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♻EPA User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Windows®

Prepared for

The Technical Review Workgroup for Metals and Asbestos (TRW)

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U.S. Environmental Protection Agency
Technical Review Workgroup for Metals and Asbestos

Members

The members of the TRW Lead Committee are technical staff from EPA Regions, Office of Solid Waste and Emergency Response (OSWER) Headquarters, and Office of Research and Development National Center for Environmental Assessment (ORD/NCEA). Lead Committee members generally have an active interest and recognized scientific expertise in metals or asbestos risk assessment. For more information see: http://www.epa.gov/superfund/lead/trw.htm.

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Acronyms and Abbreviations

CERCLA	*Comprehensive Emergency Response Compensation Liability Act*
dL deciliter	
g gram	
GI gastrointestinal	
GM geometric	mean
GSD	Geometric Standard Deviation
IEUBKwin	Integrated Exposure Uptake Biokinetic Model for Lead in Children, Windows version
FDA	Food and Drug Administration
L liter	
LOC	level of concern
MSA	Multiple Source Analysis
MSD	Mass fraction of soil to dust
m^3 cubic	meters
OSWER	Office of Solid Waste and Emergency Response
Pb lead	
PbB blood	lead
PbD dust	lead
PbS soil	lead
PDF	Probability Density Function
PRG Preli	minary Remediation Goal
RCRA	*Resource Conservation Recovery Act*
TRW	Technical Review Workgroup for Metals and Asbestos
µg microgram	

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1.0 Introduction

The Integrated Exposure Uptake Biokinetic Model for Lead (Pb) in Children, Windows (IEUBKwin) is a stand-alone personal computer (PC)-compatible software package. The model utilizes four interrelated modules (exposure, uptake, biokinetic, and probability distribution) to estimate blood lead (PbB) levels in children exposed to lead (Pb)-contaminated media. IEUBKwin allows the user to estimate, for a hypothetical child or population of children, a plausible distribution of PbB concentrations centered on a geometric mean PbB concentration. The geometric mean PbB is predicted from available information about the child's or children's exposure to lead. From this distribution, the model estimates the risk (*i.e.,* probability) that a child's or a population of children's PbB concentration will exceed a certain level of concern (typically 10 µg/dL).

IEUBKwin should be viewed as a tool for making rapid calculations and recalculations of an extremely complex set of equations which includes many exposure, uptake, and biokinetic parameters. It has been recommended as a risk assessment tool to support the implementation of the July 14, 1994, Office of Solid Waste and Emergency Response (OSWER) Directive entitled *Revised Interim Soil Lead Guidance for Comprehensive Environmental Response Compensation Liability Act (CERCLA) Sites and Resource Conservation and Recovery Act (RCRA) Corrective Action Facilities*, as well as the subsequent August 1998 OSWER Directive entitled *Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*. The development of the IEUBKwin model included Independent Validation and Verification and a limited peer review of the software and documentation.

1.1 PURPOSE OF THE USER'S GUIDE

This User's Guide is intended to serve as a comprehensive reference for use of IEUBKwin. It provides the basics needed for accurate application and interpretation of the model, including how to install and run the model, model inputs, model analysis, model output, interpretation of model results, minimum requirements for risk assessment application, and example scenarios. Users of the model can refer to the IEUBK Guidance Manual (U.S. EPA, 1994) or the IEUBK Structure Paper (White *et al.*, 1998) for supplemental information concerning the parameters and correct application of IEUBKwin.

1.1.1 Overview of the IEUBKwin Model

The focus of the integrated exposure uptake biokinetic (IEUBK) model for lead in children is the prediction of blood lead concentrations in young children exposed to lead from several sources and by several routes. The model is a four-step process that mathematically and statistically links environmental lead exposure to blood lead concentrations for a population of children (0-84 months of age). Figure 1-1 provides a schematic showing the sources of exposure to

environmental lead and the absorption and processing of lead by the human body (IEUBK Guidance Manual, U.S. EPA, 1994).

The four model components each reflect a different aspect of the overall biologic process:

Exposure Component. Exposure can be thought of as the contact of a chemical, or other agent, with the absorption or exchange boundaries of an organism, such as the gut, lungs, and skin. Quantitation of a child's exposure to lead (µg/day) requires estimation of the concentration of lead in the environmental media that the child contacts (usually µg/g, µg/m^3, or µg/L, multiplied by a term to describe the amount of contact the child has with the medium (usually g/day, m^3/day, or liters/day), and a term for the duration of that contact (usually days). The results from the exposure component of the IEUBK model are estimated intake rates for the quantities of lead inhaled or ingested from environmental media. The media addressed by the IEUBK model include soil, house dust, drinking water, air, and food. Paint is usually addressed in terms of its contribution to the measured concentration of lead in soil or house dust.

Uptake Component. The uptake component models the process by which lead intake (lead that has entered the child's body through ingestion or inhalation) is transferred to the blood plasma. Uptake (µg/day) is the quantity of lead absorbed per unit time from portals of entry (gut, lung) into the systemic circulation of blood. Only a fraction of the lead entering the body through the respiratory or gastrointestinal (GI) tracts is actually absorbed into the systemic circulation. This absorption fraction is, by convention, termed bioavailability and provides the most convenient parameterization of the uptake process. The IEUBK model addresses the different bioavailabilities of lead from different environmental media and provides for a partial saturation of absorption at high levels of lead intake.

Biokinetic Component. The biokinetic component of the IEUBK model is a mathematic expression of the movement of absorbed lead throughout the body over time by physiologic or biochemical processes. The biokinetic component converts the total lead uptake rate from the uptake component into an input to the central plasma-extracellular fluid (ECF) compartment. Transfer coefficients are used to model movement of lead between the internal compartments and to the excretion pathways. The quantities are combined with the total lead uptake rate to continuously recalculate the lead masses in each of the body compartments and especially the changing concentration of lead in blood.

Variability. An important goal of the IEUBK model is to address variability in blood lead concentrations among exposed children. Children having contact with the same concentrations of environmental lead can develop very different blood lead concentrations due to differences in behavior, household characteristics, and individual patterns of lead uptake and biokinetics. The IEUBK model uses a log-normal probability distribution to characterize this variability. The biokinetic component output provides a central estimate of blood lead concentration, which is used to provide the geometric standard deviation (GSD). The recommended default value for this parameter (1.6) was

derived from empirical studies with young children where both blood and environmental lead concentrations were measured.
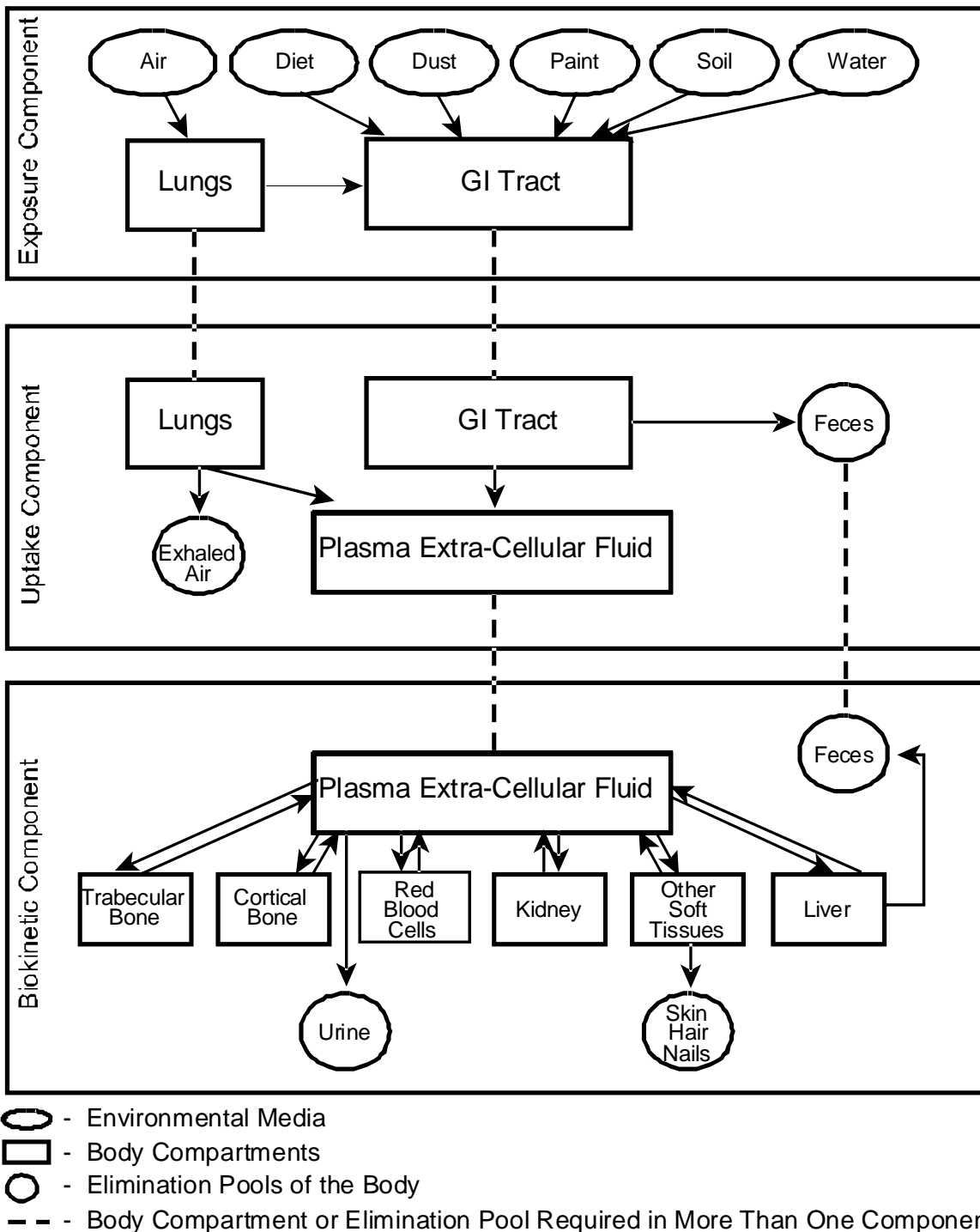
Figure 1-1. Biological Structure of the IEUBKwin Model.

1.2 Loading and Starting the Model

IEUBKWIN.EXE;	AIR.INP;	DIET.INP;	GIBIO.INP;
MATERNAL.INP;	MULTISRC.INP;	OTHER.INP;	SOIL.INP;
WATER.INP;	BATCHRUN.INP;	BATCHRUN.DAT;	UNINST.ISU

The "IEUBKWIN.EXE" file is the main program file; the "*.INP" files contain the default values for the *Parameter Input* pull-down options; the "BATCHRUN.DAT" file is the example input file for batch mode runs; and the "UNINST.ISU" file is used by Windows to completely uninstall the program.

Following extraction, the user must agree to the software license agreement, register the software with the U.S. EPA, and specify a location for installation. IEUBKwin is intended to be run as a desktop application rather than from a network installation. It is recommended that a local copy of the application be saved onto the PC from which it will be run. As part of the model installation, a desktop icon labeled *IEUBKwin* will be installed. To run the model, double-click the *IEUBKwin* icon from the *Programs* menu. A *Disclaimer* will appear on the screen. Read the *Disclaimer* then close the *Disclaimer* window by clicking on the <<Close>> button.

The most current information pertaining to IEUBKwin model and Pb risk assessment is available on the Technical Review Workgroup (TRW) website. The TRW home page may be found at **http://www.epa.gov/superfund/lead**.

Questions concerning the use and interpretation of IEUBKwin model may be submitted to the IEUBK technical support center via the TRW web page.

IEUBKwin is menu driven, with on-line, context-sensitive help available in almost every menu or window. In addition to the buttons that provide quick access to commonly-used model features, the main pull-down menus and the associated options remain. The contents of each these menus are listed below:

1. **File Menu**
   - Select Run Mode
   - Print
   - Print Setup
   - Close
   - Exit

Under *Select Run Mode* the user may choose to run the model in *Research* or *Site Risk Assessment* mode, depending upon individual needs. If the user chooses to run the model in the *Site Risk Assessment* mode, the model will prompt the user for a user name, date, site name, and operable unit. In addition, the model will require the user to input a comment into a comment screen whenever the user modifies the default value of an input parameter.

