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California Population Indoor Exposure Model (CPIEM) Version 2.0

Contract No. 98-327

User's Guide

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Highlights of the New Version

The goals of this project were to enhance the original version of CPIEM, implemented as an MS-DOS program for personal computer, in order to improve the accuracy of estimates of the exposure of Californians to air pollutants, to enhance the characterization of uncertainty and variability or the estimates, and to upgrade the underlying technology to take advantage of Microsoft Windows.

The specific objectives of the project were threefold.

- Identify, review, and incorporate new default data into CPIEM. New data includes indoor concentration distributions, outdoor concentration distributions, building air exchange rates, pollutant penetration factors, pollutant reactivity factors, and pollutant adsorption factors.
- Identify and incorporate improvements to the CPIEM estimation capabilities. New capabilities include an uncertainty module designed to be used in conjunction with CPIEM, various adjustments to activity pattern weights, disaggregation of the removal rate term of the mass-balance equation to represent various processes, and additional exposure statistic (time-weighted average exposure concentration).
- Identify and incorporate improvements to the efficiency and ease of use of the CPIEM by converting CPIEM from QuickBasic to VisualBasic, improving user interfaces, and improving output reports.

New Input Data

At the direction of ARB new indoor concentration data was limited to studies conducted in California. A total of 24 concentration distributions were added covering residential, office, school, vehicle, and public access building microenvironments. The pollutants addressed with the new distributions include formaldehyde, benzene, trichloroethylene, perchloroethylene, benzo(a)pyrene, carbon monoxide, nitrogen dioxide, PM10, ozone, 1-3, butadiene, and MTBE.

At the direction of ARB new mass balance parameter data on air exchange rates and emission factors for consumer products were limited to studies in California, but new data for penetration factor and removal rates were not. A total of 10 distributions were added to the default database covering the parameters of adsorption, reactive decay, penetration, and air exchange rates.

The outdoor concentration database in the original version of CPIEM includes measurements from the late 1980's to the early 1990's. These were updated with more recent measurements.

Daily averages for selected air pollutants measured in California between 1997 and 1999 were taken from the ARB monitoring network, as well as data from the San Francisco Bay Area Air Quality Management District (BAAQMD) toxics monitoring network, and the South Coast Air Quality Management District (SCAQMD) toxics monitoring network. Normal and lognormal distributions were fitted to the daily averages, and the best fitting distribution selected. A total of 96 distributions were added to the outdoor concentration default database, covering benzene, formaldehyde, benzo(a)pyrene, chloroform, trichloroethylene, and perchloroethylene. A distribution was provided for each pollutant/region/year combination, for each pollutant/region combination for the overall 3-year period, for each pollutant/year combination throughout the state, and for each pollutant for the overall 3-year period throughout the state.

New Estimation Capabilities

An additional software program, UNC1.0, is also provided to facilitate the estimation of uncertainty of the exposure distributions predicted by CPIEM2.0. UNC1.0 was designed to be used in conjunction with CPIEM2.0. For input variable distributions that are uncertain, UNC1.0 creates sets of input distribution parameters with Monte Carlo sampling. Each set is provided to CPIEM2.0 for iterative simulations. At the conclusion of the simulations UNC1.0 combines the resulting exposure distributions to estimate uncertainty distributions for selected percentile values.

The original CPIEM provided oniy a single set of weights for the population activity patterns when constructing exposure and dose distributions. CPIEM 2.0 has been enhanced so that the user may select a set of activity pattern weights from the following choices:

- No weights, i.e. all weights are equal.
- TIMEWT, the original model default, which adjusts for deliberate oversampling of certain populations and day-types.
- SAMPWT, which adjusts for deliberate oversampling of certain populations.

The original weights, which reflect the population structure at the time the activity surveys were taken, are provided in the default file, POP.mdb. However, a second file of activity patterns has been provided with post-stratification values for TIMEWT and SAMPWT (POP_NEW.mdb). The age and gender post-stratification adjustments were computed using California Department of Finance year 2000 projected population counts. Age groups were chosen as 0-4, 5-11, 12-17, 18-29, 30-39, 40-49, 50-65, and 66 or greater. The user may substitute this file of more recent data for POP.mdb by re-naming it as POP.mdb. (To avoid overwriting the original POP.mdb, first save it under another name.) In addition, the user is now able to supply his or her own set of weights by providing a properly formatted file in the same subdirectory and re-naming it to POP.mdb.

