6.0 ANALYSIS OF EXAMPLE OPTIONS FOR THE §403 STANDARDS

Chapter 6 of the §403 risk analysis presented the methodology used to characterize reductions to childhood health effect and blood-lead concentration endpoints expected to result after interventions are conducted in response to the proposed §403 rule and applied this methodology to a broad range of example options for standards. Assumptions were made on post-intervention environmental-lead levels, which were applied to those HUD National Survey housing units where a particular intervention was triggered as a result of having environmental-lead levels that exceeded an example standard. Then, the IEUBK and empirical models were used to generate the post-§403 blood-lead concentration distribution given post-§403 environmental-lead levels. These results, combined with similar model-based estimates in the pre-§403 environment presented in Chapter 5, were used to obtain a final post-§403 blood-lead distribution which was comparable to the baseline distribution generated by data from Phase 2 of NHANES III. This procedure was detailed in Chapter 6 and Appendix F1 of the §403 risk analysis report. This was the distribution upon which the health effects and blood-lead concentration endpoints were estimated in the post-§403 environment.

The risk management procedure in Chapter 6 of the §403 risk analysis report considered example standards for the following risk assessment measures:

- Average floor dust-lead loading
- Average window sill dust-lead loading
- Average soil-lead concentration
- Amount of deteriorated lead-based paint requiring paint maintenance
- Amount of deteriorated lead-based paint requiring paint abatement

Note that the lead-based paint standards considered in the risk management procedure differed somewhat from the standards proposed in the §403 rule (see Chapter 1 of this report), as the rule considered only a single tier rather than a two-tiered standard.

Section 6.1 presents additional detail and results on the performance characteristics analyses, a non-modeling data analysis procedure used by EPA to help establish levels of concern within the §403 rule. Performance characteristics analyses cited in the §403 proposed rule are detailed, and additional performance characteristics analyses performed after the proposed rule to address public comments and to finalize the rule are presented.

Section 6.2 investigates the incidence of children with elevated blood-lead concentrations in homes where no candidate standard is met or exceeded (i.e., children who would be "missed" by a specified set of candidate standards).

Since the §403 risk analysis report was published, public comment resulted in an additional investigation into the assumptions made in the risk management on average dust-lead loading following an intervention involving dust cleaning (40 $\mu g/ft^2$ on floors, 100 $\mu g/ft^2$ on window sills). The results of

this investigation are presented in Section 6.3. Based on this investigation, the impact of alternative assumptions on post-intervention dust-lead loadings on characterizing the reduction in risk as a result of implementing §403 rules was evaluated through a sensitivity analysis presented in Section 6.4. Also included in Section 6.4 are sensitivity analyses applied to baseline (pre-§403) data within Section 5.1 of this report to evaluate the impact of potential changes to the HUD National Survey data and assumptions on non-zero thresholds for the IQ/blood-lead relationship, where the analyses are implemented on data representing the post-§403 environment.

6.1 PERFORMANCE CHARACTERISTICS ANALYSES

The procedures defined and discussed in the §403 risk analysis report used statistical modeling techniques to characterize risks of lead exposure to children in the nation's housing stock and how these risks may be reduced as a result of interventions performed to reduce lead-based paint hazards in the housing stock under the §403 rule. While using the findings of this risk analysis to evaluate options for the standards specified in the §403 rule, EPA also wished to base its evaluation partially on a non-modeling approach using data from field studies that measured lead levels in both children's blood and in the same environmental media targeted by the §403 rule. In particular, given the data reported in these studies, EPA was interested in observing how often a specified set of candidate standards would "trigger" interventions in housing units within these studies and the extent to which these units contained a child with an elevated blood-lead concentration ($10 µg/dL). Such an investigation provided useful information on the performance of a specified set of candidate standards without some of the complexities associated with making conclusions from statistical modeling analyses.

EPA employed *performance characteristics analysis*, sometimes referred to as *sensitivity/specificity analysis*, as a non-modeling approach to evaluating candidate §403 standards. The underlying statistical principle of this approach involves conditional probabilities and has been documented in references such as Fleiss (1981, Section 1.2). This chapter presents the findings of performance characteristics analyses applied to data from the Rochester Lead-in-Dust study. Applying data from this study was highly appropriate under the objective to evaluate candidate lead standards in the §403 rulemaking. The form of the study data used in this analysis is discussed in detail within Section 6.1.1. The methods used to perform this performance characteristics analysis are presented in Section 6.1.2. Section 6.1.3 presents the results of performance characteristics analysis presented in the preamble and which were used in the §403 rulemaking. Finally, Section 6.1.4 presents additional performance characteristics analyses performed after the §403 proposed rule was published, where these analyses considered other sets of standards (including the standards specified in the §403 proposed rule) and other means of handling data on amount of deteriorated paint within a household.

6.1.1 Data Used in The Performance Characteristics Analysis

The performance characteristics analysis was applied to data from the recently-conducted Rochester Lead-in-Dust study. A summary of objectives and design information for this study is found in Section 3.2.2.2 of the §403 risk analysis report. The Rochester study data were selected for this analysis for the following reasons:

- The study reported information for all media for which §403 standards were proposed (e.g., dust-lead on floors and window sills, soil-lead, condition of lead-based paint).

- The study measured blood-lead concentration in 205 children aged 12-31 months who resided in the selected homes.

- The dust sampling methods used in this study included the wipe technique, from which dust-lead loadings were measured.

- For some homes, soil was sampled from multiple locations (i.e., dripline and play areas), allowing for yardwide average soil-lead concentration to be estimated.

- While homes and children were targeted for selection in this study, the selection process was more random and more representative of a general population than is the case with other lead exposure studies.

The primary concern with using data from the Rochester study in this analysis is the degree to which the study may be considered representative of the nation as a whole. The study selected a targeted sample which was limited to a single geographic area. The sample consisted of children who had moderate exposure to lead in their home environment and did not necessarily include children with very high or very low exposure to lead. In particular,

- 22.9% of the children in this study (47 children total) had blood-lead concentrations at or above 10 µg/dL, compared to the national estimate of 5.9% for children aged 1-2 years according to Phase 2 of the Third National Health and Nutrition Examination Survey (NHANES III) (CDC, 1997).

- The geometric mean blood-lead concentration for the study children was 6.38 µg/dL with a geometric standard deviation (GSD) of 1.85. This compares with a geometric mean of 3.1 µg/dL and GSD of 2.09 estimated for U.S. children aged 1-2 years according to Phase 2 of NHANES III (CDC, 1997).

- At least 84% of the housing units included in this study were built prior to 1940, compared to the estimated 20% of the entire U.S. housing stock made within the §403 risk analysis (Table 3-5 of USEPA, 1998). There is a well-documented relationship between age of housing and presence of lead-based paint hazards.

- While geometric mean floor dust-lead loadings were comparable between the Rochester study and the HUD National Survey (after converting the data to wipe-equivalent loadings), whose results are considered nationally-representative, geometric mean estimates of window sill dust-lead loading and soil-lead concentration were higher for the Rochester study relative to HUD National Survey estimates (Section 3.2).

Despite these limitations, the Rochester study is considered one of the best resources of data for characterizing the relationship between children's blood-lead concentration and residential environmental-lead levels, and therefore, for evaluating national standards for lead in the nation's housing stock.

While data were available for 205 units in the Rochester study, somewhat fewer of these units had values for all required data endpoints for this analysis. In particular, 177 units had data reported on the amount of deteriorated lead-based paint, plus lead measurements for floor dust (wipe), window sill dust (wipe), and soil (dripline and/or play area). Of these units, 77 had soil-lead data for both dripline and play areas, thereby allowing an average concentration across these two areas to be calculated.

For the analysis presented in the §403 proposed rule, the following five data endpoints were calculated for each Rochester study housing unit:

- Area-weighted average uncarpeted floor wipe dust-lead loading (i.e., the measured loading for each sample was weighted by the area of the sample when averaged)
- Area-weighted average window sill wipe dust-lead loading
- Average of dripline and play area soil-lead concentrations
- The percentage of interior painted components tested in the study that contained lead-based paint (measurements at or above 1.0 mg/cm^2) and some level of deterioration (paint condition listed as fair or poor)
- The percentage of exterior painted components tested in the study that contained lead-based paint and some level of deterioration.

Note that these endpoints are comparable to the standards included in the §403 proposed rule, with the exception of the latter two paint-lead measurements. While the proposed §403 standard for the paint component is expressed as a square footage of deteriorated lead-based paint for components with large surface areas (2 ft^2 for interior surfaces, 10 ft^2 for exterior surfaces) or as the percentage of total painted surface area that is deteriorated for components with small surface areas (10%), no indication on the amount of deteriorated lead-based paint on a given component (either in square feet or as a percentage of the total surface area) was recorded in the Rochester study. Instead, each paint-lead measurement was associated with an indicator of the paint's condition (good, fair, poor). Therefore, for this analysis, the amount of deteriorated lead-based paint in a housing unit was taken to be the percentage of tested components in the housing unit that contained lead-based paint along with some level of deterioration (i.e., condition of paint either fair or poor). This result was assumed to be a good estimate of the total amount of lead-based paint in the unit that was deteriorated.

6.1.2 Analysis Approach

The performance characteristics analysis classified each housing unit in the Rochester study according to two different criteria:

1. Whether or not the unit exceeded any of the candidate standards for the various media being controlled.

2. Whether or not the unit contained a child with elevated blood-lead concentration ($ 10 µg/dL).

The first criterion represented whether a housing unit was "triggered" for any intervention by exceeding at least one candidate standard, while the second represented whether the unit contained a child requiring attention as a result of having an elevated blood-lead concentration. The first criterion was determined by noting whether the value for at least one of the five endpoints mentioned at the end of the previous section exceeded the standard associated with the type of measurement represented by that endpoint.

For a given set of candidate standards, the set of housing units in the Rochester study was identified that had data for all of the above five endpoints. These units were classified according to whether or not they achieved the above two criteria. These results are summarized in the manner illustrated within the 2x2 frequency table in Table 6-1. From this information, the four performance characteristics defined in Table 6-1 were then calculated: sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). These characteristics provide the necessary information for evaluating the sets of standards on their ability to target the proper set of units for intervention.

In this analysis, a "false positive" corresponds to triggering a housing unit for intervention when it does not contain a child with an elevated blood-lead concentration, while a "false negative" corresponds to not triggering a housing unit containing a child with an elevated blood-lead concentration. Note that the proportion of false positives is equal to one minus the specificity, while the proportion of false negatives is equal to one minus the sensitivity.

While information from all four performance characteristics are important for evaluating the performance of a given set of standards, typically one or two characteristics are given more weight than the others in the performance evaluation process. For example, in the preamble, EPA evaluated candidate standards for dust-lead loading on uncarpeted floors and window sills according to whether the performance characteristics analysis yielded a value of NPV from 95 to 99 percent under the given set of standards. This implied that no more than 5% of children living in housing units with environmental-lead levels below the standards would have elevated blood-lead concentrations (i.e., at or above 10 µg/dL). More recent Agency inquiries have focused on

Table 6-1. Definitions of Performance Characteristics Used to Evaluate How Various Combinations of Environmental-Lead Standards Classify Housing Units in the Rochester Lead-in-Dust Study

		Any of the Standards Exceeded?	
		No	Yes
Blood-Lead Concentration At or Above 10 μg/dL?	Yes	a	b
	No	c	d

In the above table, the letter 'b' represents the number of children which have a blood-lead concentration at or above 10 μg/dL who live in a residence with environmental-lead levels that exceed at least one of the specified standards. Letters 'a', 'c', and 'd' represent similar counts. The total number of housing units equals a + b + c + d. From these counts, the following performance characteristics are calculated:

Performance Characteristic	Definition	Calculation
Sensitivity (or True Positive Rate, or 1 - False Negative Rate)	Probability of a housing unit exceeding at least one standard given that there is a resident child with an elevated blood concentration ($10 μg/dL)	b/(a + b)
Specificity (or True Negative Rate, or 1 - False Positive Rate)	Probability of a housing unit not exceeding at least one standard given that a resident child has a low blood-lead concentration (< 10 μg/dL).	c/(c + d)
Positive Predictive Value (PPV)	Probability of a resident child having an elevated blood-lead concentration ($10 μg/dL) given that the housing unit exceeds at least one standard.	b/(b + d)
Negative Predictive Value (NPV)	Probability of a resident child having a low blood-lead concentration (< 10 μg/dL) given that the housing unit does not exceed at least one standard.	c/(a + c)

the ability of candidate standards to "trigger" housing units containing elevated blood-lead children, which corresponds to maximizing the sensitivity.

Figure 6-1 provides an example (based on hypothetical data) of an ideal situation for selecting a single standard (e.g., dripline soil-lead concentration). In this example, a dripline soil-lead concentration standard of 400 µg/g would result in all four performance characteristics achieving their maximum value of 1 (or 100%). Thus, all homes triggered for intervention (i.e., exceeding the standard) would contain a child with an elevated blood-lead concentration, and all homes containing a child with an elevated blood-lead concentration would be triggered for intervention. This situation is very unlikely to occur typically. Therefore, in a less than ideal situation (i.e., with typical data), one may wish to maximize each characteristic or some subset of the most important characteristic(s). If all four characteristics are equally important, one approach is to maximize the unweighted sum of the four characteristics. In the ideal situation represented by Figure 6-1, this sum would equal 4 (or 400%). With actual data, however, this sum will be less than 4. Figure 6-2 illustrates a situation (again, based on hypothetical data) where both the NPV and sensitivity equal 100%, but the PPV and specificity are less than 100%. This situation would be acceptable if only the NPV and sensitivity needed to be maximized.

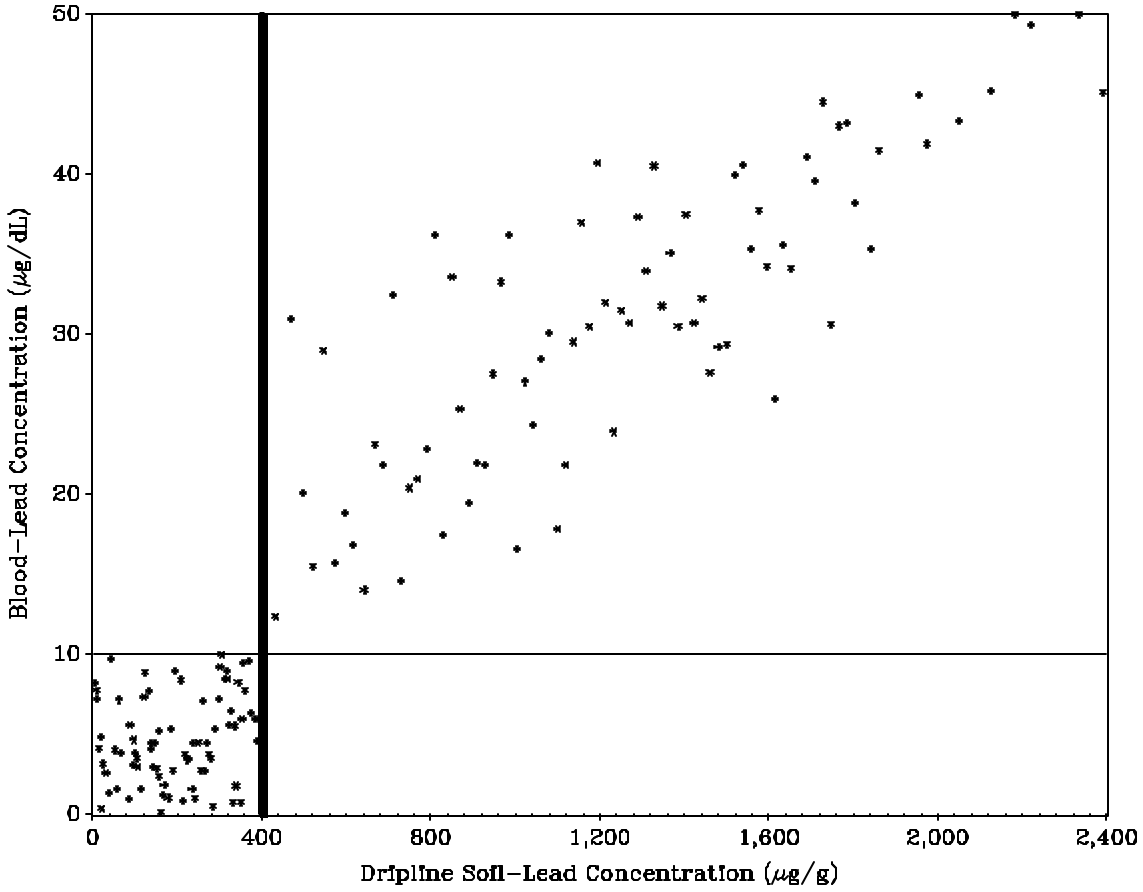

Figure 6-1. Example of an Ideal Situation for Establishing Potential Dripline Soil-Lead Standards

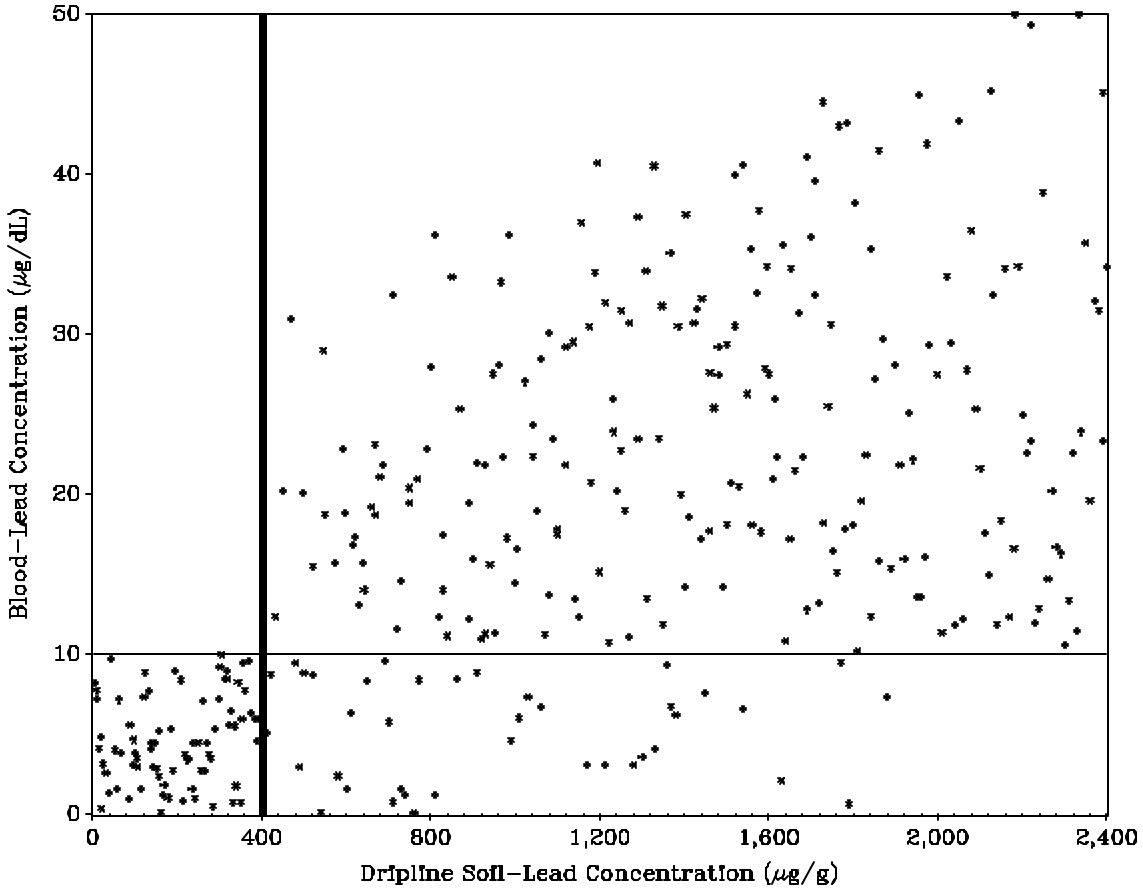

Figure 6-2. Example of a Situation Where the Negative Predictive Value and Sensitivity Equal 100%, but the Positive Predictive Value and Specificity are Less than 100%

The performance characteristics analysis was repeated for different sets of standards. For each analysis, the information within Table 6-1 was calculated, and those sets of standards that maximized the desired performance criteria were identified.

The different analyses presented in the subsequent sections of this chapter were performed on different subsets of housing units in the Rochester study. The results are purely descriptive in that they represent combinations of candidate standards that meet the specified performance criteria when considering the housing units in the Rochester study and are not based on any underlying probability model. Different results are possible if this analysis were to be applied to data from different studies. In addition, only point estimates of the performance characteristics are presented. The uncertainty in these estimates is primarily dependent on sample size, and to a lesser degree on measurement error.

6.1.3 Results Cited in the §403 Proposed Rule

The analysis presented in this section were cited in section B.1.d of Part IV of the preamble. This section of the preamble contained a brief presentation of the information presented in Section 6.1.2 above, then cited findings of analyses documented in a memorandum dated 9/3/97 from Battelle (Ronald Menton and Warren Strauss) to EPA (Todd Holderman). EPA requested that Battelle perform this analysis in an action item of a meeting between Battelle and EPA on August 27, 1997. A copy of the cited memorandum is found in Appendix G.