2.   Parameter Input Menu Options
- Air Data
- Dietary Data
- Drinking Water Data
- Soil/Dust Data
- Maternal Data
- Alternate Source Data
- GI Values/Bioavailability
- Reset All Parameters
- Load Input From File
- Save Input To File

3.   Computation Menu Options
- Run the Model (Single Run)
- Multiple Runs
- Blood Pb *vs.* Media Pb
- Find Blood Pb Concentration
- Batch Mode Model Runs

4.   Output Menu Options
- View Text Result File
- Rename Text Result File
- Rename Blood Media Graph File
- Rename Single Run Graph File
- Rename Multiple Run Graph File

5.   Graph Menu Options
- Blood Pb Concentration *vs.* Media Pb Concentration
- Distribution Probability Percent
- Distribution Probability Density Histogram
- Distribution Probability for Multiple Runs
- Probability Density for Multiple Runs

6.   Help Options
- Contact Information
- General Help
- Menu Information
- File Extensions in IEUBKwin
- Significant Figures in IEUBKwin
- About IEUBKwin Lead Model

2.0 Inputs

IEUBKwin contains more than 100 input parameters that are initially set to default values. Of these 100 input parameters, there are 46 external input parameters that may be changed by the user; the remaining internal model parameters are set to fixed default values. The default values represent national averages or plausible central values that were developed based on many years of research. However, to most effectively use the model, it is necessary to use valid site-specific information as much as is feasible. This section provides a brief description of how a user can change IEUBKwin parameters to better match the conditions at a specific site.

The array of valid applications for which IEUBKwin can be used is as follows:

> *Category A*: One location.
> > A1: One living unit, one child.[1]
> > A2: One living unit, more than one child.
> > A3: More than one living unit, more than one child, homogeneous media concentrations.
>
> *Category B:* Multiple locations, one neighborhood, homogeneous media concentrations.
>
> *Category C:* Multiple locations, one neighborhood, heterogeneous media concentrations.
>
> *Category D:* Multiple locations, more than one neighborhood, potentially heterogeneous neighborhood ingestion/absorption parameters.

A single run of IEUBKwin is sufficient for categories A and B. Categories C and D require classification or disaggregation of the neighborhood into distinct exposure subgroups, with the possibility of different ingestion or absorption parameters for different neighborhoods in Category D. Neighborhood-scale and community-scale risk estimation requires aggregating the risk estimates for individuals or subgroups. The differences between these levels are sketched in Figure 2-1. Category A requires calculating only a single PbB distribution. Category B requires calculating a PbB distribution for each child, but since each child of the same age has the same exposure scenario, a single run of the model is sufficient to characterize risk for this subgroup. In Category C, there are different media concentrations for different individual. Risk estimates must be calculated for each individual or homogeneous subgroup, then added up across sites and children. Category D allows for the case where not only exposure concentrations, but other basic exposure and bioavailability parameters differ among the exposed groups.

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[1]The IEUBK model is not intended to be used as a substitute for blood lead measurement and medical evaluation of a specific child at risk. Medical evaluation can take into account specific information on behavior and risk factors, such as nutritional status, that are beyond the scope of a broadly applicable environmental risk model. (See FAQ on PbB studies at (http://www.epa.gov/superfund/lead)).

A. Single child
Single site of exposure

Probability

Blood Lead
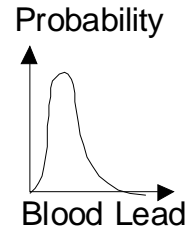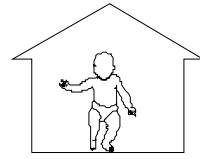
B. Multiple children or population
Single location or locations with homogeneous concentrations

Child 1   Child 2   Child 3
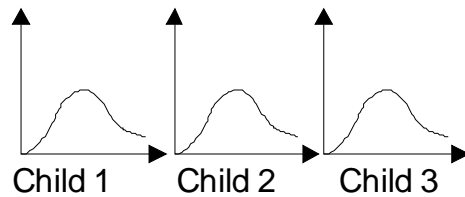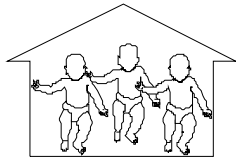
C. Multiple children or population in neighborhood
Multiple sites with exposures to different media concentrations

Site 1   Site 2   Site 2   Site 3
Child 1   Child 2   Child 3   Child 4
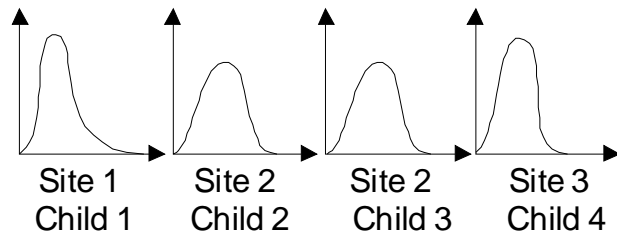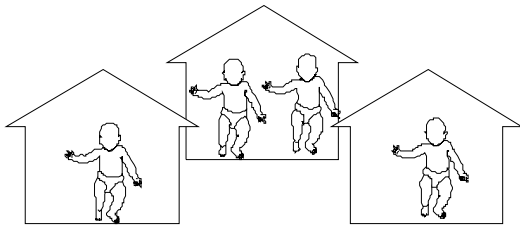
D. Multiple children or population in heterogeneous community or region, different neighbohood exposure scenarios
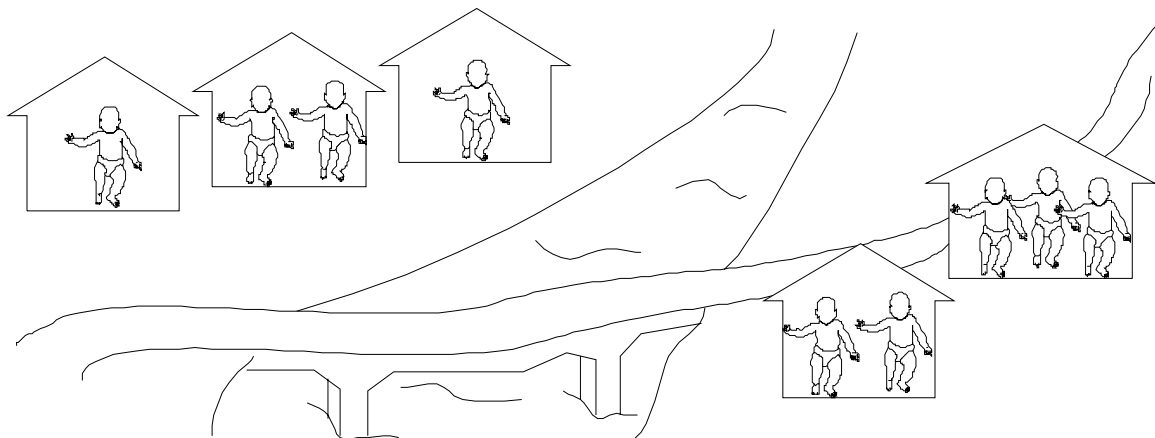
Figure 2-1. Categories of Application of IEUBKwin.

2.1 Input Windows

There are seven parameter input windows where parameters can be modified to reflect the site-specific conditions. IEUBKwin input options are button at the top of the screen and are as follows:

- *Air Data*
- *Dietary Data*
- *Drinking Water Data*
- *Soil/Dust Data*
- *Maternal Data*
- *Alternative Source Data*
- *GI Values/Bioavailability*

The parameter values shown in the input windows are set to EPA-specified default values. Where site-specific data are available, the user is encouraged to alter inputs for environmental media Pb concentrations. However, the user should change parameters such as the mass fraction of soil to dust (MSD), bioavailability, geometric standard deviation (GSD), soil ingestion rates, and dietary data only if the user has a thorough understanding of the methodology behind those parameters and valid site-specific monitoring data that are specifically applicable to the parameters. Generally, the TRW considers that "valid" site-specific information will reflect data quality indicators such as completeness, comparability, representativeness, precision, and accuracy.

The user can reset any modified parameters to their default values by using the *Reset All Parameters* command on the *Parameter Input* pull-down menu. If further information about an input parameter or default value is required, consult the IEUBK Guidance Manual (U.S. EPA, 1994). The input windows were designed to allow users to tab between fields to facilitate the data entry process. Note that a value is not saved for use in a model run until the user clicks the <<OK>> button on the input screen. If <<Cancel>> is selected (or if the window is closed using the "X" in the upper right corner of the window), the model retains the initial default values. The model does not substitute default values for soil, water, or air prior to performing calculations when any input values are missing.

Additionally, the user has the option to load a complete set of input data from a previously saved file (see Section 2.3). The *Load Input From File* option is located on the *Parameter Input* pull-down menu. The loaded site-specific data should provide the model with the necessary information to predict PbB levels in children who live on or near the site in question.

When changing any of the input parameters, the user may enter values with as many as six significant figures. In IEUBKwin, three significant figures are reported to the right of the decimal point for all output data except blood lead concentration which is reported to one digit to the right of the decimal point. However, it should be noted that the true precision of any calculated output can be strongly influenced by the least precise input value. An explanation of how significant figures are used in IEUBKwin can be found in the *Help* pull-down menu.

Each *Parameter Input* menu option includes context-sensitive help windows to aid the user. These windows are available for most input parameters and are accessed by clicking on the <<Help ?>> button. This feature opens a new window which shows the available guidance for the subject. In addition, the user has online access to the complete documentation for the model under the Help pull down menu.

Finally, IEUBKwin has been developed to warn the user when she or he has entered unacceptable input values. Currently, IEUBKwin contains three classes of error messages that will appear when the user enters inappropriate input values. These classes of error messages address:

- Input values that result in greater than 100 percent. In cases where the user enters an input value in the form of a percent, the value may not exceed 100 percent. Similarly, when percent values are summed, the total may not exceed 100 percent.

- Negative values. Negative input values are not allowed in IEUBKwin.

- Valid model inputs. Although the user is permitted to enter any values into the IEUBKwin model (given the limits above), in certain instances, the input is limited based on scientific evidence (for example, the plausible range of GSD values).

2.2 DETAILED DESCRIPTIONS OF INPUT OPTIONS

The following is a discussion of the *Parameter Input* pull-down menu options for IEUBKwin. Help menus and the IEUBK Guidance Manual (U.S. EPA, 1994) provide further assistance and discussion on data entry. A detailed list of default values for IEUBKwin model parameters are presented in Table 2-1, and the user should refer to the IEUBK Guidance Manual (U.S. EPA, 1994) for additional information.

Aside from the mathematical limits described in Section 2.1, there is no limit to the range of values permitted in the IEUBKwin model per se. However, empirical validation of the model did not address situations where the predicted blood lead concentration exceeds 30 μg/dL; therefore, such results must be interpreted with caution (Zaragoza and Hogan, 1998). In addition, values for some input parameters are limited by physiology or scientific data as discussed in the IEUBK Guidance Manual (U.S. EPA, 1994). Additional information on plausible limits for certain parameters is also available from the Input Parameters section of the FAQs of the TRW website (http://www.epa.gov/superfund/lead).