The original version of provided only a single factor, k, to represent pollutant removal in the mass balance algorithm of the Level 3 module. However, there are several removal processes that pertain to various pollutants, including reactive decay, deep adsorption, and deposition. CPEIM 2.0 allows the user to specify a distribution for one or more of these processes to be used in the mass-balance algorithm.

The original version of CPIEM provided only 2 output metrics: integrated exposure, measured in units of $\mu g\text{-}h/m^3$, and dose, measured in units of μg. CPIEM 2.0 provides an additional output metric of time-weighted average exposure, measured in units of $\mu g/m^3$.

Efficiency Improvements

In order to take advantage of newer technology to improve efficiency and ease of use the CPIEM computer code from a QuickBasic platform to a Visual Basic\Windows platform. The Windows platform of this new version of CPIEM greatly improves the software's efficiency and ease of use with standard, easily understood drop-down menus and dialogue boxes. The graphic outputs are presentation quality. Scenarios are easily saved and edited to facilitate sensitivity analysis.

The new Windows-based user interface closely replicates the original one, but provides improved reporting capabilities. Specific improvements include:

- More legible model reports, suitable for reproduction in color or in black and white.
- Elimination of the check-mark model for "visiting" data screens.
- Implementation of field-level data validation checks to block users from entering values in the wrong formats.
- Creation of an installation program to install the complete model on a target PC running Windows.

Matching model predictions forCPIEM1.0 and CPIEM2.0.

One of the differences between this version and the original version of CPIEM that resulted from porting to the Windows platform is the use of a different random number generator as a default. Thus, if CPIEM2.0 is run with its default ramdom number generator, the user will not obtain identical results to those predicted by the DOS-based version, ever with the same data and parameter values. If a matching run is desired, CPIEM2.0 provides an optional random number generator, as explained section 2.3.7.

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1. Introduction and Overview

1.1. Introduction

Under Section 39660.5 of the California Health and Safety Code, the State of California Air Resources Board (ARB) is charged with assessing human exposure to toxic air contaminants in indoor environments and identifying the relative contribution of indoor exposures to total human exposure, taking into account both ambient and indoor air environments. The Indoor Air Quality/Personal Exposure Assessment Program (Indoor Program), established within ARB's Research Division in 1986 to investigate indoor and personal exposures to air pollutants, has the primary responsibility for obtaining and analyzing information related to this section of the code.

Indoor exposure assessment is a critical component of assessing total exposure to toxic air contaminants because (1) residents in California and other areas of the country spend a majority of their time indoors, and (2) for many pollutants, indoor-air concentrations are typically higher than those outdoors. Assessment of indoor exposures can be particularly complicated due to the considerable variety in (1) structure types and building-construction characteristics, (2) indoor sources such as appliances, construction and interior finishing materials, furnishings, and consumer products, and (3) occupant activities including movement patterns, uses of various types of sources, operation of space-conditioning equipment, and opening or closing of windows.

To fully consider indoor exposures in assessing risk, the ARB needs estimates of average and peak indoor exposures of the California population as well as estimates of indoor exposures for sensitive subgroups of that population. However, the quantity and type of data available for use in developing such estimates vary from compound to compound and are usually very limited. Personal exposure data, not necessarily restricted to time spent indoors, are available for some compounds whereas for others only indoor-concentration data or source-emissions data (or none of these) may be available.

Calculating indoor exposures for a given population involves the integration of information on individuals' location/activity patterns (that is, how and where people spend their time) and concentrations encountered by these individuals at various indoor locations. If concentration measurements have not been collected in some of the locations of interest, then some estimate or prediction of the concentration distribution is also needed. In the past, ARB staff have gone through a fairly involved and time-consuming task of locating, developing and interfacing various pieces of information needed to support indoor exposure assessments. The model described in this document--the California Population Indoor Exposure Model (CPIEM)--is a software program that has been designed to expedite the exposure-assessment process by providing a user interface and calculation tools for supplying and integrating all required information. Two key requirements of the software are that it be (1) user friendly and (2) reasonably accurate without being overly complex.