The analyses presented in Appendix G were performed on data for the 77 housing units in the Rochester study that had all necessary data for the analysis, including soil-lead concentrations for both dripline and play areas. As the §403 proposed rule was to contain a yardwide average soil-lead standard, it was desired to consider only those housing units that had soil-lead data for both locations. The considerable reduction in the number of Rochester study housing units whose data were considered in this analysis (from 205 to 77 units) was due primarily to the fact that play-area soil-lead concentration was measured for less than half of the study units.

The combinations of candidate standards considered in this analysis were those requested by EPA at the time, when EPA was actively considering candidate standards in the rulemaking. These combinations included all 8x4x9x3=864 combinations of the following:

- uncarpeted floor dust-lead loading: 50, 75, 100, 125, 150, 175, 200, 400 µg/ft^2
- window sill dust-lead loading: 100, 300, 500, 800 µg/ft^2
- average soil-lead concentration: 200, 300, 400, 500, 600, 700, 900, 1000, 1500 µg/g
- maximum of percent of interior/exterior painted surfaces with deteriorated lead-based paint: 5, 10, 20%

Note that the type of endpoint that represented the paint-lead measurement in this analysis (i.e., the last bullet) differed from the type of paint-lead standard that EPA ultimately proposed in the §403 proposed rule.

The purpose of this analysis was to identify those sets of candidate standards (from the 864 combinations above) which, when applying the performance characteristics analysis under those sets of standards, resulted in values of negative predictive value (as defined in Table 6-1 above) that met one of the following three criteria:

- NPV $\geq$ 99%
- 95% $\leq$ NPV < 99%
- 90% $\leq$ NPV < 95%.

The findings of this analysis are documented in Tables 1 and 2 of Appendix G.

Twenty-one of the 77 housing units whose data were included in the analysis did not exceed any of the candidate standards in at least one of the 864 combinations of candidate standards. These housing units, with the values of the endpoints used to compare to the candidate standards and children's blood-lead concentration, are listed in Table 6-2. This means that the denominator of NPV (i.e., the number of housing units that do not exceed at least one of the candidate standards being considered) never exceeded 21 across the 864 combinations. For some combinations, the denominator was as small as 2. Furthermore, all but two of the 21 units in Table 6-2 contained children with blood-lead concentrations below 10 µg/dL. As a result, the value of NPV was no lower than 84.6% across all 864 combinations of candidate standards. At least one of the above three criteria for NPV was met for 808 (93.5%) of the combinations. Of these 808 combinations, NPV equaled 100% for 690 of the combinations, equaled 95% for seven combinations, and was at least 90% but below 95% for the remaining 111 combinations.

All of the remaining 56 housing units in the analysis that are not represented in Table 6-2 exceeded either the soil-lead standard or one of the two paint standards (i.e., interior and/or exterior) in each of the 864 combinations of candidate standards. That is, each of these houses had at least one of the following:

- average soil-lead concentration of at least 1500 µg/g
- at least 20% of painted surfaces with deteriorated lead-based paint in the interior and/or exterior.

Therefore, the 56 housing units not represented in Table 6-2 were triggered in each of the 864 combinations of candidate standards, without regard to the floor or window sill standards.

The results presented in this section led to the following conclusions stated in Part IV of the preamble:

> *"For uncarpeted floors, dust-lead loadings ranged from 50 µg/ft^2 to 400 µg/ft^2 depending on the dust-lead loading on interior window sills and the soil-lead concentration. For interior window sills, dust-lead loadings ranged from 100 µg/ft^2 to 800 µg/ft^2 depending on the dust-lead loading on uncarpeted floors and the soil-lead concentration. These ranges are significantly higher than the ranges yielded by the multimedia approach."*
>
> *"Soil-lead concentrations ranged from 200 ppm to 1,500 ppm depending on dust-lead loadings on uncarpeted floors and interior window sills and the exceedance probability."*

The ranges cited in the preamble were precisely the lower and upper ranges of the candidate standards considered in this analysis. These findings reflect the very high values of the NPV across the combinations of standards considered in this analysis.

Table 6-2. Set of 21 Housing Units in the Rochester Study in Which No Standard Was Exceeded in at Least One of the 864 Combinations of Candidate Standards

Housing ID	Statistics Compared to the Candidate Standards[1]					Blood-Lead Conc. (μg/dL)
	Floor Dust-Lead Loading (μg/ft^2)	Window Sill Dust-Lead Loading (μg/ft^2)	Average Soil-Lead Conc. (μg/g)	% of Interior Components with Deteriorated LBP	% of Exterior Components with Deteriorated LBP	
00034	63.60	349.9	438.5	17	0	7.1
00132	17.30	90.6	268.0	0	0	6.0
00302	2.55	70.7	124.5	0	0	4.8
00637	59.00	74.9	950.0	0	0	13.3
00874	12.90	293.7	102.9	0	0	2.1
00974	14.90	45.6	51.1	0	0	8.9
01047	20.83	372.3	574.3	18	0	3.9
01062	12.40	87.1	447.5	0	0	7.4
01195	12.25	32.2	830.5	0	0	6.9
01228	3.37	16.2	419.0	0	0	4.6
01930	19.35	118.8	773.4	0	0	4.6
01971	5.10	41.9	506.0	11	0	6.1
01991	15.50	398.9	104.0	0	0	7.5
02290	2.65	74.1	465.0	11	0	4.9
02411	10.48	178.5	828.5	10	0	9.0
02837	4.29	2.8	458.5	0	0	8.9
03174	18.60	235.6	625.5	0	0	5.8
03360	12.43	702.0	912.0	0	0	11.3
03527	6.08	148.8	539.5	14	0	4.5
05343	10.30	75.7	552.0	13	0	5.6
05498	19.15	66.0	1150.5	0	0	5.8

[1] See Section 6.1.1 for the definitions of these statistics.

6.1.4 Results of Analysis on Specified Sets of Standards

The analyses presented in Section 6.1.3 were performed prior to release of the §403 proposed rule and contributed to the information presented in the preamble. Since the proposed rule was released, EPA has requested additional performance characteristics analyses be performed on various combinations of candidate standards, to address various issues raised within the public comments to the proposed rule and in support of preparing the final §403 rule. This section presents the results of these additional performance characteristics analyses. Additional performance characteristics analysis results are presented in Appendix J.

As discussed in Section 6.1.3, one of the limitations of the analyses presented in the preamble was the relatively small number of housing units (77) in the Rochester study whose data were used in the analyses. This small number was primarily due to the lack of available soil-lead concentrations from play areas and the desire to have soil-lead data for both dripline and play areas in order to calculate a yardwide average. Thus, the additional analyses presented in this section re-defined how the soil-lead measure was calculated (with different approaches taken to this re-definition), thereby increasing the number of units whose data could be included in the analysis.

6.1.4.1 Analyses Performed on 41 Combinations of Candidate Standards, in Three Iterations. The candidate standards that were considered in this analysis were the following:

- uncarpeted floor dust-lead loading: 5, 10, 20, 25, 40, 50, 100, 200 $\mu g/ft^2$
- window sill dust-lead loading: 250 $\mu g/ft^2$
- yardwide average soil-lead concentration: 400, 1200, 2000, 5000 $\mu g/g$
- amount of deteriorated lead-based paint: 2% of interior painted surfaces or 10% of exterior painted surfaces.

Thus, different candidate standards for floor dust-lead loading and soil-lead concentration were considered, while only a single candidate standard was considered for window sills (i.e., that specified in the §403 proposed rule) and deteriorated lead-based paint. This analysis considered a total of 41 combinations of candidate standards, corresponding to the 8x4=32 combinations of the above candidates, as well as the additional 9 combinations:

- only the paint standards (1 additional combination)
- only the paint and soil-lead concentration standards (4 additional combinations)
- only the paint, soil-lead concentration, and window sill dust-lead loading standards (4 additional combinations).

For each combination, the four performance characteristics were calculated and presented, as well as the number of housing units that exceed at least one of the specified standards.

Note that the above candidate paint standard (percentage of paint that is deteriorated lead-based paint) is not expressed in the manner that the proposed paint standard in the §403 proposed rule

was expressed (amount of deteriorated lead-based paint, in square feet). As discussed in Section 6.1.1 above, the Rochester study measured only lead content in paint plus an indicator of paint condition, and therefore, did not measure the surface area containing deteriorated lead-based paint. For the Rochester study data, the above paint standard triggered all units with deteriorated lead-based paint present, as the lowest observed non-zero percentage of deteriorated lead-based paint was 8% for interior surfaces and 14% for exterior surfaces.

Three iterations of this analysis was performed, with each iteration involving data for a different number of housing units:

> Iteration #1: Instead of requiring soil-lead concentrations be reported for both dripline and play areas, as was done within the analysis cited in Section 6.1.3 above, average soil-lead concentration was set equal to the reported concentration at one of these areas if no concentration is reported for the other area. This approach permitted data for 177 housing units to be used in the analysis.
>
> Iteration #2: After taking the approach in iteration #1, any units that did not have soil-lead concentration reported due to having no bare soil available from which to sample were assigned a soil-lead concentration of 0 ppm. This approach was taken as Title IV of TSCA restricts the §403 soil-lead hazard standard to bare soil and further assuming that any covered soil at these units would not pose a soil-lead hazard. This approach permitted data for 184 housing units to be used in the analysis.
>
> Iteration #3: After taking the approach in iterations #1 and #2, the 21 remaining units having missing data for at least one endpoint had an imputed value assigned to the endpoint(s) equal to the average value across units within the same year-built category (pre-1940, 1940-1959, 1960-1979, post-1979) and having the same indicator of whether or not lead-based paint is present in the unit. This method followed the same approach taken in the §403 risk analysis (Section 3.3.1.1 of the §403 risk analysis report) to impute data for housing units in the HUD National Survey. This approach permitted data for 205 housing units to be used in the analysis.

The results of each iteration are now presented.

Iteration #1: Data for 177 Housing Units.

Table 6-3 presents the results of the performance characteristics analyses performed on data for 177 housing units (#1 above) under the 41 combinations of standards listed above. Note from this table that the fixed paint standards (which were equivalent to finding any deteriorated lead-based paint in the unit) triggered an intervention for nearly three-fourths of the 177 units. These paint standards considered jointly with a soil-lead concentration standard of 400 µg/g resulted in 100% sensitivity and negative predictive value regardless of the dust standards. Sensitivity and negative predictive values of 100% were also met at a soil-lead concentration standard of 1200 µg/g if the floor dust-lead loading standard was at 10 $\mu g/ft^2$ and the window sill

Table 6-3. Results of Performance Characteristics Analysis Performed on Data for 177 Units in the Rochester Lead-in-Dust Study for Specified Sets of Standards[1]

LBP = lead-based paint; EBL = elevated blood-lead level ($ 10 μg/dL)

Set of Standards					SENSITIVITY	SPECIFICITY	POSITIVE PREDICTIVE VALUE	NEGATIVE PREDICTIVE VALUE	
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading (μg/ft^2)	Floor Dust-Lead Loading (μg/ft^2)	# (%) of the 177 Housing Units That Are At or Above At Least One Standard	# (%) of the 43 Housing Units with EBL Children That Are At or Above At Least One Standard	# (%) of the 134 Housing Units with No EBL Children That Are At or Above No Standards	# (%) of Housing Units That Are At or Above At Least One Standard That Have EBL Children[2]	# (%) of Housing Units That Are At or Above No Standards That Do Not Have EBL Children[3]	Sum of Four Performance Characteristics (%)
2	10	--	--	--	132 (74.6%)	36 (83.7%)	38 (28.4%)	36/132 (27.3%)	38/45 (84.4%)	223.8
2	10	400	--	--	154 (87.0%)	43 (100%)	23 (17.2%)	43/154 (27.9%)	23/23 (100%)	245.1
2	10	400	250	--	156 (88.1%)	43 (100%)	21 (15.7%)	43/156 (27.6%)	21/21 (100%)	243.2
2	10	400	250	200	156 (88.1%)	43 (100%)	21 (15.7%)	43/156 (27.6%)	21/21 (100%)	243.2
2	10	400	250	100	156 (88.1%)	43 (100%)	21 (15.7%)	43/156 (27.6%)	21/21 (100%)	243.2
2	10	400	250	50	156 (88.1%)	43 (100%)	21 (15.7%)	43/156 (27.6%)	21/21 (100%)	243.2
72	10	400	250	40	156 (88.1%)	43 (100%)	21 (15.7%)	43/156 (27.6%)	21/21 (100%)	243.2
2	10	400	250	25	156 (88.1%)	43 (100%)	21 (15.7%)	43/156 (27.6%)	21/21 (100%)	243.2
2	10	400	250	20	159 (89.8%)	43 (100%)	18 (13.4%)	43/159 (27.0%)	18/18 (100%)	240.5
2	10	400	250	10	168 (94.9%)	43 (100%)	9 (6.7%)	43/168 (25.6%)	9/9 (100%)	233.3
2	10	400	250	5	173 (97.7%)	43 (100%)	4 (3.0%)	43/173 (24.9%)	4/4 (100%)	227.8
2	10	1200	--	--	137 (77.4%)	39 (90.7%)	36 (26.9%)	39/137 (28.5%)	36/40 (90.0%)	236.0
2	10	1200	250	--	141 (79.7%)	40 (93.0%)	33 (24.6%)	40/141 (28.4%)	33/36 (91.7%)	237.7
2	10	1200	250	200	141 (79.7%)	40 (93.0%)	33 (24.6%)	40/141 (28.4%)	33/36 (91.7%)	237.7
2	10	1200	250	100	141 (79.7%)	40 (93.0%)	33 (24.6%)	40/141 (28.4%)	33/36 (91.7%)	237.7

Table 6-3. (cont.)

Set of Standards					SENSITIVITY		SPECIFICITY	POSITIVE PREDICTIVE VALUE	NEGATIVE PREDICTIVE VALUE	
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading ($\mu g/ft^2$)	Floor Dust-Lead Loading ($\mu g/ft^2$)	# (%) of the 177 Housing Units That Are At or Above At Least One Standard	# (%) of the 43 Housing Units with EBL Children That Are At or Above At Least One Standard	# (%) of the 134 Housing Units with No EBL Children That Are At or Above No Standards	# (%) of Housing Units That Have At or Above At Least One Standard That Have EBL Children[2]	# (%) of Housing Units That Are At or Above No Standards That Do Not Have EBL Children[3]	Sum of Four Performance Characteristics (%)
2	10	1200	250	50	142 (80.2%)	41 (95.3%)	33 (24.6%)	41/142 (28.9%)	33/35 (94.3%)	243.1
2	10	1200	250	40	143 (80.8%)	41 (95.3%)	32 (23.9%)	41/143 (28.7%)	32/34 (94.1%)	242.0
2	10	1200	250	25	143 (80.8%)	41 (95.3%)	32 (23.9%)	41/143 (28.7%)	32/34 (94.1%)	242.0
2	10	1200	250	20	147 (83.1%)	42 (97.7%)	29 (21.6%)	42/147 (28.6%)	29/30 (96.7%)	244.6
2	10	1200	250	10	165 (93.2%)	43 (100%)	12 (9.0%)	43/165 (26.1%)	12/12 (100%)	235.0
2	10	1200	250	5	171 (96.6%)	43 (100%)	6 (4.5%)	43/171 (25.1%)	6/6 (100%)	229.6
2	10	2000	--	--	135 (76.3%)	38 (88.4%)	37 (27.6%)	38/135 (28.1%)	37/42 (88.1%)	232.2
2	10	2000	250	--	140 (79.1%)	39 (90.7%)	33 (24.6%)	39/140 (27.9%)	33/37 (89.2%)	232.4
2	10	2000	250	200	140 (79.1%)	39 (90.7%)	33 (24.6%)	39/140 (27.9%)	33/37 (89.2%)	232.4
2	10	2000	250	100	140 (79.1%)	39 (90.7%)	33 (24.6%)	39/140 (27.9%)	33/37 (89.2%)	232.4
2	**10**	**2000**	**250**	**50**	**141 (79.7%)**	**40 (93.0%)**	**33 (24.6%)**	**40/141 (28.4%)**	**33/36 (91.7%)**	**237.7**
2	10	2000	250	40	142 (80.2%)	40 (93.0%)	32 (23.9%)	40/142 (28.2%)	32/35 (91.4%)	236.5
2	10	2000	250	25	142 (80.2%)	40 (93.0%)	32 (23.9%)	40/142 (28.2%)	32/35 (91.4%)	236.5
2	10	2000	250	20	147 (83.1%)	42 (97.7%)	29 (21.6%)	42/147 (28.6%)	29/30 (96.7%)	244.6
2	10	2000	250	10	165 (93.2%)	43 (100%)	12 (9.0%)	43/165 (26.1%)	12/12 (100%)	235.0
2	10	2000	250	5	171 (96.6%)	43 (100%)	6 (4.5%)	43/171 (25.1%)	6/6 (100%)	229.6

Table 6-3. (cont.)

Set of Standards					SENSITIVITY		SPECIFICITY	POSITIVE PREDICTIVE VALUE	NEGATIVE PREDICTIVE VALUE	
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading (μg/ft^2)	Floor Dust-Lead Loading (μg/ft^2)	# (%) of the 177 Housing Units That Are At or Above At Least One Standard	# (%) of the 43 Housing Units with EBL Children That Are At or Above At Least One Standard	# (%) of the 134 Housing Units with No EBL Children That Are At or Above No Standards	# (%) of Housing Units That Are At or Above At Least One Standard That Have EBL Children[2]	# (%) of Housing Units That Are At or Above No Standards That Do Not Have EBL Children[3]	Sum of Four Performance Character-istics (%)
2	10	5000	--	--	133 (75.1%)	37 (86.0%)	38 (28.4%)	37/133 (27.8%)	38/44 (86.4%)	228.6
2	10	5000	250	--	138 (78.0%)	38 (88.4%)	34 (25.4%)	38/138 (27.5%)	34/39 (87.2%)	228.5
2	10	5000	250	200	138 (78.0%)	38 (88.4%)	34 (25.4%)	38/138 (27.5%)	34/39 (87.2%)	228.5
2	10	5000	250	100	138 (78.0%)	38 (88.4%)	34 (25.4%)	38/138 (27.5%)	34/39 (87.2%)	228.5
2	10	5000	250	50	139 (78.5%)	39 (90.7%)	34 (25.4%)	39/139 (28.1%)	34/38 (89.5%)	233.6
2	10	5000	250	40	140 (79.1%)	39 (90.7%)	33 (24.6%)	39/140 (27.9%)	33/37 (89.2%)	232.4
2	10	5000	250	25	140 (79.1%)	39 (90.7%)	33 (24.6%)	39/140 (27.9%)	33/37 (89.2%)	232.4
2	10	5000	250	20	145 (81.9%)	41 (95.3%)	30 (22.4%)	41/145 (28.3%)	30/32 (93.8%)	239.8
2	10	5000	250	10	164 (92.7%)	43 (100%)	13 (9.7%)	43/164 (26.2%)	13/13 (100%)	235.9
2	10	5000	250	5	171 (96.6%)	43 (100%)	6 (4.5%)	43/171 (25.1%)	6/6 (100%)	229.6

[1] Calculations are based on data from 177 of 205 units in the Rochester Lead-in-Dust study that had available data for average (wipe) floor dust-lead loading, average (wipe) window sill dust-lead loading, average soil-lead concentration (across dripline and play areas, with only one of the two areas represented if no data existed for the other area), percentage of interior lead-based paint that is deteriorated, and percentage of exterior lead-based paint that is deteriorated. Of these 177 units, 43 have children with elevated blood-lead concentrations ($ 10 μg/dL).

[2] Cell entries are as follows: (number of homes at or above at least one standard that have EBL children)/(total number of homes at or above at least one standard), followed by the corresponding percentage (in parentheses).

[3] Cell entries are as follows: (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not at or above any standard), followed by the corresponding percentage (in parentheses).

dust-lead loading was at 250 µg/ft^2, although the specificity declined considerably at these standards. When the floor dust-lead loading standard was raised to 20 µg/ft^2 in this situation, both the sensitivity and negative predictive value remained above 95%. However, at soil-lead standards of 1200 µg/g or higher, the 95% criterion for both sensitivity and negative predictive value were no longer achieved once the floor dust-lead loading standard exceeded 20 µg/ft^2.

Among the 32 combinations of standards included in Table 6-3, the sum of the four performance characteristics (i.e., the last column of the table) was maximized at 244.6% at a floor dust-lead loading standard of 20 µg/ft^2 and a soil-lead standard of either 1200 or 2000 µg/g. (The paint and window sill standards were fixed in each combination.)

The proposed §403 standards, assuming the different approach taken in this analysis to interpreting the paint standards, resulted in a 93% sensitivity (40 of 43 units containing an elevated blood-lead child are triggered) and nearly a 92% negative predictive value (see shaded/bold row within Table 6-3). The sum of the four performance characteristics was 237.7%. Nearly 80% of the 177 units exceeded at least one of the proposed §403 standards.

Iteration #2: Data for 184 Housing Units.

Table 6-4 presents the same types of results as in Table 6-3, but it reflects analyses that included data for seven additional housing units where soil-lead concentration was assumed to be 0 µg/g due to having no bare soil present for sampling (i.e., a total of 184 housing units). Only one of these seven additional units contained a child with an elevated blood-lead concentration.