Table 2–1. Default Values for IEUBKwin Model Parameters

Parameter	Default Value	Units
Indoor air lead concentration (% of outdoor)	30	%
AIR (by year)		

Air concentration
Age =   0-1 year (0-11 mo)
        1-2 years (12-23 mo)
        2-3 years (24-35 mo)
        3-4 years (36-47 mo)
        4-5 years (48-59 mo)
        5-6 years (60-71 mo)
        6-7 years (72-84 mo)
	0.10
	0.10
	0.10
	0.10
	0.10
	0.10
	0.10
		$\mu g/m^3$
		$\mu g/m^3$
		$\mu g/m^3$
		$\mu g/m^3$
		$\mu g/m^3$
		$\mu g/m^3$
		$\mu g/m^3$

Time outdoors
Age =   0-1 year (0-11 mo)
        1-2 years (12-23 mo)
        2-3 years (24-35 mo)
        3-7 years (36-84 mo)
	1
	2
	3
	4
		h/day
		h/day
		h/day
		h/day

Ventilation rate
Age =   0-1 year (0-11 mo)
        1-2 years (12-23 mo)
        2-3 years (24-35 mo)
        3-4 years (36-47 mo)
        4-5 years (48-59 mo)
        5-6 years (60-71 mo)
        6-7 years (72-84 mo)
	2
	3
	5
	5
	5
	7
	7
		m^3/day
		m^3/day
		m^3/day
		m^3/day
		m^3/day
		m^3/day
		m^3/day

Lung absorption	32	%
DATA ENTRY FOR DIET (by year)		

Dietary lead intake
Age =   0-1 year (0-11 mo)
        1-2 years (12-23 mo)
        2-3 years (24-35 mo)
        3-4 years (36-47 mo)
        4-5 years (48-59 mo)
        5-6 years (60-71 mo)
        6-7 years (72-84 mo)
	2.26
	1.96
	2.13
	2.04
	1.95
	2.05
	2.22
		µg Pb /day
		µg Pb /day
		µg Pb /day
		µg Pb /day
		µg Pb /day
		µg Pb /day
		µg Pb /day

DATA ENTRY FOR ALTERNATE DIET SOURCES (by food class)		

Concentration:
    home-grown fruits
    home-grown vegetables
    fish from fishing
    game animals from hunting
	0
	0
	0
	0
		µg Pb/g
		µg Pb/g
		µg Pb/g
		µg Pb/g

Percent of food class:
    home-grown fruits
    home-grown vegetables
    fish from fishing
    game animals from hunting
	0
	0
	0
	0
		%
		%
		%
		%

Table 2–1. Default Values for IEUBKwin Model Parameters

Parameter	Default Value	Units
DATA ENTRY FOR DRINKING WATER		
Lead concentration in drinking water	4	µg/L

Ingestion rate
Age =   0-1 year (0-11 mo)
         1-2 years (12-23 mo)
         2-3 years (24-35 mo)
         3-4 years (36-47 mo)
         4-5 years (48-59 mo)
         5-6 years (60-71 mo)
         6-7 years (72-84 mo)
	0.20
	0.50
	0.52
	0.53
	0.55
	0.58
	0.59
		L/day
		L/day
		L/day
		L/day
		L/day
		L/day
		L/day

DATA ENTRY FOR ALTERNATE DRINKING WATER SOURCES		

Concentration
        first-draw water
        flushed water
        fountain water
	4
	1
	10
		µg/L
		µg/L
		µg/L

Percentage of total intake
        first-draw water
        flushed water
 	
        fountain water
	50
	100 minus first draw
	and fountain
	15
		%
		
		%

DATA ENTRY FOR SOIL/DUST (constant over time)		

Concentration (starting values to be modified using appropriate site data)
        soil
        dust
	200
	200
		µg/g
		µg/g

Soil/dust ingestion weighting factor (percent soil)	45	%
DATA ENTRY FOR SOIL/DUST INGESTION (by year)		

Soil/Dust ingestion
Age =   0-1 year (0-11 mo)
         1-2 years (12-23 mo)
         2-3 years (24-35 mo)
         3-4 years (36-47 mo)
         4-5 years (48-59 mo)
         5-6 years (60-71 mo)
         6-7 years (72-84 mo)
	0.085
	0.135
	0.135
	0.135
	0.100
	0.090
	0.085
		g/day
		g/day
		g/day
		g/day
		g/day
		g/day
		g/day

DATA ENTRY FOR SOIL/DUST MULTIPLE SOURCE ANALYSIS (constant over time)		
Fraction of indoor dust lead attributable to soil (MSD)	0.70	unitless
Ratio of dust lead concentration to outdoor air lead concentration	100	µg Pb/g dust per µg Pb/m^3 air

Table 2–1. Default Values for IEUBKwin Model Parameters

Parameter	Default Value	Units
DATA ENTRY FOR SOIL/DUST MULTIPLE SOURCE ANALYSIS WITH ALTERNATIVE HOUSEHOLD DUST LEAD SOURCES (constant over time)		
Concentration (starting values to be modified using appropriate site data)		
household dust (calculated value)	150	μg/g
secondary occupational dust	1,200	μg/g
school dust	200	μg/g
daycare center dust	200	μg/g
second home	200	μg/g
interior lead-based paint	1,200	μg/g
Percentage		
household dust (calculated value)	100 minus all other	%
secondary occupational dust	0	%
school dust	0	%
daycare center dust	0	%
second home	0	%
interior lead-based paint	0	%
BIOAVAILABILITY DATA ENTRY FOR ALL GUT ABSORPTION PATHWAYS		
Total lead absorption (at low intake)		
diet	50	%
drinking water	50	%
soil	30	%
dust	30	%
alternate source	0	%
Fraction of total net absorption at low intake rate that is attributable to non saturable (passive) processes.	0.2 u	nitless
DATA ENTRY FOR ALTERNATE SOURCES (by year)		
Total lead intake		
Age = 0-1 year (0-11 mo)	0	μg/day
1-2 years (12-23 mo)	0	μg/day
2-3 years (24-35 mo)	0	μg/day
3-4 years (36-47 mo)	0	μg/day
4-5 years (48-59 mo)	0	μg/day
5-6 years (60-71 mo)	0	μg/day
6-7 years (72-84 mo)	0	μg/day
DATA ENTRY MENU FOR MATERNAL-TO-NEWBORN LEAD EXPOSURE		
Mothers blood lead concentration at childbirth	1.0	μg/dL
DATA ENTRY MENU FOR PLOTTING AND RISK ESTIMATION		
Geometric standard deviation (GSD) for blood lead	1.6	unitless
Blood lead level of concern, or cutoff	10	μg/dL
COMPUTATION OPTIONS		
Iteration time step for numerical integration	4	h

2.2.1   Air Data

The *Air Data* option on the *Parameter Input* pull-down menu opens the *Air Data* input window. Model default values can be replaced with site-specific data for the following parameters:

- Indoor air Pb concentration as a percentage of outdoor air Pb concentration ($\mu g/m^3$)
- Outdoor air Pb concentration ($\mu g/m^3$)
- Time spent outdoors (hr/day)
- Ventilation rate (m^3/day)
- Lung absorption (%)

The default outdoor air Pb concentration is 0.1 $\mu g/m^3$. As a default, the model calculates indoor air Pb concentration as 30 percent of the outdoor air Pb concentration. Because the indoor air Pb concentration is treated as a fraction of outdoor concentration, the model does not allow a value greater than 100 percent to be entered in this field. If the user is working on a site where indoor air Pb concentration is in fact greater than the outdoor air Pb concentration, contact the TRW (see Section 1.2 for contact information). With the exception of the indoor air Pb concentration, the model allows the user to vary the value of each parameter by age.

2.2.2   Dietary Data

The *Dietary Data* input window includes information on that portion of total Pb intake which enters the body through the consumption of food. The default daily dietary Pb intake values for each age apply to a typical child in the United States. These estimates are derived based upon Food and Drug Administration (FDA) food monitoring data collected 1995-2003 (FDA, 2006).

The model also allows the user to directly alter the dietary lead intake amounts by age. If site-specific data suggest that default dietary intake rates differ due to the consumption of local produce, fish, or game animals, that information may be entered by answering <<YES>> to *Use Alternate Dietary Values?* in the *Dietary Data* input window. The value in the first column of the *Dietary Data* input window is the observed concentration of Pb in the local food item. The second column is the amount of food of a given type obtained from local sources, as a percent of total consumption of that food type. Alternate dietary data should <u>not</u> be used in combination with changes to default age-specific lead intake data. Local fish and game animal meat are part of the same "meat" category, and the percentage values for this food category may not be greater than 100. Home grown fruits and home grown vegetables are part of the "fruit and vegetable" category. Limitations on inputs for the "meat" or the "fruit and vegetable" category are explained in the <<?>> button for each input parameter. Additional guidance is available from the FAQs of the TRW website (http://www.epa.gov/superfund/lead).

2.2.3   Drinking Water Data

The *Drinking Water Data* input window is divided into two sections: water consumption rates and environmental concentrations. The default consumption rates are age-dependent and based on national averages. These consumption rates should be changed only when valid site-specific monitoring data is available. When entering a water Pb concentration, the user has two options: either use one concentration for all water sources (Option 1), or use source-dependent values (Option 2). Option 1 is selected by answering <<NO>> to *Use Alternate Water Values?* If the user elects Option 1, the user can either select the default value (4 µg/L) or change the water Pb default concentration to reflect conditions at the site. Option 2 is selected by answering <<YES>> to the *Use Alternate Water Values?* By selecting Option 2, the user can enter site-specific values for the following parameters:

- Percentage of total consumed as first draw (%) [default=50%]
- Concentration of lead in first draw (µg/L) [default=4 µg/L]
- Concentration of lead in flushed (µg/L) [default=1 µg/L]
- Percentage of total consumed from fountains (%) [default=15%]
- Concentration of lead in fountain water (µg/L) [default=10 µg/L]

Note that total water consumed is the sum of first draw, flushed, and fountain water.

2.2.4   Soil/Dust Data

Because soil and dust are often the primary sources of Pb exposure at a site, the *Soil/Dust Data* menu option is the most detailed and complex of the input windows. The first parameter that can be modified by the user is the *Soil/Dust Ingestion Weighting Factor*. This value represents the percentage of total soil/dust ingestion that is derived from soil and the percent that is derived from dust. The value in the parameter input window of the model is the percent from soil. The combined soil/dust ingestion weighting factor equals 100 percent.

- The *Soil/Dust Data* input window allows the user to adjust the rate at which a child ingests soil and dust. These values should only be adjusted if site-specific, technically-supportable data that are applicable to this parameter are available. The user should consult the Ingestion Rate short sheet that is available on the TRW website for further information concerning the use of site-specific soil ingestion values. (See Appendix C or [Short Sheet: IEUBK Model Soil/Dust Ingestion Rates, EPA #540-F-00-007, OSWER #9285.7-33, December 1999] http://www.epa.gov/superfund/lead)

2.2.4.1   Lead in Soil

When site-specific soil values are used, the TRW recommends replacing the default constant dust value (200 µg/g) with valid site-specific data. At a minimum, soil concentration data is needed to obtain modeling results that are predictive of site risks. If no valid site-specific dust data are available, it is strongly recommended that user use the Multiple Source Analysis (MSA)

option to estimate dust lead concentrations as a function of soil lead concentrations. This approach presumes, however, that there are not significant indoor sources of lead dust, *i.e.,* deteriorating lead-based paint.

When specifying a concentration of Pb in soil, the user has the following two options:

- Use an alternate site-specific constant value in place of the default value (200 µg/g). When the user inputs a constant value for soil (or dust), the value is applied to all age ranges. The 200 µg/g value, while serving as a plausible value for many urban settings, is not intended to be a substitute for site data.

- Use the *Variable Values* option to change the concentration of soil to which children are exposed by age. If the user chooses to enter a value instead of using the model default or a site-specific constant value across all age ranges, the user must select the *Variable Values* option and enter the new value into each age field.

2.2.4.2   *Lead in Dust*

By default, the IEUBK model defaults to *Multiple Source Analysis* because it assumes that site-specific dust concentrations are not measured and therefore, *Multiple Source Analysis* should be used to determine the appropriate dust concentration. If site-specific dust measurements are available, this information can be entered as a *Constant Value* or *Variable Values* (by age) before running the model by selecting the appropriate mode in the soil dust input window.

When specifying a concentration of Pb in dust, the user has the following three options:

- Use an alternate site-specific constant value in place of the default value (200 µg/g).

- Use the *Variable Values* option to change the concentration of dust that children are exposed to by age. If the user chooses to enter variable values instead of using the model default or a site-specific constant value, the user must select the *Variable Values* option and enter the new value into each age field.

- Use *Multiple Source Analysis* for dust concentrations. *Multiple Source Analysis* allows the use of information about the contribution of soil lead (PbS), air Pb, and other sources to derive a value for indoor dust lead (PbD). The data entry line in *Multiple Source Analysis* represents the contribution of Pb in soil to the concentration of Pb in indoor dust. If there were no other sources to contribute to indoor PbD (such as lead-based paint), this would be the ratio of the PbD concentration to the PbS concentration. As indicated in the IEUBK Guidance Manual (U.S. EPA, 1994), the default value of 0.70 is appropriate to neighborhoods or residences in which soil materials are available for contact and track-in into the house. In the absence of indoor sources of lead of established significance, the TRW recommends that the soil contribution to dust lead be evaluated by comparing the average or arithmetic mean of soil lead concentrations from a representative area in the child's yard, and an average of dust lead concentrations from representative areas frequented by children

inside the house. There are complicated statistical and practical matters involved in evaluating this parameter. See the TRW short sheet on MSD, available from the TRW website. (See Appendix C or [Short Sheet: IEUBK Model Mass Fraction of Soil in Indoor Dust (M_{SD}) Variable, EPA #540-F-00-008, OSWER #9285.7-34, June 1998] http://www.epa.gov/superfund/lead).