This document is intended to assist the user in understanding (1) the general structure and purpose of the model, (2) the types of inputs required and how these inputs can be provided or accessed, (3) the types of calculations performed by the model and the extent to which these calculations can be controlled, and (4) how the results of the calculations can be saved and further analyzed. The remainder of this section provides an overview of the model and summarizes the input requirements. Hardware/software requirements and procedures for installing and accessing the software are outlined in Appendix A. Subsequent sections of this

document provide guidance and assistance to the user in supplying/accessing model inputs, executing model calculations, and viewing or saving model outputs. Some example applications and results are also provided.

1.2. Overview of CPIEM

The primary function of the model is to combine indoor-air concentration distributions with Californians' location/activity profiles to produce exposure distributions for different types of indoor environments. This function is achieved through a Monte Carlo simulation in which a number of location/activity profiles that were collected in prior ARB-sponsored studies are randomly sampled and combined with randomly chosen airborne concentrations for specific environments. At the user's option, all available location and activity profiles can be selected instead of a random sample. The location/activity profiles were collected through telephone interviews involving California adults, adolescents and children for a sample of households spread throughout the state. Ideally, the concentration data are derived from air-monitoring studies that have been performed in a random sample of indoor environments in one or more region of the state. However, for many compounds the concentration data are either limited or nonexistent. Consequently, the model also provides a capability for mathematical modeling of hourly and daily average indoor-air concentration distributions, based on distributional information for parameters such as source emission rates, building volumes and air exchange rates.

The conceptual hierarchy of the model is illustrated in Figure 1-1. Level 3 of the model utilizes a mass-balance equation to estimate concentration distributions for specific types of indoor environments such as residences, offices and schools. Level 2 of the model uses measured or modeled concentration distributions for one or more environment, together with location/activity patterns (i.e., amount of time spent in each environment at specific activity levels), to calculate exposure distributions for the chosen environment(s). Level 1 of the model aggregates the environment-specific exposure estimates to develop a distribution of "total indoor air" exposures, that is, the portion of total (24-hour) exposure associated with time spent indoors. Level 1-2 calculations are performed together as one integrated module within the model. Given the functional roles of the model levels, Level 1-2 is used interchangeably with "exposure/dose distributions" throughout the remainder of this document and Level 3 equates to "concentration distributions."

For each sampled location/activity profile, Level 1-2 of the model estimates both inhalation exposure and potential inhaled dose. Inhalation exposure is defined as the time-integrated concentration encountered by an individual while in an indoor environment:

$$C_T = \int_O^T C(t)\, dt$$

where C(t) is the concentration in the environment at time t, T is the amount of time spent in the environment, and C_T is the time-integrated concentration. If the concentration is measured in g/m3 and time in hours, then the units for CT are µg-h/m3. The average concentration in the environment, $\overline{C}_T$ (µg/m^3), is equal to C_T divided by T. $\overline{C}_T$ is not included in the summary statistics reported by the model; however, both C_T and T are included in the detailed results that are provided, enabling the user to calculate $\overline{C}_T$ if desired.

Potential inhaled dose is the product of the time-integrated concentration and the individual's breathing rate (that is, amount of air inhaled per unit time while in the environment):

$$D_T = \int_O^T B(t)\, C(t)\, dt$$

where B(t) is the breathing rate at time t and D_T is the potential inhaled dose over the time duration T. If the breathing rate is assumed to be constant and this constant rate is expressed as $\bar{B}_T$, then the potential inhaled dose can be expressed as:

$$D_T = \bar{B}_T \int_O^T C(t)\, dt = \bar{B}_T \cdot \bar{C}_T \cdot T$$

If the breathing rate is in units of m^3/h and the units for $\bar{C}_T$ and T are as above, then D_T is expressed in µg (i.e., $m^3/h \cdot µg/m^3 \cdot h$). For the model, the average breathing rate while in the environment is assigned from activity codes contained in each location/activity profile; this assignment is conditional on the individual age/sex category—adult male, adult female, or child (under age 12).

