually (≥ media standard)		For each medium individually, this is the percent of homes that have at least one sample that does not pass the media standard.
Sensitivity (LCB, UCB) Specificity (LCB, UCB) Positive Predictive Value (LCB, UCB) Negative Predictive Value (LCB, UCB)		The performance characteristics and confidence bounds are calculated as discussed above. LCB is defined as lower 95% confidence bound and UCB is defined as upper 95% confidence bound.
Estimated cost of a risk assessment or lead hazard screen	Basic Fee	Estimated cost of the risk assessment or lead hazard screen performed under the protocol when a basic fee is charged for the activity. (See Section 5.1.1.2.)
	Separate Fee	Estimated cost of a risk assessment or lead hazard screen performed under the protocol when separate fees are charge for the activity. (See Section 5.1.1.2.)

5.2 OBJECTIVE 2: ABILITY OF ESTIMATORS AND SAMPLING PROTOCOLS TO DETERMINE TRUE AVERAGE LEAD LEVELS

The statistical analysis for this objective used variability estimates calculated from environmental samples in the Rochester study, CAP Study, and Rhode Island Department of Health data, along with distributional assumptions to estimate error probabilities associated with concluding that the unobservable, "true" average lead level in a home was above or below the standard. The unobservable, "true" floor, window sill, and window well dust lead loading and soil lead concentration within a home were assumed to be characterized by an average log lead loading. The precision and accuracy of the characterization of this unobservable, "true" mean log lead level depends on the type of statistic used to report the lead level found in the home. For instance, using the geometric mean floor dust-lead loading to compare to the Interim Guidance standard may better reflect the unobservable, "true" dust-lead level in the home than the maximum floor dust-lead loading value. The analysis under this objective did the following:

1. Compared the ability of the maximum value, geometric mean, and arithmetic mean to characterize floor dust, window sill dust, and window well dust lead loadings and soil lead concentration.
2. Characterized a) the probability of no lead-based paint hazards being found in the home when the unobservable, "true" media lead level at the home is assumed to be above the media standard (Type II error or false negative) and b) the probability of finding lead-based paint hazards in the home when the unobservable, "true" media lead level at the home is assumed to be at or below the media standard (Type I error or false positive).
3. Compared the effect of different standards (i.e., Interim Guidance and Proposed Rule standards) on the error probabilities.

An assessment of the paint lead error probabilities will not be made in this report. Paint hazards are characterized on a component-by-component basis. This is different from soil and dust where the samples collected are assumed to represent the "average" house level. Because of this difference, calculation and interpretation of the paint error probabilities are more complex and not included in the results presented.

5.2.1 Key Analysis Assumptions

Two key assumptions were made prior to the analysis.

1. *For the dust-lead and soil-lead samples, the log-transformed data followed a normal distribution with some mean and unknown variance.* This assumption is based on previous studies that have shown that dust-lead loadings and soil-lead concentrations are often well-described by a lognormal distribution [18].

2. *No one room in a home was more indicative of a child's dust lead exposure than any other room in the home.* This assumption was made to allow the impact of any one room on the dust-lead hazard to a child to be assessed without introducing any constraints. Given this assumption, the uncertainty associated with measured environmental lead levels within a home are assumed to be due to room-to-room sampling variation, within-room sampling variation, and measurement error in collecting the samples. Similar assumptions were made with respect to soil samples – dripline soil samples taken on more than one side of a house were considered equally indicative of a child's exposure to soil lead at that house.

Note that floor dust, window sill dust, window well dust, dripline soil, and play area soil were all analyzed separately in this analysis.

5.2.2 Error Probability Calculations

To compare the effectiveness of the three estimators (maximum value, arithmetic mean, and geometric mean) in providing an accurate assessment of the assumed "true" house lead levels, a hypothesis test was constructed:

$$H_{oj}: \mu_i < S_i$$
$$H_{1j}: \mu_i \geq S_i$$

where

μ_i is the unobservable, "true" average lead level within a home for each medium/component i,

S_i is the standard for medium/component i,

i represents the medium/component (floor dust, window sill dust, window well dust, and soil),

j represents the type of estimator (geometric mean, arithmetic mean, and maximum value).

Under the null hypothesis, H_0, the unobservable, "true" house lead level for medium/component i is assumed to be below the medium/component standard, while under the alternative hypothesis,

H_1, the home's unobservable, "true" lead level for medium/component i is assumed to be above or equal to the medium/component standard. Of interest are the probabilities of correct and incorrect decisions based on the estimated medium/component lead level at the home. These probabilities are based on the Type I (false positive) and Type II (false negative) error probabilities.

$$
\begin{aligned}
P\text{ (Type I or false positive error)} &= P(\text{reject } H_o \mid H_o \text{ is true}) \\
&= P(Y_{ij} \geq S_i \mid \mu_i < S_i)
\end{aligned}
$$

$$
\begin{aligned}
P\text{ (Type II or false negative error)} &= P(\text{do not reject } H_o \mid H_1 \text{ is true}) \\
&= P(Y_{ij} < S_i \mid \mu_i \geq S_i)
\end{aligned}
$$

where Y_{ij} is the estimated average lead level in the home for component/medium *i* and statistic *j* and the remaining terms are as defined above.

Note that the probabilities depend on the assumed, "true" lead level at the house (μ_i). To calculate these probabilities, the following information is needed:

1. The sampling distribution of the three estimators (maximum value, arithmetic mean, geometric mean) of μ
2. Estimates for the within-house variation (σ) for each medium/component
3. An assumption about the unobservable, "true" lead levels in the house.

Appendix L provides descriptions of the sampling distributions of the estimators (maximum value, arithmetic mean, geometric mean) of μ. The within-house variation calculations, σ, are discussed below. To calculate the Type I error probabilities, the unobservable, "true" average lead levels in the home are assumed to be less than the media/component standard. To calculate the Type II error probabilities the unobservable, "true" average lead levels are assumed to be greater than or equal to the medium/component standard.

The error probabilities are calculated for a risk assessment, "simple" lead hazard screen, and a "compound" lead hazard screen. "Simple" and "compound" lead hazard screens are defined below. To summarize the error probability calculations, graphs and tables are provided comparing the error probabilities associated with each estimator for various assumed "true" lead levels in the home for each medium/component.

5.2.3 Within-House Variation Calculations

Given the above key assumptions and using a general mixed effects model, the observed log-transformed lead level for a medium/component was modeled as

$$\log(Y) = \mu + r + \epsilon,$$

where

- Y is the observed dust-lead or soil-lead level and is assumed to follow a normal distribution with mean μ and variance $\sigma^2 = \sigma^2_r + \sigma^2_\epsilon$
- μ is the unobservable, true average (log) dust-lead or soil-lead level within a home
- r is the room-to-room (location-to-location, in the case of soil-lead) random effect
- ϵ is the combined within-room (within-location, in the case of soil-lead) random effect and random measurement error.

The room-to-room random effect, r, is a random variable and is assumed to follow a normal distribution with mean zero and unknown variance σ^2_r (room-to-room variation). The combination of the within-room random effect and random error (measurement error), ϵ, is also a random variable and assumed to follow a normal distribution with mean zero and unknown variance σ^2_ϵ (within-room and measurement variation). The observed log lead level, log(Y), is then assumed to follow a normal distribution with mean μ and variance $\sigma^2 = \sigma^2_r + \sigma^2_\epsilon$, where σ^2 is the within-house variation. Note that this implies that the untransformed response, Y, has a lognormal distribution.

5.2.4 Data Used to Characterize Within-House Variation

Three sets of data were used to calculate within-house variation in floor dust-lead loadings, window sill dust-lead loadings, window well dust-lead loadings, and soil-lead concentrations: the Rochester Lead-In-Dust Study data, the CAP Study data, and the Rhode Island Department of Health data. Table 5-6 describes these data. As described in Section 4.1, in the Rochester study dust wipe samples were collected from floors, window sills, and window wells; and soil samples were collected from the foundation of the homes and play areas in the yard of the home. For the Rhode Island Department of Health data described in Section 4.2, dust wipe samples were collected from carpeted and uncarpeted floors, window wells, and window sills in the bedroom, dining room, hallway, kitchen, living room, and play area; and soil samples were collected from the foundation of the home. No distinction between carpeted and uncarpeted floors was made for this analysis.

Table 5-6. Data Used for Calculating the Within-House Components of Variation.

Data	Media	Component/ Location	Number of Houses	Number of Samples
Rochester Study[1]	Dust	Floor	204	808
		Window Sill	196	363
		Window Well	189	406
CAP Study[1]	Soil	Foundations	52	118
		Boundaries	52	120
Rhode Island Depart- ment of Health[2]	Dust	Floor	105	250
		Window Sill	49	69
		Window Well	54	84
	Soil	Side of House/ Foundations	244	540

[1] Components of variation were obtained from the draft final EPA report titled "Components of Variation of Lead in Household Dust, Soil, and Paint" [18].
[2] Mixed models were fitted to the data for this analysis.

The CAP Study soil samples were obtained from the exterior entryway, foundation of the home, and boundary of the property.

Note that in the Rochester study, each house had only a single soil sample from a given location, precluding the estimation of the within-house variability for soil. In the CAP Study, multiple soil samples at a home were collected from the foundations and property boundaries, allowing the calculation of within-house soil sampling variability. For this analysis, the CAP Study variability was used in the assessment of the Rochester study data, even though the Rochester study and CAP Study were conducted in different regions of the country.

The within-house variability estimates for the Rochester study floor, window sill, and window well dust wipes and the CAP Study soil samples were extracted from the draft final report, "Components of Variation of Lead in Household Dust, Soil, and Paint" [18]. A mixed model analysis was performed on the Rhode Island floor dust, window sill dust, window well dust, and soil sample results to obtain the within-house variability estimates for this set of data. The specifics of the type of mixed model analysis performed can be found in [18].

Section 402 currently recommends the use of the Section 403 Interim Guidance standards for risk assessments. When the Section 403 Proposed Rule becomes final, the standards in this document will supersede the Interim Guidance standards. Both sets of standards were presented in Table 1-1. One exception to both the Interim Guidance and Proposed Rule made in this analysis was to include and compare both uncarpeted and carpeted floors to the standard presented for the uncarpeted floors. In addition, the Proposed Rule makes a distinction between play area soil and mid-yard soil. The CAP Study data only makes a distinction between foundation and boundary soil. Therefore, for this analysis the boundary soil was considered a surrogate for the mid-yard soil specified by the Proposed Rule.

5.2.5 Error Probability Calculations Associated with "Simple" and "Compound" Lead Hazard Screens

As mentioned above, the error probabilities were calculated for a "simple" and a "compound" lead hazard screen. The distinction between the terms "simple" and "compound" and the associated error probability calculations are provided below.

In Section 402, when a lead hazard screen finds lead-based paint hazards in a home, the home is required to undergo a full risk assessment. The probability that a lead hazard screen incorrectly <u>finds lead-based paint hazards or no lead-based paint hazards</u> is called the "simple" lead hazard screen error probability. A "compound" lead hazard screen error probability is the probability of the risk assessment finding lead-based paint hazards or no lead-based paint hazards, given that the lead hazard screen found lead-based paint hazards in the home (i.e., the probability that a home <u>is assessed to have lead-based paint hazards or no lead-based paint hazards when a lead hazard screen indicated a lead-based paint hazard</u>.

Since the "simple" lead hazard screen merely determines whether or not a home has lead-based paint hazards on the basis of a lead hazard screen, only Type I (false positive) error probabilities are presented in Section 6.2.2.2. Type I and II (false positive and false negative) error probabilities are presented for the "compound" lead hazard screen. To calculate the "compound" lead hazard screen error probabilities, an assumption was made that the measurements taken during a lead hazard screening stage are independent from the measurements taken during the risk assessment stage. Given this assumption, the "compound" lead hazard screen error probabilities are based on the following compound probabilities.

Since a house is determined to have lead-based paint hazards when the lead hazard screen finds lead-based paint hazards and then the risk assessment finds lead-based paint hazards, the probability of a Type I (false positive) error for a "compound" lead hazard screen is:

P(lead hazard screen finds lead-based paint hazards and risk assessment finds lead-based paint hazards | assumed true lead level < medium standard) =

P(lead hazard screen finds lead-based paint hazards | assumed true lead level < medium standard)*

P(risk assessment finds lead-based paint hazards | assumed true lead level < medium standard).

Under the above described hypothesis setting, this can be written as

$$P(Y_{ij} \geq (½*S_i)\ ,\ Z_{ij} \geq (½*S_i) \mid \mu_i < (½*S_i)) = P(Y_{ij} \geq (½*S_i) \mid \mu_i < (½*S_i)) * P(Z_{ij} \geq (½*S_i) \mid \mu_i < (½*S_i)),$$

where

Y_{ij} is the calculated lead level for medium/component *i* and statistic *j* during lead hazard screen

Z_{ij} is the calculated lead level for medium/component *i* and statistic *j* during risk assessment

S_i is the standard for medium/component *i* (floor dust, window sill dust, window well dust, and soil). *Note: The lead hazard screen uses ½ the Interim Guidance or Proposed Rule standard as a level for comparison.*

μ_i is the assumed unobservable, "true" lead level in home for medium *i*.

A house is determined to have no lead-based paint hazards when either the lead hazard screen initially finds no lead-based paint hazards <u>or</u> when the lead hazard screen finds lead-based paint hazards, but the risk assessment finds no lead-based paint hazards. As a result, the probability of a Type II (false negative) error for a "compound" lead hazard screen is:

P(lead hazard screen finds no lead-based paint hazards <u>or</u>
lead hazard screen finds lead-based paint hazards but risk assessment finds no lead-based paint hazards | true lead level ≥ medium standard) =

P(lead hazard screen finds no lead-based paint hazards | true lead level ≥ medium standard) +
[P(lead hazard screen finds lead-based paint hazards | true lead level ≥ medium standard) *
P(risk assessment finds no lead-based paint hazards | true lead level ≥ medium standard)].

Under the above hypothesis setting and the descriptions of Y_{ij}, Z_{ij}, S_i, and μ_i, this can be written as

$$P(Y_{ij} < * (½*S_i) \text{ or } Y_{ij} \geq (½*S_i), Z_{ij} < (½*S_i) \mid \mu_i \geq (½*S_i)) =$$
$$P(Y_{ij} < (½*S_i) \mid \mu_i \geq (½*S_i)) + [P(Y_{ij} \geq (½*S_i) \mid \mu_i \geq (½*S_i)) * P(Z_{ij} < (½*S_i) \mid \mu_i \geq (½*S_i))].$$

5.3 OBJECTIVE 3: SAMPLING LOCATIONS RISK ASSESSORS MAY WANT TO TARGET TO EVALUATE POTENTIAL LEAD HAZARDS

As described in Appendix A, Section 402 does not explicitly specify the locations from which a risk assessor is required to sample dust [5]. As stated on page A-4, a certified risk assessor is directed as follows during a lead hazard screen at a residential dwelling: "two composite dust samples shall be collected, one from the floors and the other from the windows in rooms, hallways or stairwells where one or more children, age 6 and under, are most likely to come in contact with dust." On page A-5, the specifications for a risk assessment direct the following for the certified risk assessor: "dust samples (either composite or single-surface samples) from the window and floor shall be collected in all living areas where one or more children, age 6 and under, are most likely to come in contact with dust." Given these recommendations, a risk assessor may sample dust from the child's play area or bedroom, the kitchen, entryway, or bathroom, etc.

The goal of Objective 3 was to assess dust-lead loadings from sampling locations that a risk assessor may want to target to assure that the potential lead hazard to a child is best evaluated. The first step in the analysis was to assess the correlation coefficients between blood-lead concentration and dust-lead loadings for each sampling location and component. The second step was to build a pathways model to be assessed using structural equation modeling. The results from the second step provided recommendations for sampling. Each step is described below.

5.3.1 Data Used in the Analysis

The Rochester Lead-In-Dust Study data and the Rhode Island Department of Health data were evaluated for the appropriateness of being included in the Objective 3 analysis. A sufficient number of homes in the Rochester study had multiple rooms with multiple components sampled, while the Rhode Island data source did not. As a result, only the Rochester study data were included in the Objective 3 analysis. Table 5-7 displays the rooms sampled in the Rochester study and the types of components sampled in each room.

Table 5-7. Rooms and Types of Components Sampled in the Rochester Study.

Sampled Room	Component Sampled (Number of Homes)		
	Floor	Window Sill	Window Well
Child's Bedroom	✔ (197)	✔ (163)	✔ (150)
Child's Play Area	✔ (192)	✔ (164)	✔ (138)
Kitchen	✔ (203)		✔ (118)
Interior Entryway	✔ (179)		
Living Room	✔ (41)	✔ (31)	

Note: The number of homes with at least one dust sample taken from the given room and component is given in parentheses.

The rooms and components sampled varied from house to house. Therefore, throughout this analysis, the number of dust wipe samples available was very important for determining which relationships could be investigated.

5.3.2 Correlation Analysis

The first step in evaluating the objective was to assess the correlation between blood-lead concentrations and dust-lead loadings from different rooms and components, as well as the correlation among the dust-lead loadings. The strength of the relationship of loadings with blood-lead indicated which variables may be direct pathways of lead exposure to the blood. The strength of relationships among the loadings indicated which variables may be considered indirect pathways of lead exposure to the blood. Direct and indirect pathways are explained below.

Pearson correlation coefficients (r) were calculated on the natural logarithmically transformed blood-lead concentrations and dust-wipe lead loadings. If the absolute value of r was near 1, this implied that the linear association between the two variables being evaluated was strong. If the absolute value of r was near 0, this implied that there was little to no linear association between the two variables. These correlation coefficients provided indications of which rooms and components should be included in the pathways analysis.

5.3.3 Pathways Analysis

Figure 5-3 illustrates the lead pathways that were assessed using the Rochester study data. The pathways analysis was performed on data for 83 homes. These homes had data for all components specified within Figure 5-3. To keep the number of homes from being reduced further, dust-lead loadings from living room components and from kitchen window wells were not included in the pathways analysis (note that including kitchen window well samples would have excluded an additional 28 homes). The pathways model was created to assess, using structural equation modeling (SEM), the direct and indirect association between a sampling location or component and blood-lead concentrations. Several structural equation models describing pathways by which blood is exposed to environmental-lead have been assessed [13, 14, 15, 16, 17].

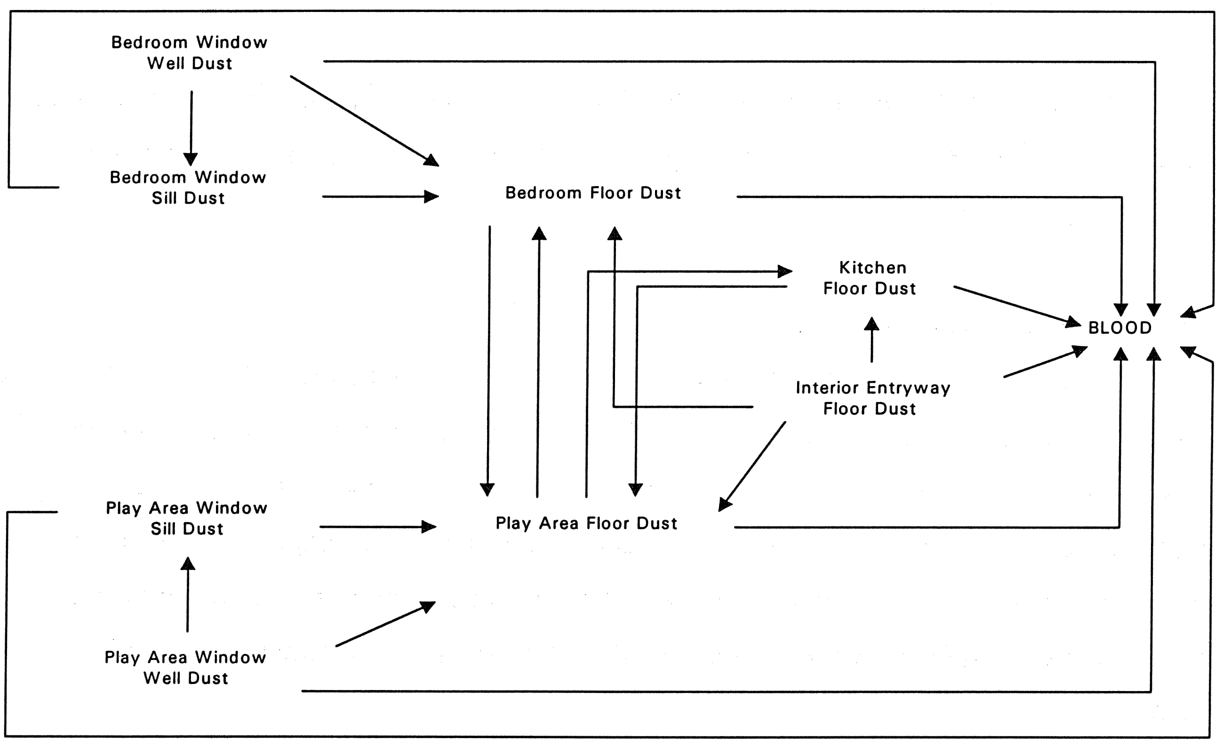


Figure 5-3. Pathways of Lead Exposure Investigated Using the Rochester Study Data.

To explain how structural equation modeling relates to other more commonly used statistical analysis techniques, and to explain the meaning of 'direct' and 'indirect' effects on the blood-lead concentration, consider Figure 5-3, which shows the pathways assessed in this analysis.

Figure 5-3 contains the direct effects on blood-lead of

- Bedroom floor, window sill, and window well dust
- Kitchen floor dust
- Interior entryway floor dust
- Play area floor, window sill, and window well dust

and the indirect effects on blood-lead of

- Bedroom floor dust via the play area floor dust
- Bedroom window sill dust via the bedroom floor dust
- Bedroom window well dust via the bedroom window sill dust or the bedroom floor dust
- Play area floor via the bedroom floor dust
- Play area window sill via the play are floor dust
- Play area window well dust via the play area window sill dust or the play area floor dust
- Kitchen floor dust via the play area floor dust
- Interior entryway dust via the play area floor dust, bedroom floor dust, or the kitchen floor dust.

To statistically assess these pathways, a SEM is constructed. Equations (1) through (6) below mathematically represent the pathways presented in Figure 5-3.

(1) *Blood* = Bedroom Floor Dust + Bedroom Window Sill Dust + Bedroom Window Well Dust + Play Area Floor Dust + Play Area Window Sill Dust + Play Area Window Well Dust + Kitchen Floor Dust + Interior Entryway Floor Dust

(2) *Kitchen Floor Dust* = Play Area Floor Dust + Interior Entryway Floor Dust

(3) *Play Area Floor Dust* = Play Area Window Sill Dust + Play Area Window Well Dust + Bedroom Floor Dust + Kitchen Floor Dust + Interior Entryway Floor Dust

(4) *Bedroom Floor Dust* = Bedroom Window Sill Dust + Bedroom Window Well Dust + Play Area Floor Dust + Interior Entryway Floor Dust

(5) *Play Area Window Sill Dust* = Play Area Window Well Dust

(6) *Bedroom Window Sill Dust* = Bedroom Window Well Dust

Similar to multiple regression or analysis of variance (ANOVA), the direct effect of

- Bedroom floor dust, bedroom window sill dust, bedroom window well dust, play area floor dust, play area window sill dust, play area window well dust, kitchen floor dust, interior entryway floor dust on blood in equation (1)
- Play area floor dust and interior entryway floor dust on kitchen floor dust in equation (2)
- Play area window sill dust, play area window well dust, bedroom floor dust, kitchen floor dust, interior entryway floor dust on play area floor dust in equation (3)
- Bedroom window sill dust, bedroom window well dust, play area floor dust, interior entryway floor dust on bedroom floor dust in equation (4)
- Play area window well dust on play area window sill dust in equation (5)
- Bedroom window well dust on bedroom window sill dust in equation (6).

can be examined using SEM. Unlike multiple regression and ANOVA, the indirect effects listed above can be assessed using SEM by evaluating all six equations simultaneously.

Note that the pathways analysis performed for Objective 3 is a little different from pathways analyses that have been discussed in the literature [13, 14, 15, 16, 17]. In the literature, generally, all the sources from which lead may enter into a child's environment are examined and included in the analysis – sources such as a floor dust, window sill dust, window well dust, soil, paint, hand dust, pica, etc. The floor dust, window sill dust, and window well dust variables in the published analyses usually represent an average floor dust-lead, window sill dust-lead, and window well dust-lead loading or concentration, respectively, over all rooms sampled (such as bedroom, play area, kitchen, living room, entryway, etc.). The analysis in this report is slightly different. First, the interior dust-lead sources are isolated: floor dust-lead, window sill dust-lead, and window well dust-lead, and no other sources of lead are considered. Second, the individual room floor dust, window sill dust, and window well dust-lead loadings are assessed, not the average over all rooms. For instance, in this analysis, the effect of bedroom floor dust, play area floor dust, kitchen floor dust, and interior entryway floor dust-lead loadings on a child's blood lead concentration are assessed; while in the published analyses, the average floor dust-lead loading over the bedroom, play area, kitchen, and interior entryway may have been assessed. Not averaging the dust-lead loadings in this report allowed an assessment of the effect of sampling location on identifying hazards.

6.0 RESULTS

This section presents the findings and results from the analyses discussed in Section 5. Section 6.1 presents the results of the risk assessor cost interviews and performance characteristics analysis. Section 6.2 provides the error probabilities analysis results, and Section 6.3 presents the results of the correlation and pathways analyses.

6.1 OBJECTIVE 1: PROBABILITY OF CORRECTLY IDENTIFYING A LEAD-BASED PAINT HEALTH HAZARD IN SINGLE FAMILY HOUSING AND THE COSTS ASSOCIATED WITH THE RISK ASSESSMENT

6.1.1 Risk Assessor Cost Summaries

Caution: *As discussed in Section 5.1, the sample of risk assessors providing cost data was not selected to be a statistically representative sample. Data were collected from nine contractors in nine different States. Initial interviews were conducted in May 1997, with follow-up interviews of seven contractors conducted in April, 1998.*

Four types of summaries of the risk assessor cost interviews are provided below:

1. Average total costs of an activity: risk assessment, lead hazard screen, inspection, and risk assessment/inspection

2. Average cost per environmental sample

3. Average number of environmental samples collected

4. Average, minimum, maximum, and sample size or frequency and sample size for all responses on the questionnaire.

Note that, as discussed in Section 5.1, each contractor was assigned an ID corresponding to the region in which the contractor is located (northeast=NE, south=S, and west=W). These IDs were used to represent the contractors throughout this summary.

6.1.1.1 Summary of the Risk Assessment, Lead Hazard Screen, Inspection, and Risk Assessment/Inspection Costs

Figure 6-1 shows the total costs for a risk assessment, lead hazard screen, inspection, and risk assessment/inspection, as specified by each contractor. The average across all nine contractors is specified by the results labels "overall," and are also presented in Table 6-1.

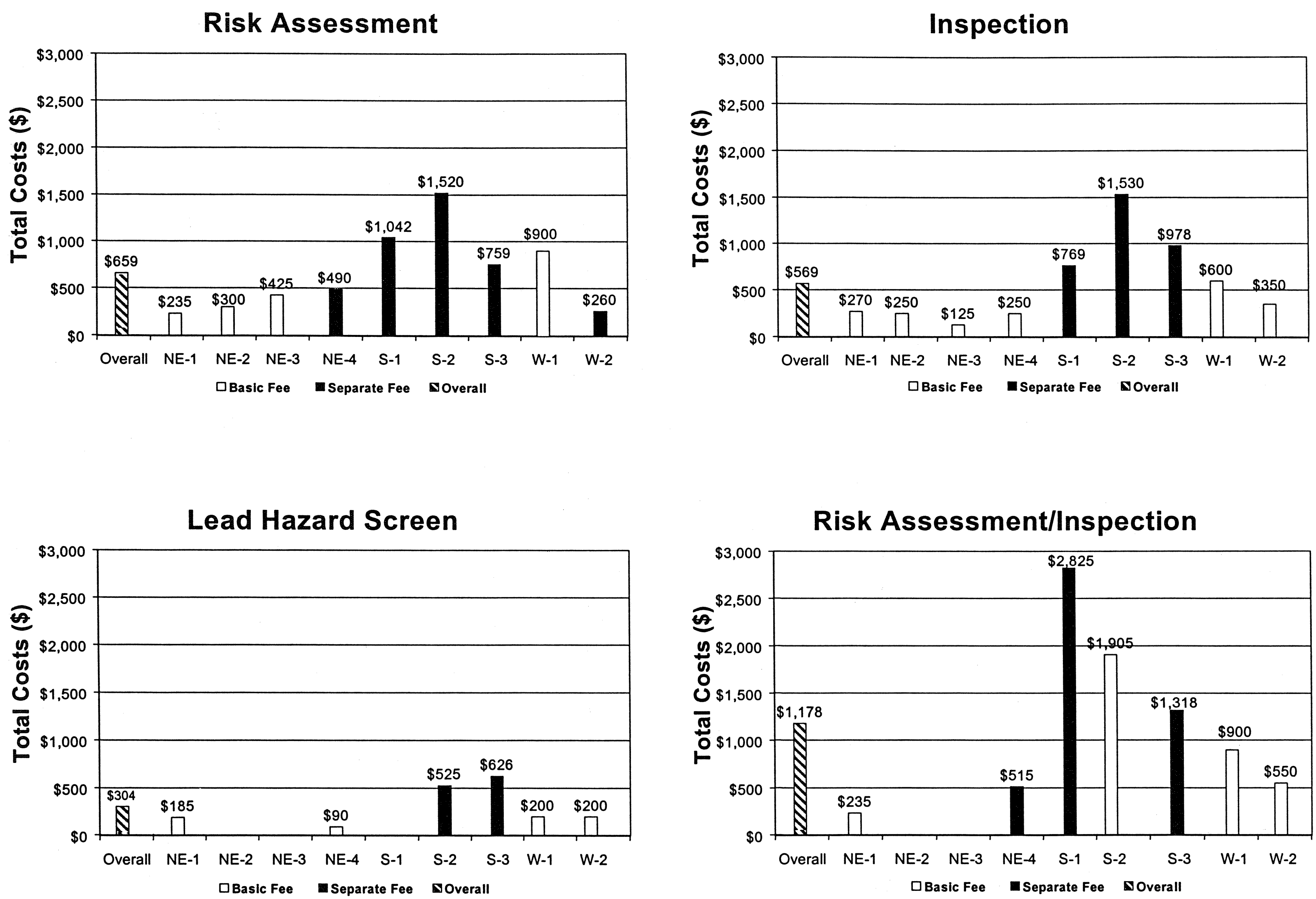


Figure 6-1. Total Costs for a Risk Assessment, Inspection, Lead Hazard Screen, and a Risk Assessment/Inspection.

Table 6-1. Average Total Cost of a Risk Assessment, Lead Hazard Screen, Inspection, and Risk Assessment/Inspection With and Without Extremely High Costs.

Activity	Average Total Cost ($)	
	All Surveyed Contractors	Excluding Three Contractors (S-1, S-2, S-3) with High Costs
Risk Assessment	$659	$435
Lead Hazard Screen	$304	$169
Inspection	$569	$308
Risk Assessment/Inspection	$1,178	$550

Figure 6-1 shows that an overall average total cost for a risk assessment is $659, $304 for a lead hazard screen, $569 for an inspection, and $1,178 for a risk assessment/inspection. Total costs ranged from $90 for a lead hazard screen by a contractor in the northeast to $2,825 for a risk assessment/inspection by a contractor in the south. The large disparity in prices among the contractors appears to be related to the extensiveness of lead poisoning prevention programs in a region. For instance, regions that have well established and very active prevention programs (such as the northeast) have lower inspection and screen costs than regions that have less active programs (such as the south). The contractors represented by dark blocks in Figure 6-1 generally charge a separate fee for each component of the activity and strongly influence the overall average with their extremely high costs. The fees for the three contractors in the south were typically higher than those reported by the other contractors. When the costs for these three contractors were removed and the averages recalculated, as shown in Table 6-1, the average total cost was $435, $169, $308, and $550 for a risk assessment, lead hazard screen, inspection, and risk assessment/inspection, respectively. This is a reduction of one-half to one-third of the overall average cost of the activity. These reduced averages may be more representative of the average cost of these activities when promulgation of the Section 403 rule makes these activities more commonplace.

Reasons for the disparity in costs among the contractors were not explored with the survey respondents during the initial interview. Through a round of follow-up phone calls, one of the contractors with the highest costs indicated that he thought his prices were higher due to the fact that they perform fewer risk assessment activities in his area of the country. Comments from the other contractors with higher costs were not obtained.

During the follow-up interviews, the seven contractors who could be reached indicated that the costs of performing a risk assessment, lead hazard screen, inspection, and risk assessment/inspection had generally stayed the same, with some contractors reducing the costs because the 1997 HUD Guidelines revision of Chapter 7 reduced the number of XRF readings needed for the testing.

For contractors who charge separate fees for the visual assessment, environmental sampling, and report of a risk assessment, lead hazard screen, inspection, and risk assessment/inspection, summaries of these separate fees are presented in Figures 6-2 through 6-5. The top chart in each figure corresponds to visual assessment costs, the middle chart represents environmental sampling costs, and the bottom chart represents report costs. Across all four activities, the visual assessment costs ranged from $150 for a risk assessment and lead hazard screen to $1,500 for a risk assessment/inspection. All contractors but one had visual assessment costs of $750 or less. The typical environmental sampling costs ranged from $19 for an inspection performed by a contractor from the south to $1,325 for a risk assessment/inspection performed by the same contractor. The reports for each of the activities ranged in costs from $50 for a risk assessment report to $500 for a risk assessment, inspection, or risk assessment/ inspection report. Note that the contractors who charged separate costs for each component of an activity generally had higher costs than those that charged the basic fee.

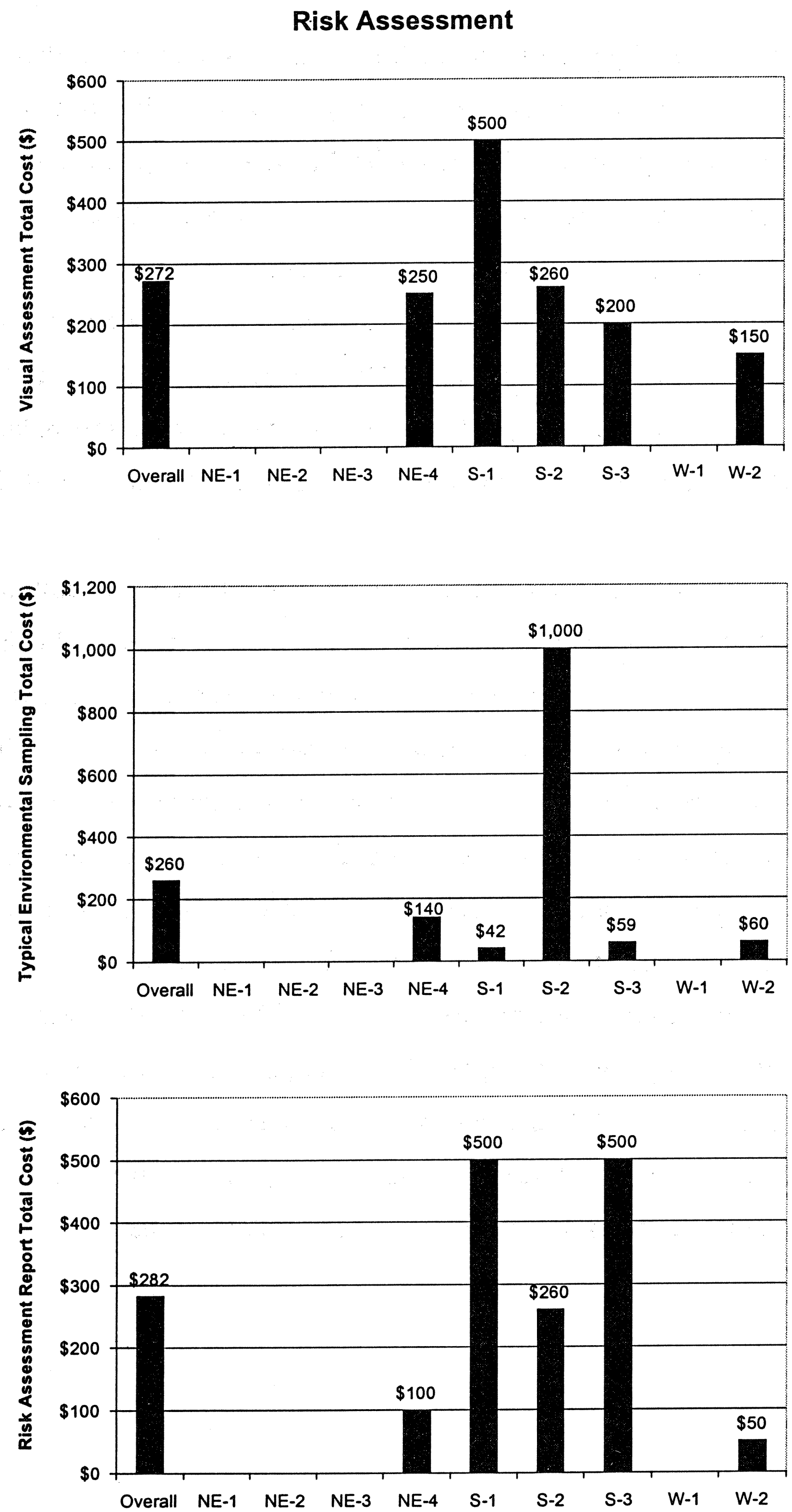


Figure 6-2. Estimated Costs ($) of the Visual Assessment, Typical Environmental Sampling, and the Risk Assessment Report for a Risk Assessment.

Lead Hazard Screen

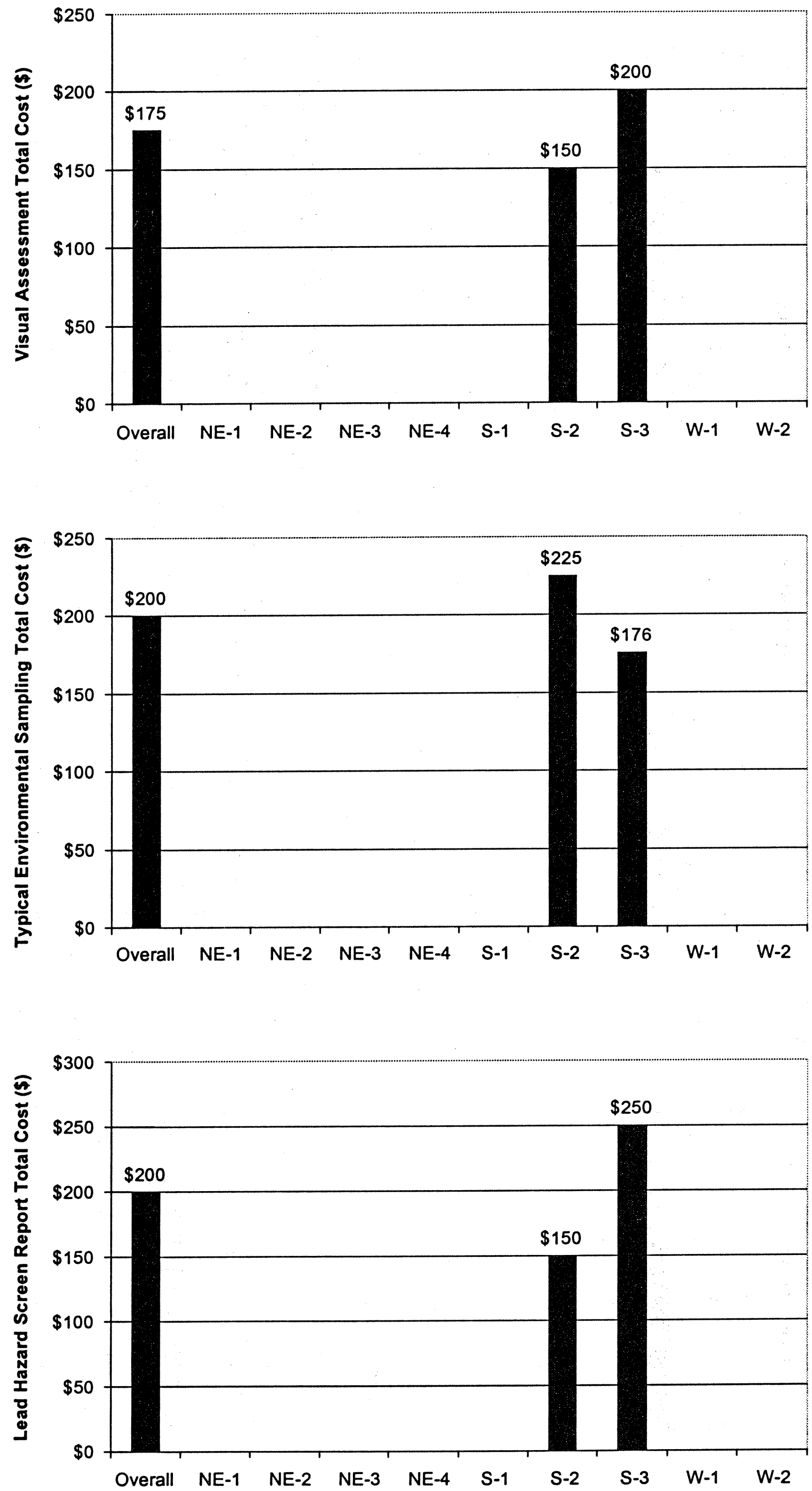


Figure 6-3. Estimated Costs ($) of the Visual Assessment, Typical Environmental Sampling, and the Lead Hazard Screen Report for a Lead Hazard Screen.

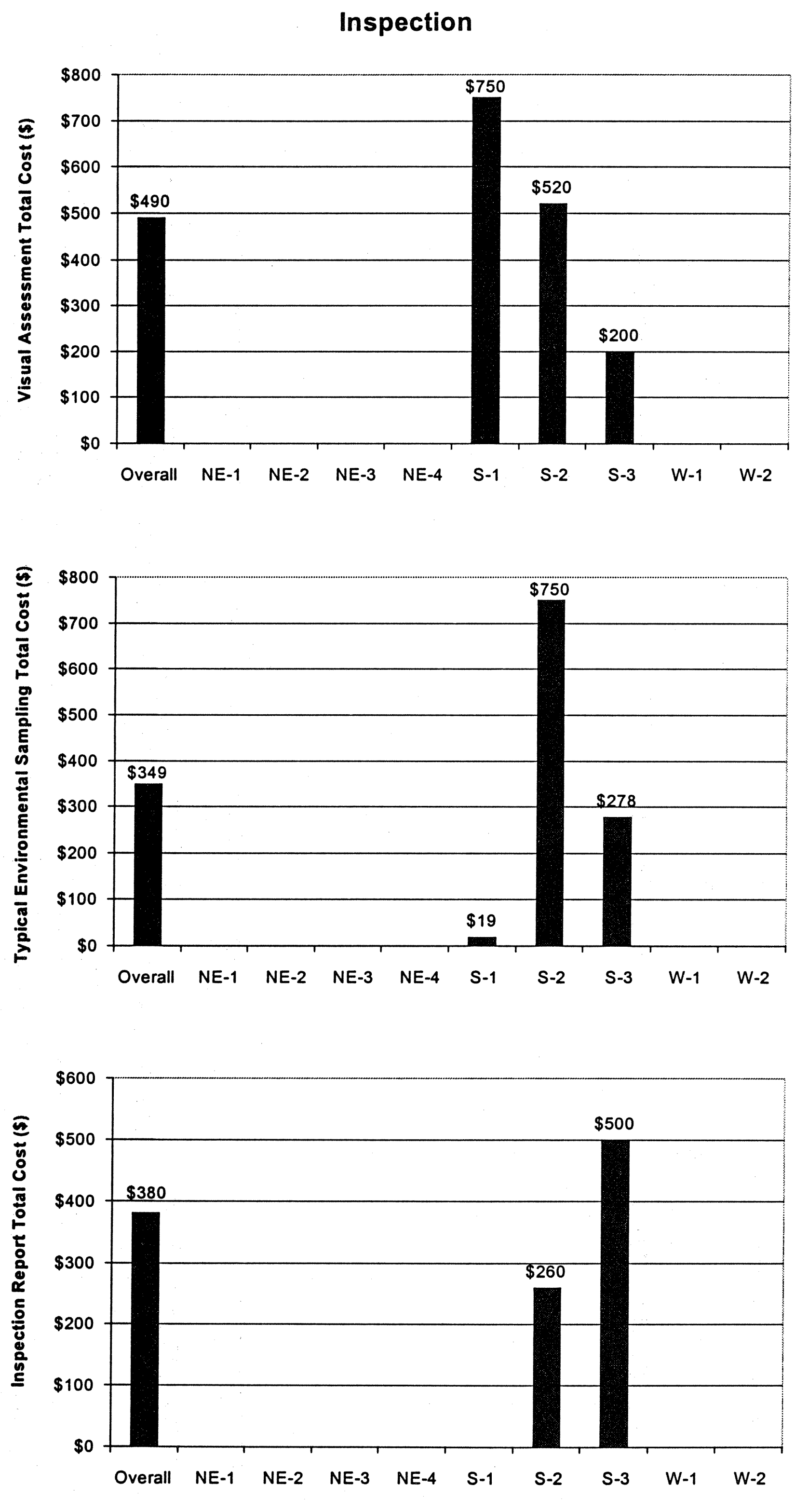


Figure 6-4. Estimated Costs ($) of the Visual Assessment, Typical Environmental Sampling, and the Inspection Report for an Inspection.

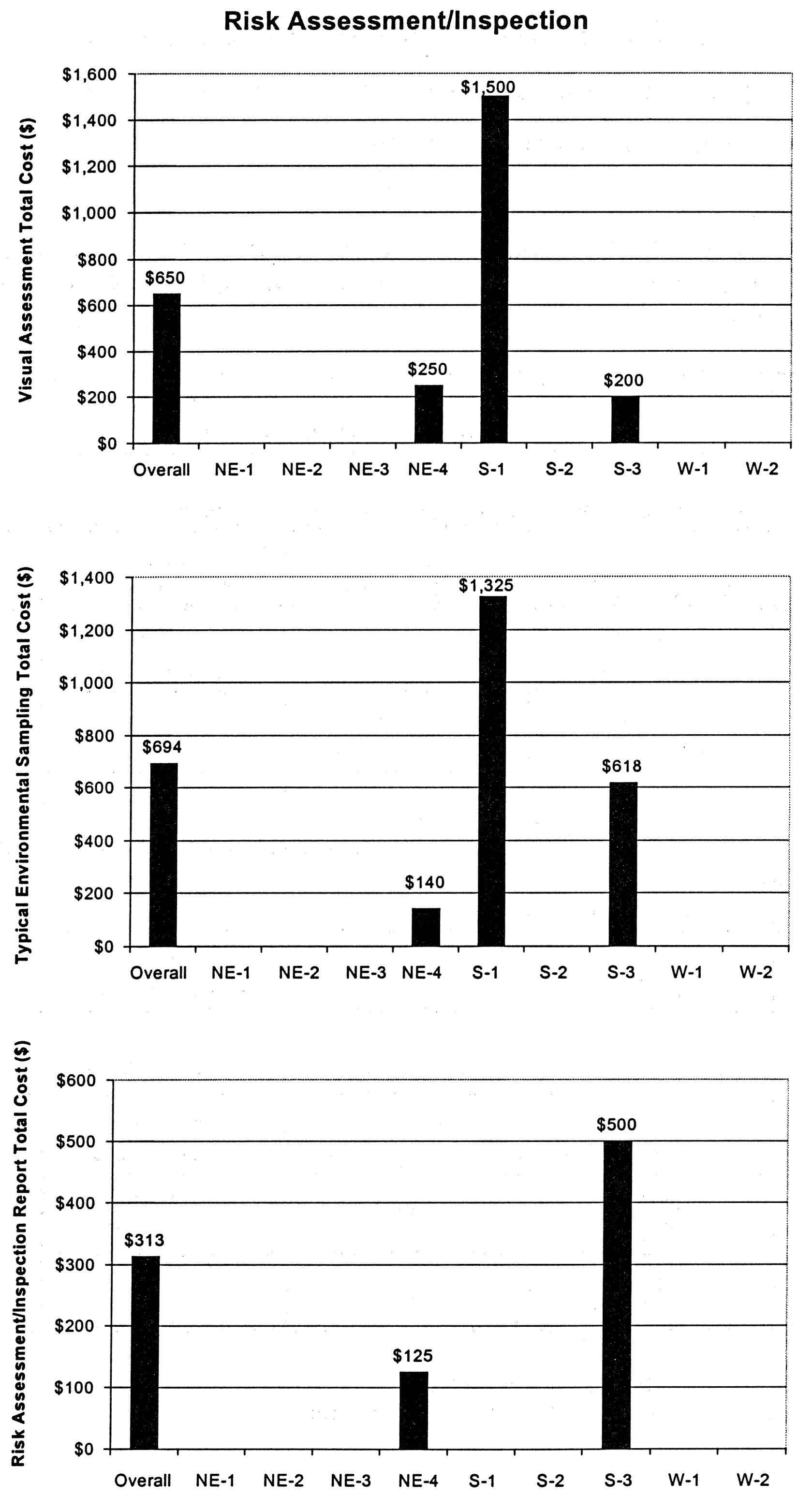


Figure 6-5. Estimated Costs ($) of the Visual Assessment, Typical Environmental Sampling, and the Risk Assessment/Inspection Report for a Risk Assessment/Inspection.

6.1.1.2 Summary of the Costs per Environmental Sample

Table 6-2 presents the average cost per environmental sample (dust, soil, water) collected for each activity. The averages were calculated over all media/components and are presented over all contractors and for each contractor individually.

Table 6-2. Average Cost Per Environmental Sample (Dust, Soil, Water) Collected for a Risk Assessment, Lead Hazard Screen, Inspection, and Risk Assessment/Inspection, By Contractor.

Contractor	Average Total Costs ($)[a] Minimum Costs – Maximum Costs			
	Risk Assessment	Lead Hazard Screen	Inspection	Risk Assessment/ Inspection
Overall	$18.20 $5.00–$30.00	$20.64 $10.00–$25.00	$17.40 $5.00–$25.00	$16.43 $5.00–$30.00
NE-1	$15.00 $15.00–$15.00	(b)	$15.00 $15.00–$15.00	$15.00 $15.00–$15.00
NE-2	$10.00 $10.00–$10.00	$11.00 $10.00–$12.00	(b)	$10.00 $10.00–$10.00
NE-3	$25.00 $25.00–$25.00	(b)	(b)	(b)
NE-4	$20.00 $20.00–$20	(b)	(b)	$20.00 $20.00–$20.00
S-1	$22.88 $16.50–$30.00	(b)	$18.50 $18.50–$18.50	$22.88 $16.50–$30.00
S-2	$25.00 $25.00–$25.00	$25.00 $25.00–$25.00	$25.00 $25.00–$25.00	$25.00 $25.00–$25.00
S-3	$19.50 $18.50–$20.00	$19.50 $18.50–$20.00	$18.50 $18.50–$18.50	$19.40 $18.50–$20.00
W-1	$5.00 $5.00–$5.00	(b)	$5.00 $5.00–$5.00	$5.00 $5.00–$5.00
W-2	$15.00 $15.00–$15.00	(b)	(b)	$15.00 $15.00–$15.00

[a] No paint costs were available for any of the activities.
[b] The costs for the activity were not reported by the contractor.