The second data entry line is the contribution to indoor dust from the deposition of airborne Pb, over and above the PbS contribution. The current default value is an additive increment of 100 µg/g Pb in house dust for each µg Pb/m³ air.

The final set of inputs allows the user to consider additional sources of indoor dust by entering data into the *Indoor Dust Lead Sources* portion of the MSA screen. The user has the option to enter a concentration and the fraction of dust intake to baseline indoor dust; secondary occupational dust; dust at school, daycare or second home; and the exposure to Pb in dust from household paint measured as a percentage of total dust ingestion and concentration.

The sum of all these alternate source percentages may not be greater than 100. The model will automatically adjust the indoor dust percentage so that the sum of all sources is 100. When all the alternate source data have been entered, the model will calculate the *Multiple Source Average* concentration and display it in the *Soil/Dust Data* window.

2.2.5 Maternal Data

The *Maternal Data* input window, on the *Parameter Input* pull-down menu, allows the user to consider the impact of Pb transferred from the mother to the fetus *in utero*. The Pb that is stored in the tissues of the newborn child is calculated by entering the maternal PbB value at the time of delivery (default = 1.0 µg/dL). The empirical validation effort for the IEUBK model did not include data specific to the disposition of maternally supplied lead in a young child, and model predictions in this regard should be interpreted with caution.

2.2.6 Alternate Source Data

The *Alternate Source Data* input window, on the *Parameter Input* pull-down menu, allows the user to input Pb concentrations from sources that are not covered under other menus in the model. Examples include the direct ingestion of lead-based paint and the use of cosmetics or home remedies. In cases where alternate sources exist, the intake of Pb (µg/day) must be calculated from the site-specific data available. If the alternate source is lead-based paint, this exposure is *in addition to* exposure to lead-based paint in house dust, which is covered in the *Multiple Source Analysis* input window on the *Soil/Dust Data* option. If values are entered in the *Alternate Source Data* input window, then the *Total Percent Accessible for Alternate* must be changed in the *GI/Bioavailability* input window on the *Parameter Input* pull-down menu (see Section 2.2.7).

Building an exposure scenario using the *Alternate Source Data* should be done with care. The model assumes all entries represent <u>chronic exposure</u>. Remember that the model's output represents only those children defined by the exposure scenario.

2.2.7   GI Values/Bioavailability

The GI Values/Bioavailability option on the Parameter Input pull-down menu allows the user to make adjustments to the gastrointestinal absorption coefficient to account for site-specific information on bioavailability. If this option is selected, a disclaimer window appears which indicates that the user should only change default values if alternative bioavailability information is available. Relative bioavailability is indexed by measuring the bioavailability of a particular substance relative to the bioavailability of a standardized reference material, such as soluble lead acetate. For the IEUBK model, soluble lead in water and food is estimated to have 50 percent absolute bioavailability based on the bioavailability of soluble lead acetate.

Relative bioavailability is indexed by measuring the bioavailability of a particular substance relative to the bioavailability of a standardized reference material, such as soluble lead acetate. For the IEUBK model, soluble lead in water and food is estimated to have 50 percent absolute bioavailability based on the bioavailability of soluble lead acetate. Furthermore, qualitative estimates of relative bioavailability can be made in the uncertainty section of a risk assessment.

After selecting «OK», the *GI Values/Bioavailability Information* input window appears. The TRW recommends not changing the bioavailability default without a thorough understanding of the absorption methodology. Additional guidance on bioavailability is available from the TRW website. (See Appendix C or [Short Sheet: IEUBK Model Bioavailability Variable, EPA #540-F-00-006, OSWER #9285.7-32] http://www.epa.gov/superfund/lead).

2.2.8   Geometric Standard Deviation (GSD)

Geometric Standard Deviation (GSD) is a measure of the relative variability in PbB of a child of a specified age, or children from a hypothetical population whose Pb exposures are known. The GSD in IEUBKwin encompasses biological and behavioral differences, measurement variability from repeat sampling, variability as a result of sample locations, and analytical variability. The default value of 1.6 is recommended. This GSD value is based on specific analyses of data from several neighborhoods with paired data for environmental Pb concentration and measured PbB levels. The TRW recommends that site-specific estimates of GSD not be substituted for the default value without detailed, scientifically defensible studies documenting site-specific differences in child behavior or Pb kinetics. Should the user decide to modify the GSD, IEUBKwin currently accepts values within the range of 1.3 to 1.8 for the GSD based on results of site-specific data. If the user enters values outside of this range, a warning screen will appear telling the user to select a different value. A GSD short sheet is currently under development and will be available at the TRW website upon completion. Additional guidance is available through the FAQ *How can I derive a site-specific geometric standard deviation (GSD)?* on the TRW website (http://www.epa.gov/superfund/lead).

2.3 SAVE AND LOAD INPUT PARAMETERS

If the user wishes to retain the current set of model input parameters (media concentrations, intake rates, and bioavailability values) as the starting point for another analysis, the data can be saved using the «Save Input to File» command on the *Parameter Input* pull-down menu. The user may create a filename (eight characters or shorter), which will be stored in the form [NAME].svd. It should be noted that, the IEUBKwin model has a 16-bit dynamic library, and is not a full 32-bit application, and therefore does not support long filenames. The model also uses a directory structure such that the user may specify the location of the saved input file; by default the model will save the input file in the *IEUBKwin* subfolder under the *Programs* directory which is where all file types (*i.e.,* input files, results files) are stored unless otherwise specified by the user. Saved parameter data can be loaded using the «Load Input from a File» command found on the *Parameter Input* pull-down menu. It should be noted that, if the user loads a saved text input file, the same checks will be performed by the model to determine the appropriateness of the input values as when the user enters input values from the model input modules. The model does not read tab or comma-delimited batch mode files.

3.0 Model Analysis

This section describes the types of analyses that can be run with IEUBKwin. Further discussion can be found in the IEUBK Guidance Manual (U.S. EPA, 1994).

3.1 OPTIONS FOR MODEL ANALYSES

Effective use of IEUBKwin requires entering data that are appropriate to the site(s), parameter(s), and subject(s). The most convenient way to accomplish this is to construct a multi-media, site-specific exposure scenario. The user should be aware that a site-specific risk assessment requires site-specific soil concentrations which may be augmented by site-specific data for dust, air, food, and other adjustable defaults.

The use of site-specific data is recommended to tailor the exposure to the conditions at the site. Site-specific data are most commonly used in place of the model default values for Pb concentrations in soil, dust, air, and water. Site-specific data for locally caught fish or home-grown vegetables are sometimes used to augment dietary default values. However, such data should be evaluated for validity prior to use. Model default values should only be replaced when site-specific data specific to the parameters are more representative. IEUBKwin default values should never be adjusted simply to attain a better match between modeled and empirical PbB concentrations.

Prior to using IEUBKwin to calculate PbB levels, the user should decide what type of analysis should be run: single simulation run, multiple simulation run, or batch mode. Each of these is appropriate for certain scenarios, and inappropriate for others. A single simulation allows the user to run scenarios for a single location, or multiple locations with homogenous media concentrations (Categories A and B of Figure 2-1, Section 2.0). By contrast, multiple runs allow the user to specify a range Pb concentrations for a specific environmental media and obtain results of model runs at multiple points within that range. Batch mode allows the user to run input data for many locations having different media concentrations in a single run of the model. Additionally, batch mode allows the use of different ages or different values for Pb concentration in soil, dust, water, air, and alternate Pb sources for each exposure scenario. The media intake and absorption parameters are the same for every exposure scenario in a batch mode run and must be specified before using the *Run Batch Mode Model* option, unless default values are used. Output options for results from Single, Multiple, and Batch Mode runs are presented below.

3.2 OVERVIEW OF MODEL OUTPUT

IEUBKwin can calculate four primary outputs:
- Geometric mean PbB levels, by age
- Percent of children with PbB in excess of a user-specified level of concern (typically 10 µg/dL)
- Average media-specific daily Pb uptake rates
- Media-specific remediation goals

The output data can be saved and presented in tables, graphs, or text files. By default, the model will generate a text file of the output unless otherwise specified by the user prior to running the model. Screen captures of graphs (for use in technical reports) can be performed by applying the *Print Screen* feature available on most PC keyboards, re-sizing the image to the appropriate dimensions, and exporting the image to the desired application (*e.g.,* Corel WordPerfect or Microsoft Word). While printed tables and graphs allow convenient documentation of IEUBKwin results in risk assessments, text files can also be exported to most statistical software packages for additional analysis. The appropriate procedures to follow when exporting output data to Lotus 1-2-3 or Microsoft Excel are described in Appendix A.

3.3 SELECTING OUTPUT ALTERNATIVES

Results of IEUBKwin simulations may be saved in several forms. The user should select the most useful forms in advance, because the results of some interactive simulations cannot be recovered without repeating the analysis once the user has bypassed the opportunity to save the results.

3.3.1   What Graphical Options are Included in IEUBKwin?

IEUBKwin incorporates some output options that facilitate presentation risk assessment results. The graphical output choices in the IEUBKwin *Graph* pull-down menu include the following choices:
- PbB concentration *vs.* media Pb concentration
- Distribution probability percent
- Distribution probability density
- Distribution probability for multiple runs
- Probability density for multiple runs

Some plots may be used for single runs, while others are applicable for multiple runs. These plots present estimates of a plausible distribution of PbB levels that are centered on the calculated geometric mean blood lead. To derive the distribution around the geometric mean, IEUBKwin uses a geometric standard deviation–a value describing the spread around the geometric mean PbB. From this distribution, IEUBKwin calculates the probability that a child's PbB will exceed a user-selected PbB level of concern (typically 10 µg/dL) according to the equation $z = (\ln(10) - \ln(GM)/\ln(GSD)$. For more information see Appendix B.

As discussed above, the GSD is a measure of relative variability in PbB levels of children of a specific age or a hypothetical population of children whose Pb exposure is known. The GSD in IEUBKwin encompasses biological and behavioral differences, measurement variability from repeat sampling, variability as a result of sample locations, and analytical variability. The default value of 1.6 is recommended. Figure 3-1 illustrates the impact of the relative positions of the level of concern (LOC) and the geometric mean (GM) on the proportion of children "at risk" for two populations with different GSDs. If LOC>GM, then the area for children at risk (shaded plus solid) for GSD=1.7 is greater than the area (solid) for GSD=1.4. In situations where the

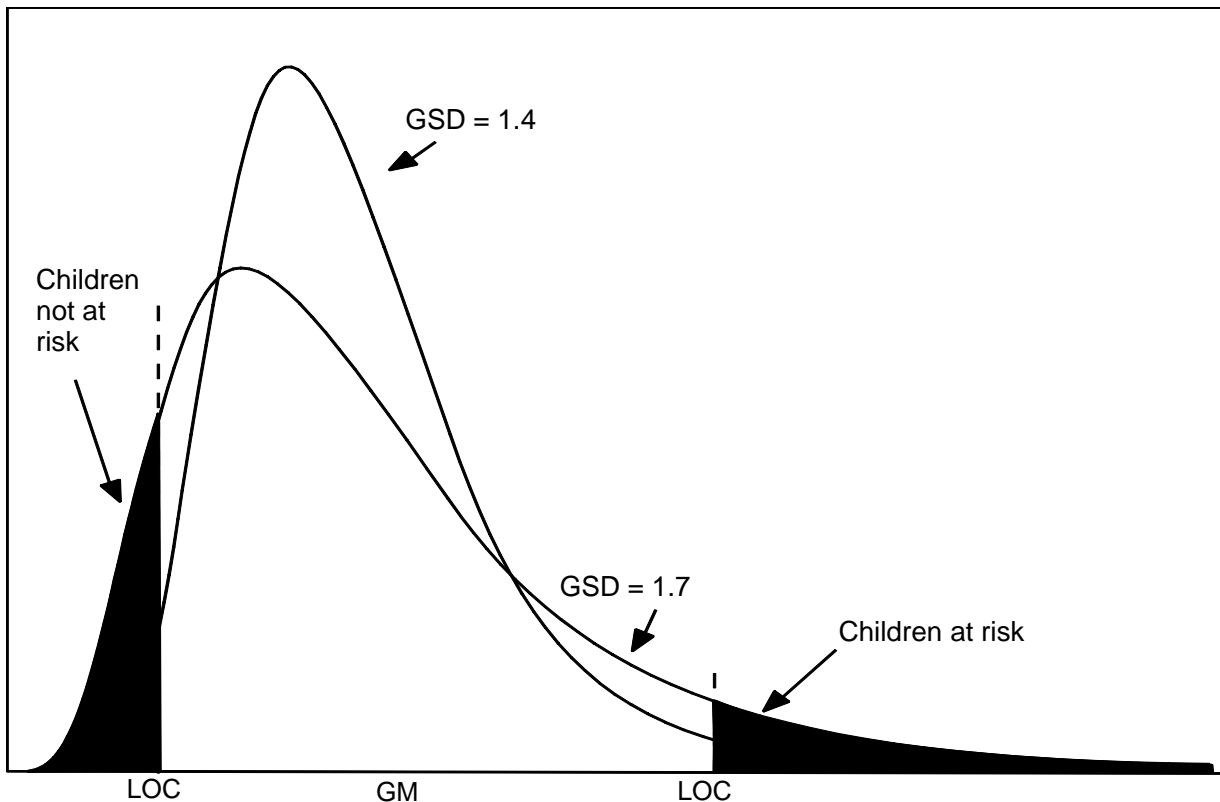typical GM blood lead concentrations are predicted to be higher than the LOC, the graph would look different.

