Exposure Assessment for Lead Dust Generated During Renovation, Repair, and Painting in Residences and Child-Occupied Facilities

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1. Introduction

This report describes the approach and initial results for the exposure assessment performed in support of the final Lead Renovation, Repair, and Painting (LRRP) rule. This exposure assessment is designed to characterize the children's lead exposures associated with LRRP activities, and will include the estimation of the potential exposures with current conditions and with the LRRP rule in place. This assessment will also consider exposures resulting from LRRP activities in child-occupied facilities.

Chapter 1 provides an overview of the approach, describes the types of buildings covered in this exposure assessment, identifies the relevant sources and pathways for lead exposures associated with renovation, repair, and painting (RRP) activities in these buildings, and describes the exposure durations for the assessment. Chapter 2 describes the selected exposure scenarios, including the RRP activities and control types considered. Chapters 3 and 4 describe the approaches and initial results for the assessment of lead exposures to RRP activity-relevant media (i.e., indoor dust and outdoor soil) and background sources (i.e., diet, drinking water, and air), respectively. Chapter 5 provides the references for the report.

1.1 Overview of Approach

The approach for this draft exposure assessment is focused on developing a scientifically sound analysis framework and characterizing a reasonable range of results (considering both uncertainty and variability) using this framework. For this draft, readily available data sources were identified and the best inputs and assumptions, given the available time, were identified. Throughout the report, it is noted where inputs and assumptions should be reconsidered in subsequent drafts of the exposure assessment.

For this draft, exposure concentrations were estimated for a series of scenarios. Each scenario is defined by a unique combination of activity type (e.g., replacing windows) and control strategy. The scenarios evaluated in this draft were limited by the available data sources; some of the identified scenarios could not be included in this draft due to data gaps. It is expected that EPA's Office of Pollution Prevention and Toxics (OPPT) dust study will be available for use in the revised exposure assessment and should aid in filling some of these gaps. This study is expected to include additional information on lead dust and soil loadings associated with different RRP activities and is expected to be used in revising and expanding this exposure assessment.

A recent study which includes data on lead dust levels during RRP activities is available and will be used in developing the exposure assessment if appropriate. In November, 2006, the Lead-Safe Work Practices Survey Project Report was provided to the Agency. The Lead-Safe Work Practices Survey was conducted by the National Association of Home Builders to measure the amount of lead dust generated during typical RRP activities and assess whether routine RRP activities increase lead dust levels in the work area and property. Both air samples and surface dust wipe samples were collected during RRP activities conducted in five separate residential properties included in the study. This study will be evaluated for its relevance in developing the RRP exposure assessment and may be included in future drafts of the exposure assessment.

The results of this assessment include a complete set of exposure concentration results for each scenario, based on best estimate or central tendency (CT) assumptions. In addition, a sensitivity analysis was conducted where each input varied from a low-end estimate to a high-end estimate (one input value at a time) to characterize the sensitivity of estimated exposure concentrations to changes in each input, given a reasonable range of values for the input. The results of this sensitivity analysis provide insight into which inputs are most important and help in determining which inputs should be the focus of additional analysis for the revised exposure assessment.

1.2 Universe of Included Building Types

This exposure assessment is focused on lead exposures in two types of buildings: residences with children under six years of age, and COFs. For the purposes of this assessment, COFs are defined as a building, or a portion of a building, constructed prior to 1978, visited regularly by the same child, under age 6, on at least two different days within any week, provided that each day's visit lasts at least 6 hours and the combined weekly visit lasts at least 6 hours, and the combined annual visits last at least 60 hours. Examples of COFs are day-care centers, preschools, and kindergarten classrooms.

There is potentially some overlap between the buildings covered under the "residences" category and those categorized as COFs.

This draft exposure assessment focuses on a set of exposure scenarios that was developed to address exposures in residences. Exposures associated with COFs are not explicitly addressed in this draft assessment because the potential RRP activities for these types of buildings have not yet been fully characterized. Note, however, that the exposure scenarios included in this draft assessment may indirectly characterize exposures for some types of COFs, particularly where there is overlap between the definitions of "residence" and "COF." COFs will be more comprehensively characterized in the revised exposure assessment.

For all building types, the exposure assessment will consider the age of the building (i.e., vintage) when calculating exposures. The building's vintage plays an important role in several elements of the exposure assessment, including estimating lead loadings with different types of RRP activities and estimating background concentrations, because older homes may contain older lead-based paints, which often have higher lead concentrations. Data were not available for the draft exposure assessment to consider vintage; however, this will be considered in the revised exposure assessment.

1.3 Sources and Exposure Pathways

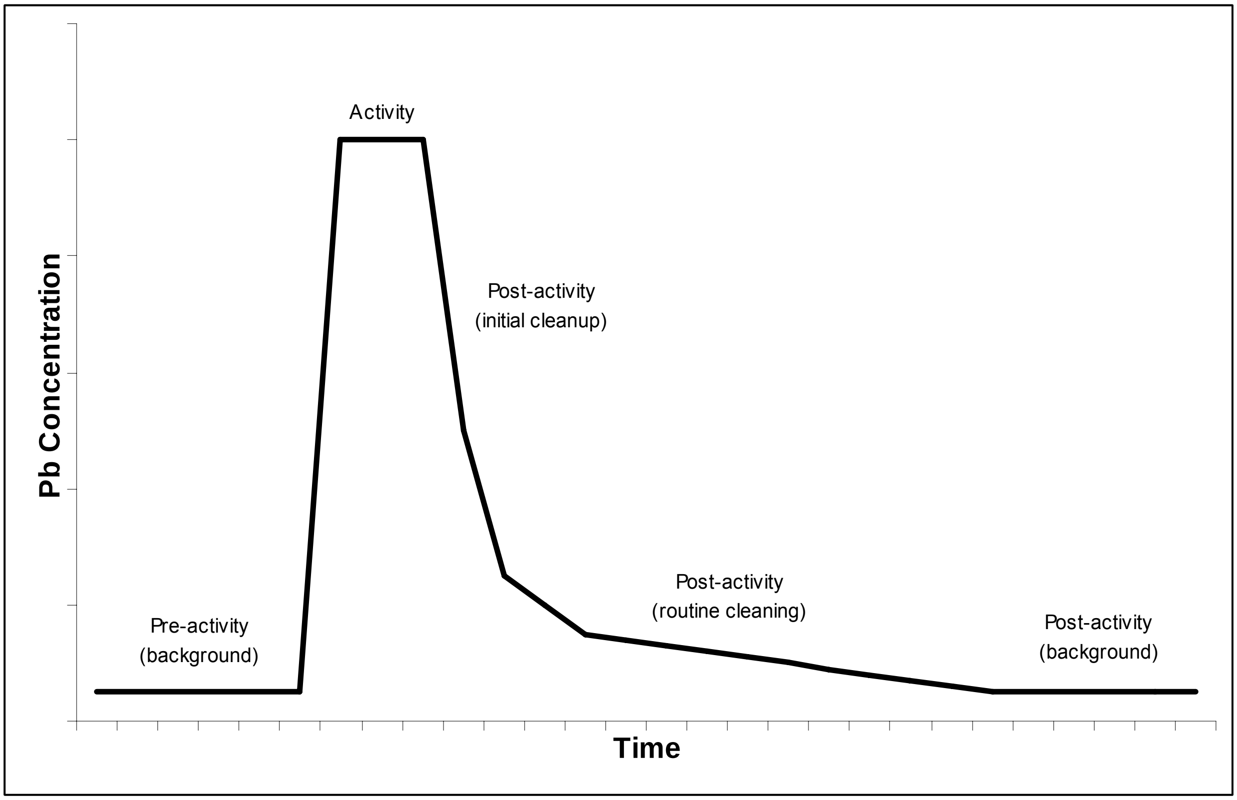
Without understanding all of the different types of lead sources and their contributions to blood lead levels, it is difficult to characterize how changes in lead exposures associated with RRP activities would affect children's IQ, given the non-linearity in blood lead models and exposure-response relationships. For this assessment, lead sources are divided into two categories: sources impacting indoor dust and outdoor soil lead concentrations, and all other sources (i.e., air, drinking water, and diet). This distinction is made because RRP activities are expected to contribute to lead concentrations in indoor dust and outdoor soil, and these contributions will vary depending on the types of controls being used (see Section 2.2 for more details). Exposures to air, drinking water, and diet are characterized using a single, constant "background" concentration that is assumed to be unaffected by any RRP activities (see Chapter 4 for more details on these exposure concentrations).

In the draft exposure assessment, inhalation exposures are assumed to be unaffected by RRP activities, and are included in the "other sources" category. This assumption may underestimate the impacts of RRP activities on lead exposures because these activities may result in elevated air concentrations of lead, which could contribute to the overall health impacts. Due to a lack of available data characterizing air concentrations associated with RRP activities, the impact of this assumption could not be evaluated in this exposure assessment. However, the OPPT dust study is expected to provide this type of data and may allow for the evaluation of this assumption in the revised exposure assessment. If subsequent analyses indicate that inhalation exposures have the potential to impact overall risk estimates, they will be characterized in a manner similar to that used to characterize indoor dust and outdoor soil concentrations (i.e., not characterized using a single, constant "background" concentration), to extent feasible given the available data.

1.4 Exposure Duration

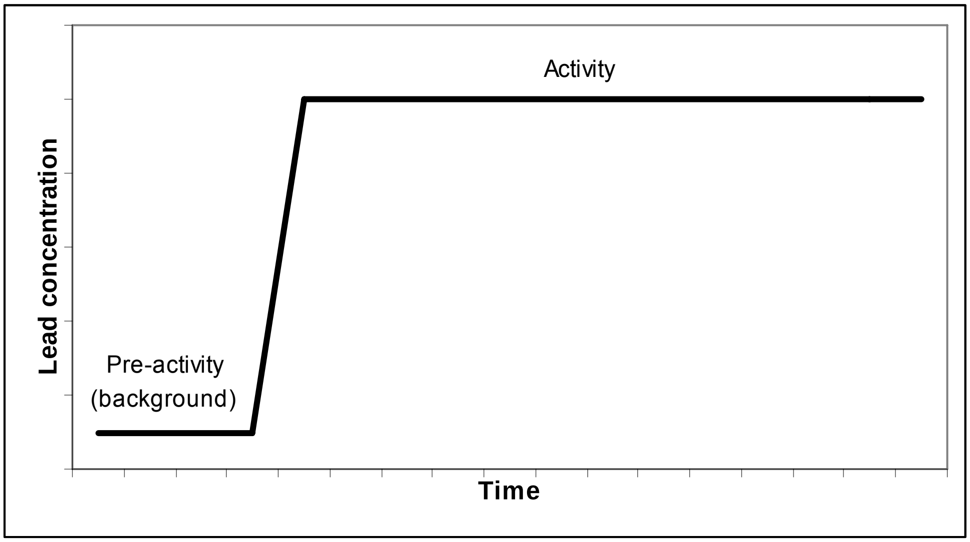
For this exposure assessment, environmental media concentrations will be estimated over time for the exposure duration, and then provided as inputs to a blood lead model. For each scenario, the period of exposure considered in this assessment is six years. For interior dust exposures, this period is divided into five phases (as illustrated in Exhibit 1): pre-activity (background), activity, post-activity (initial cleanup), post-activity (routine cleaning), and post-activity (background). Exposure concentrations are estimated for each phase separately. During the pre-activity (background) phase, exposures will be represented by the estimated constant background indoor dust concentrations. During the activity phase, exposure concentrations will be represented by the sum of the background dust concentrations and the estimated activity-related dust concentrations. The post-activity (initial cleanup) phase refers to the one-time cleaning conducted by the contractor immediately following completion of the activity. Exposure concentrations for the post-activity (initial cleanup) phase will be represented by a one-time reduction in the activity phase concentration calculated using the initial cleaning efficiency (described in more detail in Chapter 3). The post-activity (routine cleaning) phase refers to the regular (repeated) cleaning performed by the resident. Exposure concentrations for the post-activity (routine cleaning) phase will be represented by time-varying estimates of dust concentrations calculated using the activity concentration and the routine cleaning efficiency (described in more detail in Chapter 3). The final phase, post-activity (background), begins when the post-activity (routine cleaning) dust concentrations are approximately equal to the background dust concentrations, and continues until the end of the exposure period. For this phase, exposure concentrations will be represented by the estimated constant background indoor dust concentrations.

Exhibit 1. Phases of the Exposure Period, Indoor Dust



For outdoor soil exposures, this period is divided into two phases (as illustrated in Exhibit 2): pre-activity (background), and activity. Exposure concentrations are estimated for each phase separately. During the pre-activity (background) phase, exposures will be represented by the estimated constant background outdoor soil concentrations. During the activity phase, exposure concentrations will be represented by the sum of the background soil concentrations and the estimated activity-related soil concentrations. Unlike for indoor dust, there are no assumed loss processes that result in a reduction of the activity-related soil concentrations and thus soil concentrations are assumed to remain at activity phase levels for the remainder of the exposure period.

Exhibit 2. Phases of the Exposure Period, Outdoor Soil



For the blood lead modeling, individual simulations will be performed using ages between 0 and 5 as the starting points for the activity (the number of simulations will be based on the shape of the estimated exposure distributions). For each of these simulations, the length of the different phases may be different; in some cases, one or more of the phases may not be included based on the time the activity starts and the length of the different periods (e.g., if activity starts at age 0, the pre-activity phase would not be included). In addition, blood lead levels associated with RRP activities will be estimated for women of child-bearing age and used to characterize fetal exposures.

2. Exposure Scenarios

This draft exposure assessment uses a scenario-based approach, where each scenario consists of a unique combination of RRP activity type and control type. A separate set of exposure concentration results were generated for each scenario to evaluate the range of exposure conditions possible both with and without implementation of the LRRP rule. Section 2.1 describes the RRP activity types addressed in this assessment and Section 2.2 describes the control types considered.

2.1 Types of Activities

Exhibit 3 presents the types of activities for residential exposures covered by this draft exposure assessment.[1] Each activity is associated with a different combination of tasks, such as drilling and sawing. This exhibit indicates the relevant exposure media for each activity – indoor dust for inside activities and outdoor soil for outside activities. For some of these activities, it is possible that there are contributions to lead concentrations in both indoor dust and outdoor soil. This assessment is limited in this regard because the data identified to date only include lead loadings for either indoor dust or outdoor soil for each activity. This is recognized as a limitation of this assessment and may be revisited if sufficient data are identified.