Overall, the average total cost per sample ranged from $16 per sample for the risk assessment/inspection to $21 per sample for the lead hazard screen. The lowest cost per sample was $5 for a contractor in the west region, while the highest cost per sample was $25 for a contractor in the south region. Generally, across the four activities, the costs per sample remained nearly the same for a given contractor.

Table 6-3 presents the average collection cost, average analysis cost, and average total cost, per environmental sample, for each of the media/components sampled. As discussed in Section 5, the total cost was the sum of the collection and analysis costs. Because only one contractor reported collection costs separately, total costs typically reflect just the cost of analysis.

Table 6-3. Average Cost Per Sample Collected for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, or Risk Assessment/Inspection For All Contractors.

		Average Cost Per Sample ($) Minimum Cost – Maximum Cost (N=# of Contractors Responding)		
Media	Type of Sample	Collection Cost	Analysis Cost	Total Cost
Dust	Composite	$10.00 $10.00 – $10.00 (N=1)	$17.50 $15.00 – $20.00 (N=3)	$20.00 $15.00 – $25.00 (N=3)
	Single	$10.00 $10.00 – $10.00 (N=1)	$18.39 $ 5.00 – $30.00 (N=9)	$18.71 $ 5.00 – $30.00 (N=9)
Paint	Paint Chips – Composite	(a)	(a)	(a)
	Paint Chips – Single	(a)	(a)	(a)
	XRF	(a)	(a)	(a)
Soil	Composite	$15.00 $15.00 – $15.00 (N=1)	$16.05 $ 5.00 – $25.00 (N=7)	$17.48 $ 5.00 – $25.00 (N=7)
	Single	(a)	(a)	(a)
Water		$15.00 $15.00 – $15.00 (N=1)	$11.82 $ 5.00 – $15.00 (N=5)	$13.18 $ 5.00 – $25.00 (N=5)

[a] No cost was reported by any contractor. (See text for paint cost information obtained in follow-up interviews.)

Table 6-3 shows that the average total costs per environmental sample were highest for the three contractors who collected dust composite samples, at $20 per sample, with costs ranging from $15 to $25 per composite sample. The lowest cost per sample was $13 for water, where five contractors reported costs ranging from $5 to $25 per sample. No breakdowns on the cost per sample for paint were reported by any of the contractors during the initial interviews. Tables G-1 through G-9 in Appendix G present similar summaries for each of the contractors.

The follow-up interviews found that, for contractor S-3, the risk assessment dust sampling costs were reduced from $20 per sample to $15 per sample for collection and analysis, but the soil composite sampling increased from $20 per sample to a range of $35 to $50 per sample for collection and analysis. In the initial interview, contractor S-2 specified no collection cost for dust, soil, or paint sampling under any of the activities, but indicated a $15 collection cost in the follow-up interview. In the follow-up interview, contractor NE-3 indicated an increase in costs for dust, soil, and water sampling from $25 for collection and analysis to $35 and an increase in XRF testing from $125 for the first hour to $150. Contractor NE-2 indicated in a follow-up interview that the analysis costs for soil samples increased from $10 to $12, but the basic fee for an inspection decreased from $250 to $195.

In the initial interviews, no paint sampling information was obtained; but, during the follow-up interviews, one contractor charged $50 per hour for XRF testing, two others charged a flat fee of $200 and $365 for XRF sampling, and two other contractors charged $15 per sample for collection and analysis of paint chips.

6.1.1.3 Summary of the Number of Environmental Samples Collected

The average number of samples (of all environmental media) collected for a particular environmental assessment activity at a given house is summarized in Table 6-4 for each contractor and over all contractors. Over all contractors, the average number of samples collected ranged from five for a lead hazard screen to 42 for an inspection. The fewest number of samples reported was two for a risk assessment, inspection, or risk assessment/inspection performed by contractor NE-1. The highest number of samples reported was 250 for a risk assessment and inspection by contractor NE-2, which represented the expected number of XRF measurements.

Table 6-4. Average Number of Environmental Samples Collected for a Risk Assessment, Lead Hazard Screen, Inspection, and Risk Assessment/Inspection, Over All Media, By Contractor.

Contractor	Average Number of Samples Collected Minimum # Samples – Maximum # Samples			
	Risk Assessment	Lead Hazard Screen	Inspection	Risk Assessment/ Inspection
Overall	18 1–250	5 1–10	42 1–250	10 1–50
NE-1	2 1–3	(a)	2 1–5	2 1–5
NE-2	116 6–250	5 1–10	225 200–250	7 6–8
NE-3	4 2–8	(a)	65 65–65	(a)
NE-4	7 7–7	10 10–10	10 10–10	9 7–10
S-1	36 20–50	(a)	50 50–50	36 20–50
S-2	13 5–25	3 2–5	30 30–30	15 5–30
S-3	8 3–10	6 3–10	28 15–40	15 7–40
W-1	4 3–5	(a)	4 3–4	3 1–5
W-2	(b)	(a)	(a)	(b)

[a] The number of samples collected for the activity was not reported by the contractor.

[b] This contractor generally did not perform risk assessments; therefore, no applicable information was available.

Table 6-5 presents the average number of dust, paint, soil, and water samples, calculated over the four activities and all contractors. On average, 4 composite dust samples, 8 single dust samples, 91 XRF measurements, 3 composite soil samples, and 1 water sample were collected when one of the four activities were performed. These averages are all in line with the recommendations given in the guidance documents. The follow-up interviews indicated that generally, the number of samples remained the same, with only the XRF samples being reduced because of the 1997 updates to the HUD Guidelines. Similar summaries are provided in Tables G-1 through G-9 in Appendix G for each of the contractors.

Table 6-5. Average Number of Samples Collected for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, or Risk Assessment/Inspection For All Contractors.

Media	Type of Sample	Average Number of Samples Minimum # Samples – Maximum # Samples (N = # of Contractors Responding)
Dust	Composite	4 2 – 8 (N = 3)
	Single Area	8 2 – 25 (N = 8)
Paint	Paint Chips – Composite	(a)
	Paint Chips – Single Area	(a)
	XRF	91 10 – 250 (N = 3)
Soil	Composite	3 1 – 10 (N = 7)
	Single Area	(a)
Water		1 1 – 1 (N = 2)

[a] The number of samples collected was not reported by any contractor.

6.1.2 Performance Characteristic Analysis Results

As discussed in Section 5.1, only the Rochester Lead-In-Dust Study data had the appropriate information to assess Sampling Protocols A, B, and C outlined in Tables 5-2, 5-3, and 5-4, respectively. Using the performance characteristic summary measures discussed in Section 5.1, the results presented below assess

1. The impact of the number of rooms in which dust wipe samples are obtained on the outcome of a full risk assessment (Sampling Protocol A)

2. The impact of various methods of characterizing the dust wipe samples on the outcome of a full risk assessment (Sampling Protocol B)

3. The outcome of a full risk assessment versus the outcome of a lead hazard screen (Sampling Protocol C)

4. The impact of changing from the Interim Guidance standards to the Proposed Rule standards on a full risk assessment and a lead hazard screen

5. The estimated cost of performing a risk assessment or lead hazard screen.

6.1.2.1 Results of Protocol A Analysis: Assessment of the Impact of the Number of Rooms in Which Dust Wipes Are Collected on a Risk Assessment Outcome

As discussed in Section 5.1 and summarized in Table 5-2, Protocol A was designed to assess the impact of obtaining dust wipe samples from floors, window sills, and window wells in two, three, and four specified rooms where, 6, 7, and 8 to 9 dust wipe samples were obtained, respectively, during a risk assessment. The two rooms sampled were the bedroom and play area; the bedroom, play area, and entryway were the three rooms sampled; and the bedroom, play area, entryway, and kitchen were the four rooms sampled. The child's bedroom and primary play area were always sampled since the HUD Guidelines recommend that sampling occur in these two rooms. The entryway and kitchen were sampled to assess how additional sampling (allowed under the HUD Guidelines) may affect the outcome of a risk assessment as characterized by the performance characteristics.

Tables 6-6 and 6-7 present the performance characteristic summary statistics when a full risk assessment is performed under the Interim Guidance and Proposed Rule standards, respectively, using Protocol A and XRF measurements from surfaces with ≥5% deteriorated paint. Under both sets of standards, the impact of sampling from additional rooms appears to be minimal in terms of the number of homes found to have lead-based paint hazards and the protectiveness of the sampling. The number of homes found to have lead-based paint hazards remains constant at 85.5% under the Interim Guidance standards and slightly increases from 74.7% to 77.1% under the Proposed Rule. Under the Interim Guidance, all four performance characteristics remain constant at 88.2% for sensitivity, 15.2% for specificity, 21.1% for PPV, and 83.3% for NPV. The sensitivity, PPV, and NPV increase from 82.4% to 88.2%, 22.6% to 23.4%, and 85.7% to 89.5% for the Proposed Rule as the number of rooms sampled increases from 2 to 4 rooms. The specificity decreases from 27.3% to 25.8%. Though there are some differences, a check of the lower and upper confidence bounds indicates that these differences are not statistically significant, indicating that the effect of the additional rooms in sampling does not

Table 6-6. Sampling Protocol A: Assessment of the Impact of the Number and Type of Rooms in Which Dust Wipe Samples are Collected on the Outcome of a Full Risk Assessment, Using the Interim Guidance Standards (XRF Paint Samples from Surfaces With ≥5% Deteriorated Paint).

	Sampling Protocol Group A		
	A-1 (4 Rooms)	A-2 (3 Rooms)	A-3 (2 Rooms)
# Homes Included in Analysis	83	83	83
Number of Individual Dust Samples / Homes	8-9	7	6
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	85.5%	85.5%	85.5%
% of Blood Samples ≥10 μg/dL	20.5%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (≥ Media Standard) (# of Homes Below Media Standard / # Homes in Which Samples Were Collected)			
All Floors	9.6% (8/83)	7.2% (6/83)	2.4% (2/83)
Carpeted Floors Only	3.9% (3/76)	3.9% (3/76)	1.3% (1/75)
Uncarpeted Floors Only	7.3% (6/82)	6.9% (4/58)	3.4% (1/29)
Window Sill	21.7% (18/83)	21.7% (18/83)	21.7% (18/83)
Window Well	81.9% (68/83)	80.7% (67/83)	80.7% (67/83)
Soil	7.8% (6/77)	7.8% (6/77)	7.8% (6/77)
Dripline Soil Only	7.8% (6/77)	7.8% (6/77)	7.8% (6/77)
Play Area Soil Only	0% (0/40)	0% (0/40)	0% (0/40)
Paint (≥5% deteriorated)	79.7% (51/64)	79.7% (51/64)	79.7% (51/64)
Performance Characteristics			
Sensitivity (LCB, UCB)	88.2% (63.6%, 98.5%)	88.2% (63.6%, 98.5%)	88.2% (63.6%, 98.5%)
Specificity (LCB, UCB)	15.2% (7.5%, 26.1%)	15.2% (7.5%, 26.1%)	15.2% (7.5%, 26.1%)
Positive Predictive Value (LCB, UCB)	21.1% (12.3%, 32.4%)	21.1% (12.3%, 32.4%)	21.1% (12.3%, 32.4%)
Negative Predictive Value (LCB, UCB)	83.3% (51.6%, 97.9%)	83.3% (51.6%, 97.9%)	83.3% (51.6%, 97.9%)

Notes: 1. For 2, 3, and 4 rooms, respectively, 6, 7, and 8-9 dust wipe samples were obtained from floors, window sills, and window wells. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. See Table 5-2 for definitions of sampling protocols A-1, A-2, and A-3.

Table 6-7 Sampling Protocol A: Assessment of the Impact of the Number and Type of Rooms in Which Dust Wipe Samples are Collected on the Outcome of a Full Risk Assessment, Using the Proposed Rule Standards (XRF Paint Samples from Surfaces With ≥5% Deteriorated Paint).

	Sampling Protocol Group A		
	A-1 (4 Rooms)	A-2 (3 Rooms)	A-3 (2 Rooms)
# Homes Included in Analysis	83	83	83
Number of Individual Dust Samples per Home	8-9	7	6
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	77.1%	75.9%	74.7%
% of Blood Samples ≥10 μg/dL	20.5%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (≥ Media Standard) (# of Homes Below Media Standard / # Homes in Which Samples Were Collected)			
All Floors	10.8% (9/83)	9.6% (8/83)	4.8% (4/83)
Carpeted Floors Only	2.6% (2/76)	2.6% (2/76)	1.3% (1/75)
Uncarpeted Floors Only	9.8% (8/82)	12.1% (7/58)	10.3% (3/29)
Window Sill	28.9% (24/83)	28.9% (24/83)	28.9% (24/83)
Window Well	NA		
Soil (Average of average dripline and average play area)	27.3% (21/77)	27.3% (21/77)	27.3% (21/77)
Dripline Soil Only	NA		
Play Area Soil Only	NA		
Paint (≥5% deteriorated)	79.7% (51/64)	79.7% (51/64)	79.7% (51/64)
Performance Characteristics			
Sensitivity (LCB, UCB)	88.2% (63.6%, 98.5%)	82.4% (56.6%, 96.2%)	82.4% (56.6%, 96.2%)
Specificity (LCB, UCB)	25.8% (15.8%, 38.0%)	25.8% (15.8%, 38.0%)	27.3% (17.0%, 39.6%)
Positive Predictive Value (LCB, UCB)	23.4% (13.8%, 35.7%)	22.2% (12.7%, 34.5%)	22.6% (12.9%, 35.0%)
Negative Predictive Value (LCB, UCB)	89.5% (66.9%, 98.7%)	85.0% (62.1%, 96.8%)	85.7% (63.7%, 97.0%)

Notes: 1. For 2, 3, and 4 rooms, respectively, 6, 7, and 8-9 dust wipe samples were obtained from floors and window sills. Window well samples are not required under the Proposed Rule. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. See Table 5-2 for definitions of sampling protocols A-1, A-2, and A-3.
3 NA indicates that these samples were not included in the analysis.

statistically significantly affect the outcome of the risk assessment as measured by the performance characteristics. Tables G-10 and G-11 in Appendix G show similar results when the analysis is run using XRF samples obtained from surfaces with >15% deteriorated paint.

Since the focus of the analysis was on dust wipe sampling in additional rooms, performance characteristics were calculated excluding the soil and paint sampling. Table 6-8 presents a summary of these results.

Table 6-8. Sampling Protocol A: Summary of the Assessment of the Impact of the Number and Type of Rooms in Which Dust Wipe Samples are Collected on the Outcome of a Risk Assessment, Using the Interim Guidance and Proposed Rule Standards (No Soil and Paint Sampling Included).

	Sampling Protocol Group A					
	Interim Guidance			Proposed Rule		
	A-1 (4 Rooms)	A-2 (3 Rooms)	A-3 (2 Rooms)	A-1 (4 Rooms)	A-2 (3 Rooms)	A-3 (2 Rooms)
# Homes Included in Analysis	83					
% of Homes in Which Lead-Based Paint Hazards Were Found	81.9%	80.7%	80.7%	33.7%	32.5%	30.1%
Performance Characteristics						
Sensitivity	88.2%	88.2%	88.2%	64.7%	58.8%	58.8%
Specificity	19.7%	21.2%	21.2%	74.2%	74.2%	77.3%
Positive Predictive Value	22.1%	22.4%	22.4%	39.3%	37.0%	40.0%
Negative Predictive Value	86.7%	87.5%	87.5%	89.1%	87.5%	87.9%

Note: See Table 5-2 for definitions of sampling protocols A-1, A-2, and A-3.

Table 6-8 shows that, even when focusing only on the dust wipe samples, there is very little difference in the performance characteristics as the number of rooms sampled increases and the sampling is isolated to only the dust wipe sampling. The details of the analysis are presented in Tables G-12 and G-13 in Appendix G where the confidence intervals about the performance characteristics indicate that the small differences observed are not statistically significant.

In the Rochester data, only floor samples were obtained in the interior entryway and floor and/or window well samples were obtained in the kitchen. Of the 83 homes included in this analysis, entryway floors were sampled in 83 homes, kitchen floors in 83 homes, and kitchen window wells in 55 homes. Given the high number of homes that had samples taken in the kitchen and entryway, Table 6-9 summarizes the additional number of homes in which lead-based paint hazards were found when the entryway was sampled after the bedroom and play area had been sampled and when the kitchen was sampled after the bedroom, play area, and entryway had been sampled. As can be seen in Table 6-9, very few additional homes were found to have lead-based paint hazards when the entryway and then the kitchen were sampled. This helps explain why the performance characteristics did not change significantly when the additional rooms were sampled.

Table 6-9. Number of Additional Homes in Which Lead-Based Paint Hazards Were Found When the Entryway and Kitchen Were Sampled.

Component	Number of Additional Homes Found to Have Lead-Based Paint Hazards			
	Interim Guidance		Proposed Rule	
	Entryway (Bedroom and Play Area are Baseline)	Kitchen (Bedroom, Play Area, and Entryway are Baseline)	Entryway (Bedroom and Play Area are Baseline)	Kitchen (Bedroom, Play Area, and Entryway are Baseline)
Floors	4	2	4	1
Carpeted	2	0	1	0
Uncarpeted	3	2	4	1
Window Sills	0	0	0	0
Window Wells	0	1	0	0

It should be noted that the results of these analyses are based on an assumption that at least 6 samples are collected when 2 rooms are sampled. If fewer samples are collected when only examining 2 rooms (e.g., 2 samples in 2 rooms or 4 samples in 4 rooms) the results may be different.

The differences observed between the Interim Guidance and Proposed Rule performance characteristics are discussed in Section 6.1.2.4.

6.1.2.2 Results of Protocol B Analysis: Assessment of the Impact of Various Methods of Characterizing Dust Wipe Samples on the Outcome of a Risk Assessment

Currently, when a certified risk assessor performs a risk assessment under EPA's Interim 403 Guidance or HUD's 1995 Guidelines, a home is determined to have lead-based paint hazards if any sample does not pass the standards outlined in each document. Under EPA's Proposed Rule, a home is determined to have lead-based paint hazards if the arithmetic mean of all uncarpeted floor dust wipe samples or window sill dust wipe samples or the average of the dripline and mid-yard soil samples is above the proposed standards.

The purpose of this analysis was to assess the effectiveness of using an arithmetic mean, geometric mean, or maximum value of the dust wipe samples as a method of characterizing the dust lead in a home under the different standards (see Table 5-3). Tables 6-10 and 6-11 present the performance characteristic results for a full risk assessment (XRF samples taken from surfaces with ≥5% deteriorated paint) using the Interim Guidance and Proposed Rule standards, respectively.

Tables 6-10 and 6-11 show that the percentage of homes found to have lead-based paint hazards is highest for the maximum value and lowest for the geometric mean. Under the Interim Guidance, sensitivity and NPV were highest for the maximum value and lowest for the geometric mean. Under the Proposed Rule, the sensitivity was highest for the maximum value and arithmetic mean and lowest for the geometric mean, while the NPV was highest for the arithmetic mean and lowest for the maximum value.

The percentage of homes found to have lead-based paint hazards under the Interim Guidance ranged from 77.7% for the geometric mean to 85.7% for the maximum value; and, under the Proposed Rule standards, ranged from 73.2% for the geometric mean to 79.5% for the maximum value. For both standards, the percentage of homes found to have lead-based paint hazards when using the arithmetic mean was between the geometric mean and maximum value findings.

Table 6-10. Sampling Protocol B: Assessment of the Impact of Various Methods of Characterizing Dust Wipe Samples Obtained in a Full Risk Assessment, Using the Interim Guidance Standards (XRF Paint Samples from Surfaces With ≥5% Deteriorated Paint).

	Sampling Protocol Group B		
	B-1 (Geometric Mean)	**B-2 (Arithmetic Mean)**	**B-3 (Maximum Value)**
# Homes Included in Analysis	112	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	77.7%	81.3%	85.7%
% of Blood Samples ≥10 μg/dL	21.4%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (≥ Media Standard) (# of Homes Below Media Standard / # Homes in Which Samples Were Collected)			
All Floors	1.8% (2/112)	3.6% (4/112)	8.0% (9/112)
Carpeted Floors Only	0.0% (0/102)	1.0% (1/102)	3.9% (4/102)
Uncarpeted Floors Only	1.8% (2/109)	2.8% (3/109)	5.5% (6/109)
Window Sill	16.1% (18/112)	22.3% (25/112)	27.7% (31/112)
Window Well	67.9% (76/112)	75.9% (85/112)	83.0% (93/112)
Soil	7.6% (8/105)	7.6% (8/105)	7.6% (8/105)
Dripline Soil Only	7.7% (8/104)	7.7% (8/104)	7.7% (8/104)
Play Area Soil Only	0% (0/52)	0% (0/52)	0% (0/52)
Paint (≥5% deteriorated)	77.3% (68/88)	77.3% (68/88)	77.3% (68/88)
Performance Characteristics			
Sensitivity (LCB, UCB)	83.3% (62.6%, 95.3%)	87.5% (67.6%, 97.3%)	91.7% (73.0%, 99.0%)
Specificity (LCB, UCB)	23.9% (15.4%, 34.1%)	20.5% (12.6%, 30.4%)	15.9% (9.0%, 25.2%)
Positive Predictive Value (LCB, UCB)	23.0% (14.6%, 33.2%)	23.1% (14.9%, 33.1%)	22.9% (15.0%, 32.6%)
Negative Predictive Value (LCB, UCB)	84.0% (63.9%, 95.5%)	85.7% (63.7%, 97.0%)	87.5% (61.7%, 98.4%)

Notes: 1. Floor, window sill, and window well samples were collected as dust wipes. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.

2. See Table 5-3 for definitions of sampling protocols B-1, B-2, and B-3.

Table 6-11. Sampling Protocol B: Assessment of the Impact of Various Methods of Characterizing Dust Wipe Samples Obtained in a Full Risk Assessment, Using the Proposed Rule Standards (XRF Paint Samples from Surfaces With ≥5% Deteriorated Paint).

	Sampling Protocol Group B		
	B-1 (Geometric Mean)	B-2 (Arithmetic Mean)	B-3 (Maximum Value)
# Homes Included in Analysis	112	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	73.2%	75.9%	79.5%
% of Blood Samples ≥10 µg/dL	21.4%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (≥ Media Standard) (# of Homes Below Media Standard / # Homes in Which Samples Were Collected)			
All Floors	5.4% (6/112)	8.9% (10/112)	19.6% (22/112)
Carpeted Floors Only	2.9% (3/102)	2.9% (3/102)	4.9% (5/102)
Uncarpeted Floors Only	3.7% (4/109)	7.3% (8/109)	16.5% (18/109)
Window Sill	28.6% (32/112)	32.1% (36/112)	49.1% (55/112)
Window Well	NA		
Soil (Average of average dripline and average play area)	27.6% (29/105)	27.6% (29/105)	27.6% (29/105)
Dripline Soil Only	NA		
Play Area Soil Only	NA		
Paint (≥5% deteriorated)	77.3% (68/88)	77.3% (68/88)	77.3% (68/88)
Performance Characteristics			
Sensitivity (LCB, UCB)	87.5% (67.6%, 97.3%)	91.7% (73.0%, 99.0%)	91.7% (73.0%, 99.0%)
Specificity (LCB, UCB)	30.7% (21.3%, 41.4%)	28.4% (19.3%, 39.0%)	23.9% (15.4%, 34.1%)
Positive Predictive Value (LCB, UCB)	25.6% (16.6%, 36.4%)	25.9% (17.0%, 36.5%)	24.7% (16.2%, 35.0%)
Negative Predictive Value (LCB, UCB)	90.0% (73.5%, 97.9%)	92.6% (75.7%, 99.1%)	91.3% (72.0%, 98.9%)

Notes:
1. Floor and window sill samples were collected as dust wipes. Window well samples are not included in the Proposed Rule sampling scheme. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. See Table 5-3 for definitions of sampling protocols B-1, B-2, and B-3.
3 NA indicates that these samples were not included in the analysis.

Under the Interim Guidance standards, the maximum value had the highest sensitivity and NPV (91.7% and 87.5%, respectively) and the lowest specificity (15.9%) while the geometric mean was lowest (83.3% and 84.0% for the sensitivity and NPV, respectively). Under the Proposed Rule, the arithmetic mean and maximum value had the highest sensitivity at 91.7%, and the arithmetic mean had the highest NPV at 92.6%. The geometric mean had the lowest sensitivity and NPV at 87.5% and 90.0%, respectively. Overall, there were not large differences in the performance characteristics among any of the three statistics. Tables G-14 and G-15 present similar summaries when XRF measurements are taken on surfaces with >15% deteriorated paint.

Again, since the focus of this analysis was on the effect of the various summary methods on characterizing the dust levels in the home, the performance characteristics were calculated excluding the soil and paint samples from the analysis. Table 6-12 presents a summary of the results and Tables G-16 and G-17 present the details of the analysis.

Table 6-12. Sampling Protocol B: Assessment of the Impact of Various Methods of Characterizing Dust Wipe Samples Obtained in a Full Risk Assessment, Using the Interim Guidance and Proposed Rule Standards (No Soil and Paint Sampling).

	Sampling Protocol Group B					
	Interim Guidance			Proposed Rule		
	B-1 (Geometric Mean)	B-2 (Arithmetic Mean)	B-3 (Maximum Value)	B-1 (Geometric Mean)	B-2 (Arithmetic Mean)	B-3 (Maximum Value)
# Homes Included in Analysis	112					
% of Homes in Which Lead-Based Paint Hazards Were Found	67.9%	75.9%	83.0%	31.3%	35.7%	57.1%
Performance Characteristics						
Sensitivity	70.8%	79.2%	91.7%	54.2%	62.5%	75.0%
Specificity	33.0%	25.0%	19.3%	75.0%	71.6%	47.7%
Positive Predictive Value	22.4%	22.4%	23.7%	37.1%	37.5%	28.1%
Negative Predictive Value	80.6%	81.5%	89.5%	85.7%	87.5%	87.5%

Note: See Table 5-3 for definitions of sampling protocols B-1, B-2, and B-3.

When they are based only on the dust samples, differences in performance characteristics are more pronounced. Under the Interim Guidance, the sensitivity increased from 79.2% to 91.7% when using the maximum value rather than the arithmetic mean and NPV increased from 81.5% to 89.5%. Under the Proposed Rule, the percentage of homes found to have lead-based paint hazards increased from 35.7% to 57.1% when using the maximum value rather than the arithmetic mean and the sensitivity increased from 62.5% to 75%.

The differences observed in the percentage of homes found to have lead-based paint hazards and the performance characteristics for the two sets of standards are discussed below.

6.1.2.3 Results of Protocol C Analysis: Comparison of Full Risk Assessment Outcome to a Lead Hazard Screen Outcome

The Protocol C analysis compared the outcome of a risk assessment to the outcome of a lead hazard screen. The lead hazard screen is meant to be a lower-cost assessment for well maintained homes constructed after 1960 or homes considered unlikely to have significant lead paint, dust, or soil hazards. The lead hazard screen requires fewer environmental samples (i.e., soil is not sampled as it is in a risk assessment, and a choice of window components sampled is allowed), while applying more stringent standards for passage of the assessment (i.e., half the Interim Guidance or Proposed Rule standards, whichever set of standards the assessment is being performed under). Because fewer samples are required, the chances of passing a home when a hazard exists may be higher than if a full risk assessment is performed. Note that for a lead hazard screen, Section 402 only prescribes that "windows" be sampled. The 1995 HUD Guidelines interpreted "windows" as sampling only the window wells and not the window sills. The Section 403 Interim Guidance and Proposed Rule do not make an interpretation, but the Proposed Rule does not provide a standard for window well sampling. The different standards and interpretations result in various scenarios under which a lead hazard screen could be performed including potentially sampling no windows. Tables 6-13 and 6-14 assess the various choices a risk assessor could make when performing a lead hazard screen.

Table 6-13. Sampling Protocol C: Comparison of Full Risk Assessment Outcome to Several Lead Hazard Screen Outcomes, Using the Interim Guidance Standards (XRF Paint Samples From Surfaces With ≥5% Deteriorated Paint).

	Sampling Protocol Group C			
	C-1 (Risk Assessment)	C-2 (Lead Hazard Screen)		
# Homes Included in Analysis	112	112	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	85.7%	83.9%	83.9%	83.9%
% of Blood Samples ≥10 µg/dL	21.4%			
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)				
All Floors	8.0% (9/112)	8.9% (10/112)	8.9% (10/112)	8.9% (10/112)
Carpeted Floors Only	3.9% (4/102)	2.9% (3/102)	2.9% (3/102)	2.9% (3/102)
Uncarpeted Floors Only	5.5% (6/102)	7.3% (8/109)	7.3% (8/109)	7.3% (8/109)
Window Sill	27.7% (31/112)	NA	32.1% (36/112)	32.1% (36/112)
Window Well	83.0% (93/112)	82.1% (92/112)	NA	82.1% (92/112)
Soil	7.6% (8/105)	NA	NA	NA
Dripline Soil Only	7.7% (8/104)	NA	NA	NA
Play Area Soil Only	0% (0/52)	NA	NA	NA
Paint (≥5% deteriorated)	77.3% (68/88)	77.3% (68/88)	77.3% (68/88)	77.3% (68/88)
Performance Characteristics				
Sensitivity (LCB, UCB)	91.7% (73%, 99.0%)	87.5% (67%, 97%)	83.3% (62%, 95%)	91.7% (73%, 99%)
Specificity (LCB, UCB)	15.9% (9%, 25%)	17.0% (10%, 27%)	37.5% (27%, 49%)	19.3% (12%, 29%)
Positive Predictive Value (LCB, UCB)	22.9% (15%, 33%)	22.3% (14%, 32%)	26.7% (17%, 38%)	23.7% (16%, 34%)
Negative Predictive Value (LCB, UCB)	87.5% (62%, 98%)	83.3% (59%, 96%)	89.2% (75%, 97%)	89.5% (67%, 99%)

Notes: 1. Floor, window sill, and window well samples were collected as dust wipes. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. See Table 5-4 for definitions of sampling protocols C-1 and C-2.
3. NA indicates that these samples were not included in the analysis.

Table 6-14. Sampling Protocol C: Comparison of Full Risk Assessment Outcome to Several Lead Hazard Screen Outcomes, Using the Proposed Rule Standards (XRF Paint Samples From Surfaces With ≥5% Deteriorated Paint).

	Sampling Protocol Group C		
	C-1 (Risk Assessment)	C-2 (Lead Hazard Screen)	
# Homes Included in Analysis	112	112	112
% of Homes in Which Lead-Based Paint Hazard Were Found (# Homes Below Standards / # Homes)	75.9%	67.0%	67.0%
% of Blood Samples ≥10 μg/dL	21.4%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	8.9% (10/112)	30.4% (34/112)	30.4% (34/112)
Carpeted Floors Only	2.9% (3/102)	10.8% (11/102)	10.8% (11/102)
Uncarpeted Floors Only	7.3% (8/109)	26.6% (29/109)	26.6% (29/109)
Window Sill	32.1% (36/112)	NA	64.3% (72/112)
Window Well	NA	NA	NA
Soil (Average of average dripline and average play area)	27.6% (29/105)	NA	NA
Dripline Soil Only	NA	NA	NA
Play Area Soil Only	NA	NA	NA
Paint (≥5% deteriorated)	77.3% (68/88)	77.3% (68/88)	77.3% (68/88)
Performance Characteristics			
Sensitivity (LCB, UCB)	91.7% (73%, 99%)	83.3% (63%, 95%)	91.7% (73%, 99%)
Specificity (LCB, UCB)	28.4% (19%, 39%)	37.5% (27%, 49%)	25.0% (16%, 35%)
Positive Predictive Value (LCB, UCB)	25.9% (17%, 37%)	26.7% (17%, 38%)	25.0% (16%, 35%)
Negative Predictive Value (LCB, UCB)	92.6% (76%, 99%)	89.2% (75%, 97%)	91.7% (73%, 99%)

Notes: 1. Floor and window sill samples were collected as dust wipes. Window well samples are not included in the Proposed Rule sampling scheme. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. See Table 5-4 for definitions of sampling protocols C-1 and C-2.
3. NA indicates that these samples were not included in the analysis.

Most of the homes in the Rochester Study would not have been recommended for a hazard screen since more than 80% were built prior to 1940 and an additional 5% were built prior to 1970. This should be taken into account when interpreting the results in Tables 6-13, 6-14, and G-23, which present the performance characteristics for a risk assessment and lead hazard screen, calculated under the Interim Guidance and Proposed Rule standards, respectively, when XRF measurements were taken from surfaces with greater than 5% deteriorated paint and different window components were sampled.

As shown in Table 6-13, under the Interim Guidance standards, a risk assessment attains a sensitivity of 91.7% and an NPV of 87.5%. A lead hazard screen 1) sampling window wells attained a sensitivity of 87.5% and an NPV of 83.3%, 2) sampling window sills attained a sensitivity of 83.3% and an NPV of 89.2%, and 3) sampling window sills and window wells a sensitivity of 91.7% and an NPV of 89.5%. Under the Proposed Rule, as shown in Table 6-14, the risk assessment attains a sensitivity of 91.7% and an NPV of 92.6%. The lead hazard screen based on window sills had a sensitivity of 91.7% and an NPV of 91.7% and, based on no window samples, had a sensitivity of 83.3% and an NPV of 89.2%.

Table G-23 in Appendix G compares the performance characteristics for a lead hazard screen performed under the Interim Guidance sampling window wells to a lead hazard screen performed under the Proposed Rules sampling window sills.

6.1.2.4 Comparison of the Performance Characteristics under the Interim Guidance Standards and the Proposed Rule Standards

Differences between the Proposed Rule and the Interim Guidance were described in detail in Section 1.0. Changes in the performance characteristics will be driven by four primary factors:

1. Lower dust standards associated with the Proposed Rule
2. Lower soil standards associated with the Proposed Rule
3. Exclusion of window well sampling in the Proposed Rule
4. The use of the arithmetic mean in the Proposed Rule to characterize dust and soil lead levels.

Each of these can have a different and sometimes conflicting effect. For example, lower soil standards under the Proposed Rule would increase the proportion of homes found to have lead-based paint hazards, while use of the arithmetic mean under the Proposed Rule may decrease the proportion of homes found to have lead-based paint hazards.

The purpose of this analysis is to both assess how all changes in the Proposed Rule act jointly to affect performance characteristics, as well as to discuss the expected effect of the individual changes.

As discussed above, fewer homes were found to have lead-based paint hazards when the Proposed Standards were used rather than the Interim Guidance. Sensitivity and NPV remained high, and specificity and PPV increased with the use of the Proposed Rule. Therefore, overall, the Proposed Rule appears to offer an improvement over the Interim Guidance by maintaining the probability of correctly finding lead-based paint hazards in a home while reducing the probability of incorrectly finding lead-based paint hazards in a home.

Lower Dust-Lead and Soil-Lead Standards

To assess the effect that lower dust and soil standards have on performance characteristics, consider Table 6-15, which shows the performance characteristics when the arithmetic mean and maximum value are used to characterize the soil-lead concentrations and the floor-dust and window sill dust-lead loadings under the Interim Guidance and Proposed Rule standards. The details of the performance characteristics are provided in Tables G-20 and G-21 for the Interim Guidance and Proposed Rule standards, respectively.

Table 6-15 shows that, for the Rochester Study data, more homes were shown to have lead-based paint hazards with the lower standards; but sensitivity and NPV increased, while specificity decreased. In the first two columns, the arithmetic mean is used to characterize the floor dust, window sill dust, and soil lead levels. Under the Proposed Rule, 52.7% percent of the homes were shown to have lead-based paint hazards, with 32.1% a result of window sills and 27.6% a result of the soil standards. The sensitivity and NPV are high at 87.5% and 94.3%, respectively. Under the Interim Guidance, 29.5% of the homes were shown to have lead-based paint hazards, with 22.3% of the homes as a result of window sills and only 7.6% of the homes for a result of soil. The sensitivity and NPV of 45.8% and 83.5%, respectively, are lower than for the Proposed Rule. Similar results are observed when the maximum value is used to characterize the floor, window sill, and soil lead levels under the two sets of standards.

Table 6-15. Summary of the Assessment of Lowered Soil and Dust Standards Associated with the Proposed Rule Relative to the Interim Guidance.

	Lead in Dust Characterized by the Arithmetic Mean		Lead in Dust Characterized by the Maximum Value	
	Interim Guidance	Proposed Rule	Interim Guidance	Proposed Rule
# Homes Included in Analysis	112			
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	29.5%	52.7%	36.6%	67.0%
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)				
All Floors	3.6%	8.9%	8.0%	19.6%
Carpeted Floors Only	1.0%	2.9%	3.9%	4.9%
Uncarpeted Floors Only	2.8%	7.3%	5.5%	16.5%
Window Sill	22.3%	32.1%	27.7%	49.1%
Window Well	NA	NA	NA	NA
Soil (Average of average dripline and average play area)	7.6%	27.6%	7.6%	27.6%
Dripline Soil Only	7.7%	NA	7.7%	NA
Play Area Soil Only	0.0%	NA	0.0%	NA
Paint	NA	NA	NA	NA
Performance Characteristics				
Sensitivity	45.8%	87.5%	58.3%	87.5%
Specificity	75.0%	56.8%	69.3%	38.6%
Positive Predictive Value	33.3%	35.6%	34.1%	28.0%
Negative Predictive Value	83.5%	94.3%	85.9%	91.9%

Notes:
1. Floor and window sill samples were collected as dust wipes. Window well samples are not included in the Proposed Rule sampling scheme. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample.
2. NA indicates that these samples were not included in the analysis.
3. See Tables G-20 and G-21 in Appendix G for the details behind the calculations of the percentages.

Exclusion of Window Well Sampling

The Proposed Rule does not include a standard for lead in window well dust. To understand the impact that not sampling dust from window wells may have on the outcome of a risk assessment, Table 6-16 presents performance characteristics for 1) the Interim Guidance standards including only floor, window sill, and window well dust-lead and soil-lead samples and 2) the Proposed Rule standards including only floor and window sill

Table 6-16. Summary of the Assessment of the Exclusion of Window Well Sampling Under the Proposed Rule Relative to the Interim Guidance.

	Lead in Dust Characterized by the Arithmetic Mean		Lead in Dust Characterized by the Maximum Value	
	Interim Guidance	Proposed Rule	Interim Guidance	Proposed Rule
# Homes Included in Analysis	112			
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	77.7%	52.7%	83.9%	67.0%
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)				
All Floors	3.6%	8.9%	8.0%	19.6%
Carpeted Floors Only	1.0%	2.9%	3.9%	4.9%
Uncarpeted Floors Only	2.8%	7.3%	5.5%	16.5%
Window Sill	22.3%	32.1%	27.7%	49.1%
Window Well	75.9%	NA	83.0%	NA
Soil (Average of average dripline and average play area)	7.6%	27.6%	7.6%	27.6%
Dripline Soil Only	7.7%	NA	7.7%	NA
Play Area Soil Only	0.0%	NA	0.0%	NA
Paint (≥5% deteriorated)	NA	NA	NA	NA
Performance Characteristics				
Sensitivity	83.3%	87.5%	91.7%	87.5%
Specificity	23.9%	56.8%	18.2%	38.6%
Positive Predictive Value	23.0%	35.6%	23.4%	28.0%
Negative Predictive Value	84.0%	94.3%	88.9%	91.9%

Notes:
1. Floor, window sill, and window well samples were collected as dust wipes. Window well samples are not included in the Proposed Rule sampling scheme. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample.
2. NA indicates that these samples were not included in the analysis.
3. See Tables G-21 and G-22 in Appendix G for the details behind the calculation of the percentages.

dust-lead and soil-lead samples. The details of the performance characteristics are presented in Tables G-21 and G-22 for the Proposed Rule and Interim Guidance standards, respectively.

Comparing Table 6-15 to 6-16 shows that when the window well samples were included in the testing, more homes were found to have lead-based paint hazards under the Interim Guidance, even though the standards were lowered in the Proposed Rule. When either the arithmetic mean or maximum value are used to characterize the dust levels, the window well samples drive the conclusion that a home has lead-based paint hazards. For example, when the maximum value is used to characterize the dust samples, 83.9% of the homes are found to have lead-based paint hazards under the Interim Guidance, with 83% of the homes a result of window wells. While more homes are found to have lead-based paint hazards under the Interim Guidance, the Proposed Rule has higher sensitivity and NPV when using the arithmetic mean and higher NPV when using the maximum value (Table 6-16). This indicates that, when using the Rochester study data and with the lower standards in the Proposed Rule, the removal of the window well samples from the assessment does not affect the ability of the assessment to detect health hazards. The inclusion of the window wells appears to unnecessarily conclude that homes have lead-based paint hazards.

The exclusion of the window well dust samples impacts the outcome of the lead hazard screen. The Section 402 protocols recommend that dust samples be collected from floors and window wells during a lead hazard screen. Under the Proposed Rule, dust samples may be taken only from the floor during a lead hazard screen. As shown in Table 6-14, the lead hazard screen is not as discriminating when based only on floor dust and paint samples.

Use of the Arithmetic Mean to Characterize Dust-Lead Loadings and Soil-Lead Concentrations

The Interim Guidance recommends that the maximum of the floor dust, window sill dust, window well dust, and soil sample results be compared to the respective standards. If any one sample result is greater than the standard, the home is found to have lead-based paint hazards. The Proposed Rule recommends that the arithmetic mean of the floor dust, window sill dust, and soil sample results be compared to the respective revised standards. If the arithmetic average of any one medium/component is greater than its respective standard, the home is found to have lead-based paint hazards. To understand the effect these summary methods may have, consider Table 6-15 again.

As discussed earlier, for both sets of standards, fewer homes are found to have lead-based paint hazards when the arithmetic mean is used to characterize the dust levels than when the maximum value is used. Under the Interim Guidance standards, the sensitivity, PPV, and NPV are higher for the maximum value than for the arithmetic mean. Under the Proposed Rule, the specificity, PPV, and NPV are higher using the arithmetic mean; and the sensitivity is the same regardless of the summary method. Therefore, under the Proposed Rule standards, the arithmetic mean provides better performance characteristics than the maximum value.

Table 6-17 presents an overall summary of the performance characteristics calculated for a full risk assessment performed under the Interim Guidance and Proposed Rule. The details of the table were provided in Tables 6-10 and 6-11. Overall, Table 6-17 shows that, under the Proposed Rule, the combination of the arithmetic mean, lower media standards, and the removal of the window wells from the sampling protocol results in an assessment that fails fewer homes unnecessarily, yet maintains the ability to identify health hazards.

6.1.2.5 Estimated Costs of Performing a Risk Assessment and a Lead Hazard Screen

Using the risk assessment and lead hazard screen cost estimates discussed earlier, estimated costs of risk assessments and lead hazard screens under Protocol A and Protocol C are presented below. Note that Protocol B assesses the effect of different dust summary measures on the outcome of a risk assessment. The number of samples taken are the same as in Protocol A-1. Therefore, the estimated cost for Protocol B is the same as the estimated cost for A-1.

Protocol A assessed the effect of sampling dust from additional rooms on the outcome of a risk assessment. Table 6-18 presents the estimated cost of the risk assessment when the number of rooms in which dust samples are obtained increases from 2 to 4 (i.e., number of dust samples increases from 6 to 8).

If a basic fee were charged for the risk assessment, the estimated costs of the assessments varied slightly depending on the number of rooms (i.e., number of dust samples) in which samples are obtained. The basic fee estimations ranged from $547.50 for a risk assessment that had 6 dust samples taken to $584.11 when up to 9 dust samples were taken. If separate fees were charged for the visual assessment, environmental sampling, and risk assessment report, the estimated cost of the assessment remained the same no matter how many rooms were sampled for dust (i.e., dust samples taken).

Table 6-17. Summary of the Comparison of the Interim Guidance Results and Proposed Rule Results for a Full Risk Assessment.

	Interim Guidance[a]	Proposed Rule[b]
# Homes Included in Analysis	112	
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	85.7%	75.9%
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards/ # Homes in Which Samples Were Collected)		
Floors	8.0%	8.9%
Carpeted Floors Only	3.9%	2.9%
Uncarpeted Floors Only	5.5%	7.3%
Window Sill	27.7%	32.1%
Window Well	83.0%	NA
Soil (Average of average dripline and average play area)	7.6%	27.6%
Dripline Soil Only	7.7%	NA
Play Area Soil Only	0.0%	NA
Paint (≥5% deteriorated)	77.3%	77.3%
Performance Characteristics		
Sensitivity	91.7%	91.7%
Specificity	15.9%	28.4%
Positive Predictive Value	22.9%	25.9%
Negative Predictive Value	87.5%	92.6%

[a] The maximum value of the floor, window sill, and window well dust and soil samples were compared to the respective standard.
[b] The arithmetic mean of the floor, window sill, and window well dust and soil samples were compared to the respective standard.

Notes: 1. Floor, window sill, and window well samples were collected as dust wipes. Window well samples are not included in the Proposed Rule sampling scheme. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. NA indicates that these samples were not included in the analysis.
3. See Tables 6-10 and 6-11 for the details behind the calculations of the percentages.

Table 6-18. Sampling Protocol A: Comparison of the Estimated Costs of a Full Risk Assessment when Dust Samples are Taken in Two, Three, and Four Rooms.

	Sampling Protocol Group A		
	A-1 (4 Rooms)	A-2 (3 Rooms)	A-3 (2 Rooms)
Number of Individual Samples per Home	8-9	7	6
Estimated Cost of Activity			
Basic Fee	$584.11	$561.50	$547.50
Separate Fee	$814.00	$814.00	$814.00

Notes: 1. Floor, window sill, and window well samples were collected as dust wipes; soil was collected as a core sample; and XRF measurements were taken for paint.
2. See Table 5-2 for definitions of sampling protocols A-1, A-2, and A-3.

One of the advantages of the lead hazard screen is the reduction in the number of samples, which implies a cost savings for the assessment. Table 6-19 presents the estimated cost for a full risk assessment and lead hazard screen when a basic fee is charged for the assessment and separate fees are charged the different components of the assessment/screening.

Table 6-19. Sampling Protocol C: Comparison of the Estimated Cost of a Full Risk Assessment Outcome to the Cost of a Lead Hazard Screen Outcome.

	Sampling Protocol Group C	
	C-1 (Risk Assessment)	C-2 (Lead Hazard Screen)
Estimated Costs of Activity		
Basic Fee	$584.11	$126.00
Separate Fee	$814.00	$575.25

Notes: 1. Floor, window sill, and window well samples were collected as dust wipes; soil was collected as a core sample; and XRF measurements were taken for paint.
2. See Table 5-4 for definitions of sampling protocols C-1 and C-2.

As expected, the estimated costs of a lead hazard screen were less than for a risk assessment. Under Protocol C, when a basic fee was charged, the lead hazard screen cost $126.00, while a risk assessment cost $547.50. If separate fees were charged for the visual assessment, the environmental sampling, and the report, the lead hazard screen was estimated to cost $575.25 and the risk assessment to cost $814.00.

6.2 OBJECTIVE 2: ABILITY OF ESTIMATORS AND SAMPLING PROTOCOLS TO DETERMINE TRUE AVERAGE LEAD LEVELS

The ability of three statistics – geometric mean, arithmetic mean, and maximum value – to estimate the unobservable, "true" average dust and soil levels in a single home was assessed in this analysis.

As discussed in Section 5.2, the Rochester Lead-In-Dust Study data, the Rhode Island Department of Health data, and the CAP Study data were used to calculate the variance components needed to calculate the geometric mean, arithmetic mean, and maximum value error probabilities. Section 4 and Section 5.2 provide details on the data, as well as the variance component and error probability calculations.

Presented below are

1. A discussion of the within-house variance components
2. A comparison of the geometric mean, arithmetic mean, and maximum value error probabilities for a risk assessment, a "compound" lead hazard screen, and a "simple" lead hazard screen
3. A discussion of the effect of the number of samples collected for floor dust, window sill dust, window well dust, and soil on the error probabilities
4. A discussion of the effect the different media/component standards, Interim Guidance and Proposed Rule, have on error probabilities.

6.2.1 Within-House Variance Components

Three sets of data were used to calculate within-house variance components needed for the error probability calculations. The Rochester study data were used to calculate within-house components of variation for floor, window sill, and window well dust-wipe results; the CAP Study data were used to calculate the within-house component of variation for soil results; and the Rhode Island Department of Health data were used to calculate within-house components of variation for all media/components. Table 6-20 presents the estimated within-house components of variations for each set of data, media, and component. The components of variation were calculated using log-transformed dust-lead loadings and soil-lead concentrations. Because some of the estimates were calculated in previous EPA work, the source from which the estimates were extracted is also provided.

Table 6-20. Estimated Within-House Components of Variation[1] for Each Data Source, Medium, and Component.

Data Source	Medium	Dust Component/ Soil Location	Within-House Variance (σ_i^2)	Source of Variance Component Value
Rochester Study	Dust	Floor	0.848	Draft Final EPA report, "Components of Variation of Lead in Household Dust, Soil, and Paint"[18]
		Window Sill	1.304	
		Window Well	3.273	
CAP Study	Soil	Foundations	0.602	
		Boundaries	0.239	
Rhode Island Department of Health Data	Dust	Floor	0.708	New mixed model analysis (Section 5.2)
		Window Sill	1.617	
		Window Well	1.758	
	Soil	Side of House/ Foundations	1.034	

1 The components of variation were calculated with log-transformed dust-lead loadings and soil-lead concentrations

Table 6-20 shows that the floor and window sill dust within-house variances are similar across the Rochester study and Rhode Island Department of Health data, while the Rochester study window well variance component is nearly double the Rhode Island data window well variance component. The combined side of house/foundation soil component of variation for the Rhode Island data soil is larger than either the foundation or boundary soil variation seen for the CAP Study data.

6.2.2 Effect of the Use of the Geometric Mean, Arithmetic Mean, and Maximum Value on the Error Probabilities

Two sets of analyses were conducted to evaluate the effect of the different estimators on determining a lead hazard as characterized by the error probabilities. The first set of analyses assesses the effect of the estimators when a risk assessment and "compound" lead hazard screen are conducted, while the second set evaluates the effect when a "simple" lead hazard screen is conducted. The definitions of "simple" and "compound" lead hazard screens are provided in Section 5.2.

6.2.2.1 Risk Assessment and "Compound" Lead Hazard Screen

Using the within-house variabilities listed in Table 6-20 and the calculations discussed in Section 5.2, the error probabilities for performing a risk assessment and a "compound" lead hazard screen, when each media/component is evaluated separately, were calculated for the geometric mean, arithmetic mean, and maximum value and when 2, 3, or 4 samples were collected for floor dust, window sill dust, window well dust, and soil. Figures 6-6 and 6-7 present the results for dust and soil, respectively, when the error probabilities were calculated under the Interim Guidance standards and the within-house variation from the Rochester Study and CAP Study data were used. Figures 6-8 and 6-9 present the same results when using the within-house variation from the Rhode Island Department of Health data. Tables 6-21 through 6-24 present the actual Type I (false positive) and Type II (false negative) error probabilities for the floor dust, window sill dust, window well dust, and soil, respectively, when 2, 3, and 4 samples are collected; the assumed "true" house media/component lead levels are assumed to be one-half the Interim Guidance standard, at the standard, and double the standard; and the Rochester study and CAP Study variances are used. Tables H-1 through H-4 present similar results when the Rhode Island Department of Health data are used to calculate the within-house variance components.