Slight reductions in the values of the performance characteristics were seen from Table 6-3 to Table 6-4 with the addition of these seven units. The one additional unit containing a child with elevated blood-lead concentration did not exceed any of the paint, soil, or window sill standards in the table and exceeded only floor dust-lead loading standards below 50 µg/ft^2. However, as in Table 2-3, sensitivity and negative predictive values of 100% (and the considerable declines in specificity) continued to occur at a soil-lead concentration standard of 1200 µg/g if the floor dust-lead loading standard was at 10 µg/ft^2 and the window sill dust-lead loading was at 250 µg/ft^2.

Despite the general declines in the values of the four performance characteristics from Table 6-3, the largest observed value of the sum of these characteristics among the 32 combinations of standards (245.0) was slightly larger than in Table 6-3. This value was observed for the same two combinations of standards for which the maximum occurred in Table 6-3: a floor dust-lead loading standard of 20 µg/ft^2 and a soil-lead standard of either 1200 or 2000 µg/g.

The proposed §403 standards, assuming the different approach taken in this analysis to interpreting the paint standards, resulted in nearly a 91% sensitivity and nearly a 90% negative predictive value, which were slight declines from Table 6-3 (see shaded/bold row within Table 6-4). The sum of the four performance characteristics was 233.2%.

Table 6-4. Results of Performance Characteristics Analysis Performed on Data for 184 Units in the Rochester Lead-in-Dust Study for Specified Sets of Standards[1]

LBP = lead-based paint; EBL = elevated blood-lead level ($ 10 μg/dL)

Set of Standards						SENSITIVITY	SPECIFICITY	POSITIVE PREDICTIVE VALUE	NEGATIVE PREDICTIVE VALUE	
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading (μg/ft^2)	Floor Dust-Lead Loading (μg/ft^2)	# (%) of the 184 Housing Units That That Are At or Above At Least One Standard	# (%) of the 44 Housing Units with EBL Children That That Are At or Above At Least One Standard	# (%) of the 140 Housing Units with No EBL Children That Are At or Above No Standards	# (%) of Housing Units That Are At or Above At Least One Standard That Have EBL Children[2]	# (%) of Housing Units That Are At or Above No Standards That Do Not Have EBL Children[3]	Sum of Four Performance Character-istics (%)
2	10	--	--	--	136 (73.9%)	36 (81.8%)	40 (28.6%)	36/136 (26.5%)	40/48 (83.3%)	220.2
2	10	400	--	--	158 (85.9%)	43 (97.7%)	25 (17.9%)	43/158 (27.2%)	25/26 (96.2%)	239.0
2	10	400	250	--	160 (87.0%)	43 (97.7%)	23 (16.4%)	43/160 (26.9%)	23/24 (95.8%)	236.9
2	10	400	250	200	160 (87.0%)	43 (97.7%)	23 (16.4%)	43/160 (26.9%)	23/24 (95.8%)	236.9
2	10	400	250	100	160 (87.0%)	43 (97.7%)	23 (16.4%)	43/160 (26.9%)	23/24 (95.8%)	236.9
2	10	400	250	50	160 (87.0%)	43 (97.7%)	23 (16.4%)	43/160 (26.9%)	23/24 (95.8%)	236.9
2	10	400	250	40	161 (87.5%)	44 (100%)	23 (16.4%)	44/161 (27.3%)	23/23 (100%)	243.8
2	10	400	250	25	161 (87.5%)	44 (100%)	23 (16.4%)	44/161 (27.3%)	23/23 (100%)	243.8
2	10	400	250	20	164 (89.1%)	44 (100%)	20 (14.3%)	44/164 (26.8%)	20/20 (100%)	241.1
2	10	400	250	10	173 (94.0%)	44 (100%)	11 (7.9%)	44/173 (25.4%)	11/11 (100%)	233.3
2	10	400	250	5	179 (97.3%)	44 (100%)	5 (3.6%)	44/179 (24.6%)	5/5 (100%)	228.2
2	10	1200	--	--	141 (76.6%)	39 (88.6%)	38 (27.1%)	39/141 (27.7%)	38/43 (88.4%)	231.8
2	10	1200	250	--	145 (78.8%)	40 (90.9%)	35 (25.0%)	40/145 (27.6%)	35/39 (89.7%)	233.2
2	10	1200	250	200	145 (78.8%)	40 (90.9%)	35 (25.0%)	40/145 (27.6%)	35/39 (89.7%)	233.2
2	10	1200	250	100	145 (78.8%)	40 (90.9%)	35 (25.0%)	40/145 (27.6%)	35/39 (89.7%)	233.2
2	10	1200	250	50	146 (79.3%)	41 (93.2%)	35 (25.0%)	41/146 (28.1%)	35/38 (92.1%)	238.4

Table 6-4. (cont.)

Set of Standards						SENSITIVITY	SPECIFICITY	POSITIVE PREDICTIVE VALUE	NEGATIVE PREDICTIVE VALUE	
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading ($\mu g/ft^2$)	Floor Dust-Lead Loading ($\mu g/ft^2$)	# (%) of the 184 Housing Units That That Are At or Above At Least One Standard	# (%) of the 44 Housing Units with EBL Children That That Are At or Above At Least One Standard	# (%) of the 140 Housing Units with No EBL Children That Are At or Above No Standards	# (%) of Housing Units That Are At or Above At Least One Standard That Have EBL Children[2]	# (%) of Housing Units That Are At or Above No Standards That Do Not Have EBL Children[3]	Sum of Four Performance Character-istics (%)
2	10	1200	250	40	148 (80.4%)	42 (95.5%)	34 (24.3%)	42/148 (28.4%)	34/36 (94.4%)	242.6
2	10	1200	250	25	148 (80.4%)	42 (95.5%)	34 (24.3%)	42/148 (28.4%)	34/36 (94.4%)	242.6
2	10	1200	250	20	152 (82.6%)	43 (97.7%)	31 (22.1%)	43/152 (28.3%)	31/32 (96.9%)	245.0
2	10	1200	250	10	170 (92.4%)	44 (100%)	14 (10.0%)	44/170 (25.9%)	14/14 (100%)	235.9
2	10	1200	250	5	177 (96.2%)	44 (100%)	7 (5.0%)	44/177 (24.9%)	7/7 (100%)	229.9
2	10	2000	--	--	139 (75.5%)	38 (86.4%)	39 (27.9%)	38/139 (27.3%)	39/45 (86.7%)	228.2
2	10	2000	250	--	144 (78.3%)	39 (88.6%)	35 (25.0%)	39/144 (27.1%)	35/40 (87.5%)	228.2
2	10	2000	250	200	144 (78.3%)	39 (88.6%)	35 (25.0%)	39/144 (27.1%)	35/40 (87.5%)	228.2
2	10	2000	250	100	144 (78.3%)	39 (88.6%)	35 (25.0%)	39/144 (27.1%)	35/40 (87.5%)	228.2
2	**10**	**2000**	**250**	**50**	**145 (78.8%)**	**40 (90.9%)**	**35 (25.0%)**	**40/145 (27.6%)**	**35/39 (89.7%)**	**233.2**
2	10	2000	250	40	147 (79.9%)	41 (93.2%)	34 (24.3%)	41/147 (27.9%)	34/37 (91.9%)	237.3
2	10	2000	250	25	147 (79.9%)	41 (93.2%)	34 (24.3%)	41/147 (27.9%)	34/37 (91.9%)	237.3
2	10	2000	250	20	152 (82.6%)	43 (97.7%)	31 (22.1%)	43/152 (28.3%)	31/32 (96.9%)	245.0
2	10	2000	250	10	170 (92.4%)	44 (100%)	14 (10.0%)	44/170 (25.9%)	14/14 (100%)	235.9
2	10	2000	250	5	177 (96.2%)	44 (100%)	7 (5.0%)	44/177 (24.9%)	7/7 (100%)	229.9

Table 6-4. (cont.)

Set of Standards					# (%) of the 184 Housing Units That That Are At or Above At Least One Standard	SENSITIVITY	SPECIFICITY	POSITIVE PREDICTIVE VALUE	NEGATIVE PREDICTIVE VALUE	Sum of Four Performance Character-istics (%)
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading (μg/ft^2)	Floor Dust-Lead Loading (μg/ft^2)		# (%) of the 44 Housing Units with EBL Children That That Are At or Above At Least One Standard	# (%) of the 140 Housing Units with No EBL Children That Are At or Above No Standards	# (%) of Housing Units That Are At or Above At Least One Standard That Have EBL Children[2]	# (%) of Housing Units That Are At or Above No Standards That Do Not Have EBL Children[3]	
2	10	5000	--	--	137 (74.5%)	37 (84.1%)	40 (28.6%)	37/137 (27.0%)	40/47 (85.1%)	224.8
2	10	5000	250	--	142 (77.2%)	38 (86.4%)	36 (25.7%)	38/142 (26.8%)	36/42 (85.7%)	224.6
2	10	5000	250	200	142 (77.2%)	38 (86.4%)	36 (25.7%)	38/142 (26.8%)	36/42 (85.7%)	224.6
2	10	5000	250	100	142 (77.2%)	38 (86.4%)	36 (25.7%)	38/142 (26.8%)	36/42 (85.7%)	224.6
2	10	5000	250	50	143 (77.7%)	39 (88.6%)	36 (25.7%)	39/143 (27.3%)	36/41 (87.8%)	229.4
2	10	5000	250	40	145 (78.8%)	40 (90.9%)	35 (25.0%)	40/145 (27.6%)	35/39 (89.7%)	233.2
2	10	5000	250	25	145 (78.8%)	40 (90.9%)	35 (25.0%)	40/145 (27.6%)	35/39 (89.7%)	233.2
2	10	5000	250	20	150 (81.5%)	42 (95.5%)	32 (22.9%)	42/150 (28.0%)	32/34 (94.1%)	240.4
2	10	5000	250	10	169 (91.8%)	44 (100%)	15 (10.7%)	44/169 (26.0%)	15/15 (100%)	236.7
2	10	5000	250	5	177 (96.2%)	44 (100%)	7 (5.0%)	44/177 (24.9%)	7/7 (100%)	229.9

[1] Calculations are based on data from 184 of 205 units in the Rochester Lead-in-Dust study that had available data for average (wipe) floor dust-lead loading, average (wipe) window sill dust-lead loading, average soil-lead concentration (across dripline and play areas, with only one of the two areas represented if no data existed for the other area), percentage of interior lead-based paint that is deteriorated, and percentage of exterior lead-based paint that is deteriorated. Homes having no reported soil-lead concentration but with no bare soil reported are assumed to have a soil-lead concentration of 0 ppm for these calculations. Of these 184 units, 44 have children with elevated blood-lead concentrations ($ 10 μg/dL).

[2] Cell entries are as follows: (number of homes at or above at least one standard that have EBL children)/(total number of homes at or above at least one standard), followed by the corresponding percentage (in parentheses).

[3] Cell entries are as follows: (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not at or above any standard), followed by the corresponding percentage (in parentheses).

Iteration #3: Data for 205 Housing Units.

The third set of performance characteristics analyses was performed on data for all 205 housing units in the Rochester study. The previous analyses involved data for fewer housing units as some units did not have recorded data for the key endpoints used in the analyses to compare to the various candidate standards. Therefore, this analysis replaced incidences of missing data with data values that were imputed from information available from other study units. It was assumed that these imputed values were accurate estimates of what would have been reported for these units. This estimate for a housing unit could vary considerably from what would have been reported, however, based on actual conditions and behaviors in the household.

As all 205 housing units had reported values for child's blood-lead concentration and for the percentage of tested interior components containing deteriorated lead-based paint, no imputation was necessary for these two endpoints. The other four endpoints had at least one housing unit with missing data. For each of these four endpoints, Table 6-5 contains the number of housing units with missing data according to year-built category and whether or not the unit contains lead-based paint, along with the imputed data value assigned to these units, which equaled the average value across all units in that same category that had non-missing data. The imputed data values depended on the year-built category and lead-based paint indicator as these two variables are typically important predictors of these values. This same approach was used in the §403 risk analysis to impute environmental-lead data values for HUD National Survey units having missing data (see Section 3.3.1.1 of USEPA, 1998).

The data imputation process documented in Table 6-5 resulted in assigning imputed data to 21 units: 19 built prior to 1940, one built from 1940-1959, and one built after 1979. A total of eight average uncarpeted floor dust-lead loadings, nine average window sill dust-lead loadings, six average soil-lead concentrations, and one percentage of deteriorated lead-based paint on exterior surfaces were imputed.

Table 6-6 presents estimates of the four performance characteristics for the 41 combinations of standards, using reported and imputed data for 205 housing units in the Rochester study. These estimates are very similar to those in Table 6-4 that were calculated from data for 184 housing units. The same conclusions can be drawn from these results as were made from the results in Tables 6-3 and 6-4. This implies that at the given combinations of candidate standards considered in these analyses, the methods used in this section to estimate performance characteristics were relatively robust across the different sets of data used in the analyses (i.e., 177, 184, or 205 units).

As sensitivity and negative predictive value are the two performance characteristics of most interest to Agency reviewers, the results for these two characteristics from Tables 6-3, 6-4, and 6-6 are summarized in Table 6-7. This summary emphasizes the relative stability of the estimates across the different approaches used to make the calculations.

Table 6-5. Numbers of Housing Units with Missing Data for Four Endpoints and the Imputed Data Values Assigned to These Units in This Analysis

Year-Built Category	Lead-Based Paint Present?	Area-Weighted Average Uncarpeted Floor Dust-Lead Loading		Area-Weighted Average Window Sill Dust-Lead Loading		Average Soil-Lead Concentration		% of Exterior Components Containing Deteriorated Lead-Based Paint	
		# Units with Missing Data	Imputed Value ($\mu g/ft^2$)[1]	# Units with Missing Data	Imputed Value ($\mu g/ft^2$)[1]	# Units with Missing Data	Imputed Value ($\mu g/g$)[1]	# Units with Missing Data	Imputed Value (%)[1]
Pre-1940	Yes	6	160.2 (157)	5	633.2 (158)	5	1258 (158)	1	25.2% (162)
	No	1	13.3 (8)	3	95.2 (6)	1	631.7 (8)	0	--
1940-1959	Yes	0	--	1	569.0 (12)	0	--	0	--
	No	0	--	0	--	0	--	0	--
1960-1979	--	0	--	0	--	0	--	0	--
Post-1979	Yes	1	91.3 (3)	0	--	0	--	0	--
	No	0	--	0	--	0	--	0	--

[1] Number in parentheses equals the number of values (i.e., housing units) entering into calculation of the imputed value, which is the average of these values.

Table 6-6. Results of Performance Characteristics Analysis Performed on Data for 205 Units in the Rochester Lead-in-Dust Study for Specified Sets of Standards[1]

LBP = lead-based paint; EBL = elevated blood-lead level ($ 10 μg/dL)

Set of Standards						SENSITIVITY	SPECIFICITY	POSITIVE PREDICTIVE VALUE	NEGATIVE PREDICTIVE VALUE	
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading (μg/ft^2)	Floor Dust-Lead Loading (μg/ft^2)	# (%) of the 205 Housing Units That Are At or Above At Least One Standard	# (%) of the 48 Housing Units with EBL Children That Are At or Above At Least One Standard	# (%) of the 157 Housing Units with No EBL Children That Are At or Above No Standards	# (%) of Housing Units That Are At or Above At Least One Standard That Have EBL Children[2]	# (%) of Housing Units That Are At or Above No Standards That Do Not Have EBL Children[3]	Sum of Four Performance Character-istics (%)
2	10	--	--	--	151 (73.7%)	39 (81.3%)	45 (28.7%)	39/151 (25.8%)	45/54 (83.3%)	219.1
2	10	400	--	--	177 (86.3%)	47 (97.9%)	27 (17.2%)	47/177 (26.6%)	27/28 (96.4%)	238.1
2	10	400	250	--	179 (87.3%)	47 (97.9%)	25 (15.9%)	47/179 (26.3%)	25/26 (96.2%)	236.3
2	10	400	250	200	179 (87.3%)	47 (97.9%)	25 (15.9%)	47/179 (26.3%)	25/26 (96.2%)	236.3
2	10	400	250	100	179 (87.3%)	47 (97.9%)	25 (15.9%)	47/179 (26.3%)	25/26 (96.2%)	236.3
2	10	400	250	50	180 (87.8%)	47 (97.9%)	24 (15.3%)	47/180 (26.1%)	24/25 (96.0%)	235.3
2	10	400	250	40	181 (88.3%)	48 (100%)	24 (15.3%)	48/181 (26.5%)	24/24 (100%)	241.8
2	10	400	250	25	181 (88.3%)	48 (100%)	24 (15.3%)	48/181 (26.5%)	24/24 (100%)	241.8
2	10	400	250	20	184 (89.8%)	48 (100%)	21 (13.4%)	48/184 (26.1%)	21/21 (100%)	239.5
2	10	400	250	10	193 (94.1%)	48 (100%)	12 (7.6%)	48/193 (24.9%)	12/12 (100%)	232.5
2	10	400	250	5	199 (97.1%)	48 (100%)	6 (3.8%)	48/199 (24.1%)	6/6 (100%)	227.9
2	10	1200	--	--	159 (77.6%)	43 (89.6%)	41 (26.1%)	43/159 (27.0%)	41/46 (89.1%)	231.9
2	10	1200	250	--	163 (79.5%)	44 (91.7%)	38 (24.2%)	44/163 (27.0%)	38/42 (90.5%)	233.3
2	10	1200	250	200	163 (79.5%)	44 (91.7%)	38 (24.2%)	44/163 (27.0%)	38/42 (90.5%)	233.3
2	10	1200	250	100	163 (79.5%)	44 (91.7%)	38 (24.2%)	44/163 (27.0%)	38/42 (90.5%)	233.3
2	10	1200	250	50	165 (80.5%)	45 (93.8%)	37 (23.6%)	45/165 (27.3%)	37/40 (92.5%)	237.1

Table 6-6. (cont.)

Set of Standards					# (%) of the 205 Housing Units That Are At or Above At Least One Standard	SENSITIVITY # (%) of the 48 Housing Units with EBL Children That Are At or Above At Least One Standard	SPECIFICITY # (%) of the 157 Housing Units with No EBL Children That Are At or Above No Standards	POSITIVE PREDICTIVE VALUE # (%) of Housing Units That Are At or Above At Least One Standard That Have EBL Children[2]	NEGATIVE PREDICTIVE VALUE # (%) of Housing Units That Are At or Above No Standards That Do Not Have EBL Children[3]	Sum of Four Performance Character-istics (%)
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading ($\mu g/ft^2$)	Floor Dust-Lead Loading ($\mu g/ft^2$)						
2	10	1200	250	40	167 (81.5%)	46 (95.8%)	36 (22.9%)	46/167 (27.5%)	36/38 (94.7%)	241.0
2	10	1200	250	25	167 (81.5%)	46 (95.8%)	36 (22.9%)	46/167 (27.5%)	36/38 (94.7%)	241.0
2	10	1200	250	20	171 (83.4%)	47 (97.9%)	33 (21.0%)	47/171 (27.5%)	33/34 (97.1%)	243.5
2	10	1200	250	10	190 (92.7%)	48 (100%)	15 (9.6%)	48/190 (25.3%)	15/15 (100%)	234.8
2	10	1200	250	5	197 (96.1%)	48 (100%)	8 (5.1%)	48/197 (24.4%)	8/8 (100%)	229.5
2	10	2000	--	--	155 (75.6%)	42 (87.5%)	44 (28.0%)	42/155 (27.1%)	44/50 (88.0%)	230.6
2	10	2000	250	--	162 (79.0%)	43 (89.6%)	38 (24.2%)	43/162 (26.5%)	38/43 (88.4%)	228.7
2	10	2000	250	200	162 (79.0%)	43 (89.6%)	38 (24.2%)	43/162 (26.5%)	38/43 (88.4%)	228.7
2	10	2000	250	100	162 (79.0%)	43 (89.6%)	38 (24.2%)	43/162 (26.5%)	38/43 (88.4%)	228.7
2	**10**	**2000**	**250**	**50**	**164 (80.0%)**	**44 (91.7%)**	**37 (23.6%)**	**44/164 (26.8%)**	**37/41 (90.2%)**	**232.3**
2	10	2000	250	40	166 (81.0%)	45 (93.8%)	36 (22.9%)	45/166 (27.1%)	36/39 (92.3%)	236.1
2	10	2000	250	25	166 (81.0%)	45 (93.8%)	36 (22.9%)	45/166 (27.1%)	36/39 (92.3%)	236.1
2	10	2000	250	20	171 (83.4%)	47 (97.9%)	33 (21.0%)	47/171 (27.5%)	33/34 (97.1%)	243.5
2	10	2000	250	10	190 (92.7%)	48 (100%)	15 (9.6%)	48/190 (25.3%)	15/15 (100%)	234.8
2	10	2000	250	5	197 (96.1%)	48 (100%)	8 (5.1%)	48/197 (24.4%)	8/8 (100%)	229.5

Table 6-6. (cont.)