The list of activities included in Exhibit 3 is based on the types of RRP activities expected to be included in OPPT's dust study. Given that the results of the dust study are not yet available, activity-based exposure concentrations were estimated for this draft exposure assessment based on other available sources, primarily OPPT's Environmental Field Sampling Study (USEPA 1997) (see Chapter 3 for more details). Some of these activities (as indicated in Exhibit 3) were not included in the draft exposure assessment because there were not sufficient data to characterize lead loadings in the workspace associated with these activities. These activities will be included in the revised exposure assessment, provided sufficient data are available in OPPT's dust study to fully characterize them.

[1] Activities associated with exposures in COFs are not explicitly addressed in the draft exposure assessment, as discussed in Section 1.2. Additional activities will be included in the revised exposure assessment to address activities associated with COFs.

Exhibit 3. RRP Activities Included in Exposure Assessment[a]

Activity	Relevant Media		Included in Draft EA?	Description
	Indoor dust	Outdoor soil		
Renovating kitchen	✓		✓	Complete replacement of kitchen (cabinets, appliances, etc.)
Three cutouts	✓		✓	2 ft^2 each of painted surface
Replacing windows	✓		✓	6 ft^2 of painted surface
Replacing exterior doors	✓		✓	25-50 ft^2 of painted surface
Scraping LBP, interior flat component	✓		✓	50-75 ft^2 of painted surface
Scraping LBP, interior door	✓		✓	20-40 ft^2 of painted surface
Replacing fascia boards		✓		50 ft^2 of painted surface
Exterior LBP removal[b]		✓	✓	Removal of LBP through a variety of techniques

[a] LBP = lead-based paint; EA = exposure assessment

[b] The range of exterior LBP removal practices considered in the draft exposure assessment include activities such as dry scraping, chemical removal, and heat gun removal. Additional scenarios may be added to the refined assessment for individual LBP removal techniques if supported by the data provided in the forthcoming OPPT dust study.

2.2 Types of Controls

There are methods for control of lead released during RRP activities being considered for the LRRP Rule: plastic sheeting and workspace cleaning. The following four control combinations are included in this exposure assessment:

- No plastic sheeting, basic cleaning (baseline controls);
- No plastic sheeting, full rule cleaning;
- Plastic sheeting, basic cleaning; and
- Plastic sheeting, full rule cleaning (full rule implementation controls).

Only the baseline controls and full rule implementation controls are addressed in this draft exposure assessment. Sufficient data were not available to evaluate the effectiveness of the other two combinations for this assessment. The results of the OPPT dust study are expected to be used to revise this exposure assessment as it pertains to these control combinations. In addition, the revised exposure assessment will also examine exposures with different degrees of partial compliance, as well as the use of control techniques in the absence of a LRRP Rule.

3. Exposures to Indoor Dust and Outdoor Soil

This chapter presents the methodology used to estimate exposure concentrations in indoor dust and outdoor dust and summarizes the results of the analysis. Section 3.1 presents the background concentrations used for indoor dust and outdoor soil and how they were derived. Section 3.2 presents the approaches for estimating indoor dust and outdoor soil concentrations with both baseline and full rule implementation controls for the seven activity types analyzed in this draft exposure assessment. Section 3.3 presents the estimated indoor dust or outdoor soil for each scenario. Section 3.4 describes the sensitivity analysis and presents a summary of its results.

3.1 Background Media Concentrations

A child's exposure to lead over the first six years of life consists of both exposure to lead released as a result of RRP activities and exposure to background lead concentrations in the home. It is necessary to know these background concentrations for accurate estimation of blood lead levels and to allow for the determination of the portion of the blood lead levels attributable to RRP activities with and without implementation of the rule.

3.1.1 Indoor Dust

For indoor lead background dust concentrations, two different sources of lead loading data were used. The default lead loading value (2.0 $\mu g/ft^2$) is the 75th percentile of background lead loading values in the U.S. housing stock across all floor types as reported in HUD (2002). The 75th percentile was selected as a reasonable default estimate because these data represent all housing in the United States (i.e., they are not specific to housing with lead-based paint). HUD (2002) estimates that 40 percent of all homes have lead-based paint (LBP) and homes with LBP are expected to have higher lead loading values; therefore, the 75th percentile value for the entire U.S. housing stock was used to capture the effect of the higher typical loading in homes with LBP. The low lead loading value (0.375 $\mu g/ft^2$) is the 25th percentile of U.S. housing stock background lead loading values across all floor types as reported in HUD (2002). This value was chosen as a reasonable low-end estimate because it was the lowest floor load presented in HUD (2002), which includes all U.S. housing and likely provides relatively low loadings compared to those for houses with LBP. It is important to note that the reporting of 0.375 $\mu g/ft^2$ as the 25th percentile in HUD (2002) was influenced significantly by HUD's decision to represent all non-detects in their sampling with 0.375 $\mu g/ft^2$ (the detection limit was reported as 1.5 $\mu g/ft^2$). The high lead loading value (520 $\mu g/ft^2$) is the highest background loading reported in the Staes and Rinehart (1995) summary of studies examining mean pre-abatement floor dust levels in houses with lead contamination. The value was deemed a reasonable high-end estimate because the report pertains to homes in which lead levels are elevated sufficiently to necessitate abatement activities and thus should be on the high end of loading levels in houses with LBP. Each of these indoor lead loading values was converted to lead concentrations using a conversion function discussed in Appendix C.

3.1.2 Outdoor Soil

The outdoor soil lead background concentration range is derived from HUD (2002), which presents empirical data from a survey of all U.S. housing at the main entrance, dripline and midyard positions associated with one wall, and dripline and midyard positions associated with a second wall. The soil lead concentration chosen as a reasonable default value (103.7 ppm) was the smaller of the 75th percentile concentrations for the two dripline locations. A 75th percentile concentration was used because, as mentioned in Section 3.1.1, this data set is representative of all housing in the United States and therefore likely underestimates the background concentrations for housing with LBP. The same rationale applies to using a dripline value rather than a midyard value, but the smaller 75th percentile concentration for dripline locations was used to prevent overcorrection. The low lead concentration value (7.8 ppm), which is the 25th percentile value for one of the midyard locations in HUD (2002), was deemed a reasonable low value given that it is the smallest 25th percentile value reported in HUD (2002). The largest reported 95th percentile concentration across the locations (1,445 ppm) in HUD (2002) was selected as a reasonable estimation of the high background lead concentration in soil.

3.2 Methodology

This section describes the methodology used to estimate indoor dust and outdoor soil concentrations for the selected scenarios. As presented in Exhibit 3, either indoor dust or outdoor soil concentrations, but not both, were estimated for each of the seven selected scenarios. For scenarios associated with indoor activities, indoor dust concentrations were estimated; for scenarios associated with outdoor activities, outdoor soil concentrations were estimated. The methodology applied for estimating both indoor dust and outdoor soil concentrations is described in detail in Appendix A. This methodology is similar to the approach used in the Economic Analysis (USEPA 2006a). The primary differences between the approach used in the Economic Analysis and that used in this assessment are:

- This assessment examined the time-varying nature of exposure concentrations, from pre-activity through six years after completion of the activity. The Economic Analysis used annual average indoor dust and outdoor soil exposure concentrations to represent exposures for the entire exposure duration.

- This assessment reconsidered many of the input values used in the Economic Analysis and revised these values where appropriate and supported by available data.

Many of the inputs used in this analysis, particularly those used to estimate lead concentrations in the workspace for each activity, will be revisited in the revised exposure assessment based on the results of OPPT's dust study. This study is expected to evaluate additional control options and provide additional datasets that can be used to characterize workspace lead concentrations for a wider range of activity types.

The remainder of this section briefly describes the steps involved in estimating indoor dust and outdoor soil concentrations for the baseline and full rule implementation control scenarios. Refer to Appendix A for a more detailed description of the methodology and to Appendix B for a description of the inputs used to calculate these concentrations.

3.2.1 Indoor Dust

3.2.1.1 Baseline

For the baseline control scenarios, indoor dust concentrations were estimated by completing the following steps:

- Estimated lead loading in the workspace based on the tasks required for the scenario's activity.

- Converted lead loading to activity lead concentration using a regression model developed by ICF based on the 1997 HUD National Survey data that established house dust loading-house dust concentration relationships for unremediated housing units (refer to Appendix C for more information about this regression model). Added background indoor dust concentration to activity lead concentration to estimate total indoor dust lead concentration in the workspace.

- Estimated lead concentration in rooms adjacent to the workspace by applying a conversion factor that relates workspace dust concentrations to adjacent room concentrations (see Appendix A for more details). All adjacent rooms were assumed to have the same concentration.

- Estimated overall house Pb concentration in indoor dust by summing the area-weighted workspace, adjacent room, and remainder of house (assumed to have background only) concentrations.

- Estimated the change in overall house Pb concentration in indoor dust over time based on the estimated household cleaning frequency and cleaning efficiency. When the estimated concentration reached background concentrations, it was assumed that the indoor dust concentrations are equal to background for the remainder of the exposure period.

3.2.1.2 Full Rule Implementation

For the full rule implementation control scenarios, indoor dust concentrations were estimated using the same approach used for the baseline controls, with one exception. For the full rule implementation scenarios, lead loadings in the workspace were estimated by assuming they are equal to the EPA floor lead hazard level of 40 $\mu g/ft^2$ from initiation of the activity through its completion. This value accounts for the reduction in lead loading associated with the LRRP Rule controls.

3.2.2 Outdoor Soil

3.2.2.1 Baseline

For the baseline control scenarios, outdoor dust concentrations were estimated by completing the following steps:

- Estimated lead loading within the area surrounding the house that will be impacted by the RRP activity (i.e., within 18” of house). The 18” distance was chosen based on a University of Illinois (2002) study that found that 94 to 99.8% of lead loading from five methods of exterior lead paint removal fell between 6” and 18” of the building’s perimeter.

- Converted lead loading to lead concentration based on an assumed soil mixing depth and soil density and added background to estimate lead concentration in area surrounding house.

- Estimated overall area-weighted yard concentration of lead using estimated concentration for area of activity within 18” of house and assuming the remainder of the yard has only background concentrations. This estimated concentration was assumed to remain until the end of the exposure period (i.e., no loss processes or cleanup were estimated).

3.2.2.2 Full Rule Implementation

For the full rule implementation control scenarios, outdoor soil concentrations were estimated using the same approach used for the baseline controls, with one exception. For the full rule implementation scenarios, it was assumed that the implemented controls were 100 percent effective in controlling lead loadings to soil. Thus, for these scenarios, soil concentrations were assumed to be equivalent to background for the entire exposure period. The sensitivity analysis (described in Section 3.4) assessed the impact of this assumption.

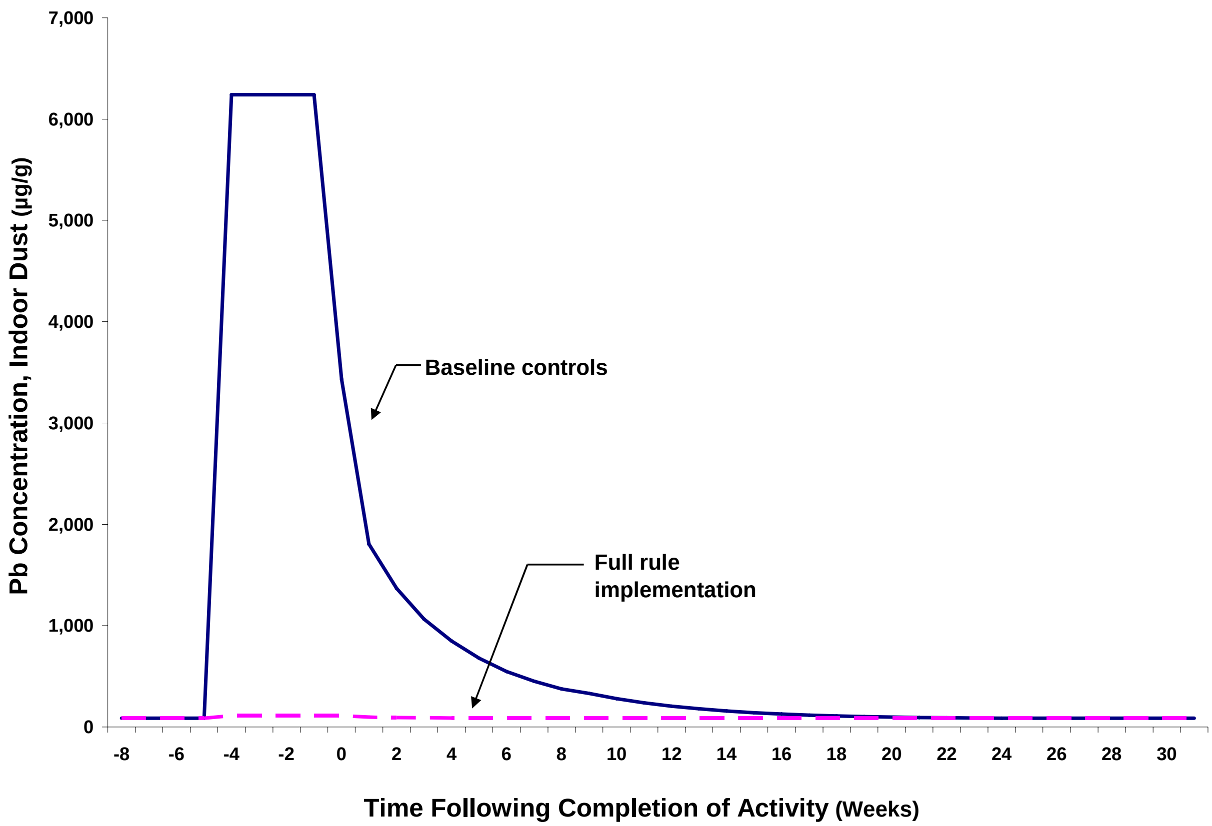
3.3 Estimated Media Concentrations

This section presents the estimated indoor dust or outdoor soil concentrations (depending on the scenario) for the baseline and full rule implementation control options. For each scenario, the estimated concentrations fall into the four phases described in Section 1.4: pre-activity, activity, post-activity (cleanup), and post-activity (background). The concentrations for these phases are presented in time-series graphs below. In these graphs, negative times on the X-axis refer to times prior to completion of the activity (i.e., the pre-activity and activity phases). In each graph, 2 to 4 weeks of pre-activity is assumed for presentation purposes; in actual duration of this period will depend on the assumed starting time for the activity in the blood lead modeling.