In Figure 6-6 through 6-9, the solid vertical line in each graph represents the media standard for which passage or failure of the home is determined. For instance, under the Interim Guidance and a risk assessment, the dust standards are 100 $\mu g/ft^2$ for floors, 500 $\mu g/ft^2$ for window sills, and 800 $\mu g/ft^2$ for window wells. For a lead hazard screen under the Interim Guidance, the dust standards are 50 $\mu g/ft^2$ for floors, 250 $\mu g/ft^2$ for window sills, and 400 $\mu g/ft^2$ for window wells (i.e., half the standards used for the risk assessment). To the left of the solid vertical line are the Type I (false positive) error probabilities (i.e., incorrectly concluding that lead-based paint hazards exist) and to the right are the Type II (false negative) error probabilities (i.e., incorrectly concluding that no lead-based paint hazards exist). The x-axis is the assumed "true" house average lead level for a given medium and component, and the y-axis is the error probability.

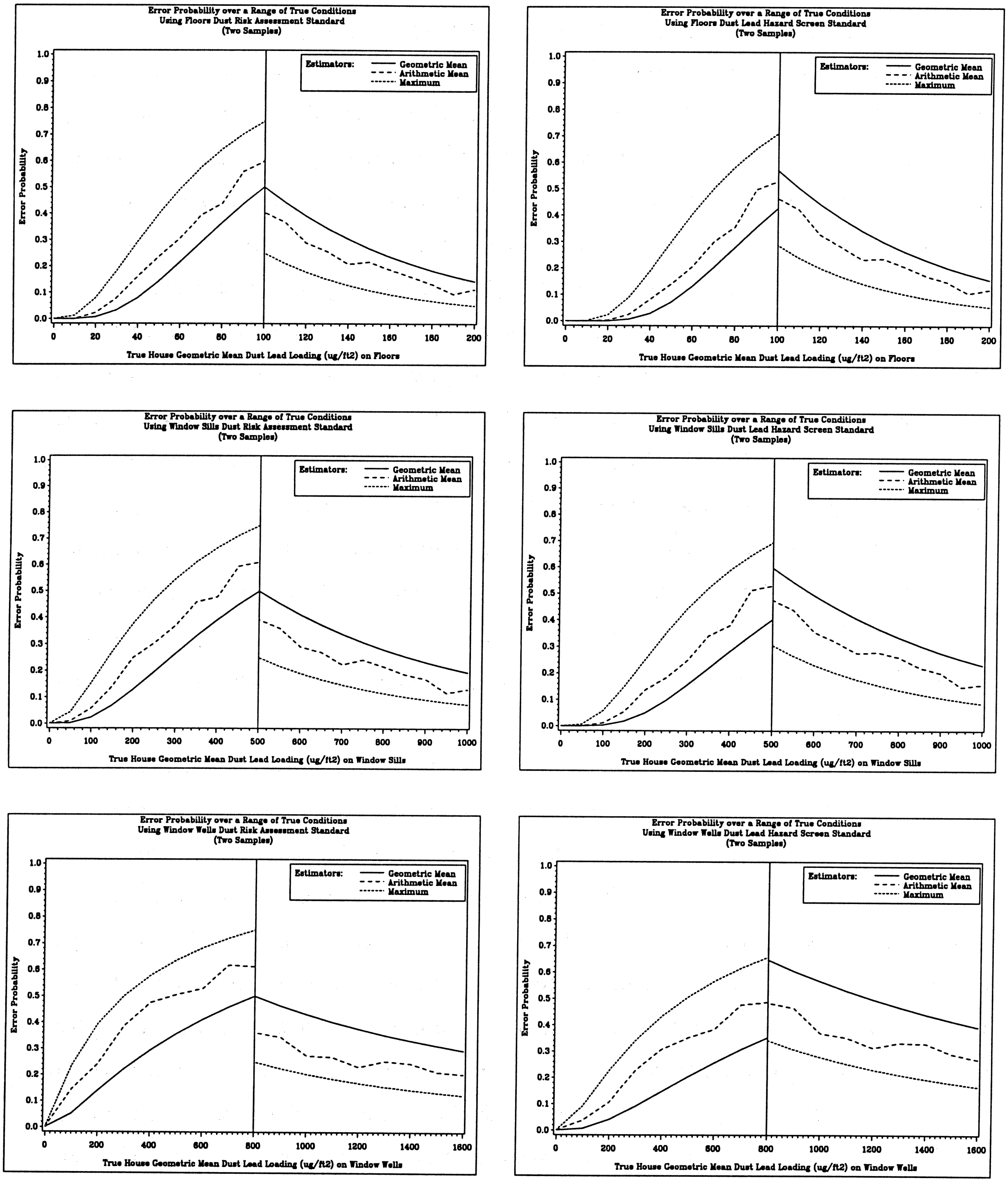


Figure 6-6. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Two Floor, Window Sill, and Window Well Dust Samples</u> Using the Interim Guidance Standards – Variance Components from the Rochester Lead-In-Dust Study Homes.

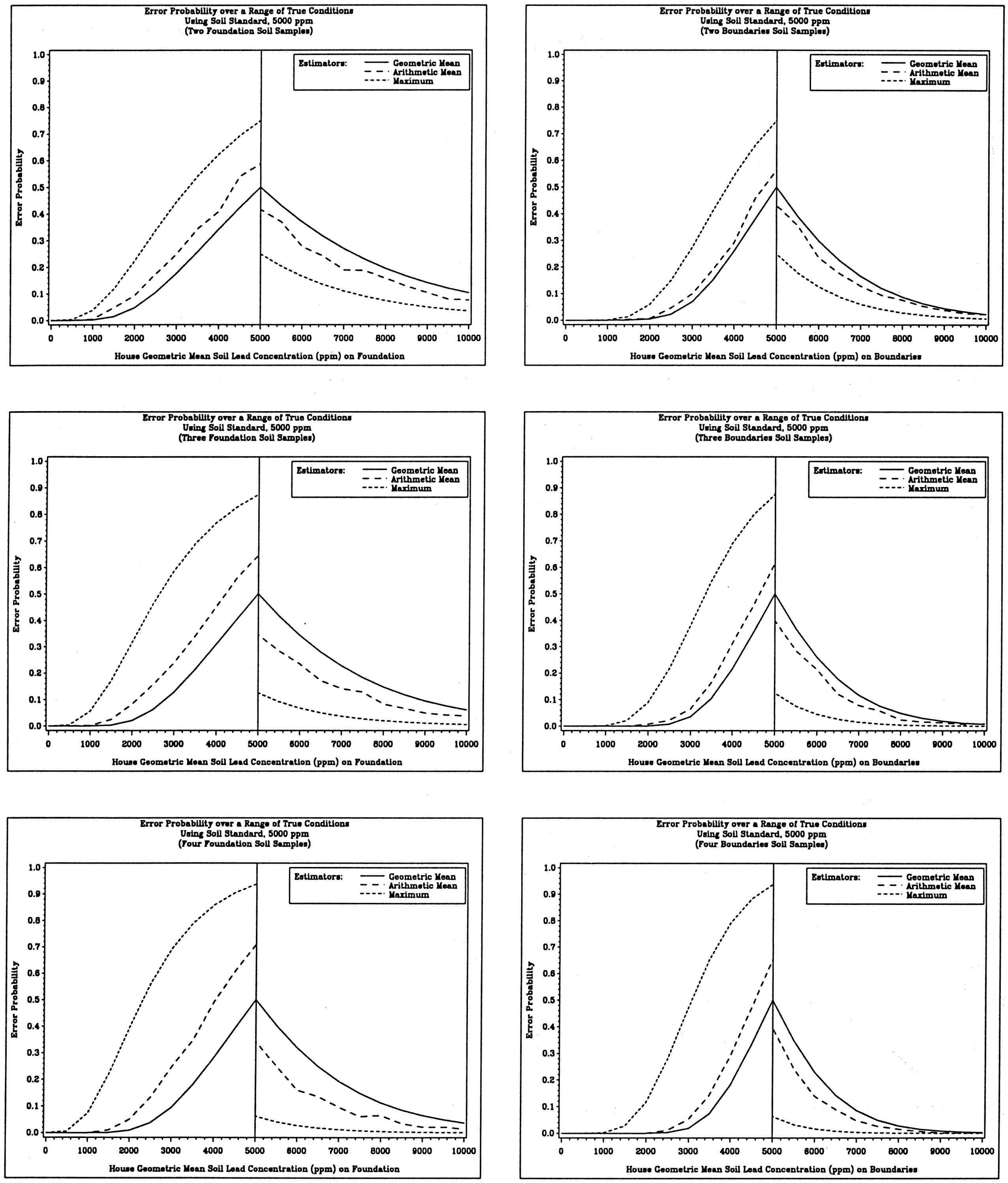


Figure 6-7. Comparison of Risk Assessment Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Two, Three, and Four Soil Samples</u> Using the Interim Guidance Standards – Variance Components from the Foundation of the Home and Boundary of the Property in the CAP Study Data.

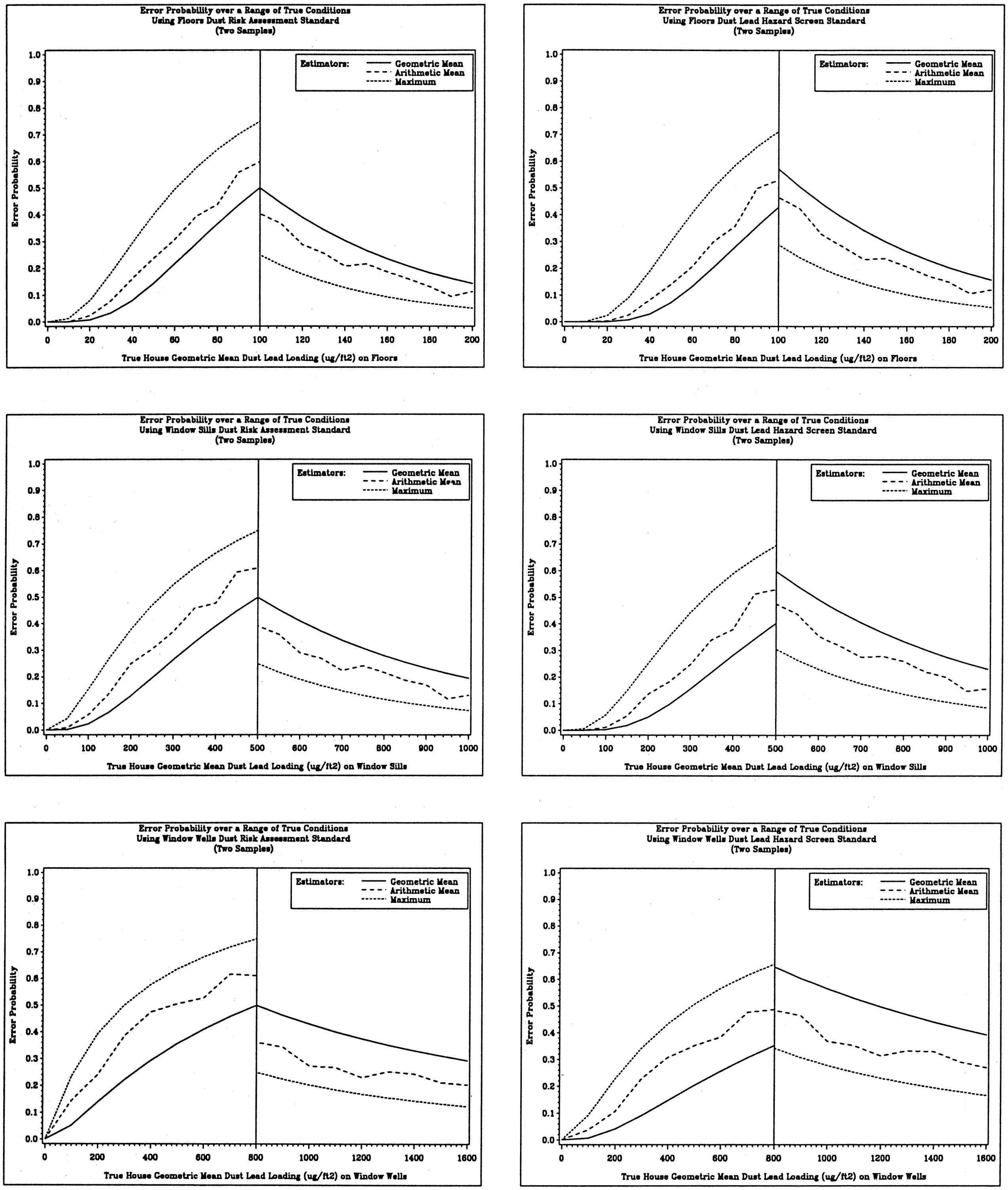


Figure 6-8. **Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Two Floor, Window Sill, and Window Well Dust Samples Using the Interim Guidance Standards – Variance Components from the Rhode Island Department of Health Homes.**

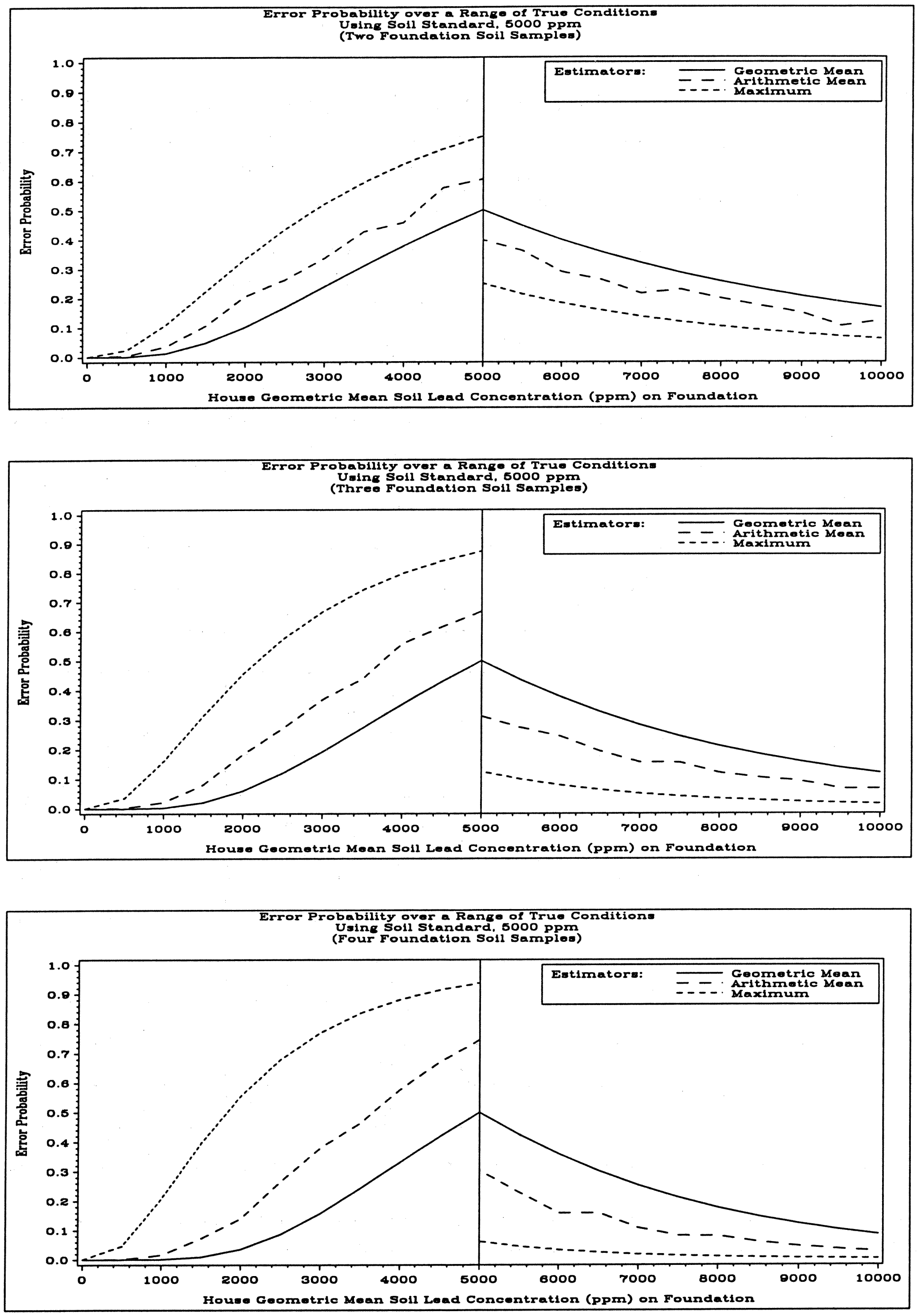


Figure 6-9. Comparison of Risk Assessment Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Two, Three, and Four Soil Samples Collected from Side of the House/Foundation for Homes Using the Interim Guidance Standards – Variance Components from the Rhode Island Department of Health Data.

Table 6-21. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Levels For Two, Three, and Four Floor Dust Samples Using the Interim Guidance Standards[1] – Variance Components from the Rochester Study Data.

Assessment	Number of Samples	Assumed "True" House Floor Lead Loading (µg/ft²)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
"Compound" Lead Hazard Screen	2	50	0.140	0.072	0.300	.	.	.
		100	0.530	0.428	0.712	0.465	0.572	0.288
		200	.	.	.	0.120	0.158	0.055
	3	50	0.150	0.048	0.469	.	.	.
		100	0.623	0.452	0.865	0.355	0.548	0.135
		200	.	.	.	0.059	0.100	0.012
	4	50	0.150	0.033	0.601	.	.	.
		100	0.712	0.467	0.935	0.339	0.533	0.065
		200	.	.	.	0.025	0.067	0.003
Risk Assessment	2	50	0.237	0.144	0.401	.	.	.
		100	0.598	0.500	0.750	0.404	0.500	0.250
		200	.	.	.	0.113	0.144	0.051
	3	50	0.231	0.096	0.536	.	.	.
		100	0.660	0.500	0.875	0.326	0.500	0.125
		200	.	.	.	0.056	0.096	0.012
	4	50	0.206	0.066	0.641	.	.	.
		100	0.730	0.500	0.938	0.316	0.500	0.063
		200	.	.	.	0.024	0.066	0.003

[1] The floor dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 100 µg/ft² for the risk assessment and 50 µg/ft² for the lead hazard screen.

Table 6-22. Comparison of Risk Assessment Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Levels For Two, Three, and Four Window Sill Dust Samples Using the Interim Guidance Standards[1] – Variance Components from the Rochester Study Data.

Assessment	Number of Samples	Assumed "True" House Window Sill Lead Loading ($\mu g/ft^2$)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
"Compound" Lead Hazard Screen	2	250	0.182	0.098	0.352	.	.	.
		500	0.530	0.402	0.695	0.475	0.598	0.305
		1000	.	.	.	0.157	0.230	0.086
	3	250	0.214	0.073	0.537	.	.	.
		500	0.629	0.427	0.857	0.350	0.573	0.143
		1000	.	.		0.086	0.162	0.021
	4	250	0.255	0.056	0.674	.	.	.
		500	0.736	0.444	0.932	0.319	0.556	0.068
		1000	.	.	.	0.039	0.119	0.006
Risk Assessment	2	250	0.304	0.195	0.470	.	.	.
		500	0.610	0.500	0.750	0.392	0.500	0.250
		1,000	.	.	.	0.131	0.195	0.074
	3	250	0.316	0.147	0.614	.	.	.
		500	0.681	0.500	0.875	0.303	0.500	0.125
		1,000	.	.	.	0.076	0.147	0.020
	4	250	0.335	0.112	0.719	.	.	.
		500	0.763	0.500	0.938	0.288	0.500	0.063
		1,000	.	.	.	0.036	0.112	0.005

[1] The window sill dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 500 $\mu g/ft^2$ for the risk assessment.

Table 6-23. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Levels For Two, Three, and Four Window Well Dust Samples Using the Interim Guidance Standards[1] – Variance Components from the Rochester Study Data.

Assessment	Number of Samples	Assumed "True" House Window Well Lead Loading (μg/ft²)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
"Compound" Lead Hazard Screen	2	400	0.308	0.147	0.434	.	.	.
		800	0.488	0.353	0.658	0.485	0.647	0.342
		1,600	.	.	.	0.270	0.392	0.166
	3	400	0.405	0.127	0.636	.	.	.
		800	0.642	0.373	0.837	0.328	0.627	0.163
		1,600	.	.	.	0.152	0.322	0.054
	4	400	0.463	0.111	0.771	.	.	.
		800	0.743	0.389	0.923	0.278	0.611	0.077
		1,600	.	.	.	0.078	0.271	0.018
Risk Assessment	2	400	0.475	0.294	0.579	.	.	.
		800	0.612	0.500	0.750	0.362	0.500	0.250
		1,600	.	.	.	0.203	0.294	0.123
	3	400	0.537	0.253	0.726	.	.	.
		800	0.729	0.500	0.875	0.253	0.500	0.125
		1,600	.	.	.	0.119	0.253	0.043
	4	400	0.578	0.222	0.822	.	.	.
		800	0.794	0.500	0.938	0.223	0.500	0.063
		1,600	.	.	.	0.064	0.222	0.015

1 The window well dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 800 μg/ft² for the risk assessment and 400 μg/ft² for the lead hazard screen.

Table 6-24. Comparison of Boundary and Foundation <u>Two, Three, and Four Soil Sample</u> Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Levels Using the Interim Guidance Standards[1] – Variance Components from the CAP Study Data.

Location	Number of Samples	Assumed "True" House Soil Lead Concentration (ppm)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
Boundary of Property	2	2,500	0.046	0.022	0.150	.	.	.
		5,000	0.563	0.500	0.750	0.432	0.500	0.250
		7,500	.	.	.	0.094	0.120	0.041
	3	2,500	0.022	0.007	0.217	.	.	.
		5,000	0.615	0.500	0.875	0.399	0.500	0.125
		7,500	.	.	.	0.057	0.075	0.008
	4	2,500	0.011	0.002	0.278	.	.	.
		5,000	0.654	0.500	0.938	0.396	0.500	0.063
		7,500	.	.	.	0.026	0.049	0.002
Foundation	2	2,500	0.173	0.103	0.337	.	.	.
		5,000	0.587	0.500	0.750	0.416	0.500	0.250
		7,500	.	.	.	0.187	0.230	0.090
	3	2,500	0.155	0.061	0.460	.	.	.
		5,000	0.645	0.500	0.875	0.346	0.500	0.125
		7,500	.	.	.	0.128	0.183	0.027
	4	2,500	0.132	0.037	0.561	.	.	.
		5,000	0.709	0.500	0.938	0.342	0.500	0.063
		7,500	.	.	.	0.061	0.148	0.008

[1] The soil standard at which a home is found to have lead-based paint hazards was assumed to be 5,000 ppm.

As the assumed "true" average lead level moves further from the standard of comparison, the Type I (false positive) and Type II (false negative) error probabilities, for all three statistics, approach zero. The geometric mean always produces the lowest Type I (false positive) error probabilities, while the maximum value produces the highest Type I (false positive) error probabilities. The reverse is true for Type II (false negative) errors. The error probabilities for the arithmetic mean always lie somewhere between that for the maximum value and the geometric mean. These observations hold true for all media/components.

Tables 6-21 through 6-24 and H-1 through H-4, in combination with Figures 6-6 through 6-9, show the following results:

1. Type I (false positive) error rates were very high when using the maximum value. For example, as shown in Tables 6-24 and H-2, for both the Rochester and Rhode Island variance components, when four window sill samples were used in the error probability calculations the maximum value errors remained above 0.500. This was true for floors and window wells even when the "true" media lead loading was assumed to be half the standard. Similar observations were made when four soil samples were taken at the foundation of the home (see Tables 6-24 and H-4)

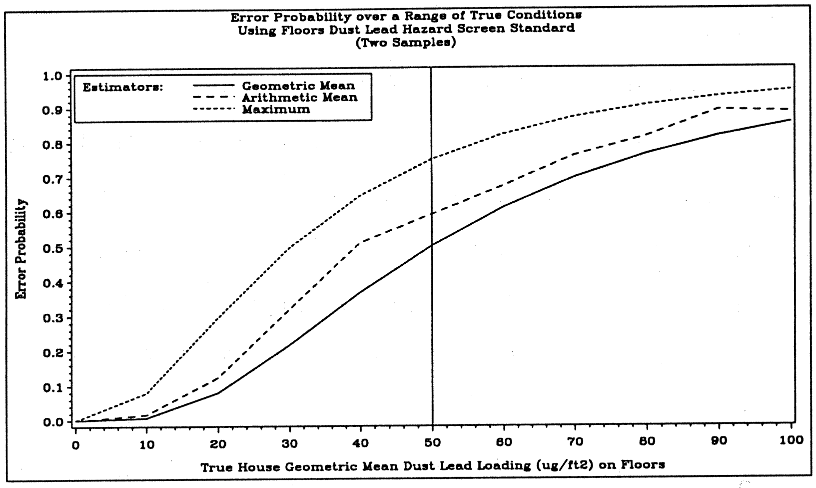
2. Both Type I (false positive) and Type II (false negative) error rates were high (usually over 0.250) for all three statistics when the "true" media lead level was within 20% of the standard. This is true for both the Rochester and Rhode Island data. For instance, as shown in Figure 6-6, when two floor samples from a risk assessment were used in the error probability calculations and the assumed "true" average floor dust-lead loading was assumed to be 80 $\mu g/ft^2$, the geometric mean, arithmetic mean, and maximum value Type I (false positive) error rates were 0.33, 0.42, and 0.65, respectively. This implies that there is a very large "gray" area around the standard with a high probability of a "wrong" decision.

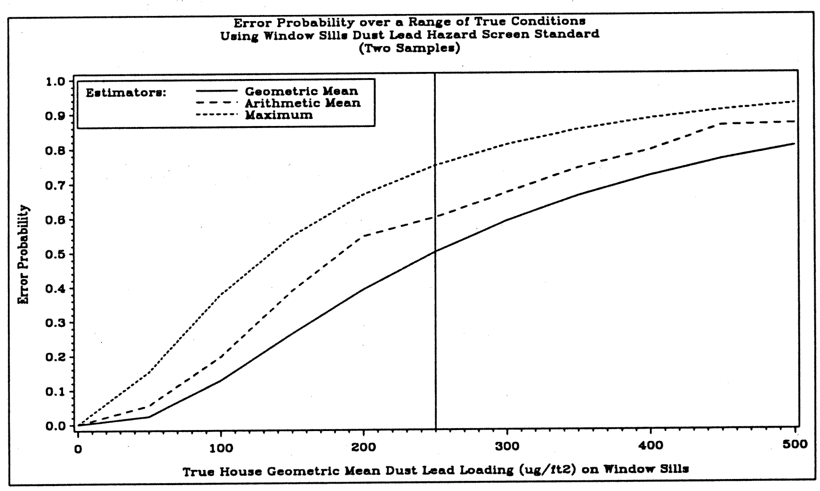
Which estimator is best may depend on which type of error is more "acceptable." If the maximum value is used under the Interim Guidance, then more homes will be found to have lead-based paint hazards when the true house lead level is actually below the standard, but fewer homes will be found to have no lead-based paint hazards when in fact the true lead level is above or equal to the standard. On the other hand, if the geometric mean is used, then fewer homes will be found to have lead-based paint hazards when the true house lead level is below the standard, but more homes will be found to have no lead-based paint hazards when the true lead level is above or equal to the standard. If the extreme differences in the Type I (false positive) and Type II (false negative) errors seen with the geometric mean and maximum value cause concern, a compromise may be the arithmetic mean. Note that the results presented are for the Interim Guidance. The effect of the lower standards in the Proposed Rule on the choice of estimator is discussed in Section 6.2.4.

6.2.2.2 "Simple" Lead Hazard Screen

Only Type I (false positive) error probabilities for the three statistics were calculated for a "simple" lead hazard screen. As discussed in Section 5.2, these probabilities do not indicate whether a home was incorrectly found to have lead-based paint hazards based on the media standards, but whether a home was incorrectly found to have lead-based paint hazards based on a lead hazard screen. This precludes Type II (false negative) error probabilities being presented for the "simple" lead hazard screen. Figure 6-10 presents, for the Rochester data, graphs of the error probabilities for the three estimators when two floor and window well samples were collected, as calculated under the Interim Guidance standards, while Figures H-5 and H-6 present similar graphs when three and four dust samples are taken. Table 6-25 presents the actual probabilities included in the graph when two, three, and four floor dust and window well dust samples are taken.

Since a risk assessor must perform a full risk assessment when a home is found to have lead-based paint hazards based on the lead hazard screen, the Type I (false positive) error probabilities give an indication of the percent of time a full risk assessment may have to be performed in addition to the lead hazard screening. For instance, in Table 6-25 consider when four floor dust samples are used in the error probability calculations and the assumed true house floor dust-lead loading is 30 $\mu g/ft^2$, i.e., below the hazard screen Interim Guidance cut-off of 50 $\mu g/ft^2$. The probability of incorrectly finding lead-based paint hazards in a home is 0.134 for the geometric mean, 0.328 for the arithmetic mean, and 0.745 for the maximum value. That is, when the maximum value is used to characterize the floor dust-lead loadings in the home, 74.5% of the time the lead hazard screen will find lead-based paint hazards, forcing additional testing through a full risk assessment even though the true lead levels were below the standard. This high error rate for the maximum value has a high monetary value since two assessments will need to be performed when, in fact, the less costly lead hazard screen may have been appropriate in determining that no lead-based paint hazards exist in the home if another estimator had been used to characterize the lead levels in the home. As shown in Figures H-7 through H-9 and Table H-5, similar observations can be made for the Rhode Island data.





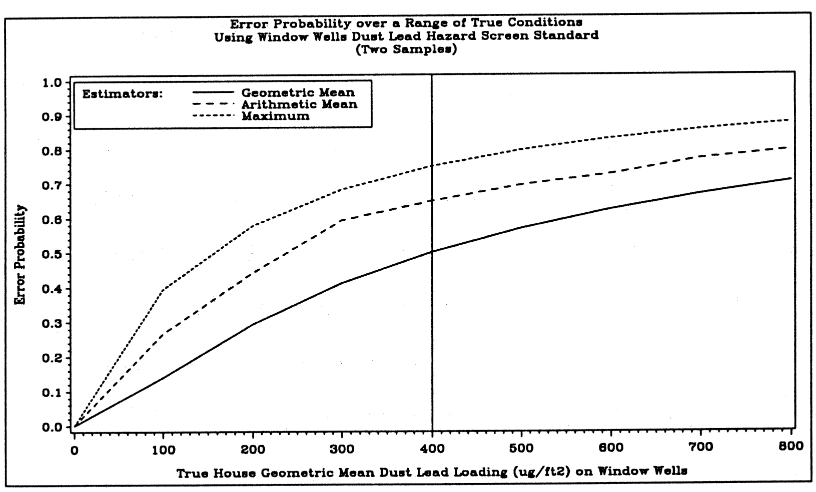


Figure 6-10. Comparison of "Simple" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Two Floor and Window Well Dust Samples Using the Interim Guidance Standards – Variance Components from the Rochester Lead-In-Dust Study Homes.

Table 6-25. "Simple" Lead Hazard Screen Error Probabilities for Each Statistic Over a Range of Assumed True House Lead Levels For Two, Three, and Four Floor and Window Well Dust Samples Using the Interim Guidance Standards[1] – Variance Components From the Rochester Lead-In-Dust Study Data.

Location	Number of Samples	Assumed "True" House Dust Lead Loading (μg/ft²)	Type I (False Positive) Error Probability		
			Under the Geometric Mean	Under the Arithmetic Mean	Under the Maximum Value
Floors	2	30	0.216	0.318	0.495
		50	0.500	0.591	0.750
		70	0.697	0.761	0.872
		100	0.856	0.887	0.949
	3	30	0.168	0.326	0.641
		50	0.500	0.649	0.875
		70	0.737	0.839	0.954
		100	0.904	0.944	0.988
	4	30	0.134	0.328	0.745
		50	0.500	0.730	0.938
		70	0.768	0.890	0.984
		100	0.934	0.976	0.997
Window Sills	2	100	0.128	0.196	0.378
		250	0.500	0.600	0.750
		400	0.720	0.793	0.884
		500	0.805	0.869	0.926
	3	100	0.082	0.214	0.509
		250	0.500	0.677	0.875
		400	0.762	0.865	0.961
		500	0.853	0.924	0.980
	4	100	0.054	0.226	0.613
		250	0.500	0.762	0.938
		400	0.795	0.917	0.987
		500	0.888	0.964	0.995
Window Wells	2	200	0.294	0.442	0.579
		400	0.500	0.649	0.750
		600	0.624	0.727	0.831
		800	0.706	0.797	0.877
	3	200	0.253	0.507	0.726
		400	0.500	0.754	0.875
		600	0.651	0.830	0.930
		800	0.747	0.881	0.957
	4	200	0.222	0.561	0.822
		400	0.500	0.801	0.938
		600	0.673	0.883	0.971
		800	0.778	0.936	0.985

[1] The floor dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 50 μg/ft² and the window well dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 400 μg/ft².

6.2.3 Effect of the Number of Media Samples Collected

As discussed in the performance characteristics analysis, the Section 402 protocols do not require a risk assessor to collect a specific number of samples. For example, the recommendation in the HUD Guidelines is to collect between 6 and 8 floor, window sill, and window well dust samples. This analysis assesses the effect of collecting 2, 3, and 4 floor-dust, window sill-dust, window well-dust, and soil samples on the ability to identify a lead hazard.

Table 6-26 presents a summary of the Type I (false positive) error probabilities as the number of samples increases, under the Interim Guidance standards using variance components as estimated from the Rochester study data.

Table 6-26 illustrates that the level of protection in a risk assessment is dependent on the number of samples collected. For instance, when the true average window sill dust-lead loading is assumed to be 250 $\mu g/ft^2$ (i.e., half the standard), the Type I (false positive) error rates for the geometric mean are 0.195, 0.147, and 0.112 when 2, 3, and 4 rooms are sampled respectively. For the arithmetic mean, the rates are 0.304, 0.316, and 0.335 for 2, 3, and 4 rooms sampled; and the rates are 0.470, 0.614, and 0.719 for the maximum value when 2, 3, and 4 rooms are sampled, respectively. These observations are similar for the "compound" lead hazard screen and for the Rhode Island Department of health data. Tables 6-21 through 6-25 and H-1 through H-4 present all the Type I (false positive) and Type II (false negative) error probabilities.

In general, across all media and data sets, as the number of samples increases the Type I (false positive) probability of error for the maximum value increases. The arithmetic mean and geometric mean error probabilities are not as dependent on the number of samples collected and either increase or decrease as the number of samples increase. One notable exception to the geometric mean Type I (false positive) error probabilities occurs for the "compound" lead hazard screen. For both the floors and the window wells in the Rochester and Rhode Island data, the error probabilities increase as the number of samples increase when the true house media lead loading is equal to the media standard. The Type II (false negative) error probabilities all decrease as the number of samples increases for all three statistics.

Table 6-26. Summary of the Type I (False Positive) Error Probabilities when Two, Three, and Four Floor, Window Sill, and Window Well Dust and Soil Samples are Collected for a Risk Assessment Under the Interim Guidance Standards – Variance Components From the Rochester Lead-In-Dust Study Data.

Media/Component (Assumed "True" Media Level)	Number of Samples	Type I (False Positive) Error Probability		
		Geometric Mean	Arithmetic Mean	Maximum Value
Floor Dust (50μg/ft^2)	2	0.144	0.237	0.401
	3	0.096	0.231	0.536
	4	0.066	0.206	0.641
Window Sill Dust (250μg/ft^2)	2	0.195	0.304	0.470
	3	0.147	0.316	0.614
	4	0.112	0.335	0.719
Window Well Dust (400μg/ft^2)	2	0.294	0.475	0.579
	3	0.253	0.537	0.726
	4	0.222	0.578	0.822
Soil (Boundary) (2500μg/g)	2	0.022	0.046	0.150
	3	0.007	0.022	0.217
	4	0.002	0.011	0.278

6.2.4 Effect of the Interim Guidance and Proposed Rule Standards on the Error Probabilities

To assess the impact that the Proposed Rule reduced dust and soil standards have on the Type I (false positive) and Type II (false negative) error probabilities, consider Tables 6-27 and 6-28, which present summaries of the Type I (false positive) and Type II (false negative) error probabilities for 2, 3, and 4 floor dust, window sill dust, and soil samples when the error probabilities are calculated under the Interim Guidance and Proposed Rule standards and the Rochester and CAP variance components are used. (The error probability results and graphs for the Proposed Rule standards, similar to those already presented for the Interim Guidance standards, can be found in Appendix I.)

In general, lowering the standards as in the Proposed Rule may lower the probability of a wrong decision. For discussion of this point, ignore the fact that the Proposed Rule requires the arithmetic mean for floor dust, window sill dust, and soil samples, and compare the Type II (false negative) maximum value error probability shown in Table 6-28, when four samples are

Table 6-27. **Summary of Type I (False Positive) Error Probabilities for Two, Three, and Four Floor Dust, Window Sill Dust, and Soil Samples Under the Interim Guidance and Proposed Rule Standards – Variance Components from the Rochester Lead-In-Dust Study Data and the CAP Study Data.**

Assessment	Number of Rooms	Assumed "True" House Lead Level ($\mu g/ft^2$)	Type I (False Positive) Error					
			Interim Guidance			Proposed Rule		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
Floor Dust	2	25	0.050	0.002	0.150	0.237	0.144	0.401
		50	0.237	0.144	0.401	0.598	0.500	0.750
	3	25	0.002	0.001	0.200	0.231	0.096	0.536
		50	0.231	0.096	0.536	0.660	0.500	0.875
	4	25	0.001	0.000	0.275	0.206	0.066	0.641
		50	0.206	0.066	0.641	0.730	0.500	0.938
Window Sill Dust	2	100	0.057	0.023	0.152	0.249	0.128	0.378
		250	0.304	0.195	0.470	0.610	0.500	0.750
	3	100	0.052	0.007	0.220	0.239	0.082	0.509
		250	0.316	0.147	0.614	0.681	0.500	0.875
	4	100	0.033	0.002	0.282	0.202	0.054	0.613
		250	0.335	0.112	0.719	0.763	0.500	0.938
Soil (Foundation)	2	1,000	0.004	0.002	0.038	0.173	0.103	0.337
		2,000	0.093	0.047	0.224	0.587	0.500	0.750
	3	1,000	0.002	0.000	0.056	0.155	0.061	0.460
		2,000	0.082	0.020	0.316	0.645	0.500	0.875
	4	1,000	0.000	0.000	0.074	0.132	0.037	0.561
		2,000	0.050	0.009	0.397	0.709	0.500	0.938

Table 6-28. Summary of Type II (False Negative) Error Probabilities for Two, Three, and Four Floor Dust, Window Sill Dust, and Soil Samples Under the Interim Guidance and Proposed Rule Standards – Variance Components from the Rochester Lead-In-Dust Study Data and the CAP Study Data.

Assessment	Number of Rooms	Assumed "True" House Lead Level (µg/ft²)	Type II (False Negative) Error					
			Interim Guidance			Proposed Rule		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
Floor Dust	2	150	0.216	0.267	0.109	0.026	0.046	0.014
	3		0.148	0.223	0.036	0.010	0.019	0.002
	4		0.073	0.189	0.012	0.002	0.009	<0.001
Window Sill Dust	2	750	0.242	0.308	0.131	0.053	0.087	0.028
	3		0.163	0.269	0.047	0.024	0.048	0.005
	4		0.091	0.239	0.017	0.006	0.027	0.001
Soil	2	6,000	0.278	0.370	0.166	0.016	0.023	0.006
	3		0.234	0.342	0.067	0.004	0.007	<0.001
	4		0.160	0.319	0.027	0.001	0.002	<0.001

collected for floor dust during a risk assessment and the assumed "true" house floor dust lead loading is 150 µg/ft². This comparison shows that, under the Interim Guidance, the maximum value error is 0.012, while the Proposed Rule error probability is <0.001. This illustrates a reduction in the chances of incorrectly concluding that a home has no lead-based paint hazards when it in fact does. Now consider the same risk assessment, but assume the true house floor dust lead loading is 25 µg/ft². From Table 6-27, the Interim Guidance probability of incorrectly finding lead-based paint hazards in a home is 0.275, while the Proposed Rule Type I (false positive) error probability is 0.641. This illustrates a large increase in the chances of incorrectly concluding that a home has lead-based paint hazards when the home does not. Therefore, the Proposed Rule standards, when using a maximum value, have decreased the chances of incorrectly concluding that no lead-based paint hazards exist, but have increased the chances of incorrectly concluding that lead-based paint hazards *do* exist.

The Proposed Rule requires the arithmetic mean of the floor dust, window sill dust, and soil samples be compared to the Proposed Rule standards. To understand the implications of the change in the estimator as well as the decrease in the media standards, consider the same scenarios described above. When four floor dust samples are collected for a risk assessment and the house floor dust-lead loading is assumed to be 150 $\mu g/ft^2$, the Interim Guidance Type II (false negative) error is still 0.012, but the Proposed Rule Type II (false negative) error probability using the arithmetic mean is 0.002. When a true house floor dust-lead loading is assumed to be 25 $\mu g/ft^2$, the Type I (false positive) error probability is 0.275 for the Interim Guidance and 0.206 for the Proposed Rule when the arithmetic mean is used. This comparison illustrates that the Proposed Rule showed slight decreases in the chances of incorrectly finding no lead-based paint hazards in a home when it should have and moderate decreases in the chances of incorrectly finding lead-based paint hazards in a home when it should not have. The combination of lowering the standards and using the arithmetic mean as the characterization of floor dust lead, window sill dust lead, and soil lead in the home, as described in the Proposed Rule, seems to have improved the discrimination of the risk assessment.

6.3 OBJECTIVE 3: SAMPLING LOCATIONS RISK ASSESSORS MAY WANT TO TARGET TO EVALUATE POTENTIAL LEAD HAZARDS

Section 402 does not require risk assessors to collect dust samples from specific rooms. The purpose of this analysis is to assess whether certain rooms may need to be sampled to best assess the dust lead hazard in the home. Two types of analyses were conducted using the Rochester data: a correlation analysis and a pathways model analysis. The results from each are discussed below. The specifics of the analysis calculations were presented in Section 5.3.

6.3.1 Correlation Analysis Results

Pearson correlation coefficients were calculated between log-transformed blood-lead concentrations and log-transformed dust-lead loadings for the dust-wipe samples presented in Table 5-4. These correlations are found in Table J-1 of Appendix J. This table shows that, at the 0.05 level, the log-transformed blood-lead concentrations were significantly positively correlated with the log-transformed dust-lead loadings for all rooms and components except for living room floors and living room window sills. The significant correlations ranged from 0.20 for play area window wells to 0.33 for bedroom window sills. The reason for the lack of significant correlations between blood-lead concentrations and living room dust-lead loadings may be due to small sample size rather than lack of a linear relationship. Only 41 homes had floor dust wipe samples taken in the living room, and only 31 homes had window sill dust samples taken in the living room. Due to the small sample size, dust-wipe data from living rooms were not included in the pathways analysis.

The most statistically significant correlations among the log-transformed dust-lead loadings from different rooms and components occurred between the kitchen and play area window wells (r = 0.65), the interior entryway and kitchen floors (r = 0.52), and the play area and bedroom floors (r = 0.51). The correlations provided an indication of relationships that may be present and that were more closely examined in the pathways model analysis.

6.3.2 Pathways Model Results

Figure 6-11 illustrates those pathways found to be statistically significant at the 0.05 level in this analysis, and Table J-2 in Appendix J provides the parameter estimates from the structural equation modeling analysis. Note that the natural log-transformed data were used to generate the parameter estimates in Table J-2, making interpretation of the parameter estimates difficult. The purpose of this analysis was not merely to obtain estimates of model parameters, but to indicate those rooms or components that may be most highly recommended for dust-wipe sampling during risk assessment activities.

The results shown in Figure 6-11 indicate that the play area floor dust was a direct pathway to blood. No other statistically significant pathways of lead exposure to the blood were observed in this analysis. The window well was directly related to the window sill dust in the play area, but neither were found to be pathways of lead to the floor dust in this room. The interior entryway dust and the bedroom window sill dust were direct pathways of lead exposure for the bedroom floor, while the bedroom window wells were an indirect pathway through the bedroom window sill.

These results indicate that a risk assessor may want to consider taking dust-wipe samples in the child's play area to obtain the best information on potential lead hazards available to the child. In, addition, in both the bedroom and the play area, the window wells were direct pathways of lead to the window sills. This indicates that sampling one or the other may provide the same information as sampling both.

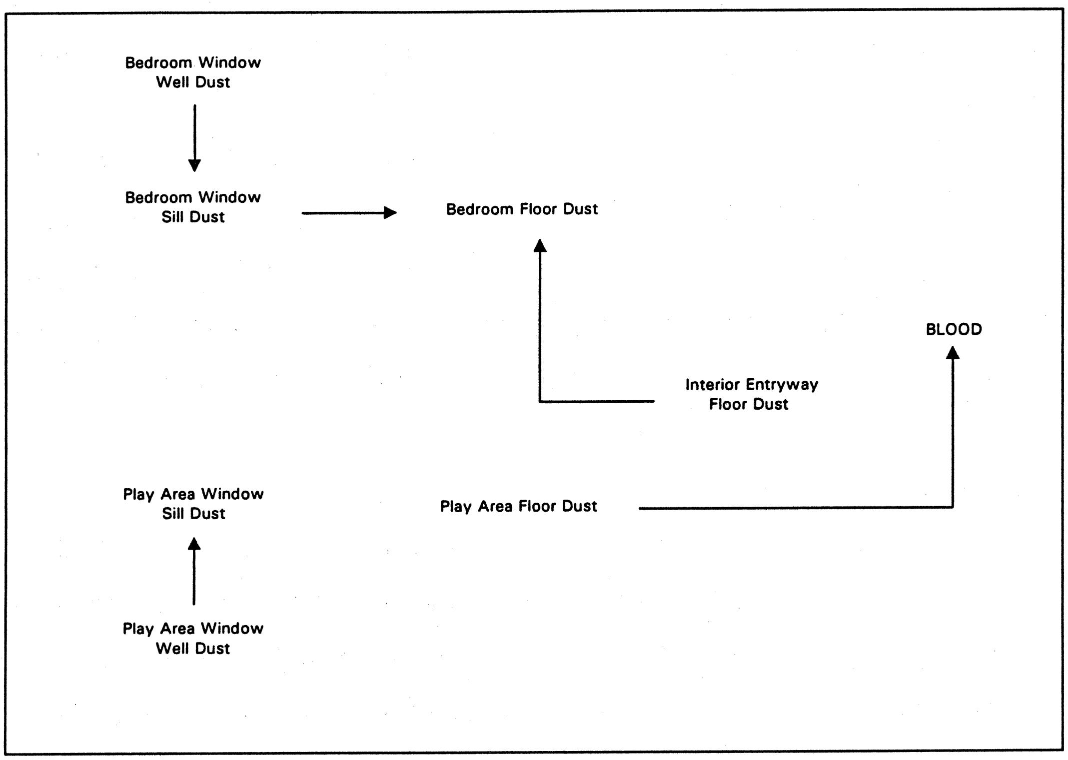


Figure 6-11. Statistically Significant Pathways of Lead Exposure Using the Rochester Study Data.

7.0 DISCUSSION

This section discusses how the performance characteristic and error probability results seen in Section 6 compare, how the pathways results in this report compare to results in the literature, and the impact of changing from Interim Guidance standards to the Proposed Rule standards.

7.1 PERFORMANCE CHARACTERISTICS AND ERROR PROBABILITIES

For Objectives 1 and 2, two types of analysis methods were used to examine how the different standards, sampling schemes, and statistics used to characterize the lead levels in a home affect the probability of correctly identifying a lead-based paint health hazard. The Objective 1 analysis used performance characteristics, while the Objective 2 analysis used error probabilities. Table 7-1 lists the probabilities calculated for the performance characteristic and the error probability analysis.

Table 7-1. Probabilities Calculated for the Performance Characteristic and Error Probability Analysis.

Performance Characteristics		Error Probability	
Sensitivity:	$P(Y \geq S \mid B \geq 10\ \mu g/dL)$	Type I (False Positive) Error:	$P(Y \geq S \mid \mu < S)$
Specificity:	$P(Y < S \mid B < 10\ \mu g/dL)$	Type II (False Negative) Error:	$P(Y < S \mid \mu \geq S)$
PPV:	$P(B \geq 10\ \mu g/dL \mid Y \geq S)$		
NPV:	$P(B < 10\ \mu g/dL \mid Y < S)$		

Note: Y = Calculated lead level in the home for component/media/statistic
S = Standard for the component/media
B = Child's blood lead concentration
μ = Assumed "true" average lead level in the home for component/media

The performance characteristics measure the probability of identifying a health hazard available to a child through the lead found in the home, while the error probabilities assess the probability of correctly identifying lead hazards in the home.

7.2 PATHWAYS ANALYSIS

The approach of the Objective 3 analysis, a pathways analyses using structural equation models, has been performed over the last several years to evaluate and understand the sources and routes by which children are exposed to lead. One example of such an analysis is in the EPA draft report titled, "Analysis of Pathways of Residential Lead Exposure in Children." [25] This report by design assesses whether lead found in a child's home environment directly or indirectly impacts the child's blood lead concentration. Sources of lead that were assessed included floor dust, interior entryway dust, exterior entryway dust, window sill dust, window well dust, water, air ducts, and soil. The objectives of these types of analyses are quite different from those for the pathways analysis conducted in this report.

The purpose of the pathways analysis in this report was to assess which interior dust sampling locations a risk assessor may want to target to ensure the best evaluation of the potential lead hazard to a child. In this analysis, floor dust and window sill and window well dust wipe samples from various locations in the home including the kitchen, interior entryway, play area, and bedroom were assessed, while no other sources of lead were considered. Generally, dust sample results from the various rooms are averaged into one dust measurement for the home, according to type of component. The analysis for this report focused on how to incorporate sampling location into this measurement.

The results of the pathways analysis using the Rochester study data indicated that the play area floor dust-lead is the only direct contributor to the child's blood-lead concentration. The bedroom window well dust-lead was a direct contributor to the bedroom window sill dust-lead, which in turn contributed to the bedroom floor dust-lead. Similarly, the play area window well dust-lead contributed to the play area window sill dust-lead. An additional contributor to the bedroom floor dust-lead was the interior entryway floor dust-lead. These results may recommend that a risk assessor sample dust from the floor in a child's play area to gain an understanding of the potential hazard to a child. This is consistent with the intent of the Interim Guidance, the HUD Guidelines, and the Proposed Rule. In addition, since window well dust-lead consistently contributes to the window sill dust-lead, a risk assessor may not need to sample from both places. The Proposed Rule seems to have addressed this issue, recommending that sampling occur at the window sill and not requiring the window well to be sampled in a risk assessment.

7.3. PROPOSED RULE COMPARED TO THE INTERIM GUIDANCE

Overall, it appears that the Proposed Rule provides a better approach for performing risk assessments than the Interim Guidelines. The combination of the lower media hazard standards, the removal of requirements for sampling from the window well, and the change to an arithmetic mean estimator for characterizing the floor dust-lead, window sill dust-lead, and soil-lead seem to provide a more accurate reflection of the hazards available in homes.