Figure 3-1. The Impact of GSD on Plausible Geometric Mean PbB Distributions.

If LOC<GSD, then the area for children *not* at risk (shaded plus solid in lower tail) for GSD=1.7 is larger than the area for children not at risk (solid in lower tail) for GSD=1.4. While this might at first appear to suggest that risks are lower in this case with a higher GSD, the user should note that the graph with the high GSD also indicates an increased risk of even higher blood lead levels at values in excess of the LOC. Both distributions presented in the figure are based on the same data set.

3.4 COMPUTATION OPTIONS

3.4.1 Run a Single Simulation

This option uses only the currently loaded parameter set (the default values and site-specific data specified by the user). After the user selects *Run the Model (Single Run)* from the *Computation* pull-down menu, the model prompts the user to choose a time step for numerical iteration. This is a technical matter which does not usually need to be changed from the default. The default time step is 4 hours. The time step does not determine the averaging time used to define average daily intakes of lead. The time step is used in the biokinetic component of the model in

combination with compartmental transfer times to calculate the distribution of lead among bodily tissues.

If you want to save the results for reference or further analysis, the user can assign a unique file name, otherwise the default file name will be assigned. If you want to analyze the data using a spreadsheet, checking this box will save the data in a tab-delimited format for import into a statistical software package or spreadsheet program (see details in Appendix A).

3.4.1.1   Single-Run Options

Single-run plotting options in IEUBKwin include the following:

- The average of the geometric mean PbB concentrations for children in sequential 1-year age intervals, the input concentrations for several media, and the media-specific daily Pb uptake for each year are saved internally. The output file that is automatically generated is RunModel.txt.

- Plotting the cumulative probability distribution for exceeding any user-specified PbB level of concern for a single exposure scenario (Option 2—*Distribution Probability Percent*). This is sometimes called the exceedance probability distribution.

- Plotting the log-normal probability density function of PbB levels for a single exposure scenario predicting geometric mean PbB (Option 3—*Distribution Probability Density*).

The probability density function gives users a better idea of the spread of PbB levels for children exposed to a single set of environmental Pb concentrations. The plot of the exceedance probability distribution also shows the fraction of children above a PbB level of concern for the single-exposure case (*e.g.,* what fractions of children are above 10 μg/dL). The user may print the probability plots after viewing. The single-run media plots are saved as [name].GRF. If saved, these graphs may be viewed at a later date using the *Graph* pull down menu.

3.4.2   Calculating a Blood Lead Concentration Associated with Media-Specific Concentration

The user may select *Find Blood Pb Concentration* from the *Computation* pull-down menu and enter a known media lead concentration to determine the predicted concentration of lead in blood associated with that media concentration.

This module generates a plot of the relationship between blood lead concentration and the exposure to lead in a specific, user-selected, environmental medium (*e.g.*, soil, dust, drinking water, air, or diet). The module can be used to explore the sensitivity of the predicted blood lead concentration to assumptions about exposures to lead in specific media. The module can also be used to explore the sensitivity to other exposure assumptions. For example, the effect of

alternative assumptions regarding the soil lead absorption fraction can be explored by comparing plots of blood lead concentration vs soil lead concentration, when different values for the lead absorption fraction are assumed.

3.4.3   Run Multiple Simulations

This option uses the currently loaded parameter set (default values and site-specific data specified by the user) but repeats the run for either a range of concentrations for a user-specified medium. To conduct this simulation run, select the medium, the range of values for that medium, and the number of time steps for numerical iteration. With Multiple Runs the user can determine PbB concentration by age group based on a range of media Pb concentrations and can search for the medium Pb concentration associated with an age-specified PbB concentration.

3.4.3.1   Multiple-Run Options

IEUBKwin has additional features that allow the user to combine output from several runs onto single plots. These multiple-run options include both blood lead concentration vs. media lead concentration plots and a sequence of graphics-overlay simulation runs (multiple runs) as described below. For both of these options, the media range option saves input data for geometric mean PbB *vs.* media Pb plots for a range of evenly spaced media Pb concentrations. For example, the user may generate plots of PbB *vs.* PbS concentrations smoothly interpolated from calculated values at 250, 500, 750, and 1,000 µg/g for children aged 12 to 24 months. Results are saved as filename [name].LIN. The data in the [name].LAY overlay file include the geometric mean PbB for children in the age range, and the Pb concentration in soil and other media. The actual plots of probability density or cumulative distribution functions depend on the GSD value selected for use in risk estimates, and these plots can be printed. While this option is useful in recognizing the pattern between increasing media concentrations and increasing blood lead levels, the results are not intended to directly support risk-based decisions. These graphs show the predicted geometric mean blood lead levels, and not the probability of exceeding 10 µg/dL as a risk criterion in EPA's risk management guidance for lead.

- Geometric mean blood lead concentration vs. media lead concentration graph, where each run increases the Pb concentration in a specified medium by a user-defined amount across a range (Option 1—*Distribution Probability for Multiple Runs*).

- Overlaid plots of the cumulative exceedance probability distributions of PbB levels for multiple media concentrations, where each run increases the Pb concentration in a specified medium by a user-defined amount (Option 4—*Distribution Probability for Multiple Runs*).

- Overlaid plots of the log-normal probability density functions of PbB levels for multiple exposure scenarios, where each run increases the Pb concentration in a specified medium by a user-defined amount (Option 5—*Probability Density for Multiple Runs*).

Overlaid plots cannot be used unless the user has previously created an output file from the *Computation* menu, with the file extension *.LAY. The overlaid probability density functions give most users a better idea of how the probability of exceeding a PbB level of concern increases with each incremental increase in environmental lead. The exceedance probability distributions may be used to estimate the increases in the fraction of elevated PbB levels or to visually estimate the environmental Pb levels corresponding to a specified fraction of unprotected children above the level of concern.

3.4.4 Run Batch Mode Simulation

The input data file for a batch run must be created outside of IEUBKwin using any text editor (*e.g.*, Notepad). The following conventions must be observed in creating the batch file:

- The input data file must be an ASCII file with no special characters. The model does not read tab or comma-delimited batch mode files.

- The data set must have a DAT extension (*i.e.,* [name].dat).

- The first three lines of the input data file can be any identifiers that the user may require; usually the first line is the run name, the second line is the modeling options used in the run, and the third line consists of the headers for variables in the data set.

- The data fields are entered format-free, although the use of regular spacing and alignment of decimal points are recommended to improve readability.

- The maximum width is 8 spaces per column.

- The variable values should be separated by spaces.

- For quicker runs, the recommended limit is 500 rows of data.

- The missing values must be shown by a single decimal point.

- Each line in the input data file must contain data or blank values for missing data for the following 10 variables:

1. Child identifier code
2. Family or residence unit identifier code
3. Area or neighborhood identifier code
4. Child's age in months
5. PbS concentration in µg/g

6. PbD concentration in µg/g
7. Drinking water Pb concentration in µg/L*
8. Air Pb concentration in µg/m^3*
9. Daily intake of Pb from "alternate" sources in µg Pb/g
10. Observed child PbB level in µg/dL*

Any of these (*) may be left blank by just placing a period in the middle of the data column. There is no need for PbB values, since the model can calculate risk for a group of locations or

residences. For many users the easiest way to create a batch mode input file is to use a spreadsheet (see Appendix A). As noted above, the child's age (in months) must be entered. The media concentrations for water and air from the parameter input windows will be entered if values for these media are missing. Either a PbS concentration or a PbD value is needed for the simulation, along with a stand-in value (imputation rule) if one is missing (*e.g.*, if the user does not fill in PbD values, the current default is to replace a missing PbD concentration with the PbS concentration). The user may prefer to create an input data file with missing PbD concentrations replaced by some fraction of the PbS concentration.

Note that IEUBKwin considers only two significant digits (to the right of the decimal point) from the data input file for running batch mode; however, the model uses double precision (eight digits) in all its calculations. In the current stand alone version, IEUBKwin is not capable of executing consecutive batch mode files from a list of files.

The batch mode option can be used to develop estimates for statistical analyses of simulated community PbB distributions with or without observed PbB levels. When PbB data are available, batch mode also provides a tool for developing empirical comparisons of the model predictions and measured blood lead concentrations.

Output consists of files [name].TXT that contain predicted PbB concentrations for each case or record (child) in the input data file. The output files also document the missing value imputations when some of the input data on residential media Pb concentrations are missing. The files may be used as input for statistical analysis in other software programs (see Appendix A).

A feature that is new to the 32-bit version allows for processing of multiple batch mode input files. The Batch Run Dialog includes a list box, which will list the batch input data files available for processing. The user may add or remove files from the queue. The results are written to a single file BATCHRUN.TXT (unless another file name is specified). Each input file is processed sequentially, and the results appended to the results file below the previous run. Results are identified by repeating the header, which identifies the input file name.

Additional guidance on Batch Mode inputs and use is available in the FAQs on the TRW website. (http://www.epa.gov/superfund/lead)

4.0 Interpretation of Results

4.1 UNDERSTANDING THE OUTPUT

Each of the output options described above allows the user to examine a different aspect of IEUBKwin simulation. The output from a single simulation run may be displayed in several forms. Most users wish to see the variability associated with a predicted PbB concentration. This range can be demonstrated graphically by selecting the intrinsic variability GSD, and then plotting a cumulative probability distribution. The range of plausible PbB values may be determined graphically as defined by upper and lower percentiles of the distribution. For example, the 5th and 95th percentiles of the distribution will include 90 percent of the children with the given site-specific or household-specific exposure scenario. Note that the plausible range reflects predicted variability among individuals with the same exposure scenario, and should not be confused with a statistical confidence limit (which is a measure of statistical uncertainty in a predicted value such as a geometric mean).

The other output characteristic that many users wish to see is the estimated probability of exceeding the specified PbB level of concern, corresponding to the given exposure scenario or scenarios (for multiple runs in a given medium). According to the IEUBK Guidance Manual (U.S. EPA, 1994), there are two valid interpretations for this output:

1. The output of the model may be considered to be the best estimate of a plausible range of PbB concentrations for a hypothetical child under a specific Pb exposure scenario. The range of values is centered on the geometric mean PbB concentration expected for a typical child with this exposure scenario. The portion of the upper tail of the probability distribution exceeding some chosen PbB level of concern provides an estimate of the risk of exceeding that level for a typical child of that age residing in the same household and with the same exposure history.

2. The output of the model may also be considered to be the predicted geometric mean PbB of a *population* of children under the same Pb exposure scenario. That portion of the upper tail that exceeds some chosen PbB level of concern indicates the fraction of the population exceeding that level when all of these children have the same exposure history.