Remodeling Kitchen

The estimated indoor dust concentrations for the "Remodeling Kitchen" scenario are presented in Exhibit 4. For baseline controls, the estimated indoor dust concentration during the activity is 6,242 µg/g. After completion of the activity, this concentration returns to background within approximately 25 weeks. For full rule implementation, the estimated indoor dust concentration during the activity is 112 µg/g. After completion of the activity, this concentration returns to background within five weeks.

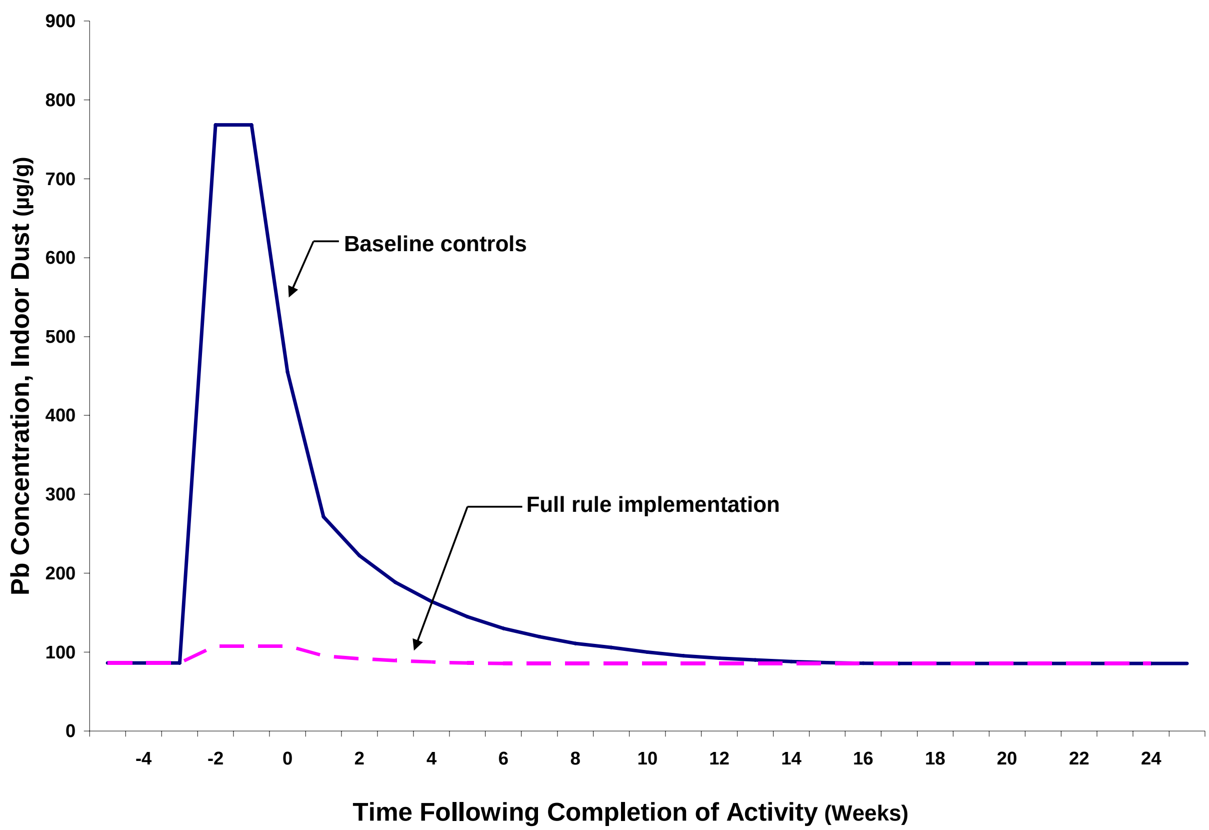
Exhibit 4. Indoor Dust Concentrations for "Remodeling Kitchen": Baseline and Full Rule Implementation Controls



3.3.1 Three Cutouts

The estimated indoor dust concentrations for the "Three Cutouts" scenario are presented in Exhibit 5. For baseline controls, the estimated indoor dust concentration during the activity is 768 µg/g. After completion of the activity, this concentration returns to background within approximately 16 weeks. For full rule implementation, the estimated indoor dust concentration during the activity is 108 µg/g. After completion of the activity, this concentration returns to background within approximately five weeks.

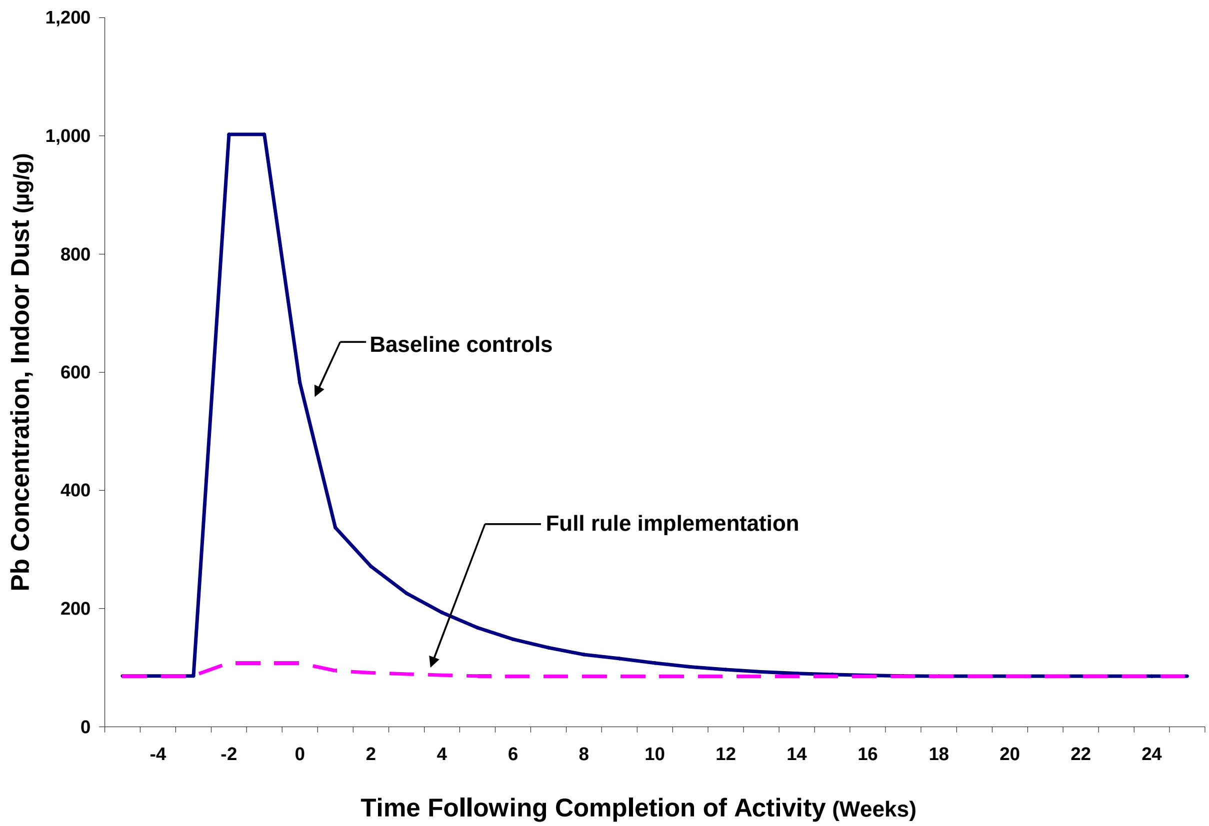
Exhibit 5. Indoor Dust Concentrations for "Three Cutouts": Baseline and Full Rule Implementation Controls



3.3.2 Replacing Windows

The estimated indoor dust concentrations for the "Replacing Windows" scenario are presented in Exhibit 6. For baseline controls, the estimated indoor dust concentration during the activity is 1,003 µg/g. After completion of the activity, this concentration returns to background within approximately 17 weeks. For full rule implementation, the estimated indoor dust concentration during the activity is 108 µg/g. After completion of the activity, this concentration returns to background within approximately five weeks.

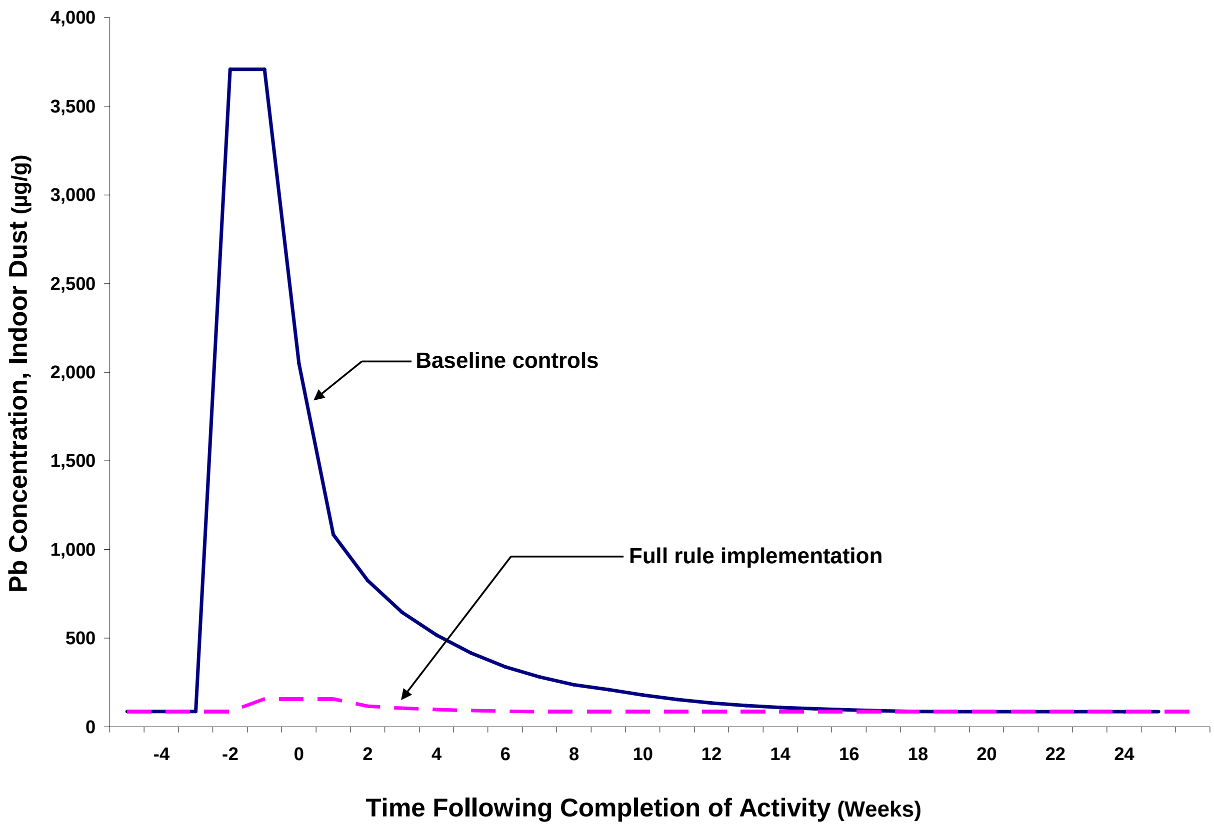
Exhibit 6. Indoor Dust Concentrations for "Replacing Windows": Baseline and Full Rule Implementation Controls



3.3.3 Replacing Exterior Doors

The estimated indoor dust concentrations for the "Replacing Exterior Doors" scenario are presented in Exhibit 7. For baseline controls, the estimated indoor dust concentration during the activity is 3,709 µg/g. After completion of the activity, this concentration returns to background within approximately 19 weeks. For full rule implementation, the estimated indoor dust concentration during the activity is 157 µg/g. After completion of the activity, this concentration returns to background within approximately six weeks.

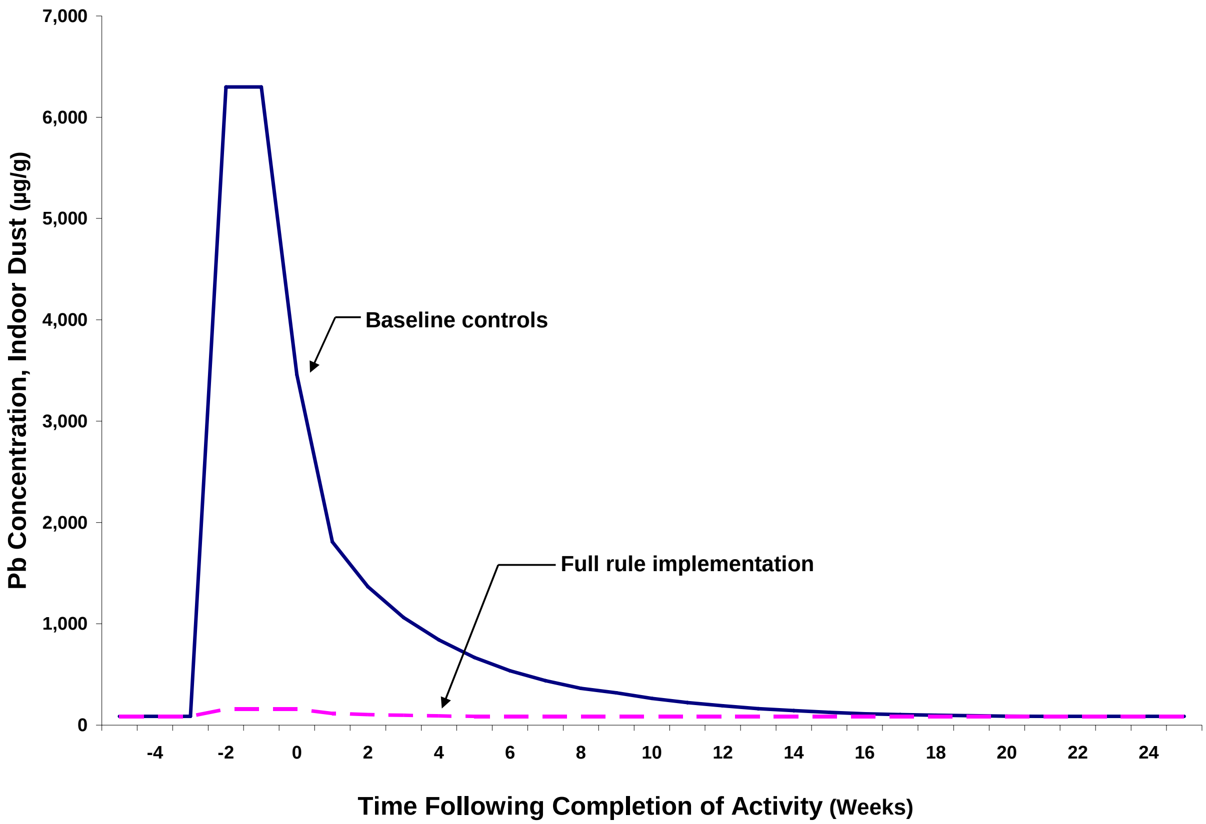
Exhibit 7. Indoor Dust Concentrations for "Replacing Exterior Doors": Baseline and Full Rule Implementation Controls



3.3.4 Scraping Lead-Based Paint, Interior Flat Component

The estimated indoor dust concentrations for the "Scraping Lead-Based Paint, Interior Flat Component" scenario are presented in Exhibit 8. For baseline controls, the estimated indoor dust concentration during the activity is 6,299 µg/g. After completion of the activity, this concentration returns to background within approximately 21 weeks. For full rule implementation, the estimated indoor dust concentration during the activity is 157 µg/g. After completion of the activity, this concentration returns to background within approximately six weeks.