8.0 REFERENCES

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APPENDIX A

Section 402 Guidance for Risk Analysis Procedures

APPENDIX A

Section 402 Guidance for Risk Analysis Procedures

The following are excerpts from the U.S. EPA Federal Register titled "Lead: Requirements for Lead-Based Paint Activities in Target Housing and Child-Occupied Facilities, Final Rule" and dated August 29, 1996. The information below are direct quotations from the document that are applicable to the work presented in this document.

Section 745.227 Work practice standards for conducting lead-based paint activities: target housing and child-occupied facilities.

(a) Effective date, applicability, and terms.

(1) Beginning on March 1, 1999, all lead-based paint activities shall be performed pursuant to the work practice standards contained in this section.

(2) When performing any lead-based paint activity described by the certified individual as an inspection, lead-hazard screen, risk assessment or abatement, a certified individual must perform that activity in compliance with the appropriate requirements below.

(3) Documented methodologies that are appropriate for this section are found in the following: The U.S. Department of Housing and Urban Development (HUD) Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing; the EPA Guidance on Residential Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil; the EPA Residential Sampling for Lead: Protocols for Dust and Soil Sampling (EPA report number 7474-R-95-001); Regulations, guidance, methods or protocols issued by States and Indian Tribes that have been authorized by EPA; and other equivalent methods and guidelines.

(4) Clearance levels are appropriate for the purposes of this section may be found in the EPA Guidance on Residential Lead-Based Paint, Lead-Contaminated Dust, and Lead Contaminated Soil or other equivalent guidelines.

(b) Inspection.

(1) An inspection shall be conducted only by a person certified by EPA as an inspector or risk assessor and, if conducted, must be conducted according to the procedures in this paragraph.

(2) When conducting an inspection, the following locations shall be selected according to documented methodologies and tested for the presence of lead-based paint: (i) In a residential dwelling and child-occupied facility, each component with a distinct painting history and each exterior component with a distinct painting history shall be tested for lead-based paint, except those components that the inspector or risk assessor determines to have been replaced after 1978, or to not contain lead-based paint; and (ii) In a multi-family dwelling or child-occupied facility, each component with a distinct painting history in every common area, except those components that the inspector or risk assessor determines to have been replaced after 1978, or to not contain lead-based paint.

(3) Paint shall be sampled in the following manner: (i) The analysis of paint to determine the presence of lead shall be conducted using documented methodologies which incorporate adequate quality control procedures; and/or (ii) All collected paint chip samples shall be analyzed according to paragraph (f) of this section to determine if they contain detectable levels of lead that can be quantified numerically.

(4) The certified inspector or risk assessor shall prepare an inspection report which shall include the following information: (i) Date of each inspection. (ii) Address of building. (iii) Date of construction. (iv) Apartment numbers (if applicable). (v) Name, address, and telephone number of the owner or owners of each residential dwelling or child-occupied facility. (vi) Name, signature, and certification number of each certified inspector and/or risk assessor conducting testing. (vii) Name, address, and telephone number of the certified firm employing each inspector and/or risk assessor, if applicable. (viii) Each testing method and device and/or sampling procedure employed for paint analysis, including quality control data and, if used, the serial number of any x-ray fluorescence (XRF) device. (ix) Specific locations of each painted component tested for the presence of lead-based paint. (x) The results of the inspection expressed in terms appropriate to the sampling method used.

(c) Lead hazard screen.

(1) A lead hazard screen shall be conducted only by a person certified by EPA as a risk assessor.

(2) If conducted, a lead hazard screen shall be conducted as follows: (i) Background information regarding the physical characteristics of the residential dwelling or child-occupied

facility and occupant use patterns that may cause lead-based paint exposure to one or more children age 6 years and under shall be collected. (ii) A visual inspection of the residential dwelling or child-occupied facility shall be conducted to: (A) Determine if any deteriorated paint is present, and (B) Locate at least two dust sampling locations. (iii) If deteriorated paint is present, each surface with deteriorated paint, which is determined, using documented methodologies, to be in poor condition and to have a distinct painting history, shall be tested for the presence of lead. (iv) In residential dwellings, two composite dust samples shall be collected, one from the floors and the other from the windows, in rooms, hallways or stairwells where one or more children, age 6 and under, are most likely to come in contact with dust. (v) In multi-family dwellings and child-occupied facilities, in addition to the floor and window samples required in paragraph (c)(1)(iii) of this section, the risk assessor shall also collect composite dust samples from common areas where one or more children, age 6 and under, are most likely to come into contact with dust.

(3) Dust samples shall be collected and analyzed in the following manner: (i) All dust samples shall be taken using documented methodologies that incorporate adequate quality control procedures. (ii) All collected dust samples shall be analyzed according to paragraph (f) of this section to determine if they contain detectable levels of lead that can be quantified numerically.

(4) Paint shall be sampled in the following manner: (i) The analysis of paint to determine the presence of lead shall be conducted using documented methodologies which incorporate adequate quality control procedures; and/or (ii) All collected paint chip samples shall be analyzed according to paragraph (f) of this section to determine if they contain detectable levels of lead that can be quantified numerically.

(5) The risk assessor shall prepare a lead hazard screen report, which shall include the following information: (i) The information required in a risk assessment report as specified in paragraph (d) of this section, including paragraphs (d)(11)(i) through (d)(11)(xiv), and excluding paragraphs (d)(11)(xv) through (d)(11)(xviii) of this section. Additionally, any background information collected pursuant to paragraph (c)(2)(i) of this section shall be included in the risk assessment report; and (ii) Recommendations, if warranted, for a follow-up risk assessment, and as appropriate, any further actions.

(d) Risk assessment.

(1) A risk assessment shall be conducted only by a person certified by EPA as a risk assessor and, if conducted, must be conducted according to the procedures in this paragraph.

(2) A visual inspection for risk assessment of the residential dwelling or child-occupied facility shall be undertaken to locate the existence of deteriorated paint, assess the extent and causes of the deterioration, and other potential lead-based paint hazards.

(3) Background information regarding the physical characteristics of the residential dwelling or child-occupied facility and occupant use patterns that may cause lead-based paint exposure to one or more children age 6 years and under shall be collected.

(4) Each surface with deteriorated paint, which is determined, using documented methodologies, to be in poor condition and to have a distinct painting history, shall be tested for the presence of lead. Each other surface determined, using documented methodologies, to be a potential lead-based paint hazard and having a distinct painting history, shall also be tested for the presence of lead.

(5) In residential dwellings, dust samples (either composite or single-surface samples) from the window and floor shall be collected in all living areas where one or more children, age 6 and under, are most likely to come into contact with dust.

(6) For multi-family dwellings and child-occupied facilities, the samples required in paragraph (d)(4) of this section shall be taken. In addition, window and floor dust samples (either composite or single- surface samples) shall be collected in the following locations: (i) Common areas adjacent to the sampled residential dwelling or child-occupied facility; and (ii) Other common areas in the building where the risk assessor determines that one or more children, age 6 and under, are likely to come into contact with dust.

(7) For child-occupied facilities, window and floor dust samples (either composite or single-surface samples) shall be collected in each room, hallway or stairwell utilized by one or more children, age 6 and under, and in other common areas in the child-occupied facility where the risk assessor determines one or more children, age 6 and under, are likely to come into contact with dust.

(8) Soil samples shall be collected and analyzed for lead concentrations in the following locations: (i) Exterior play areas where bare soil is present; and (ii) Dripline/foundation areas where bare soil is present.

(9) Any paint, dust, or soil sampling or testing shall be conducted using documented methodologies that incorporate adequate quality control procedures.

(10) Any collected paint chip, dust, or soil samples shall be analyzed according to paragraph (f) of this section to determine if they contain detectable levels of lead that can be quantified numerically.

(11) The certified risk assessor shall prepare a risk assessment report which shall include the following information:

(i) Date of assessment.

(ii) Address of each building.

(iii) Date of construction of buildings.

(iv) Apartment number (if applicable).

(v) Name, address, and telephone number of each owner of each building.

(vi) Name, signature, and certification of the certified risk assessor conducting the assessment.

(vii) Name, address, and telephone number of the certified firm employing each certified risk assessor if applicable.

(viii) Name, address, and telephone number of each recognized laboratory conducting analysis of collected samples.

(ix) Results of the visual inspection.

(x) Testing method and sampling procedure for paint analysis employed.

(xi) Specific locations of each painted component tested for the presence of lead.

(xii) All data collected from on-site testing, including quality control data and, if used, the serial number of any XRF device.

(xiii) All results of laboratory analysis on collected paint, soil, and dust samples.

(xiv) Any other sampling results.

(xv) Any background information collected pursuant to paragraph (d)(3) of this section.

(xvi) To the extent that they are used as part of the lead-based paint hazard determination, the results of any previous inspections or analyses for the presence of lead-based paint, or other assessments of lead-based paint-related hazards.

(xvii) A description of the location, type, and severity of identified lead-based paint hazards and any other potential lead hazards.

(xviii) A description of interim controls and/or abatement options for each identified lead-based paint hazard and a suggested prioritization for addressing each hazard. If the use of an encapsulant or enclosure is recommended, the report shall recommend a maintenance and monitoring schedule for the encapsulant or enclosure.

Section 745.223 Definitions.

The definitions in subpart A apply to this subpart. In addition, the following definitions apply.

Abatement means any measure or set of measures designed to permanently eliminate lead-based paint hazards. Abatement includes, but is not limited to:

(1) The removal of lead-based paint and lead-contaminated dust, the permanent enclosure or encapsulation of lead-based paint, the replacement of lead-painted surfaces or fixtures, and the removal or covering of lead-contaminated soil; and

(2) All preparation, cleanup, disposal, and post-abatement clearance testing activities associated with such measures.

(3) Specifically, abatement includes, but is not limited to: (i) Projects for which there is a written contract or other documentation, which provides that an individual or firm will be conducting activities in or to a residential dwelling or child-occupied facility that: (A) Shall result in the permanent elimination of lead-based paint hazards; or (B) Are designed to permanently eliminate lead-based paint hazards and are described in paragraphs (1) and (2) of this definition. (ii) Projects resulting in the permanent elimination of lead-based paint hazards, conducted by firms or individuals certified in accordance with Section 745.226, unless such projects are covered by paragraph (4) of this definition; (iii) Projects resulting in the permanent elimination of lead-based paint hazards, conducted by firms or individuals who, through their company name or promotional literature, represent, advertise, or hold themselves out to be in the business of performing lead-based paint activities as identified and defined by this section, unless such projects are covered by paragraph (4) of this definition; or (iv) Projects resulting in the

permanent elimination of lead-based paint hazards, that are conducted in response to State or local abatement orders.

(4) Abatement does not include renovation, remodeling, landscaping or other activities, when such activities are not designed to permanently eliminate lead-based paint hazards, but, instead, are designed to repair, restore, or remodel a given structure or dwelling, even though these activities may incidentally result in a reduction or elimination of lead-based paint hazards. Furthermore, abatement does not include interim controls, operations and maintenance activities, or other measures and activities designed to temporarily, but not permanently, reduce lead-based paint hazards.

Accredited training program means a training program that has been accredited by EPA pursuant to Section 745.225 to provide training for individuals engaged in lead-based paint activities.

Adequate quality control means a plan or design which ensures the authenticity, integrity, and accuracy of samples, including dust, soil, and paint chip or paint film samples. Adequate quality control also includes provisions for representative sampling.

Certified firm means a company, partnership, corporation, sole proprietorship, association, or other business entity that performs lead-based paint activities to which EPA has issued a certificate of approval pursuant to Section 745.226(f).

Certified inspector means an individual who has been trained by an accredited training program, as defined by this section, and certified by EPA pursuant to Section 745.226 to conduct inspections. A certified inspector also samples for the presence of lead in dust and soil for the purposes of abatement clearance testing.

Certified abatement worker means an individual who has been trained by an accredited training program, as defined by this section, and certified by EPA pursuant to Section 745.226 to perform abatements.

Certified project designer means an individual who has been trained by an accredited training program, as defined by this section, and certified by EPA pursuant to Section 745.226 to prepare abatement project designs, occupant protection plans, and abatement reports.

Certified risk assessor means an individual who has been trained by an accredited training program, as defined by this section, and certified by EPA pursuant to Section 745.226 to conduct risk assessments. A risk assessor also samples for the presence of lead in dust and soil for the purposes of abatement clearance testing.

Certified supervisor means an individual who has been trained by an accredited training program, as defined by this section, and certified by EPA pursuant to Section 745.226 to supervise and conduct abatements, and to prepare occupant protection plans and abatement reports.

Child-occupied facility means a building, or portion of a building, constructed prior to 1978, visited regularly by the same child, 6 years of age or under, on at least two different days within any week (Sunday through Saturday period), provided that each day's visit lasts at least 3 hours and the combined weekly visit lasts at least 6 hours, and the combined annual visits last at least 60 hours. Child-occupied facilities may include, but are not limited to, day-care centers, preschools and kindergarten classrooms.

Clearance levels are values that indicate the maximum amount of lead permitted in dust on a surface following completion of an abatement activity.

Common area means a portion of a building that is generally accessible to all occupants. Such an area may include, but is not limited to, hallways, stairways, laundry and recreational rooms, playgrounds, community centers, garages, and boundary fences.

Component or building component means specific design or structural elements or fixtures of a building, residential dwelling, or child-occupied facility that are distinguished from each other by form, function, and location. These include, but are not limited to, interior components such as: ceilings, crown molding, walls, chair rails, doors, door trim, floors, fireplaces, radiators and other heating units, shelves, shelf supports, stair treads, stair risers, stair stringers, newel posts, railing caps, balustrades, windows and trim (including sashes, window heads, jambs, sills or stools and troughs), built in cabinets, columns, beams, bathroom vanities, counter tops, and air conditioners; and exterior components such as: painted roofing, chimneys, flashing, gutters and downspouts, ceilings, soffits, fascias, rake boards, cornerboards, bulkheads, doors and door trim, fences, floors, joists, lattice work, railings and railing caps, siding, handrails, stair risers and treads, stair stringers, columns, balustrades, window sills or stools and troughs, casings, sashes and wells, and air conditioners.

Containment means a process to protect workers and the environment by controlling exposures to the lead-contaminated dust and debris created during an abatement.

Course agenda means an outline of the key topics to be covered during a training course, including the time allotted to teach each topic.

Course test means an evaluation of the overall effectiveness of the training which shall test the trainees' knowledge and retention of the topics covered during the course.

Course test blue print means written documentation identifying the proportion of course test questions devoted to each major topic in the course curriculum.

Deteriorated paint means paint that is cracking, flaking, chipping, peeling, or otherwise separating from the substrate of a building component.

Discipline means one of the specific types or categories of lead-based paint activities identified in this subpart for which individuals may receive training from accredited programs and become certified by EPA. For example, "abatement worker" is a discipline. Distinct painting history means the application history, as indicated by its visual appearance or a record of application, over time, of paint or other surface coatings to a component or room. Documented methodologies are methods or protocols used to sample for the presence of lead in paint, dust, and soil.

Elevated blood lead level (EBL) means an excessive absorption of lead that is a confirmed concentration of lead in whole blood of 20µg/dl (micrograms of lead per deciliter of whole blood) for a single venous test or of 15-19µg/dl in two consecutive tests taken 3 to 4 months apart.

Encapsulant means a substance that forms a barrier between lead-based paint and the environment using a liquid-applied coating (with or without reinforcement materials) or an adhesively bonded covering material.

Encapsulation means the application of an encapsulant.

Enclosure means the use of rigid, durable construction materials that are mechanically fastened to the substrate in order to act as a barrier between lead-based paint and the environment.

Guest instructor means an individual designated by the training program manager or principal instructor to provide instruction specific to the lecture, hands-on activities, or work practice components of a course.

Hands-on skills assessment means an evaluation which tests the trainees' ability to satisfactorily perform the work practices and procedures identified in Section 745.225(d), as well as any other skill taught in a training course.

Hazardous waste means any waste as defined in 40 CFR 261.3.

Inspection means a surface-by-surface investigation to determine the presence of lead-based paint and the provision of a report explaining the results of the investigation.

Interim certification means the status of an individual who has successfully completed the appropriate training course in a discipline from an accredited training program, as defined by this section, but has not yet received formal certification in that discipline from EPA pursuant to Section 745.226. Interim certifications expire 6 months after the completion of the training course, and is equivalent to a certificate for the 6-month period.

Interim controls means a set of measures designed to temporarily reduce human exposure or likely exposure to lead-based paint hazards, including specialized cleaning, repairs, maintenance, painting, temporary containment, ongoing monitoring of lead-based paint hazards or potential hazards, and the establishment and operation of management and resident education programs.

Lead-based paint means paint or other surface coatings that contain lead equal to or in excess of 1.0 milligrams per square centimeter or more than 0.5 percent by weight.

Lead-based paint activities means, in the case of target housing and child-occupied facilities, inspection, risk assessment, and abatement, as defined in this subpart.

Lead-based paint hazard means any condition that causes exposure to lead from lead-contaminated dust, lead-contaminated soil, or lead-contaminated paint that is deteriorated or present in accessible surfaces, friction surfaces, or impact surfaces that would result in adverse human health effects as identified by the Administrator pursuant to TSCA section 403.

Lead-contaminated dust means surface dust in residential dwellings, or child-occupied facilities that contains an area or mass concentration of lead at or in excess of levels identified by the Administrator pursuant to TSCA section 403.

Lead-contaminated soil means bare soil on residential real property and on the property of a child-occupied facility that contains lead at or in excess of levels identified by the Administrator pursuant to TSCA section 403.

Lead-hazard screen is a limited risk assessment activity that involves limited paint and dust sampling as described in Section 745.227(c).

Living area means any area of a residential dwelling used by one or more children age 6 and under, including, but not limited to, living rooms, kitchen areas, dens, play rooms, and children's bedrooms.

Multi-family dwelling means a structure that contains more than one separate residential dwelling unit, which is used or occupied, or intended to be used or occupied, in whole or in part, as the home or residence of one or more persons.

Paint in poor condition means more than 10 square feet of deteriorated paint on exterior components with large surface areas; or more than 2 square feet of deteriorated paint on interior components with large surface areas (e.g., walls, ceilings, floors, doors); or more than 10 percent of the total surface area of the component is deteriorated on interior or exterior components with small surface areas (window sills, baseboards, soffits, trim).

Permanently covered soil means soil which has been separated from human contact by the placement of a barrier consisting of solid, relatively impermeable materials, such as pavement or concrete. Grass, mulch, and other landscaping materials are not considered permanent covering.

Person means any natural or judicial person including any individual, corporation, partnership, or association; any Indian Tribe, State, or political subdivision thereof; any interstate body; and any department, agency, or instrumentality of the Federal government.

Principal instructor means the individual who has the primary responsibility for organizing and teaching a particular course.

Recognized laboratory means an environmental laboratory recognized by EPA pursuant to TSCA section 405(b) as being capable of performing an analysis for lead compounds in paint, soil, and dust.

Reduction means measures designed to reduce or eliminate human exposure to lead-based paint hazards through methods including interim controls and abatement.

Residential dwelling means (1) a detached single family dwelling unit, including attached structures such as porches and stoops; or (2) a single family dwelling unit in a structure that contains more than one separate residential dwelling unit, which is used or occupied, or intended to be used or occupied, in whole or in part, as the home or residence of one or more persons.

Risk assessment means (1) an on-site investigation to determine the existence, nature, severity, and location of lead-based paint hazards, and (2) the provision of a report by the individual or the firm conducting the risk assessment, explaining the results of the investigation and options for reducing lead-based paint hazards.

Target housing means any housing constructed prior to 1978, except housing for the elderly or persons with disabilities (unless any one or more children age 6 years or under resides or is expected to reside in such housing for the elderly or persons with disabilities) or any 0-bedroom dwelling.

Training curriculum means an established set of course topics for instruction in an accredited training program for a particular discipline designed to provide specialized knowledge and skills.

Training hour means at least 50 minutes of actual learning, including, but not limited to, time devoted to lecture, learning activities, small group activities, demonstrations, evaluations, and/or hands-on experience.

Training manager means the individual responsible for administering a training program and monitoring the performance of principal instructors and guest instructors.

Visual inspection for clearance testing means the visual examination of a residential dwelling or a child-occupied facility following an abatement to determine whether or not the abatement has been successfully completed.

Visual inspection for risk assessment means the visual examination of a residential dwelling or a child-occupied facility to determine the existence of deteriorated lead-based paint or other potential sources of lead-based paint hazards.

IV. Relationship of Sections 402 and 404 to Section 403 of TSCA

Under section 403 of TSCA, EPA is developing a rule that will identify conditions of lead-based paint, and lead levels and conditions in residential dust and soil that would result in a hazard to building occupants, especially children age 6 and under. In combination with the work practice standards contained in Section 745.227 of today's final rule, the Agency expects that the levels and conditions identified in the TSCA section 403 rule will provide clear direction on how to identify, prioritize and respond to hazards from lead in and around target housing.

VII. Framework for Work Practice Standards for Conducting Lead-Based Paint Activities in Target Housing and Child-Occupied Facilities

A. Introduction

Section 745.227 establishes standards for conducting three lead-based paint activities: inspection, risk assessment and abatement. In addition, Section 745.227 provides requirements for conducting three related tasks that may be performed as either single tasks or as a part of an inspection, risk assessment or abatement. These three tasks are: a lead hazard screen, laboratory analysis, and composite dust sampling. Section 745.227 also establishes certain recordkeeping requirements. This section of the rule also establishes the dates by which compliance with these standards and procedures is required. The standards and procedures for conducting the lead-based paint activities contained in Section 745.227 are being issued under authority of TSCA section 402(a), which directs EPA to issue such standards, taking into account reliability, effectiveness and safety.

B. Scope and Applicability

Under today's final rule, the standards for lead-based paint activities contained in Section 745.227 apply only in target housing and child-occupied facilities. Standards for lead-based paint activities conducted in steel structures and public and commercial buildings, which had been proposed on September 2, 1994, will be addressed after further Agency review. A discussion of the Agency's decision to address steel structures and public and commercial buildings outside this rulemaking is presented in Unit II.A. of this preamble. Another important feature of the standards contained in Section 745.227 is that they do not mandate circumstances under which any particular lead-based paint activity must be performed. Instead the decision to, for example conduct an inspection, is left to the building owner. Additionally, the Agency is preparing a rule under TSCA section 403 that will identify conditions of lead-based paint and lead levels and conditions in residential soil and dust that would result in a hazard to building occupants. Although the TSCA section 403 rule has not yet been proposed, Agency guidance on this subject was issued July 14, 1994, and is discussed in detail in Unit IV. of this preamble. The section 403 Guidance also includes recommendations on actions that can be taken in response to conditions of lead-based paint and lead levels and conditions in residential soil and dust. Until the final section 403 rule is promulgated, the Agency recommends that individuals and firms refer to the section 403 Guidance for assistance in identifying the presence of a lead-based paint hazard and deciding whether to conduct lead-based paint activities. The primary purpose of the standards in today's final rule is to provide certified individuals and firms with a set of minimum requirements to be followed when conducting inspection, risk assessment or abatement activities. These requirements are primarily procedural in nature: for inspection, risk assessment and abatement activities, the standards specify the steps that EPA believes must be taken to conduct those activities safely, effectively and reliably. For abatement activities, the standards also place restrictions on certain techniques used to eliminate lead-based paint.

C. Use of Guidance and Recordkeeping Requirements

Today's final rule does not prescribe detailed work practices that should be followed for each unique situation in which lead-based paint activities may be conducted. For that level of detail, individuals should consult Federal and State guidance that provides specific instruction on how to conduct inspection, risk assessment and abatement activities. These guidance documents include: the U.S. Department of Housing and Urban Development's Guidelines for the Control of Lead-Based Paint Hazards in Housing (HUD Guidelines) (Ref. 6), the section 403 Guidance, EPA's Residential Sampling for Lead: Protocols for Dust and Soil Sampling (Ref. 7), and any additional guidance issued by States or Indian Tribes that have been authorized by EPA under Section 745.324 of this rule. While not regulatory requirements, these documents are recommended by the Agency because they provide reliable and effective information on this subject. Additionally, training courses that have been accredited by EPA or an EPA-authorized State or Tribe will provide detailed instruction on inspection, risk assessment and abatement standards and methodologies. To complement the existing guidance documents, the Agency is currently preparing a technical guidance document as a companion to this rule. The Agency will distribute this guidance document to accredited training providers, the lead-based paint activities contracting community, and State and local governments, prior to the date that compliance with Section 745.225 of this rule is required. In its decision to recommend guidance as an adjunct to the requirements at Section 745.227, the Agency carefully considered several factors, including enforcement issues and comments received from the public on this approach. With regard to enforcement, many of the work practice standards contained in Section 745.227 of today's final rule, such as sampling methodologies and visual inspection techniques, refer to guidance. As a result, the Agency recognizes that there are questions about the extent to which it will be able to take an enforcement action against individuals who choose not to use the various guidance recommended by EPA. Nonetheless, the Agency has many reasons for deciding to reference and develop guidance as a supplement to this rule, rather than to promulgate rigid work practice standards. The September 2, 1994 proposal specifically requested comments on the use of guidance as a supplement to the rule's basic regulatory requirements. In general, the majority of commenters support the use of guidance as a supplement to the regulatory requirements contained in Section 745.227. In some cases, commenters directly expressed their support, whereas in other cases, commenters expressed neither support nor opposition. Overall, the Agency believes that commenters accepted its proposed approach of referring to guidance. The Agency believes there are several reasons to recommend guidance rather than to establish detailed national work practice standards for the purposes of providing instruction on how to conduct specific lead-based paint activities.

First, as discussed in the September 1994 proposed rule, the Agency drew from a large body of existing information and research, and the input from a broad range of individuals and groups, to develop its proposed regulatory standards for lead-based paint activities. Based on that information and input, the standards proposed in September included strict reporting requirements and documentation of the quality control measures and methodologies employed when conducting inspection, risk assessment and abatement activities. These reporting and documentation requirements remain a critical component of the standards established by today's final rule. In combination with the rule's basic work practice standards, training, certification and accreditation requirements, the reporting/documentation activities will help to ensure the effectiveness of the standards and facilitate the use of guidance.

A second reason for relying on non-regulatory guidance instead of rule-based standards is the number of differences that can be found in the structure, design and occupant use patterns of the residential dwellings and child-occupied facilities covered by this rule. For example, under the standards for conducting a risk assessment at Section 745.227(d)(4), a risk assessor is required to collect dust samples in rooms where children aged 6 years and under are most likely to come into contact with dust. The rule does not prescribe precisely which rooms or how many samples to collect, because the risk assessor needs to consider site-specific variables to determine which rooms should be sampled and the number of samples that should be taken from each room. These variables include: the size and number of rooms in the building; interior design elements in a building and differences in designated play areas for a child; the location of windows and doors; the condition of door frames, window troughs and stools; and occupant use patterns.

As a specific example, in a small residential dwelling, a child may not have a separate playroom, but may play in selected areas of one room or more, such as a corner in a living room or dining room, or may have a bedroom that doubles as a playroom. On the other hand, in a large residential dwelling, a child may have a separate playroom and bedroom, and certain areas in a living room or family room for play activity. Furthermore, a child's pattern of use in a residential dwelling can vary considerably, and that pattern may only be possible to determine through an interview with a guardian.

Based on these and other variables that may be encountered when conducting a risk assessment, inspection or abatement, the Agency believes that to try to anticipate and attempt to list all circumstances that may be encountered would make the regulation overly prescriptive and rigid. However, by establishing minimum requirements and basic procedures for conducting inspection, risk assessment and abatement activities, the Agency is setting a safe, reliable and effective baseline of steps for certified individuals and firms to follow to make sound decisions based on site-specific conditions.

A third reason for the Agency's decision to avoid being overly prescriptive is the state of technology within the lead-based paint activities field. Although there has been progress in the development of new technologies to support specific lead-based paint identification techniques and abatement methods, the Agency recognizes that the field is advancing and that the technologies and methods that will help define it are still evolving.

Consequently, the standards contained in today's final rule do not specify that certain technologies or methods be utilized for sampling and analysis. Additionally, the rule does not prescribe any specific methods or technologies for conducting an abatement, although it does restrict certain work practices known to pose risks to building occupants, workers and the environment.

As had been proposed, today's final rule relies on the use of documented methodologies that incorporate adequate quality control measures. These methodologies and measures are available in existing Federal and State guidance documents, and will be taught at accredited training programs.

Although not overly detailed or prescriptive, EPA believes that the work practice standards contained in today's final rule under Section 745.227 provide a baseline, which in combination with the training, certification and accreditation requirements contained in Sections 745.225 and 745.226, will ensure that lead-based paint activities are conducted reliably, safely and effectively.

VIII. Response to Comments on Work Practice Standards for Conducting Lead-Based Paint Activities in Target Housing and Child-Occupied Facilities

B. Inspection

The objective of an inspection is to determine, and then report on, the existence of lead-based paint through a surface-by-surface investigation of a residential dwelling or child-occupied facility. As such, an inspection involves identifying the presence of lead in paint. An inspection does not include taking dust or soil samples. An inspection must be conducted by either a certified inspector or a certified risk assessor, and must include the provision of a report explaining the results of the investigation.

The inspection standards contained in Section 745.227(b) reflect the Agency's decision not to provide detailed regulatory requirements on how to perform specific lead-based paint identification tasks, such as taking a paint chip sample or using an X-ray fluorescence (XRF) device. In the final rule, the Agency also has removed specific requirements to use the HUD Guidelines when collecting paint chip samples or when using an XRF device to test for the presence of lead-based paint.

Instead, the Agency requires that a lead-based paint inspection be conducted using documented methodologies and adequate quality control measures. These documented methodologies are defined as methods or protocols used to sample for the presence of lead in paint, dust, and soil. Documented methodologies that are appropriate for the purposes of this section may be found in: (1) The HUD Guidelines; the EPA Guidance on Residential Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil (60 FR 47248); the EPA's Residential Sampling for Lead: Protocols for Dust and Soil Sampling and other EPA sampling guidance; and (2) Regulations, guidance, methods or protocols issued by States and

Indian Tribes that have been authorized under Section 745.324. Additionally these methodologies will be included in EPA's technical guidance on lead-based paint activities.

Although commenters generally supported this approach, at least three responses suggested that the Agency provide detailed regulations for lead-based paint testing. However, one of these commenters indicated that guidance may be an acceptable approach for establishing testing protocols. These commenters were concerned about the enforcement issues associated with the rule's dependence on documented methodologies, which to date have only been issued by HUD, EPA and various State agencies, primarily as guidance.

However, other commenters did not object to the Agency's use of documented methodologies, provided that records are kept as part of the inspection, and that such methodologies are acknowledged as documented methodologies by EPA through future guidance or regulations. As discussed, the Agency is currently preparing a technical guidance document for conducting lead-based paint activities. Additionally, it is possible that the Agency may amend the regulation with more detailed standards in the future, if there is a need to do so.

One reason commenters suggested that the Agency not require certain inspection techniques is that such requirements often have the effect of discouraging the development of emerging or new technologies. For example, the Agency currently does not recommend that chemical test kits be used for lead-based paint testing (Ref. 8). However, EPA recognizes that at some point in the future, test kit technology is likely to be improved so that the kits can provide reliable test results. At that time, the Agency will be able to recommend chemical test kits for testing for the presence of lead in paint.

Two other key issues raised by commenters were: (1) Potential limitations of the proposed procedures for conducting an inspection, assuming that an inspection involves the investigation for lead-based paint throughout an entire residential dwelling or child-occupied facility, rather than a "partial inspection" of just one or more rooms in a residential dwelling or child-occupied facility; and (2) the standard contained in Section 745.227(b)(2), which requires the testing of all components of a residential dwelling or child-occupied facility with a "distinct painting history," yet allows inspectors not to test those components determined by the inspector or risk assessor as having been replaced after 1978.

1. *Partial inspections*. The Agency recognizes that there may be a demand for lead-based paint identification services that do not involve a surface-by-surface investigation for

the presence of lead-based paint throughout an entire residential dwelling or child-occupied facility. For example, a homeowner may only be interested in determining if lead is present in the paint in a child's bedroom, not necessarily the entire residential dwelling. In this instance, it is unlikely that the homeowner will want to pay for an inspection, as defined under today's regulations. Although not required, the Agency recommends that a certified inspector or risk assessor be used in cases, such as these, where an individual or firm believes it is only necessary to conduct a "partial inspection" of a property.

More specifically, in response to commenters on this issue, the Agency believes that the definition of an inspection, which under Section 745.227(b) requires that testing for lead-based paint take place throughout an entire residential dwelling or child-occupied facility, is appropriate for several reasons.

One reason is that the statutory definition of an inspection in section 401(7) of TSCA calls for a "surface-by-surface investigation to determine the presence of lead-based paint and the provision of a report explaining the results of the investigation." As discussed in the September 2, 1994 proposal, the Agency believes that an inspection is intended to provide a comprehensive inventory of all lead-based paint in a residential dwelling or child-occupied facility. As such, the Agency acknowledges, that the value of a lead-based paint inspection may appeal only to those individuals interested in getting a complete report on painted components in a residential dwelling or child-occupied facility. Although it is difficult to predict, the Agency believes that such a report may be of value to property owners or managers of large multi-family dwellings and child-occupied facilities and home buyers.

Furthermore, the Agency notes that its inspection requirements are consistent with general trends in the housing market, particularly in federally-owned housing or housing receiving federal assistance. That is, inspections are being conducted to ensure that building owners are informed of the presence of lead-based paint throughout a residential dwelling or child-occupied facility, not just one or two rooms.

Lastly, the Agency believes that by establishing requirements only for "whole house" inspections it will help ensure that the information needed to determine whether lead-based paint is present in a residential dwelling or child-occupied facility is accurately presented. Again, the Agency recognizes that an inspection, as defined under today's final rule, may not provide a value to all persons. Nonetheless, the Agency believes that by requiring that an inspection be conducted throughout a residential dwelling or child-occupied facility it will ensure that a person contracting for the inspection will obtain accurate and reliable information regarding the presence of lead-based paint throughout a residential dwelling and child-occupied facility.

2. *Distinct painting history*. On the issue of inspecting and sampling all components sharing a distinct painting history, except those components replaced after 1978, there are several points that commenters raised. First, some commenters suggested that the proposed requirement to take one sample per component in every room and one sample per exterior component with a distinct painting history was overly burdensome in that it required taking an excessive number of samples. The assumption of these commenters was that an inspection requires that each and every painted component throughout a residential dwelling had to be individually tested. The Agency would like to clarify that an inspection does not necessarily require that a large number of paint samples be taken.

To clarify this point, the Agency directs commenters to carefully review the definitions of "component" and "distinct painting history" as contained in Section 745.223 of today's final rule. According to these definitions, in a room with four walls painted at the same time with the same paint, only one paint sample would need to be taken to characterize the lead content of the paint on the walls. This is because, although each wall can be considered a separate "component," the walls share the same distinct painting history. On the other hand, if there were window frames in the room that had been painted with a different paint than the walls (for example a semi-gloss instead of a flat), two samples would need to be taken, one from the walls and one from the windows. As this example demonstrates, the Agency does not believe that an inspection will involve excessive sampling.

In contrast, other commenters disagreed with these requirements for an inspection, suggesting that they would result in insufficient numbers of samples. Based on the definition of "distinct painting history," these commenters interpreted the proposal to mean that if all rooms in a residential dwelling had been painted recently with the same paint and in the same color (for example, a white latex paint), it would be possible for an inspector to take only one paint sample from the home.

In response, the Agency notes that in this case it would be clear to an inspector that trim, doors, and windows are usually painted with a different paint type. Determining the distinct paint history of such components involves not just an examination of the visible top coat, but the unique layers of paint beneath the surface. A visible examination of these paint layers is easily accomplished by making a discrete incision into the painted surface.

C. Risk Assessment Activities

TSCA section 401(16) provides that the objective of a risk assessment is to determine, and then report, the existence, nature, severity, and location of lead-based paint hazards in residential dwellings through an on-site investigation. The definition also identifies specific activities that will be employed when conducting a risk assessment, including: (1) The gathering of information regarding the age and history of the housing and occupancy by children aged 6 years and under, (2) visual inspection, (3) limited wipe sampling or other environmental sampling techniques, (4) other activity as may be appropriate, and (5) the provision of a report explaining the results of the investigation. This definition of risk assessment serves as the basis for the standards and procedures associated with a risk assessment contained in Section 745.227(d).

The risk assessment procedures in today's final rule, as in the proposal, require the risk assessor to make a recommendation of lead hazard control strategies to address all lead-based paint hazards identified as a result of the risk assessment. This activity was not enumerated in the statutory definition, but was added pursuant to TSCA section 401(16), which stated that a risk assessment may include "other activities" as may be appropriate.

The Agency's reason for adding this requirement was to ensure that the individual or firm hiring or contracting for the services of a risk assessor was provided with some reliable guidance on how to respond to the results of a risk assessment.

1. Lead hazard screen.

Pursuant to TSCA section 401(16), a risk assessment may include "other activities" as may be appropriate. Based on this language, today's final rule also includes the "lead hazard screen," as a risk assessment activity. The requirements for the screen are contained in Section 745.227(c). The reason for including a lead hazard screen in the proposal and today's final rule is to, where appropriate, avoid the costs of conducting a comprehensive risk assessment, particularly in well-maintained housing and child-occupied facilities constructed after 1960, or in housing and child-occupied facilities considered unlikely to have significant lead paint, dust or soil hazards.

The Agency received two comments on the addition of a lead hazard screen as a risk assessment activity; one commenter noted that the Agency needed to list more explicitly standards for conducting a lead hazard screen.

The commenters also agreed that the lead hazard screen should focus on determining the absence of a lead-based paint hazard, rather than the presence of such a hazard and the risks it may pose to building occupants. In response, today's final rule includes specific procedures and standards for conducting a lead hazard screen in Section 745.227(c). Furthermore, because the lead hazard screen employs highly sensitive evaluation criteria and limited sampling, the Agency believes that these standards will provide the risk assessor with a basis for determining the absence of lead-based paint hazards.

If any one of the dust samples collected during a lead hazard screen contains a lead level greater than one-half of the applicable clearance level for the tested component, or if any sampled paint is found to be lead-based paint, that is an indication, but not a requirement, that the residential dwelling should undergo a full risk assessment. As discussed subsequently in this preamble, clearance levels for specific components can be found in the HUD Guidelines and in EPA's section 403 Guidance, as well as in several State guidance documents.

Clearance levels are used as the basis for determining whether a lead-based paint abatement has been successfully completed and that a residential dwelling or child-occupied facility may be re-occupied (if building occupants were relocated during an abatement). Currently, under the section 403 Guidance, clearance levels for dust also serve as the levels for determining the presence of lead-contaminated dust, which may pose a lead-based paint hazard. A standard for the lead hazard screen of one-half of the applicable clearance levels is extremely stringent. As such, the Agency believes that a dust sample containing less than that level is a reliable indicator that there are no lead-based paint hazards. The work practice standards and evaluation criteria for a lead hazard screen contained in Section 745.227(c) are modeled after the HUD Guidelines recommendations for conducting a lead hazard screen.

As discussed previously in the preamble, the Agency recommends that the lead hazard screen be used primarily in well-maintained homes constructed after 1960. According to HUD, it is estimated that approximately 37 million privately owned homes and 428,000 public housing units, or roughly 90 percent of the nation's housing stock built prior to 1960, contain lead-based paint. Generally, if maintenance has been deferred on these homes, there is a high probability for the presence of some deteriorated lead-based paint and/or lead-contaminated dust. Consequently, the value and any cost savings that may be achieved by conducting a lead hazard screen in poorly maintained, pre-1960 homes, rather than a full risk assessment, may not be realized. For instance, in a pre-1960 home with several components that have deteriorated paint, in practice, just as many deteriorated paint surfaces will be tested for a lead hazard screen as for a risk assessment. However, when conducting the lead hazard screen, a risk assessor is not required to attempt to determine whether those surfaces pose a lead-based paint hazard.

In fact, homeowners and building owners may decide that a lead hazard screen would merely add time and cost to the evaluation process in properties that would more likely benefit from a risk assessment. These benefits include a comprehensive report, not only on the existence of lead-based paint hazards, but also on the nature, severity, and location of those hazards. Furthermore, the risk assessment also would provide options on how to reduce or eliminate the lead-based paint hazards.

Other standards and activities required as a part of the lead hazard screen in Section 745.227(c) include: (1) The collection of background information regarding the physical characteristics of the residential dwelling or child-occupied facility and occupant use patterns that may cause lead-based paint exposure to one or more children age 6 years and under, (2) a visual inspection, (3) the sampling of components with deteriorated paint with a distinct painting history in poor condition, (4) the collection of a minimum of two composite dust samples (one for floors and one for windows), and (5) the preparation of a report on the results of the screen. Specifically, Section 745.227(c) requires that in a residential dwelling two composite samples be taken--one from the floors and one from the windows in rooms where one or more children, age 6 and under, are most likely to come into contact with dust. Additionally, in multi-family dwellings and child-occupied facilities, composite dust samples are to be taken from any common areas where one or more children age 6 years and under are likely to come into contact with dust.

2. Risk assessment

In addition to the requirements of a lead hazard screen, the standards for a risk assessment contained in Section 745.227(d)(3) also involve the collection and review of background information regarding the physical characteristics of a building, and the occupant use patterns that may pose a lead-based paint hazard to children aged 6 years and under. More than two dust samples and soil samples also may be required under Section 745.227(d)(4), (5), (6) and (7), respectively. Lastly, the risk assessment report must include options for reducing and/or eliminating lead-based paint hazards.

The requirements contained in Section 745.227(d) of today's final rule differ from those proposed in September 1994 in that they reflect the Agency's decision to reduce the detail and specificity of the rule. However, based on the documentation and recordkeeping requirements for a risk assessment, and the rule's training, certification and accreditation requirements, the Agency believes that the standards contained in today's final rule will promote reliable, safe and effective risk assessments.

For example, the proposed rule specified several items of information to be collected as background information during a risk assessment, including the age of the building and any additions being evaluated, copies of any previous inspection reports, and a schematic site plan of the building. In its review of the comments on the proposed rule, the Agency noted that many of these requirements would be met during the preparation of a risk assessment report. For instance, among the items to be presented in a risk assessment report, as contained in Section 745.227(d)(10) are: the date of construction of the building, data collected as a result of any previous inspection or other analyses available to the risk assessor, and the specific locations of any identified lead-based paint hazards or potential hazards.

In eliminating specific instructions regarding the background information to be collected, the Agency believes that the standards for conducting a risk assessment have been simplified without diminishing the reliability, safety, and effectiveness of those standards. This is because today's final rule has eliminated the duplicative reporting requirements included in the September 2, 1994 proposal by requiring that the information only be contained in the risk assessment report.

In addition to these changes, the Agency has slightly modified Section 745.227(d)(10)(xviii), which requires a risk assessor to provide options for eliminating and/or reducing lead-based paint hazards in the risk assessment report. Under the proposed rule, the risk assessor would have been required to provide not only options, but to recommend one option over another and to include a rationale or justification for his or her selected option. The final rule no longer requires the risk assessor to recommend one option over another, provided the recommended options are all presented in the risk assessment report.

These changes were largely based on comments urging the Agency to allow the individual or firm contracting for the risk assessment to select from the options presented in the report. Although the Agency does not necessarily believe that the proposed requirements would have forced a building owner to select the option recommended by a risk assessor, the Agency is willing to provide building owners with more flexibility in reviewing risk assessment reports and selecting among remediation options.

In response to comments on the latitude a risk assessor is given in determining dust sampling locations and the extent of paint deterioration, the Agency believes, as discussed in Unit VI.A. of this preamble, that because the risk assessor will be a trained specialist equipped with the requisite professional judgement needed to evaluate lead-based paint hazards, added specificity is unnecessary in the rule. The Agency also stresses that due to major differences in the structure, design and condition, and occupant use patterns of various buildings, it is best not to identify specific room locations, e.g., kitchen, playroom, bedroom, for the purposes of sampling dust. Instead, the regulations in Section 745.227(d)(4), (d)(5), and (d)(6) require that dust samples be collected in rooms and areas where young children are most likely to come into contact with dust.

Similarly, the final rule clarifies that only deteriorated paint with a distinct paint history found to be in poor condition shall be sampled for the presence of lead. "Paint in poor condition" is defined in today's final rule as more than 10 square feet of deteriorated paint on exterior components with large surface areas; or more than 2 square feet of deteriorated paint on interior components with large surface areas (e.g., walls, ceilings, floors, doors); or interior or exterior components with small surface areas (window sills, baseboards, soffits, trim) on which more than 10 percent of the total surface area of the component is deteriorated. This determination is to be made by the risk assessor based on a documented methodology such as the HUD Guidelines.

As discussed earlier in Unit VII.C. of this preamble, such locations include the playrooms and bedrooms of children, kitchens, and living rooms, as well as common areas associated with a residential dwelling or child-occupied facility.

The Agency also reiterates that detailed instruction on where and how to sample dust is included in the HUD Guidelines, existing EPA guidance and various State regulations and guidance documents, and that these instructions will be taught in accredited training programs and included in future Agency guidance.

Lastly, the Agency has clarified the standards for collecting soil samples contained in Section 745.227(d)(7) such that samples need only to be taken from exterior play areas and dripline/foundation areas where bare soil is present. This requirement is in keeping with the statutory definition of lead-contaminated soil, which basically is the same definition used in today's final rule. As defined in Section 745.223, lead-contaminated soil means bare soil on residential real property and on the property of a child-occupied facility that contains lead at or in excess of levels determined to be hazardous as identified by the EPA Administrator pursuant to TSCA section 403. Guidance on how to collect bare soil samples is provided in EPA's Residential Sampling for Lead: Protocols for Dust and Soil Sampling document and the HUD Guidelines.

D. Composite Sampling

Under today's final rule, composite dust and soil sampling is expressly permitted for the purposes of conducting a lead hazard screen, risk assessment, or clearance following an abatement.

This change from the September 2, 1994 proposal is based on comments the Agency received in support of composite sampling for dust and soil, as well as limited evidence supporting the use of composite dust and soil sampling to determine the presence of lead in dust and soil. The Agency also believes that composite sampling is useful because it provides a means for "averaging" the potential for exposure to lead-based paint hazards in a residential dwelling or child-occupied facility. Furthermore, the Agency is permitting use of the technique due to laboratory cost savings generated by sampling analysis.

However, it is important that the individual who is receiving the results of a composite understand their limitations and can correctly interpret the results of a composite sample. A brief discussion of this subject can be found in this section, and a thorough discussion of this issue is contained in the HUD guidelines, and will be presented in the risk assessor and supervisor course.

Specific instruction on the taking of composite dust and soil samples is provided in the HUD Guidelines. The technique essentially involves combining several subsamples from the same types of components into one sample for analysis. A composite dust sample is different from a single-surface sample because it combines at least two dust samples from more than one sampling area into one sample.

Pursuant to Section 745.227(g) of today's final rule, composite dust samples must consist of at least two subsamples. At this time the Agency recommends that a composite sample consist of no more than four subsamples, unless the laboratory contracted to analyze the composite sample agrees to accept a sample consisting of more than four subsamples. This recommendation is based on current limitations in the laboratory analysis of composite samples consisting of more than four subsamples (i.e., using available technology, composite samples that combine more than four subsamples are difficult to properly analyze). However, because some EPA-recognized laboratories are acquiring the ability to analyze composite samples consisting of more than four subsamples, the final rule does not explicitly restrict a composite sample from containing more than four subsamples.

Pursuant to Section 745.227(g) of today's final rule, composite dust samples shall not consist of subsamples from more than one type of component. For example, subsamples from four uncarpeted floors from four rooms may be combined into one composite sample. However, in these same four rooms, the rule prohibits two subsamples from windows in two of the rooms from being composited with two subsamples from floors in the other two rooms. This restriction is due to the varying levels of lead that may be present on different components, and the potential hazard that a component may present. For example, dust samples from floors generally tend to indicate a lower level of contamination, while the frequency of contamination is generally higher in windows. Consequently, the interpretation of the results from a composite sample consisting of subsamples from different components would not adequately characterize the location of the hazard. One of the primary benefits derived from composite sampling is lower sampling costs due to fewer laboratory analyses. Lead levels generally vary significantly from one component to another, and a single surface sample from one component alone (i.e., from one area of a floor in a room to another of the same floor) may not represent the potential for exposure. Composite sampling provides a means to determine potential exposures to lead-based paint hazards by obtaining a wide cross-section of possible exposure pathways. However, composite sampling may yield laboratory results that are not as informative as single-surface sampling. For example, dust samples from the floors of three rooms might be composited where only one of the floors contains lead-contaminated dust higher than the clearance level contained in the section 403 Guidance for uncarpeted floors of 100 $\mu g/ft^2$. This might cause the composited sample to fail clearance. On the other hand, if three single-surface floor dust samples were taken for clearance testing, the laboratory analyses would have precisely indicated which one of the three rooms exceeded the clearance level, and the inspector or risk assessor would know exactly which room needed to be recleaned and retested. Because of these limitations, it is imperative that a risk assessor, inspector, or supervisor understands and correctly interprets composite samples.

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APPENDIX B

Summary of the Activities of a Risk Assessor As Specified in the Risk Assessor Curriculum

APPENDIX B

Summary of the Activities of a Risk Assessor As Specified in the Risk Assessor Curriculum

B1.0 BACKGROUND AND OBJECTIVE

This document provides a summary of the activities a risk assessor performs for inspections, lead hazard screens, risk assessments and risk assessments/inspections, as described in the Section 402 rule. Though the emphasis is on a risk assessment, discussions of the other activities are also provided.

The information provided will help guide the following tasks:

a. Development of forms to evaluate the costs of inspections, hazard screens, risk assessments, risk assessments/inspections, and elevated blood-lead investigations.

b. Statistical analysis of the effectiveness of a risk assessment or lead hazard screen given the choices of a risk assessor.

Table B-1 provides a very brief summary of the purpose, scope, and consequence of the inspection, lead hazard screen, risk assessment and risk assessment/inspection documented in Section 402 [2] and the student manual for the lead-based paint risk assessment model curriculum [1] being used to train risk assessors.

It should be noted that this document focuses on current guidance and protocols as promulgated in the Section 402 rule [2], the Section 403 guidance [3], the HUD Guidelines [4], and the model training curriculum for risk assessors [1]. Promulgation of the Section 403 rule, which will identify conditions that result in a lead based paint hazard, may affect the guidance and sampling recommendations that are summarized in this document. Note that a good portion of the information listed was extracted from the "Lead-Based Paint Risk Assessment Model Curriculum [1]." Additional information to clarify the curriculum was extracted from the Section 402 rule [2], the Section 403 guidance [3], and the HUD Guidelines [4].

B1.1 DEFINITIONS

There are several terms which will be used throughout the discussion. To avoid misinterpretations the definitions of the terms are provided below.

- A **RISK ASSESSMENT** is an on-site investigation of a residential dwelling for lead-based paint hazards. Risk assessments include investigating the age, history, management, and maintenance of the dwelling; conducting a visual assessment; performing limited environmental sampling, such as dust wipe samples, soil samples, and deteriorated paint samples; and reporting the results that identify acceptable abatement and interim control strategies based on specific conditions and the owner's capabilities.

- An **INSPECTION** is a surface-by-surface investigation for determining the presence of lead-based paint.

- A **LEAD HAZARD SCREEN** is an alternative to a risk assessment that involves limited paint and dust sampling in homes in relatively good condition.

- **LEAD-BASED PAINT** is any paint or other surface coatings that contain lead equal to or in excess of 1.0 mg/cm^2 or more than 0.5 percent by weight (5,000 µg/g, 5,000 ppm, or 5,000 mg/kg).