Set of Standards					# (%) of the 205 Housing Units That Are At or Above At Least One Standard	SENSITIVITY	SPECIFICITY	POSITIVE PREDICTIVE VALUE	NEGATIVE PREDICTIVE VALUE	Sum of Four Performance Character-istics (%)
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading ($\mu g/ft^2$)	Floor Dust-Lead Loading ($\mu g/ft^2$)		# (%) of the 48 Housing Units with EBL Children That Are At or Above At Least One Standard	# (%) of the 157 Housing Units with No EBL Children That Are At or Above No Standards	# (%) of Housing Units That Are At or Above At Least One Standard That Have EBL Children[2]	# (%) of Housing Units That Are At or Above No Standards That Do Not Have EBL Children[3]	
2	10	5000	--	--	152 (74.1%)	40 (83.3%)	45 (28.7%)	40/152 (26.3%)	45/53 (84.9%)	223.2
2	10	5000	250	--	159 (77.6%)	41 (85.4%)	39 (24.8%)	41/159 (25.8%)	39/46 (84.8%)	220.8
2	10	5000	250	200	159 (77.6%)	41 (85.4%)	39 (24.8%)	41/159 (25.8%)	39/46 (84.8%)	220.8
2	10	5000	250	100	159 (77.6%)	41 (85.4%)	39 (24.8%)	41/159 (25.8%)	39/46 (84.8%)	220.8
2	10	5000	250	50	161 (78.5%)	42 (87.5%)	38 (24.2%)	42/161 (26.1%)	38/44 (86.4%)	224.2
2	10	5000	250	40	163 (79.5%)	43 (89.6%)	37 (23.6%)	43/163 (26.4%)	37/42 (88.1%)	227.6
2	10	5000	250	25	163 (79.5%)	43 (89.6%)	37 (23.6%)	43/163 (26.4%)	37/42 (88.1%)	227.6
2	10	5000	250	20	168 (82.0%)	45 (93.8%)	34 (21.7%)	45/168 (26.8%)	34/37 (91.9%)	234.1
2	10	5000	250	10	189 (92.2%)	48 (100%)	16 (10.2%)	48/189 (25.4%)	16/16 (100%)	235.6
2	10	5000	250	5	197 (96.1%)	48 (100%)	8 (5.1%)	48/197 (24.4%)	8/8 (100%)	229.5

[1] This analysis used the same data values used in Table 6-4, except missing values for the given endpoints were replaced by imputed numbers given in Table 6-5. Homes having no reported soil-lead concentration but with no bare soil reported are assumed to have a soil-lead concentration of 0 ppm for these calculations. Of these 205 units, 48 have children with elevated blood-lead concentrations ($ 10 μg/dL).

[2] Cell entries are as follows: (number of homes at or above at least one standard that have EBL children)/(total number of homes at or above at least one standard), followed by the corresponding percentage (in parentheses).

[3] Cell entries are as follows: (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not at or above any standard), followed by the corresponding percentage (in parentheses).

Table 6-7. Estimates of Sensitivity and Negative Predictive Value Presented in Tables 6-3, 6-4, and 6-6

Set of Standards					SENSITIVITY (% of Housing Units with EBL Children That Are At or Above At Least One Standard)			NEGATIVE PREDICTIVE VALUE (% of Housing Units At or Above No Standards That Do Not Have EBL Children)		
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading ($\mu g/ft^2$)	Floor Dust-Lead Loading ($\mu g/ft^2$)	Data for 177 units (Table 6-3)	Data for 184 units (Table 6-4)	Data for 205 units (Table 6-6)	Data for 177 units (Table 6-3)	Data for 184 units (Table 6-4)	Data for 205 units (Table 6-6)
2	10	--	--	--	83.7%	81.8%	81.3%	84.4%	83.3%	83.3%
2	10	400	--	--	100%	97.7%	97.9%	100%	96.2%	96.4%
2	10	400	250	--	100%	97.7%	97.9%	100%	95.8%	96.2%
2	10	400	250	200	100%	97.7%	97.9%	100%	95.8%	96.2%
2	10	400	250	100	100%	97.7%	97.9%	100%	95.8%	96.2%
2	10	400	250	50	100%	97.7%	97.9%	100%	95.8%	96.0%
2	10	400	250	40	100%	100%	100%	100%	100%	100%
2	10	400	250	25	100%	100%	100%	100%	100%	100%
2	10	400	250	20	100%	100%	100%	100%	100%	100%
2	10	400	250	10	100%	100%	100%	100%	100%	100%
2	10	400	250	5	100%	100%	100%	100%	100%	100%
2	10	1200	--	--	90.7%	88.6%	89.6%	90.0%	88.4%	89.1%
2	10	1200	250	--	93.0%	90.9%	91.7%	91.7%	89.7%	90.5%
2	10	1200	250	200	93.0%	90.9%	91.7%	91.7%	89.7%	90.5%
2	10	1200	250	100	93.0%	90.9%	91.7%	91.7%	89.7%	90.5%
2	10	1200	250	50	95.3%	93.2%	93.8%	94.3%	92.1%	92.5%
2	10	1200	250	40	95.3%	95.5%	95.8%	94.1%	94.4%	94.7%
2	10	1200	250	25	95.3%	95.5%	95.8%	94.1%	94.4%	94.7%
2	10	1200	250	20	97.7%	97.7%	97.9%	96.7%	96.9%	97.1%
2	10	1200	250	10	100%	100%	100%	100%	100%	100%
2	10	1200	250	5	100%	100%	100%	100%	100%	100%
2	10	2000	--	--	88.4%	86.4%	87.5%	88.1%	86.7%	88.0%
2	10	2000	250	--	90.7%	88.6%	89.6%	89.2%	87.5%	88.4%
2	10	2000	250	200	90.7%	88.6%	89.6%	89.2%	87.5%	88.4%
2	10	2000	250	100	90.7%	88.6%	89.6%	89.2%	87.5%	88.4%
2	**10**	**2000**	**250**	**50**	**93.0%**	**90.9%**	**91.7%**	**91.7%**	**89.7%**	**90.2%**
2	10	2000	250	40	93.0%	93.2%	93.8%	91.4%	91.9%	92.3%
2	10	2000	250	25	93.0%	93.2%	93.8%	91.4%	91.9%	92.3%

Table 6-7. (cont.)

Set of Standards					SENSITIVITY (% of Housing Units with EBL Children That Are At or Above At Least One Standard)			NEGATIVE PREDICTIVE VALUE (% of Housing Units At or Above No Standards That Do Not Have EBL Children)		
% of Interior Paint that is Damaged LBP	% of Exterior Paint that is Damaged LBP	Soil-Lead Conc. (ppm)	Window Sill Dust-Lead Loading ($\mu g/ft^2$)	Floor Dust-Lead Loading ($\mu g/ft^2$)	Data for 177 units (Table 6-3)	Data for 184 units (Table 6-4)	Data for 205 units (Table 6-6)	Data for 177 units (Table 6-3)	Data for 184 units (Table 6-4)	Data for 205 units (Table 6-6)
2	10	2000	250	20	97.7%	97.7%	97.9%	96.7%	96.9%	97.1%
2	10	2000	250	10	100%	100%	100%	100%	100%	100%
2	10	2000	250	5	100%	100%	100%	100%	100%	100%
2	10	5000	--	--	86.0%	84.1%	83.3%	86.4%	85.1%	84.9%
2	10	5000	250	--	88.4%	86.4%	85.4%	87.2%	85.7%	84.8%
2	10	5000	250	200	88.4%	86.4%	85.4%	87.2%	85.7%	84.8%
2	10	5000	250	100	88.4%	86.4%	85.4%	87.2%	85.7%	84.8%
2	10	5000	250	50	90.7%	88.6%	87.5%	89.5%	87.8%	86.4%
2	10	5000	250	40	90.7%	90.9%	89.6%	89.2%	89.7%	88.1%
2	10	5000	250	25	90.7%	90.9%	89.6%	89.2%	89.7%	88.1%
2	10	5000	250	20	95.3%	95.5%	93.8%	93.8%	94.1%	91.9%
2	10	5000	250	10	100%	100%	100%	100%	100%	100%
2	10	5000	250	5	100%	100%	100%	100%	100%	100%

6.1.4.2 Considering only Soil and Dust Standards. The analysis in the previous subsection emphasized the difficulty in evaluating candidate paint standards using the Rochester data, not only due to the fact that the Rochester study did not measure total area corresponding to deteriorated lead-based paint, but also that most of the housing units with deteriorated lead-based paint exceeded the candidate standards that were considered in that analysis. In the analysis presented in this subsection, a paint standard was not considered. Instead, the performance characteristics analysis considered only candidate standards for soil-lead, floor dust-lead, and window sill dust-lead, and then investigated the percentage of painted surfaces that contained deteriorated lead-based paint for those houses that did not exceed any of these three candidate standards, in an effort to characterize the extent to which these houses would possibly exceed a paint standard. The candidate standards for dust and soil in this analysis were the same as in the previous subsection:

- uncarpeted floor dust-lead loading: 5, 10, 20, 25, 40, 50, 100, 200 $\mu g/ft^2$
- window sill dust-lead loading: 250 $\mu g/ft^2$
- yardwide average soil-lead concentration: 400, 1200, 2000, 5000 $\mu g/g$

The following 57 combinations of candidate standards were considered in this analysis:

- 8x1x4=32 combinations of the candidate floor-dust, sill-dust, and soil standards
- 4x1=4 combinations of only the candidate soil and sill-dust standards
- 1x8=8 combinations of only the candidate floor-dust and sill-dust standards
- 4 candidate soil standards without the others
- 1 sill-lead standard without the others
- 8 candidate floor-lead standards without the others.

The analysis was applied to data for housing units in the Rochester study having data that could be compared to each of the standards included in the given combinaton. Average soil-lead concentration for housing units equaled the average of the dripline and play area soil-lead measures. Units having either dripline soil-lead data or play area soil-lead data, but not both, had an average soil-lead concentration equal to the reported concentration at the area represented by the available data. An average soil-lead concentration of 0 ppm was assigned to housing units having no soil-lead data and no bare soil from which to sample.

Table 6-8 contains the results of the performance characteristics analysis, with each row of the table corresponding to one of the 57 combinations of candidate standards being considered. The following are examples of how to interpret the findings within Table 6-8:

- Consider combinations of all three standards where the candidate soil-lead standard is 400 ppm and window sill-dust standard is 250 $\mu g/ft^2$. At an uncarpeted floor-dust standard of 50 $\mu g/ft^2$, only one of the 44 homes containing children with elevated blood-lead concentration did not exceed any of these three standards and did not contain any deteriorated lead-based paint. (Two other homes with an elevated blood-lead child also do not exceed these dust or soil standards, but they do contain some deteriorated lead-based paint.) Therefore, under these standards, this particular unit would not be triggered for intervention, regardless of the paint standard, despite the unit containing a child with an elevated blood-lead concentration. However, if the uncarpeted floor-dust standard was lowered to 40 $\mu g/ft^2$, the house would exceed this lower floor standard.

- Consider the combination involving only a floor dust-lead standard of 20 $\mu g/ft^2$ and a window sill dust-lead standard of 250 $\mu g/ft^2$. A total of 106 of the 188 homes met or exceeded at least one of these two standards, including 36 of the 45 homes with elevated blood-lead children. Of the 82 homes that did not meet or exceed either dust standard, 9 contained an elevated blood-lead child, of which 2 had no deteriorated lead-based paint in either the interior or exterior. This means that if only dust and paint standards were considered, these two homes would not be triggered for any intervention, despite containing elevated blood-lead children.

Table 6-8. Results of Performance Characteristics Analysis Performed on Data for Housing Units in the Rochester Lead-in-Dust Study, for Specified Sets of Candidate Standards for Lead in Dust and Soil Only

LBP = lead-based paint ($ 1.0 mg/cm^2); EBL = elevated blood-lead level ($ 10 μg/dL)

"Deteriorated lead-based paint" on a tested surface implies >5% of the lead-based paint is peeling, cracking, worn, chalking, flaking, blistering, or otherwise separating from the substrate.

Set of Candidate Standards for Lead in ...[1]			# Units At or Above At Least One Standard /Total # Units[2]	Performance Characteristics				Sum of the 4 Performance Characteristics (%)	# Units with EBL Children That Are At or Above No Standard and Have No Deteriorated LBP	# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Interior Paint Surfaces Having Deteriorated LBP equals[7] ...				# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Exterior Paint Surfaces Having Deteriorated LBP equals[7] ...			
Soil (ppm)	Window Sill Dust (μg/ft^2)	Floor Dust (μg/ft^2)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]			0%	10-30%	31-50%	>50%	0%	20-50%	51-75%	>75%
400	--	--	142/198	40/47 (85.1%)	49/151 (32.5%)	40/142 (28.2%)	49/56 (87.5%)	233.2	1	1	3	1	2	3	2	0	2
1200	--	--	55/198	22/47 (46.8%)	118/151 (78.1%)	22/55 (40.0%)	118/143 (82.5%)	247.5	5	8	9	4	4	10	8	4	3
2000	--	--	26/198	10/47 (21.3%)	135/151 (89.4%)	10/26 (38.5%)	135/172 (78.5%)	227.6	6	10	13	8	6	14	11	7	5
5000	--	--	6/198	3/47 (6.4%)	148/151 (98.0%)	3/6 (50.0%)	148/192 (77.1%)	231.5	8	12	15	10	7	19	13	7	5
--	250	--	73/195	25/45 (55.6%)	102/150 (68.0%)	25/73 (34.2%)	102/122 (83.6%)	241.4	7	10	4	4	2	12	3	2	3
--	--	200	5/196	3/47 (6.4%)	147/149 (98.7%)	3/5 (60.0%)	147/191 (77.0%)	242.0	8	12	16	9	7	20	12	7	5
--	--	100	9/196	5/47 (10.6%)	145/149 (97.3%)	5/9 (55.6%)	145/187 (77.5%)	241.0	8	12	16	9	5	20	11	7	4
--	--	50	19/196	9/47 (19.1%)	139/149 (93.3%)	9/19 (47.4%)	139/177 (78.5%)	238.3	7	11	15	7	5	19	10	5	4

Table 6-8. (cont.)

Set of Candidate Standards for Lead in ...[1]			# Units At or Above At Least One Standard /Total # Units[2]	Performance Characteristics				Sum of the 4 Performance Characteristics (%)	# Units with EBL Children That Are At or Above No Standard and Have No Deteriorated LBP	# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Interior Paint Surfaces Having Deteriorated LBP equals[7] ...				# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Exterior Paint Surfaces Having Deteriorated LBP equals[7] ...			
Soil (ppm)	Window Sill Dust ($\mu g/ft^2$)	Floor Dust ($\mu g/ft^2$)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]			0%	10-30%	31-50%	>50%	0%	20-50%	51-75%	>75%
--	--	40	31/196	16/47 (34.0%)	134/149 (89.9%)	16/31 (51.6%)	134/165 (81.2%)	256.8	6	9	13	7	2	15	8	4	4
--	--	25	58/196	26/47 (55.3%)	117/149 (78.5%)	26/58 (44.8%)	117/138 (84.8%)	263.5	5	8	7	4	2	12	6	2	1
--	--	20	84/196	31/47 (66.0%)	96/149 (64.4%)	31/84 (36.9%)	96/112 (85.7%)	253.0	3	6	6	3	1	7	6	2	1
--	--	10	150/196	44/47 (93.6%)	43/149 (28.9%)	44/150 (29.3%)	43/46 (93.5%)	245.3	0	0	3	0	0	2	1	0	0
--	--	5	179/196	45/47 (95.7%)	15/149 (10.1%)	45/179 (25.1%)	15/17 (88.2%)	219.2	0	0	2	0	0	2	0	0	0
400	250	--	147/190	41/44 (93.2%)	40/146 (27.4%)	41/147 (27.9%)	40/43 (93.0%)	241.5	1	1	1	0	1	2	0	0	1
1200	250	--	93/190	33/44 (75.0%)	86/146 (58.9%)	33/93 (35.5%)	86/97 (88.7%)	258.0	4	6	1	2	2	7	1	2	1
2000	250	--	81/190	27/44 (61.4%)	92/146 (63.0%)	27/81 (33.3%)	92/109 (84.4%)	242.1	5	8	4	3	2	10	2	2	3
5000	250	--	72/190	25/44 (56.8%)	99/146 (67.8%)	25/72 (34.7%)	99/118 (83.9%)	243.2	6	9	4	4	2	11	3	2	3
--	250	200	70/188	25/45 (55.6%)	98/143 (68.5%)	25/70 (35.7%)	98/118 (83.1%)	242.9	7	10	4	4	2	12	3	2	3
--	250	100	71/188	25/45 (55.6%)	97/143 (67.8%)	25/71 (35.2%)	97/117 (82.9%)	241.5	7	10	4	4	2	12	3	2	3

Table 6-8. (cont.)

Set of Candidate Standards for Lead in ...[1]			# Units At or Above At Least One Standard /Total # Units[2]	Performance Characteristics				Sum of the 4 Performance Characteristics (%)	# Units with EBL Children That Are At or Above No Standard and Have No Deteriorated LBP	# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Interior Paint Surfaces Having Deteriorated LBP equals[7] ...				# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Exterior Paint Surfaces Having Deteriorated LBP equals[7] ...			
				Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]										
Soil (ppm)	Window Sill Dust ($\mu g/ft^2$)	Floor Dust ($\mu g/ft^2$)								0%	10-30%	31-50%	>50%	0%	20-50%	51-75%	>75%
--	250	50	75/188	27/45 (60.0%)	95/143 (66.4%)	27/75 (36.0%)	95/113 (84.1%)	246.5	6	9	4	3	2	11	3	1	3
--	250	40	80/188	30/45 (66.7%)	93/143 (65.0%)	30/80 (37.5%)	93/108 (86.1%)	255.3	5	7	4	3	1	9	2	1	3
--	250	25	93/188	34/45 (75.6%)	84/143 (58.7%)	34/93 (36.6%)	84/95 (88.4%)	259.3	4	6	2	2	1	7	2	1	1
--	250	20	106/188	36/45 (80.0%)	73/143 (51.0%)	36/106 (34.0%)	73/82 (89.0%)	254.0	2	4	2	2	1	5	2	1	1
--	250	10	150/188	44/45 (97.8%)	37/143 (25.9%)	44/150 (29.3%)	37/38 (97.4%)	250.4	0	0	1	0	0	1	0	0	0
--	250	5	175/188	44/45 (97.8%)	12/143 (8.4%)	44/175 (25.1%)	12/13 (92.3%)	223.6	0	0	1	0	0	1	0	0	0
400	250	200	144/184	41/44 (93.2%)	37/140 (26.4%)	41/144 (28.5%)	37/40 (92.5%)	240.6	1	1	1	0	1	2	0	0	1
400	250	100	144/184	41/44 (93.2%)	37/140 (26.4%)	41/144 (28.5%)	37/40 (92.5%)	240.6	1	1	1	0	1	2	0	0	1
400	250	50	144/184	41/44 (93.2%)	37/140 (26.4%)	41/144 (28.5%)	37/40 (92.5%)	240.6	1	1	1	0	1	2	0	0	1
400	250	40	145/184	42/44 (95.5%)	37/140 (26.4%)	42/145 (29.0%)	37/39 (94.9%)	245.7	0	0	1	0	1	1	0	0	1
400	250	25	146/184	42/44 (95.5%)	36/140 (25.7%)	42/146 (28.8%)	36/38 (94.7%)	244.7	0	0	1	0	1	1	0	0	1

Table 6-8. (cont.)

Set of Candidate Standards for Lead in ...[1]			# Units At or Above At Least One Standard /Total # Units[2]	Performance Characteristics				Sum of the 4 Performance Characteristics (%)	# Units with EBL Children That Are At or Above No Standard and Have No Deteriorated LBP	# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Interior Paint Surfaces Having Deteriorated LBP equals[7] ...				# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Exterior Paint Surfaces Having Deteriorated LBP equals[7] ...			
				Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]										
Soil (ppm)	Window Sill Dust ($\mu g/ft^2$)	Floor Dust ($\mu g/ft^2$)								0%	10-30%	31-50%	>50%	0%	20-50%	51-75%	>75%
400	250	20	153/184	42/44 (95.5%)	29/140 (20.7%)	42/153 (27.5%)	29/31 (93.5%)	237.2	0	0	1	0	1	1	0	0	1
400	250	10	169/184	43/44 (97.7%)	14/140 (10.0%)	43/169 (25.4%)	14/15 (93.3%)	226.5	0	0	1	0	0	1	0	0	0
400	250	5	177/184	43/44 (97.7%)	6/140 (4.3%)	43/177 (24.3%)	6/7 (85.7%)	212.0	0	0	1	0	0	1	0	0	0
1200	250	200	91/184	33/44 (75.0%)	82/140 (58.6%)	33/91 (36.3%)	82/93 (88.2%)	258.0	4	6	1	2	2	7	1	2	1
1200	250	100	91/184	33/44 (75.0%)	82/140 (58.6%)	33/91 (36.3%)	82/93 (88.2%)	258.0	4	6	1	2	2	7	1	2	1
1200	250	50	95/184	35/44 (79.5%)	80/140 (57.1%)	35/95 (36.8%)	80/89 (89.9%)	263.4	3	5	1	1	2	6	1	1	1
1200	250	40	100/184	38/44 (86.4%)	78/140 (55.7%)	38/100 (38.0%)	78/84 (92.9%)	272.9	2	3	1	1	1	4	0	1	1
1200	250	25	107/184	38/44 (86.4%)	71/140 (50.7%)	38/107 (35.5%)	71/77 (92.2%)	264.8	2	3	1	1	1	4	0	1	1
1200	250	20	118/184	39/44 (88.6%)	61/140 (43.6%)	39/118 (33.1%)	61/66 (92.4%)	257.7	1	2	1	1	1	3	0	1	1
1200	250	10	155/184	43/44 (97.7%)	28/140 (20.0%)	43/155 (27.7%)	28/29 (96.6%)	242.0	0	0	1	0	0	1	0	0	0
1200	250	5	173/184	43/44 (97.7%)	10/140 (7.1%)	43/173 (24.9%)	10/11 (90.9%)	220.6	0	0	1	0	0	1	0	0	0

Table 6-8. (cont.)