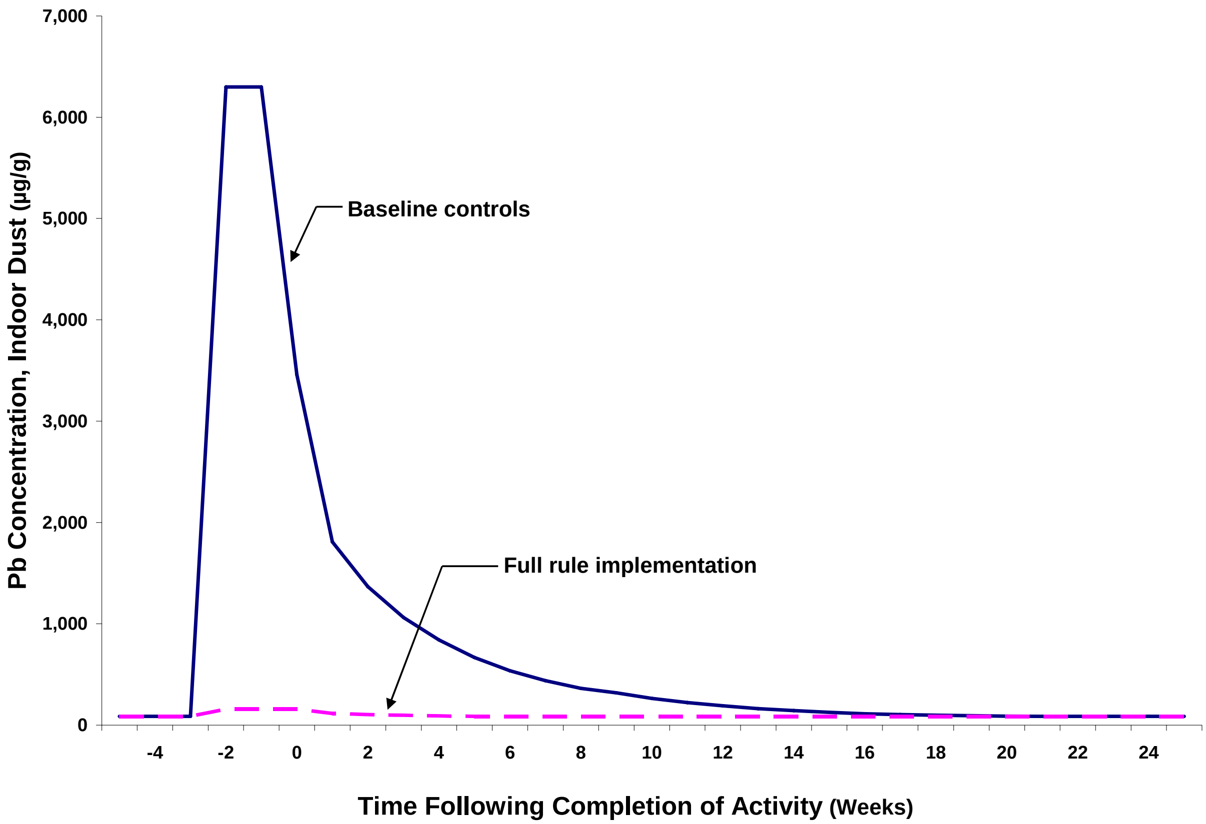
Exhibit 8. Indoor Dust Concentrations for "Scraping Lead-Based Paint, Interior Flat Component": Baseline and Full Rule Implementation Controls



3.3.5 Scraping Lead-Based Paint, Interior Door

The estimated indoor dust concentrations for the "Scraping Lead-Based Paint, Interior Door" scenario are presented in Exhibit 9. For baseline controls, the estimated indoor dust concentration during the activity is 6,299 µg/g. After completion of the activity, this concentration returns to background within approximately 21 weeks. For full rule implementation, the estimated indoor dust concentration during the activity is 157 µg/g. After completion of the activity, this concentration returns to background within approximately six weeks.

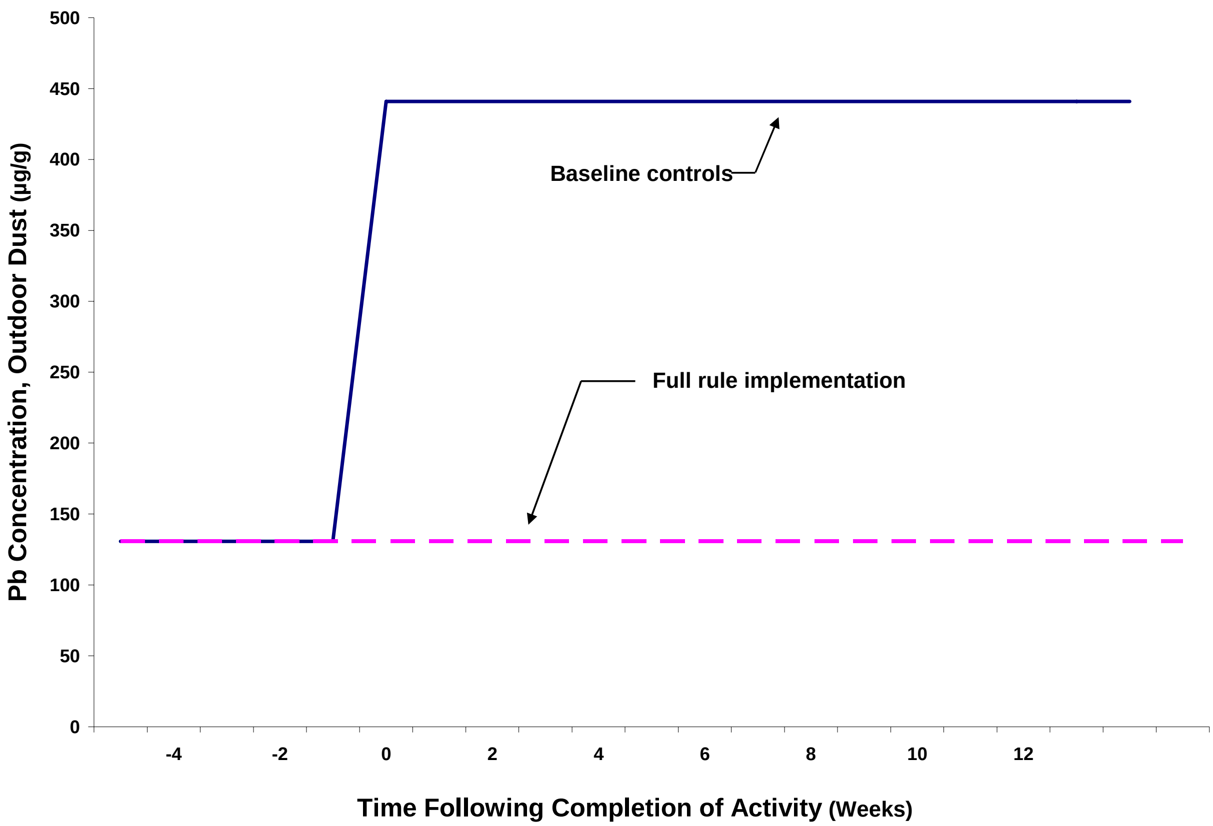
Exhibit 9. Indoor Dust Concentrations for "Scraping Lead-Based Paint, Interior Door": Baseline and Full Rule Implementation Controls



3.3.6 Exterior Lead-Based Paint Removal

The estimated outdoor soil concentrations for the “Exterior Lead-Based Paint Removal” scenario are presented in Exhibit 10. For baseline controls, the estimated outdoor soil concentration during the activity is 441 µg/g. For full rule implementation, the estimated outdoor soil concentration during the activity is 131 µg/g (i.e., background). These concentrations do not change after completion of the activity because it was assumed there was no cleanup or degradation over time.

Exhibit 10. Outdoor Soil Concentrations for “Exterior Lead-Based Paint Removal”: Baseline and Full Rule Implementation Controls



3.3.7 Summary of Results

With baseline controls, the “Scraping Lead-Based Paint, Interior Flat Component” and “Scraping Lead-Based Paint, Interior Door” activities were associated with the highest indoor dust concentrations during the activity. The concentrations for both of these activities returned to background within approximately 21 weeks, which was four weeks sooner than the “Remodeling Kitchen” activity, which had the next highest indoor dust concentration during the activity. The overall lead loading in the workspace for the “Remodeling Kitchen” activity was much higher (more than double) than any other activity, but due to the smaller assumed workspace and adjacent room sizes, the overall average house concentrations were lower than the “Scraping Lead-Based Paint” activities during the activity. By the third week, the overall average house concentrations for the "Remodeling Kitchen" activity are the highest among all activities. The "Three Cutouts" and "Replacing Windows" activities were associated with the lowest activity indoor dust concentrations, a result primarily of their lower relative lead loadings. The "Replacing Exterior Doors" activity was associated with substantially higher (roughly four times higher) activity concentrations than the "Three Cutouts" and "Replacing Windows" activities, but lower concentrations (roughly half) than the other three activities. As expected, the full rule implementation indoor dust concentrations did not vary much across activities, which is largely a result of the assumption that all workspaces, regardless of activity, will achieve dust loadings of 40 $\mu g/ft^2$ post-activity. The only differences in the estimated indoor dust concentrations across activities are driven by the different assumptions about the size of the workspace and adjacent rooms.

For outdoor soil, only one activity type was considered. The estimated soil concentrations for baseline controls were over three times higher than the estimated concentration with full rule implementation. This difference is a direct result of the assumption that the implemented controls will be 100 percent effective, leaving only background soil concentrations for the full rule implementation.

3.4 Sensitivity Analysis

3.4.1 Approach

Given the number of inputs involved in calculating indoor dust and soil concentrations for the selected scenarios, as well as the significant uncertainty associated with many of these inputs, a sensitivity analysis was performed to evaluate the sensitivity of these calculations to changes in inputs within a reasonable range. For each input included in the analysis, this range was represented by a "low" and a "high" value (see Appendix B). These values were not intended to capture the full range of theoretically possible values; instead, they were selected to represent a range of values that can be reasonably expected to occur in the types of buildings included in this assessment. The results of this analysis should not be interpreted as the range of possible exposure concentrations; instead, they indicate the sensitivity of the exposure concentration calculations to reasonable changes in these inputs. This analysis will be important in determining where to focus additional analysis for the revised exposure assessment.

For this analysis, each selected input was changed to its "low" value, and the resulting exposure concentrations recalculated. Next, the input was changed to its "high" value, and the resulting exposure concentrations again recalculated. This process was repeated for all selected inputs. In addition, for the inputs involved in calculating routine cleaning efficiencies, this analysis examined the impact of varying several of these inputs simultaneously to better capture the overall range of impacts associated with different routine cleaning assumptions. The results of this analysis are presented in Appendix D, and discussed in the following sections.

3.4.2 Results

Given the number of inputs considered, the presentation of these results is separated into a series of tables. In each table, the "Default" column refers to the results calculated using all of the values in Appendix B in the "Default" column. These results represent the "best guess" results for this analysis. The results in the “Low” and “High” columns represent the results when a particular input was changed from the “Default” value to the “Low” or “High” value.

3.4.2.1 Indoor dust

The first six tables in Appendix D contain the sensitivity results for scenario for the following parameters:

- Background concentration;
- Conversion from workspace to adjacent room;
- Post-activity cleanup efficiency;
- Percent house workspace;
- Percent house adjacent room; and
- Lead loading.

Each of these tables presents the sensitivity results for a specific input parameter, with each row of the tables presenting the results for one of the six scenarios. The following inputs had the widest associated ranges of indoor dust concentrations for baseline controls:

- Percent house workspace;
- Lead loading;
- Post-activity cleanup efficiency.

For the full rule implementation scenario, only one input, “Background soil concentration,” had a significant range. This was expected, as the lead loadings associated with this control scenario are fairly limited and thus the selected background concentration has a significant impact on the estimated exposure concentrations. Three of these inputs, “Post-activity Cleanup Efficiency,” Percent House Adjacent Room,” and “Lead Loading,” did not have any differences between the default and sensitivity simulations. In all three cases, this was a result of the methodology used to estimate activity concentrations for the full rule implementation controls, which assumed a constant loading based on the lead hazard level instead of using data on actual levels. These inputs should be reexamined in the revised exposure assessment if data on post-activity concentrations are available for this control type.

Of the inputs with significant ranges for baseline scenarios, “Percent House Workspace” for the “Remodeling Kitchen” scenario had the widest range of estimated indoor dust concentrations, primarily because the default value for this scenario was lower than for the other scenarios and this scenario had the highest loading, which resulted in higher overall concentrations when the size of the workspace was increased. This was also the case for the “Scraping LBP, Interior Flat Component” and “Scraping LBP, Interior Door” scenarios for this input, but to a lesser extent due to the slightly smaller range of input values and the lower lead loading associated with the activities. The “Lead Loading” input was associated with a wide range of concentrations for all six scenarios. This is expected, as this is the input that provides lead loadings to the workspace based on the activity. Likewise, “Post-activity Cleanup Efficiency” had a wide range of concentrations across all activities, which was expected based on the fact that this input is inversely proportional to estimated concentrations.