- **LEAD BASED PAINT HAZARD** is a condition in which exposure to lead from lead-contaminated dust, lead-contaminated soil, deteriorated lead-based paint, or from lead-based paint present on accessible, friction, or impact surfaces that would result in adverse human health effects.

B.1.2 OVERVIEW OF THE LEAD HAZARD EVALUATION PROCESS

For single family housing, one or more of the following steps may have to be completed prior to a risk assessment or other evaluation.

1. Provide information to the owner about lead hazards and how they can be evaluated.
2. Help owner determine the type of activity that should be conducted-risk assessment, inspection, lead hazard screen, or risk assessment/inspection.
3. Discuss the history of the property and the future plans of the owner, resources, and occupants.
4. Set up visual inspection of the property, plan for environmental sampling, and set up analysis of samples by an EPA-recognized laboratory.

Table B-1. Purpose, Scope, and Consequences of an Inspection, Lead Hazard Screen, Risk Assessment, Risk Assessment/ Inspection and EBL Investigation

	Inspection	Lead Hazard Screen	Risk Assessment	Risk Assessment/Inspection
Purpose	Attempts to find out which surfaces have lead-based paint.	Conducted on housing in good condition as defined by HUD guidelines. Determines if a full risk assessment is needed.	To determine and then to report the existence, nature, severity, and location of lead-based paint hazards in housing through an on-site investigation and the possible means of correcting any hazards identified by surveying likely sources including soil, dust, and paint.	To determine where the lead-based paint in a dwelling is located and where lead-based paint hazards are located.
Scope	Focuses on identifying the presence or absence of lead-based paint on all surfaces.	Focuses on determining if the property needs to have a full risk assessment or if the property does not have lead-based paint hazards and needs no action.	Focuses on the likely lead-based paint hazard at the property that the client owns or resides in.	Combines a surface-by surface measurement of lead based paint with soil and dust sampling to provide the owner with information on what should be done immediately and what can be done later.
Consequences	Allows the property owner to classify all painted surfaces as either LBP or non-LBP.	Property owner may need to have a full risk assessment if property may have lead-based paint hazards.	The property owner has authority to make decisions about the lead hazard control options taken. However, some states and localities may have certain provisions.	The property owner receives information to know what should be done immediately and what can be done later.

5. The risk assessor must identify the most appropriate strategies for a specific property. The risk assessor should discuss motivating factors and review these with the property owner:

   - Legal or insurance requirements;
   - Property disposition (sale or turnover)
   - Liability issues
   - Preventive measures for children at risk
   - Preventive measures prior to renovation or remodeling
   - Response to a child with elevated blood lead levels
   - Cost.

Once the necessary steps outlined above have been completed one or more of the following steps may be necessary.

1. Determine whether a risk assessment, inspection, a combination risk assessment/inspection, or a lead hazard screen should be conducted.

2. Get background information on the dwelling, owner's plans, resources, and occupants (if present).

3. Arrange a date to do the visual examination and environmental sampling. Make any necessary arrangements with the owner to notify residents. Some education on why this work is being done may be necessary, especially if an inspection has already been done.

4. Conduct environmental sampling, and send samples to an EPA-recognized laboratory.

5. Combine visual findings with environmental sampling results, and determine if hazards are present.

6. Provide owner with a range of options to control any hazards found, along with rough, estimated costs and reevaluation schedules.

7. Document all findings and determinations in a standard report.

B2.0 RISK ASSESSMENT

The purpose of a risk assessment is to uncover only housing-related lead-based paint hazards by surveying likely sources. Activities included in a risk assessment are a visual examination of the property, collection of dust, soil, and paint samples, and the writing of a risk assessment report. Discussed below are the specifics of each of these activities.

B2.1 VISUAL EXAMINATION

The purpose of the visual examination is for the risk assessor to locate and assess potential lead-based paint hazards and their causes.

The visual examination evaluates:

- deteriorated paint and visible causes of such deterioration;
- visible dust accumulation;
- areas of bare residential soil;
- painted surfaces that are either impact points or subject to friction;
- painted surfaces where a child's chewing is suspected.

The focus should be on locating current visible lead hazards. The risk assessor locates lead-based paint hazards by locating areas where paint, dust, and soil may be hazardous and by conducting environmental sampling. If paint on certain components is known through other tests or other information not to contain lead at or above the regulatory limit, it is not necessary for the risk assessor to evaluate its condition.

The exterior visual examination should address the roof; windows; porches; masonry and foundations; other painted surfaces and bare residential soil. The interior visual examination should address the attics; drop ceilings; windows; doors; baseboards and moldings; stairs and floors; plumbing; and the basement.

During a visual examination walk-through the following should be taken into consideration:

1. Determine the exterior and interior condition of the building.

2. During the walk-through survey the risk assessor should determine:

a. If the property is in good repair or if there are significant structural or moisture problems (cracks in walls, sagging walls, holes in the roof, and extensive water stains.

b. Does the property have large amounts of deteriorated paint and/or visible dust accumulation?

   Paint deterioration may be categorized as:

   1) Surface-coat failure – top layer of paint flaking, peeling or otherwise detaching from layers below;

   2) Multi-coat failure – several top layers of paint or other coatings (e.g., wallpaper) are delaminating from layers below;

   3) Paint failure revealing unsound substrate or structure – paint delamination reveals the substrate or underlying structure is unsound (e.g., rotted wood or plaster off lathe);

   4) Paint abrasion – paint is rubbing because of mechanical friction (e.g., windows) or from human contact (e.g., painted stairs and floors scuffed by walking or other contact);

   5) Chipped paint – pieces of paint are loosened or broken because of impact (e.g., doors, baseboards, or chair rails).

c. Are the windows and doors old and possibly coated with lead-based paint; are the windows and/or doors relatively new and hence unlikely to be coated with lead-based paint; and are the window and door tracks generally painted and/or do the troughs contain chips and dust?

d. Is there any obvious exterior source of lead (old house next door that has lots of peeling paint or battery recycling shop that is located nearby)?

e. Determine the property's recent maintenance history.

B2.2 ENVIRONMENTAL SAMPLING

In order to evaluate lead hazards the collection of dust, soil, and paint samples is necessary. The specifics of sampling are presented in this section by media.

Note that all laboratories used to do environmental sampling analysis in a risk assessment should be recognized as proficient through one of the accrediting organizations in the EPA National Lead Laboratory Accreditation Program (NLLAP).

B2.2.1 Dust

For children, dust is an important pathway of exposure to lead. Studies have shown that dust lead levels are among the strongest predictors of children's blood-lead levels compared with a number of other variables.

Units of Measure of Lead in Dust

Lead in dust can be measured by loading (area concentration), a measure of the total amount of lead present in micrograms of lead per square foot of surface area ($\mu g/ft^2$), or by mass concentration, a measure of the amount of lead contained in dust expressed as micrograms of lead per gram of dust ($\mu g/g$). Loading is measured directly by wipe sampling and vacuum sampling. Mass concentration is usually measured by vacuum sampling and cannot be measured by the standard wipe sampling methods. Wipe sampling is the recommended method for routine risk assessments for the following reasons:

- It is relatively simple and inexpensive
- It has been correlated with children's blood lead levels in a number of studies;
- Current EPA, HUD, and state standards are based on wipe sampling;
- Vacuum sampling methods are not standardized;
- Since there are no concentration standards, it is not possible to identify hazards using vacuum sampling.

EPA Guidance Levels for Dust

The following interim guidance (July 1994) should be used for lead risk assessment until the permanent health-based standards defining "dangerous levels of lead in house dust" are determined as required of EPA through Title X legislation:

Floors (Bare)	100 μg/ft² (as determined by wipe sampling only)
Interior window sills (stools)	500 μg/ft² (as determined by wipe sampling only)
Window troughs (wells)	800 μg/ft² (as determined by wipe sampling only)

Dust samples can be taken as single samples or composite samples. Composite samples have the advantage of being lower in cost per surface sampled and an increased surface area can be wiped for about the same analysis cost. The disadvantages of using composites are that information on a specific sampling location is lost and laboratories have to adopt special handling and digestion procedures. If composite samples are used, a minimum of three separate composite dust samples should be collected. The composite samples should be collected from bare floors or carpeted floor for wall-to-wall carpets, window sills, and window troughs.

The following are rules for composite sampling:

1. No less than 2 and no more than 4 individual wipes should be included in each composite sample.

2. Separate composite samples are required from carpeted and hard surfaces (e.g., a single composite sample should not be collected from both carpeted and bare floors). Whenever possible, hard floors should be sampled instead of carpets. Collection efficiencies may vary considerably on carpets.

3. Separate composite samples are required from each different component sampled (e.g., a composite sample should not be collected with both floor and window sill subsamples contained in one composite sample).

4. Separate composite samples are required for each dwelling.

5. Floor surface areas sampled in each room should be approximately the same size (1ft² or 929 cm²). Window trough and interior window sill sampling sizes are dependent on window characteristics but should be as similar as possible from room to room (e.g., the surface sampling area should not be skewed so that one room is over sampled.

6. The same wipe should not be used to sample two different spots. A new wipe should be used for each spot sampled.

7. When composite samples are submitted for analysis blank and spike (control) quality assurance/quality control samples should also be included and analyzed.

Single-surface samples should be used:

1. when information is needed to determine leaded dust levels in a specific location. For example, pet sleeping areas, porch areas, laundry areas where contaminated clothing is washed, or lead hobby areas;

2. in other areas where leaded dust levels are expected to be high to determine if targeted cleaning efforts are needed.

Composite samples should be used:

1. when controlling costs is essential;

2. when there is no reason to suspect that dust levels from the same types of surfaces in different rooms will vary greatly;

3. when the costs of multiple-room clean-up will not greatly exceed the cost of single room clean-up.

The Number and Location of Samples

A. For composite samples, the following rooms should be sampled (at a minimum):

   1. principal play room for children (TV room, living room, or dining room);
   2. kitchen;
   3. bedroom of the youngest child;
   4. bedroom of the next oldest child.

   In vacant dwellings substitutions may be made such as, the living room for the play room and smallest bedroom for the youngest child's room.

B. For single-surface samples at least 6-8 samples are necessary for evaluating the hazards in each dwelling.

   Children are most likely to come in contact with dust in

   1. the entry way (including porches)
   2. child's principal play area (TV room, living room, or dining room)
   3. children's bedrooms, kitchen, and bathroom.

   Within these rooms, areas that are likely to have high dust levels include:

1. floors near friction or impact spots, or areas with deteriorated paint
2. interior window sills (of frequently opened windows)
3. window trough (of frequently opened windows) and
4. cabinet with deteriorated paint (housing dishes, toothbrushes, eating utensils, etc.)

B2.2.2 Soil

Several studies have shown that soil contaminated with lead contributes significantly to the blood-lead levels found in children. Exposure occurs through direct ingestion of soil, track-in of soil into the interior of the house, or through a combination of the two. Soil may be contaminated with lead from several sources (1) weathering and "chalking of lead-based paint on the building's exterior, (2) nearby demolition or renovation activities, (3) previous repainting jobs involving scraping of exterior lead-based paint, (4) airborne contamination from the emissions of engines burning leaded gasoline in past years (although leaded gasoline has been generally phased out under the EPA ban much lead entered the environment from this source up until the late 1980s, and (5) point sources of airborne lead such as lead smelters and battery manufacturing plants.

Children become exposed to lead when they get their hands dirty in soil and put their fingers or other objects into their mouths. Lead contaminated soil is also a potential source of lead in interior house dust, since residents and their pets can easily track soil into the dwelling. Also, vegetables grown in lead contaminated soil may take up lead and be ingested by the residents of the dwelling. As a result, testing of bare soil around a dwelling and in play areas is required for lead-based paint risk assessments.

Units of Measure of Lead in Soil

Soil lead levels are usually expressed in micrograms of lead per gram of soil (µg/g). This is equivalent to milligrams per kilogram (mg/kg) or parts per million by weight (ppm). Some laboratories may report concentration in weight percent which can be converted to µg/g or mg/kg.

EPA Guidance Levels for Soil

Until health based standards are developed, EPA guidance states the following levels of concern.

Bare Soil Lead Concentration (ppm):

400 ppm – Areas expected to be used by children, including residential backyards, daycare, and school yards, playgrounds, public parks, and other areas where children gather.

2,000 ppm – Areas where contact by children is less likely or infrequent.

5,000 ppm – Abatement of soil required regardless of the expected contact by children.

Soil Sampling

In order to reduce variability and costs, all routine soil samples collected for lead-based paint risk assessment purposes are composite samples. One composite sample is taken from the child's play area if it can be identified and a second from the building foundation. Soil samples are taken by (1) coring or (2) scooping. Composite samples should consist of 3-10 subsamples. Other areas that may be sampled are gardens, pet sleeping areas, parking areas possibly contaminated from vehicle exhaust, or sandboxes. Samples taken along the building foundation should be 2-6 feet apart. If there is no bare soil then sampling is not necessary. This includes areas where all soil is covered by pavement or thick grass cover, ivy, or similar material. In most cases there are some areas that should be sampled. If paint chips are present in the soil, they should be included as part of the soil sample but no special attempt should be made to oversample paint chips.

B2.2.3 Paint

In a risk assessment previous paint testing results should be reviewed to be sure the owner can rely on the data to determine which surfaces have lead-based paint and which do not.

Interim Guidelines for Paint

The federal standards for lead-based paint are 1.0 mg/cm^2 or 5,000 µg/g (equivalent to 5,000 ppm, 5,000 mg/kg, or 0.5 percent by weight).

Paint Sampling

Deteriorated paint means paint that is cracking, flaking, chipping, peeling, or otherwise separating from the substrate of a building component. All deteriorated paint films should be measured to determine if they contain levels of lead at or above the applicable limit. If there are a large number of surfaces with deteriorated paint, it may be best to complete an inspection since the added expense is not great.

Risk assessments usually need to measure 2-10 paint films. Paint films can be composited to help reduce cost especially if it is likely that none of the paint films is above the applicable standard. The laboratory doing the analysis must have special capability to do this type of assessment. Since a number of samples are combined, the results will indicate whether or not any of the surfaces sampled could be over the limit. If the analysis is positive then only analysis of single surface samples can determine exactly which samples are over or under the limit. The risk assessor should collect duplicate samples to avoid having to make a return trip to the house.

Intact paint, on friction, impact, or accessible or chewable surfaces need not be measured for lead. The lead hazards associated with these surfaces are determined through dust analysis and visual inspection, not through XRF or paint chip analysis.

The lead content in deteriorated paint films should be determined by using either portable XRF analysis of deteriorated paint or laboratory analysis of paint chips. Protocols for these analyses are available from EPA, HUD, and ASTM. XRF may be more cost effective than laboratory analysis of chips especially if the dwelling has a large number of deteriorated surfaces. Current Chemical Spot Test Kits are not recommended as a method to measure lead in deteriorated paint.

Sampling Locations

The risk assessor should select an unobtrusive area (behind pictures, behind furniture, near corners, underneath protruding surfaces (mantels, window sills) to take paint film samples where

- all paint films are present,
- there is the least deterioration, and
- the smallest possible substrate is included with the paint sample.

When several layers of paint are present on a surface, all layers of paint should be sampled. The following are reasons why all layers should be sampled.

- No additional cost is incurred by sampling all layers, and if currently intact layers peel in the future, repeated sampling will not be required.
- The information helps the owner plan future activity even if the layers with lead are now intact.
- No available technology can clearly distinguish which layers contain lead and which do not.
- The presence of deteriorated paint is an indication that other layers are more likely to fail in the future.
- Repairing deteriorated layers will usually involve some abrasion of the intact layers below, possibly resulting in a dust hazard.
- Different methods of paint analysis will be consistent only if all layers are analyzed (e.g., XRF, which measures all layers of a surface, will produce different results from laboratory paint chip analysis if the latter includes only some of the layers).

B2.2.4 Other Media

The risk assessment may also include the evaluation of lead in water or other components of multiple family dwellings, etc. (The present study is not concerned with these data and this summary does not include information on these entities.)

B2.3. RISK ASSESSMENT REPORT

The risk assessment must also include a risk assessment report which (1) summarizes the results by indicating where hazards are found; (2) indicates the range of hazard control options likely to be effective (indicating ongoing monitoring and maintenance of each option); (3) includes all raw data and identifying information; and (4) in some jurisdictions may become a legal document.

The risk assessment report includes a section on identifying information; a section on completed management, maintenance and environmental results forms and analysis; and a section on lead hazard control plan. The risk assessor must make clear to the owner that the choice of how to control the hazard is up to the owner, not the risk assessor.

The four functions of the final risk assessment report are:

1. It summarizes the results of the risk assessment indicating where hazards are found.
2. It indicates the range of hazard control options likely to be effective.
3. It includes all raw data and identifying information.
4. It may become a legal document in some jurisdictions.

When the results of any environmental sampling are above the guidance levels listed earlier, the dwelling fails the risk assessment. When all samples are below the lead hazard screen guidance levels, the dwelling is considered to be free of lead-based paint hazards. Only a full paint inspection determines for sure if the dwelling is lead-free. The risk assessor should provide the owner with documentation of the screening and the negative finding. The risk assessor should make sure that the results of the screen are sufficient to satisfy local or insurance standards before signing any certificates of a lead hazard status that may be requested by an owner.

B3.0 LEAD HAZARD SCREEN

A lead hazard screen, where appropriate, avoids the costs of conducting a comprehensive risk assessment, particularly in well-maintained housing and child-occupied facilities constructed after 1960, or in housing and child-occupied facilities considered unlikely to have significant lead paint, dust or soil hazards.

The lead hazard screen should focus on determining the absence of a lead-based paint hazard, rather than the presence of such a hazard and the risks it may pose to building occupants.

In the lead hazard screen a visual inspection is conducted. Deteriorated paint is sampled and two composite dust samples are collected, one from the floor and the other from the window troughs in locations where one or more children, age 6 and under, are most likely to come in contact with dust. Paint and dust samples are analyzed. A hazard screen report and recommendations if appropriate are provided for the owner. See Table B-2 for a comparison of the lead hazard screen with a full risk assessment and a paint inspection.

B4.0 LEAD-BASED PAINT INSPECTION

Lead-based paint inspections can be performed by either a certified inspector technician or a certified risk assessor. Inspections measure the concentration of lead in paint on a surface-by-surface basis. Inspections results enable the owner to manage all lead-based paint, since the exact locations of the lead-based paint have been identified. However, the inspection does not determine whether the paint presents an immediate hazard. The collection of dust and soil samples is not part of a routine paint inspection. Thus, if a risk assessment is not performed along with the paint inspection, a full determination of the location and natures of all lead-based paint hazard cannot be made. In addition, no hazard control measures can be suggested by the inspector.

A paint inspection is the preferred evaluation method when an owner has decided to abate all lead-based paint or when there is a low expectation of the presence of lead-based paint. Inspections are also appropriate when extensive renovation that is about to occur will disturb painted surfaces.

The recommended method for measuring the lead level in paint is with a portable XRF instrument manufactured for paint analysis. The use of paint-chip sampling and laboratory analysis is secondary because it is time-consuming, costly, and requires extensive repairs of painted surfaces. In a residential dwelling and child occupied facility, each component with a distinct painting history and each exterior component with a distinct painting is tested for lead-based paint, except those components known to have been replaced after 1978, or do not contain lead-based paint. Paint is defined to be lead-based if the lead content equals or exceeds either 1.0 mg/cm^2 or 0.5% by weight. An inspection report is prepared to include all the relevant information, i.e., method of testing, locations, the results of the inspection in terms of the appropriate sampling method. See Table A-2 for a comparison of activities that must be performed for a lead-based inspection with the activities in a lead hazard screen and a risk assessment.

Table B-2. Comparison of a Lead Hazard Screen, a Risk Assessment, and a Paint Inspection

Component	Lead Hazard Screen	Full Risk Assessment	Paint Inspection
Visual Inspection	Yes	Yes	Yes
Paint	Deteriorated Paint Only	Deteriorated Paint Only	Surface-by-Surface
Dust	2 Composite 1. Floor (entryway) from 1st child's bedroom, 2nd child's bedroom, children's principal play area, additional location 2. Window trough from 1st child's bedroom, 2nd child's bedroom, children's principal play area, and additional location	3 or 4 Composite 1 Uncarpeted floor (include entryway) 1 Window sill 1 Window trough Or 6-8 single surface	Optional
Soil	No	2 Composite 1 Foundation 1 Play areas	Optional
Water	No	Optional	Optional
Air	No	No	No
Paint Guidance Level	1.0 mg/cm² or 5,000 ppm or 0.5%	1.0 mg/cm² or 5,000 ppm or 0.5%	1.0 mg/cm² or 5,000 ppm or 0.5%
Dust Guidance Level	floors = 50 μg/ft² window troughs = 400 μg/ft²	floors = 100 μg/ft² window sills = 500 μg/ft² window troughs = 800 μg/ft²	Same as risk assessment if conducted
Soil guidance Level	None determined	400 μg/g high contact 2,000 μg/g residential yard 5,000 μg/g permanent abatement	Same as risk assessment if conducted
Housing Condition	Yes	Yes	Not Required
Use Patterns Assessment	No	Yes	No
Management and maintenance data	No	Optional – depends on property type	No

B5.0 RISK ASSESSMENT/INSPECTION

It is sometimes advisable to conduct a risk assessment and paint inspection. By combining measurements of soil and dust with surface-by-surface paint analysis, and collecting maintenance and management data, lead-based paint hazards can be identified in a comprehensive fashion and addressed appropriately.

B6.0 REFERENCES

[1] Lead-Based Paint Risk Assessment Model Curriculum" prepared by the U.S. Environmental Protection Agency, Chemical Management Division, 1995.

[2] U.S. Environmental Protection Agency, "Lead: Requirements for Lead-Based Paint Activities in Target Housing and Child-Occupied Facilities, Final Rule", Memorandum Federal Register, pp. 45777-45830, August 29, 1996.

[3] U.S. Environmental Protection Agency, "Guidance on Identification of Lead-Based Paint Hazards", Memorandum Federal Register, pp.47248-47257, September 11, 1995.

[4] U.S. Department of Housing and Urban Development, "Guideline for the Evaluation and Control of Lead-Based Paint Hazards in Housing," Office of Lead-Based Paint Abatement and Poisoning Prevention, HUD-1539-LBP, July 1995.

APPENDIX C
Risk Assessor Cost Questionnaire

COST EVALUATION OF LEAD RISK ASSESSMENT, LEAD HAZARD SCREEN, INSPECTION, AND RISK ASSESSMENT/INSPECTION

INFORMATION TO BE FILLED IN PRIOR TO MAKING PHONE CALL

DATE: ____________________ PARTICIPANT ID: ____________________

NAME OF COMPANY: ____

STREET ADDRESS: ____

CITY: ____________________ STATE: |_|_| ZIP: |_|_|_|_|_|-|_|_|_|_|

CONTACT PERSON: ____

POSITION: ____

TELEPHONE NUMBER: (|_|_|_|) |_|_|_|-|_|_|_|_| ext. __________

GREETING

Hello, my name is ____________________ and I'm calling from the Battelle Memorial Institute in Columbus, Ohio. We are doing a study with the Environmental Protection Agency to assess the capacity of the Section 402 lead risk assessment protocol to protect the health of children in housing containing lead based paint and to assess the value of different risk assessment protocols in light of costs. Part of our task involves contacting contractors in various communities and asking them to participate in a brief evaluation regarding the cost of conducting a lead risk assessment, lead hazard screen, inspection, or risk assessment/inspection. Would you have 5-10 minutes to answer some questions? For your participation, you will receive a summary of the results from this survey within 6 months of its completion. The summaries would allow you to assess how your costs compare to other contractors. Can I ask you the questions?

☐ Yes
☐ No

Reason for not participating: ____

____

____

INTERVIEWER: ____

TOTAL TIME FOR INTERVIEW: ____________________

A. INITIAL CONSULTATION

A1. Do you have a charge for initially coming to a home to consult with the owner about the property and whether a risk assessment, hazard screen, inspection, or risk assessment/inspection should be conducted?

YES .... 22% (n=9)
NO ..... ***{Go to question B1}*** .... 78% (n=9)

A2. Do you have different consultation fees for different expected activities?

YES .... 0% (n=2)
NO ..... ***{Go to question B1}*** .... 100% (n=2)

A3. What are your consultation fees for a:

a. Risk Assessment · (n=0) (· – ·)

b. Lead Hazard Screen · (n=0) (· – ·)

c. Inspection · (n=0) (· – ·)

d. Risk Assessment/ Inspection · (n=0) (· – ·)

B. FULL RISK ASSESSMENT

The next few questions are specific to performing a FULL RISK ASSESSMENT only. Assume that you are at the home to perform the risk assessment.

B1. Do you have a basic fee for performing a full risk assessment or does your fee depend on the activities performed?

a. Basic Fee .... 44% (n=9)
{Go to question B2}

b. Separate Fees for each activity ... 56% (n=9)
{Go to question B10}

BASIC FEE INFORMATION

B2. What is your basic fee for a risk assessment?

$422.50 (n=4) ($190-$900)

B3. a. Is there a Visual Inspection included in the Basic Fee?

Yes .... 100% (n=4) ...... ***{Go to B4}***
No ..... 0% (n=4)

b. What is the additional fee to perform a Visual Inspection?

(n=0) (· – ·)

B4. a. Is a Risk Assessment Report included in the Basic Fee?

Yes .... 100% (n=4) ..... ***{Go to B5}***
No ..... 0% (n=4)

b. What is the additional fee for the Risk Assessment Report?

(n=0) (· – ·)

B5. Is Environmental Sampling included in the Basic Fee?

Yes .... 50% (n=4) ... ***{Go to B6}***
No ...... 50% (n=4) ... ***{Go to B9}***

B. FULL RISK ASSESSMENT (Continued)

B6. How many and what type of environmental samples are collected for the basic fee (i.e., the average number of samples collected)?

Medium	Location	Type of Sample or Method of Collection ***(Check)***	No. of Samples Collected
a. Soil		☐ Scoop	3 (n=1) (3-3) · (n=0) (· – ·)
b. Dust		☐ Single Samples ☐ Composite Samples	6 (n=2) (5-8) · (n=0) (· – ·)
	c. Floor	☐ Single Samples ☐ Composite Samples	· (n=0) (· – ·) · (n=0) (· – ·)
	d. Window Sill	☐ Single Samples ☐ Composite Samples	· (n=0) (· – ·) · (n=0) (· – ·)
	e. Window Well	☐ Single Samples ☐ Composite Samples	· (n=0) (· – ·) · (n=0) (· – ·)
Paint		f. XRF	225 (n=1) (200-250)
		g. Paint Chips – Single Samples	· (n=0) (· – ·)
		h. Paint Chips – Composite Samples	· (n=0) (· – ·)
i. Water			· (n=0) (· – ·)

j. Other Optional Samples

<u>Dust</u>: 6-8
<u>Paint</u>: If needed. If paint peeling, will take a single. Varies. 200-250.
<u>Soil</u>: If needed.
<u>Water</u>: If needed.

B7. If more samples are required, do you have incremental costs for each additional sample?

Yes . . . . 100% (n=2) . . . . ***{Go to B8}***
No . . . . 0% (n=2) . . . . ***{Go to C1}***

B. FULL RISK ASSESSMENT (Continued)

B8. What are the incremental costs :

Medium	Type of Sample	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost of Environmental Samples
Dust	a. Single	· (n=0) (· – ·)	$7.50 (n=2) ($5-$10)	$7.50 (n=2) ($5-$10)
	b. Composite	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
Soil	c. Composite	· (n=0) (· – ·)	$7.50 (n=2) ($5-$10)	$7.50 (n=2) ($5-$10)
Paint	d. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	e. Paint Chips – Single Samples	· (n=0) (· – ·)	$5 (n=1) ($5-$5)	$5 (n=1) ($5-$5)
	f. Paint Chips – Composite Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
g. Water		· (n=0) (· – ·)	$7.50 (n=2) ($5-$10)	$7.50 (n=2) ($5-$10)
h. Other Optional Samples				

(COMPLETED SECTION B — GO TO QUESTION C1)

B. FULL RISK ASSESSMENT (Continued)

B9. What are the additional fees for performing environmental sampling?

Medium	Type of Sample	No. of Samples	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost of Environmental Samples
Dust	a. Single	4 (n=2) (3-8)	$10 (n=1) ($10-$10)	$15 (n=2) ($11-$15)	$100 (n=2) ($45-$200)
	b. Composite	6 (n=1) (3-8)	$10 (n=1) ($10-$10)	$15 (n=1) ($15-$15)	$150 (n=1) ($75-$200)
Soil	c. Composite	2 (n=2) (1-4)	$15 (n=1) ($15-$15)	$12.50 (n=2) ($10-$15)	$42.50 (n=2) ($15-$120)
Paint	d. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	e. Paint Chips – Single Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	f. Paint Chips – Composite Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
g. Water		1 (n=1) (1-1)	$15 (n=1) ($15-$15)	$12.50 (n=2) ($10-$15)	$12.50 (n=2) ($10-$15)
h. Other Optional Samples					
Soil	Single	3 (n=1) (2-4)	$15 (n=1) ($15-$15)	$10 (n=1) ($10-$10)	$75 (n=1) ($50-$100)

(COMPLETED SECTION B — GO TO QUESTION C1)

SEPARATE FEE FOR EACH ACTIVITY

What is the overall cost for

B10. A Visual Assessment $272 (n=5) ($150-$500)

B11. A Risk Assessment Report $282 (n=5) ($50-$500)

B12. Typical Environmental Sampling $260 (n=5) ($41.50-$1000)

B. FULL RISK ASSESSMENT (Continued)

B9. What are the additional fees for performing environmental sampling?

Medium	Type of Sample	No. of Samples	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost of Environmental Samples
Dust	a. Single	4 (n=2) (3-8)	$10 (n=1) ($10-$10)	$15 (n=2) ($11-$15)	$100 (n=2) ($45-$200)
	b. Composite	6 (n=1) (3-8)	$10 (n=1) ($10-$10)	$15 (n=1) ($15-$15)	$150 (n=1) ($75-$200)
Soil	c. Composite	2 (n=2) (1-4)	$15 (n=1) ($15-$15)	$12.50 (n=2) ($10-$15)	$42.50 (n=2) ($15-$120)
Paint	d. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	e. Paint Chips – Single Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	f. Paint Chips – Composite Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
g. Water		1 (n=1) (1-1)	$15 (n=1) ($15-$15)	$12.50 (n=2) ($10-$15)	$12.50 (n=2) ($10-$15)
h. Other Optional Samples					
Soil	Single	3 (n=1) (2-4)	$15 (n=1) ($15-$15)	$10 (n=1) ($10-$10)	$75 (n=1) ($50-$100)

(COMPLETED SECTION B — GO TO QUESTION C1)

SEPARATE FEE FOR EACH ACTIVITY

What is the overall cost for

B10. A Visual Assessment $272 (n=5) ($150-$500)

B11. A Risk Assessment Report $282 (n=5) ($50-$500)

B12. Typical Environmental Sampling $260 (n=5) ($41.50-$1000)

B. FULL RISK ASSESSMENT (Continued)

B15. What are the incremental costs?

Medium	Type of Sample	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Dust	a. Single	· (n=0) (· – ·)	$21.50 (n=5) ($15-$30)	$21.50 (n=5) ($15-$30)
	b. Composite	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
Soil	c. Composite	· (n=0) (· – ·)	$20 (n=3) ($15=$25)	$20 (n=3) ($15-$25)
Paint	d. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	e. Paint Chips – Single Samples	· (n=0) (· – ·)	$20.58 (n=3) ($16.50-$25)	$20.58 (n=3) ($16.50-$25)
	f. Paint Chips – Composite Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
g. Water		· (n=0) (· – ·)	$15 (n=1) ($15-$15)	$15 (n=1) ($15-$15)
h. Other Optional Samples				

(COMPLETED SECTION B — GO TO QUESTION C1)

C. LEAD HAZARD SCREEN

C1. Do you have a basic fee for performing a lead hazard screen or does your fee depend on the activities performed?

a. Basic Fee .... 62% (n=8)
{Go to question C2}

b. Separate Fees for each activity ... 38% (n=8)
{Go to question C10}

BASIC FEE INFORMATION

C2. What is your basic fee for a Lead Hazard Screen?

$157.50 (n=4) ($90-$200)

C3. a. Is there a Visual Inspection included in the Basic Fee?

Yes .... 100% (n=5) .... ***{Go to C4}***
No ..... 0% (n=5)

b. What is the additional fee to perform a Visual Inspection?

· (n=0) (· – ·)

C4. a. Is a Risk Assessment Report included in the Basic Fee?

Yes .... 100% (n=5) .... ***{Go to C5}***
No .... 0% (n=5)

b. What is the additional fee for the Risk Assessment Report?

· (n=0) (· – ·)

C5. Is Environmental Sampling included in the Basic Fee?

Yes .... 100% (n=5) ... ***{Go to C6}***
No ...... 0% (n=5) .. ***{Go to C9}***

C. LEAD HAZARD SCREEN (Continued)

C6. How many and what type of environmental samples are collected for the basic fee (i.e., the average number of samples collected?

Medium	Location	Type of Sample or Method of Collection (Check)	No. of Samples
a. Dust		☐ Single Samples ☐ Composite Samples	9 (n=1) (8-10) · (n=0) (· – ·)
	b. Floor	☐ Single Samples ☐ Composite Samples	· (n=0) (· – ·) · (n=0) (· – ·)
	c. Window Well	☐ Single Samples ☐ Composite Samples	· (n=0) (· – ·) · (n=0) (· – ·)
d. Soil		☐ Composite Samples	2 (n=1) (1-2)
Paint		e. XRF	10 (n=1) (10-10)
		f. Paint Chips – Single Samples	· (n=0) (· – ·)
		g. Paint Chips – Composite Samples	· (n=0) (· – ·)
h. Other Optional Samples <u>Dust</u>: For an average 3 bedroom home. <u>Paint</u>: 3 samples per room being screened. No additional costs. Whatever necessary. <u>Soil</u>: For an average 3 bedroom home.			

C7. If more samples are required, do you have incremental costs for each additional sample?

Yes . . . . 20% (n=5) . . . . . ***{Go to C8}***
No . . . . 80% (n=5) . . . . . ***{Go to D1}***

C. LEAD HAZARD SCREEN (Continued)

C8. What are the incremental costs ?

Medium	Type of Sample	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Dust	a. Single	· (n=0) (· – ·)	$10 (n=1) ($10-$10)	$10 (n=1) ($10-$10)
	b. Composite	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
Soil	c.	· (n=0) (· – ·)	$12 (n=1) ($12-$12)	$12 (n=1) ($12-$12)
Paint	d. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	e. Paint Chips – Single Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	f. Paint Chips – Composite Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
g. Other Optional Samples <u>Paint</u>: Free				

(COMPLETED SECTION C — GO TO QUESTION D1)

C. LEAD HAZARD SCREEN (Continued)

C9. What are the additional fees for performing environmental sampling?

Medium	Type of Sample	No. of Samples	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Dust	a. Composite	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
Soil	b. Composite	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
Paint	c. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	d. Paint Chips – Single Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	e. Paint Chips – Composite	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
f. Other Optional Samples					

(COMPLETED SECTION C — GO TO QUESTION D1)

SEPARATE FEE FOR EACH ACTIVITY

What is the overall cost for

C10. A Visual Assessment $175 (n=2) ($150-$200)

C11. A Hazard Screen Report $200 (n=2) ($150-$250)

C12. Typical Environmental Sampling $200.25 (n=2) ($175.50-$225)

C. LEAD HAZARD SCREEN (Continued)

C13. What are the individual environmental sampling costs for

Medium	Type of Sample	No. of Samples	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Dust	a. Composite	6 (n=1) (6-6)	· (n=0) (· – ·)	$20 (n=1) ($20-$20)	$120 (n=1) ($120-$120)
Soil	b. Composite	2 (n=1) (2-2)	· (n=0) (· – ·)	$25 (n=1) ($25-$25)	$50 (n=1) ($50-$50)
Paint	c. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	d. Paint Chips – Single Samples	5.75 (n=2) (3-10)	· (n=0) (· – ·)	$21.75 (n=2) ($18.50-$25)	$122.63 (n=2) ($55.50-$185)
	e. Paint Chips – Composite Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
f. Other Optional Samples					
Dust	Single	4 (n=2) (2-6)	· (n=0) (· – ·)	$22.5 (n=2) ($20-$25)	$85 (n=2) ($50-$120)

Paint: Varies depending on home circumstance.

C14. If more environmental samples are required do you have incremental costs for each additional sample?

Yes . . . 100% (n=2) . . ***{Go to C15}***
No . . . . 0% (n=2) . . . ***{Go to D1}***

C. LEAD HAZARD SCREEN (Continued)

C15. What are the incremental costs?

Medium	Type of Sample	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Dust	a. Composite	· (n=0) (· – ·)	$20 (n=1) ($20-$20)	$20 (n=1) ($20-$20)
Soil	b. Composite	· (n=0) (· – ·)	$25 (n=1) ($25-$25)	$25 (n=1) ($25-$25)
Paint	c. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	d. Paint Chips – Single Samples	· (n=0) (· – ·)	$21.75 (n=2) ($18.50-$25)	$21.75 (n=2) ($18.50-$25)
	e. Paint Chips – Composite Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
f. Other Optional Samples				
Dust	Single	· (n=0) (· – ·)	$22.50 (n=2) ($20-$25)	$22.50 (n=2) ($20-$25)

(COMPLETED SECTION C — GO TO QUESTION D1)

D. INSPECTION

D1. Do you have a basic fee for performing an inspection or does your fee depend on the activities performed?

a. Basic Fee .... 67% (n=9)
{Go to question D2}

b. Separate Fees for each activity ... 33% (n=9)
{Go to question D10}

BASIC FEE INFORMATION

D2. What is your basic fee for an Inspection?

$300 (n=6) ($125-$600)

D3. a. Is there a Visual Inspection included in the Basic Fee?

Yes .... 100% (n=9) .... ***{Go to D4}***
No ..... 0% (n=9)

b. What is the additional fee to perform a Visual Inspection?

· (n=0) (· – ·)

D4. a. Is a Risk Assessment Report included in the Basic Fee?

Yes .... 83% (n=6) ..... ***{Go to D5}***
No ..... 17% (n=6)

b. What is the additional fee for the Risk Assessment Report?

· (n=0) (· – ·)

D5. Is Environmental Sampling included in the Basic Fee?

Yes .... 83% (n=6) ..... ***{Go to D6}***
No ..... 17% (n=6) ..... ***{Go to D9}***

D. INSPECTION (Continued)

D6. How many and what type of environmental samples are collected for the basic fee (i.e., the average number of samples collected)?

Medium	Type of Sample or Method of Collection (Check)	No. of Samples	
Paint	a. XRF	117 (n=2)	(10-250)
	b. Paint Chips – Single Samples	· (n=0)	(· – ·)
	c. Paint Chips – Composite Samples	· (n=0)	(· – ·)
Dust	Single	4.25 (n=2)	(3-5)
Soil	Composite	1 (n=1)	(1-1)
Water		1 (n=1)	(1-1)

d. Other Optional Samples

Dust: 3-4 where children play.
Paint: As many as needed.
As necessitated, usually 10.
For modest 3 bedroom, 200-250 reading.

D7. If more samples are required, do you have incremental costs for each additional sample?

Yes .... 40% (n=5) ..... *{Go to D8}*
No ..... 60% (n=5) ..... *{Go to E1}*

D. INSPECTION (Continued)

D8. What are the incremental costs?

Medium	Type of Sample	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost Per Environmental Samples
Paint Surface-by-Surface	a. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	b. Paint Chips – Single Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	c. Paint Chips – Composite Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
d. Other Optional Samples				
Dust		· (n=0) (· – ·)	$10 (n=2) ($5-$15)	$10 (n=2) ($5-$15)
Soil		· (n=0) (· – ·)	$15 (n=1) ($15-$15)	$15 (n=1) ($15-$15)
Water		· (n=0) (· – ·)	$15 (n=1) ($15-$15)	$15 (n=1) ($15-$15)

Dust: Only charge if more than 3-4 addition.

(COMPLETED SECTION D — GO TO QUESTION E1)

D. INSPECTION (Continued)

D9. What are the additional fees for performing environmental sampling?

Medium	Type of Sample	No. of Samples	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Paint Surface-by-Surface	a. XRF	65 (n=1) (65-65)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	b. Paint Chips – Single Samples	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
c. Other Optional Samples					

(COMPLETED SECTION D — GO TO QUESTION E1)

SEPARATE FEE FOR EACH ACTIVITY

What is the overall cost of

D10. A Visual Assessment $490 (n=3) ($200-$750)

D11. An Inspection Report $380 (n=2) ($260-$500)

D12. Typical Environmental Sampling $348.67 (n=3) ($18.50-$750)

D. INSPECTION (Continued)

D13. What are the individual environmental sampling costs for

Medium	Type of Sample	No. of Samples	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Paint Surface-by-Surface	a. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	b. Paint Chips – Single Samples	35.83 (n=3) (15-50)	· (n=0) (· – ·)	$20.67 (n=3) ($18.50-$25)	$727.92 (n=3) ($277.50-$925)
c. Other Optional Samples Paint Surface-by-Surface: Varies depending on home circumstances.					

D14. If more environmental samples are required do you have incremental costs for each additional sample?

Yes . . . 100% (n=3) . . *{Go to D15}*
No . . . . 0% (n=3) . . . *{Go to E1}*

D. INSPECTION (Continued)

D15. What are the incremental costs?

Medium	Type of Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Paint Surface-by-Surface	a. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)
	b. Paint Chips – Single Samples	$20.67 (n=3) ($18.50-$25)	$20.67 (n=3) ($18.50-$25)
c. Other Optional Samples			

(COMPLETED SECTION D — GO TO QUESTION E1)

E. RISK ASSESSMENT/INSPECTION

E1. Is the cost of performing a combination risk assessment/inspection different from the cost of the risk assessment plus the cost of the inspection?

Yes .... 89% (n=9)
No .... ***{Conclude Interview – Go to Last Page}*** .... 11% (n=9)

E2. Do you have a basic fee for performing a combination risk assessment/inspection? Does your fee depend on the activities performed?

a. Basic Fee .... 62% (n=8)
{Go to question E3}
b. Separate Fees for each activity .... 38% (n=8)
{Go to question E11}

BASIC FEE INFORMATION

E3. What is your basic fee for a Risk Assessment/Inspection?

$886.25 (n=4) ($190-$1905)

E4. a. Is there a Visual Inspection included in the Basic Fee?

Yes .... 100% (n=5) .... ***{Go to E5}***
No ..... 0% (n=5)

b. What is the additional fee to perform a Visual Inspection?

· (n=0) (· – ·)

E5. a. Is a Risk Assessment Report included in the Basic Fee?

Yes .... 100% (n=5) .... ***{Go to E6}***
No ..... 0% (n=5)

b. What is the additional fee for the Risk Assessment Report?

· (n=0) (· – ·)

E6. Is Environmental Sampling included in the Basic Fee?

Yes .... 80% (n=5) ...... ***{Go to E7}***
No ...... 20% (n=5) ...... ***{Go to E10}***

E. RISK ASSESSMENT/INSPECTION (Continued)

E7. How many and what type of environmental samples are collected for the basic fee (i.e., the average number of samples collected)?

Medium	Location	Type of Sample or Method of Collection (Check)	No. of Samples
a. Soil		☐ Composite	3 (n=3) (1-5) · (n=0) (· – ·)
b. Dust		☐ Single Samples ☐ Composite Samples	10 (n=1) (10-10) 2 (n=1) (2-2)
	c. Floor	☐ Single Samples ☐ Composite Samples	· (n=0) (· – ·) · (n=0) (· – ·)
	d. Window Sill	☐ Single Samples ☐ Composite Samples	· (n=0) (· – ·) · (n=0) (· – ·)
	e. Window Well	☐ Single Samples ☐ Composite Samples	· (n=0) (· – ·) · (n=0) (· – ·)
Paint		f. XRF	· (n=0) (· – ·)
		g. Paint Chips – Single Samples	15 (n=2) (1-30)
		h. Paint Chips – Composite Samples	· (n=0) (· – ·)
i. Other Optional Samples			
Dust			6 (n=2) (5-8)
Water			1 (n=1) (1-1)

<u>Paint</u>: As many as necessary. If paint is peeling.
<u>Soil</u>: If needed.
<u>Water</u>: If needed.

E8. If more samples are required, do you have incremental costs for each additional sample?

Yes . . . . 100% (n=4)
No . . . ***{Conclude Interview – Go to Last Page}*** . . . . 0% (n=4)

E. RISK ASSESSMENT/INSPECTION (Continued)

E9. What are the incremental costs ?

Medium	Type of Sample	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Dust	a. Single Sample	· (n=0) (· – ·)	$13.75 (n=4) ($5-$25)	$13.75 (n=4) ($5-$25)
	b. Composite Sample	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
Soil	c. Composite	· (n=0) (· – ·)	$13.75 (n=4) ($5-$25)	$13.75 (n=4) ($5-$25)
Paint Surface-by-Surface	d. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	e. Paint Chip (1 sample from each component in a room)	· (n=0) (· – ·)	$15 (n=2) ($5-$25)	$15 (n=2) ($5-$25)
f. Other Optional Samples				
Water		· (n=0) (· – ·)	$10 (n=3) ($5-$15)	$10 (n=3) ($5-$15)

Paint Surface-by-Surface: Additional samples are free.

(COMPLETED SECTION E — CONCLUDE INTERVIEW — GO TO LAST PAGE)

E. RISK ASSESSMENT/INSPECTION (Continued)

E10. What are the additional fees for performing environmental sampling?

Medium	Type of Sample	No. of Samples	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Dust	a. Single Sample	5 (n=1) (5-5)	· (n=0) (· – ·)	$15 (n=1) ($15-$15)	$75 (n=1) ($75-$75)
	b. Composite Sample	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
Soil	c. Composite	1 (n=1) (1-1)	· (n=0) (· – ·)	$15 (n=1) ($15-$15)	$15 (n=1) ($15-$15)
Paint Surface-by-Surface	d. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	e. Paint Chip (1 sample from each component in a room)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
f. Other Optional Samples					
Water	Single	1 (n=1) (1-1)	· (n=0) (· – ·)	$15 (n=1) ($15-$15)	$15 (n=1) ($15-$15)

Paint Surface-by-Surface: No additional fee.

(COMPLETED SECTION E — CONCLUDE INTERVIEW — GO TO LAST PAGE)

SEPARATE FEE FOR EACH ACTIVITY

What is the overall cost of

E11. A Visual Assessment — $650 (n=3) ($200-$1500)

E12. A Risk Assessment/ Inspection Report — $312.50 (n=2) ($125-$500)

E13. Typical Environmental Sampling — $694.17 (n=3) ($140-$1325)

E. RISK ASSESSMENT/INSPECTION (Continued)

E14. What are the individual environmental sampling costs for

Medium	Type of Sample	No. of Samples	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Dust	a. Single Sample	12.33 (n=3) (7-25)	· (n=0) (· – ·)	$22.5 (n=3) ($20-$30)	$302.92 (n=3) ($140-$750)
	b. Composite Sample	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
Soil	c. Composite	10 (n=1) (10-10)	· (n=0) (· – ·)	$20 (n=1) ($20-$20)	$200 (n=1) ($200-$200)
Paint Surface-by-Surface	d. XRF	10 (n=1) (10-10)	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	e. Paint Chip (1 sample from each component in a room)	38.75 (n=2) (15-50)	· (n=0) (· – ·)	$18.30 (n=2) ($16.5-$20)	$710.63 (n=2) ($277.50-$1000)

f. Other Optional Samples

Dust: Varies depending on home circumstance.
Paint: Varies depending on home circumstance.

E15. If more environmental samples are required do you have incremental costs for each additional sample?

Yes .... 100% (n=3)
No .. 0% (n=3) .... ***{Conclude Interview – Go to Last Page}***

E. RISK ASSESSMENT/INSPECTION (Continued)

E16. What are the incremental costs?

Medium	Type of Sample	Collection Cost Per Sample	Analysis Cost/ Sample	Total Cost per Environmental Samples
Dust	a. Single Sample	· (n=0) (· – ·)	$22.50 (n=3) ($20-$30)	$22.50 (n=3) ($20-$30)
	b. Composite Sample	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
Soil	c. Composite	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
Paint Surface-by-Surface	d. XRF	· (n=0) (· – ·)	· (n=0) (· – ·)	· (n=0) (· – ·)
	e. Paint Chip (1 sample from each component in a room)	· (n=0) (· – ·)	$18.38 (n=2) ($16.50-$20)	$18.38 (n=2) ($16.50-$20)
f. Other Optional Samples				

(COMPLETED SECTION E — CONCLUDE INTERVIEW)

CONCLUSION TO INTERVIEW

I would like to thank you for participating in this evaluation. Let me just double check your address so we can send the results when they are available. {Go to first page.}

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APPENDIX D

Choices for a Risk Assessor

APPENDIX D

Choices for a Risk Assessor

As described in section 402 and summarized in Appendix A, by design a risk assessor is given the freedom to make sampling choices while performing a risk assessment. Listed below are the areas in which a risk assessor may make a choice.

1. Types of samples taken or techniques used to collect the samples

Dust	Composite or single samples
Soil	Core or surface scrapings
Paint	XRF or bulk (paint scrapings)

2. Sampling locations

Dust	Composite samples	Child's principal play area, kitchen, bedroom of youngest child between 6 months and 6 years of age, and bedroom of next oldest child
	Single samples	Entry way (including porches), child's principal play area, children's bedrooms, kitchen, bathroom, other rooms

3. Sampling components

Dust	Composite samples	Uncarpeted floors (carpeted if no uncarpeted floors available), interior window sills, window troughs
	Single samples	Uncarpeted floors (carpeted if no uncarpeted floors available), interior window sills, window troughs

4. Number of samples

Dust	Composite samples	3 or more composite samples; 2 to 4 single samples per composite
	Single samples	6 or more single samples
	Soil	1 or 2 composite samples

5. Performing a Lead Hazard Screen.

APPENDIX E

Blood and Environmental Sampling Standards

APPENDIX E

Blood and Environmental Sampling Standards

The environmental levels (media standards) used to determine if a home passes or fails a risk assessment are based upon EPA's Section 403 Interim Guidance and Section 403 Proposed Rule on identification of lead-based paint hazards. The blood-lead concentration target levels are based on EPA's Section 403 Interim Guidance and CDC's recommendations. Listed below are the standards used in the analysis.

Blood — Section 402 describes an elevated blood-lead level (EBL) as an excessive absorption of lead that is a confirmed concentration of lead in whole blood of 20 µg/dL for a single venous test or 15 to 19 µg/dL in two consecutive samples taken 3 to 4 months apart. The CDC elevated blood lead level is defined as 10 µg/dL or greater.

Dust — The *risk assessment* standards for uncarpeted floors (or carpeted floors if uncarpeted floors are not available), window sills, and windows troughs are

Floors ≥ 100 µg/ft²
Window sills ≥ 500 µg/ft²
Window troughs ≥ 800 µg/ft²

for Section 403 Interim Guidance, and

Floors ≥ 50 µg/ft²
Window sills ≥ 250 µg/ft²

for Section 403 Proposed Rule.

No window trough standard was specified in Section 403 Proposed Rule.