Each location/activity profile contains a weight variable (TIMEWT) that is used to compensate for unequal selection probabilities across the participants of ARB-sponsored surveys from which the profiles were developed for use in this model. The weight variable is used by the model to calculate weighted summary statistics (see Section 5.0) for exposure or dose.

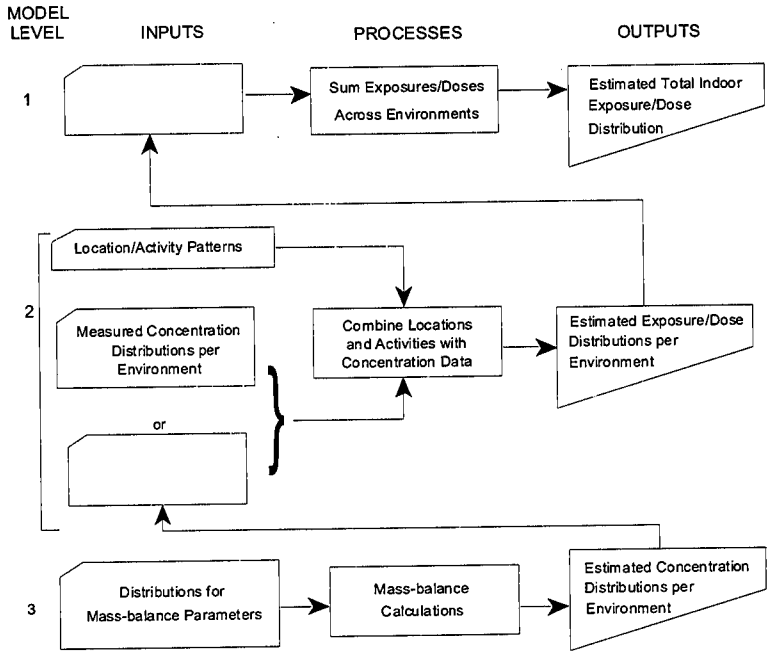

Figure 1-1 Conceptual Hierarchy of CPIEM

1.3. Functional Overview of CPIEM

In general, the user must:

1. Create a scenario that defines the pollutant to be modeled and the level of model calculations (Level 1-2: Exposure/Dose distributions, or Level 3: Indoor Concentration distributions).
2. Supply inputs corresponding to the selected level: the micro environment, number of trials to use, random seed number, integration period, population subgroup, indoor concentrations, and breathing rates for Exposure/Dose and indoor source, outdoor concentration, penetration factors, outdoor sinks, volumes, and air exchange rates for Indoor Concentrations.
3. Specify a folder where output files will be stored. Default is the CPIEM application root directory (typically C:\Program Files\Cpiem).
4. Run the scenario.
5. Exercise options for viewing and printing the results.

The types of inputs required for each model level are indicated in the table below. These inputs are supplied through pull-down menus associated with the "Exposure/Doses" (Level 1-2) and "Concentrations" (Level 3). Although defaults are provided where possible, the user will still need to take some action in complying with the input requirements.

For the Level1-2, the user has the option of performing Exposure (Integrated or Time Weighted Average) or Dose runs and generating the corresponding statistical summary output files (*.ste or *.std). In Level3, the user has the option of generating and viewing daily average concentrations only, or the hourly average results as well (*.stc).

Detailed files containing results for each model trial are automatically saved by CPIEM. For Level 1-2, the detailed file (*.prn) contains both exposure and dose for each environment and in total across environments. For Level 3, the detailed file (*.asc) contains both hourly average concentrations and the daily average.