To analyze the overall impact of routine cleaning on exposures to lead in indoor dust, values for the weekly cleaning frequency and routine cleaning efficiency parameters were varied simultaneously, with one set of exposure estimates for each unique combination of input values (with the possible values including the "low," "high," and "default" values presented in Appendix B). The results of these analyses are presented in Exhibit D-7. These calculations were only performed for a single activity type, "Remodeling Kitchen," to limit the required analysis. It is expected that the results for other activity types will be consistent with these results. A summary of the time required for the estimated indoor dust concentrations to reach background is provided in Exhibit 11. Given the importance of exposure duration in estimating overall risks, changes in this time are very important to understanding the overall impact of an input value on estimated risks. As illustrated in this exhibit, there is a wide range of times associated with the different cleaning frequencies and efficiencies, for both the baseline (from 6 to 112 weeks) and full rule implementation controls (from 1 to 32 weeks).

Exhibit 11. Summary of Sensitivities to Routine Cleaning Input Parameters

Routine Cleaning Frequency	Routine Cleaning Efficiency	Time Before Background Concentration is Reached (weeks)	
		Baseline Controls	Full Rule Implementation
Default	Default	25	5
Default	Min	29	8
Default	Max	11	2
Min	Default	100	20
Min	Min	116	32
Min	Max	44	8
Max	Default	13	3
Max	Min	15	4
Max	Max	6	1

3.4.2.2 Outdoor soil

Exhibit D-11 provides the sensitivity results for the "Exterior Paint Removal" scenario for the following parameters:

- Area within 18 inches of perimeter of home;
- Background soil concentration;
- Efficiency of control;
- Lead loading;
- Percent of house perimeter involved in project;
- Soil density;
- Soil depth; and
- Yard size.

The following inputs had the widest associated ranges of outdoor soil concentrations:

- Background soil concentration;
- Lead loading;
- Percent of house perimeter involved in activity; and
- Soil depth.

For the full rule implementation scenario, only "Background soil concentration" had a significant range. This was expected as the lead loadings associated with this control scenario are zero (due to the assumption of 100 percent control efficiency) and thus the selected background concentration drives the estimated exposure concentrations. The "Efficiency of Control" had a small impact, but it was limited by the small range of efficiencies considered. None of the remaining inputs had any impact, due to the assumption of 100 percent control efficiency in the default scenario.

For the baseline control scenarios, the widest range of estimated exposure concentrations was associated with the "Background soil concentration." This input was significant because the range of values for this input was fairly wide. The "Lead Loading" and "Percent of house perimeter involved in activity" were influential because they contribute directly to the amount of lead entering the soil from the activity. "Soil Depth" was somewhat influential due to its use in converting lead loading into lead concentration.

3.4.3 Conclusions

Given the results of this analysis, it is clear that the uncertainty and variability associated with several of the input parameters has a significant impact on the estimated indoor dust exposure concentrations. The values selected for the "Percent House Workspace" and "Lead Loading" parameters are highly uncertain and, given the sensitivity of the calculations to this input, this clearly has an impact on the results. Additional data may be available from OPPT's dust study to refine the loading estimates, but additional data sources would be useful in understanding the size of workspaces for different types of activities. In addition, all of the values for the cleaning-related inputs, particularly those associated with routine cleaning, are highly uncertain and have a substantial impact on the results.

With the exception of "Background Soil Concentration," the inputs used in calculating outdoor soil concentrations have a relatively smaller impact on estimated exposure concentrations.

3.4.4 Considerations for Revised Exposure Assessment

Although the sensitivity analysis approach used in this draft exposure assessment is useful for understanding which inputs have the potential to be most influential, it is limited by the range of input values considered and by the overall methodology. The approach applied for the draft exposure assessment did not separately consider the relative impact of each input on estimated exposure concentrations, independent of the range of possible values. It also potentially places too much emphasis on the selected range of values, which have significant uncertainty.

In light of these limitations, the revised exposure assessment will consider revising the distributions of inputs and implementing a more sophisticated sensitivity analysis approach. Specifically, two additional measures of sensitivity, the elasticity and the sensitivity score, will be considered for the revised exposure assessment. Elasticity indicates "structural" sensitivity, while sensitivity score indicates "actual" sensitivity after accounting for the estimated variability in an input property. The elasticity provides information useful for understanding how the model operates and is used to compare with expected results, given knowledge of the model and the processes being simulated. The sensitivity score is useful in the context of assessing the influence of input properties, or how the variability of the input property affects the variability of the results.

Elasticity is the percent change in a model output value resulting from a one percent change in the value of a particular property, with all other properties unchanged. A positive value of elasticity results from an increase in an input value giving an increased output value, or a decrease in an input value giving a decreased output value. A negative value of elasticity means that an input increase resulted in an output decrease, or vice-versa.

The sensitivity score is the elasticity weighted by a normalized measure of the variability and/or uncertainty of the model input property, which takes the form of a normalized range or normalized standard deviation of the input property. It provides a measure of the variation in the output value resulting from the natural variability and uncertainty of the input property by weighting the elasticity by the coefficient of variation (CV) of the input property. The CVs quantify the degree of natural variability of the input property and the uncertainty of the estimate of the input property. It is equal to the standard deviation divided by the mean of the property, where the standard deviation reflects both variability and uncertainty.

4. Exposures to Other Sources

As discussed in Section 1.3, exposures via sources other than indoor dust and outdoor soil were characterized in this assessment. Three sources were identified as relevant for this assessment: drinking water, non-water diet, and air. For purposes of this assessment, ingestion exposures associated with these sources were assumed not to be related to soil or indoor dust Pb concentrations, and all of the exposed children are assumed to receive the same age-specific background exposures.

All of the exposed populations (i.e., children under six years of age) are assumed to consume drinking water with the same "typical" Pb exposure concentration. While there is a rather large amount of data in the literature, in many cases, the data are from "first-draw" samples, non-random ("priority") samples, or from communities where Pb levels were known to be elevated. After reviewing the literature, the average drinking water concentration exposure was estimated to be 4.61 µg/L, based on data from two recent studies of residential water concentrations in U.S. and Canadian homes and apartments (Moir et al. 1996, Clayton et al. 1999). The range of values seen in these studies (0.84 to 16 µg/L) was considered to be representative of randomly sampled residential water in houses constructed since Pb pipe and solder were banned for residential use. The selected value is close to the "default" value (4.0 µg/L) recommended for use with the IEUBK model when evaluating the blood Pb impacts of soil contamination (USEPA 1994). Much higher values have been encountered in homes with Pb piping and/or very corrosive water.

In addition to drinking water, it is expected that young children will be exposed to Pb in the foods they consume. In this assessment, all exposed children are assumed to receive the age-specific estimates of dietary Pb intake developed by EPA's Office of Solid Waste and Emergency Response (USEPA 2006b). EPA developed these estimates by analyzing food consumption data from the NHANES III survey conducted by the National Center for Health Statistics, and food residue data from the U.S. Food and Drug Administration's (FDA) Total Dietary Study. The daily intake values shown in Exhibit 11 are considerably lower than those developed using the same methodology in the 1980s and 1990s. Pb concentrations in food have decreased dramatically since the prohibition of Pb solder in food containers in 1982.

Exhibit 11. Summary of Non-Water Dietary Pb Intake Estimates

Age Category (months)	Updated Dietary Pb Intake Estimate (µg/day)
0-11	3.16
12-23	2.6
24-35	2.87
36-47	2.74
48-59	2.61
60-71	2.74
72-84	2.99

There is some potential for double-counting of water and dietary Pb intake because some food categories (e.g., baby formula, soup) are prepared using domestic water. This double-counting is minimized by limiting the estimated intake of domestic water to "direct ingestion" (i.e., consumption direct from the tap).

Background inhalation exposures were also considered in this assessment. As discussed in Chapter 1, sufficient data were not available to characterize inhalation exposures associated with different RRP activities and therefore these exposures were not characterized separately for each activity. Instead, a "typical" ambient air concentration of Pb in the U.S was estimated based on a review of the 2005 annual average total suspended particulate (TSP) monitoring data for Pb contained in EPA's Air Quality Systems (AQS) database (USEPA 2006c). The range of concentrations in this database is quite large, with a 5^{th} percentile concentration of 0.002 $\mu g/m^3$ and a 95^{th} percentile concentration of 0.37 $\mu g/m^3$. Based on these data, the median concentration (0.025 $\mu g/m^3$) was selected as the inhalation exposure concentration. This value is likely biased high because lead monitors are often located in areas with nearby lead emission sources. If the blood lead modeling indicates that inhalation exposures are significant contributors to overall blood lead levels, this value may need to be reconsidered.

5. References

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Appendix A. Methodology for Calculating Indoor Dust and Outdoor Soil Concentrations

Appendix A describes the calculations used to estimate Pb concentrations prior to, during, and after each activity for each control option, as described in Section 1.4. Sections A.1, A.2, A.3, A.4, and A.5, respectively, identify the calculations and assumptions associated with pre-activity concentrations (background), concentrations during activity, post-activity concentrations (initial cleanup), post-activity concentrations (routine cleanup), and post-activity concentrations (background).

A.1 PRE-ACTIVITY BACKGROUND PB CONCENTRATIONS

A.1.1 Indoor Dust

As described in Section 3.1.1, background indoor dust levels were derived from the literature in terms of lead loading (µg/ft^2). In order to calculate background indoor dust concentrations, these loadings were converted to concentrations using the regression equation described in Appendix C, which is summarized below.

Regression Equation: $$DCONC_{BG} = e^{(4.028687+0.608317(\ln(DLOAD_{BG})))} \quad \textbf{(Eq. 1)}$$

where:
- $DCONC_{BG}$ = background indoor dust concentration, in µg/g
- $DLOAD_{BG}$ = background indoor dust loading, in µg/ft^2

This concentration was assumed to represent indoor dust concentrations for the period prior to initiation of the activity.

A.1.2 Outdoor Soil

The selected values for background outdoor soil lead concentrations, described in Section 3.1.2, are in terms of concentration and thus did not require any additional calculations. The selected concentration was assumed to represent outdoor soil concentrations for the period prior to initiation of the activity.

A.2 PB CONCENTRATIONS DURING ACTIVITY

A.2.1 Indoor Dust – Baseline Controls

As presented in Exhibit 3, there are seven RRP activities included in this draft exposure assessment. Six of these activities are assumed to contribute to indoor dust Pb concentrations. These concentrations are estimated based on the lead loading associated with the activity, the size of the house and workspace, and the background concentration. For this draft exposure assessment, indoor dust concentrations are calculated as whole house averages and therefore need to account for not only dust concentrations in the workspace, but also in adjacent rooms and in the rest of the house. Concentrations in the workspace are calculated based on the activity, concentrations in adjacent rooms are calculated as a percentage (16 percent, see Appendix B for further explanation) of the concentrations in the workspace, and concentrations in the remainder of the house are assumed to be at background (see Section A.1.1). The total area-weighted Pb concentration in indoor dust for a housing unit is calculated as:

$$DCONC_{H,BL,A} = (PAW)*(DCONC_{Work}) + (PAA)*(DCONC_{Adj}) + (PAR)*(DCONC_{BG}) \quad \textbf{(Eq. 2)}$$

or

$$DCONC_{H,BL,A} = (PAW)*(DCONC_{Work})+(PAA)*(WS\text{-}to\text{-}ADJ)*(DCONC_{Work})+(1\text{-}PAW\text{-}PAA)*(DCONC_{BG}) \quad \textbf{(Eq. 3)}$$

where:

$DCONC_{H,BL,A}$	=	Average indoor dust Pb concentration in housing unit with baseline controls during the activity, in µg/g
PAW	=	Percent area workspace (see Exhibit B-3)
$DCONC_{Work}$	=	Indoor dust Pb concentration in the workspace, in µg/g (see below)
PAA	=	Percent area adjacent room (see Exhibit B-3)
$DCONC_{Adj}$	=	Indoor dust Pb concentration in the adjacent room, in µg/g (calculated as WS-to-ADJ * $CONC_{Work}$)
PAR	=	Percent area rest of house (calculated as 1-PAW-PAA)
$DCONC_{BG}$	=	Background indoor dust Pb concentration, in µg/g (see Section A.1.1)
WS-to-ADJ	=	Conversion from workspace lead concentration to adjacent room lead concentration (see Exhibit B-2)

The only input whose values are not provided in Appendix B or calculated as described above is $DCONC_{Work}$. The values for this input are a function of the types of work the activity involves, the amount of loading each type of work produces, and the number of times which a specific task is performed. $DCONC_{Work}$ is calculated as:

$$DCONC_{Work} = e^{(4.0425+0.5848(\ln(DLOAD_{Work})))} \quad \textbf{(Eq. 4)}$$

where:

$DLOAD_{Work}$	=	$\sum(NUM_i * DLOAD_i)$
NUM_i	=	Number of times task *i* is performed for this activity
$DLOAD_i$	=	Lead loading associated with one instance of task *i*, in µg/ft^2 (see Exhibit B-1)

Exhibit A-1 provides the types and number of tasks each activity involves.