A common misinterpretation of IEUBKwin is that it predicts *community* geometric mean PbB and the fraction of the population of children at risk when the input is the mean or geometric mean of household-specific environmental Pb concentrations. That misinterpretation arises, particularly when the environmental variables have a wide distribution among the neighborhoods of the community. A correct approach requires applying the model to each individual home (or area with homogeneous lead concentrations) and combining these results as an aggregate to form an estimate of neighborhood or community risk.

It should be noted that the user may experience some discrepancies in the appearance of the graphs produced with IEUBKwin as a result of the limitations of Visual Basic C++, the

programming tool used to develop the model. Specifically, scientific notation is used for values less than 0.01 (*e.g.,* 10^{-2}) on graphical outputs; however, improper formatting of the scientific notation occurs as a result of the Visual Basic C++ programming functions and cannot be corrected. This discrepancy should be eliminated in future versions of the model, and currently does not functionally impede upon the user's ability to read and interpret graphs.

The National Contingency Plan[2] states that the Superfund process for establishing cleanup numbers for contaminated sites consider nine criteria concerning risks associated with remedial alternatives analysis that apply to. The nine criteria are as follows:

Prim   ary Criteria
1. Overall protection of human health and the environment
2. Compliance with applicable or relevant and appropriate standards, limitations, criteria, and requirements (ARARs)

Balancing   Criteria
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility and volume
5. Short-term effectiveness
6. Implementability
7. Cost

Modifying   Criteria
8. State acceptance
9. Community acceptance

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[2]For more information, see 40CFR §300.430.

5.0 Model Application and Documentation

The output of IEUBKwin helps users develop an understanding of the potential risk for elevated PbB levels in children. Through different model run scenarios, these potential risks can be calculated for a number of different hypothetical situations, including risks for a single child, a group of neighborhood children, or an entire community. With proper application and documentation, IEUBKwin can effectively and accurately predict the risks at lead-contaminated sites.

5.1 MODEL APPLICATION

IEUBKwin is designed to facilitate two processes: rapid delineation of the relationship between environmental Pb and PbB in children and calculation of their risk of elevated PbB *(i.e.*, the probability that a given child or group of children will have PbB concentrations exceeding a specified level of concern). As such, IEUBKwin provides a tool for site-specific risk assessment for young children exposed to Pb from different media and through different pathways in their environment. The intended applications of IEUBKwin are to:

- Provide a summary of children's long-term, primary residential exposure to lead.

- Provide a best estimate of the geometric mean PbB concentration for a typical child, aged 6 months to 84 months, assumed to reside at a given residence.

- Provide a basis for estimating the risk of elevated PbB *(i.e.,* for exceeding a designated PbB concentration of concern) for a hypothetical child of specified age with a given site-specific residential Pb exposure.

- Provide a basis for estimating the risk of elevated PbB concentrations among populations of children under age 7 in a given neighborhood by aggregating the individual residential risk estimates.

- Predict likely changes in risk of elevated PbB concentrations from exposure to soil, dust, water, or air Pb following abatement actions designed to reduce exposure levels from one or more environmental media.

- Provide assistance in determining appropriate soil or dust Pb target cleanup levels at specific residential sites.

- Provide assistance in estimating PbB concentrations associated with soil or dust Pb concentrations at undeveloped residential sites that may be developed in the future.

EPA has established default values for all of the user-specified parameters in IEUBKwin. Use of the default parameters is recommended unless valid site-specific monitoring data exist to define values that are higher or lower. Site-specific data are commonly used in place of the model default values for Pb concentrations in soil, dust, air, and water. However, for intake rates,

bioavailability and PbB distribution parameters, the TRW recommends that the default values be used, unless accompanied by strong evidence supporting the use of site-specific values. Model default values should never be adjusted simply to attain a better match between modeled and empirical blood lead. Information on situations where it might not be advisable to use the IEUBK model can be found in the IEUBK Guidance Manual (U.S. EPA, 1994) and Section 2.0 of this manual.

5.2 MODEL DOCUMENTATION (MINIMUM REQUIREMENTS)

By reviewing every adjustable parameter in the model and noting which ones have been modified in a particular run, the user has a permanent record of the input. The data used in the model runs should be saved so the results can be reproduced. Different levels of documentation are required for specific applications of the model. The text of risk assessments should contain a full discussion describing the inputs, use, and outputs of the model. Any model output referenced should be included in appendices of the risk assessment, including distribution and density curves, text outputs, and batch mode files. A listing of model inputs should be included in the text or as an appendix to the risk assessment. IEUBKwin captures data and comments in the risk assessment mode in a tabular format. This information can be exported to a spreadsheet application (*e.g.,* Lotus 1-2-3, Microsoft Excel) for submission to EPA (see Appendix A).

5.3 USER RESPONSIBILITIES

The user is responsible for using model input parameters that are appropriate to the site. Generally the minimum site-specific data collection and analyses include, but are not necessarily limited to, collection of an adequate number of representative soil and dust samples, and determination of the Pb concentrations and physical or chemical properties that affect transport and bioavailability. The typical input data include a multimedia household environmental Pb study that includes soil, dust, paint, water, and air; information on Pb exposures outside a child's home; information on family demographics and child behavior patterns in the community that may affect access to Pb sources; and characterization of physical and chemical properties that affect bioaccessibility and bioavailability.

6.0 Example Scenarios

This section presents examples and results obtained from reasonably straight-forward applications of IEUBKwin. The first part of this section presents results obtained for single runs of the model, when only soil, dust, and water lead concentrations are entered into the model. Additional examples cover the sum of the individual risks approach, and the assessment of risk using grouped data for a neighborhood. These examples are relatively simple and are intended to cover the most common applications of IEUBKwin. Several additional examples, some more complex in nature, are presented for the user in the IEUBK Guidance Manual (U.S. EPA, 1994).

6.1 SIMPLE CASE SINGLE RUNS

If the model is run using the following inputs, the user should calculate the following outputs for children aged 0 to 84 months. These data can be used as a quick test of the model.

Table 6–1. Simple Case Runs

	Input Parameters					Output Parameters	
	Soil (mg/kg)	Dust (mg/kg)	Water (µg/L)	Age (months)	All other inputs	Geometric mean (µg/dL)	% Above 10 µg/dL
Run 1	Default Defa	ult	Default	0-84	Default 2.	7	0.287
Run 2	500	500	Default	0-84	Default	6.0	13.899
Run 3	500	500	50	0-84	Default	8.8	39.572
Run 4	1,000	1,000	Default	0-84	Default	10.2	51.496
Run 5	1,000	1,000	50	0-84	Default	12.6	68.553

6.2 "SUM OF INDIVIDUAL RISKS" APPROACH

Suppose that there are data on four households with children in a neighborhood. Residents of each household are exposed to lead-contaminated soil. The first house has 250 µg/g Pb in soil, the second house has 250 µg/g, the third house has 1,000 µg/g, and the fourth house has 1,000 µg/g. Dust lead (PbD) concentrations are assumed to be 70 percent of the PbS concentration in houses 2 and 4, and 15 percent of the PbS concentration in houses 1 and 3. As an estimate of air Pb contribution to PbD at 0.1 µg Pb/m^3, 10 µg/g was added to PbD. The respective PbD concentrations are 47.5 µg/g, 185 µg/g, 160 µg/g, and 710 µg/g. All other parameters are set to default values.

The samples are assumed to be representative of the exposure distribution in the neighborhood. The selection of four houses is for illustration purposes only. The risk estimates are intended to be unbiased estimates of potential risk for other years in which different children, not in the current sample, may occupy the same or other houses in the neighborhood. Obviously, a reliable

estimate of neighborhood risk will require more than four houses. The probability density of PbB for the four houses is shown in Figure 6-1 and the interpreted results in Table 6-2.
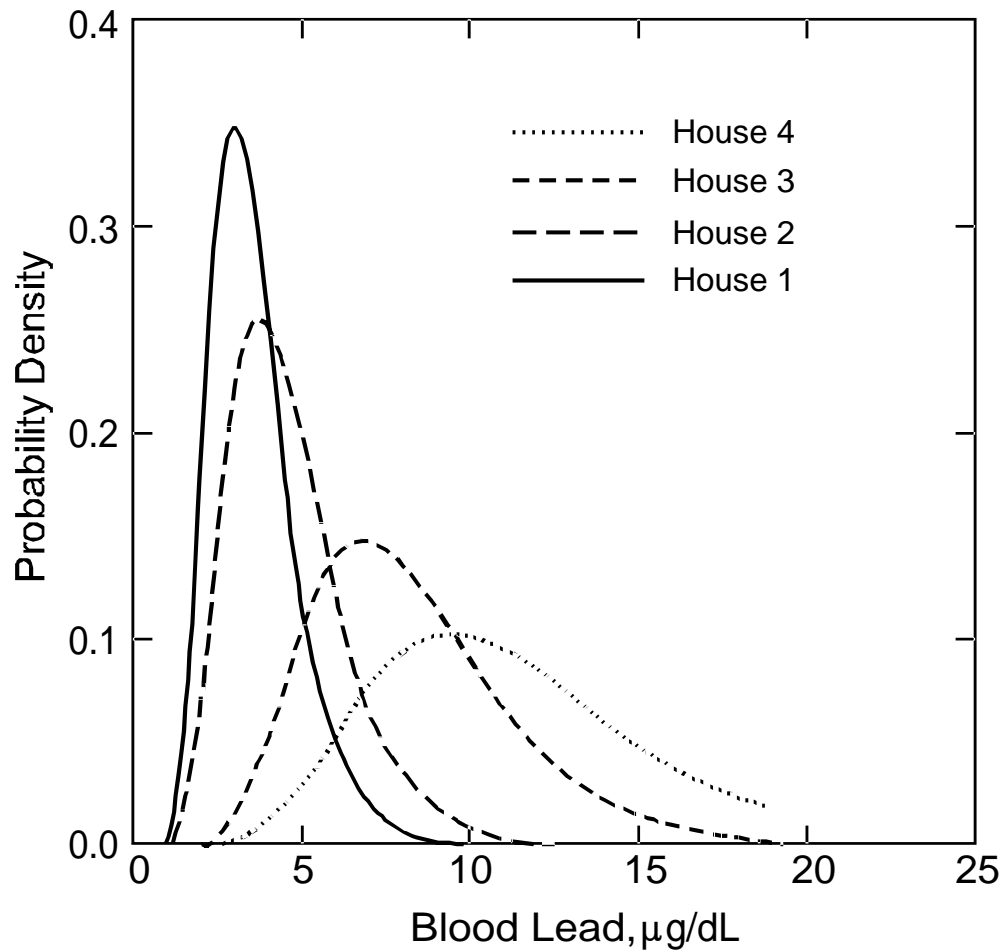

Figure 6-1. Hypothetical Probability Density of Blood Lead in Houses 1 to 4.

Table 6–2. Interpreted Results for Figure 6–1

House number	PbS concentration (μg/g)	PbD concentration (μg/g)	Probability of exceeding 10 μg/dL
1	250	47.5[a] 0.	106
2	250	185[b] 0.	736
3	1,000	160[a] 1	6.729
4	1,000	710[b] 4	0.534
Risk from all houses 1-4			**58.105**

[a] Calculated using multiple source analysis and an MSD of 0.15
[b] Calculated using multiple source analysis and an MSD of 0.70

The sum of the risks for these four houses 0.106% + 0.736% + 16.729% + 40.534% = 58.105%. That is, 0.581 children are expected to have PbB concentrations exceeding 10 μg/dL, or an average risk for a child living in this neighborhood would be 58.1%/4=14.5%. The risk at two of the residences (houses 3 and 4) in the neighborhood is above the OSWER specified level of protectiveness which aims to limit exposure to PbS levels such that a typical child or a group of similarly exposed children would have an estimated risk of no more than 5 percent exceeding the PbB level of concern (typically 10 μg/dL).

The use of aggregate neighborhood input data requires that the user compare the probability density function (PDF) and elevated PbB risk calculated from aggregate parameters with the correct PDF and elevated PbB risk functions, which are the mathematical composites of the individual PDF and risk functions. Expressed mathematically:

true neighborhood PDF = (PDF(site 1) + PDF(site 2) +...)/N   (Equation 6-1)
true neighborhood risk = (risk(site 1) + risk(site 2) +...)/N   (Equation 6-2)

The approach outlined here does not require any mathematical assumptions about the distribution of soil and dust Pb concentrations, nor of any other parameters or variables except for PbB. The conditional distribution of individual PbB is assumed to be log-normal with a constant GSD (given specified values of Pb exposure variables that determine the geometric mean PbB for individuals in that exact environment). The method suggested is the most convenient and flexible framework determined for neighborhood assessment concerning the effect of PbS abatement.