Set of Candidate Standards for Lead in ...[1]			# Units At or Above At Least One Standard /Total # Units[2]	Performance Characteristics				Sum of the 4 Performance Characteristics (%)	# Units with EBL Children That Are At or Above No Standard and Have No Deteriorated LBP	# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Interior Paint Surfaces Having Deteriorated LBP equals[7] ...				# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Exterior Paint Surfaces Having Deteriorated LBP equals[7] ...			
				Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]										
Soil (ppm)	Window Sill Dust ($\mu g/ft^2$)	Floor Dust ($\mu g/ft^2$)								0%	10-30%	31-50%	>50%	0%	20-50%	51-75%	>75%
2000	250	200	79/184	27/44 (61.4%)	88/140 (62.9%)	27/79 (34.2%)	88/105 (83.8%)	242.2	5	8	4	3	2	10	2	2	3
2000	250	100	79/184	27/44 (61.4%)	88/140 (62.9%)	27/79 (34.2%)	88/105 (83.8%)	242.2	5	8	4	3	2	10	2	2	3
2000	250	50	83/184	29/44 (65.9%)	86/140 (61.4%)	29/83 (34.9%)	86/101 (85.1%)	247.4	4	7	4	2	2	9	2	1	3
2000	250	40	88/184	32/44 (72.7%)	84/140 (60.0%)	32/88 (36.4%)	84/96 (87.5%)	256.6	3	5	4	2	1	7	1	1	3
2000	250	25	99/184	35/44 (79.5%)	76/140 (54.3%)	35/99 (35.4%)	76/85 (89.4%)	258.6	3	5	2	1	1	6	1	1	1
2000	250	20	112/184	37/44 (84.1%)	65/140 (46.4%)	37/112 (33.0%)	65/72 (90.3%)	253.8	1	3	2	1	1	4	1	1	1
2000	250	10	152/184	43/44 (97.7%)	31/140 (22.1%)	43/152 (28.3%)	31/32 (96.9%)	245.0	0	0	1	0	0	1	0	0	0
2000	250	5	172/184	43/44 (97.7%)	11/140 (7.9%)	43/172 (25.0%)	11/12 (91.7%)	222.3	0	0	1	0	0	1	0	0	0
5000	250	200	70/184	25/44 (56.8%)	95/140 (67.9%)	25/70 (35.7%)	95/114 (83.3%)	243.7	6	9	4	4	2	11	3	2	3
5000	250	100	71/184	25/44 (56.8%)	94/140 (67.1%)	25/71 (35.2%)	94/113 (83.2%)	242.4	6	9	4	4	2	11	3	2	3
5000	250	50	75/184	27/44 (61.4%)	92/140 (65.7%)	27/75 (36.0%)	92/109 (84.4%)	247.5	5	8	4	3	2	10	3	1	3

Table 6-8. (cont.)

Set of Candidate Standards for Lead in ...[1]			# Units At or Above At Least One Standard /Total # Units[2]	Performance Characteristics				Sum of the 4 Performance Characteristics (%)	# Units with EBL Children That Are At or Above No Standard and Have No Deteriorated LBP	# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Interior Paint Surfaces Having Deteriorated LBP equals[7] ...				# Units with EBL Children That Are At or Above No Standard, Where the % of Tested Exterior Paint Surfaces Having Deteriorated LBP equals[7] ...			
Soil (ppm)	Window Sill Dust ($\mu g/ft^2$)	Floor Dust ($\mu g/ft^2$)		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]			0%	10-30%	31-50%	>50%	0%	20-50%	51-75%	>75%
5000	250	40	80/184	30/44 (68.2%)	90/140 (64.3%)	30/80 (37.5%)	90/104 (86.5%)	256.5	4	6	4	3	1	8	2	1	3
5000	250	25	92/184	33/44 (75.0%)	81/140 (57.9%)	33/92 (35.9%)	81/92 (88.0%)	256.8	4	6	2	2	1	7	2	1	1
5000	250	20	105/184	35/44 (79.5%)	70/140 (50.0%)	35/105 (33.3%)	70/79 (88.6%)	251.5	2	4	2	2	1	5	2	1	1
5000	250	10	148/184	43/44 (97.7%)	35/140 (25.0%)	43/148 (29.1%)	35/36 (97.2%)	249.0	0	0	1	0	0	1	0	0	0
5000	250	5	172/184	43/44 (97.7%)	11/140 (7.9%)	43/172 (25.0%)	11/12 (91.7%)	222.3	0	0	1	0	0	1	0	0	0

[1] The data compared to these standards are average (wipe) floor dust-lead loading, average (wipe) window sill dust-lead loading, and average soil-lead concentration (across dripline and play areas, with only one of the two areas represented if no data existed for the other area). Units having no reported soil-lead concentration but with no bare soil reported were assumed to have a soil-lead concentration of 0 ppm.

[2] Total number of units having available data that could be compared to all specified candidate standards, as well as data on the percentage of tested interior lead-based paint that is deteriorated and the percentage of tested exterior lead-based paint that is deteriorated.

[3] Cell entries are(number of homes at or above at least one standard that have EBL children)/ number of homes containing EBL children), followed by the corresponding percentage (in parentheses).

[4] Cell entries are (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not containing EBL children), followed by the corresponding percentage (in parentheses).

[5] Cell entries are (number of homes at or above at least one standard that have EBL children)/(total number of homes at or above at least one standard), followed by the corresponding percentage (in parentheses).

[6] Cell entries are (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not at or above any standard), followed by the corresponding percentage (in parentheses).

[7] No housing units had between 0 and 10% deteriorated lead-based paint on interior tested surfaces or between or between 0 and 20% deteriorated lead-based paint on exterior tested surfaces.

6.1.4.3 Analysis Involving Only Dust-Lead Standards and a Standard on the Amount of Deteriorated Paint.

In some cases, a risk assessment may involve only dust sampling (of floors and window sills) and a visual inspection of painted surfaces for deterioration. That is, no testing of painted surface for lead within the paint would be done, and no soil sampling would be done. In this setting, it was of interest to investigate the extent to which candidate dust-lead loading standards, with standards on the maximum percentage of surfaces with deteriorated paint, performed in the absence of soil standards, within a performance characteristics analysis. The combinations of standards considered in this analysis were the following:

- uncarpeted floor dust-lead loading: 5, 10, 20, 25, 40, 50, 100 $\mu g/ft^2$
- window sill dust-lead loading: 125, 250 $\mu g/ft^2$
- maximum amount of deteriorated paint on a tested surface: >5%, >15%.

The candidate paint standards were defined to coincide with the type of paint condition measurement made in the Rochester study. The following 63 combinations of these candidate standards were considered in this analysis:

- 7x2x2=28 combinations of the candidate floor-dust, sill-dust, and paint standards
- 7x2=14 combinations of only the candidate floor-dust and sill-dust standards
- 7x2=14 combinations of only the candidate floor-dust and paint standards
- 7 candidate floor-lead standards without the others.

Table 6-9 contains the results of the performance characteristics analysis, with each row of the table corresponding to one of the 63 combinations of candidate standards being considered. The following are examples of what can be concluded from Table 6-9:

- While, on their own, the higher candidate floor dust-lead standards trigger few units containing elevated blood-lead children, the number of these homes that are triggered with the addition of a deteriorated paint standard increases dramatically (e.g., from 10.6% to 70.2% at a floor dust-lead standard of 100 $\mu g/ft^2$, if the 15% paint standard is added).

- The performance characteristics do not appear to increase substantially with an increase in the sill standard from 125 to 250 $\mu g/ft^2$.

If the risk assessment does, in fact, do paint testing for lead, then the above standard for paint can be re-defined to represent the maximum amount of deteriorated lead-based paint on a tested surface. Table 6-10 contains the results of the performance characteristics analysis where the paint standard is modified in this manner.

Table 6-9. Results of Performance Characteristics Analysis Performed on Data for Housing Units in the Rochester Lead-in-Dust Study, for Specified Sets of Candidate Standards for Dust-Lead Loadings and Observed Amount of Damaged Paint on a Tested Surface

EBL = elevated blood-lead level ($10 μg/dL)

Set of Candidate Standards			# Units At Or Above At Least One Standard / Total # Units[2]	Performance Characteristics			
Uncarpeted Floor Dust-Lead Loading (μg/ft^2)	Window Sill Dust-Lead Loading (μg/ft^2)	Max. Amt. Of Damaged Paint on a Tested Surface (%)[1]		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]
100	--	--	9/197	5/47 (10.6%)	146/150 (97.3%)	5/9 (55.6%)	146/188 (77.7%)
50	--	--	19/197	9/47 (19.1%)	140/150 (93.3%)	9/19 (47.4%)	140/178 (78.7%)
40	--	--	31/197	16/47 (34.0%)	135/150 (90.0%)	16/31 (51.6%)	135/166 (81.3%)
25	--	--	58/197	26/47 (55.3%)	118/150 (78.7%)	26/58 (44.8%)	118/139 (84.9%)
20	--	--	84/197	31/47 (66.0%)	97/150 (64.7%)	31/84 (36.9%)	97/113 (85.8%)
10	--	--	150/197	44/47 (93.6%)	44/150 (29.3%)	44/150 (29.3%)	44/47 (93.6%)
5	--	--	180/197	45/47 (95.7%)	15/150 (10.0%)	45/180 (25.0%)	15/17 (88.2%)
100	250	--	71/189	25/45 (55.6%)	98/144 (68.1%)	25/71 (35.2%)	98/118 (83.1%)
50	250	--	75/189	27/45 (60.0%)	96/144 (66.7%)	27/75 (36.0%)	96/114 (84.2%)
40	250	--	80/189	30/45 (66.7%)	94/144 (65.3%)	30/80 (37.5%)	94/109 (86.2%)
25	250	--	93/189	34/45 (75.6%)	85/144 (59.0%)	34/93 (36.6%)	85/96 (88.5%)
20	250	--	106/189	36/45 (80.0%)	74/144 (51.4%)	36/106 (34.0%)	74/83 (89.2%)
10	250	--	150/189	44/45 (97.8%)	38/144 (26.4%)	44/150 (29.3%)	38/39 (97.4%)
5	250	--	176/189	44/45 (97.8%)	12/144 (8.3%)	44/176 (25.0%)	12/13 (92.3%)
100	125	--	116/189	35/45 (77.8%)	63/144 (43.8%)	35/116 (30.2%)	63/73 (86.3%)
50	125	--	118/189	36/45 (80.0%)	62/144 (43.1%)	36/118 (30.5%)	62/71 (87.3%)
40	125	--	122/189	38/45 (84.4%)	60/144 (41.7%)	38/122 (31.1%)	60/67 (89.6%)
25	125	--	128/189	39/45 (86.7%)	55/144 (38.2%)	39/128 (30.5%)	55/61 (90.2%)
20	125	--	134/189	40/45 (88.9%)	50/144 (34.7%)	40/134 (29.9%)	50/55 (90.9%)
10	125	--	159/189	45/45 (100%)	30/144 (20.8%)	45/159 (28.3%)	30/30 (100%)
5	125	--	180/189	45/45 (100%)	9/144 (6.3%)	45/180 (25.0%)	9/9 (100%)
100	--	>15%	101/197	33/47 (70.2%)	82/150 (54.7%)	33/101 (32.7%)	82/96 (85.4%)
50	--	>15%	105/197	34/47 (72.3%)	79/150 (52.7%)	34/105 (32.4%)	79/92 (85.9%)
40	--	>15%	108/197	35/47 (74.5%)	77/150 (51.3%)	35/108 (32.4%)	77/89 (86.5%)
25	--	>15%	116/197	35/47 (74.5%)	69/150 (46.0%)	35/116 (30.2%)	69/81 (85.2%)
20	--	>15%	127/197	38/47 (80.9%)	61/150 (40.7%)	38/127 (29.9%)	61/70 (87.1%)
10	--	>15%	170/197	46/47 (97.9%)	26/150 (17.3%)	46/170 (27.1%)	26/27 (96.3%)

Table 6-9. (cont.)

Set of Candidate Standards			# Units At Or Above At Least One Standard / Total # Units[2]	Performance Characteristics			
Uncarpeted Floor Dust-Lead Loading ($\mu g/ft^2$)	Window Sill Dust-Lead Loading ($\mu g/ft^2$)	Max. Amt. Of Damaged Paint on a Tested Surface (%)[1]		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]
5	--	>15%	188/197	47/47 (100%)	9/150 (6.0%)	47/188 (25.0%)	9/9 (100%)
100	--	>5%	164/197	43/47 (91.5%)	29/150 (19.3%)	43/164 (26.2%)	29/33 (87.9%)
50	--	>5%	165/197	44/47 (93.6%)	29/150 (19.3%)	44/165 (26.7%)	29/32 (90.6%)
40	--	>5%	167/197	45/47 (95.7%)	28/150 (18.7%)	45/167 (26.9%)	28/30 (93.3%)
25	--	>5%	167/197	45/47 (95.7%)	28/150 (18.7%)	45/167 (26.9%)	28/30 (93.3%)
20	--	>5%	168/197	45/47 (95.7%)	27/150 (18.0%)	45/168 (26.8%)	27/29 (93.1%)
10	--	>5%	185/197	47/47 (100%)	12/150 (8.0%)	47/185 (25.4%)	12/12 (100%)
5	--	>5%	192/197	47/47 (100%)	5/150 (3.3%)	47/192 (24.5%)	5/5 (100%)
100	250	>15%	118/189	36/45 (80.0%)	62/144 (43.1%)	36/118 (30.5%)	62/71 (87.3%)
50	250	>15%	120/189	37/45 (82.2%)	61/144 (42.4%)	37/120 (30.8%)	61/69 (88.4%)
40	250	>15%	123/189	38/45 (84.4%)	59/144 (41.0%)	38/123 (30.9%)	59/66 (89.4%)
25	250	>15%	127/189	38/45 (84.4%)	55/144 (38.2%)	38/127 (29.9%)	55/62 (88.7%)
20	250	>15%	134/189	40/45 (88.9%)	50/144 (34.7%)	40/134 (29.9%)	50/55 (90.9%)
10	250	>15%	167/189	45/45 (100%)	22/144 (15.3%)	45/167 (26.9%)	22/22 (100%)
5	250	>15%	182/189	45/45 (100%)	7/144 (4.9%)	45/182 (24.7%)	7/7 (100%)
100	125	>15%	142/189	39/45 (86.7%)	41/144 (28.5%)	39/142 (27.5%)	41/47 (87.2%)
50	125	>15%	144/189	40/45 (88.9%)	40/144 (27.8%)	40/144 (27.8%)	40/45 (88.9%)
40	125	>15%	147/189	41/45 (91.1%)	38/144 (26.4%)	41/147 (27.9%)	38/42 (90.5%)
25	125	>15%	149/189	41/45 (91.1%)	36/144 (25.0%)	41/149 (27.5%)	36/40 (90.0%)
20	125	>15%	152/189	42/45 (93.3%)	34/144 (23.6%)	42/152 (27.6%)	34/37 (91.9%)
10	125	>15%	171/189	45/45 (100%)	18/144 (12.5%)	45/171 (26.3%)	18/18 (100%)
5	125	>15%	182/189	45/45 (100%)	7/144 (4.9%)	45/182 (24.7%)	7/7 (100%)
100	250	>5%	162/189	41/45 (91.1%)	23/144 (16.0%)	41/162 (25.3%)	23/27 (85.2%)
50	250	>5%	163/189	42/45 (93.3%)	23/144 (16.0%)	42/163 (25.8%)	23/26 (88.5%)
40	250	>5%	165/189	43/45 (95.6%)	22/144 (15.3%)	43/165 (26.1%)	22/24 (91.7%)
25	250	>5%	165/189	43/45 (95.6%)	22/144 (15.3%)	43/165 (26.1%)	22/24 (91.7%)
20	250	>5%	166/189	43/45 (95.6%)	21/144 (14.6%)	43/166 (25.9%)	21/23 (91.3%)
10	250	>5%	179/189	45/45 (100%)	10/144 (6.9%)	45/179 (25.1%)	10/10 (100%)
5	250	>5%	185/189	45/45 (100%)	4/144 (2.8%)	45/185 (24.3%)	4/4 (100%)

Table 6-9. (cont.)

Set of Candidate Standards			# Units At Or Above At Least One Standard / Total # Units[2]	Performance Characteristics			
Uncarpeted Floor Dust-Lead Loading ($\mu g/ft^2$)	Window Sill Dust-Lead Loading ($\mu g/ft^2$)	Max. Amt. Of Damaged Paint on a Tested Surface (%)[1]		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]
100	125	>5%	166/189	42/45 (93.3%)	20/144 (13.9%)	42/166 (25.3%)	20/23 (87.0%)
50	125	>5%	167/189	43/45 (95.6%)	20/144 (13.9%)	43/167 (25.7%)	20/22 (90.9%)
40	125	>5%	169/189	44/45 (97.8%)	19/144 (13.2%)	44/169 (26.0%)	19/20 (95.0%)
25	125	>5%	169/189	44/45 (97.8%)	19/144 (13.2%)	44/169 (26.0%)	19/20 (95.0%)
20	125	>5%	170/189	44/45 (97.8%)	18/144 (12.5%)	44/170 (25.9%)	18/19 (94.7%)
10	125	>5%	179/189	45/45 (100%)	10/144 (6.9%)	45/179 (25.1%)	10/10 (100%)
5	125	>5%	185/189	45/45 (100%)	4/144 (2.8%)	45/185 (24.3%)	4/4 (100%)

[1] In the Rochester study, each measurement of lead in paint had the amount of damaged paint specified as "<5%" (good condition), "5-15%" (fair condition), or ">15%" (poor condition) of the tested surface, with no indication of total damaged surface area.
[2] Total number of units having available data that could be compared to all specified candidate standards.
[3] Cell entries are(number of homes at or above at least one standard that have EBL children)/ number of homes containing EBL children), followed by the corresponding percentage (in parentheses).
[4] Cell entries are (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not containing EBL children), followed by the corresponding percentage (in parentheses).
[5] Cell entries are (number of homes at or above at least one standard that have EBL children)/(total number of homes at or above at least one standard), followed by the corresponding percentage (in parentheses).
[6] Cell entries are (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not at or above any standard), followed by the corresponding percentage (in parentheses).

Table 6-10. Results of Performance Characteristics Analysis Performed on Data for Housing Units in the Rochester Lead-in-Dust Study, for Specified Sets of Candidate Standards for Dust-Lead Loadings and Observed Amount of Damaged Lead-Based Paint on a Tested Surface

EBL = elevated blood-lead level ($10 μg/dL); LBP = Lead-Based Paint

Set of Candidate Standards			# Units At Or Above At Least One Standard / Total # Units[2]	Performance Characteristics			
Uncarpeted Floor Dust-Lead Loading (μg/ft^2)	Window Sill Dust-Lead Loading (μg/ft^2)	Max. Amt. Of Damaged LBP on a Tested Surface (%)[1]		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]
100	--	--	9/197	5/47 (10.6%)	146/150 (97.3%)	5/9 (55.6%)	146/188 (77.7%)
50	--	--	19/197	9/47 (19.1%)	140/150 (93.3%)	9/19 (47.4%)	140/178 (78.7%)
40	--	--	31/197	16/47 (34.0%)	135/150 (90.0%)	16/31 (51.6%)	135/166 (81.3%)
25	--	--	58/197	26/47 (55.3%)	118/150 (78.7%)	26/58 (44.8%)	118/139 (84.9%)
20	--	--	84/197	31/47 (66.0%)	97/150 (64.7%)	31/84 (36.9%)	97/113 (85.8%)
10	--	--	150/197	44/47 (93.6%)	44/150 (29.3%)	44/150 (29.3%)	44/47 (93.6%)
5	--	--	180/197	45/47 (95.7%)	15/150 (10.0%)	45/180 (25.0%)	15/17 (88.2%)
100	250	--	71/189	25/45 (55.6%)	98/144 (68.1%)	25/71 (35.2%)	98/118 (83.1%)
50	250	--	75/189	27/45 (60.0%)	96/144 (66.7%)	27/75 (36.0%)	96/114 (84.2%)
40	250	--	80/189	30/45 (66.7%)	94/144 (65.3%)	30/80 (37.5%)	94/109 (86.2%)
25	250	--	93/189	34/45 (75.6%)	85/144 (59.0%)	34/93 (36.6%)	85/96 (88.5%)
20	250	--	106/189	36/45 (80.0%)	74/144 (51.4%)	36/106 (34.0%)	74/83 (89.2%)
10	250	--	150/189	44/45 (97.8%)	38/144 (26.4%)	44/150 (29.3%)	38/39 (97.4%)
5	250	--	176/189	44/45 (97.8%)	12/144 (8.3%)	44/176 (25.0%)	12/13 (92.3%)
100	125	--	116/189	35/45 (77.8%)	63/144 (43.8%)	35/116 (30.2%)	63/73 (86.3%)
50	125	--	118/189	36/45 (80.0%)	62/144 (43.1%)	36/118 (30.5%)	62/71 (87.3%)
40	125	--	122/189	38/45 (84.4%)	60/144 (41.7%)	38/122 (31.1%)	60/67 (89.6%)
25	125	--	128/189	39/45 (86.7%)	55/144 (38.2%)	39/128 (30.5%)	55/61 (90.2%)
20	125	--	134/189	40/45 (88.9%)	50/144 (34.7%)	40/134 (29.9%)	50/55 (90.9%)
10	125	--	159/189	45/45 (100%)	30/144 (20.8%)	45/159 (28.3%)	30/30 (100%)
5	125	--	180/189	45/45 (100%)	9/144 (6.3%)	45/180 (25.0%)	9/9 (100%)
100	--	>15%	84/197	27/47 (57.4%)	93/150 (62.0%)	27/84 (32.1%)	93/113 (82.3%)
50	--	>15%	88/197	28/47 (59.6%)	90/150 (60.0%)	28/88 (31.8%)	90/109 (82.6%)
40	--	>15%	94/197	31/47 (66.0%)	87/150 (58.0%)	31/94 (33.0%)	87/103 (84.5%)
25	--	>15%	104/197	33/47 (70.2%)	79/150 (52.7%)	33/104 (31.7%)	79/93 (84.9%)
20	--	>15%	115/197	36/47 (76.6%)	71/150 (47.3%)	36/115 (31.3%)	71/82 (86.6%)
10	--	>15%	162/197	44/47 (93.6%)	32/150 (21.3%)	44/162 (27.2%)	32/35 (91.4%)

Table 6-10. (cont.)