Exhibit A-1. Tasks Associated with Each Type of Activity

Activity	Number of times tasks performed					
	Component Removal	Demolition	Door removal	Drilling	Paint removal	Sawing
Remodeling Kitchen	10	4	1	9	12	8
Scraping LBP, Interior Flat Component					4	
Scraping LBP, Interior Door					4	
Three Cutouts						1
Replacing Windows		1			1	
Replacing Exterior Doors			1		1	

Source: ICF estimates, based on data provided in U.S. Census Bureau 1995, 1997, and 2003

A.2.2 Indoor Dust – Full Rule Implementation

Indoor dust concentrations with full rule implementation are calculated in much the same way as those with baseline controls. There are two primary differences, however. First, instead of defining $DCONC_{Work}$ as a function of the activity, it is defined as a constant loading that is independent of the activity. This loading is set to EPA's floor Pb hazard threshold of 40 µg/ft^2 to account for the reduction in Pb loading associated with the LRRP controls. Second, it is assumed that Pb loading is fully contained within the workspace. Therefore, the post-activity Pb concentration in any adjacent room ($DCONC_{ADJ}$) is assumed to be equivalent to the pre-activity background concentration ($DCONC_{BG}$). The total area weighted indoor dust Pb concentration within a housing unit for full rule implementation is calculated as follows:

$$DCONC_{H,FR,A} = (PAW)*(DCONC_{Floor}) + (PAA)*(DCONC_{BG}) + (PAR)*(DCONC_{BG}) \quad \textbf{(Eq. 5)}$$

where: $$DCONC_{Floor} = e^{(4.028687+0.608317(\ln(DLOAD_{Floor})))} \quad \textbf{(Eq. 6)}$$

$DCONC_{H,FR,A}$	=	Average indoor dust Pb concentration in housing unit with full rule implementation during the activity, in µg/g
$DLOAD_{Floor}$	=	Lead loading in the workspace with full rule implementation, based on EPA floor hazard threshold (40 µg/ft^2)
$DCONC_{Floor}$	=	Indoor dust Pb concentration in the workspace based on EPA floor Pb hazard threshold, in µg/g (see below)
PAW	=	Percent area workspace (see Exhibit B-3)
PAA	=	Percent area adjacent room (see Exhibit B-3)
PAR	=	Percent area rest of house (calculated as 1-PAW-PAA)

$DCONC_{BG}$	=	Background indoor dust Pb concentration, in µg/g (see Section A.1.1)

A.2.3 Outdoor Soil – Baseline Controls

Only one of the seven RRP activities presented in Exhibit 3 is assumed to contribute to outdoor soil concentrations, "Exterior Lead-Based Paint Removal." Average lead concentrations in soil across the yard for this activity were calculated using the following equation:

$$SCONC_{Y,S,A} = (1 - PercImpact_{Yard}) * SCONC_{BG} + PercImpact_{Yard} * (SCONC_{Act} + SCONC_{BG}) \quad \textbf{(Eq. 7)}$$

where:			
	$SCONC_{Y,S,A}$	=	Average outdoor soil concentration in yard for baseline controls during the activity, µg/g
	$PercImpact_{Yard}$	=	Percent of yard impacted by activity
	$SCONC_{BG}$	=	Background outdoor soil Pb concentration, in µg/g (see Section A.1.2)
	$SCONC_{Act}$	=	Outdoor soil concentration in area surrounding house that is impacted by activity, in µg/g

The area of impact of this activity is assumed to be the dripline, which is assumed to extend 18 inches from the house (see Section 3.2.2.1). $PercImpact_{Yard}$ is calculated based on the following equation:

$$PercImpact_{Yard} = (AreaInDripline * PercHouseImpact) / YardSize \quad \textbf{(Eq. 8)}$$

where:			
	AreaInDripline	=	Area surrounding the house that falls within the dripline (assumed to be 18"), in m^2
	PercHouseImpact	=	Percent of the house impacted by the activity (see Exhibit B-4)
	YardSize	=	size of yard, in m^2

$SCONC_{Act}$ is calculated based on the estimated loading from the activity, the size of the yard, the percentage of the yard impacted by the activity, soil characteristics, and the efficiency of the controls. These concentrations were estimated using the following equation:

$$SCONC_{Act} = \frac{SLOAD_{Act} * 0.001 \frac{ft^2}{cm^2}}{SoilDepth * SoilDensity} * 1{,}000 \frac{\mu g}{mg} * ControlEfficiency \quad \textbf{(Eq. 9)}$$

where:			
	$SLOAD_{Act}$	=	Lead loading associated with activity, mg/ft^2 (see Exhibit B-4)
	SoilDepth	=	Soil mixing depth, in cm (see Exhibit B-4)
	SoilDensity	=	Density of soil, in g/cm^3 (see Exhibit B-4)
	ControlEfficiency	=	Efficiency of control (see Exhibit B-4)

A.2.4 Outdoor Soil – Full Rule Implementation

Outdoor soil concentrations with full rule implementation are calculated in the same way as the baseline control concentrations. The only differences in concentrations are a result of different control efficiency assumptions.

A.3 LEAD CONCENTRATIONS POST-ACTIVITY (INITIAL CLEANUP)

There are no differences in how baseline and full rule implementation concentrations are calculated for the post-activity (initial cleanup) period. The only differences in the estimated concentrations result from differences in input values.

A.3.1 Indoor Dust

Lead concentrations in indoor dust immediately after the post-activity initial cleanup are calculated using the following equation:

$$DCONC_{H,PA,0} = DCONC_{H,A} * PostActCleanEfficiency \quad \textbf{(Eq. 10)}$$

where:

$DCONC_{H,PA,0}$	=	Average indoor dust Pb concentration in housing unit immediately following the post-activity initial cleanup, in µg/g
$DCONC_{H,A}$	=	Average indoor dust Pb concentration in housing unit during the activity, in µg/g
PostActCleanEfficiency	=	Post-activity cleanup efficiency (see Exhibit B-1)

A.3.2 Outdoor Soil

It is assumed that there is no cleanup or degradation of Pb in outdoor soil; therefore, the post-activity (initial cleanup) concentrations are identical to the activity concentrations.

A.4 LEAD CONCENTRATIONS POST-ACTIVITY (ROUTINE CLEANUP)

A.4.1 Indoor Dust

Lead concentrations in indoor dust following the post-activity initial cleanup are a function of the frequency and efficiency of routine cleaning. After each cleaning, the lead concentration in indoor dust is estimated using the following equation:

$$DCONC_{H,RC,T} = DCONC_{H,RC,T-1} * RoutineCleanEfficiency \quad \textbf{(Eq. 11)}$$

where:

$DCONC_{H,RC,X}$	=	Average indoor dust Pb concentration in housing unit after cleaning X after completion of activity, in µg/g

$DCONC_{H,RC,X-1}$	=	Average indoor dust Pb concentration in housing unit after cleaning (X-1) after completion of activity, in µg/g
$RoutineCleanEfficiency_X$	=	Post-activity cleanup efficiency for the X^{th} cleaning (see Exhibit B-1)

$RoutineCleanEfficiency_X$ is assumed to change with each subsequent cleaning through the 10^{th} cleaning (after the 10^{th}, it is assumed to remain constant), as described in Exhibit B-1. To estimate the indoor dust concentration at any single time, the time (in weeks) is multiplied by the weekly cleaning frequency to calculate the number of cleanings that have occurred to that point. Based on the number of cleanings, the indoor dust concentration is calculated based on Equation 11. It is assumed that indoor dust concentrations do not change between cleanings.

A.4.2 Outdoor Soil

It is assumed that there is no cleanup or degradation of Pb in outdoor soil; therefore, the post-activity (routine cleanup) concentrations are identical to the activity concentrations.

A.5 LEAD CONCENTRATIONS POST-ACTIVITY (BACKGROUND)

A.5.1 Indoor Dust

Post-activity Pb concentrations will gradually decrease until they have reached the background concentrations which existed prior to initiation of the activity. These values are calculated by applying the post-activity initial and routine cleanup efficiencies over time. Background concentrations in indoor dust are calculated as described in Section A.1.1.

A.5.2 Outdoor Soil

It is assumed that there is no cleanup or degradation of Pb in outdoor soil; therefore, the post-activity (background) concentrations are identical to the activity concentrations.

Appendix B. Inputs Used for Estimating Media Concentrations for Baseline and Full Rule Implementation Control Scenarios

This appendix presents the input parameter values used in this assessment. Appendix A describes how each of these parameters is used. This appendix presents the input values in five tables. The first table, Exhibit B-1, presents all of the input values used to calculate indoor dust exposures that are not specific to a particular activity or control type. Exhibit B-2 presents all of the input values used to calculate indoor dust exposures that are specific to the control type and independent of activity type. Exhibit B-3 presents that input values used to calculate indoor dust exposures that are specific to activity type and independent of control type. There are no input parameters that are specific to both the activity type and control type. Exhibit B-4 presents all of the input values used to calculate outdoor soil exposures that are not specific to a particular control type, and Exhibit B-5 presents all of the input values used to calculate outdoor soil exposures that are specific to a particular control type. Only one activity type was estimated to contribute to outdoor soil exposures and thus there were no activity type-specific input values.

Exhibit B-1. Inputs for Indoor Dust Exposure Concentration Calculations – All Control Options and Activity Types

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
Background indoor dust concentration	86	31	2,522	µg/g	✓	HUD 2002	See Section 3.1.1
Cleaning frequency	1	0.25	2	cleanings/ week	✓	HUD 2002	These values are estimated based on the following inferences from the HUD 2002 data: 57% of homes are cleaned at least weekly, 25% of homes are cleaned at least once every two weeks, 10% of homes are cleaned every 3 weeks, 3% of homes are cleaned at least once per month, and 5% of homes are cleaned less than once per month. These inferences were used to estimate that the high number of cleanings is twice per week, the default number of cleanings is once per week, and the low number of cleanings is once every four weeks.

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
Loading - Component removal	549	549	592	$\mu g/ft^2$		USEPA 1997	The maximum air concentration for one unit or hour (139 µg/m3, USEPA 1997) was divided by the average concentration for one unit or hour (129 µg/m3, USEPA 1997) to get 1.08. This was multiplied by the default loading value (549 µg/ft2, USEPA 1997) to get a high value of 592 µg/ft2. No low-end air concentrations were provided, so the default loading factor was used.
Loading - Demolition	1,505	1,505	5,570	$\mu g/ft^2$		USEPA 1997	The maximum air concentration for one unit or hour (396 µg/m3, USEPA 1997) was divided by the average concentration for one unit or hour (107 µg/m3, USEPA 1997) to get 3.70. This was multiplied by the default loading value (1,505 µg/ft2, USEPA 1997) to get a high value of 5,570 µg/ft2. No low-end air concentrations were provided, so the default loading factor was used.
Loading – Door removal	5,912	5,912	44,856	$\mu g/ft^2$		USEPA 1997	The maximum air concentration for one unit or hour (3,953 µg/m3, USEPA 1997) was divided by the average concentration for one unit or hour (521 µg/m3, USEPA 1997) to get 7.59. This was multiplied by the default loading value (5,912 µg/ft2, USEPA 1997) to get a high value of 44,856 µg/ft2. No low-end air concentrations were provided, so the default loading factor was used.

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
Loading - Drilling	112	112	1,945	$\mu g/ft^2$		USEPA 1997	The maximum air concentration for one unit or hour (191 µg/m3, USEPA 1997) was divided by the average concentration for one unit or hour (11 µg/m3, USEPA 1997) to get 17.36. This was multiplied by the default loading value (112 µg/ft2, USEPA 1997) to get a high value of 1,945 µg/ft2. No low-end air concentrations were provided, so the default loading factor was used.
Loading - Paint removal	9,118	9,118	50,547	$\mu g/ft^2$		USEPA 1997	The maximum air concentration for one unit or hour (3,110 µg/m3, USEPA 1997) was divided by the average concentration for one unit or hour (561 µg/m3, USEPA 1997) to get 5.54. This was multiplied by the default loading value (9,118 µg/ft2, USEPA 1997) to get a high value of 50,547 µg/ft2. No low-end air concentrations were provided, so the default loading factor was used.
Loading - Sawing	6,539	6,539	40,534	$\mu g/ft^2$		USEPA 1997	The maximum air concentration for one unit or hour (2,151 µg/m3, USEPA 1997) was divided by the average concentration for one unit or hour (347 µg/m3, USEPA 1997) to get 6.20. This was multiplied by the default loading value (6,539 µg/ft2, USEPA 1997) to get a high value of 40,534 µg/ft2. No low-end air concentrations were provided, so the default loading factor was used.

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
Routine cleaning efficiency	1st: 49% 2nd: 25% 3rd: 23% 4th: 22% 5th: 22% 6th: 22% 7th: 20% 8th: 20% 9th: 15% 10th: 20% 11+: 20%	1st: 21% 2nd: 21% 3rd: 20% 4th: 19% 5th: 20% 6th: 20% 7th: 19% 8th: 18% 9th: 16% 10th: 19% 11+: 19%	1st: 76% 2nd: 40% 3rd: 38% 4th: 36% 5th: 38% 6th: 40% 7th: 33% 8th: 50% 9th: 0% 10th: 50% 11+: 50%	%	✓	Yiin 2002; USEPA 1997	Values developed based on cleaning efficiency data for multiple cleanings for carpet (Yiin 2002) and non-carpeted surfaces (USEPA 1997). The efficiencies were area-weighted based on an assumption of 36% carpet and 64% non-carpeted surfaces (from USEPA 2006a, Chapter 5, page 12). Default values are based on the midpoint of the ranges presented in Yiin 2002 and USEPA 1997, low values are based on the minimums, and high values are based on the maximums.

Exhibit B-2. Inputs for Indoor Dust Exposure Concentration Calculations – Control Scenario-Specific, All Activity Types

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
No plastic, basic cleanup (baseline controls)							
Conversion from workspace lead concentration to adjacent room lead concentration	0.16	0.095	0.225	unitless	✓	USEPA 1997	Calculated the conversion factor based on comparison of average airborne lead concentrations (from USEPA 1997) for window replacements for the same room (7.5 µg/m3) and the adjacent room (1.2 µg/m3). This ratio was calculated as 1.2 µg/m3 / 7.5 µg/m3 = 0.16 and is expected according to the analysis to be characteristic of the "workroom-adjacent room" floor lead loadings relationship for other work components. The low-end value is based on the maximum measured airborne lead concentrations for window replacements provided in the same table for the workroom (44.3 µg/m3) and the adjacent room (4.2 µg/m3). There was no high-end value provided, so one was estimated by taking the difference between the default and low values and adding that to the default.

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
Post-activity cleanup efficiency	53%	0%	89%	%	✓	Yiin 2002; USEPA 1997; USEPA 2006a (Chp 5, pg 12); CETL 2001	The default value was calculated based on the midpoint of the range of carpet cleaning efficiencies from Yiin 2002 (25.3%) and the non-carpeted surface cleaning efficiency of 68.4% from USEPA (1997), weighted by the percentage of house that is carpeted (36%) vs. not carpeted (64%) (from USEPA 2006a, Chapter 5, page 12). The low value assumes no cleanup occurs post-activity. The high value was calculated based on the maximum carpeted cleaning efficiency (84%) and the maximum non-carpeted cleaning efficiency reported in CETL 2001, weighted by the percentage of house that is carpeted (36%) vs. not carpeted (64%) (from USEPA 2006a, Chapter 5, page 12).
Plastic, full cleanup (full rule implementation)							
Conversion from workspace lead concentration to adjacent room lead concentration	0	0	0.16	unitless	✓	Assumption; USEPA 1997	Assumed that the control measures will completely prevent the transfer of lead out of the workspace. Therefore, the default and low conversion factors are assumed to be zero. The high conversion factor is assumed to equal the default conversion factor for the baseline scenario.
Total lead dust (loading plus background)	40	40	40	$\mu g/ft^2$		Assumption, based on USEPA 2001	Assumed that the proposed containment, cleaning and cleaning verification of the rule cumulatively results in floor lead dust levels below the USEPA clearance level of 40 µg/ft2, as reported in USEPA 2001. It is assumed that this refers to total lead dust and not lead dust loading only.