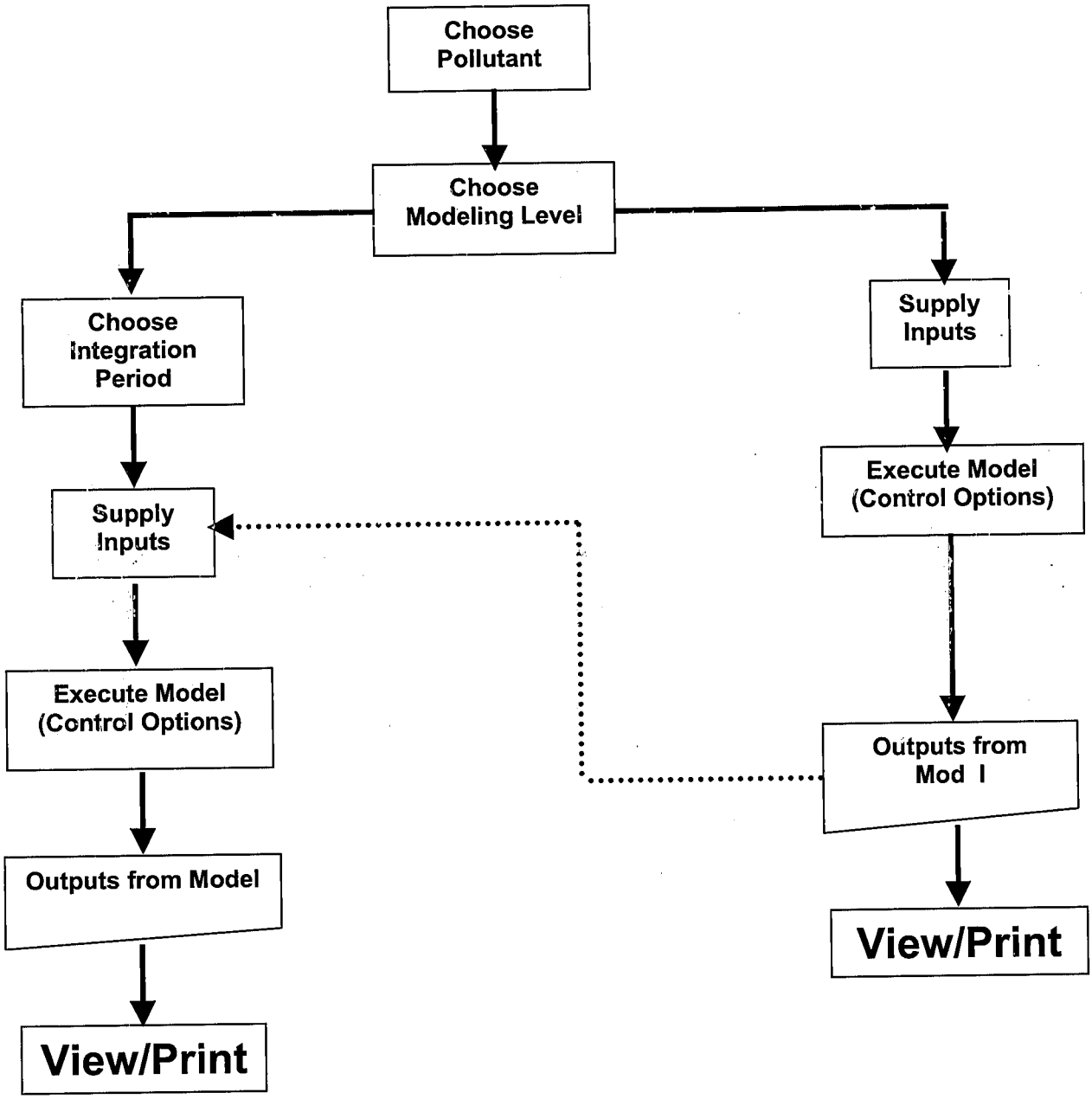

Figure 1-2 Model Overview from User Interface Standpoint

Exposure/Dose Distributions (Level 1-2)	
Pollutant	Indoor Concentrations
Integration Period	Breathing Rates
Population Subgroup	Random Number Seed
Number of Trials	
Indoor Concentration Distributions (Level 3)	
Pollutant	Volumes
Indoor Sources	Air Exchange Rates
Outdoor Concentrations	Number of Trials
Penetration Factors	Random Number Seed
Indoor Sinks	

Table 1-1 Inputs Required for Each Level of the Model

1.4. Starting CPIEM

You can launch CPIEM via the Programs menu and clicking **CPIEM 2.0**. CPIEM will display a splash screen with information about the program.