Set of Candidate Standards			# Units At Or Above At Least One Standard / Total # Units[2]	Performance Characteristics			
Uncarpeted Floor Dust-Lead Loading ($\mu g/ft^2$)	Window Sill Dust-Lead Loading ($\mu g/ft^2$)	Max. Amt. Of Damaged LBP on a Tested Surface (%)[1]		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]
5	--	>15%	183/197	45/47 (95.7%)	12/150 (8.0%)	45/183 (24.6%)	12/14 (85.7%)
100	--	>5%	146/197	39/47 (83.0%)	43/150 (28.7%)	39/146 (26.7%)	43/51 (84.3%)
50	--	>5%	147/197	40/47 (85.1%)	43/150 (28.7%)	40/147 (27.2%)	43/50 (86.0%)
40	--	>5%	149/197	41/47 (87.2%)	42/150 (28.0%)	41/149 (27.5%)	42/48 (87.5%)
25	--	>5%	150/197	42/47 (89.4%)	42/150 (28.0%)	42/150 (28.0%)	42/47 (89.4%)
20	--	>5%	155/197	44/47 (93.6%)	39/150 (26.0%)	44/155 (28.4%)	39/42 (92.9%)
10	--	>5%	181/197	47/47 (100%)	16/150 (10.7%)	47/181 (26.0%)	16/16 (100%)
5	--	>5%	189/197	47/47 (100%)	8/150 (5.3%)	47/189 (24.9%)	8/8 (100%)
100	250	>15%	107/189	32/45 (71.1%)	69/144 (47.9%)	32/107 (29.9%)	69/82 (84.1%)
50	250	>15%	109/189	33/45 (73.3%)	68/144 (47.2%)	33/109 (30.3%)	68/80 (85.0%)
40	250	>15%	114/189	36/45 (80.0%)	66/144 (45.8%)	36/114 (31.6%)	66/75 (88.0%)
25	250	>15%	119/189	37/45 (82.2%)	62/144 (43.1%)	37/119 (31.1%)	62/70 (88.6%)
20	250	>15%	126/189	39/45 (86.7%)	57/144 (39.6%)	39/126 (31.0%)	57/63 (90.5%)
10	250	>15%	160/189	44/45 (97.8%)	28/144 (19.4%)	44/160 (27.5%)	28/29 (96.6%)
5	250	>15%	178/189	44/45 (97.8%)	10/144 (6.9%)	44/178 (24.7%)	10/11 (90.9%)
100	125	>15%	135/189	37/45 (82.2%)	46/144 (31.9%)	37/135 (27.4%)	46/54 (85.2%)
50	125	>15%	137/189	38/45 (84.4%)	45/144 (31.3%)	38/137 (27.7%)	45/52 (86.5%)
40	125	>15%	141/189	40/45 (88.9%)	43/144 (29.9%)	40/141 (28.4%)	43/48 (89.6%)
25	125	>15%	144/189	41/45 (91.1%)	41/144 (28.5%)	41/144 (28.5%)	41/45 (91.1%)
20	125	>15%	147/189	42/45 (93.3%)	39/144 (27.1%)	42/147 (28.6%)	39/42 (92.9%)
10	125	>15%	167/189	45/45 (100%)	22/144 (15.3%)	45/167 (26.9%)	22/22 (100%)
5	125	>15%	181/189	45/45 (100%)	8/144 (5.6%)	45/181 (24.9%)	8/8 (100%)
100	250	>5%	147/189	38/45 (84.4%)	35/144 (24.3%)	38/147 (25.9%)	35/42 (83.3%)
50	250	>5%	148/189	39/45 (86.7%)	35/144 (24.3%)	39/148 (26.4%)	35/41 (85.4%)
40	250	>5%	150/189	40/45 (88.9%)	34/144 (23.6%)	40/150 (26.7%)	34/39 (87.2%)
25	250	>5%	151/189	41/45 (91.1%)	34/144 (23.6%)	41/151 (27.2%)	34/38 (89.5%)
20	250	>5%	156/189	43/45 (95.6%)	31/144 (21.5%)	43/156 (27.6%)	31/33 (93.9%)
10	250	>5%	175/189	45/45 (100%)	14/144 (9.7%)	45/175 (25.7%)	14/14 (100%)
5	250	>5%	182/189	45/45 (100%)	7/144 (4.9%)	45/182 (24.7%)	7/7 (100%)

Table 6-10. (cont.)

Set of Candidate Standards			# Units At Or Above At Least One Standard / Total # Units[2]	Performance Characteristics			
Uncarpeted Floor Dust-Lead Loading ($\mu g/ft^2$)	Window Sill Dust-Lead Loading ($\mu g/ft^2$)	Max. Amt. Of Damaged LBP on a Tested Surface (%)[1]		Sensitivity # (%) of Units with EBL Children That Are At or Above At Least One Standard[3]	Specificity # (%) of Units with No EBL Children That Are At or Above No Standard[4]	PPV # (%) of Units At or Above At Least One Standard That Have EBL Children[5]	NPV # (%) of Units At or Above No Standard That Do Not Have EBL Children[6]
100	125	>5%	156/189	40/45 (88.9%)	28/144 (19.4%)	40/156 (25.6%)	28/33 (84.8%)
50	125	>5%	157/189	41/45 (91.1%)	28/144 (19.4%)	41/157 (26.1%)	28/32 (87.5%)
40	125	>5%	159/189	42/45 (93.3%)	27/144 (18.8%)	42/159 (26.4%)	27/30 (90.0%)
25	125	>5%	160/189	43/45 (95.6%)	27/144 (18.8%)	43/160 (26.9%)	27/29 (93.1%)
20	125	>5%	163/189	44/45 (97.8%)	25/144 (17.4%)	44/163 (27.0%)	25/26 (96.2%)
10	125	>5%	176/189	45/45 (100%)	13/144 (9.0%)	45/176 (25.6%)	13/13 (100%)
5	125	>5%	183/189	45/45 (100%)	6/144 (4.2%)	45/183 (24.6%)	6/6 (100%)

[1] In the Rochester study, each measurement of lead in paint had the amount of damaged paint specified as "<5%" (good condition), "5-15%" (fair condition), or ">15%" (poor condition) of the tested surface, with no indication of total damaged surface area.
[2] Total number of units having available data that could be compared to all specified candidate standards.
[3] Cell entries are(number of homes at or above at least one standard that have EBL children)/ number of homes containing EBL children), followed by the corresponding percentage (in parentheses).
[4] Cell entries are (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not containing EBL children), followed by the corresponding percentage (in parentheses).
[5] Cell entries are (number of homes at or above at least one standard that have EBL children)/(total number of homes at or above at least one standard), followed by the corresponding percentage (in parentheses).
[6] Cell entries are (number of homes not at or above at least one standard that do not have EBL children)/(total number of homes not at or above any standard), followed by the corresponding percentage (in parentheses).

6.2 INVESTIGATING INCIDENCE OF ELEVATED BLOOD-LEAD CONCENTRATION IN HOUSING UNITS MEETING ALL EXAMPLE OPTIONS FOR STANDARDS

An alternative to the performance characteristics analysis approach (Section 6.1) to evaluating a set of candidate standards is to use statistical modeling techniques to predict a distribution of blood-lead concentration as a function of environmental-lead levels found in homes which do not exceed any of the candidate standards, then estimate the percentage of children residing in these homes that are expected to have elevated blood-lead levels (i.e., at or above 10 µg/dL). It is desired to select a set of candidate standards so that the likelihood of children with elevated blood-lead concentration residing in homes that do not exceed any of the candidate standards would be very low. This section presents a modeling approach to estimate this likelihood, using the alternative Rochester multimedia model presented in Section 4.2 of this report ("Model A" in Table 4-1), and applies this approach to data from the Rochester study.

Recall from Section 4.2 that the reason for developing the alternative Rochester multimedia model was to have the risk estimates from model-based analyses be more comparable to the results of the performance characteristics analysis presented in the §403 proposed rule (Section 6.1.3) and the results of the follow-up performance characteristics analyses (Section 6.1.4). In particular, both the performance characteristics analysis and the model-based approach involving the alternative Rochester multimedia model use the following types of data as input when characterizing risk:

- household average (wipe) dust-lead loading from uncarpeted floors
- household average (wipe) dust-lead loading from window sills
- yard-wide average soil-lead concentration
- the larger of the following two percentages: % of interior tested surfaces that contain deteriorated lead-based paint (LBP), and % of exterior tested surfaces that contain deteriorated LBP

In the model-based analysis approach presented below, the candidate standards were used to identify a subset of homes in the Rochester study that were below all of the candidate standards, calculate the average (across homes) of the above three measures of lead levels in dust and soil, and fit the multimedia model to these average lead levels in order to predict a distribution of blood-lead concentrations for children residing in these homes. For simplicity, this analysis assumes that the homes do not contain deteriorated lead-based paint. Because the slope estimate for the paint variable in the alternative Rochester multimedia model is nearly zero (Table 4-1 of Section 4.2), making the assumption that no deteriorated lead-based paint exists in these homes should have a very minor impact on the resulting risk estimates.

6.2.1 The Model-Based Approach

This model-based approach had the following four steps:

1. For a given set of candidate standards for floor dust-lead loading, window sill dust-lead loading, and soil-lead concentration, identify those homes in the Rochester study that exceed none of the candidate standards in this set.

2. For each of the following three household measures, calculate the average across the homes identified in step #1: the household average floor dust-lead loadings, household average window sill dust-lead loading and for yard-wide average soil-lead concentration. These three averages are assumed to represent lead levels in housing represented by the Rochester study homes in step #1 (i.e., homes not exceeding any of the candidate dust and soil standards).

3. Use the three averages calculated in step #2 as input to the alternative Rochester multimedia model from Section 4.2 (assuming no deteriorated lead-based paint exists in the units).

4. Assume that log-transformed blood-lead concentration for children residing in the homes identified in step #1 is normally distributed with mean equal to the predicted log-transformed blood-lead concentration that is output from the model fitting in step #3, and standard deviation equal to ln(1.6). (Recall that this assumption on variability was made throughout the §403 risk analysis.) Using normal distribution theory, determine the percentage of children represented by this blood-lead distribution that have log-transformed blood-lead concentration or above log(10), or equivalently, that have blood-lead concentration at or above 10 µg/dL.

6.2.2 Examples of Applying the Model-Based Approach

To illustrate how the approach in Section 6.2.1 is applied to data from the Rochester study, the following combinations of candidate dust-lead and soil-lead standards are considered:

- (uncarpeted) floor dust-lead loading: either 40 or 50 µg/ft^2
- window sill dust-lead loading: 250 µg/ft^2
- yard-wide soil-lead concentration: 400 µg/g.

When the candidate floor dust-lead loading standard is 40 µg/ft^2, then the performance characteristics analyses documented in Table 6-8 of Section 6.1 (i.e., the row of Table 6-8 corresponding to these three candidate standards) indicates that 39 of the 184 Rochester study homes having measurements for dust-lead, soil-lead, and deteriorated lead-based paint do not exceed any of the three candidate standards. Across these 39 homes, the following averages were calculated from the Rochester study data:

- household average (uncarpeted) floor dust-lead loading: 12.7 µg/ft^2
- household average window sill dust-lead loading: 87.0 µg/ft^2

- yard-wide average soil-lead concentration: 125.3 µg/g.

When fitting the alternative Rochester multimedia model to these three averages (assuming no deteriorated lead-based paint), the model predicts a geometric mean blood-lead concentration of 4.68 µg/dL. If the standard deviation of log-transformed data is assumed to be 1.6 and normal distribution theory is applied as described above, then the estimated percentage of children with blood-lead concentration at or above 10 ug/dL in homes that do not exceed any of the candidate standards is 5.30%. This matches closely with the estimate of 5.1%, or 2 of these 39 homes in the Rochester study dataset, which the performance characteristics analysis (Table 6-8) indicated contained children with elevated blood-lead concentrations.

If the candidate floor dust-lead loading standard is increased to 50 µg/ft^2, then the number of Rochester study homes having measurements for dust-lead, soil-lead, and deteriorated lead-based paint and that do not exceed any of the three candidate standards increases by one home, to 40 total homes. Across these 40 homes, the following averages were calculated from the Rochester study data:

- household average (uncarpeted) floor dust-lead loading: 13.4 µg/ft^2
- household average window sill dust-lead loading: 85.6 µg/ft^2
- yard-wide average soil-lead concentration: 122.2 µg/g.

The predicted geometric mean blood-lead concentration under these assumed dust-lead and soil-lead levels (assuming no deteriorated lead-based paint) is 4.69 µg/dL, and the estimated percentage of children with blood-lead concentration at or above 10 ug/dL is 5.34%. This is a very slight increase from the estimate generated under the candidate floor dust-lead loading standard of 40 µg/ft^2. The performance characteristics analysis (Table 6-8) indicated that under these candidate standards, 7.5% of homes not exceeding any of the standards (i.e., 3 of these 40 homes in the Rochester study dataset) contained children with elevated blood-lead concentrations.

While these examples illustrate the estimation process, they also show that the number of homes in the given dataset whose lead levels fall below all specified candidate standards can be quite small, especially when at least one of the candidate standards is set at the low end of the distribution of lead levels (i.e., most homes have data that fall above the candidate standard). Therefore, as the set of candidate standards becomes more stringent, and as the size of the sample from which the environmental-lead data originate becomes smaller as a result, the variability associated with the estimated risk increases. Furthermore, as the set of candidate standards becomes less stringent (i.e., as the standards increase), the group of homes not exceeding any of the candidate standards is more likely to remain the same, and as a result, the estimated risk eventually reaches a plateau. This occurs in the above examples, as increasing the candidate floor dust-lead loading standard from 40 to 50 µg/ft^2 does little, if any, to increase the estimated risk beyond 5.3% under this approach and under the given set of data, assuming the candidate standards for the other media (window sill dust, soil) remain fixed.

The Rochester study data were used in this analysis as the multimedia model was fitted based on the Rochester data. If data from other studies were used instead, it would be necessary to verify that the model parameter estimates adequately reflect the underlying variability in these data in the same manner that they reflect variability in the Rochester study data.

While the approach presented in this section is relatively easy to implement, it could be modified even further in an attempt to achieve more accurate risk estimates. Such a modification could reduce the level of simplicity associated with applying the approach. For example, rather than calculate average environmental-lead levels across all homes and fit the model once to these averages, a simulation approach could be applied in an attempt to more accurately represent the entire distribution of environmental-lead levels in these homes and the resulting blood-lead distribution associated with exposure across the entire distribution of environmental-lead levels.

6.3 REVIEW OF PUBLISHED INFORMATION ON POST-INTERVENTION DUST-LEAD LOADINGS

This section summarizes published information on lead loadings (amount of lead per unit surface area) in dust samples collected by wipe techniques, as reported by earlier lead intervention studies. This information is used to evaluate assumptions made on post-intervention dust-lead loadings (40 $\mu g/ft^2$ for floors, 100 $\mu g/ft^2$ for window sills) within the §403 risk analysis. Details to supplement the summaries in this section are presented in Appendix H.

The following seven studies have been identified in which some type of paint or dust intervention was performed, dust samples were collected using wipes or some other technique (e.g., BRM vacuum) whose results could be converted to wipe-equivalent dust-lead loadings, and post-intervention dust-lead loadings on floors and/or window sills were reported (references for these studies are included in Appendix H):

- Baltimore Experimental Paint Abatement Studies
- Baltimore Follow-up Paint Abatement Study
- Baltimore Repair & Maintenance (R&M) Study
- Boston Interim Dust Intervention Study
- HUD Grantees Evaluation (data available through September 1997)
- Denver Comprehensive Abatement Performance (CAP) Study
- Jersey City Children's Lead Exposure and Reduction (CLEAR) Study

These studies employed a variety of intervention strategies, including single or repeated dust cleanings and interim control or complete abatement of lead-based paint. Dust-lead loadings were measured at varying intervals following intervention. Post-intervention dust-lead loadings were summarized for 19 groups of housing units across these seven studies. These study groups are defined in Appendix H.

For both floors and window sills, geometric mean and median dust-lead loadings were observed below the post-intervention assumptions established in the §403 risk analysis in a majority of

the study groups. However, this does not preclude results for individual housing units from being above the assumed levels. Furthermore, the extent to which results for these studies represent the nation's housing stock has not been determined. Results are now presented separately for floors and window sills (with more detailed presentations found in Appendix H).

6.3.1 Post-Intervention Floor Dust-Lead Loadings

Summaries of post-intervention floor (wipe) dust-lead loadings are presented in Table 6-11 according to housing group within each study. According to Table 6-11, all but two of the 19 study groups reported geometric mean or median floor dust-lead loadings at or below 41 $\mu g/ft^2$ from 6 months to 6 years post-intervention. The other two study groups were from the Baltimore Experimental Paint Abatement Study, where pre-intervention geometric mean dust-lead loadings were much greater (556 $\mu g/ft^2$ and 1261 $\mu g/ft^2$) than any other study group (at most 58.6 $\mu g/ft^2$). Eleven study groups reported geometric mean or median floor dust-lead loadings at or below 21 $\mu g/ft^2$ at follow-up periods ranging from 12 months to 2 years. Of these 11 groups, four of the HUD Grantees study groups reported median floor dust-lead loadings at or below 10 $\mu g/ft^2$ at 12 months post-intervention. Median pre-intervention floor dust-lead loadings in these four groups ranged from 9 to 26 $\mu g/ft^2$.

In the HUD Grantees evaluation, seven of the eight largest grantees have median floor dust-lead loadings at or below 21 $\mu g/ft^2$ at 12 months post-intervention, compared to a median of 14 $\mu g/ft^2$ across all grantees. Although pre-intervention floor dust-lead loadings were lower in the HUD Grantees evaluation compared to other studies, these preliminary results suggest that floor dust-lead loadings can be maintained at levels below 40 $\mu g/ft^2$ for at least 12 months post-intervention.

Results from the Denver CAP study, the Baltimore Follow-up Paint Abatement study, the Baltimore R&M study, the Boston Interim Dust Intervention study, and the Jersey City CLEAR study suggest that geometric mean floor dust-lead loadings of below 40 $\mu g/ft^2$ can be observed even beyond 12 months post-intervention and up to six years post-intervention, under the same conditions experienced by the housing units in these studies.

6.3.2 Post-Intervention Window Sill Dust-Lead Loadings

Summaries of post-intervention window sill wipe dust-lead loadings are presented in Table 6-12 according to housing group. Post-intervention geometric means or medians range from 24 $\mu g/ft^2$ to 958 $\mu g/ft^2$, which are considerably higher than the summaries for floors. Eleven study groups had geometric mean or median post-intervention window sill dust-lead loadings below 100 $\mu g/ft^2$, 6 groups were at or below 51 $\mu g/ft^2$, and 3 groups were at or below 41 $\mu g/ft^2$.

All but one of the HUD Grantees study groups (the Milwaukee grantee) had median window sill dust-lead loadings below 100 $\mu g/ft^2$ at 12 months post-intervention. As the intervention strategy for homes in the HUD Grantees evaluation frequently included partial or

Table 6-11. Summaries of Pre- and Post-Intervention Floor Wipe Dust-Lead Loadings for Housing Groups Within Seven Studies

Study	Study Group	Pre-Intervention Floor Dust-Lead Loadings[1] ($\mu g/ft^2$)	Post-Intervention Floor Dust-Lead Loadings[1]	
			Time Following Intervention (Months)	Summary Value ($\mu g/ft^2$)
Baltimore Experimental Paint Abatement Studies[2]	Study 1	1261	6-9	99
	Study 2	556	1.5 - 3.5 Years	69
Baltimore Follow-up Paint Abatement Study[2]	12-Month Follow-up	NA	10-14	20
	19-Month Follow-up	NA	14-24	36
Baltimore R&M Study[3]	Previously-Abated Units	45.6	4 - 6 Years	33.0
	Units Slated for R&M Intervention	58.6	24	35.0
Boston Interim Dust Intervention Study[2]	Automatic Intervention	33.2	6	23.9
	Randomized Intervention	37.3	6	31.4
HUD Grantees[4]	All Grantees	19	12	14
	Baltimore	41	12	41
	Boston	24	12	18
	Massachusetts	24	12	9
	Milwaukee	14	12	10
	Minnesota	18	12	18
	Rhode Island	26	12	6
	Vermont	28	12	21
	Wisconsin	9	12	5
Denver CAP Study[5]	Abated Units	NA	2 Years	21.0
Jersey City CLEAR Study	Intervention Group	22	12	15

[1] Values are geometric means except for the HUD Grantees studies, where values are medians. "NA" indicates not available.
[2] Results are adjusted to reflect total dust-lead loadings by exponentiating the "bioavailable" dust-lead loadings as reported in the study to the 1.1416 power.
[3] Results for the Baltimore R&M Study are converted from BRM dust-lead loadings to wipe-equivalent loadings.
[4] Data collected through September, 1997
[5] Results for the Denver CAP study are converted from CAP cyclone dust-lead loadings to wipe-equivalent loadings.