Exhibit B-3. Inputs for Indoor Dust Exposure Concentration Calculations – All Controls, Activity Type-Specific

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
REMODELING KITCHEN							
Lead loading	180,158	180,158	1,021,397	μg/ft^2	✓	Calculated	See Appendix A
Percentage of house that is workspace	6.0%	3.0%	30.0%	%	✓	US Census Bureau 1997, 2003; USEPA 2006a	Based on calculations performed in USEPA 2006a (which are based on data from US Census Bureau 1997, 2003) that provide the percentage of the house that is work area for kitchen projects. There is no explicit range provided for this type of project, but a range of percentages is provided across project types, from 3% for bathrooms to 30% for non-room-specific events.
Percentage of house that is adjacent room	6.0%	3.0%	30.0%	%	✓	Assumption	Assumed that the percentage of the home constituted by the adjacent rooms is equal to the percentage constituted by the workspace.
THREE CUTOUTS							
Lead loading	6,539	6,539	40,534	μg/ft^2	✓	Calculated	See Appendix A

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
Percentage of house that is workspace	5%	3%	30%	%	✓	US Census Bureau 1997, 2003; USEPA 2006a	Based on calculations performed in USEPA 2006a (which are based on data from US Census Bureau 1997, 2003) that provide the percentage of the house that is work area for a range of different types of projects. None of these types match this activity type. Given the relatively small scale of this activity, the size for the "Addition" activity was selected as the default because it was relatively small and considered reasonably similar to this activity. There is no explicit range provided for that type of project, but a range of percentages is provided across project types, from 3% for bathrooms to 30% for non-room-specific events.
Percentage of house that is adjacent room	5%	3%	30%	%	✓	Assumption	Assumed that the percentage of the home constituted by the adjacent rooms is equal to the percentage constituted by the workspace.
REPLACING WINDOWS							
Lead loading	10,623	10,623	56,117	$\mu g/ft^2$	✓	Calculated	See Appendix A

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
Percentage of house that is workspace	5%	3%	30%	%	✓	US Census Bureau 1997, 2003; USEPA 2006a	Based on calculations performed in USEPA 2006a (which are based on data from US Census Bureau 1997, 2003) that provide the percentage of the house that is work area for a range of different types of projects. None of these types match this activity type. Given the relatively small scale of this activity, the size for the “Addition” activity was selected as the default because it was relatively small and considered reasonably similar to this activity. There is no explicit range provided for that type of project, but a range of percentages is provided across project types, from 3% for bathrooms to 30% for non-room-specific events.
Percentage of house that is adjacent room	5%	3%	30%	%	✓	Assumption	Assumed that the percentage of the home constituted by the adjacent rooms is equal to the percentage constituted by the workspace.
REPLACING EXTERIOR DOORS							
Lead loading	15,030	15,030	95,403	$\mu g/ft^2$	✓	Calculated	See Appendix A

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
Percentage of house that is workspace	16%	3%	30%	%	✓	US Census Bureau 1997, 2003; USEPA 2006a	Based on calculations performed in USEPA 2006a (which are based on data from US Census Bureau 1997, 2003) that provide the percentage of the house that is work area for the average household event across event types. None of these types match this activity type. The uncertainty associated with this value is significant as the percentage would vary depending on how many doors were replaced and in how many rooms. The range for this parameter was set based on the range of percentages provided for across project types, from 3% for bathrooms to 30% for non-room-specific events. The average of this range is selected as the default.
Percentage of house that is adjacent room	16%	3%	30%	%	✓	Assumption	Assumed that the percentage of the home constituted by the adjacent rooms is equal to the percentage constituted by the workspace.
SCRAPING LEAD-BASED PAINT, INTERIOR FLAT COMPONENT							
Lead loading	36,472	36,472	202,188	$\mu g/ft^2$	✓	Calculated	See Appendix A
Percentage of house that is workspace	16%	3%	30%	%	✓	US Census Bureau 1997, 2003; USEPA 2006a	Based on calculations performed in USEPA 2006a (which are based on data from US Census Bureau 1997, 2003) that provide the percentage of the house that is work area for the average household event across event types. None of these types match this activity type. The range for this parameter was set based on the range of percentages provided for across project types from 3% for bathrooms to 30% for non-room-specific events. The average of this range is selected as the default.

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
Percentage of house that is adjacent room	16%	3%	30%	%	✓	Assumption	Assumed that the percentage of the home constituted by the adjacent rooms is equal to the percentage constituted by the workspace.
SCRAPING LEAD-BASED PAINT, INTERIOR DOOR							
Lead loading	36,472	36,472	202,188	$\mu g/ft^2$	✓	Calculated	See Appendix A
Percentage of house that is workspace	16%	3%	30%	%	✓	US Census Bureau 1997, 2003; USEPA 2006a	Based on calculations performed in USEPA 2006a (which are based on data from US Census Bureau 1997, 2003) that provide the percentage of the house that is work area for the average household event across event types. None of these types match this activity type. The range for this parameter was set based on the range of percentages provided for across project types from 3% for bathrooms to 30% for non-room-specific events. The average of this range is selected as the default.
Percentage of house that is adjacent room	16%	3%	30%	%	✓	Assumption	Assumed that the percentage of the home constituted by the adjacent rooms is equal to the percentage constituted by the workspace.

Exhibit B-4. Inputs for Outdoor Soil Exposure Concentration Calculations – All Control Types

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
Background outdoor soil concentration	103.7	7.8	1,445	µg/g	✓	HUD 2002	See Section 3.1.2
Lead Loading	34,145	10,071	58,218	mg/ft2	✓	University of Illinois 2002 (as cited in USEPA 2006a)	The low value is based on paint shaver exterior paint removal, while the high value is based on heat gun exterior paint removal. The default value was calculated as the average of these two values.
Soil mixing depth	3.5	5.0	2.0	cm	✓	USEPA 1986	
Soil density	1.36	1.10	1.60	g/cm3	✓	USEPA 1986	1.1 is dry density for clay, 1.6 is dry density for sand, and 1.36 is for loam soil.
Size of Yard	4,703	2,988	6,417	ft2	✓	USEPA 2001	
Area within 18 inches of perimeter of house	302	202	402	ft2	✓	US Census Bureau 1997, 2003; USEPA 2006a	Calculation (presented in USEPA 2006a) based on data from US Census Bureau 1997 and 2003.
Percentage of house perimeter impacted by activity	63%	25%	100%	%	✓	USEPA 2006a	

Exhibit B-5. Inputs for Outdoor Soil Exposure Concentration Calculations – Control Type-Specific

INPUTS	DEFAULT	LOW	HIGH	UNITS	IN SENSITIVITY ANALYSIS?	SOURCE	NOTES
No plastic, basic cleanup (baseline controls)							
Efficiency of control	0.0%	0.0%	0.0%	%	x	Assumption	Based on the assumption that there is no cleaning or soil replacement for exterior renovations for baseline controls and that there is no degradation of lead over time.
Plastic, full cleanup (full rule implementation)							
Efficiency of control	100%	94%	100%	%	x	Assumption, based on USEPA 2006a (p. 15)	Based on the assumption that under the full rule implementation controls, plastic would be rolled out to 10 ft from the foundation and removed at the completion of the activity. 94% was determined to be the high value as a University of Illinois study concluded that 94 to 99% of lead falls on a 12" by 12" plate centered on the work area and placed 6" from the perimeter. It is unclear whether the remaining lead would also fall within the drip line (e.g., in the 6" between the plate and perimeter or to the left or right of the centered plate) or beyond. Presumably, the 10 ft of plastic from the perimeter would catch the remainder as long as it did not settle beyond 10 ft. It is important to note that it is unclear when the study measurements were taken. Measurements one hour after stripping vs. at the end of repainting could produce different values if contractors walk on the plastic and then on the remainder of the yard or the lead dust on the plastic becomes windblown.

Appendix C. Description of Approach for Converting Lead Loadings to Lead Concentrations

The relationship between house dust loading and lead concentration for this report comes from the ICF (2006) analysis of a data set developed as part of HUD's 1997 National Survey. The analysis was used because it appears to use the largest, most nationally representative source of both house dust loading and concentration data taken simultaneously from the same households completed to date. To the extent that these data do not reflect the dust loading-dust concentration relationship in the types of buildings included in this assessment, the indoor dust lead concentrations will be biased (ICF 2006).

The data consisted of 305 wipe sample and dust concentration measurements taken from 284 households (USEPA 1998, Appendix C). The data were stratified into four vintage ranges from pre-1940 to post-1979. The data from all four ranges were pooled for the analysis. Log-Log regression provided the best fit and regression diagnostics. Two dust concentration data points, one with a value about five-fold below the next lowest, and one with a value more than 10-fold above the next highest concentration, were excluded from the analysis. The dust concentration model derived in this manner is displayed in the formula below and Exhibit C-1 (ICF 2006). The statistics associated with this model are presented in Exhibit C-2.

$$\ln(\text{House dust lead concentration, } \mu g/g) = 4.028687 + 0.608317 * \ln(\text{Dust loading, } \mu g/ft^2)$$

Exhibit C-1. Regression Analysis of HUD National Survey House Dust Lead Loading and Concentration Data

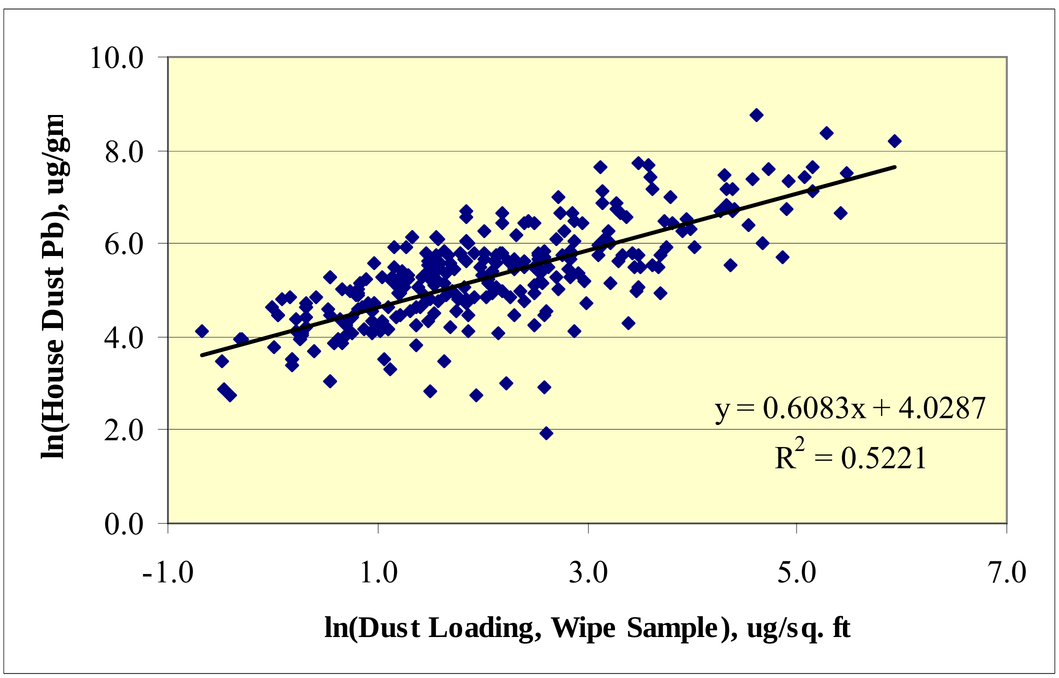

Exhibit C-2. Statistics for Regression Analysis of HUD National Survey House Dust Lead Loading and Concentration Data

Adjusted R^2	Standard error of the estimate	F-statistic	F-significance
0.521	0.747	328.871	3.46E-50
T-value (intercept)	**P-value (intercept)**	**T-value (x variable)**	**P-value (x variable)**
50.151	3.5E-148	18.135	3.46E-50

The regression analysis relating lead loading and lead dust concentrations in this report differs from the Battelle (2005) regression analysis cited in USEPA (2006a). It is important to note that the ICF (2006) analysis was not complete prior to the development of the USEPA (2006a) report. There are a number of reasons that the ICF (2006) regression analysis was used in place of Battelle (2005). First, ICF (2006) uses a data set developed as part of HUD's 1997 National Survey largest, which is currently the most nationally representative source of house dust loading and concentration data taken simultaneously from the same households. Second, the Battelle (2005) regression is based off of only three data points compared to the 307 data points used in ICF (2006). As noted in Battelle (2005), the analysis only represented a rough investigation of the mathematical relationship between loading and concentration and was "primarily meant to prompt discussion for further investigation" (Battelle 2005). Third, it is unclear whether the three Battelle (2005) data points, which are pairs of geometric floor dust lead loadings and geometric mean hand-lead levels, are based off of data where the loadings and hand-lead levels were collected simultaneously from the same households. Fourth, the Battelle (2005) is not a direct comparison of floor lead loading and lead dust concentrations, but rather a relationship between hand-lead concentrations (µg/hand) and floor dust-lead loadings. In order to approximate lead concentrations (µg/g dust), the authors had to make a number of assumptions that were not documented (e.g., a child is assumed on average to lick one-third of a hand).