6.3   RISK ASSESSMENT USING GROUPED DATA FOR A NEIGHBORHOOD

The example in the preceding section had a "neighborhood" with only four houses, so that the amount of work required was not very burdensome. In the real world, the site manager or risk assessor may be dealing with relatively homogeneous neighborhoods or small communities with several hundred households. These calculations can be simplified by grouping soil and dust lead levels into small cells with fixed ranges of values. The grouped data within each cell are all assigned the same value, such as the midpoint of the interval.

Each cell is then assigned a statistical weight. The statistical weights could be one or more of the following:

1. The number of housing units with soil and dust lead concentrations in the interval.

2. The number of children observed or expected to live in housing units with soil and dust lead concentrations in the interval.

3. The fraction of housing in a neighborhood that is expected to have soil and dust lead concentrations in the interval.

4. The fraction of area in as yet undeveloped neighborhoods with soil and dust lead concentrations in the interval.

The PDF and risk of elevated PbB in children reflects the weighted sum of the cell PDF or cell risks. If the respective weights are denoted weight (cell 1), weight (cell 2), *etc.,* and the PDFs are denoted PDF (cell 1), PDF (cell 2), *etc.,* and the risks are denoted risk (cell 1), risk (cell 2), *etc.,* then:

neighborhood PDF = [weight (cell 1) * PDF (cell 1) + weight (cell 2) *
PDF (cell 2) + etc.] / [weight (cell 1) + weight (cell 2) + etc.]   (Equation 6-3)

neighborhood risk = [weight (cell 1) * risk (cell 1) + weight call (cell 2) *
risk (cell 2) + etc.] / [weight (cell 1) + weight (cell 2) + etc.]   (Equation 6-4)

The following hypothetical example may illustrate these points. Suppose that a random sample of 250 houses and apartments has been obtained in a neighborhood. The number of houses in each interval of 250 µg/g soil and 250 µg/g dust lead is shown in Table 6-3. This same example is shown in Table 6-4 in intervals of 500 µg/g in soil and 500 µg/g in dust. There is no requirement that there be equal interval lengths in either soil or dust.

The user may then calculate neighborhood risk in any one of three ways:
- Sum of risks for 250 housing units
- Sum of risks for 14 cells or groups of width 250 µg/g soil and dust
- Sum of risks for seven cells or groups of width 500 µg/g in soil and dust

The results of calculations are shown in Tables 6-3 and 6-4. The total risk for the data shown in Table 6-3 is calculated as follows:

(30 * 0.0.065% + 50 * 1.680% + 20 * 7.360% + 10 * 1.127% + 40 * 6.005% + 30 *
14.814% + 20 * 25.597% + 10 * 13.001% + 20 * 23.582% + 10 * 34.585% + 3 *
44.829% + 4 * 52.278% + 1 * 72.123% + 2 * 65.597%)/250 = 11.74%   (Equation 6-5)

The risk calculation for the data in Table 6-4 is similar.

The total risk in Table 6-4 is calculated as follows:

(130 * 1.386% + 70 * 15.745% + 10 * 12.123% + 30 * 33.604% + 7 * 53.049% + 1 *
67.238% + 2 * 65.031%)/250 = 11.92%   (Equation 6-6)

If there are not too many cells, the amount of calculation can be noticeably reduced. However, as the intervals are made wider, there is a corresponding loss of accuracy in the neighborhood

risk estimate. The extra effort in calculating risks with 250 µg/g intervals (14 cells) is probably compensated by the increased precision, with an estimate of 11.74% instead of 11.92%. The individual risk, as shown by the calculated risk for the residences with higher soil and dust concentrations, for many residences in the neighborhood is above the OSWER specified level of protectiveness (no more than 5 percent exceeding typically 10 µg/dL). This illustrates the importance of calculating individual risk, rather than community risk, to achieve EPA's public health goal.

6.4 RISK ASSESSMENT USING NEIGHBORHOOD OR NEIGHBORHOOD-SCALE INPUT

There are situations in which it is either inconvenient or impossible to apply the IEUBK model at the intended household residence scale. For example, if only neighborhood mean values or geometric mean values of input parameters such as soil and dust lead are available, the model estimate may be far less reliable than if individual residential measurements were made. Another possibility is that there are a substantial number of soil and dust lead measurements at a site, but not at houses or locations within the site where blood lead and EBL risk estimates are needed, for example, to compare with blood leads observed at residences where there are no environmental data. There are some circumstances in which this is clearly not a valid application of the model. As we do not clearly understand the range of conditions under which the IEUBK model may be used with large-scale input data at this time, we must discourage use of the IEUBK model except with single-residence or residential lot-sized input data, or with data grouped into cells as in Section 6.3.

Table 6–3. Neighborhood Risk Estimation with Grouped Data

Hypothetical example of grouped data for a neighborhood with dust and soil samples of 250 sites of house yards. Intervals are 250 µg/g in PbS and PbD.						
Soil interval	Soil midpoint	Dust interval	Dust midpoint	Statistical weight	Geometric mean (µg/dL)[1]	Risk[2] Probability of exceeding 10 µg/dL
0-249	125	0-249	125	30	2.2	0.065
0-249	125	250-499	375	50	3.7	1.680
0-249	125	500-749	625	20	5.1	7.360
250-499	375	0-249	125	10	3.4	1.127
250-499	375	250-499	375	40	4.8	6.005
250-499	375	500-749	625	30	6.1	14.814
250-499	375	750-999	875	20	7.3	25.579
500-749	625	250-499	375	10	5.9	13.001
500-749	625	500-749	625	20	7.1	23.582
500-749	625	750-999	875	10	8.3	34.585
500-749	625	1,000-1,249	1,125	3	9.4	44.829
750-999	875	1,000-1,249	1,125	4	10.3	52.278
750-999	875	1,750-1,999	1,875	1	13.2	72.123
1,000-1,249 1,	125	1,250-1,499	1,375	2	12.1	65.597
TOTAL				250		11.74

[1] Calculated from IEUBK model with default parameters
[2] Assuming GSD=1.6

Table 6–4. Neighborhood Risk Estimation with Coarsely Grouped Data

Hypothetical example of grouped data for a neighborhood with intervals of 500 µg/g in soil Pb and dust Pb.						
Soil interval	Soil midpoint	Dust interval	Dust midpoint	Statistical weight	Geometric mean (µg/dL)[1]	Risk[2] Probability of exceeding 10 µg/dL
0-499	250	0-499	250	130	3.6	1.386
0-499	250	500-999	750	70	6.2	15.745
500-999	750	0-499	250	10	5.8	12.123
500-999	750	500-999	750	30	8.2	33.604
500-999	750	1,000-1,499	1,250	7	10.4	53.049
500-999	750	1,500-1,999	1,750	1	12.3	67.238
1,000-1,499	250	1,000-1,499	1,250	2	12.0	65.031
TOTAL				250		11.92

[1] Calculated from IEUBK model with default parameters, ages 0 to 84 months
[2] Assuming GSD=1.6

7.0 References

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Appendix A: Using Spreadsheets with IEUBKwin

A.1 IMPORTING IEUBKWIN DATA TO SPREADSHEET PACKAGES

IEUBKwin data, including batch mode output can be readily exported to spreadsheets. The following information is provided to facilitate this process.

The IEUBKwin output data (*.txt) for the risk assessment mode can be exported to a spreadsheet application (*e.g.,* Excel or Lotus 1-2-3) for submission to EPA. The data is captured in a tabular format in IEUBKwin. To export output data to Excel, the user should employ the following procedure:

1. Start Excel
2. Click   on *File/Open* and change *Files of Type* to *All Files*, locate your *.txt output file, and click *Open*.
3. On the *Text Import Wizard* screen choose *Delimited* and click *Next*. Select Tab as the *Delimiter* and *General* as *Column Data Format*. Select *Finish*.
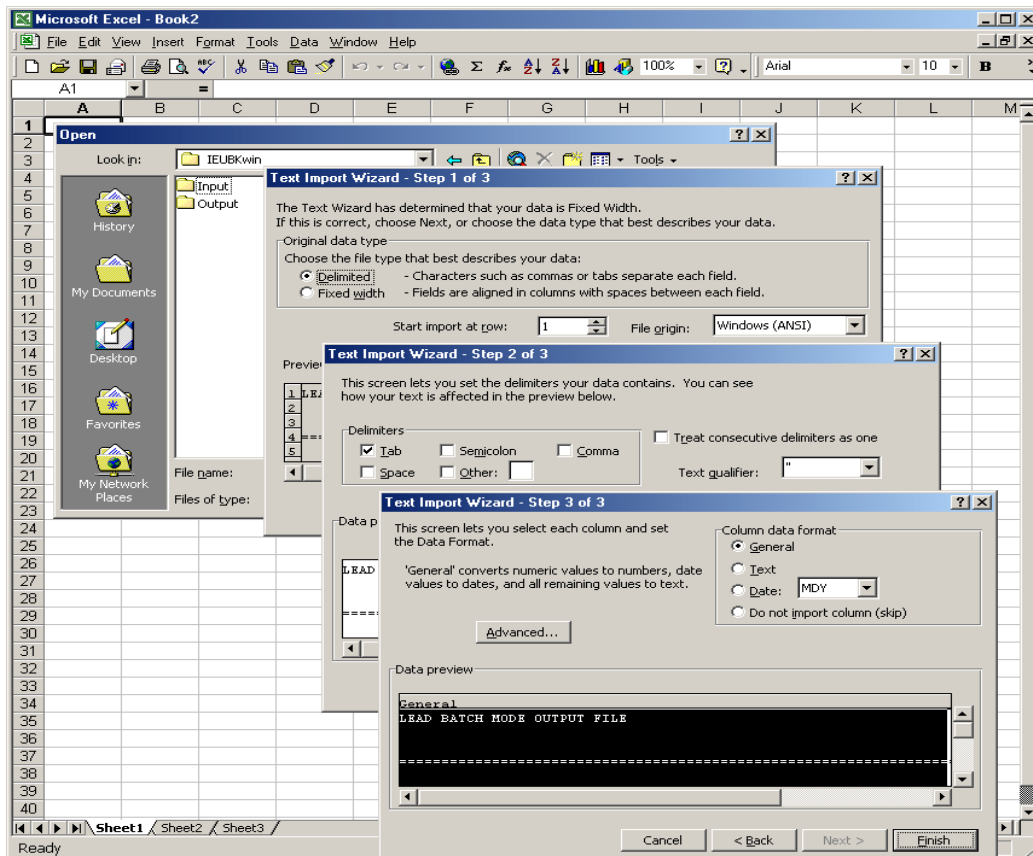4. Save the file in Excel format (*.xls).

Figure A-1. Export IEUBKwin Data Output to Microsoft Excel.

To export output data to Lotus 1-2-3, the user should employ the following procedure:
1.   Start Lotus 1-2-3
2.   Click on F*ile/Open* and change *Files of Type* to *All(*),* locate your *.txt output file, and click *Open*.
3.   On the *Text File Options* screen choose *Automatically Parse Based on File Layout*.
4.   Save file in Lotus 1-2-3 format (*.123).