The *lead hazard screen* standards for uncarpeted floors (or carpeted floors if uncarpeted floors are not available), and window trough samples are

Floors ≥ 50 µg/ft²
Window sills ≥ 250 µg/ft²
Window troughs ≥ 400 µg/ft²

for Section 403 Interim Guidance, and

Floors ≥ 25 $\mu g/ft^2$
Window sills ≥ 125 $\mu g/ft^2$

for Section 403 Proposed Rule.

Soil — The *risk assessment* standard for soil is ≥ 5000 ppm for Section 403 Interim Guidance, and ≥ 2000 ppm for Section 403 Proposed Rule

Note: This is the lowest level at which any intervention is recommended.

Paint — Section 402 defines lead-based paint as paint or other surface coatings that contain lead equal to or in excess of 1.0 mg/cm^2 or more than 0.5% by weight. Under the Section 403 Interim Guidance, any surface with deteriorated paint must be tested to see if there is lead-based paint. The Section 403 Proposed Rule requires that areas where 1) ≥ 2 ft^2 deteriorated for large interior components; 2) ≥ 10 ft^2 deteriorated for large exterior components; and 3) ≥ 10% of the surface deteriorated for small components must be tested for lead-based paint.

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APPENDIX F
Data Set Criteria

APPENDIX F

Data Set Criteria

The following are criteria to be used to evaluate the usefulness of available data sets in the assessment of section 402 risk assessment protocols. Optimally a data set will meet all the criteria. However, some analyses may not require all media. Therefore a data set may be accepted for analysis based on a subset of the criteria listed below.

General Information

1. Report the date of blood sampling.
2. Report the date of environmental sampling.
3. Report the length of time the child has lived in the home (3 or more months).

Blood

1. Pre-intervention blood-lead concentration for at least one child in a home with the child's age being between 6 months and 6 years.
2. Report the blood sampling technique (venous puncture or finger stick)

Dust

1. Report the lead loadings for the dust samples.
2. All samples taken at the time of or following the blood sampling but prior to any intervention activities.
3. More than two sampling locations (children's primary play area, kitchen, bedroom, etc.)
4. Sampling components must include uncarpeted floors (carpeted floors if no uncarpeted floors available) or window sills.

5. Six or more single samples from components in at least two locations OR Multiple composite samples (at least two composite samples from uncarpeted floors or two from window sills. If uncarpeted floors cannot be sampled then at least two composite samples from carpeted floors).

6. Sampling technique must be wipe.

7. Report the lab analysis technique for the wipes

8. Report the LOD for the samples.

Soil

1. Report the lead levels for the soil samples.

2. All samples taken at the time of or following the blood sampling but prior to any intervention activities.

3. At least one composite sample from the child's principal play area and a second composite sample from the buildings foundation. (Note: if it is reported that there is no bare soil then a soil sample will not be required).

4. Report the soil sampling technique (core or surface scraping).

5. Report ground covering information (Types of information include: bare, ground cover, % covered, etc.). Note: This is not a make or break requirement. This is the type of information a risk assessor will be collecting. If the information is not reported then an assumption might be made that the soil samples were taken from bare areas.

6. Report the lab analysis techniques for the composite soil samples.

7. Report the LOD for the samples.

Paint

1. Report the lead levels of the paint samples.

2. All samples taken prior to any interventions.

3. Report the sampling locations (interior or exterior first and then bedroom, living room, side of house, etc).

4. Report the components sampled (walls, window sills, window troughs, etc) and be able to associate with a sampling location.

5. Report the sampling technique (XRF or bulk (paint scrapings)). If paint chip sampling is used, report whether a composite sample or a single sample.

6. Report the condition of the paint (poor, % deteriorated or ft^2 deteriorated, etc.).

APPENDIX G

Summary Tables and Figures

Table G-1. Average Cost Per Sample and Average Number of Samples Collected for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, and Risk Assessment/Inspection for Agency NE-1.

Media	Type of Sample	Cost Per Sample ($) Minimum Cost – Maximum Cost			Number of Samples Collected
		Collection Cost	Analysis Cost	Total Cost	
Dust	Composite	(a)	(a)	(a)	(b)
	Single	(a)	$15.00 $15.00 – $15.00	$15.00 $15.00 – $15.00	4.3 3 – 5
Paint	Paint Chips – Composite	(a)	(a)	(a)	(b)
	Paint Chips – Single	(a)	(a)	(a)	(b)
	XRF	(a)	(a)	(a)	(b)
Soil	Composite	(a)	$15.00 $15.00 – $15.00	$15.00 $15.00 – $15.00	1 1 – 1
	Single	(a)	(a)	(a)	(b)
Water		(a)	$15.00 $15.00 – $15.00	$15.00 $15.00 – $15.00	1 1 – 1

[a] No cost was reported.
[b] The number of samples collected was not reported.

Table G-2. **Average Cost Per Sample and Average Number of Samples for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, Risk Assessment/Inspection for Agency NE-2.**

Media	Type of Sample	Cost Per Sample ($) Minimum Cost – Maximum Cost			Number of Samples Collected
		Collection Cost	Analysis Cost	Total Cost	
Dust	Composite	(a)	(a)	(a)	(b)
	Single	(a)	$10.00 $10.00 – $10.00	$10.00 $10.00 – $10.00	7.7 6 – 10
Paint	Paint Chips – Composite	(a)	(a)	(a)	(b)
	Paint Chips – Single	(a)	(a)	(a)	(b)
	XRF	(a)	(a)	(a)	225 200 – 250
Soil	Composite	(a)	$10.67 $10.00 – $12.00	$10.67 $10.00 – $12.00	1.5 1 – 2
	Single	(a)	(a)	(a)	(b)
Water		(a)	$10.00 $10.00 – $10.00	$10.00 $10.00 – $10.00	(b)

[a] No cost was reported.
[b] The number of samples collected was not reported.

Table G-3. Average Cost Per Sample and Average Number of Samples for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, Risk Assessment/Inspection for Agency NE-3.

Media	Type of Sample	Cost Per Sample ($) Minimum Cost – Maximum Cost			Number of Samples Collected
		Collection Cost	Analysis Cost	Total Cost	
Dust	Composite	$10.00 $10.00 – $10.00	$15.00 $15.00 – $15.00	$25.00 $25.00 – $25.00	5.5 3 – 8
	Single	$10.00 $10.00 – $10.00	$15.00 $15.00 – $15.00	$25.00 $25.00 – $25.00	5.5 3 – 8
Paint	Paint Chips – Composite	(a)	(a)	(a)	(b)
	Paint Chips – Single	(a)	(a)	(a)	(b)
	XRF	(a)	(a)	(a)	65 65 – 65
Soil	Composite	$15.00 $15.00 – $15.00	$10.00 $10.00 – $10.00	$25.00 $25.00 – $25.00	3 2 – 4
	Single	(a)	(a)	(a)	(b)
Water		$15.00 $15.00 – $15.00	$10.00 $10.00 – $10.00	$25.00 $25.00 – $25.00	(b)

[a] No cost was reported.
[b] The number of samples collected was not reported.

Table G-4. Average Cost Per Sample and Average Number of Samples for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, Risk Assessment/Inspection for Agency NE-4.

Media	Type of Sample	Cost Per Sample ($) Minimum Cost – Maximum Cost			Number of Samples Collected
		Collection Cost	Analysis Cost	Total Cost	
Dust	Composite	(a)	(a)	(a)	(b)
	Single	(a)	$20.00 $20.00 – $20.00	$20.00 $20.00 – $20.00	7 7 – 7
Paint	Paint Chips – Composite	(a)	(a)	(a)	(b)
	Paint Chips – Single	(a)	(a)	(a)	10 10 – 10
	XRF	(a)	(a)	(a)	(b)
Soil	Composite	(a)	(a)	(a)	(b)
	Single	(a)	(a)	(a)	(b)
Water		(a)	(a)	(a)	(b)

[a] No cost was reported.
[b] The number of samples collected was not reported.

Table G-5. Average Cost Per Sample and Average Number of Samples for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, Risk Assessment/Inspection for Agency S-1.

Media	Type of Sample	Cost Per Sample ($) Minimum Cost – Maximum Cost			Number of Samples Collected
		Collection Cost	Analysis Cost	Total Cost	
Dust	Composite	(a)	(a)	(a)	(b)
	Single	(a)	$27.50 $25.00 – $30.00	$27.50 $25.00 – $30.00	22.5 20 – 25
Paint	Paint Chips – Composite	(a)	(a)	(a)	(b)
	Paint Chips – Single	(a)	(a)	(a)	(b)
	XRF	(a)	(a)	(a)	(b)
Soil	Composite	(a)	(a)	(a)	(b)
	Single	(a)	(a)	(a)	(b)
Water		(a)	(a)	(a)	(b)

[a] No cost was reported.
[b] The number of samples collected was not reported.

Table G-6. Average Cost Per Sample and Average Number of Samples for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, Risk Assessment/Inspection for Agency S-2.

Media	Type of Sample	Cost Per Sample ($) Minimum Cost – Maximum Cost			Number of Samples Collected
		Collection Cost	Analysis Cost	Total Cost	
Dust	Composite	(a)	(a)	(a)	(b)
	Single	(a)	$25.00 $25.00 – $25.00	$25.00 $25.00 – $25.00	7.3 2 – 10
Paint	Paint Chips – Composite	(a)	(a)	(a)	(b)
	Paint Chips – Single	(a)	(a)	(a)	(b)
	XRF	(a)	(a)	(a)	(b)
Soil	Composite	(a)	$25.00 $25.00 – $25.00	$25.00 $25.00 – $25.00	4 2 – 5
	Single	(a)	(a)	(a)	(b)
Water		(a)	(a)	(a)	(b)

[a] No cost was reported.
[b] The number of samples collected was not reported.

Table G-7. Average Cost Per Sample and Average Number of Samples for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, Risk Assessment/Inspection for Agency S-3.

Media	Type of Sample	Cost Per Sample ($) Minimum Cost – Maximum Cost			Number of Samples Collected
		Collection Cost	Analysis Cost	Total Cost	
Dust	Composite	(a)	$20.00 $20.00 – $20.00	$20.00 $20.00 – $20.00	6 6 – 6
	Single	(a)	$20.00 $20.00 – $20.00	$20.00 $20.00 – $20.00	7 6 – 8
Paint	Paint Chips – Composite	(a)	(a)	(a)	(b)
	Paint Chips – Single	(a)	(a)	(a)	(b)
	XRF	(a)	(a)	(a)	(b)
Soil	Composite	(a)	$20.00 $20.00 – $20.00	$20.00 $20.00 – $20.00	10 10 – 10
	Single	(a)	(a)	(a)	(b)
Water		(a)	(a)	(a)	(b)

[a] No cost was reported.
[b] The number of samples collected was not reported.

Table G-8. Average Cost Per Sample and Average Number of Samples for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, Risk Assessment/Inspection for Agency W-1.

Media	Type of Sample	Cost Per Sample ($) Minimum Cost – Maximum Cost			Number of Samples Collected
		Collection Cost	Analysis Cost	Total Cost	
Dust	Composite	(a)	(a)	(a)	(b)
	Single	(a)	$ 5.00 $ 5.00 – $ 5.00	$ 5.00 $ 5.00 – $ 5.00	4.5 3 – 5
Paint	Paint Chips – Composite	(a)	(a)	(a)	(b)
	Paint Chips – Single	(a)	(a)	(a)	(b)
	XRF	(a)	(a)	(a)	(b)
Soil	Composite	(a)	$ 5.00 $ 5.00 – $ 5.00	$ 5.00 $ 5.00 – $ 5.00	3 3 – 3
	Single	(a)	(a)	(a)	(b)
Water		(a)	$ 5.00 $ 5.00 – $ 5.00	$ 5.00 $ 5.00 – $ 5.00	(b)

[a] No cost was reported.
[b] The number of samples collected was not reported.

Table G-9. Average Cost Per Sample and Average Number of Samples for Sampling Performed by a Certified Risk Assessor During a Risk Assessment, Lead Hazard Screen, Inspection, Risk Assessment/Inspection for Agency W-2.

Media	Type of Sample	Cost Per Sample ($) Minimum Cost – Maximum Cost			Number of Samples Collected
		Collection Cost	Analysis Cost	Total Cost	
Dust	Composite	(a)	$15.00 $15.00 – $15.00	$15.00 $15.00 – $15.00	2 2 – 2
	Single	(a)	$15.00 $15.00 – $15.00	$15.00 $15.00 – $15.00	(b)
Paint	Paint Chips – Composite	(a)	(a)	(a)	(b)
	Paint Chips – Single	(a)	(a)	(a)	(b)
	XRF	(a)	(a)	(a)	(b)
Soil	Composite	(a)	$15.00 $15.00 – $15.00	$15.00 $15.00 – $15.00	1 1 – 1
	Single	(a)	(a)	(a)	(b)
Water		(a)	$15.00 $15.00 – $15.00	$15.00 $15.00 – $15.00	1 1 – 1

[a] No cost was reported.
[b] The number of samples collected was not reported.

Table G-10. Sampling Protocol A: Assessment of the Impact of the Number of Rooms in Which Dust Wipe Samples are Collected on the Outcome of a Full Risk Assessment, Using the Interim Guidance Standards (XRF Paint Samples from Surfaces With >15% Deteriorated Paint).

	Sampling Protocol Group A		
	A-1 (4 Rooms)	A-2 (3 Rooms)	A-3 (2 Rooms)
# Homes Included in Analysis	83	83	83
Number of Individual Dust Samples per Home	8-9	7	6
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	84.3%	83.1%	83.1%
% of Blood Samples ≥ 10 μg/dL	20.5%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	9.6% (8/83)	7.2% (6/83)	2.4%(2/83)
Carpeted Floors Only	3.9% (3/76)	3.9% (3/76)	1.3% (1/75)
Uncarpeted Floors Only	7.3% (6/82)	6.9% (4/58)	3.4% (1/29)
Window Sill	21.7% (18/83)	21.7% (18/83)	21.7% (18/83)
Window Well	81.9% (68/83)	80.7% (67/83)	80.7% (67/83)
Soil	7.8% (6/77)	7.8% (6/77)	7.8% (6/77)
Dripline Soil Only	7.8% (6/77)	7.8% (6/77)	7.8% (6/77)
Play Area Soil Only	0% (0/40)	0% (0/40)	0% (0/40)
Paint (> 15% deteriorated)	90.3% (28/31)	90.3% (28/31)	90.3% (28/31)
Performance Characteristics			
Sensitivity (LCB, UCB)	88.2% (63.6%, 98.5%)	88.2% (63.6%, 98.5%)	88.2% (63.6%, 98.5%)
Specificity (LCB, UCB)	16.7% (8.6%, 27.9%)	18.2% (9.8%, 29.6%)	18.2% (9.8%, 29.6%)
Positive Predictive Value (LCB, UCB)	21.4% (12.5%, 32.9%)	21.7% (12.7%, 33.3%)	21.7% (12.7%, 33.3%)
Negative Predictive Value (LCB, UCB)	84.6% (54.6%,98.1%)	85.7% (57.2%, 98.2%)	85.7% (57.2%, 98.2%)

Notes: 1. For 2, 3, and 4 rooms, respectively, 6, 7, and 8-9 dust wipe samples were obtained from floors, window sills, and window wells. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.

2. See Table 5-3 for definitions of sampling protocols A-1, A-2, and A-3.

Table G-11. Sampling Protocol A: Assessment of the Impact of the Number of Rooms in Which Dust Wipe Samples are Collected on the Outcome of a Full Risk Assessment, Using the Proposed Rule Standards (XRF Paint Samples from Surfaces With > 15% Deteriorated Paint).

	Sampling Protocol Group A		
	A-1 (4 Rooms)	**A-2 (3 Rooms)**	**A-3 (2 Rooms)**
# Homes Included in Analysis	83	83	83
Number of Individual Dust Samples per Home	8-9	7	6
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	60.2%	59.0%	57.8%
% of Blood Samples ≥ 10 μg/dL	20.5%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	10.8% (9/83)	9.6% (8/83)	4.8% (4/83)
Carpeted Floors Only	2.6% (2/76)	2.6% (2/76)	1.3% (1/75)
Uncarpeted Floors Only	9.8% (8/82)	12.1% (7/58)	10.3% (3/29)
Window Sill	28.9% (24/83)	28.9% (24/83)	28.9% (24/83)
Window Well	NA		
Soil (Average of average dripline and average play area)	27.3% (21/77)	27.3% (21/77)	27.3% (21/77)
Dripline Soil Only	NA		
Play Area Soil Only	NA		
Paint (> 15% deteriorated)	90.3% (28/31)	90.3% (28/31)	90.3% (28/31)
Performance Characteristics			
Sensitivity (LCB, UCB)	82.4% (56.6%, 96.2%)	76.5% (50.1%, 93.2%)	76.5% (50.1%, 93.2%)
Specificity (LCB, UCB)	45.5% (33.1%, 58.2%)	45.5% (33.1%, 58.2%)	47.0% (34.6%, 59.7%)
Positive Predictive Value (LCB, UCB)	28.0% (16.2%, 42.5%)	26.5% (14.9%, 41.1%)	27.1% (15.3%, 41.8%)
Negative Predictive Value (LCB, UCB)	90.9% (75.7%, 98.1%)	88.2% (72.5%, 96.7%)	88.6% (73.3%, 96.8%)

Notes: 1. For 2, 3, and 4 rooms, respectively, 6, 7, and 8-9 dust wipe samples were obtained from floors and window sills. Window well samples are not included in the Proposed Rule sampling scheme. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.

2. See Table 5-3 for definitions of sampling protocols A-1, A-2, and A-3.

3 NA indicates that these samples were not included in the analysis.

Table G-12. Sampling Protocol A: Assessment of the Impact of the Number of Rooms in Which Dust Wipe Samples are Collected, Using the Interim Guidance Standards (No Soil or Paint Sampling).

	Sampling Protocol Group A		
	A-1 (4 Rooms)	A-2 (3 Rooms)	A-3 (2 Rooms)
# Homes Included in Analysis	83	83	83
Number of Individual Dust Samples / Homes	8-9	7	6
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	81.9%	80.7%	80.7%
% of Blood Samples ≥ 10 μg/dL	20.5%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	9.6% (8/83)	7.2% (6/83)	2.4% (2/83)
Carpeted Floors Only	3.9% (3/76)	3.9% (3/76)	1.3% (1/75)
Uncarpeted Floors Only	7.3% (6/82)	6.9% (4/58)	3.4% (1/29)
Window Sill	21.7% (18/83)	21.7% (18/83)	21.7% (18/83)
Window Well	81.9% (68/83)	80.7% (67/83)	80.7% (67/83)
Soil	NA		
Dripline Soil Only	NA		
Play Area Soil Only	NA		
Paint	NA		
Performance Characteristics			
Sensitivity (LCB, UCB)	88.2% (63.6%, 98.5%)	88.2% (63.6%, 98.5%)	88.2% (63.6%, 98.5%)
Specificity (LCB, UCB)	19.7% (10.9%, 31.3%)	21.2% (12.1%, 33.0%)	21.2% (12.1%, 33.0%)
Positive Predictive Value (LCB, UCB)	22.1% (12.9%, 33.8%)	22.4% (13.1%, 34.2%)	22.4% (13.1%, 34.2%)
Negative Predictive Value (LCB, UCB)	86.7% (59.5%, 98.3%)	87.5% (61.7%, 98.4%)	87.5% (61.7%, 98.4%)

Notes:
1. For 2, 3, and 4 rooms, respectively, 6, 7, and 8-9 dust wipe samples were obtained from floors, window sills, and window wells.
2. See Table 5-3 for definitions of sampling protocols A-1, A-2, and A-3.
3 NA indicates that these samples were not included in the analysis.

Table G-13. Sampling Protocol A: Assessment of the Impact of the Number of Rooms in Which Dust Wipe Samples are Collected, Using the Proposed Rule Standards (No Soil or Paint Sampling).

	Sampling Protocol Group A		
	A-1 (4 Rooms)	**A-2 (3 Rooms)**	**A-3 (2 Rooms)**
# Homes Included in Analysis	83	83	83
Number of Individual Dust Samples / Homes	8-9	7	6
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	33.7%	32.5%	30.1%
% of Blood Samples ≥ 10 μg/dL	20.5		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	10.8% (9/83)	9.6% (8/83)	4.8% (4/83)
Carpeted Floors Only	2.6% (2/76)	2.6% (2/76)	1.3% (1/75)
Uncarpeted Floors Only	9.8% (8/82)	12.1% (7/58)	10.3% (3/29)
Window Sill	28.9 (24/83)	28.9% (24/83)	28.9% (24/83)
Window Well	NA		
Soil (Average of average dripline and average play area)	NA		
Dripline Soil Only	NA		
Play Area Soil Only	NA		
Paint	NA		
Performance Characteristics			
Sensitivity (LCB, UCB)	64.7% (38.3%, 85.8%)	58.8% (32.9%, 81.6%)	58.8% (32.9%, 81.6%)
Specificity (LCB, UCB)	74.2% (62.0%, 84.2%)	74.2% (62.0%, 84.2%)	77.3% (65.3%, 86.7%)
Positive Predictive Value (LCB, UCB)	39.3% (21.5%, 59.4%)	37.0% (19.4%, 57.6%)	40.0% (21.1%, 61.3%)
Negative Predictive Value (LCB, UCB)	89.1% (77.8%, 95.9%)	87.5% (75.9%, 94.8%)	87.9% (76.7%, 95.0%)

Notes:
1. For 2, 3, and 4 rooms, respectively, 6, 7, and 8-9 dust wipe samples were obtained from floors and window sills. Window well samples are not included in the Proposed Rule sampling scheme.
2. See Table 5-3 for definitions of sampling protocols A-1, A-2, and A-3.
3. NA indicates that these samples were not included in the analysis.

Table G-14. Sampling Protocol B: Comparison of Various Methods of Characterizing Dust Wipe Samples Obtained in a Full Risk Assessment, Using the Interim Guidance Standards (XRF Paint Samples from Surfaces With >15% Deteriorated Paint).

	Sampling Protocol Group B		
	B-1 (Geometric Mean)	**B-2 (Arithmetic Mean)**	**B-3 (Maximum Value)**
# Homes Included in Analysis	112	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	70.5%	78.6%	84.8%
% of Blood Samples ≥ 10 μg/dL	21.4%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	1.8% (2/112)	3.6% (4/112)	8.0% (9/112)
Carpeted Floors Only	0.0% (0/102)	1.0% (1/102)	3.9% (4/102)
Uncarpeted Floors Only	1.8% (2/109)	2.8% (3/109)	5.5% (6/109)
Window Sill	16.1% (18/112)	22.3% (25/112)	27.7% (31/112)
Window Well	67.9% (76/112)	75.9% (85/112)	83.0% (93/112)
Soil	7.6% (8/105)	7.6% (8/105)	7.6% (8/105)
Dripline Soil Only	7.7% (8/104)	7.7% (8/104)	7.7% (8/104)
Play Area Soil Only	0.0% (0/52)	0.0% (0/52)	0.0% (0/52)
Paint (> 15% deteriorated paint)	88.4% (38/44)	88.4% (38/44)	88.4% (38/44)
Performance Characteristics			
Sensitivity (LCB, UCB)	75.0% (53.3%, 90.2%)	83.3% (62.6%, 95.3%)	91.7% (73.0%, 99.0%)
Specificity (LCB, UCB)	30.7% (21.3%, 41.4%)	22.7% (14.5%, 32.9%)	17.0% (9.9%, 26.6%)
Positive Predictive Value (LCB, UCB)	22.8% (14.1%, 33.6%)	22.7% (14.5%, 32.9%)	23.2% (15.1%, 32.9%)
Negative Predictive Value (LCB, UCB)	81.8% (64.5%, 93.0%)	83.3% (62.6%, 95.3%)	88.2% (63.6%, 98.5%)

Notes:
1. Floor, window sill, and window well samples were collected as dust wipes. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. See Table 5-3 for definitions of sampling protocols A-1, A-2, and A-3.

Table G-15. Sampling Protocol B: Comparison of Various Methods of Characterizing Dust Wipe Samples Obtained in a Full Risk Assessment, Using the Proposed Rule Standards (XRF Paint Samples from Surfaces With >15% Deteriorated Paint).

	Sampling Protocol Group B		
	B-1 (Geometric Mean)	B-2 (Arithmetic Mean)	B-3 (Maximum Value)
# Homes Included in Analysis	112	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	56.3%	59.8%	69.6%
% of Blood Samples ≥ 10 μg/dL	21.4%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	5.4% (6/112)	8.9% (10/112)	19.6% (22/112)
Carpeted Floors Only	2.9% (3/102)	2.9% (3/102)	4.9% (5/102)
Uncarpeted Floors Only	3.7% (4/109)	7.3% (8/109)	16.5% (18/109)
Window Sill	28.6% (32/112)	32.1% (36/112)	49.1% (55/112)
Window Well	NA		
Soil (Average of average dripline and average play area)	27.6% (29/105)	27.6% (29/105)	27.6% (29/105)
Dripline Soil Only	NA		
Play Area Soil Only	NA		
Paint (> 15% deteriorated paint)	88.4% (38/43)	88.4% (38/43)	88.4% (38/43)
Performance Characteristics			
Sensitivity (LCB, UCB)	83.3% (62.6%, 95.3%)	87.5% (67.6%, 97.3%)	87.5% (67.6%, 97.3%)
Specificity (LCB, UCB)	51.1% (40.2%, 61.9%)	47.7% (37.0%, 58.6%)	35.2% (25.3%, 46.1%)
Positive Predictive Value (LCB, UCB)	31.7% (20.6%, 44.7%)	31.3% (20.6%, 43.8%)	26.9% (17.5%, 38.2%)
Negative Predictive Value (LCB, UCB)	91.8% (80.4%, 97.7%)	93.3% (81.7%, 98.6%)	91.2% (76.3%, 98.1%)

Notes:
1. Floor and window sill samples were collected as dust wipes. Window well samples are not included in the Proposed Rule sampling scheme. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. See Table 5-4 for definitions of sampling protocols B-1, B-2, and B-3.
3. NA indicates that these samples were not included in the analysis.

Table G-16. Sampling Protocol B: Comparison of Various Methods of Characterizing Dust Wipe Samples, Using the Interim Guidance Standards (No Soil or Paint Sampling).

	Sampling Protocol Group B		
	B-1 (Geometric Mean)	B-2 (Arithmetic Mean)	B-3 (Maximum Value)
# Homes Included in Analysis	112	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	67.9%	75.9%	83.0%
% of Blood Samples ≥ 10 μg/dL	21.4%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	1.8% (2/112)	3.6% (4/112)	8% (9/112)
Carpeted Floors Only	0% (0/102)	1% (1/102)	3.9% (4/102)
Uncarpeted Floors Only	1.8% (2/109)	2.8% (3/109)	5.5% (6/109)
Window Sill	16.1% (18/112)	22.3% (25/112)	27.7% (31/112)
Window Well	67.9% (76/112)	75.9% (85/112)	83% (93/112)
Soil	NA		
Dripline Soil Only	NA		
Play Area Soil Only	NA		
Paint	NA		
Performance Characteristics			
Sensitivity (LCB, UCB)	70.8% (48.9%, 87.4%)	79.2% (57.8%, 92.9%)	91.7% (73.0%, 99.0%)
Specificity (LCB, UCB)	33.0% (23.3%, 43.8%)	25.0% (16.4%, 35.4%)	19.3% (11.7%, 29.1%)
Positive Predictive Value (LCB, UCB)	22.4% (13.6%, 33.4%)	22.4% (14.0%, 32.7%)	23.7% (15.5%, 33.6%)
Negative Predictive Value (LCB, UCB)	80.6% (64.0%, 91.8%)	81.5% (61.9%, 93.7%)	89.5% (66.9%, 98.7%)

Notes:
1. Floor, window sill, and window well samples were collected as dust wipes. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis.
2. See Table 5-4 for definitions of sampling protocols B-1, B-2, and B-3.
3. NA indicates that these samples were not included in the analysis.

Table G-17. Sampling Protocol B: Comparison of Various Methods of Characterizing Dust Wipe Samples, Using the Proposed Rule Standards (No Soil or Paint Samples).

	Sampling Protocol Group B		
	B-1 (Geometric Mean)	**B-2 (Arithmetic Mean)**	**B-3 (Maximum Value)**
# Homes Included in Analysis	112	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	31.3%	35.7%	57.1%
% of Blood Samples ≥ 10 μg/dL	21.4%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	5.4% (6/112)	8.9% (10/112)	19.6% (22/112)
Carpeted Floors Only	2.9% (3/102)	2.9% (3/102)	4.9% (5/102)
Uncarpeted Floors Only	3.7% (4/109)	7.3% (8/109)	16.5% (18/109)
Window Sill	28.6% (32/112)	32.1% (36/112)	49.1% (55/112)
Window Well	NA		
Soil (Average of average dripline and average play area)	NA		
Dripline Soil Only	NA		
Play Area Soil Only	NA		
Paint	NA		
Performance Characteristics			
Sensitivity (LCB, UCB)	54.2% (32.8%, 74.4%)	62.5% (40.6%, 81.2%)	75% (53.3%, 90.2%)
Specificity (LCB, UCB)	75.0% (64.6%, 83.6%)	71.6% (61.0%, 80.7%)	47.7% (37%, 58.6%)
Positive Predictive Value (LCB, UCB)	37.1% (21.5%, 55.1%)	37.5% (22.7%, 54.2%)	28.1% (17.6%, 40.8%)
Negative Predictive Value (LCB, UCB)	85.7% (75.9%, 92.6%)	87.5% (77.6%, 94.1%)	87.5% (74.8%, 95.3%)

Notes:
1. Floor and window sill samples were collected as dust wipes. Window well samples are not included in the Proposed Rule sampling scheme. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis.
2. See Table 5-4 for definitions of sampling protocols B-1, B-2, and B-3.
3. NA indicates that these samples were not included in the analysis.

Table G-18. Sampling Protocol Group C: Comparison of Full Risk Assessment Outcome to a Lead Hazard Screen Outcome, Using the Interim Guidance Standards (XRF Paint Samples From Surfaces With >15% Deteriorated Paint).

	Sampling Protocol Group C	
	C-1 (Risk Assessment)	C-2 (Lead Hazard Screen)
# Homes Included in Analysis	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	84.8%	83.0%
% of Blood Samples ≥ 10 μg/dL	21.4%	
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)		
All Floors	8.0% (9/112)	8.9% (10/112)
Carpeted Floors Only	3.9% (4/102)	2.9% (3/102)
Uncarpeted Floors Only	5.5% (6/109)	7.3% (8/109)
Window Sill	27.7% (31/112)	NA
Window Well	83.0% (93/112)	82.1% (92/112)
Soil	7.6% (8/105)	NA
Dripline Soil Only	7.7% (8/104)	NA
Play Area Soil Only	0% (0/52)	NA
Paint (> 15% deteriorated paint)	88.4% (38/43)	88.4% (38/43)
Performance Characteristics		
Sensitivity (LCB, UCB)	91.7% (73.0%, 99.0%)	87.5% (67.6%, 97.3%)
Specificity (LCB, UCB)	17.0% (9.9%, 26.6%)	18.2% (9.9%, 26.6%)
Positive Predictive Value (LCB, UCB)	23.2% (15.1%, 32.9%)	22.6% (14.6%, 32.4%)
Negative Predictive Value (LCB, UCB)	88.2% (63.6%, 98.5%)	84.2% (60.4%, 96.6%)

Notes: 1. Floor, window sill, and window well samples were collected as dust wipes. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. See Table 5-5 for definitions of sampling protocols C-1 and C-2.
3. NA indicates that these samples were not included in the analysis.

Table G-19. Sampling Protocol Group C: Comparison of Full Risk Assessment Outcome to a Lead Hazard Screen Outcome, Using the Proposed Rule Standards (XRF Paint Samples From Surfaces With >15% Deteriorated Paint).

	Sampling Protocol Group C	
	C-1 (Risk Assessment)	C-2 (Lead Hazard Screen)
# Homes Included in Analysis	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	59.8%	44.6%
% of Blood Samples ≥ 10 μg/dL	21.4%	
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)		
All Floors	8.9% (10/112)	30.4% (34/112)
Carpeted Floors Only	2.9% (3/102)	10.8% (11/102)
Uncarpeted Floors Only	7.3% (8/109)	26.6% (29/109)
Window Sill	32.1% (36/112)	NA
Window Well	NA	NA
Soil (Average of average dripline and average play area)	27.6% (29/105)	NA
Dripline Soil Only	NA	NA
Play Area Soil Only	NA	NA
Paint (> 15% deteriorated paint)	88.4% (38/43)	88.4% (38/43)
Performance Characteristics		
Sensitivity (LCB, UCB)	87.5% (67.6%, 97.3%)	70.8% (48.9%, 87.4%)
Specificity (LCB, UCB)	47.7% (37.0%, 58.6%)	62.5% (51.5%, 72.6%)
Positive Predictive Value (LCB, UCB)	31.3% (20.6%, 43.8%)	34.0% (21.2%, 48.8%)
Negative Predictive Value (LCB, UCB)	93.3% (81.7%, 98.6%)	88.7% (78.0%, 95.3%)

Notes:
1. Floor and window sill samples were collected as dust wipes. Window well samples are not included in the Proposed rule sampling scheme. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. See Table 5-5 for definitions of sampling protocols C-1 and C-2.
3. NA indicates that these samples were not included in the analysis.

Table G-20. Sampling Protocol B: Comparison of Various Methods of Characterizing Dust Wipe Samples, Using the Interim Guidance Standards (No Window Well or Paint Sampling).

	Sampling Protocol Group B		
	B-1 (Geometric Mean)	B-2 (Arithmetic Mean)	B-3 (Maximum Value)
# Homes Included in Analysis	112	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	22.3%	29.5%	36.6%
% of Blood Samples ≥ 10 μg/dL	21.4%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	1.8% (2/112)	3.6% (4/112)	8% (9/112)
Carpeted Floors Only	0% (0/102)	1% (1/102)	3.9% (4/102)
Uncarpeted Floors Only	1.8% (2/109)	2.8% (3/109)	5.5% (6/109)
Window Sill	16.1% (18/112)	22.3% (25/112)	27.7% (31/112)
Window Well	NA		
Soil	7.6% (8/105)	7.6% (8/105)	7.6% (8/105)
Dripline Soil Only	7.7% (8/104)	7.7% (8/104)	7.7% (8/104)
Play Area Soil Only	0% (0/52)	0% (0/52)	0% (0/52)
Paint	NA		
Performance Characteristics			
Sensitivity (LCB, UCB)	33.3% (15.6%, 55.3%)	45.8% (25.6%, 67.2%)	58.3% (36.6%, 77.9%)
Specificity (LCB%, UCB)	80.7% (70.9%, 88.3%)	75% (64.6%,.0 83.6%)	69.3% (58.6%, 78.7%)
Positive Predictive Value (LCB%, UCB)	32.0% (14.9%, 53.5%)	33.3% (18%, 51.8%)	34.1% (20.1%, 50.6%)
Negative Predictive Value (LCB%, UCB)	81.6% (71.9%, 89.1%)	83.5% (73.5%, 90.9%)	85.9% (75.6%, 93%)

Notes:
1. Floor and window sill samples were collected as dust wipes. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample.
2. See Table 5-4 for definitions of sampling protocols B-1, B-2, and B-3.
3. NA indicates that these samples were not included in the analysis.

Table G-21. Sampling Protocol Group B: Comparison of Various Methods of Characterizing Dust Wipe Samples, Using the Proposed Rule Standards (No Window Well or Paint Samples).

	Sampling Protocol Group B		
	B-1 (Geometric Mean)	B-2 (Arithmetic Mean)	B-3 (Maximum Value)
# Homes Included in Analysis	112	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	48.2%	52.7%	67.0%
% of Blood Samples ≥ 10 μg/dL	21.4%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	5.4% (6/112)	8.9% (10/112)	19.6% (22/112)
Carpeted Floors Only	2.9% (3/102)	2.9% (3/102)	4.9% (5/102)
Uncarpeted Floors Only	3.7% (4/109)	7.3% (8/109)	16.5% (18/109)
Window Sill	28.6% (32/112)	32.1% (36/112)	49.1% (55/112)
Window Well	NA		
Soil (Average of average dripline and average play area)	27.6% (29/105)	27.6% (29/105)	27.6% (29/105)
Dripline Soil Only	NA		
Play Area Soil Only	NA		
Paint	NA		
Performance Characteristics			
Sensitivity (LCB, UCB)	79.2% (57.8%, 92.9%)	87.5% (67.6%, 97.3%)	87.5% (67.6%, 97.3%)
Specificity (LCB%, UCB)	60.2% (49.2%, 70.5%)	56.8% (45.8%, 67.3%)	38.6% (28.4%, 49.6%)
Positive Predictive Value (LCB%, UCB)	35.2% (22.7%, 49.4%)	35.6% (23.6%, 49.1%)	28.0% (18.2%, 39.6%)
Negative Predictive Value (LCB%, UCB)	91.4% (81.0%, 97.1%)	94.3% (84.3%, 98.8%)	91.9% (78.1%, 98.3%)

Notes:
1. Floor and window sill samples were collected as dust wipes. Window well samples are not included in the Proposed Rule sampling scheme. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample.
2. See Table 5-4 for definitions of sampling protocols B-1, B-2, and B-3.
3. NA indicates that these samples were not included in the analysis.

Table G-22. **Sampling Protocol Group B: Comparison of Various Methods of Characterizing Dust Wipe Samples, Using the Interim Guidance Standards (No Paint Samples).**

	Sampling Protocol Group B		
	B-1 (Geometric Mean)	**B-2 (Arithmetic Mean)**	**B-3 (Maximum Value)**
# Homes Included in Analysis	112	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	69.6%	77.7%	83.9%
% of Blood Samples ≥ 10 µg/dL	21.4%		
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)			
All Floors	1.8% (2/112)	3.6% (4/112)	8% (9/112)
Carpeted Floors Only	0% (0/102)	1% (1/102)	3.9% (4/102)
Uncarpeted Floors Only	1.8% (2/109)	2.8% (3/109)	5.5% (6/109)
Window Sill	16.1% (18/112)	22.3% (25/112)	27.7% (31/112)
Window Well	67.9% (76/112)	75.9% (85/112)	83% (93/112)
Soil	7.6% (8/105)	7.6% (8/105)	7.6% (8/105)
Dripline Soil Only	7.7% (8/104)	7.7% (8/104)	7.7% (8/104)
Play Area Soil Only	0% (0/52)	0% (0/52)	0% (0/52)
Paint	NA		
Performance Characteristics			
Sensitivity (LCB, UCB)	75% (53.3%, 90.2%)	83.3% (62.6%, 95.3%)	91.7% (73.0%, 99.0%)
Specificity ((LCB%, UCB)	31.8% (22.3%, 42.6%)	23.9% (15.4%, 34.1%)	18.2% (10.8%, 27.8%)
Positive Predictive Value ((LCB%, UCB)	23.1% (14.3%, 34%)	23.0% (14.6%, 33.2%)	23.4% (15.3%, 33.3%)
Negative Predictive Value ((LCB%, UCB)	82.4% (65.5%, 93.2%)	84.0% (63.9%, 95.5%)	88.9% (65.3%, 98.6%)

Notes: 1. Floor, window sill, and window well samples were collected as dust wipes. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three core soil samples were taken on each side of the house (in general there were 12 core samples) and combined for a composite sample.

2. See Table 5-4 for definitions of sampling protocols B-1, B-2, and B-3.

3. NA indicates that these samples were not included in the analysis.

Table G-23. Sampling Protocol C: Comparison of Lead Hazard Screen Outcome, Using the Interim Guidance Standards and the Proposed Rule Standards (XRF Paint Samples From Surfaces With ≥5% Deteriorated Paint).

	Sampling Protocol Group C (Lead Hazard Screen)	
	Interim Guidance	**Proposed Rule**
# Homes Included in Analysis	112	112
% of Homes in Which Lead-Based Paint Hazards Were Found (# Homes Below Standards / # Homes)	83.9%	67.0%
% of Blood Samples ≥ 10 μg/dL	21.4%	
% of Homes in Which Lead-Based Paint Hazards Were Found Based on Media Standards (# of Homes Below Media Standards / # Homes in Which Samples Were Collected)		
All Floors	8.9% (10/112)	30.4% (34/112)
Carpeted Floors Only	2.9% (3/102)	10.8% (11/102)
Uncarpeted Floors Only	7.3% (8/109)	26.6% (29/109)
Window Sill	NA	64.3% (72/112)
Window Well	82.1 (92/112)	NA
Soil	NA	NA
Dripline Soil Only	NA	NA
Play Area Soil Only	NA	NA
Paint (≥ 5% deteriorated)	77.3% (68/88)	77.3% (68/88)
Performance Characteristics		
Sensitivity (LCB, UCB)	87.5% (67.6%, 97.3%)	91.7% (73%, 99%)
Specificity (LCB, UCB)	17.0% (9.9%, 26.6%)	25.0% (16%, 35%)
Positive Predictive Value (LCB, UCB)	22.3% (14.4%, 32.1%)	25.0% (16%, 35%)
Negative Predictive Value (LCB, UCB)	83.3% (58.6%, 96.4%)	91.7% (73%, 99%)

Notes:
1. Floor, window sill, and window well samples were collected as dust wipes. All available dust samples (wipe) taken in the bedroom, play area, entryway, and kitchen were included in the analysis. Three XRF paint-lead measurements were taken from various surfaces, and the three measurements for each surface were averaged.
2. NA indicates that these samples were not included in the analysis.

APPENDIX H

Summary Error Probability Tables and Graphs for the Interim Guidance Standards

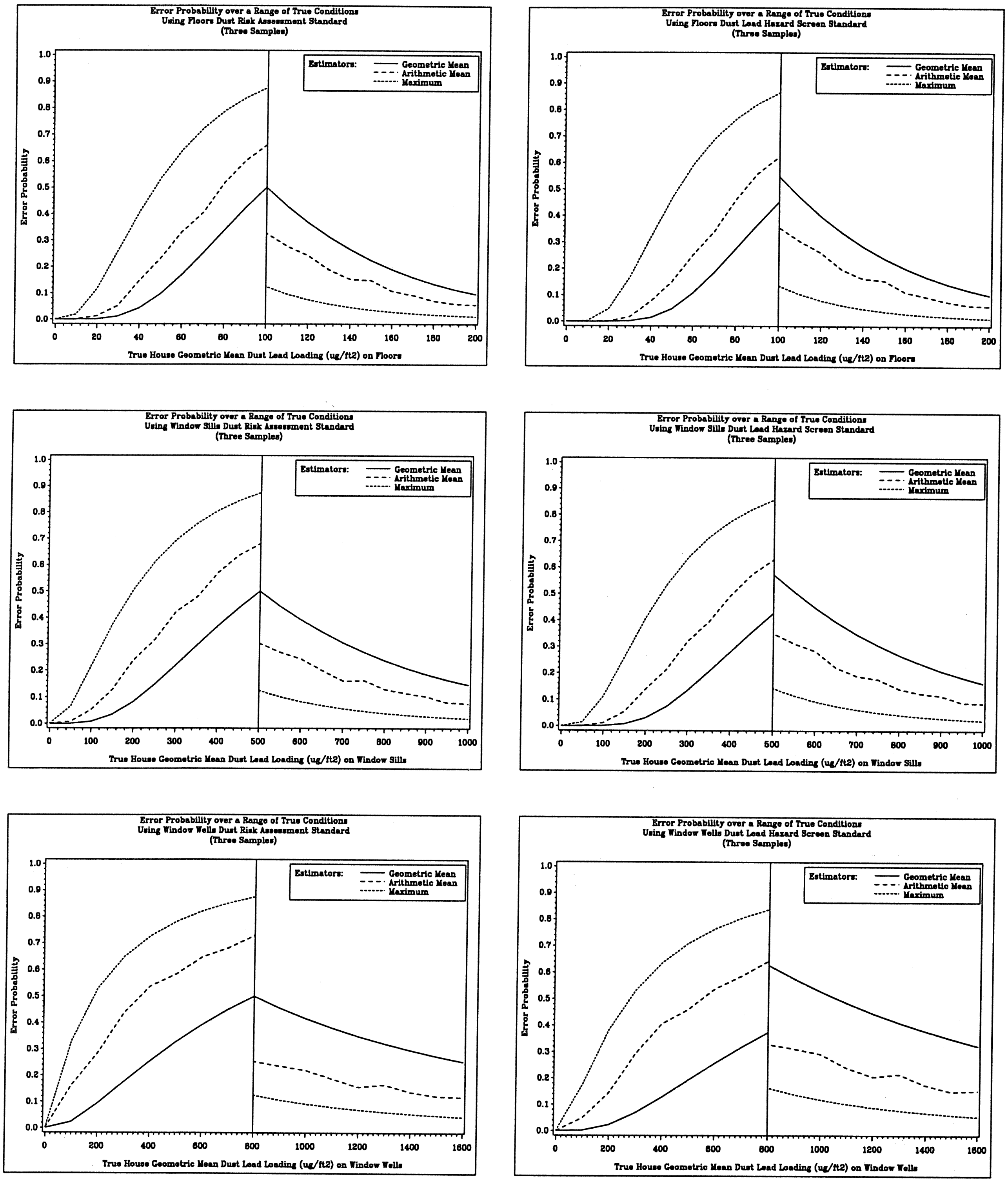


Figure H-1. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Three Floor, Window Sill, and Window Well Dust Samples Using the Interim Guidance Standards – Variance Components from the Rochester Study Lead-In-Dust Study Homes.

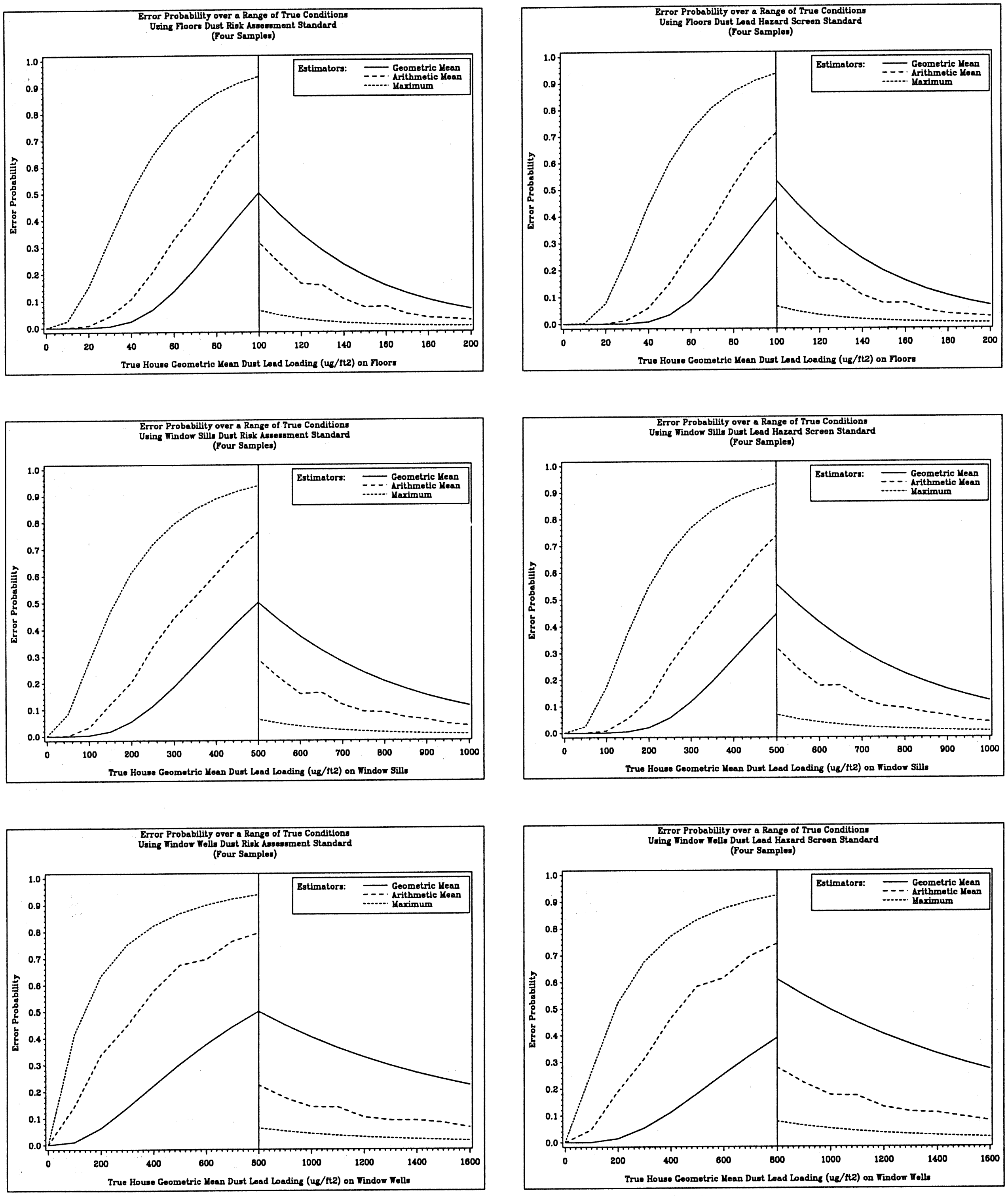


Figure H-2. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Four Floor, Window Sill, and Window Well Dust Samples</u> Using the Interim Guidance Standards – Variance Components from the Rochester Lead-In-Dust Study Data.