Table 6-12. Summaries of Pre- and Post-Intervention Window Sill Wipe Dust-Lead Loadings for Housing Groups Within Seven Studies

Study	Study Group	Pre-Intervention Sill Dust-Lead Loadings[1] ($\mu g/ft^2$)	Post-Intervention Sill Dust-Lead Loadings[1]	
			Time Following Intervention	Summary Value ($\mu g/ft^2$)
Baltimore Experimental Paint Abatement Studies[2]	Study 1	15215	6-9	958
	Study 2	2784	1.5 - 3.5 Years	199
Baltimore Follow-up Paint Abatement Study[2]	12-Month Follow-up	NA	10-14	41
	19-Month Follow-up	NA	14-24	147
Baltimore R&M Study[3]	Previously-Abated Units	163.5	4 - 6 Years	97.6
	Units Slated for R&M Intervention	778.4	24	204.9
Boston Interim Dust Intervention Study[2]	Automatic Intervention	787	6	210
	Randomized Intervention	205	6	110
HUD Grantees[4]	All Grantees	258	12	90
	Baltimore	1191	12	68
	Boston	174	12	49
	Massachusetts	328	12	50
	Milwaukee	264	12	217
	Minnesota	266	12	77
	Rhode Island	314	12	85
	Vermont	147	12	40
	Wisconsin	150	12	51
Denver CAP Study[5]	Abated Units	NA	2 Years	66.4
Jersey City CLEAR Study	Intervention Group	75	12	24

[1] Values are geometric means except for the HUD Grantees studies, where values are medians. "NA" indicates not available.
[2] Results are adjusted to reflect total dust-lead loadings by exponentiating the "bioavailable" dust-lead loadings as reported in the study to the 1.1416 power.
[3] Results for the Baltimore R&M Study are converted from BRM dust-lead loadings to wipe-equivalent loadings.
[4] Data collected through September, 1997
[5] Results for the Denver CAP study are converted from CAP cyclone dust-lead loadings to wipe-equivalent loadings.

complete window replacement, these results may not be representative of the outcomes of interventions prompted by the §403 rule.

Geometric mean window sill dust-lead loadings were below 100 µg/ft^2 for up to two years post-intervention in the Baltimore Follow-up Paint Abatement study, Denver CAP study, and Jersey City CLEAR study. However, in the Baltimore R&M study, Baltimore Experimental Paint Abatement studies, and Boston Interim Dust Intervention study, geometric mean dust-lead loadings remain above 100 µg/ft^2 over time. In addition, the 19-month follow-up study group within the Baltimore Follow-up Paint Abatement study and study group #2 of the Baltimore Experimental Paint Abatement studies suggest that geometric mean dust-lead loadings can dip below 100 µg/ft^2 immediately after intervention, but then exceed this level after one year or so.

6.4 SENSITIVITY AND UNCERTAINTY ANALYSES FOR RISK MANAGEMENT ANALYSES

The following subsections present the results of additional sensitivity and uncertainty analyses performed to gauge the level of uncertainty in the post-§403 risk estimates (and the associated decline from baseline estimates) associated with methodological assumptions. These results should be considered with those presented in the sensitivity and uncertainty analyses in Section 6.4 of the §403 risk analysis report to characterize overall uncertainty associated with the methods and assumptions taken in the risk management.

6.4.1 Considering How Baseline Environmental-Lead Levels May Have Changed Since the HUD National Survey

Section 5.1.4 of this report addressed the sensitivity of the pre-§403 model-based blood-lead distribution and the resulting health effects and blood-lead concentration endpoint estimates under the IEUBK and empirical models under different assumptions on how the national distribution of baseline environmental-lead levels as estimated using HUD National Survey data may have changed since the time of the survey (1989-1990). The same five sets of adjustments (i.e., percentage changes) made to the average baseline dust-lead loadings, dust-lead concentrations, and soil-lead concentrations for each housing unit in the HUD National Survey were considered in this sensitivity analysis to observe the impact on post-§403 risk estimates under the following set of example options for standards:

- Average floor dust-lead loading = 100 µg/ft^2
- Average window sill dust-lead loading = 500 µg/ft^2
- Average soil-lead concentration = 2,000 µg/g
- Amount of deteriorated lead-based paint requiring paint maintenance = 5 ft^2
- Amount of deteriorated lead-based paint requiring paint abatement = 20 ft^2

This set of options was the primary set considered in the sensitivity analyses within Section 6.4 of the §403 risk analysis report.

Table 6-13 presents the post-§403 estimates for the health effect and blood-lead concentration endpoints under both the IEUBK and empirical models, for each of the five sets of adjustments to the post-§403 environmental-lead levels in housing units within the HUD National Survey and under the above assumption on example standards. Also included in this table are the percentage of homes exceeding the various example standards, which will be lower than in the §403 risk analysis when declines in the appropriate environmental-lead levels are considered and higher when increases are considered. The table also lists the baseline risk estimates for comparison purposes.

Effect on risk analysis: Under the five sets of assumptions involving lower assumed baseline environmental-lead levels, the percentage of houses that exceed at least one of the example standards declined by at most about three percentage points (from 21.8% to 18.7%; Table 6-13), or about three million homes. The assumption that baseline environmental-lead levels are 25% higher than assumed in the §403 risk analysis results in an increase in the percentage of homes exceeding at least one standard from 21.8% to 24.1%, an increase of about 2.3 million homes (Table 6-13).

As would be expected, Table 6-13 shows that all assumptions on baseline environmental-lead levels result in post-§403 estimates of the predicted health effect and blood-lead concentration endpoints that are lower than baseline (the last column of the table). However, as the assumed baseline environmental-lead levels become lower in magnitude, the predicted post-§403 risks actually increase, converging to the baseline estimates. For example, as seen in Table 6-3, baseline lead levels that are 20% below what was assumed in the §403 risk analysis resulted in an estimated percentage of children with blood-lead concentrations at or above 10 µg/dL of 4.85%, compared to the §403 risk analysis estimate of 4.70%. When baseline lead levels are 50% below the §403 risk analysis estimates, the estimate of this percentage increases to 5.10%. Such a finding appears counter-intuitive when first reviewing the table. However, the alternative assumptions being considered in this sensitivity analysis are to baseline (i.e., pre-§403) environmental-lead levels. As assumptions on these baseline levels move lower, fewer homes are triggered by the §403 standards, and the post-§403 distribution of environmental-lead levels becomes less removed from the baseline distribution. As a result, post-§403 estimates of predicted health effects and blood-lead concentration are not as different from pre-§403 estimates. In contrast, as assumed baseline environmental-lead levels increase, more homes are triggered by the §403 standards and, therefore, have their environmental-lead levels drop as a result of interventions, and lower post-§403 risk estimates relative to baseline are observed.

As seen in Table 6-13, the effect that different assumptions on baseline environmental-lead levels have on the risk estimates is considerably greater under the IEUBK model than the empirical model. The percentage of children with blood-lead concentrations at or above 20 µg/dL more than triples under the IEUBK model approach when 50% declines in both dust-lead and soil-lead levels were assumed (from 0.054% to 0.166%), compared to a 16% increase under the empirical model (from 0.406% to 0.469%). Smaller percentage differences are observed for the other endpoints for both models.

Table 6-13. Sensitivity Analysis on How Changes in Household Average Baseline Dust-Lead Loadings/Concentrations and Soil-Lead Concentration Impact Post-§403 Estimates of Health Effect and Blood-Lead Concentration Endpoints for Children Aged 1-2 Years Under a Specified Set of Example Standards[1]

Assumed Percentage Change in Average Dust-Lead Loadings and Concentrations (Both Floor and Window Sill) and in Yard-wide Average Soil-Lead Concentration							Baseline Estimate (from Table 5-1 of the §403 risk analysis report)
Dust:	No change	20% decrease	50% decrease	50% decrease	No change	25% increase	
Soil:	No change	20% decrease	50% decrease	No change	50% decrease	25% increase	
Percentage of Homes Exceeding Example Standards/Triggers							
Floor Dust	4.04	2.34	0.694	0.694	4.04	5.68	
Window Sill Dust	12.5	10.8	9.10	9.10	12.5	14.3	
Soil	2.49	1.52	0.746	2.49	0.746	3.27	
Interior Paint Maintenance	2.92	2.92	2.92	2.92	2.92	2.92	
Exterior Paint Maintenance	3.49	3.49	3.49	3.49	3.49	3.49	
Interior Paint Abatement	2.43	2.43	2.43	2.43	2.43	2.43	
Exterior Paint Abatement	5.77	5.77	5.77	5.77	5.77	5.77	
Any Standard/Trigger	21.8	20.6	18.7	18.9	21.6	24.1	
Predicted Health Effect And Blood-Lead Concentration Endpoints (Based on Empirical Model)							
PbB $20 (%)	0.406	0.429	0.469	0.445	0.427	0.378	0.588
PbB $10 (%)	4.70	4.85	5.10	4.95	4.84	4.52	5.75
IQ < 70 (%)	0.110	0.111	0.112	0.111	0.111	0.110	0.115
IQ decrement $1 (%)	36.3	36.7	37.3	36.9	36.7	35.9	38.5
IQ decrement $2 (%)	9.30	9.53	9.90	9.69	9.51	9.02	10.8
IQ decrement $3 (%)	2.93	3.04	3.21	3.11	3.03	2.80	3.70
Avg. IQ decrement	1.00	1.01	1.03	1.02	1.01	0.995	1.06
Predicted Health Effect And Blood-Lead Concentration Endpoints (Based on IEUBK Model)							
PbB $20 (%)	0.0539	0.117	0.166	0.121	0.0681	0.0542	0.588
PbB $10 (%)	1.66	2.48	2.98	2.55	1.86	1.64	5.75
IQ < 70 (%)	0.0984	0.102	0.104	0.102	0.0992	0.0982	0.115
IQ decrement $1 (%)	28.3	31.0	32.7	31.6	28.8	27.7	38.5
IQ decrement $2 (%)	4.31	5.77	6.65	5.94	4.67	4.22	10.8
IQ decrement $3 (%)	0.858	1.37	1.71	1.42	0.983	0.847	3.70
Avg. IQ decrement	0.848	0.894	0.924	0.904	0.857	0.839	1.06

[1] Example dust and soil standards were set at: 100 $\mu g/ft^2$ for floor dust-lead loading, 500 $\mu g/ft^2$ for window sill dust-lead loading, and 2,000 $\mu g/g$ for soil-lead concentration. Paint maintenance is performed if more than 5 ft^2, but less than 20 ft^2 of deteriorated lead-based paint exists. Paint abatement is performed if more than 20 ft^2 of deteriorated lead-based paint exists.

6.4.2 Impact on the Estimated Incidence of IQ Point Decrement Assuming Certain Thresholds on the IQ/Blood-Lead Relationship

The sensitivity of baseline and pre-§403 model-based estimates of IQ decrements greater than 1, 2, or 3, and of the average and standard deviation of the distribution of IQ point decrements was addressed in Section 5.1.5 of this report for various assumptions of a non-zero threshold of blood-lead concentration on the IQ/blood-lead relationship. The following thresholds were considered: 1, 2, 3, 5, 8 and 10 µg/dL. In this section, post-§403 estimates of these health effect endpoints are estimated (under the same set of options presented in Section 6.4.1, using both the IEUBK and empirical models) under these same alternative blood-lead concentration thresholds. These estimates are presented in Table 6-14.

Effect on risk analysis: As was also seen in Table 5-7 of this report, Table 6-14 shows that the post-§403 risk estimates decrease as the assumed blood-lead concentration threshold increases (i.e., smaller percentages of children experience IQ score decrements under larger threshold assumptions). The IEUBK model is more sensitive than the empirical model to the threshold level. For example, the probability of a child experiencing an IQ decrement of at least 1 point decreases by 63% under the IEUBK model (from 28.3% to 10.4%) when the threshold increases from 0 to 2 µg/dL, compared to only a 52% decrease under the empirical model (from 36.3% to 17.6%). As the assumed threshold increases, the likelihood of experiencing an IQ decrement of at least 1 point as a result of lead exposure decreases to very low values under both models, and the average IQ score decrement in the population declines to small fractions of points.

6.4.3 Considering Alternative Assumptions on Post-Intervention Dust-Lead Loadings

In the risk management portion (Chapter 6) of the §403 risk analysis report, it was necessary to make assumptions on predicted post-intervention lead levels when characterizing the blood-lead concentration and health effect endpoints in a post-§403 environment. These assumptions were documented in Table 6-2 of the §403 risk analysis report. Among these assumptions were that dust cleaning activities impacted interior dust-lead loadings in the following way:

- Post-intervention household average floor (wipe) dust-lead loadings equaled the minimum of 40 µg/ft^2 and the pre-intervention value.

- Post-intervention household average window sill (wipe) dust-lead loadings equaled the minimum of 100 µg/ft^2 and the pre-intervention value.

A dust cleaning was assumed to be included among the interventions performed when either the floor-dust, window sill-dust, soil, or interior paint abatement standards were exceeded within a home. These two assumptions on post-intervention dust-lead loadings were made within the §403 risk analysis based on data reported in EPA's Comprehensive Abatement Performance

Table 6-14. Sensitivity Analysis on the Assumed Blood-Lead Concentration Threshold on IQ Decrement and Its Impact on the Post-§403 Estimates of IQ Decrement Endpoints for Children Aged 1-2 Years, Under a Specified Set of Example Standards[1]

Assumed Threshold (μg/dL)	% of Children Aged 1-2 Years with a Specified IQ Decrement Due to Lead Exposure[2]			Average IQ Decrement (# points)[3]	Standard Deviation of IQ Decrement[3]
	IQ Decrement $ 1	IQ Decrement $ 2	IQ Decrement $ 3		
Baseline Estimates (Section 5.1.1 of §403 risk analysis report)					
0	38.5	10.8	3.70	1.06	0.895
1	27.3	8.08	2.88	0.804	0.891
2	19.6	6.10	2.26	0.588	0.860
3	14.2	4.66	1.80	0.428	0.802
5	7.83	2.80	1.16	0.233	0.666
8	3.50	1.40	0.627	0.103	0.494
10	2.15	0.915	0.429	0.0638	0.408
Post-§403 Estimates Based on IEUBK Model-Generated PbB Distribution					
0	28.3	4.31	0.858	0.848	0.567
1	17.1	2.78	0.589	0.594	0.564
2	10.4	1.82	0.410	0.379	0.529
3	6.48	1.21	0.289	0.234	0.462
5	2.65	0.566	0.149	0.0907	0.325
8	0.790	0.199	0.0593	0.0250	0.188
10	0.380	0.105	0.0335	0.0116	0.134
Post-§403 Estimates Based on Empirical Model-Generated PbB Distribution					
0	36.3	9.30	2.93	1.00	0.817
1	25.1	6.79	2.24	0.752	0.814
2	17.6	5.02	1.73	0.537	0.781
3	12.5	3.75	1.35	0.380	0.721
5	6.56	2.18	0.838	0.197	0.584
8	2.76	1.03	0.434	0.0812	0.417
10	1.64	0.653	0.289	0.0480	0.337

[1] Example dust and soil standards were set at: 100 μg/ft^2 for floor dust-lead loading, 500 μg/ft^2 for window sill dust-lead loading, and 2,000 μg/g for soil-lead concentration. Paint maintenance is performed if more than 5 ft^2, but less than 20 ft^2 of deteriorated lead-based paint exists. Paint abatement is performed if more than 20 ft^2 of deteriorated lead-based paint exists.

[2] A 0.257 IQ decrement is assumed for each 1.0 μg/dL increase in PbB above the assumed threshold (see Section 4.4.1 of the §403 risk analysis report). Thus, the following hold:

- P[IQ $ 1] = P[PbB $ (threshold + 3.9 μg/dL)]
- P[IQ $ 2] = P[PbB $ (threshold + 7.8 μg/dL)]
- P[IQ $ 3] = P[PbB $ (threshold + 11.7 μg/dL)]

[3] Average and standard deviation of IQ decrement are calculated assuming no IQ decrement occurs below the assumed threshold, and a 0.257 IQ decrement is assumed for each 1.0 μg/dL increase in PbB above the threshold.

study and in the Baltimore Experimental Paint Abatement study (see Section 6.1.2 of the §403 risk analysis report and Section H2.0 of Appendix H of this report).

Tables 6-11 and 6-12 within Section 6.3 of this report presented additional information on household average (wipe) dust-lead loading at pre- and post-intervention for floors and window sills, respectively, from several recent lead intervention studies. This information, some of which was received after the §403 risk analysis report was completed, suggests that it may be common in some instances to observe household average post-intervention dust-lead loadings below the assumptions made above, even from 12 months to six years post-intervention. These findings prompted a sensitivity analysis to investigate how setting assumptions on post-intervention household average dust-lead loadings to below the 40 $\mu g/ft^2$ and 100 $\mu g/ft^2$ specifications would impact the outcome of the risk management analyses.

In this sensitivity analysis, two alternative assumptions on household average post-intervention floor dust-lead loadings were made: 10 $\mu g/ft^2$ and 25 $\mu g/ft^2$. As the geometric mean (12-month) post-intervention floor dust-lead loading in the HUD Grantees evaluation was 14 $\mu g/ft^2$ (Table 6-8) and was even lower for certain grantees, an alternative of 10 $\mu g/ft^2$ was selected. The alternative of 25 $\mu g/ft^2$ for floors was selected as it fell halfway between the assumptions of 10 and 40 $\mu g/ft^2$ and was within the range of expected variability in the summaries for several of the studies in Section 6.3.1.

Similarly, two alternative assumptions on household average post-intervention window sill dust-lead loadings were made: 50 $\mu g/ft^2$ and 75 $\mu g/ft^2$. Evidence from Table 6-12 indicates that average window sill dust-lead loadings following intervention could approach 50 $\mu g/ft^2$ in some instances, especially when floor dust-lead loadings are low. The alternative of 75 $\mu g/ft^2$ was selected as it fell halfway between the assumptions of 50 and 100 $\mu g/ft^2$, and it was similar to the average levels observed by grantees within the HUD Grantees evaluation (although the HUD Grantees evaluation included window replacement, which was not among the assumed interventions in the §403 risk analysis).

In the sensitivity analysis, if a given household's pre-intervention average floor dust-lead loading fell below the given post-intervention assumption, its post-intervention household average floor dust-lead loading was assumed to be equal to its pre-intervention average (as was done in Chapter 6 of the §403 risk analysis report). Second, this sensitivity analysis considers predictions made only by the empirical model, as the IEUBK model does not accept dust-lead loading as input. Finally, the assumptions made in determining post-intervention soil-lead concentrations (150 $\mu g/g$ following soil removal) and amount of deteriorated lead-based paint (none is present following paint intervention) remained the same as specified in Table 6-2 of the §403 risk analysis report.

Table 6-15 presents the estimated post-§403 health effect and blood-lead concentration endpoints associated with the set of example options for standards specified in Section 6.4.1 above, for the alternative assumptions on post-intervention floor and window sill dust-lead loadings specified above. Note that each alternative assumption is evaluated on its own (i.e., it is

Table 6-15. Sensitivity Analysis on How Changing the Assumption on the Post-Intervention Household Average (Wipe) Dust-Lead Loadings on Floors and Window Sills Impact Post-§403 Estimates (Based on the Empirical Model) of the Health Effect and Blood-Lead Concentration Endpoints for Children Aged 1-2 Years Under a Specified Set of Example Standards[1]

Health Effect And Blood-Lead Concentration Endpoint	Predicted Estimates of the Endpoint (Based on the Empirical Model)							
	Assumed Post-Intervention Household Average Dust-Lead Loading for Floors and Window Sills[2]							Baseline Estimate (From Table 5-1 of the §403 Risk Analysis Report)
	Floors = 40 μg/ft^2 Sills = 100 μg/ft^2	Floors = 10 μg/ft^2 Sills = 100 μg/ft^2	Floors = 25 μg/ft^2 Sills = 100 μg/ft^2	Floors = 40 μg/ft^2 Sills = 50 μg/ft^2	Floors = 40 μg/ft^2 Sills = 75 μg/ft^2	Floors = 10 μg/ft^2 Sills = 50 μg/ft^2	Floors = 25 μg/ft^2 Sills = 75 μg/ft^2	
PbB $20 (%)	0.406	0.389	0.401	0.396	0.402	0.380	0.397	0.588
PbB $10 (%)	4.70	4.59	4.67	4.64	4.68	4.53	4.64	5.75
IQ < 70 (%)	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.115
IQ decrement $1 (%)	36.3	36.1	36.3	36.2	36.3	35.9	36.2	38.5
IQ decrement $2 (%)	9.30	9.13	9.25	9.20	9.26	9.03	9.21	10.8
IQ decrement $3 (%)	2.93	2.85	2.90	2.88	2.91	2.81	2.89	3.70
Avg. IQ decrement	1.00	0.999	1.00	1.00	1.00	0.995	1.00	1.06

[1] Example dust and soil standards were set at 100 μg/ft^2 for floor dust-lead loading, 500 μg/ft^2 for window sill dust-lead loading, and 2,000 μg/g for soil-lead concentration. Paint maintenance is performed if more than 5 ft^2, but less than 20 ft^2 of deteriorated lead-based paint exists. Paint abatement is performed if more than 20 ft^2 of deteriorated lead-based paint exists. This analysis follows the same approach conducted in Section 6.3.4 of the §403 risk analysis report. Assumptions on post-intervention soil-lead concentrations and amounts of deteriorated lead-based paint are unchanged from those specified in Table 6-2 of the §403 risk analysis report.