Figur 1-3 CPIEM Splash screen

Click anywhere on the splash screen. CPIEM will display the main screen, which contains the Scenario and Help menus.

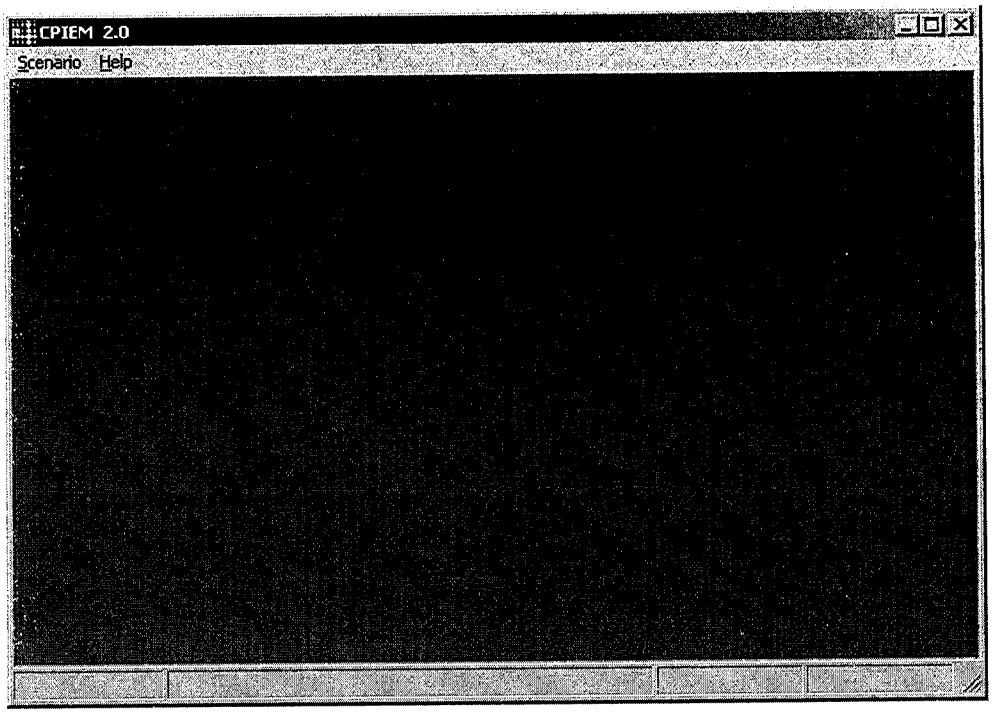

Figure 1-4 CPIEM Main screen

1.5. Special Button Definitions

CPIEM utilizes some generalized button icons that are defined as follows.

- Clicking on the continuation button, ..., will provide additional selection criteria choices.
- Clicking on the Select All button, +++, will select all criteria in the list.

Clicking on the Clear All button, ---, will de-select all criteria in the list.

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2. Scenarios

2.1. Using Scenarios

You can use scenarios to store and retrieve information associated for a given model run. Every scenario for both models will include the following information:

- Name
- Pollutant
- Model used, either Exposure/Doses or Indoor Concentrations
- A description of the scenario
- Number of trials and seed number

Additional top tier information for the Exposure/Dosage model are:

- Integration period
- Micro Environments
- The weighting approach used with the activity profiles

And,

- Indoor Sources

For the Indoor Concentrations model.

You can add a new scenario or edit an existing one.

2.2. Selecting a Scenario

From the **Scenario** menu, select **Load**. CPIEM will display the Scenarios dialog box.