To import data into Lotus 1-2-3, the user would employ the following procedure:

1.   Start Lotus 1-2-3.
2. Click   on *File/Open* and change *Files of Type* to *All Files*, locate your *.txt output file, and click *Open.*
3.   On the *Text File Options* screen choose *Automatically Parse Based on File Layout*.
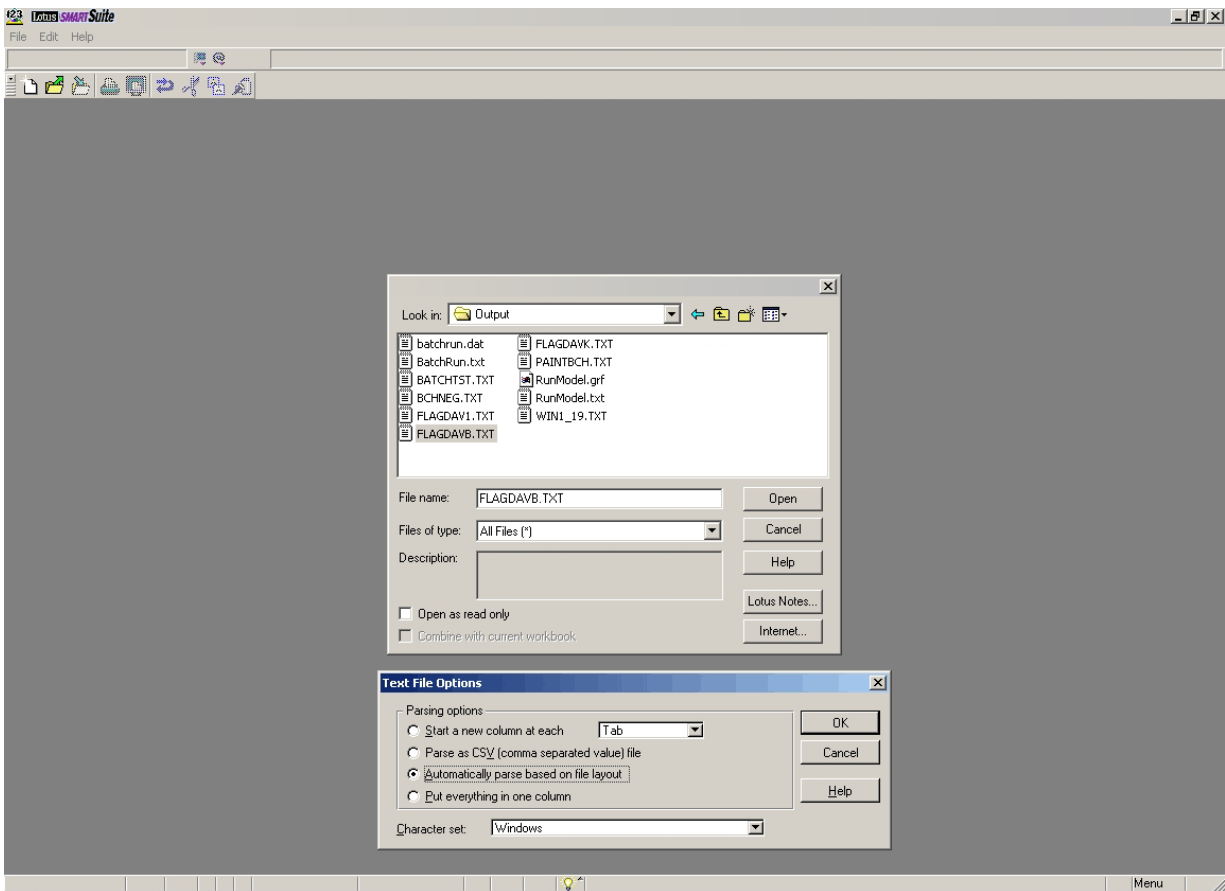4.   Save file in Lotus 1-2-3 format (*.123).

Figure A-2. Export IEUBKwin Data Output to Lotus 1-2-3.

To import data to Microsoft Excel, the user would employ this procedure:
1. Start Excel.
2. Click   on *File/Open*, change *Files of Type* to *All (*)*, locate your **.txt output file, and click *Open*.
3. On the *Text Import Wizard* screen choose *Fixed Width* and click *Next*.
    - Excel may have left out some column breaks or inserted extra column breaks. To insert additional column breaks, click at the desired position. To remove a column break, double-click it, click *Next*, select *General Format*, and click *Finish*.
4. Save the file in Excel format (*.xls).

Note that Excel will break the header text of the file into columns as well. Also, an IEUBKwin batch mode output file requires little to no editing before it is imported to other statistical programs. If the data file contains a null row, this may cause import problems with other spreadsheet packages. Once the results are loaded into a spreadsheet or statistical program, the user can apply a variety of graphical and statistical techniques in evaluating the output of IEUBKwin batch mode runs. Batch mode calculates the probability of exceedance as described in Appendix B.
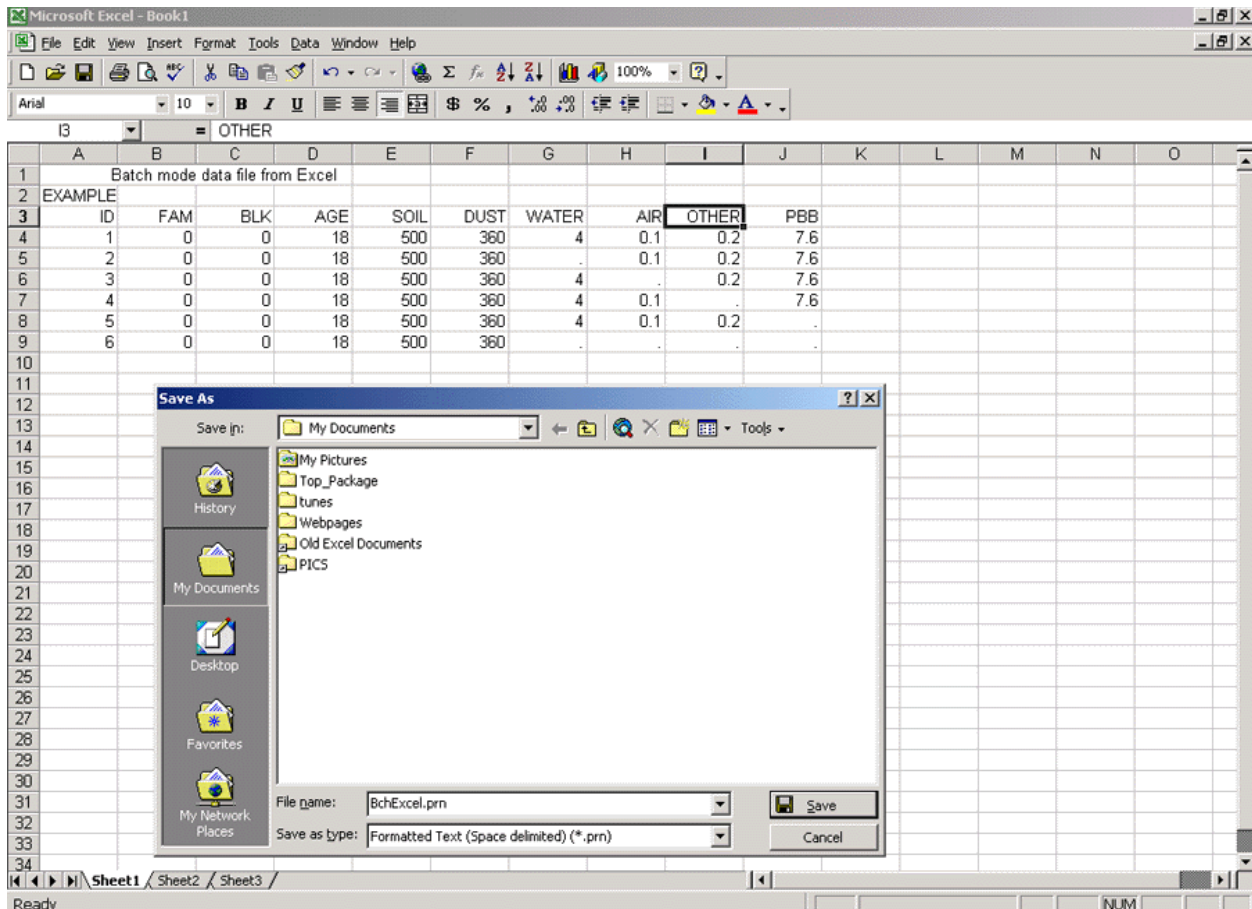

Figure A-3. Creating a Batch Data file with Microsoft Excel.

A.2 CREATING A BATCH MODE DATA INPUT FILE USING A SPREADSHEET

As described in Chapter 3, batch mode input files require rigorous formatting. These files can be can be quickly and easily created by using spreadsheets. As an example, the following procedure describes creation of a batch mode data file in Microsoft Excel:

1. Select the first 10 columns in your spreadsheet.
2. Format the columns to have a width of 8.0.
3. Right align all data (including the text descriptions at the top of the worksheet).
4. Save the file with a Formatted text (space delimited) (*.prn) extension. The name you select should have no more than 8 characters or else the IEUBK model will truncate it.
5. Manually change the file from *.prn to *.dat in your file directory.
6. Run batch mode using the newly created file.

Appendix B: Probability Distribution Function

The Z score is the distance between the PbB of 10 µg/dL and the geometric mean (GM) PbB, *in standard normal units* (Z score is also known as the *standard normal deviate*). Furthermore, the Z score is the inverse of the standard normal cumulative distribution function (*i.e.*, normal distribution with mean of 0 and standard deviation of 1). The probability of a child's blood lead level exceeding 10 µg/dL is calculated as 1– the area under the standard normal cumulative distribution function to the left of the Z score. For example:

> Given:
> > GM PbB = 5 µg/dL (*e.g.,* from IEUBKwin)
> > GSD = 1.6

> Determine probability of exceedance:

$$Z = \frac{[\ln(10) - \ln(5)]}{\ln(1.6)} = 1.48$$

> Probability of child's PbB exceeding 10 µg/dL (1-p) =

$$1 - \left[\text{Probability}(Z < 1.48)) \right] = 0.93 = 0.07$$

After calculating the Z score, the IEUBKwin model simulates a standard normal distribution using the calculated GM and selected GSD. A difference approximation method is then used to calculate the probability of exceedance (1-p). This method has simplified the calculation from the IEUBK DOS version (IEUBK 0.99d).

The z-score can also be used to estimate a percentile value for a lognormal distribution given a geometric mean and standard deviation:

$$X_p = GM \cdot GSD^{Z_P}$$

where,
    X_p = blood lead concentration at the pth percentile of the lognormal distribution
    GM   = geometric mean of the distribution
    GSD   = geometric standard deviation of the distribution
    Z_p = z-score corresponding to the pth percentile of the standard normal cumulative distribution

Note that taking the logarithm of both sides of the preceding equation and solving for Z_p yields the equation for Z given above. The following is an example of using the preceding equation for calculating the blood lead concentration corresponding to a selected probability of exceedance (1-p):

Calculate the 95th percentile blood lead concentration (X_p)
> > Given:
> > GM PbB = 5 µg/dL (*e.g.,* from IEUBKwin)
> > GSD = 1.6
> > Z_p = 1.645 (the 95th percentile Z score)
> > > $Xp = 5 \cdot (1.6)^{1.645} = 10.8 \mu g / dL$

The results indicate there is a 5% probability of a child's blood lead concentration exceeding 10.8 µg/dL, given a GM PbB concentration of 5 µg/dL and a GSD of 1.6.

Appendix C: Short Sheets Currently Available

The TRW Lead Committee website has a complete listing of all Short Sheets that are related to lead risk assessments: http://www.epa.gov/superfund/lead/guidance.htm

2000 Short Sheet: TRW Recommendations for Sampling and Analysis of Soil at Lead (Pb) Sites [EPA #540-F-00-010, OSWER #9285.7-38] (April 2000) to be consulted when using the IEUBK or the Adult Lead Methodology.
Provides recommendations and protocols for the collection, preparation, and analysis of lead in soil and dust for use in lead modeling.

1999 Short Sheet: IEUBK Model Soil/Dust Ingestion Rates [EPA #540-F-00-007, OSWER #9285.7-33] (December 1999) to be consulted when using the IEUBK model.
Provides recommendations on the substitution of default soil/dust ingestion rates in the IEUBK model.

1999 Short Sheet: IEUBK Model Bioavailability Variable [EPA #540-F-00-006, OSWER #9285.7-32] to be consulted when using the IEUBK or the Adult Lead Methodology. Discusses issues to consider and applicable methods for determining a site-specific bioavailability value for soil-borne lead.

1998 Short Sheet: IEUBK Model Mass Fraction of Soil in Indoor Dust (MSD) Variable [EPA #540-F-00-008, OSWER #9285.7-34] (June 1998) to be consulted when using the IEUBK model.
Provides updated guidance on the Mass Fraction of Soil in Indoor Dust (MSD), the fraction of house dust that is derived from the outdoor soil. The MSD is a variable in the dust lead Multiple Source Analysis module of the IEUBK model.

1997 Short Sheet: Overview of the IEUBK Model for Lead in Children [NTIS #PB99-9635-8, OSWER #9285.7-31] (August 1997) to be consulted when using the IEUBK model.
Provides general information on the IEUBK model