Appendix D. Detailed Exposure Concentration Results

Exhibit D-1. Area-Weighted Indoor Dust Lead Concentration Results (µg Pb/g dust) for the "Background Dust Concentration" Input Parameter, Immediately after Initial Cleanup (No Routine Cleaning Considered)

Scenario	Indoor Dust Pb concentrations (µg Pb/g dust)					
	Baseline			Full rule implementation		
	Default	Low	High	Default	Low	High
Remodeling Kitchen	3,433	3,380	5,792	112	61	2,403
Scraping LBP, Interior Flat Component	3,459	3,409	5,690	157	111	2,204
Scraping LBP, Interior Door	3,459	3,409	5,690	157	111	2,204
Three Cutouts	455	401	2,827	108	56	2,423
Replacing Windows	582	529	2,955	108	56	2,423
Replacing Exterior Doors	2,050	2,000	4,281	157	111	2,204

Exhibit D-2. Area-Weighted Indoor Dust Lead Concentration Results (µg Pb/g dust) for the "Conversion from Workspace to Adjacent Room" Input Parameter, Immediately after Initial Cleanup (No Routine Cleaning Considered)

Scenario	Indoor Dust Pb concentrations (µg Pb/g dust)					
	Baseline			Full rule implementation		
	Default	Low	High	Default	Low	High
Remodeling Kitchen	3,433	3,088	3,778	112	112	117
Scraping LBP, Interior Flat Component	3,459	3,111	3,807	157	157	170
Scraping LBP, Interior Door	3,459	3,111	3,807	157	157	170
Three Cutouts	455	416	493	108	108	112
Replacing Windows	582	531	634	108	108	112
Replacing Exterior Doors	2,050	1,847	2,253	157	157	170

Exhibit D-3. Area-Weighted Indoor Dust Lead Concentration Results (µg Pb/g dust) for the "Post-Activity Cleanup Efficiency" Input Parameter, Immediately after Initial Cleanup (No Routine Cleaning Considered)

Scenario	Indoor Dust Pb concentrations (µg Pb/g dust)					
	Baseline			Full rule implementation		
	Default	Low	High	Default	Low	High
Remodeling Kitchen	3,433	6,242	1,493	112	112	112
Scraping LBP, Interior Flat Component	3,459	6,299	1,498	157	157	157
Scraping LBP, Interior Door	3,459	6,299	1,498	157	157	157
Three Cutouts	455	768	238	108	108	108
Replacing Windows	582	1,003	292	108	108	108
Replacing Exterior Doors	2,050	3,709	904	157	157	157

Exhibit D-4. Area-Weighted Indoor Dust Lead Concentration Results (µg Pb/g dust) for the "Percent House Workspace" Input Parameter, Immediately after Initial Cleanup (No Routine Cleaning Considered)

Scenario	Indoor Dust Pb concentrations (µg Pb/g dust)					
	Baseline			Full rule implementation		
	Default	Low	High	Default	Low	High
Remodeling Kitchen	3,433	2,184	13,425	112	99	219
Scraping LBP, Interior Flat Component	3,459	1,415	5,661	157	99	219
Scraping LBP, Interior Door	3,459	1,415	5,661	157	99	219
Three Cutouts	455	345	1,829	108	99	219
Replacing Windows	582	434	2,433	108	99	219
Replacing Exterior Doors	2,050	860	3,331	157	99	219

Exhibit D-5. Area-Weighted Indoor Dust Lead Concentration Results for the "Percent House Adjacent Room" Input Parameter, Immediately after Initial Cleanup (No Routine Cleaning Considered)

Scenario	Indoor Dust Pb concentrations (µg Pb/g dust)					
	Baseline			Full rule implementation		
	Default	Low	High	Default	Low	High
Remodeling Kitchen	3,433	3,008	6,830	112	112	112
Scraping LBP, Interior Flat Component	3,459	2,763	4,209	157	157	157
Scraping LBP, Interior Door	3,459	2,763	4,209	157	157	157
Three Cutouts	455	417	925	108	108	108
Replacing Windows	582	532	1215	108	108	108
Replacing Exterior Doors	2,050	1,644	2,487	157	157	157

Exhibit D-6. Area-Weighted Indoor Dust Lead Concentration Results for the "Lead Loading" Input Parameter, Immediately after Initial Cleanup (No Routine Cleaning Considered)

Scenario	Indoor Dust Pb concentrations (µg Pb/g dust)					
	Baseline			Full rule implementation		
	Default	Low	High	Default	Low	High
Remodeling Kitchen	3,433	3,433	9,708	112	112	112
Scraping LBP, Interior Flat Component	3,459	3,459	9,661	157	157	157
Scraping LBP, Interior Door	3,459	3,459	9,661	157	157	157
Three Cutouts	455	455	1,210	108	108	108
Replacing Windows	582	582	1,456	108	108	108
Replacing Exterior Doors	2,050	2,050	6,146	157	157	157

Exhibit D-7. Indoor Dust Concentrations for "Kitchen Renovation" Activity with Varied Routine Cleaning Efficiency (RCE) and Cleaning Frequency (CF), Baseline Controls[a]

Week	CF-default RCE-default	CF-default RCE-min	CF-default RCE-max	CF-min RCE-default	CF-min RCE-min	CF-min RCE-max	CF-max RCE-default	CF-max RCE-min	CF-max RCE-max
0	3433	3433	3433	3433	3433	3433	3433	3433	3433
1	1804	2726	880	3433	3433	3433	1367	2173	559
2	1367	2173	559	3433	3433	3433	849	1428	269
3	1065	1751	378	3433	3433	3433	547	946	148
4	849	1428	269	1804	2726	880	376	653	100
5	678	1159	196	1804	2726	880	279	470	90
6	547	946	148	1804	2726	880	205	334	86
7	451	778	124	1804	2726	880	158	245	86
8	376	653	100	1367	2173	559	128	187	86
9	331	562	100	1367	2173	559	109	149	86
10	279	470	90	1367	2173	559	97	123	86
11	238	395	86	1367	2173	559	91	107	86
12	205	334	86	1065	1751	378	87	96	86
13	179	285	86	1065	1751	378	86	91	86
14	158	245	86	1065	1751	378	86	87	86
15	141	213	86	1065	1751	378	86	86	86
16	128	187	86	849	1428	269	86	86	86
17	117	166	86	849	1428	269	86	86	86
18	109	149	86	849	1428	269	86	86	86
19	102	135	86	849	1428	269	86	86	86
20	97	123	86	678	1159	196	86	86	86
21	93	114	86	678	1159	196	86	86	86
22	91	107	86	678	1159	196	86	86	86
23	89	101	86	678	1159	196	86	86	86
24	87	96	86	547	946	148	86	86	86
25	86	93	86	547	946	148	86	86	86
26	86	91	86	547	946	148	86	86	86
27	86	89	86	547	946	148	86	86	86
28	86	87	86	451	778	124	86	86	86
29	86	86	86	451	778	124	86	86	86
30	86	86	86	451	778	124	86	86	86

Exhibit D-7. Indoor Dust Concentrations for "Kitchen Renovation" Activity with Varied Routine Cleaning Efficiency (RCE) and Cleaning Frequency (CF), Baseline Controls[a]

Week	CF-default RCE-default	CF-default RCE-min	CF-default RCE-max	CF-min RCE-default	CF-min RCE-min	CF-min RCE-max	CF-max RCE-default	CF-max RCE-min	CF-max RCE-max
31	86	86	86	451	778	124	86	86	86
32	86	86	86	376	653	100	86	86	86
33	86	86	86	376	653	100	86	86	86
34	86	86	86	376	653	100	86	86	86
35	86	86	86	376	653	100	86	86	86
36	86	86	86	331	562	100	86	86	86
37	86	86	86	331	562	100	86	86	86
38	86	86	86	331	562	100	86	86	86
39	86	86	86	331	562	100	86	86	86
40	86	86	86	279	470	90	86	86	86
41	86	86	86	279	470	90	86	86	86
42	86	86	86	279	470	90	86	86	86
43	86	86	86	279	470	90	86	86	86
44	86	86	86	238	395	86	86	86	86
45	86	86	86	238	395	86	86	86	86
46	86	86	86	238	395	86	86	86	86
47	86	86	86	238	395	86	86	86	86
48	86	86	86	205	334	86	86	86	86
49	86	86	86	205	334	86	86	86	86
50	86	86	86	205	334	86	86	86	86
51	86	86	86	205	334	86	86	86	86
52	86	86	86	179	285	86	86	86	86
53	86	86	86	179	285	86	86	86	86
54	86	86	86	179	285	86	86	86	86
55	86	86	86	179	285	86	86	86	86
56	86	86	86	158	245	86	86	86	86
57	86	86	86	158	245	86	86	86	86
58	86	86	86	158	245	86	86	86	86
59	86	86	86	158	245	86	86	86	86
60	86	86	86	141	213	86	86	86	86
61	86	86	86	141	213	86	86	86	86

Exhibit D-7. Indoor Dust Concentrations for "Kitchen Renovation" Activity with Varied Routine Cleaning Efficiency (RCE) and Cleaning Frequency (CF), Baseline Controls[a]

Week	CF-default RCE-default	CF-default RCE-min	CF-default RCE-max	CF-min RCE-default	CF-min RCE-min	CF-min RCE-max	CF-max RCE-default	CF-max RCE-min	CF-max RCE-max
62	86	86	86	141	213	86	86	86	86
63	86	86	86	141	213	86	86	86	86
64	86	86	86	128	187	86	86	86	86
65	86	86	86	128	187	86	86	86	86
66	86	86	86	128	187	86	86	86	86
67	86	86	86	128	187	86	86	86	86
68	86	86	86	117	166	86	86	86	86
69	86	86	86	117	166	86	86	86	86
70	86	86	86	117	166	86	86	86	86
71	86	86	86	117	166	86	86	86	86
72	86	86	86	109	149	86	86	86	86
73	86	86	86	109	149	86	86	86	86
74	86	86	86	109	149	86	86	86	86
75	86	86	86	109	149	86	86	86	86
76	86	86	86	102	135	86	86	86	86
77	86	86	86	102	135	86	86	86	86
78	86	86	86	102	135	86	86	86	86
79	86	86	86	102	135	86	86	86	86
80	86	86	86	97	123	86	86	86	86
81	86	86	86	97	123	86	86	86	86
82	86	86	86	97	123	86	86	86	86
83	86	86	86	97	123	86	86	86	86
84	86	86	86	93	114	86	86	86	86
85	86	86	86	93	114	86	86	86	86
86	86	86	86	93	114	86	86	86	86
87	86	86	86	93	114	86	86	86	86
88	86	86	86	91	107	86	86	86	86
89	86	86	86	91	107	86	86	86	86
90	86	86	86	91	107	86	86	86	86
91	86	86	86	91	107	86	86	86	86
92	86	86	86	89	101	86	86	86	86

Exhibit D-7. Indoor Dust Concentrations for "Kitchen Renovation" Activity with Varied Routine Cleaning Efficiency (RCE) and Cleaning Frequency (CF), Baseline Controls[a]

Week	CF-default RCE-default	CF-default RCE-min	CF-default RCE-max	CF-min RCE-default	CF-min RCE-min	CF-min RCE-max	CF-max RCE-default	CF-max RCE-min	CF-max RCE-max
93	86	86	86	89	101	86	86	86	86
94	86	86	86	89	101	86	86	86	86
95	86	86	86	89	101	86	86	86	86
96	86	86	86	87	96	86	86	86	86
97	86	86	86	87	96	86	86	86	86
98	86	86	86	87	96	86	86	86	86
99	86	86	86	87	96	86	86	86	86
100	86	86	86	86	93	86	86	86	86
101	86	86	86	86	93	86	86	86	86
102	86	86	86	86	93	86	86	86	86
103	86	86	86	86	93	86	86	86	86
104	86	86	86	86	91	86	86	86	86
105	86	86	86	86	91	86	86	86	86
106	86	86	86	86	91	86	86	86	86
107	86	86	86	86	91	86	86	86	86
108	86	86	86	86	89	86	86	86	86
109	86	86	86	86	89	86	86	86	86
110	86	86	86	86	89	86	86	86	86
111	86	86	86	86	89	86	86	86	86
112	86	86	86	86	87	86	86	86	86
113	86	86	86	86	87	86	86	86	86
114	86	86	86	86	87	86	86	86	86
115	86	86	86	86	87	86	86	86	86
116	86	86	86	86	86	86	86	86	86

[a] Cells in grey indicate concentrations above background.

Exhibit D-8. Indoor Dust Concentrations for "Kitchen Renovation" Activity with Varied Routine Cleaning Efficiency (RCE) and Cleaning Frequency (CF), Full Rule Implementation Controls[a]

Week	CF-default RCE-default	CF-default RCE-min	CF-default RCE-max	CF-min RCE-default	CF-min RCE-min	CF-min RCE-max	CF-max RCE-default	CF-max RCE-min	CF-max RCE-max
0	112	112	112	112	112	112	112	112	112
1	97	106	88	112	112	112	93	100	86
2	93	100	86	112	112	112	88	93	86
3	90	96	86	112	112	112	86	89	86
4	88	93	86	97	106	88	86	86	86
5	86	91	86	97	106	88	86	86	86
6	86	89	86	97	106	88	86	86	86
7	86	87	86	97	106	88	86	86	86
8	86	86	86	93	100	86	86	86	86
9	86	86	86	93	100	86	86	86	86
10	86	86	86	93	100	86	86	86	86
11	86	86	86	93	100	86	86	86	86
12	86	86	86	90	96	86	86	86	86
13	86	86	86	90	96	86	86	86	86
14	86	86	86	90	96	86	86	86	86
15	86	86	86	90	96	86	86	86	86
16	86	86	86	88	93	86	86	86	86
17	86	86	86	88	93	86	86	86	86
18	86	86	86	88	93	86	86	86	86
19	86	86	86	88	93	86	86	86	86
20	86	86	86	86	91	86	86	86	86
21	86	86	86	86	91	86	86	86	86
22	86	86	86	86	91	86	86	86	86
23	86	86	86	86	91	86	86	86	86
24	86	86	86	86	89	86	86	86	86
25	86	86	86	86	89	86	86	86	86
26	86	86	86	86	89	86	86	86	86
27	86	86	86	86	89	86	86	86	86
28	86	86	86	86	87	86	86	86	86
29	86	86	86	86	87	86	86	86	86
30	86	86	86	86	87	86	86	86	86

Exhibit D-8. Indoor Dust Concentrations for "Kitchen Renovation" Activity with Varied Routine Cleaning Efficiency (RCE) and Cleaning Frequency (CF), Full Rule Implementation Controls[a]

Week	CF-default RCE-default	CF-default RCE-min	CF-default RCE-max	CF-min RCE-default	CF-min RCE-min	CF-min RCE-max	CF-max RCE-default	CF-max RCE-min	CF-max RCE-max
31	86	86	86	86	87	86	86	86	86
32	86	86	86	86	86	86	86	86	86
33	86	86	86	86	86	86	86	86	86
34	86	86	86	86	86	86	86	86	86
35	86	86	86	86	86	86	86	86	86

[a] Cells in grey indicate concentrations above background.

Exhibit D-9. Area-Weighted Outdoor Soil Lead Concentration Results Immediately after Activity Initiation Using the "Exterior Lead-Based Paint Removal" Scenario

Input Parameter	Outdoor soil Pb concentrations (µg Pb/g soil)					
	Baseline			Full rule implementation		
	Default	Low	High	Default	Low	High
Area within 18 inches of perimeter	441	338	544	131	131	131
Background soil concentration	441	318	1,755	131	8	1,445
Efficiency of control	441	441	441	131	149	131
Lead Loading	441	222	660	131	131	131
Percent of house perimeter involved in activity	441	255	627	131	131	131
Size of yard	441	619	358	131	131	131
Soil density	441	514	394	131	131	131
Soil depth	441	348	673	131	131	131