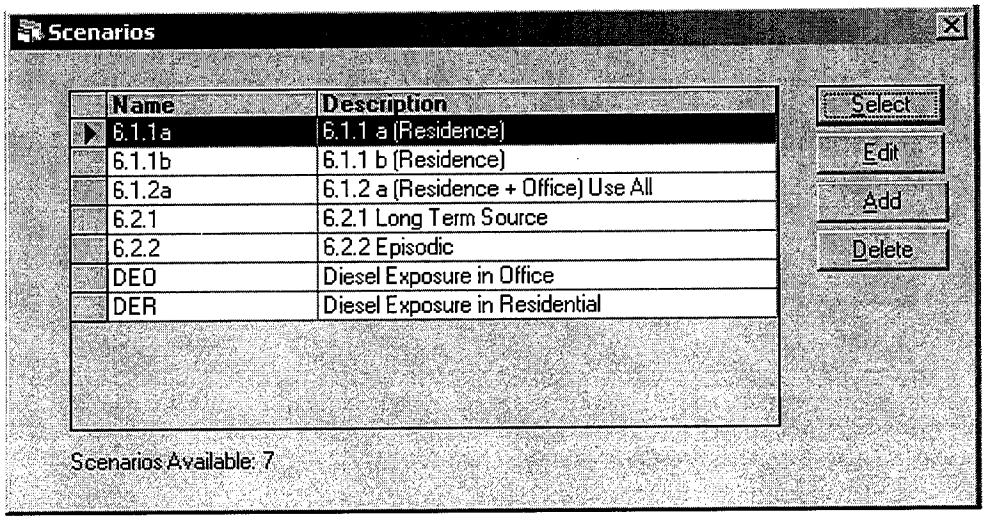

Figure 2-1 Scenarios dialog box

Highlight the desired scenario and Click **Select**. The Scenarios dialog box will close and the selected scenario will become the active one. The status bar at the bottom of the main CPIEM will display key elements for this scenario.

Figure 2-2 Status bar displaying key Scenario elements

From left to right, the first section of the status bar will display the name of the scenario. The second section is dynamic and displays elements (such as micro environment, number of activity profiles, and breathing rate case) as you add or change them. The third section displays the pollutant. The fourth section displays the level of run: Exposure/Dose (Level 1/2) or Indoor Concentration (Level 3).

2.3. Adding a Scenario

You can add a new scenario or edit an existing one. To add a new scenario, click **Add**. CPIEM will add a line for a new scenario.

To specify information for the new scenario, or to edit an existing scenario, click on the line for the scenario you want to edit and click **Edit**. CPIEM will display the Scenario Settings dialog box.