[2] Within a housing unit, the assumed post-intervention average floor dust-lead loading is the minimum of its pre-intervention average and the value for floors specified in the column heading. Similarly, the unit's assumed post-intervention average window sill dust-lead loading is the minimum of its pre-intervention average and the value for sills specified in the column heading.

the only change from the §403 risk analysis assumptions). In addition, considering the high correlation in dust-lead loadings between floors and window sills, the two lower alternatives (10 µg/ft^2 for floors and 50 µg/ft^2 for window sills) and the two higher alternatives (25 µg/ft^2 for floors and 75 µg/ft^2 for window sills) are evaluated together. For comparison purposes, post-intervention estimates under the §403 risk analysis (i.e., assuming 40 µg/ft^2 for floors and 100 µg/ft^2 for window sills) and the estimates generated under baseline (pre-§403) conditions (both presented in Table 6-7 of the §403 risk analysis report) are also included in Table 6-15.

Effect on risk analysis. Relative to the results reported in the §403 risk analysis report (column 2 of Table 6-15), the greatest deviation occurs with the most substantial change in the assumptions, i.e., the assumptions of 10 µg/ft^2 for floors and 50 µg/ft^2 for window sills (column 7 of Table 6-15). Under this particular set of alternative assumptions, the percentage of the nation's children aged 1-2 years that are anticipated to have blood-lead concentration at or above 10 µg/dL following interventions conducted in response to the §403 rule (given the example standards specified in the footnote to this table) is reduced from 4.70% to 4.53% (a 3.7% decline, equivalent to approximately 13,700 children[12]). The corresponding reduction in the percentage of children with blood-lead concentration at or above 20 µg/dL is from 0.406% to 0.380% (a 6.3% decline, equivalent to approximately 2,000 children).

Under the assumptions of 25 µg/ft^2 for floors and 75 µg/ft^2 for window sills (column 8 of Table 6-15), the percentage of the nation's children aged 1-2 years that are anticipated to have blood-lead concentration at or above 10 µg/dL is reduced from 4.70% to 4.64% (a 1.2% decline, equivalent to approximately 4,800 children). The corresponding reduction in the percentage of children with blood-lead concentration at or above 20 µg/dL is from 0.406% to 0.397% (a 2.3% decline, equivalent to approximately 750 children).

Generally, even lower percentage declines occur for the IQ endpoints compared to the blood-lead concentration endpoints. The exception occurs with the percentage of children with IQ decline of at least 3 points, where a 4.2% decline from the §403 risk analysis assumptions was observed under assumptions of 10 µg/ft^2 for floors and 50 µg/ft^2 for window sills.

This sensitivity analysis indicates that while more housing units may achieve reductions in average dust-lead levels on floors and window sills following a dust cleaning if the assumed post-intervention floor dust-lead loadings are lowered from those made in the §403 risk analysis, the corresponding reduction in the estimated blood-lead concentration and health effect endpoints appears to be modest, especially when compared to the reduction observed from pre- to post-§403 conditions.

[12] Assuming that 7.96 million children aged 1-2 years reside in the U.S. housing stock (Table 3-35 of the §403 risk analysis report).

6.4.4 Characterizing the Post-Intervention Blood-Lead Distribution Based on Relative Change from Baseline in the Geometric Mean and the Probability of a Child's Blood-Lead Concentration Exceeding 10 μg/dL

As discussed in Section 4.3.1 above and in Appendix F1 of the §403 risk analysis report, a "scaling algorithm" was used in the §403 risk analysis to characterize the distribution of blood-lead concentration in the nation's children following interventions that would be performed as a result of implementing the §403 rule (where the algorithm was applied under a specified set of example options for the standards, using a specified blood-lead prediction model, and under assumptions made on the changes in environmental-lead levels that result from the interventions). This distribution is labeled the "post-§403" distribution. This approach calculated the geometric mean (GM) and geometric standard deviation (GSD) of the post-§403 blood-lead distribution in the following manner:

$$GM_{post\text{-}403} = GM_{baseline} * (GM_{model\text{-}based\ post\text{-}403} / GM_{model\text{-}based\ pre\text{-}403}) \quad (1)$$

$$GSD_{post\text{-}403} = GSD_{baseline} * (GSD_{model\text{-}based\ post\text{-}403} / GSD_{model\text{-}based\ pre\text{-}403}) \quad (2)$$

where the subscripts indicate the blood-lead distribution which either the GM or the GSD represents. See Section 4.3.1 for additional information on this approach.

One comment received on the §403 risk analysis was that because the blood-lead concentration endpoints utilized in the risk analysis were exceedance probabilities (i.e., the likelihood of a child's blood-lead concentration exceeding a specified value), it was more important to accurately characterize the right tail of the post-§403 distribution compared to the remainder of the distribution, especially at blood-lead levels beyond 10 μg/dL. Therefore, a variant of the scaling approach was considered that involved scaling the probability of a child's blood-lead concentration exceeding 10 μg/dL rather than the GSD. If P10 was used to represent this probability, then the alternative scaling algorithm would involve scaling the geometric mean as in (1) above, but replacing (2) above with the following calculation:

$$P10_{post\text{-}403} = P10_{baseline} * (P10_{model\text{-}based\ post\text{-}403} / P10_{model\text{-}based\ pre\text{-}403}) \quad (3)$$

The resulting value is the estimate of the probability of a child's blood-lead concentration exceeding 10 μg/dL in a post-§403 environment. It is calculated by multiplying the probability as calculated in the baseline distribution by the relative change in the probability from the pre-§403 to post-§403 environment as estimated from model-based blood-lead distributions. Then, in order to calculate the other blood-lead concentration and health effect endpoints, the GSD of the post-§403 distribution would be calculated by assuming that this distribution is lognormal. Therefore,

$$GSD_{post\text{-}403} = \exp\{(\log(10) - \log(GM_{post\text{-}403}))/Ö^{-1}(1 - P10_{post\text{-}403})\} \quad (4)$$

where $Ö^{-1}$ denotes the inverse of the standard normal distribution function.

Table 6-16 presents the estimated blood-lead concentration and health effect endpoints that result when applying this alternative scaling algorithm, under both the IEUBK and empirical models. The example options for standards that are assumed in this analysis are the same as those considered in Section 6.4.1 above and are specified in a footnote to Table 6-16. For comparison purposes, this table also contains the estimates under the original version of the scaling approach that was utilized in the §403 risk analysis.

Table 6-16. Estimated Post-§403 Health and Blood-Lead Concentration Endpoints Under the Original and Alternative Scaling Algorithms for Characterizing the Post-§403 Blood-Lead Distribution

Original scaling algorithm: Geometric mean and GSD are scaled.
Alternative scaling algorithm: Geometric mean and the probability of PbB exceeding 10 μg/dL are scaled.

Health Effect and Blood-Lead Concentration Endpoints	Post-§403 Estimates Under the Risk Management Analysis (Original Scaling Algorithm)		Post-§403 Estimates Under the Alternative Scaling Algorithm	
	IEUBK Model	Empirical Model	IEUBK Model	Empirical Model
% of Children with PbB $ 20 μg/dL	0.0539	0.406	0.156	0.249
% of Children with PbB $ 10 μg/dL	1.66	4.70	2.72	3.78
%of Children with IQ < 70 due to lead exposure	0.0984	0.110	0.102	0.107
% of Children with IQ decrement $ 1 due to lead exposure	28.3	36.3	30.1	35.5
% of Children with IQ decrement $ 2 due to lead exposure	4.31	9.30	6.05	8.03
% of Children with IQ decrement $ 3 due to lead exposure	0.858	2.93	1.56	2.24
Avg. IQ decrement due to lead exposure	0.848	1.00	0.884	0.977
Geometric Mean PbB (GSD)	2.74 (1.84)	3.03 (2.04)	2.74 (1.96)	3.03 (1.96)

Note: Example dust and soil standards were set at: 100 μg/ft² for floor dust-lead loading, 500 μg/ft² for window sill dust-lead loading, and 2,000 μg/g for soil-lead concentration. Paint maintenance is performed if more than 5 ft², but less than 20 ft², of deteriorated lead-based paint exists. Paint abatement is performed if more than 20 ft² of deteriorated lead-based paint exists. GSD = geometric standard deviation. PbB = blood-lead concentration

Effect on risk analysis. As indicated in Table 6-16, when the probability of exceeding 10 µg/dL is scaled instead of the GSD, the estimated probability is approximately 64% higher under the IEUBK model (1.66% to 2.72%), but nearly 20% lower under the empirical model (4.70% to 3.78%). Note that under the alternative approach, estimates based on the IEUBK and empirical models are more similar to each other than under the original scaling algorithm. In the alternative approach, the estimated post-§403 GSD is the same under both models: 1.96. Note that there was no change in the manner in which the geometric mean blood-lead concentrations were determined, and therefore, no change is noted between the two approaches.

The above results indicate that the alternative scaling approach has a more significant impact on the IEUBK model-based estimates compared to the empirical model-based estimates. The impact of the approach on the empirical model-based estimates is a reduction in the risk estimates due to a 4% reduction in the estimated GSD, while the impact on IEUBK model-based estimates is an increase in the risk estimates due to a 6.5% increase in the estimated GSD. However, because the two approaches did not differ in how the post-§403 geometric mean blood-lead level was calculated, the empirical model estimates remain higher than the IEUBK model estimates.

6.5 LEAD EXPOSURE ASSOCIATED WITH CARPETED FLOOR-DUST

While the §403 proposed rule included a proposed lead hazard standard for dust on uncarpeted floors, EPA determined that sufficient technical data were not available to direct how the rule should address lead-contaminated dust on carpeted floors. Based upon public comments on the proposed rule, EPA is revisiting that determination. This section summarizes the key findings of statistical analyses on dust-lead loading data for carpeted floors. The analysis had the following three objectives:

1. Assess the need to have dust-lead on carpeted floors addressed by the §403 rule:

    a. Characterize the relationship between floor dust-lead levels and blood-lead concentration in young children and how this relationship differs for carpeted and uncarpeted floors (with and without adjusting for the effects of key demographic variables and for lead levels in other media in which standards have been proposed in the §403 rule).

    b. Determine the added value of including a carpet dust-lead standard given the proposed §403 standards for soil, window sills and uncarpeted floors, or expanding the definition of floors in the rule to include carpeted as well as uncarpeted floors.

2. Identify appropriate candidates for carpeted floor dust-lead standards and, in particular, whether one candidate standard should correspond to 50 µg/ft^2, the uncarpeted floor dust-lead standard from the §403 proposed rule.

3. Determine whether the wipe technique is acceptable for sampling dust from carpeted floors for evaluating the risk of lead exposure associated with carpet-dust, or whether alternative vacuum methods are more appropriate.

A more detailed presentation of the statistical analyses that address these three objectives is found in Appendix I of this report.

The carpet dust-lead measurement data used in this analysis originated from two lead exposure studies: the Rochester (NY) Lead-in-Dust study, and the pre-intervention, evaluation phase of the HUD Lead-Based Paint Hazard Control Grant ("HUD Grantees") Program (data collected through September, 1997). Both studies were introduced in Section 3.3.1 of the §403 risk analysis report; additional details on these studies that are relevant to this analysis is presented in Section I3.1 of Appendix I. The results of this analysis, along with relevant findings documented in EPA's recent literature review report on lead exposure associated with carpets, furniture, and air ducts (USEPA, 1997b), were used to address the above objectives.

The summary of the analysis results now follows. It is formatted according to the above three objectives. References to statistical significance are made at the 0.05 level. Unless otherwise indicated, references to dust-lead loadings are assumed to be for samples collected using wipe techniques. Section numbers within Appendix I are specified in parentheses where additional information can be found.

Objective #1: Is there a need to have dust-lead on carpeted floors addressed by the §403 rule?

- Using data collected in the 1997 American Housing Survey, EPA estimates that approximately 54 million housing units built prior to 1978 contain some wall-to-wall carpeting. Of these units, wall-to-wall carpeting is found in a living room in approximately 47 million units and in a bedroom in approximately 46 million units (i.e., rooms in which children reside and play most frequently, and therefore, would be targeted in a risk assessment).

- While the §403 proposed rule indicates that lead from floor dust is an important exposure source for children, the proposed floor dust-lead loading standard was only relevant for uncarpeted floors. In homes with wall-to-wall carpeting, it is expected that floor-dust samples in certain rooms can come only from carpeted floors. While no guidance was given in the §403 proposed rule on a standard to which risk assessors should compare the results of lead analyses for carpet dust samples, EPA recognizes (and many commenters on the §403 proposed rule have noted) that some recommendation for a carpet dust-lead loading standard, based on using wipe collection techniques, is necessary.

- Because children come in frequent direct contact with carpeting when it is present in their homes, any lead that may be present in carpet dust is likely to be bioavailable to children.

Objective #1a: Is there any association between carpeted floor dust-lead loadings and blood-lead concentration?

- For both carpeted and uncarpeted floors in the two studies, the correlation between household average floor (wipe) dust-lead loading and children's blood-lead concentration was positive and significantly different from zero. (Sections I4.1.1.1 and I5.1.1.1 of Appendix I)

- No evidence was found in these analyses to suggest that wipe dust-lead loadings from uncarpeted floors are a better predictor of children's blood-lead concentration than wipe dust-lead loadings from carpeted floors. (Sections I4.1.1.2, I4.1.1.4, I5.1.1.2 and I5.1.1.4 of Appendix I)

- No significant difference in the statistical relationship between average floor dust-lead loading and blood-lead concentration was found between homes with floor dust sampling conducted from mostly carpeted floors and homes with sampling from mostly uncarpeted floors. (Sections I4.1.1.3 and I5.1.1.3 of Appendix I)

- Mixed results were found when investigating whether the effect of average carpeted floor dust-lead loading on blood-lead concentration remained significant after adjusting for the effects of lead levels in soil, window sill dust, and uncarpeted floor dust (i.e., other environmental media addressed by the proposed §403 standards). The carpet dust-lead loading effect was no longer statistically significant after adjusting for these other effects when analyzing data from the Rochester study, while the effect remained statistically significant when analyzing data from the HUD Grantees program evaluation. (Sections I4.1.2 and I5.1.2 of Appendix I)

- When interpreted as a whole, these findings provide a powerful argument for expanding the floor dust-lead standard in the §403 rule to include carpeted floors.

Objective #1b: Is there any added benefit to adding a carpeted floor dust-lead loading standard to the proposed §403 standards for lead in soil, window sill dust, and dust from uncarpeted floors, or to expanding the definition of floors in the rule to include carpeted floors? (Sections I4.1.3 and I5.1.3 of Appendix I)

- The extent of any added benefit is dependent on the value of the carpet dust-lead loading standard and the particular criteria being considered in evaluating performance. Adding a new standard to a set of existing standards will not reduce sensitivity (i.e., the proportion of homes with elevated blood-lead children that are triggered by the set of

standards), but it also will not increase specificity (i.e., the proportion of homes with no elevated blood-lead children that are not triggered for an intervention by the standards).

- If the uncarpeted floor dust-lead loading standard of 50 µg/ft^2 that was proposed in the §403 proposed rule was extended to included carpeted floors as well, the resulting performance of the§403 proposed standards (based on the outcome of performance characteristics analysis) changed little, if any. If a carpeted floor standard of 40 µg/ft^2 was added to the §403 proposed standards, slight improvements in the performance characteristics were noticed. These findings were observed regardless of whether or not uncarpeted floors were available to sample (i.e., whether or not the uncarpeted floor standard was considered).

- Analyses of the Rochester study data indicated that adding a carpet dust-lead loading standard of approximately 17 µg/ft^2 to the proposed §403 standards considerably improved certain performance characteristics, particularly sensitivity, without a large decrease in specificity.

- Analysis of the HUD Grantees evaluation data indicated that adding a carpet dust-lead loading standard of approximately 5 µg/ft^2 improved sensitivity and negative predictive value (NPV, equal to the proportion of homes not triggered for intervention by the standards that do not contain elevated blood-lead concentration), but was accompanied by a considerable decrease in specificity. If the proposed carpet dust-lead loading standard was increased to approximately 13 µg/ft^2, this loss of specificity relative to the gains in sensitivity and NPV was reduced.

- In general, these analyses concluded that expanding the proposed §403 floor dust-lead standard (of 50 µg/ft^2) to encompass both carpeted and uncarpeted floors, or setting this standard slightly lower at 40 µg/ft^2, would not lead to a large decrease in specificity, but it would tend to result in only minor increases in sensitivity from what was observed when carpeted floor standards were not being considered.

Objective #2: If a carpeted floor standard is needed, what should it be? Should it be different from the proposed uncarpeted floor dust-lead loading standard of 50 µg/ft^2?

- The findings listed above for Objective #1b suggest that it may provide an advantage to have a standard for carpeted floors that is lower than the standard for uncarpeted floors. (Sections I4.1.1.2, I4.2.1, I5.1.1.2 and I5.2.1 of Appendix I)

- Having a floor dust-lead loading standard of 40 to 50 µg/ft^2 that is expanded to represent carpeted floors as well as uncarpeted floors would be at least as protective of children (in terms of the predicted blood-lead concentration at which 95% of children exposed at the standard level would be expected to fall below) than if the standard represented only uncarpeted floors. (Sections I4.2.2 and I5.2.2 of Appendix I)

- When the Rochester study data was used in a performance characteristics analysis that considered only standards for either carpeted or uncarpeted floors (Sections I4.2.3 and I5.2.3 of Appendix I), a carpeted floor dust-lead loading standard in the range of 15 to 20 $\mu g/ft^2$ maximized the total of the four performance characteristics. In contrast, a standard of 50 $\mu g/ft^2$ resulted in considerably lower performance when the standard was for carpeted floors versus uncarpeted floors. The level of sensitivity achieved by an uncarpeted floor dust-lead loading standard of 50 $\mu g/ft^2$ was achieved for carpeted floor dust-lead loading standards below approximately 33 $\mu g/ft^2$. However, the uncertainty associated with these estimates may suggest that these lower levels may not actually differ from a practical standpoint from the uncarpeted floor dust-lead loading standard in the §403 rule.

Objective #3: What dust sampling method should be used on carpeted floors? (Sections I4.3 and I5.3 of Appendix I)

- The HUD Guidelines (USHUD, 1995) support the use of wipe methods to sample carpet dust. Participants in the §403 Dialogue Group meetings raised concerns that requiring widespread use of vacuum techniques for collecting dust samples in typical risk assessments would be impractical. Therefore, it would be preferable to allow wipe sampling as an option for collecting dust samples from carpets in a risk assessment unless wipe techniques were totally unacceptable.

- Different types of dust collection methods can collect different amounts of lead within a dust sample, especially when sampling from carpets where surface dust is easier to sample than dust that is deep within the carpet fibers. A laboratory study done in conjunction with the Rochester study (Emond et al., 1997) concluded that lead recovery from carpet dust was highest with the BRM vacuum (95.2%) compared to the wipe (24.4%) and the DVM vacuum (31.4%). For this reason, different dust collection methods for collecting carpet dust would require different lead standards to which to compare the results.

- When the wipe method is used on carpets, it tends to collect only dust on the carpet surface that can readily be removed by the method. This surface dust is also that which is most likely to come into direct contact with children (USEPA, 1997b).

- Blood-lead concentration tends to be more highly associated with dust-lead loading than with dust-lead concentration in carpets. (Only dust-lead loadings can be measured under wipe techniques, while loadings or concentrations can be measured under vacuum methods.) This contributes to the technical justification that a carpet dust-lead standard would be better conveyed as a loading than as a concentration.

- Each of the three dust collection methods considered in the Rochester study (BRM vacuum, DVM vacuum, wipe) collected carpet dust samples whose dust-lead loadings

were statistically associated with blood-lead concentration, with the level of association being similar for each method.

- On both carpeted and uncarpeted floors, dust-lead loading measurements from different dust collection methods were significantly positively correlated. This suggests that using any of the three methods (including wipe) would portray the extent of a carpet dust-lead hazard in a similar fashion.

- As wipe sampling is currently the method of choice for uncarpeted floors and all three methods have significant correlations with blood-lead concentration for carpeted and uncarpeted floors, it is reasonable to develop a carpeted floor dust-lead loading standard for the wipe sampling method. As this standard would not apply to vacuum sampled dust-lead loadings, measurements for samples collected using vacuum techniques could not be directly used in risk assessment via the §403 rule without first being converted to wipe-equivalent loadings using methods such as those documented in Section 4.3 of the §403 risk analysis report.