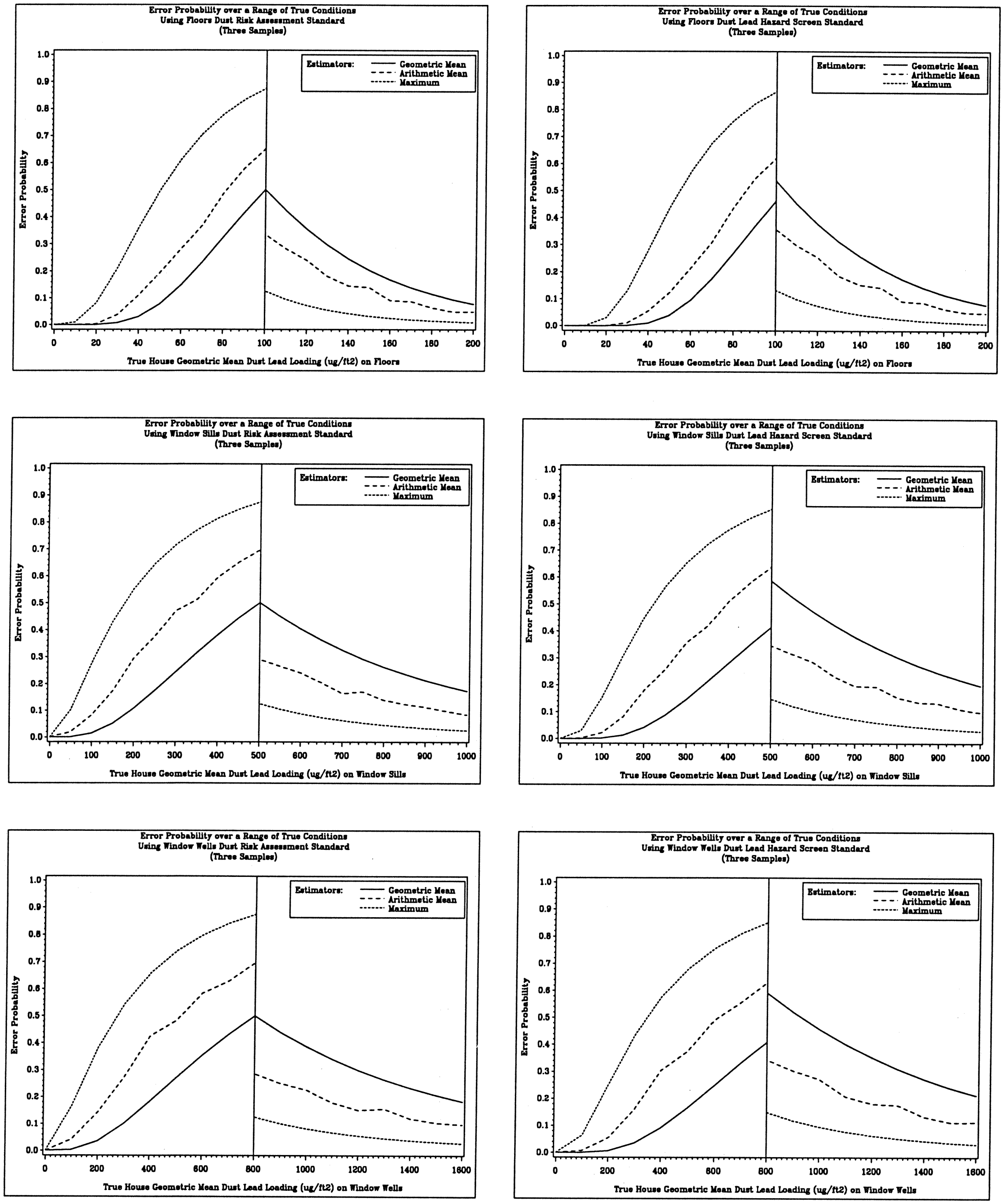


Figure H-3. **Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Three Floor, Window Sill, and Window Well Dust Samples Using the – Interim Guidance Standards – Variance Components from the Rhode Island Department of Health Homes.**

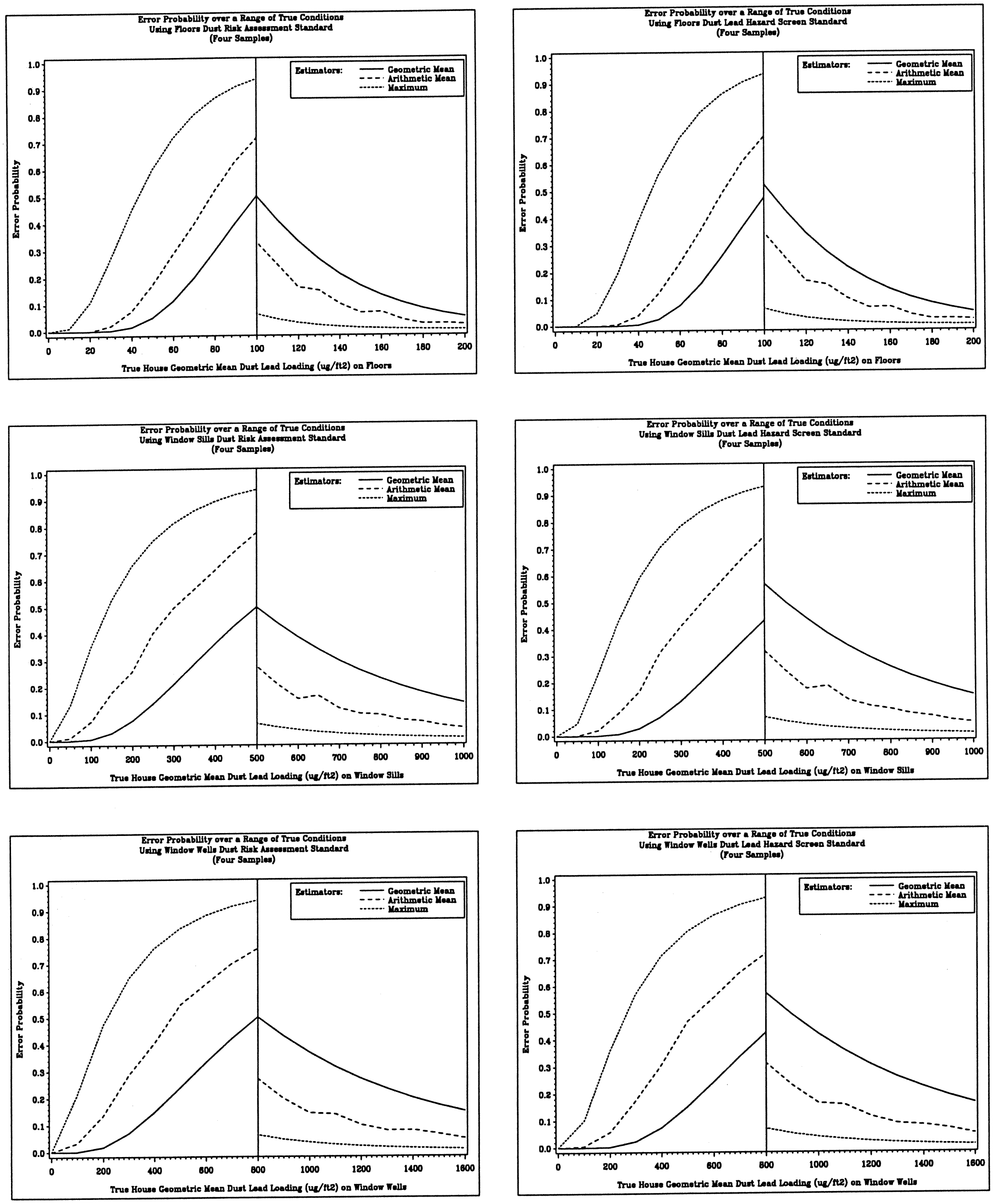


Figure H-4. **Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Four Floor, Window Sill, and Window Well Dust Samples</u> Using the Interim Guidance Standards – Variance Components from the Rhode Island Department of Health Homes.**

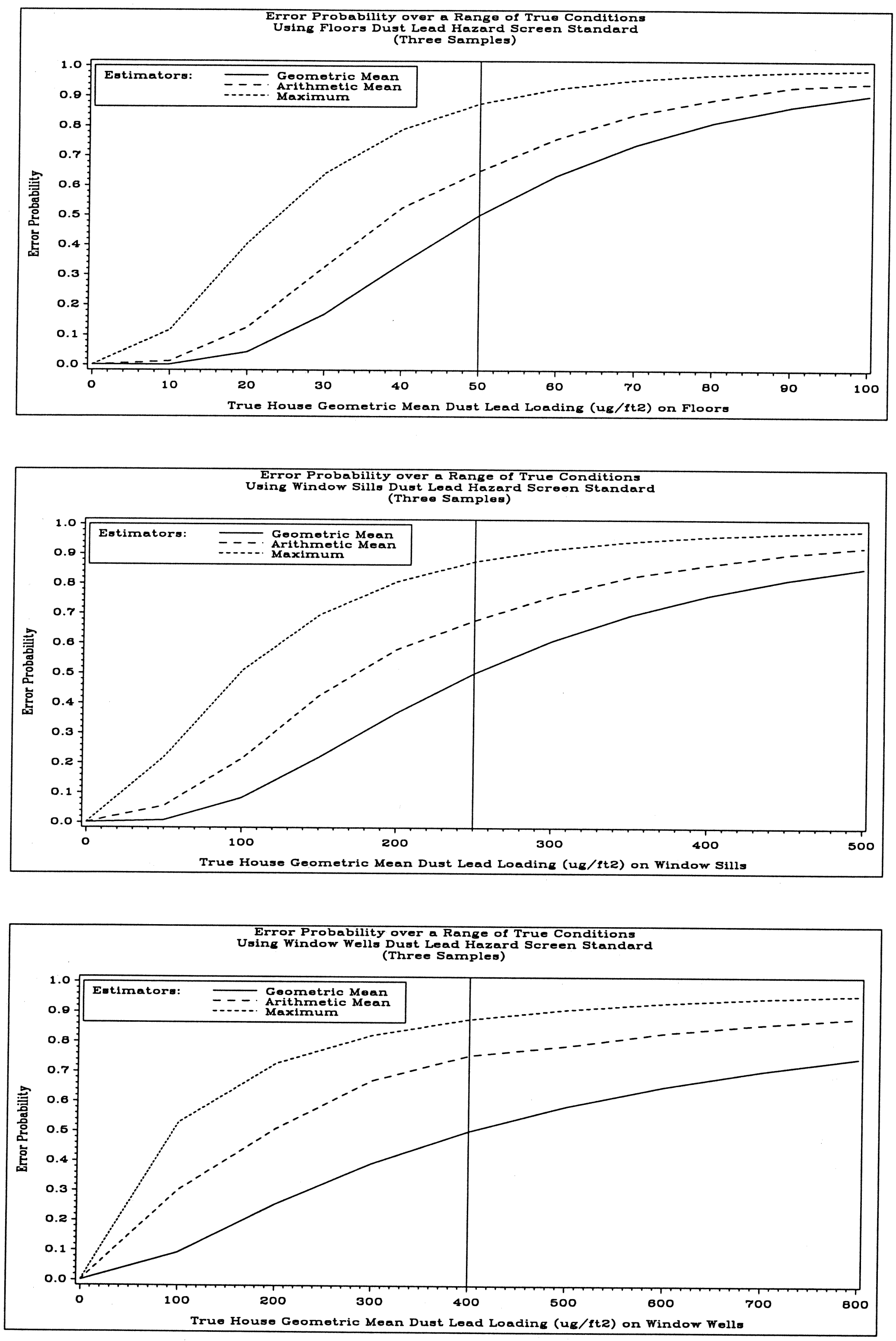
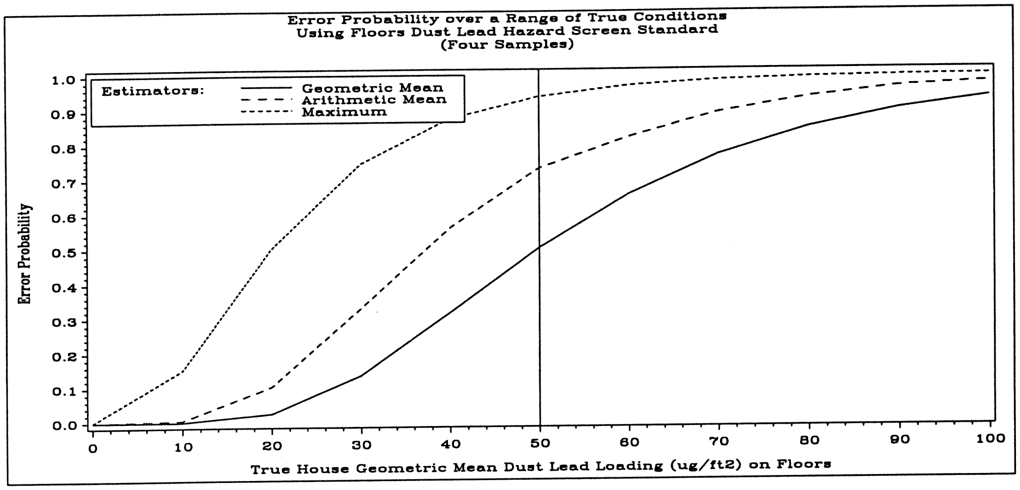
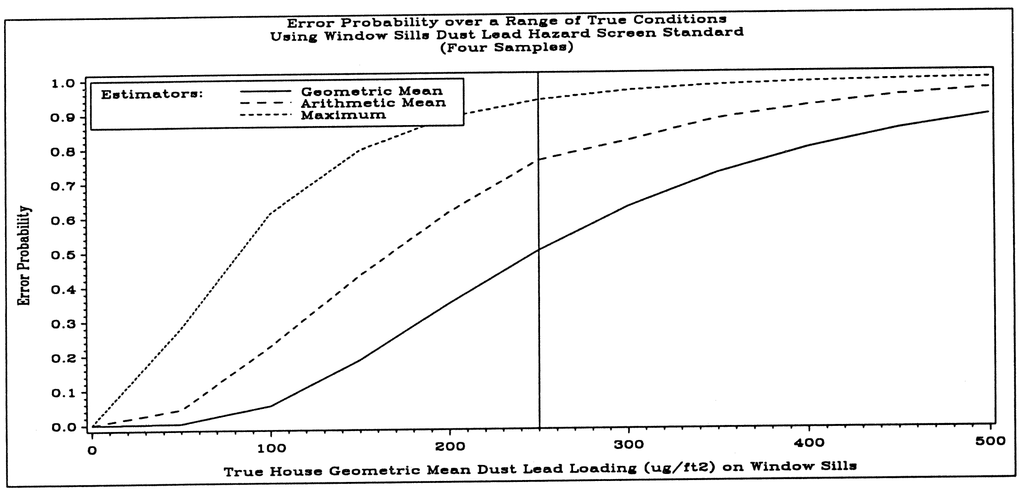


Figure H-5. **Comparison of "Simple" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Three Floor and Window Well Dust Samples Using the Interim Guidance Standards – Variance Components from the Rochester Lead-In-Dust Study Homes.**





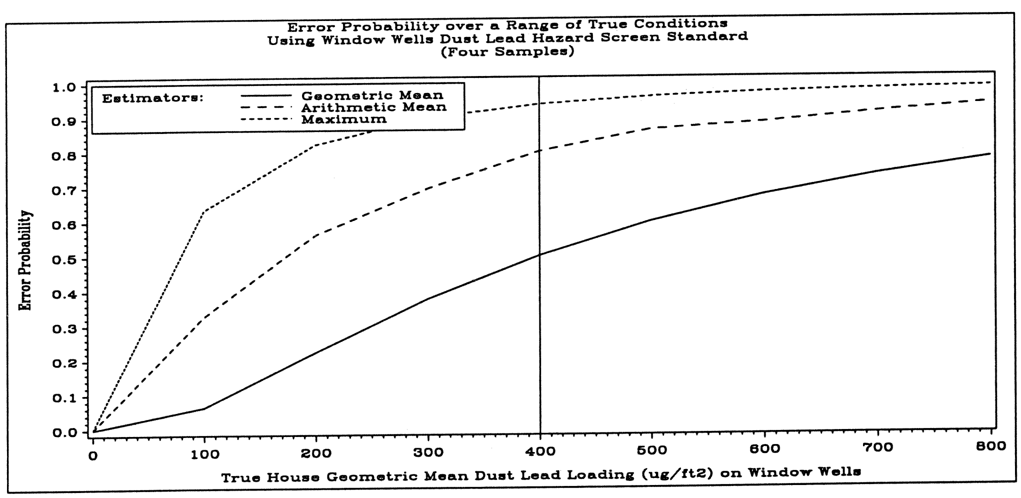
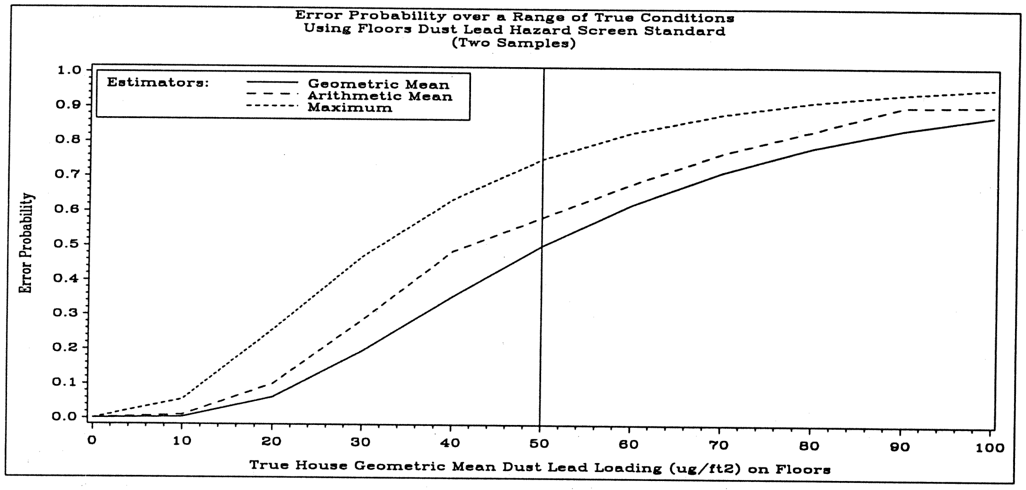
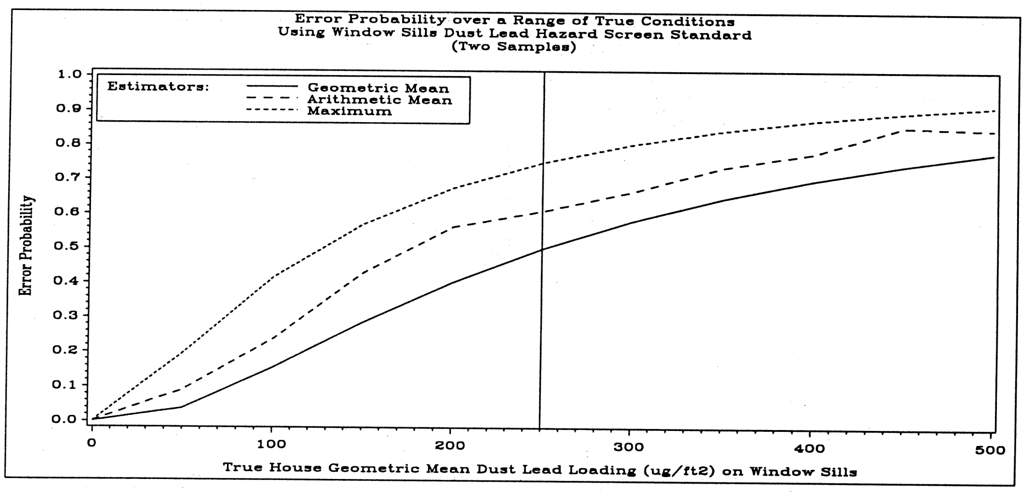


Figure H-6. **Comparison of "Simple" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Four Floor and Window Well Dust Samples</u> Using the Interim Guidance Standards – Variance Components from the Rochester Lead-In-Dust Study Homes.**





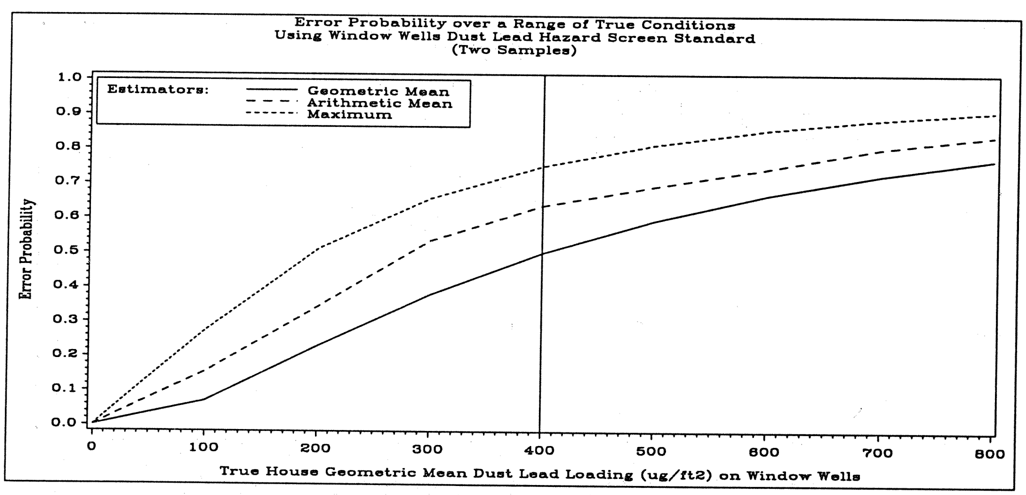
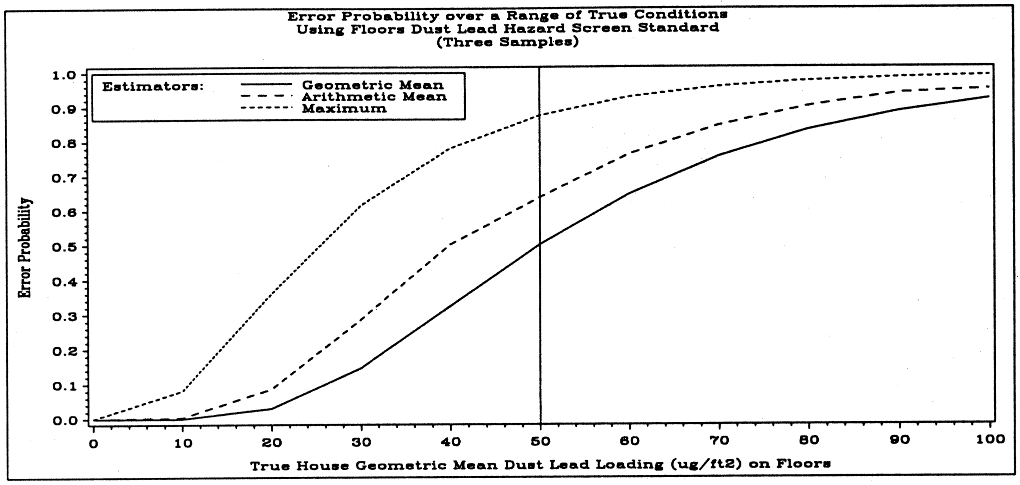
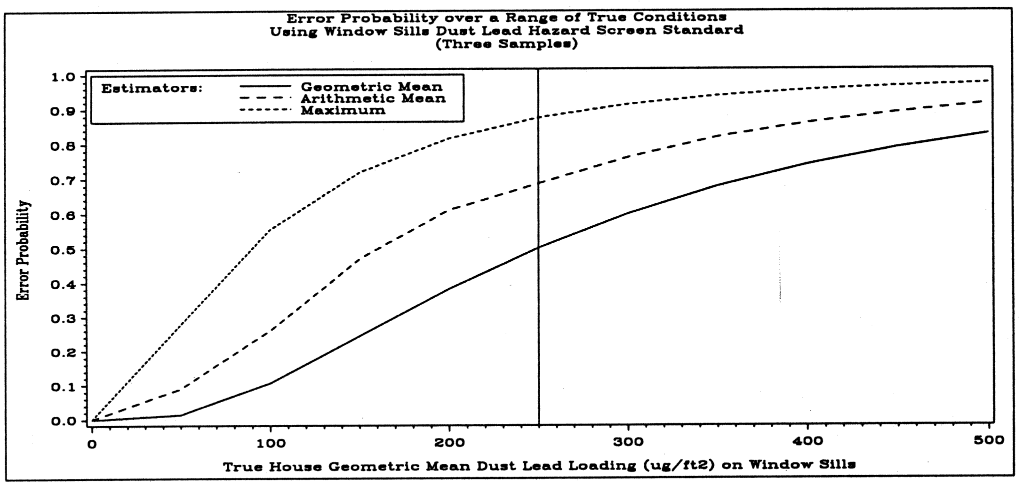


Figure H-7. Comparison of "Simple" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Two Floor and Window Well Samples Using the Interim Guidance Standards – Variance Components from the Rhode Island Department of Health Data.





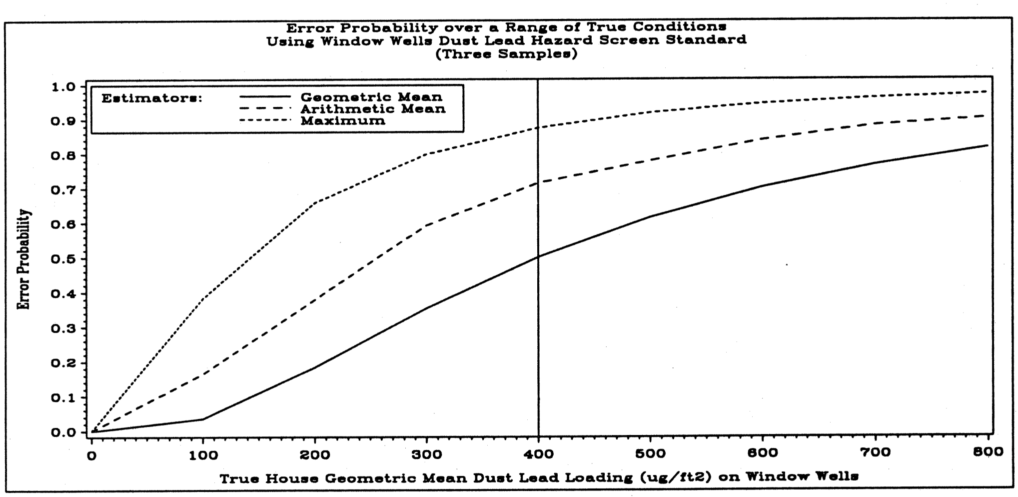
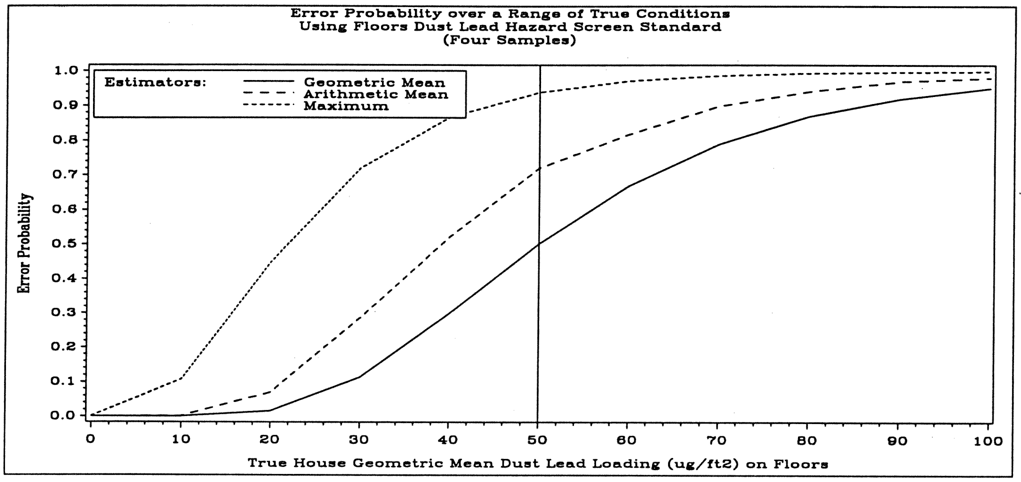
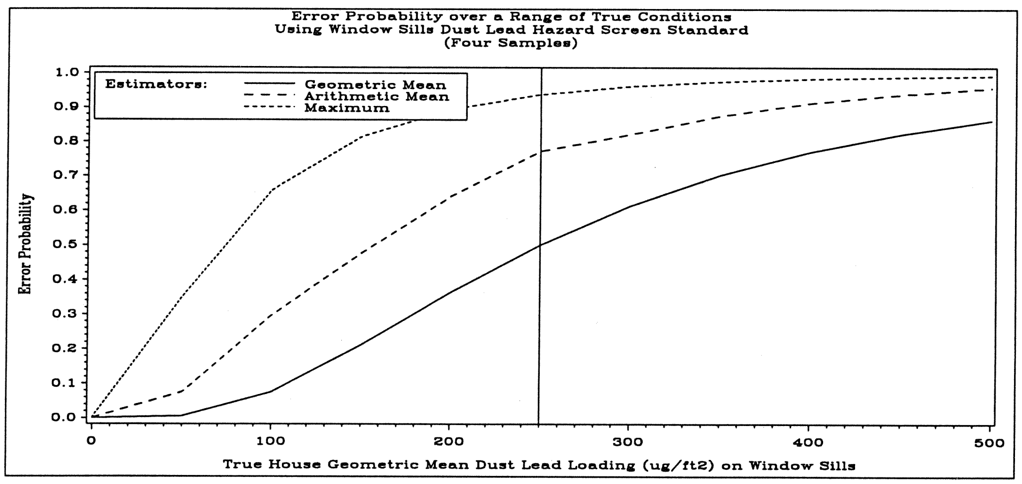


Figure H-8. **Comparison of "Simple" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Three Floor and Window Well Dust Samples</u> Using the Interim Guidance Standards – Variance Components from the Rhode Island Department of Health Data.**





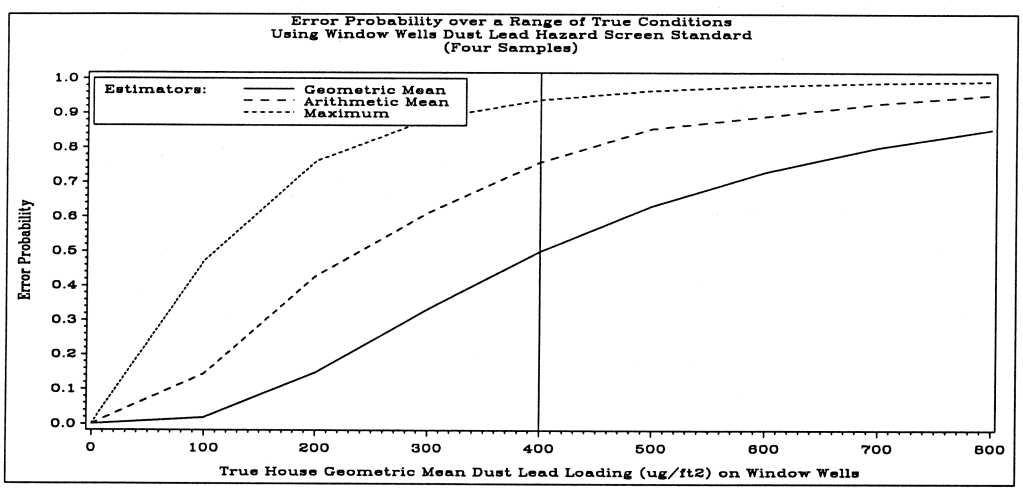


Figure H-9. Comparison of "Simple" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Four Floor and Window Well Dust Samples Using the Interim Guidance Standards – Variance Components from the Rhode Island Department of Health Data.

Table H-1. **Comparison of Risk Assessment and "Compound" Lead Hazard Screen Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Levels for the Two, Three, and Four Floor Dust Samples Using the Interim Guidance Standards [1] – Variance Components from the Rhode Island Department of Health Data.**

Assessment	Number of Samples	Assumed "True" House Floor Dust Lead Loading (µg/ft²)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
"Compound" Lead Hazard Screen	2	50	0.120	0.061	0.276	.	.	.
		100	0.538	0.439	0.718	0.466	0.561	0.282
		200	.	.	.	0.097	0.131	0.044
	3	50	0.122	0.038	0.435	.	.	.
		100	0.621	0.462	0.867	0.358	0.538	0.133
		200	.	.	.	0.048	0.079	0.009
	4	50	0.124	0.025	0.563	.	.	.
		100	0.703	0.475	0.936	0.345	0.525	0.064
		200	.	.	.	0.021	0.050	0.002
Risk Assessment	2	50	0.207	0.122	0.368	.	.	.
		100	0.593	0.500	0.750	0.411	0.500	0.250
		200	.	.	.	0.092	0.122	0.042
	3	50	0.192	0.077	0.498	.	.	.
		100	0.652	0.500	0.875	0.334	0.500	0.125
		200	.	.	.	0.048	0.077	0.009
	4	50	0.172	0.050	0.601	.	.	.
		100	0.717	0.500	0.938	0.329	0.500	0.063
		200	.	.	.	0.020	0.050	0.002

[1] The floor dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 100 µg/ft² for the risk assessment and 50 µg/ft² for the lead hazard screen.

Table H-2. **Comparison of Risk Assessment Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Levels for <u>Two, Three, and Four Window Sill Dust Samples</u> Using the Interim Guidance Standards[1] – Variance Components from the Rhode Island Department of Health Data.**

Assessment	Number of Samples	Assumed "True" House Window Sill Dust Lead Loading ($\mu g/ft^2$)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
"Compound" Lead Hazard Screen	2	250	0.205	0.110	0.375	.	.	.
		500	0.526	0.390	0.686	0.481	0.610	0.314
		1,000	.	.	.	0.185	0.268	0.103
	3	250	0.257	0.086	0.566	.	.	.
		500	0.638	0.414	0.853	0.345	0.586	0.147
		1,000	.	.	.	0.097	0.197	0.028
	4	250	0.311	0.069	0.703	.	.	.
		500	0.745	0.431	0.931	0.317	0.569	0.069
		1,000	.	.	.	0.047	0.150	0.008
Risk Assessment	2	250	0.337	0.220	0.500	.	.	.
		500	0.619	0.500	0.750	0.386	0.500	0.250
		1,000	.	.	.	0.151	0.220	0.086
	3	250	0.375	0.173	0.646	.	.	.
		500	0.697	0.500	0.875	0.289	0.500	0.125
		1,000	.	.	.	0.084	0.173	0.025
	4	250	0.403	0.138	0.750	.	.	.
		500	0.778	0.500	0.938	0.277	0.500	0.063
		1,000	.	.	.	0.043	0.138	0.007

Note: The lead hazard screen does recommend window sills be sampled.

[1] The window sill dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 500 $\mu g/ft^2$ for the risk assessment.

Table H-3. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Levels for Two, Three, and Four Window Well Dust Samples Using the Interim Guidance Standards[1] – Variance Components from the Rhode Island Department of Health Data.

Assessment	Number of Samples	Assumed "True" House Window Well Dust Lead Loading (µg/ft²)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
"Compound" Lead Hazard Screen	2	400	0.245	0.115	0.383	.	.	.
		800	0.490	0.385	0.682	0.485	0.615	0.318
		1,600	.	.	.	0.196	0.283	0.110
	3	400	0.303	0.091	0.576	.	.	.
		800	0.629	0.409	0.851	0.343	0.591	0.149
		1,600	.	.	.	0.112	0.211	0.030
	4	400	0.307	0.074	0.713	.	.	.
		800	0.720	0.426	0.930	0.313	0.574	0.070
		1,600	.	.	.	0.050	0.163	0.009
Risk Assessment	2	400	0.385	0.230	0.511	.	.	.
		800	0.584	0.500	0.750	0.385	0.500	0.250
		1,600	.	.	.	0.161	0.230	0.090
	3	400	0.424	0.183	0.658	.	.	.
		800	0.697	0.500	0.875	0.285	0.500	0.125
		1,600	.	.	.	0.097	0.183	0.027
	4	400	0.405	0.148	0.761	.	.	.
		800	0.756	0.500	0.938	0.271	0.500	0.063
		1,600	.	.	.	0.047	0.148	0.008

[1] The window well dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 800 µg/ft² for the risk assessment and 400 µg/ft² for the lead hazard screen.

Table H-4. Comparison of <u>Two, Three, and Four Side of House/Foundation Soil Samples</u> Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Levels Using the Interim Guidance Standards[1] – Variance Components from the Rhode Island Department of Health Data.

Location	Number of Samples	Assumed "True" House Soil Lead Concentration (ppm)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
Side of House/ Foundation	2	2,500	0.262	0.168	0.434	.	.	.
		5,000	0.605	0.500	0.750	0.398	0.500	0.250
		7,500	.	.	.	0.229	0.286	0.119
	3	2,500	0.271	0.119	0.574	.	.	.
		5,000	0.668	0.500	0.875	0.313	0.500	0.125
		7,500	.	.	.	0.156	0.245	0.041
	4	2,500	0.265	0.086	0.680	.	.	.
		5,000	0.745	0.500	0.938	0.304	0.500	0.063
		7,500	.	.	.	0.082	0.213	0.014

[1] The soil standard at which a home is found to have lead-based paint hazards was assumed to be 5,000 ppm.

Table H-5. "Simple" Lead Hazard Screen Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Level for Two, Three, and Four Floor and Window Well Dust Samples Using the Interim Guidance Standards[1] – Variance Components from the Rhode Island Study Data.

Location	Number of Samples	Assumed "True" House Dust Lead Loading (µg/ft²)	Type I (False Positive) Error Probability of the Statistic		
			Geometric Mean	Arithmetic Mean	Maximum Value
Floor	2	30	0.195	0.285	0.470
		50	0.500	0.582	0.750
		70	0.714	0.769	0.881
		100	0.878	0.908	0.958
	3	30	0.147	0.285	0.614
		50	0.500	0.637	0.875
		70	0.756	0.846	0.959
		100	0.923	0.952	0.991
	4	30	0.112	0.285	0.719
		50	0.500	0.719	0.938
		70	0.788	0.898	0.986
		100	0.950	0.980	0.998
Window Sills	2	100	0.154	0.237	0.416
		250	0.500	0.609	0.750
		400	0.699	0.778	0.873
		500	0.780	0.849	0.914
	3	100	0.106	0.259	0.553
		250	0.500	0.685	0.875
		400	0.739	0.859	0.955
		500	0.827	0.916	0.975
	4	100	0.075	0.296	0.659
		250	0.500	0.772	0.938
		400	0.770	0.913	0.984
		500	0.862	0.957	0.993
Window Wells	2	200	0.230	0.344	0.511
		400	0.500	0.636	0.750
		600	0.667	0.744	0.856
		800	0.770	0.839	0.910
	3	200	0.183	0.378	0.658
		400	0.500	0.715	0.875
		600	0.702	0.839	0.945
		800	0.817	0.903	0.973
	4	200	0.148	0.428	0.761
		400	0.500	0.758	0.938
		600	0.730	0.890	0.979
		800	0.852	0.953	0.992

[1] The floor dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 50 µg/ft² and the window well dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 400 µg/ft².

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APPENDIX I

Summary Error Probability Tables and Graphs for the Proposed Rule Standards

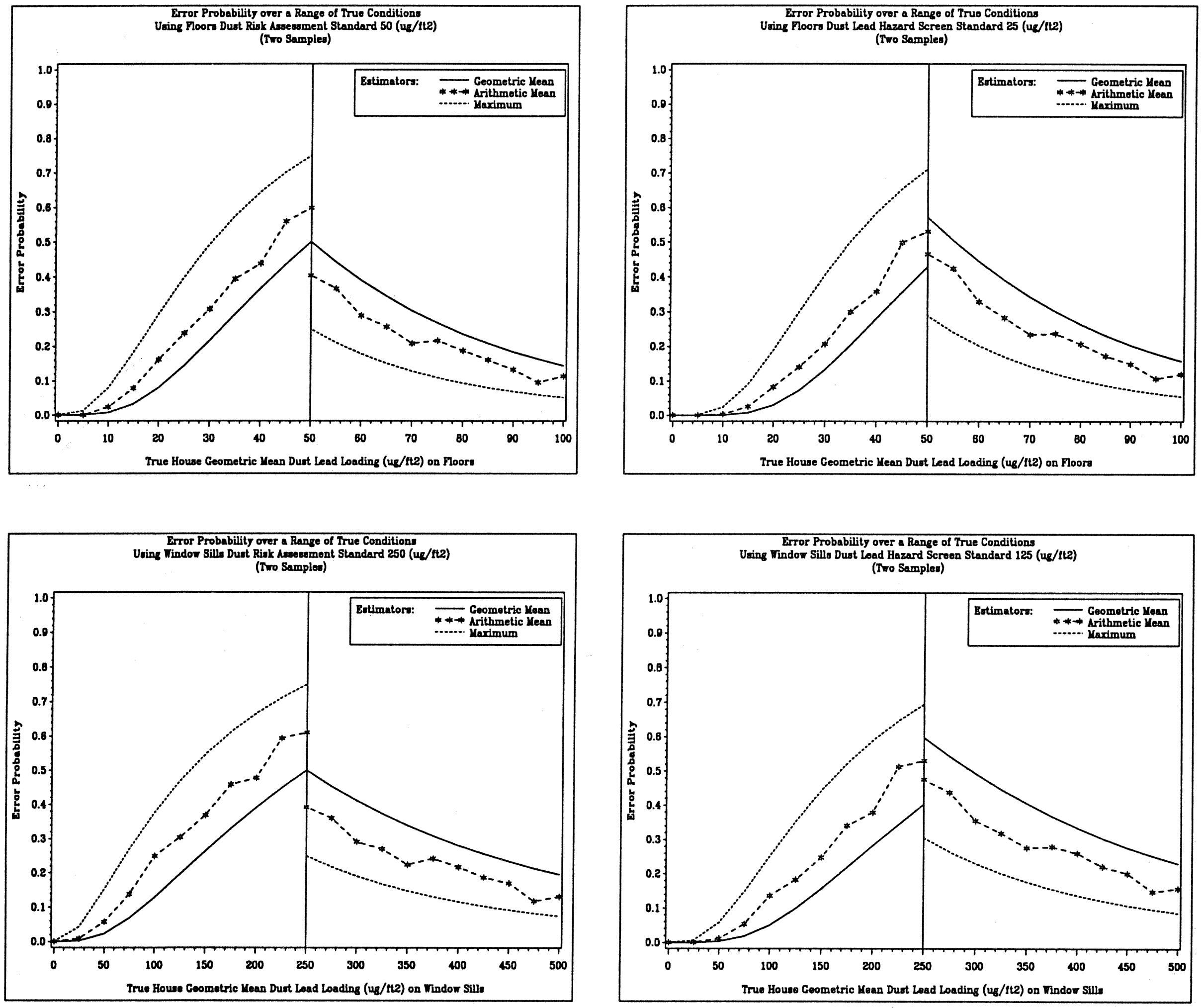


Figure I-1. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Two Floor and Window Sill Dust Samples Using the Proposed Rule Standards – Variance Components from the Rochester Lead-In-Dust Study Homes.

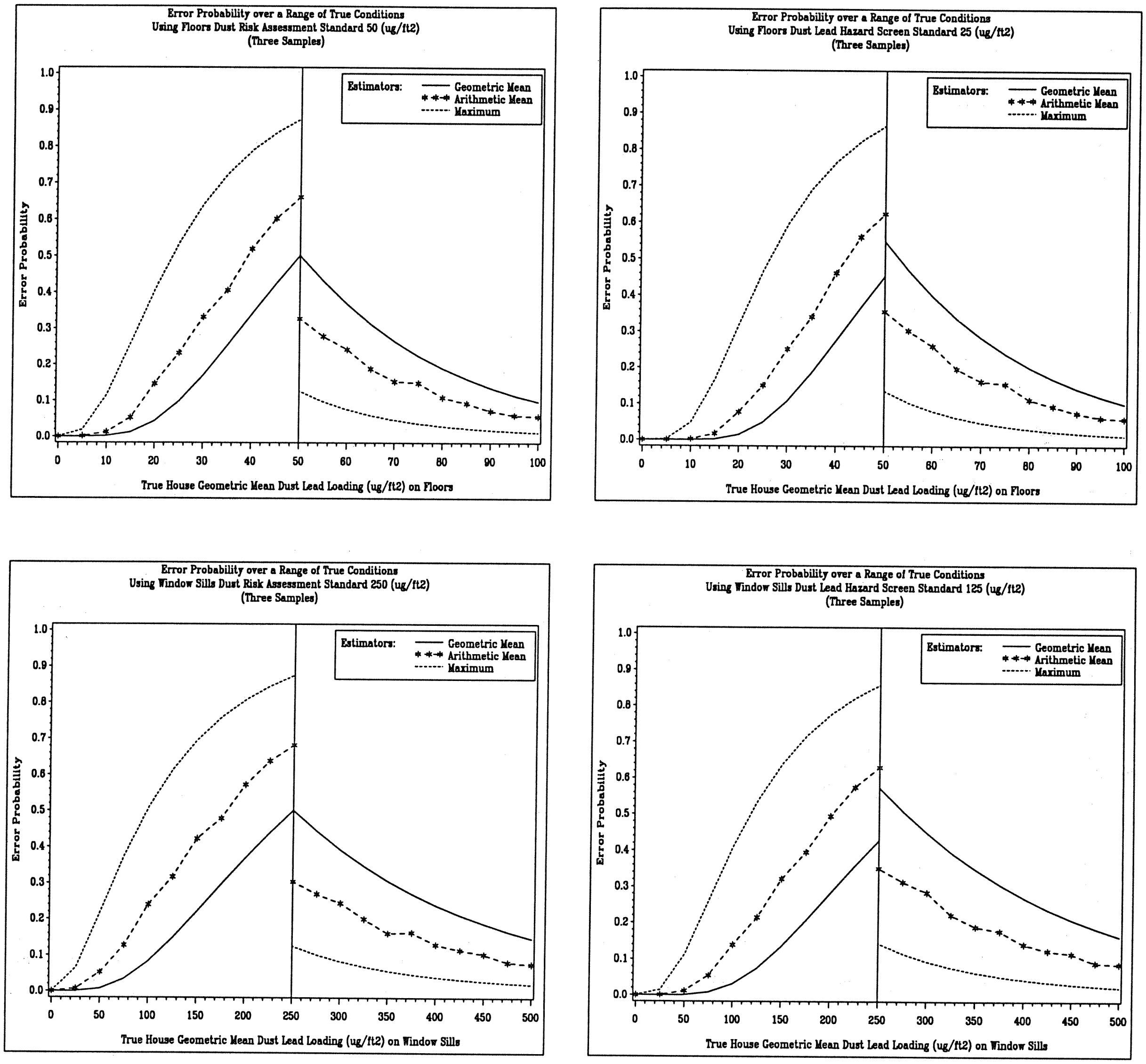


Figure I-2. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Three Floor and Window Sill Dust Samples</u> Using the Proposed Rule Standards – Variance Components from the Rochester Lead-In-Dust Study Homes.

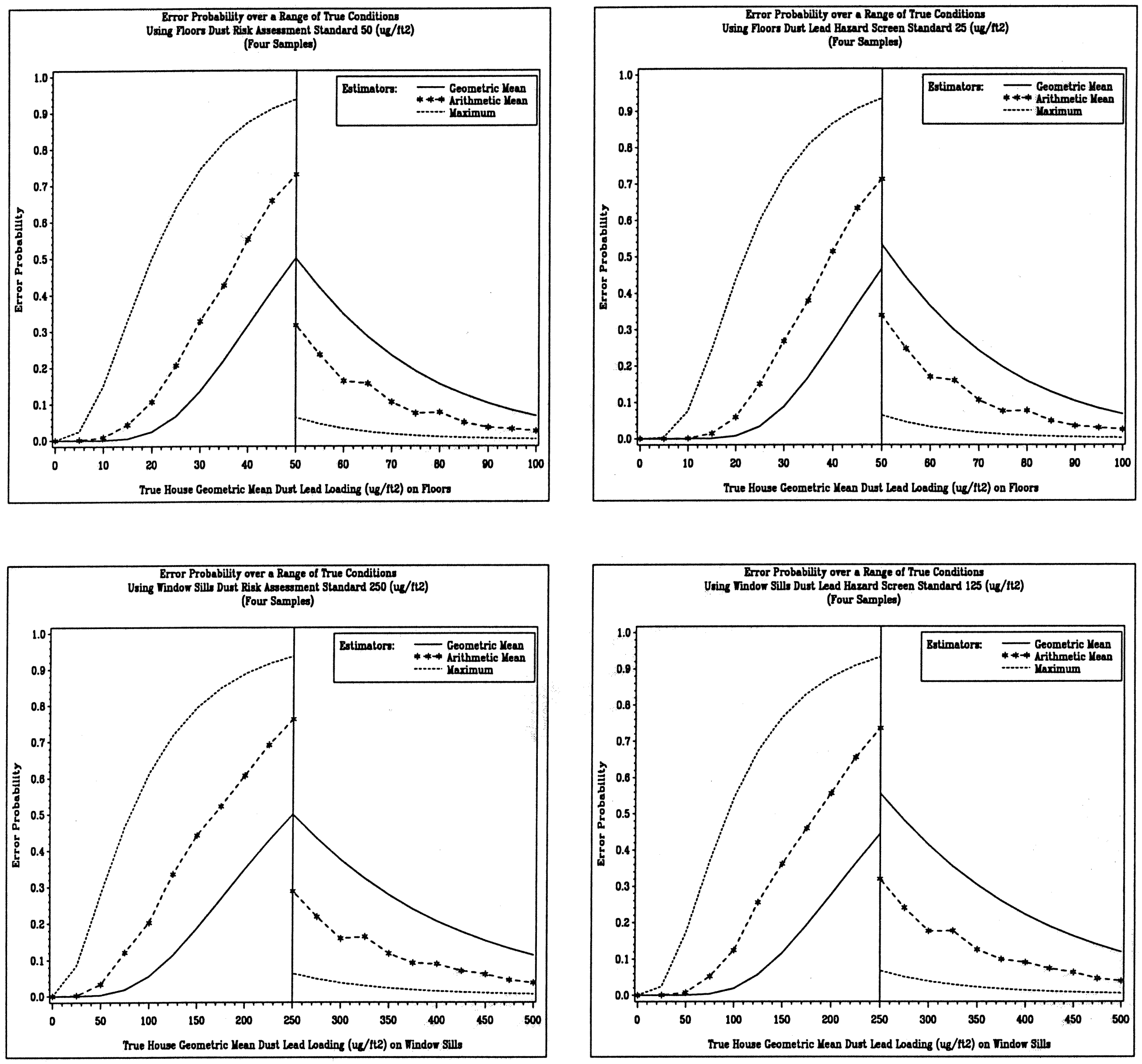


Figure I-3. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Four Floor and Window Sill Dust Samples Using the Proposed Rule Standards – Variance Components from the Rochester Study Data.

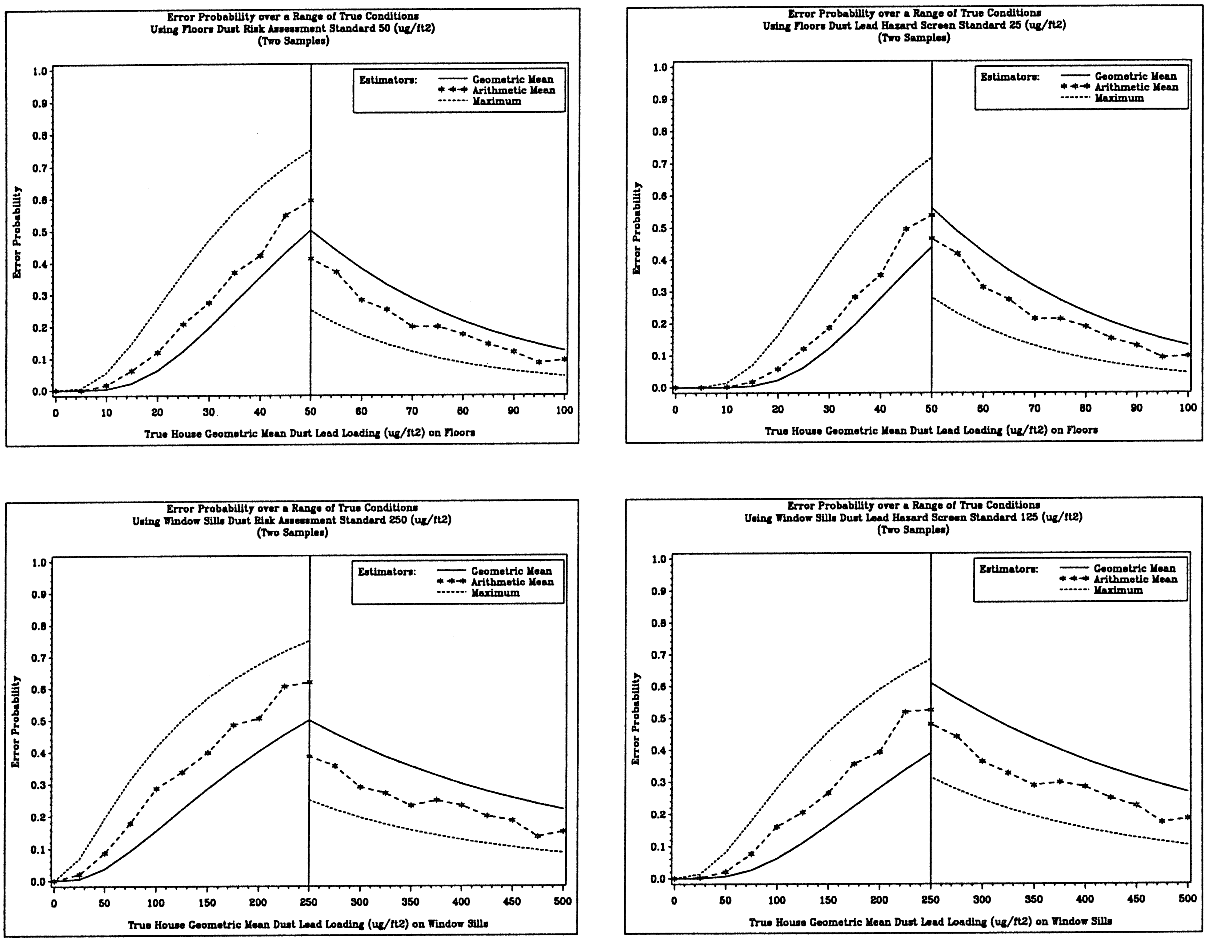


Figure I-4. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for Two Floor and Window Sill Dust Samples Using the Proposed Rule Standards – Variance Components from the Rhode Island Department of Health Homes.

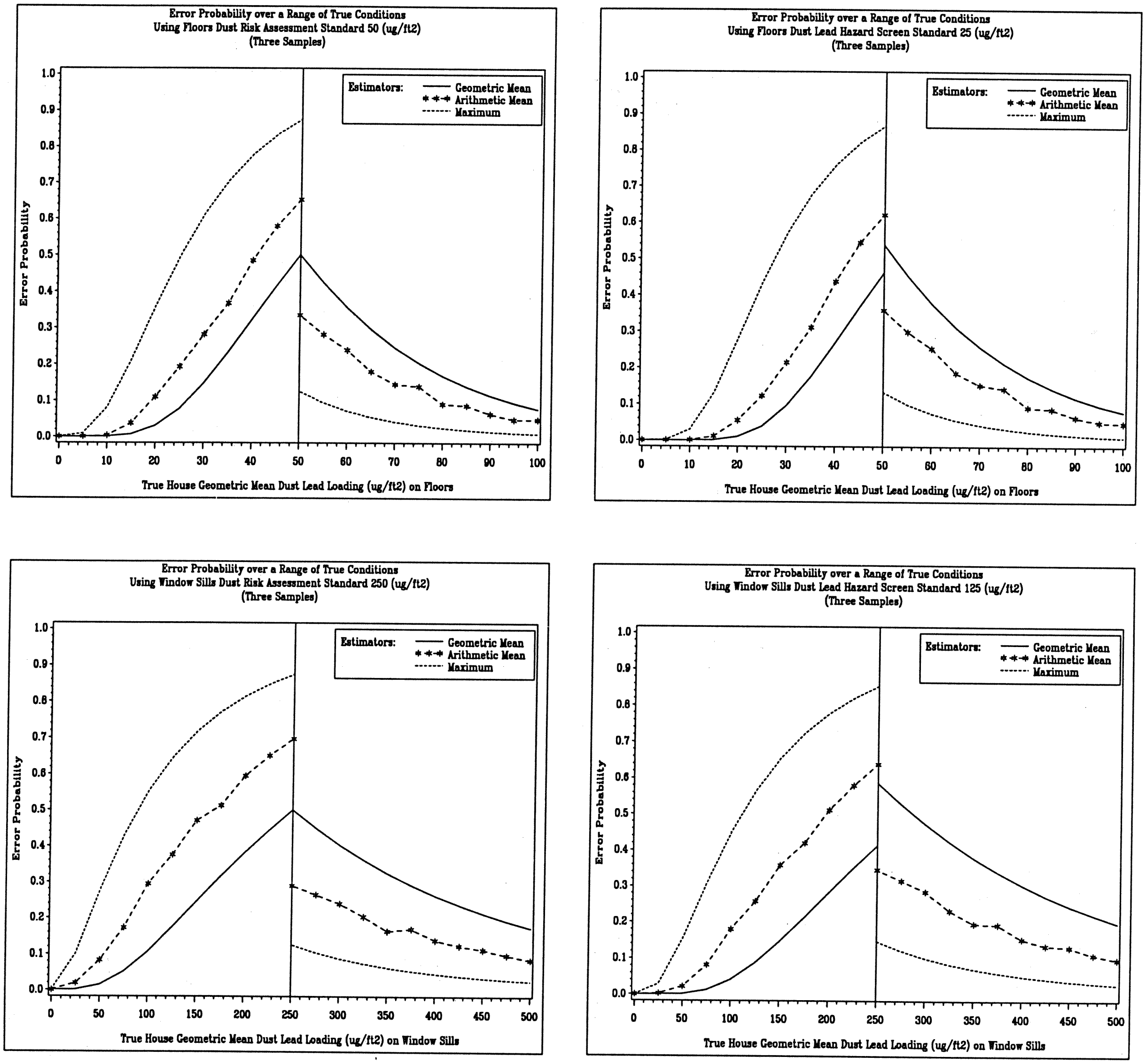


Figure I-5. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Three Floor and Window Sill Dust Samples</u> Using the Proposed Rule Standards – Variance Components from the Rhode Island Department of Health Homes.

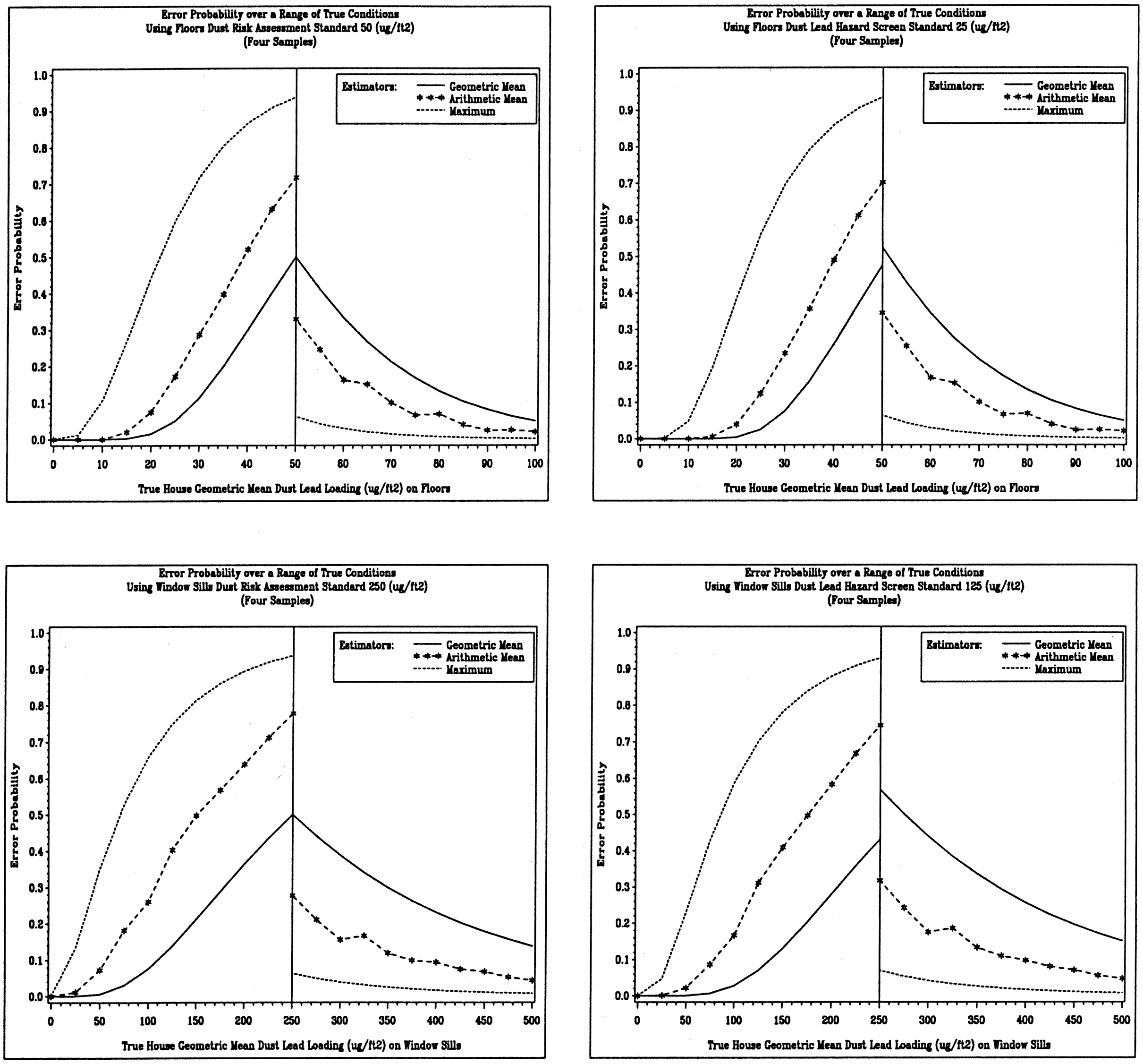


Figure I-6. Comparison of Risk Assessment and "Compound" Lead Hazard Screen Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Four Floor and Window Sill Dust Samples</u> Using the Proposed Rule Standards – Variance Components from the Rhode Island Department of Health Homes.

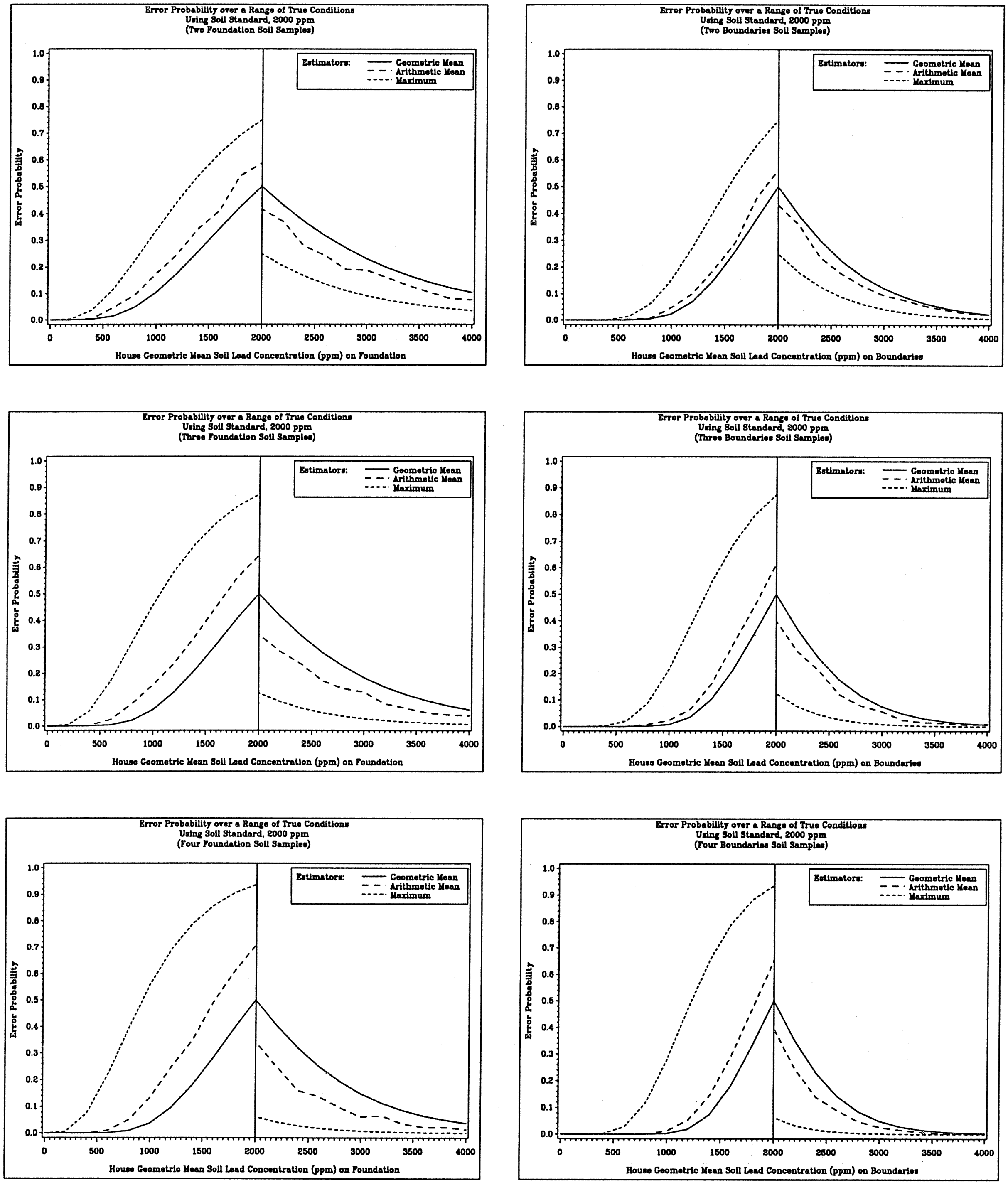
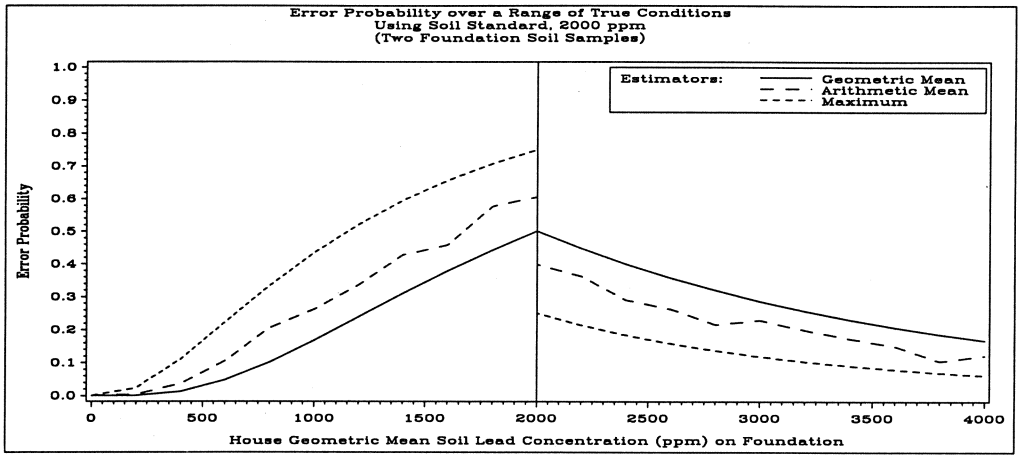
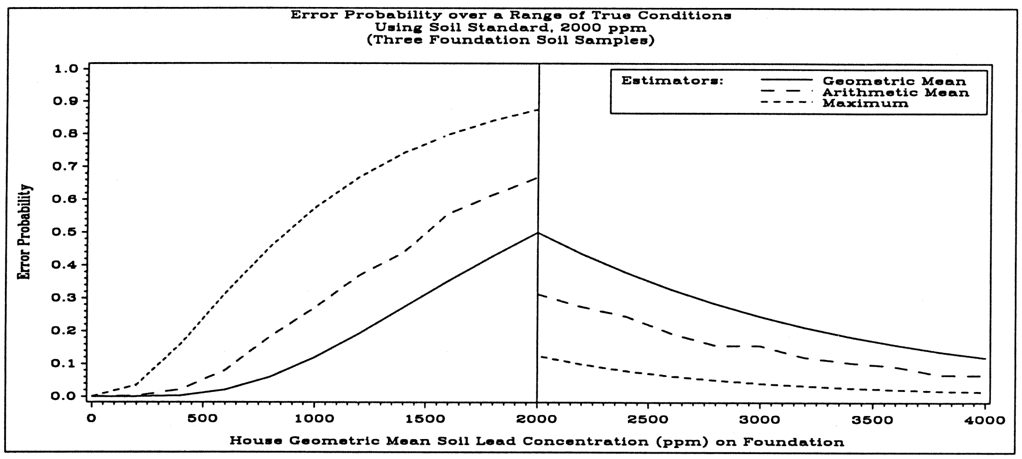


Figure I-7. Comparison of Risk Assessment Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Two, Three, and Four Soil Samples</u> Collected from the Foundation of the Home and Boundary of the Property Using the Proposed Rule Standards - Variance Components from the CAP Study Data.





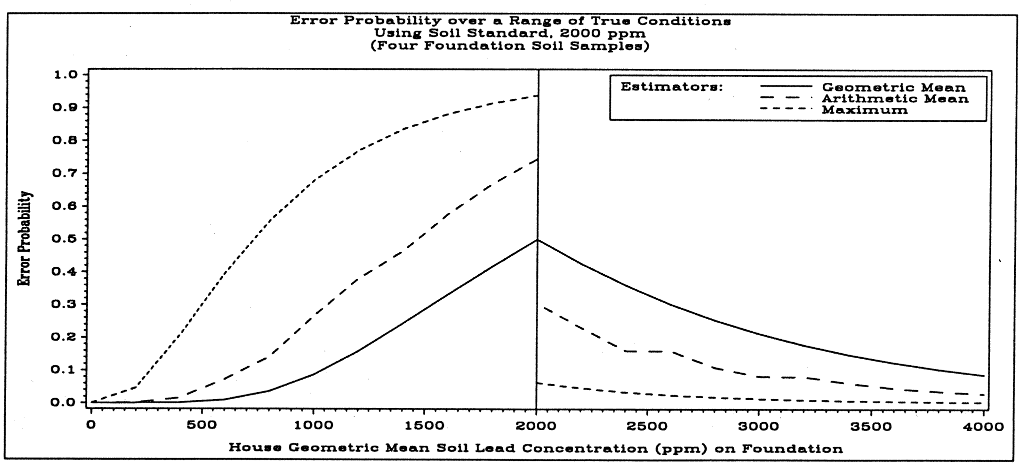


Figure I-8. Comparison of Risk Assessment Geometric Mean, Arithmetic Mean, and Maximum Value Error Probabilities for <u>Two, Three, and Four Soil Samples</u> Collected from Side of the House/Foundation for Homes Using the Proposed Rule Standards - Variance Components from the Rhode Island Department of Health Study Data.

Table I-1. Comparison of Risk Assessment Error Probabilities for Each Statistic Over A Range of Assumed "True" House Lead Levels for Two, Three, and Four Floor Dust Samples Using the Proposed Rule Standards[1] - Variance Components from the Rochester Lead-In-Dust Study Data.

Assessment	Number of Samples	Assumed "True" House Floor Dust Lead Loading ($\mu g/ft^2$)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
"Compound Lead Hazard Screen	2	25	0.140	0.072	0.300	.	.	.
		50	0.530	0.428	0.712	0.465	0.572	0.288
		100	.	.	.	0.120	0.158	0.055
	3	25	0.150	0.048	0.469	.	.	.
		50	0.623	0.452	0.865	0.355	0.548	0.135
		100	.	.	.	0.059	0.100	0.012
	4	25	0.150	0.033	0.601	.	.	.
		50	0.712	0.467	0.935	0.339	0.533	0.065
		100	.	.	.	0.025	0.067	0.003
Risk Assessment	2	25	0.237	0.144	0.401	.	.	.
		50	0.598	0.500	0.750	0.404	0.500	0.250
		100	.	.	.	0.113	0.144	0.051
	3	25	0.231	0.096	0.536	.	.	.
		50	0.660	0.500	0.875	0.326	0.500	0.125
		100	.	.	.	0.056	0.096	0.012
	4	25	0.206	0.066	0.641	.	.	.
		50	0.730	0.500	0.938	0.316	0.500	0.063
		100	.	.	.	0.024	0.066	0.003

[1] The floor dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 50 $\mu g/ft^2$ for the risk assessment and 25 $\mu g/ft^2$ for the lead hazard screen.

Table I-2. Comparison of Risk Assessment Error Probabilities for Each Statistic Over A Range of Assumed "True" House Lead Levels for Two, Three, and Four Window Sill Samples Using the Proposed Rule Standards[1] - Variance Components from the Rochester Lead-In-Dust Study Data.

Assessment	Number of Samples	Assumed "True" House Window Sill Dust Lead Loading (μg/ft²)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
"Compound" Lead Hazard Screen	2	125	0.182	0.098	0.352	.	.	.
		250	0.530	0.402	0.695	0.475	0.598	0.305
		500	.	.	.	0.157	0.230	0.086
	3	125	0.214	0.073	0.537	.	.	.
		250	0.629	0.427	0.857	0.350	0.573	0.143
		500	.	.	.	0.086	0.162	0.021
	4	125	0.255	0.056	0.674	.	.	
		250	0.736	0.444	0.932	0.319	0.556	0.068
		500	.	.	.	0.039	0.119	0.006
Risk Assessment	2	125	0.304	0.195	0.470	.	.	.
		250	0.610	0.500	0.750	0.392	0.500	0.250
		500	.	.	.	0.131	0.195	0.074
	3	125	0.316	0.147	0.614	.	.	.
		250	0.681	0.500	0.875	0.303	0.500	0.125
		500	.	.	.	0.076	0.147	0.020
	4	125	0.335	0.112	0.719	.	.	.
		250	0.763	0.500	0.938	0.288	0.500	0.063
		500	.	.	.	0.036	0.112	0.005

[1] The window sill dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 250 μg/ft².

Table I-3. Comparison of Risk Assessment Error Probabilities for Each Statistic Over A Range of Assumed "True" House Lead Levels for Two, Three, and Four Floor Samples Using the Proposed Rule Standards[1] - Variance Components from the Rhode Island Department of Health Data.

Assessment	Number of Samples	Assumed "True" House Floor Dust Lead Loading (µg/ft²)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
"Compound" Lead Hazard Screen	2	25	0.120	0.061	0.276	.	.	.
		50	0.538	0.439	0.718	0.466	0.561	0.282
		100	.	.	.	0.097	0.131	0.044
	3	25	0.122	0.038	0.435	.	.	.
		50	0.621	0.462	0.867	0.358	0.538	0.133
		100	.	.	.	0.048	0.079	0.009
	4	25	0.124	0.025	0.563	.	.	.
		50	0.703	0.475	0.936	0.345	0.525	0.064
		100	.	.	.	0.021	0.050	0.002
Risk Assessment	2	25	0.207	0.122	0.368	.	.	.
		50	0.593	0.500	0.750	0.411	0.500	0.250
		100	.	.	.	0.092	0.122	0.042
	3	25	0.192	0.077	0.498	.	.	.
		50	0.652	0.500	0.875	0.334	0.500	0.125
		100	.	.	.	0.048	0.077	0.009
	4	25	0.172	0.050	0.601	.	.	.
		50	0.717	0.500	0.938	0.329	0.500	0.063
		100	.	.	.	0.020	0.050	0.002

[1] The floor dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 50 µg/ft² for the risk assessment and 25 µg/ft² for the lead hazard screen.

Table I-4. Comparison of Risk Assessment Error Probabilities for Each Statistic Over A Range of Assumed "True" House Lead Levels for Two, Three, and Four Window Sill Samples Using the Proposed Rule Standards[1] - Variance Components from the Rhode Island Department of Health Data.

Assessment	Number of Samples	Assumed "True" House Window Sill Dust Lead Loading (µg/ft²)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
"Compound" Lead Hazard Screen	2	125	0.205	0.110	0.375	.	.	.
		250	0.526	0.390	0.686	0.481	0.610	0.314
		500	.	.	.	0.185	0.268	0.103
	3	125	0.257	0.086	0.566	.	.	.
		250	0.638	0.414	0.853	0.345	0.586	0.147
		500	.	.	.	0.097	0.197	0.028
	4	125	0.311	0.069	0.703	.	.	.
		250	0.745	0.431	0.931	0.317	0.569	0.069
		500	.	.	.	0.047	0.150	0.008
Risk Assessment	2	125	0.337	0.220	0.500	.	.	.
		250	0.619	0.500	0.750	0.386	0.500	0.250
		500	.	.	.	0.151	0.220	0.086
	3	125	0.375	0.173	0.646	.	.	.
		250	0.697	0.500	0.875	0.289	0.500	0.125
		500	.	.	.	0.084	0.173	0.025
	4	125	0.403	0.138	0.750	.	.	.
		250	0.778	0.500	0.938	0.277	0.500	0.063
		500	.	.	.	0.043	0.138	0.007

[1] The window sill dust wipe standard at which a home is found to have lead-based paint hazards was assumed to be 250 µg/ft².

Table I-5. **Comparison of Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Levels for Two, Three, and Four Boundary and Foundation Soil Samples Using the Proposed Rule Standards[1] - Variance Components from the CAP Study Data.**

Location	Number of Samples	Assumed "True" House Soil Lead Concentration (ppm)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
Boundary of Property	2	1,000	0.046	0.022	0.150	.	.	.
		2,000	0.563	0.500	0.750	0.432	0.500	0.250
		3,000	.	.	.	0.094	0.120	0.041
	3	1,000	0.022	0.007	0.217	.	.	.
		2,000	0.615	0.500	0.875	0.399	0.500	0.125
		3,000	.	.	.	0.057	0.075	0.008
	4	1,000	0.011	0.002	0.278	.	.	.
		2,000	0.654	0.500	0.938	0.396	0.500	0.063
		3,000	.	.	.	0.026	0.049	0.002
Foundation	2	1,000	0.173	0.103	0.337	.	.	.
		2,000	0.587	0.500	0.750	0.416	0.500	0.250
		3,000	.	.	.	0.187	0.230	0.090
	3	1,000	0.155	0.061	0.460	.	.	.
		2,000	0.645	0.500	0.875	0.346	0.500	0.125
		3,000	.	.	.	0.128	0.183	0.027
	4	1,000	0.132	0.037	0.561	.	.	.
		2,000	0.709	0.500	0.938	0.342	0.500	0.063
		3,000	.	.	.	0.061	0.148	0.008

[1] The soil standard at which a home is found to have lead-based paint hazards was assumed to be 2,000 ppm.

Table I-6. Comparison of Error Probabilities for Each Statistic Over a Range of Assumed "True" House Lead Levels for <u>Two, Three, and Four Side of House/Foundation Soil Samples</u> Using the Proposed Rule Standards[1] - Variance Components from the Rhode Island Department of Health Data.

Location	Number of Samples	Assumed "True" House Soil Lead Concentration (ppm)	Error Probability of the Statistic					
			Type I (False Positive) Error			Type II (False Negative) Error		
			Arithmetic Mean	Geometric Mean	Maximum Value	Arithmetic Mean	Geometric Mean	Maximum Value
Side of House/ Foundation	2	1,000	0.262	0.168	0.434	.	.	.
		2,000	0.605	0.500	0.750	0.398	0.500	0.250
		3,000	.	.	.	0.229	0.286	0.119
	3	1,000	0.271	0.119	0.574	.	.	.
		2,000	0.668	0.500	0.875	0.313	0.500	0.125
		3,000	.	.	.	0.156	0.245	0.041
	4	1,000	0.265	0.086	0.680	.	.	.
		2,000	0.745	0.500	0.938	0.304	0.500	0.063
		3,000	.	.	.	0.082	0.213	0.014

[1] The soil standard at which a home is found to have lead-based paint hazards was assumed to be 2,000 ppm.

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APPENDIX J

Summary of the Pathways Analysis for the Rochester Lead-in-Dust Study Data

Table J-1. Correlation Coefficients for Natural Log Transformed Dust-Lead Loadings and Blood-Lead Concentrations from the Rochester Study.

	LNBLDPB	LINTLD	LBEDLD	LPLYLD	LKITLD	LLIVLD	LKITWWLD	LBEDWWLD	LPLYWWLD	LLIVWSLD	LBEDWSLD	LPLYWSLD
LNBLDPB	1.00000 0.0 205	0.29692 0.0001 179	0.22046 0.0019 197	0.31972 0.0001 192	0.28870 0.0001 203	0.26216 0.0977 41	0.31198 0.0006 118	0.30129 0.0002 150	0.19655 0.0209 138	0.31113 0.0884 31	0.33405 0.0001 163	0.31387 0.0001 164
LINTLD Ln Int.Entry Load	0.29692 0.0001 179	1.00000 0.0 179	0.43618 0.0001 175	0.39098 0.0001 170	0.52370 0.0001 178	0.55006 0.0005 36	0.30116 0.0020 103	0.32466 0.0001 132	0.22018 0.0157 120	0.28263 0.1710 25	0.31077 0.0002 144	0.36873 0.0001 147
LBEDLD Ln BedRoom load	0.22046 0.0019 197	0.43618 0.0001 175	1.00000 0.0 197	0.50611 0.0001 186	0.41732 0.0001 197	0.69073 0.0001 38	0.35582 0.0001 116	0.19089 0.0206 147	0.26935 0.0018 132	0.23455 0.2296 28	0.42564 0.0001 161	0.41119 0.0001 158
LPLYLD Ln Play Area Load	0.31972 0.0001 192	0.39098 0.0001 170	0.50611 0.0001 186	1.00000 0.0 192	0.48193 0.0001 190	0.21499 0.2149 35	0.37727 0.0001 113	0.29311 0.0004 141	0.13605 0.1170 134	0.13244 0.5190 26	0.48608 0.0001 153	0.36902 0.0001 161
LKITLD Ln Kitchen Load	0.28870 0.0001 203	0.52370 0.0001 178	0.41732 0.0001 197	0.48193 0.0001 190	1.00000 0.0 203	0.17950 0.2615 41	0.18648 0.0441 117	0.35039 0.0001 149	0.21564 0.0114 137	0.27899 0.1285 31	0.42466 0.0001 162	0.23745 0.0023 163
LLIVLD Ln Living Room Load	0.26216 0.0977 41	0.55006 0.0005 36	0.69073 0.0001 38	0.21499 0.2149 35	0.17950 0.2615 41	1.00000 0.0 41	0.42562 0.0544 21	0.40543 0.0359 27	0.45656 0.0249 24	0.17586 0.3615 29	0.51409 0.0043 29	0.62851 0.0002 30
LKITWWLD Ln Kitchen W.Well Load	0.31198 0.0006 118	0.30116 0.0020 103	0.35582 0.0001 116	0.37727 0.0001 113	0.18648 0.0441 117	0.42562 0.0544 21	1.00000 0.0 118	0.50022 0.0001 90	0.64668 0.0001 87	0.52990 0.0237 18	0.41809 0.0001 95	0.44325 0.0001 100
LBEDWWLD Ln Bed Room W.Well Load	0.30129 0.0002 150	0.32466 0.0001 132	0.19089 0.0206 147	0.29311 0.0004 141	0.35039 0.0001 149	0.40543 0.0359 27	0.50022 0.0001 90	1.00000 0.0 150	0.48584 0.0001 106	0.60400 0.0023 23	0.49713 0.0001 144	0.44441 0.0001 118
LPLYWWLD Ln Play Area W.Well Load	0.19655 0.0209 138	0.22018 0.0157 120	0.26935 0.0018 132	0.13605 0.1170 134	0.21564 0.0114 137	0.45656 0.0249 24	0.64668 0.0001 87	0.48584 0.0001 106	1.00000 0.0 138	0.57280 0.0162 17	0.37726 0.0001 112	0.58455 0.0001 130
LLIVWSLD Ln Living Room W.Sill Load	0.31113 0.0884 31	0.28263 0.1710 25	0.23455 0.2296 28	0.13244 0.5190 26	0.27899 0.1285 31	0.17586 0.3615 29	0.52990 0.0237 18	0.60400 0.0023 23	0.57280 0.0162 17	1.00000 0.0 31	0.62346 0.0009 25	0.55943 0.0084 21
LBEDWSLD Ln Bed Room W.Sill Load	0.33405 0.0001 163	0.31077 0.0002 144	0.42564 0.0001 161	0.48608 0.0001 153	0.42466 0.0001 162	0.51409 0.0043 29	0.41809 0.0001 95	0.49713 0.0001 144	0.37726 0.0001 112	0.62346 0.0009 25	1.00000 0.0 163	0.45765 0.0001 132
LPLYWSLD Ln Play Area W.Sill Load	0.31387 0.0001 164	0.36873 0.0001 147	0.41119 0.0001 158	0.36902 0.0001 161	0.23745 0.0023 163	0.62851 0.0002 30	0.44325 0.0001 100	0.44441 0.0001 118	0.58455 0.0001 130	0.55943 0.0084 21	0.45765 0.0001 132	1.00000 0.0 164

Notes:
1. Analyses were conducted on natural logarithm transformed blood-lead concentrations and dust-lead loadings.
2. First number is the Pearson correlation coefficient, the second number is the p-value, and the third number is the number of observations.

Table J-2. Structural Equation Modeling Results for the Rochester Study Data.

Variables	Parameter Estimates (t-value)								
Dependent \ Independent	**Play Area Floor**	**Bedroom Floor**	**Kitchen Floor**	**Interior Entryway Floor**	**Play Area Window Sill**	**Bedroom Window Sill**	**Play Area Window Well**	**Bedroom Window Well**	R^2
Blood	**0.1611*** (1.98)	-0.0577 (-0.80)	0.0225 (0.28)	0.1038 (1.52)	0.0470 (0.92)	-0.0052 (-0.11)	0.0406 (1.23)	0.0043 (0.14)	0.24
Play Area Floor		-0.3090 (-0.52)	0.9845 (1.78)	-0.1338 (-0.67)	0.2131 (1.63)		-0.0308 (-0.51)		0.01
Bedroom Floor	-0.0050 (-0.01)		-1.6241 (-1.69)	**1.2979*** (2.04)		**0.5774*** (1.98)		-0.0269 (-0.29)	0.00
Kitchen Floor	-3.9562 (-0.45)	4.2132 (0.55)		0.2159 (0.33)					0.00
Play Area Window Sill							**0.3548*** (6.53)		0.34
Bedroom Window Sill								**0.3627*** (6.14)	0.32

Notes:
1. The first number is the estimated parameter and the second number is the corresponding t-value.
2. Bolded and a * indicates parameter estimate is statistically significant at the 0.05 level. T-values >1.96 or <-1.96 indicate significance at the 0.05 level.
3. The structural equation models were run using natural logarithm transformed dust-lead loadings and blood-lead concentrations.

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APPENDIX K

Documents Used In Obtaining Health Department Data

Example K-1. The Data Set Assessment Form For the First Contact with Health Departments

Date of Assessment: ____________________

1. Agency: Pennsylvania Department of Health
   Name: Helen Shuman
   City, State: ____________________
   Phone: (____)____________________

2. Name of Data Set: ____________________

3. Population Size: ____________________

4. Program funded by: ____________________

5. Data Available? YES NO

6. Age of children in the program: ____________________
   ____

7. Data collected:

   a. Child blood-lead concentrations? YES NO

      Frequency of the blood-lead assessment:
      ___ Every month
      ___ Every other month
      ___ Every three months
      ___ Every six months
      ___ Other (list frequency): ____________________

   b. Environmental samples collected? YES NO

      Dust? YES NO

      Soil? YES NO

      Paint? YES NO

      Other? YES NO
      Please specify: ____________________

Example K-1. The Data Set Assessment Form For the First Contact with Health Departments (Continued).

Frequency of environmental sampling? ______________________
____

c. Assessment of the exposure in home, other sources of lead exposure outside of the home, socioeconomic factors, etc. YES NO

By questionnaire? YES NO

By interview at home? YES NO

By telephone interview? YES NO

Other? YES NO
Please specify: ____________________________________

8. What is the form of the data?

Hardcopy? YES NO

Disk? YES NO

Example K-2. Letter and Data Information Sheet Sent to Health Departments for Formal Request of Data.

May 9, 1997

{Person Contacted}
{Department}
{Agency}
{Street Address}
{City, State Zip}

Dear {Person Contacted}:

This letter is a follow-up to a conversation you had with {Interviewer} of Battelle Memorial Institute and serves as a formal request for obtaining data from your agency.

The Technical Branch of the U.S. Environmental Protection Agency is interested in evaluating different sampling protocols allowable under the Section 402 risk assessment protocol (40 CFR Part 745) to determine if certain protocols are more protective of public health than others. EPA has contracted with Battelle Memorial Institute of Columbus, Ohio to conduct this study. In order to evaluate the protocols, EPA needs pre-intervention blood lead and pre-intervention environmental samples of lead in dust, soil, and paint. Your data will be used to assess how well dust, soil, or paint samples collected under a given sampling protocol can identify a health hazard as measured by the blood-lead sample. This will be done on an aggregate level such that individual results will NOT be reported.

In an earlier conversation, it was indicated that your agency has collected and maintained data that may be extremely useful for this project. We are very interested in obtaining your data. The attached sheet specifies the type of data, fields, and format (hardcopy or diskette) we are requesting. We understand that confidentiality is of great importance and will be provided. We do need to be able to link the environmental samples with the blood samples. Once that data is linked, we only require a unique identifier for each household, such as "House 1". Being able to uniquely link the blood samples with the environmental samples is very important, but we do not need to know the address of the house, the name of the child, or any other information from which the name or address could be deduced.

Results of the data analysis will be used to provide additional information to help risk assessors evaluate potential lead-based paint hazards in a residential setting. You will receive a copy of the final report, and can be included in the review process of draft interim reports if you so choose.

We appreciate your interest in helping us conduct this study. Please send your data to Virginia Sublet/Pam Hartford, Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio, 43201.

If you have any questions regarding the requested data, the intent of the study, or the use of your data please contact Susan Dillman of my staff at (202) 260-5375, Virginia Sublet of Battelle at (614) 424-5406, or Pam Hartford of Battelle at (614) 424-5448.

Sincerely,

Brion Cook, Chief
Technical Branch

Enclosures

cc: S. Dillman – U.S. EPA
V. Sublet – Battelle
P. Hartford – Battelle

DATA REQUEST AND INFORMATION SHEET

The requested data should consist of samples that were collected ***prior to any intervention activities at the home or with the child***. Also, the sample collection date for the environmental samples should be fairly close to the sample collection date for the related blood sample.

The tables listed below should be used as a guide for the exact information being requested. The first column of the tables below list the variable requested and provides a brief explanation of the variable. The second column provides an order of importance on variables requested. The last column requests the name of the variable in the data set, if the variable is in the data set. If the variable is not available, then indicate with a 'NA'. If a short answer provides the requested information, please list the information in this column instead of a variable name, e.g. the blood sampling technique may require only an answer of venous puncture since all children had blood drawn using that technique.

Pre-Intervention Child Blood Sampling Variables Requested

Variable Requested	Importance of Requested Information	Variable Name in the Data Set*
Blood sampling date	Very Important	
Blood-lead concentration	Very Important	
Age of child when sampling occurred *{Preferably between 6 months and 6 years of age}*	Very Important	
Unique identifier for the home the child resided in at time of sampling *{If there are multiple children within a home the identifier would be the same for all children}*	Very Important	
Blood sampling technique	Moderately Important	

* If a short answer provides the requested information, please list the information in this column instead of a variable name, e.g. The blood sampling technique may require only an answer of venous puncture since all children had blood drawn using that technique.

DATA REQUEST AND INFORMATION SHEET

Pre-Intervention Environmental Sampling Variables Requested

Variable Requested	Importance of Requested Information	Variable Name in the Data Set*
Unique identifier of home that can be matched to the blood sample(s).	Very Important	
Pre-Intervention Dust Samples		
Date of dust sampling	Very Important	
Dust lead level	Very Important	
Units of reported dust lead level *{i.e., µg/ft², µg/g, etc.}*	Very Important	
Sampling technique *{i.e., wipe, vacuum, etc.}*	Very Important	
Sampling location *{i.e., bedroom, play area, etc.}*	Very Important	
Sampling component *{i.e., carpeted floors, uncarpeted floors, window sill, window well}*	Very Important	
Sample type *(i.e., composite or individual samples}*	Very Important	
Lab analysis technique	Moderately Important	
Limit of detection for the lab	Moderately Important	
Pre-Intervention Soil Samples		
Date of soil sampling	Very Important	
Soil lead concentration	Very Important	
Units of reported soil lead concentration	Very Important	
Sampling technique *{i.e., core, surface scraping, etc.}*	Very Important	
Sample type *{i.e., composite or individual samples}*	Very Important	
Ground covering *{i.e., bare, grassy, % of area covered, etc.}*	Moderately Important	
Lab analysis technique	Moderately Important	
Limit of detection for the lab	Moderately Important	
Pre-Intervention Paint Samples		
Date of paint sampling	Very Important	
Paint lead levels	Very Important	
Units of reported paint lead levels *{ppm, %, mg/cm², etc.}*	Very Important	
Sampling technique *{i.e., XRF, bulk scraping, etc.}*	Very Important	
Sample type *{i.e., composite or individual samples}*	Very Important	
Sampling location *{i.e., interior or exterior, bedroom, living room, porch, etc.}*	Very Important	
Sampling component *{i.e., wall, window sill, window well, etc.}*	Very Important	
Condition of the paint *{i.e., poor, % deteriorated, etc.}*	Very Important	

* If a short answer provides the requested information, please list the information in this column instead of a variable name, e.g. The blood sampling technique may require only an answer of venous puncture since all children had blood drawn using that technique.

DATA REQUEST AND INFORMATION SHEET

Please indicate the format of your data: ☐ Hardcopy ☐ Diskette
If diskette, what software was used? ____

Please indicate if any of your data collection efforts were funded by the HUD Lead-Based Paint Hazard Control Grant Program. ☐ Yes ☐ No

---

If you are willing to help us in this project, please return a copy of this sheet with your data to the following address:

Virginia Sublet / Pam Hartford
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Or, if you have additional questions, please contact:

Virginia Sublet (614) 424-5406
Pam Hartford (614) 424-5448

Table K-1. Summary of the Health Department Data.

Agency	City, State	Data Collected	Description	Time Frame	# of Observations (# Homes)	Comments
Rhode Island Department of Health	Providence, RI	Blood	Venous and Fingerstick	1/1/1995 - 12/1/1996	400 (285)	Good distribution of environmental and blood sampling across the homes.
		Dust	Wipe and Vacuum	1/1/1995 - 12/1/1996	522 (129) [2]	
		Soil	Side and Debris	1/1/1995 - 12/1/1996	766 (264)	
		Paint	Paint Chip	1/1/1995 - 12/1/1996	4265 (325)	
		Water	Flush	1/1/1995 - 12/1/1996	272 (265) [3]	
Pinellas County Health Department	St. Petersburg, FL	Blood	Venous and Fingerstick	1994 - 1997	49 (49)	Sparse environmental sampling across the homes.
		Dust	Wipe	1994 - 1997	10 (7)	
		Soil	Surface Scraping	1994 - 1997	15 (15)	
		Paint	XRF	1994 - 1997	38 (38)	
Nebraska Health and Human Services System	Lincoln, NE	Blood	Venous and Fingerstick	2/5/1996 - 6/18/1997	15 (15)	Sparse environmental sampling across the homes.
		Dust	Wipe	7/11/1996 - 7/22/1997	38 (11)	
		Soil	Surface Scraping	7/19/1996 - 7/22/1997	26 (10)	
		Paint	XRF and bulk sampling	3/14/1997 - 7/22/1997	838 (11)	
Vermont Department of Health	Burlington, VT	Blood	Venous	1995 - 1996	110 (110)	Quite a bit of paint XRF data with excellent location specific information. Very little dust, soil, and water information.
		Dust	NA	NA	NA	
		Soil	NA	NA	NA	
		Water	NA	NA	NA	
		Paint	XRF	NA	NA (110)	

Table K-1. Summary of the Health Department Data (Continued).

Agency	City, State	Data Collected	Description	Time Frame	# of Observations (# Homes)	Comments
Ohio Department of Health	Columbus, OH	Blood	Venous	9/7/1993 - 4/21/1997	48 (21) [1]	Each house has hundreds of XRF readings but sampling dates are missing. Also sparse environmental sampling.
		Dust	Wipe	8/14/1996 - 5/5/1997	98 (23)	
		Soil	Composite Mostly Drip line	10/22/1993 - 3/18/1997	32 (20)	
		Paint	XRF	10/12/1993 - 11/12/1996	1842 (32)	
		Other	NA	NA	1 (1)	
Missouri Department of Health	Jefferson City, MO	Blood	NA	NA	76,745 (30,586)	Data is from a STELLAR data base which retains only the maximum value from the environmental sampling. Values from all the sampling were not available.
		Dust	NA	NA	912 (884)	
		Soil	NA	NA	912 (884)	
		Paint	XRF and Paint	NA	912 (884)	
		Water	NA	NA	912 (884)	

Notes: [1] This does not contain 16 observations with age missing and 9 observations with 'Unknown' or missing sampling method.
[2] There are 454 observations (109 homes) for WIPE only Dust data.
[3] This does not contain 66 observations with water collection method other than 'Flush'.

APPENDIX L

Sampling Distributions of the Statistics and Error Probability Calculations

Appendix L

Sampling Distributions of the Statistics and Error Probability Calculations

The observed natural logarithmically transformed lead level, $\log(Y_{ik})$, was assumed to follow a normal distribution with mean μ_i and variance σ_i^2, i.e.,

$$\log(Y_{ik}) \text{ iid} \sim \text{Normal}(\mu_i, \sigma_i^2),\ k=1,2, \ldots, n$$

where

Y_{ik}	k^{th} observed lead level in the home for component/media *i*
i	floor dust, window sill dust, window well dust, foundation soil, boundaries soil, or paint.

An assumption was that no room was more indicative of the risk of lead exposure to children than any other room within the house.

To compare the effectiveness of the estimators in providing an accurate assessment of the true house lead levels, a hypothesis test was constructed:

$$H_0:\ \mu_i < \log S_i$$
$$H_1:\ \mu_i \geq \log S_i.$$

Under the null hypothesis, H_0, the true house lead level for media i was below the media standard, while under the alternative hypothesis, H_1, the home's true lead level for media i was above or equal to the media standard. Of interest were the probabilities of correct and incorrect decisions based on the estimated "true" media lead level at the home. In particular, the Type I (false positive) and Type II (false negative) error probabilities defined below.

$$\begin{aligned} P\text{ (Type I Error)} &= P(\text{conclude } H_1 \mid H_o \text{ is true}) \\ &= P(Y_{ij} \geq S_i \mid \mu_i < \log S_i) \end{aligned}$$

$$\begin{aligned} P\text{ (Type II Error)} &= P(\text{conclude } H_o \mid H_1 \text{ is true}) \\ &= P(Y_{ij} < S_i \mid \mu_i \geq \log S_i) \end{aligned}$$

where

Y_{ij}	observed lead level in the home for component/media *i* and estimator *j*
S_i	standard for component/media *i*
μ_i	true average log lead level within home for each component/media *i*
i	floor dust, window sill dust, window well dust, soil, and paint,
j	geometric mean, arithmetic mean, and maximum value.

Sampling Distribution of the Geometric Mean

Let G_i = geometric mean of Y_{ik} component/media *i* with *k* rooms sampled (k locations, in the case of soil data), k = 1, 2, ..., n.

$$= \left(\prod_{k=1}^{n} Y_{ik}\right)^{\frac{1}{n}}.$$

Then $$\log(G_i) = \left(\frac{1}{n}\right)\log\left(\prod_{k=1}^{n} Y_{ik}\right) = \frac{\sum_{k=1}^{n}\log Y_{ik}}{n} \sim \text{Normal}\left(\mu_i, \frac{\sigma_i^2}{n}\right)$$

since $\log(Y_{ik})$ iid ~Normal(μ_i, σ_i^2), k=1,2, ..., n.

Therefore, under the above hypotheses,

(1) given that H_o: $\mu_i < \log S_i$ is true,

$$\begin{aligned} P(\text{Type I Error}) &= P(G_i \geq S_i) \\ &= P(\log(G_i) \geq \log(S_i)) \\ &= P([\log(G_i) - (\mu_i)]/(\sigma_i^2/n)^{1/2} \geq [\log(S_i) - (\mu_i)]/(\sigma_i^2/n)^{1/2}) \\ &= P(Z \geq [\log(S_i) - (\mu_i)]/(\sigma_i^2/n)^{1/2}), \\ &\quad \text{since } \log(G_i) \sim \text{Normal}(\mu_i, \sigma_i^2/n) \end{aligned}$$

where Z ~N(0, 1).

(2) given that H_1: $\mu_i \geq \log S_i$ is true,

$$\begin{aligned} P(\text{Type II Error}) &= P(G_i < S_i) \\ &= P(\log(G_i) < \log(S_i)) \\ &= P([\log(G_i) - (\mu_i)]/(\sigma_i^2/n)^{1/2} < [\log(S_i) - (\mu_i)]/(\sigma_i^2/n)^{1/2}) \\ &= P(Z < [\log(S_i) - (\mu_i)]/(\sigma_i^2/n)^{1/2}), \\ &\quad \text{since } \log(G_i) \sim \text{Normal}(\mu_i, \sigma_i^2/n) \end{aligned}$$

where Z ~N(0, 1).

Sampling Distribution of the Arithmetic Mean

There is no simple form of the sampling distribution of the arithmetic mean. Therefore, the error probabilities were estimated via simulation based on the empirical distribution of the arithmetic mean.

Sampling Distribution of the Maximum Value

The sampling distribution of the maximum value is derived below.

Let M_i denote the maximum value of n measurements, Y_{ij}, j = 1, ..., n on the same component/media at a single house.

Then,

(1) Given that $\mu_i < \log S_i$ is true,

$$
\begin{aligned}
P(\text{Type I Error}) &= P(M_i \geq S_i) \\
&= 1 - P(M_i < S_i) \\
&= 1 - \text{Type II Error},
\end{aligned}
$$

where Type II Error is described below.

(2) Given that $\mu_i \geq \log S_i$ is true,

$$
\begin{aligned}
P(\text{Type II Error}) &= P(M_i < S_i), \\
&= P(Y_{i1} < S_i, Y_{i2} < S_i, ..., Y_{in} < S_i,), \\
&= P(\log(Y_{i1}) < \log(S_i), \log(Y_{i2}) < \log(S_i), ..., \log(Y_{in}) < \log(S_i)) \\
&= P(\log(Y_{i1}) < \log(S_i))\cdot P(\log(Y_{i2}) < \log(S_i))\cdots P(\log(Y_{in}) < \log(S_i)) \\
&= [P(\log(Y_{i1}) < \log(S_i))]^n,
\end{aligned}
$$

since $\log(Y_i)$ are independent and identically distributed,

$$
\begin{aligned}
&= [P([\log(Y_{i1)} - (\mu_i)]/\sigma_i < [\log(S_i) - (\mu_i)]/\sigma_i]^n \\
&= [P(Z < [\log(S_i) - (\mu_i)]/\sigma_i]^n,
\end{aligned}
$$

where Z ~N(0, 1), since $\log(Y_i)$ distributed ~Normal(μ_i, σ_i^2)

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13. ABSTRACT (Maximum 200 words)

The overall purpose of this report is to characterize the probability of a certified risk assessor correctly identifying a lead-based paint hazard in single family housing units when choices allowed by the Section 402 regulations are made and when using the standards and methods prescribed in both the 403 Interim Guidance and Section 403 Proposed Rule. This report concluded that increasing the number of dust samples collected only affected the outcome of a risk assessment when the maximum value was used to characterize the dust samples; sampling play area floors provided the best indication of the lead hazard to a child in the Rochester study; removing the window wells (troughs) from the risk assessment did not affect the ability of the assessment to identify lead hazards; and the combination of the lower soil and dust standards and the use of the arithmetic mean to characterize these samples, as described in the 403 Proposed Rule, resulted in an assessment that provided nearly the same protection as the 403 Interim Guidance, but failed fewer homes.

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