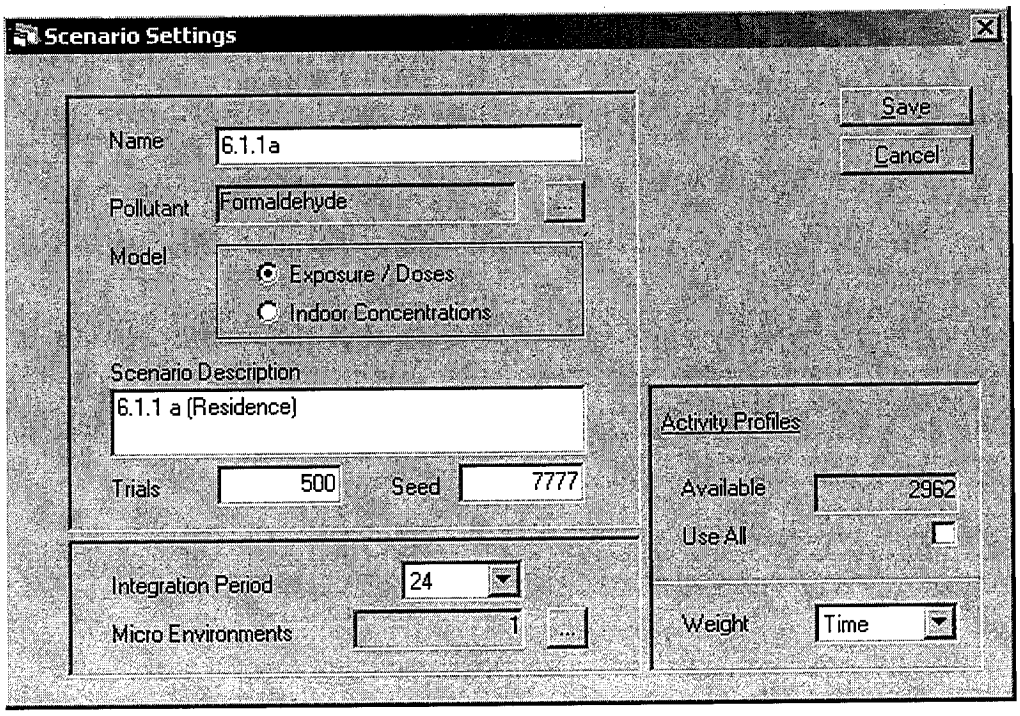

Figure 2-3 Scenario Settings dialog box

You can use the boxes, buttons, and lists to enter the information the CPIEM will use for the model run.

2.3.1. Creating a Name for the Scenario

To use a new name for the scenario, select the entire default name and type a new name. You can use up to 25 alphanumeric characters.

CPIEM saves the results of each scenario run in two files using the first six characters of the scenario name with an extension of .asc and .stc. If you run the same scenario more than once (for example, using different parameters) without changing the name, CPIEM will overwrite the asc. and .stc files. To save the results from a series of runs, you can either change the name of the scenario for each run, or you can manually change the names of the .asc and .stc files after they are generated.

NOTE: Scenario names are for user convenience only, and are not used or checked by the CPIEM software. Thus, it is possible for the user to specify the same name for various scenarios with different input specifications, although this practice is not recommended. It is the responsibility of the user to maintain scenario names in a way that will avoid confusion and/or overwriting of output files.

For more information about files used and generated in CPIEM, see Section 7.

2.3.2. Selecting a Pollutant

Only one pollutant can be selected for each run of the model. To select a pollutant, click the continuation button ..... CPIEM will display the Pollutant dialog box.

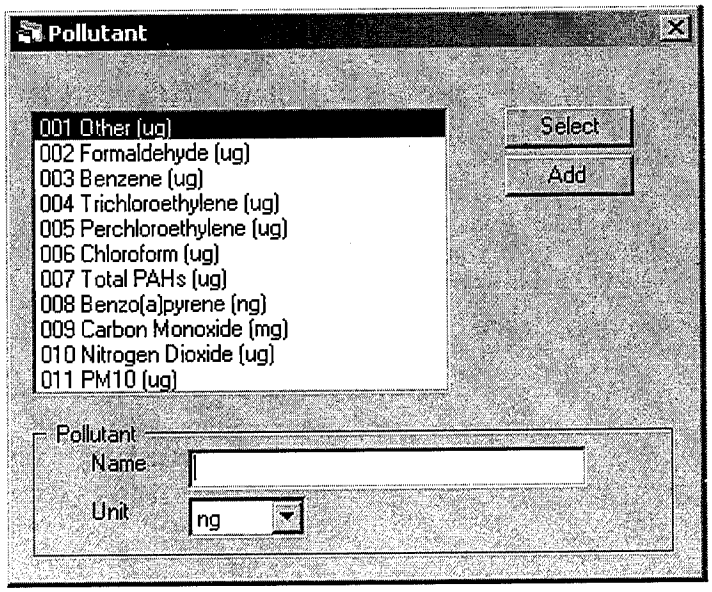

Figure 2-4 Pollutant dialog box.

You can use the Pollutant dialog box to either select a pollutant from the list or add a new pollutant.

To select a pollutant, select a pollutant from the list and click **Select**.

To add a new pollutant, type the name of the pollutant in the Name box, and then select the unit of measure (either ng, ug, or mg) from the Unit list. Click **Add**.

2.3.3. Selecting a Model

There are two models that can be selected: Exposure/Doses and Indoor Concentrations. The information you must specify for the model run changes according to whether you select Exposure/Doses and Indoor Concentrations. The default model is Exposure/Doses.

If you select Exposure/Doses, CPEIM will display the Scenario Settings dialog box with the following lists and boxes:

- Scenario Description
- Trials and Seed
- Integration Period
- Micro Environments
- Activity Profiles

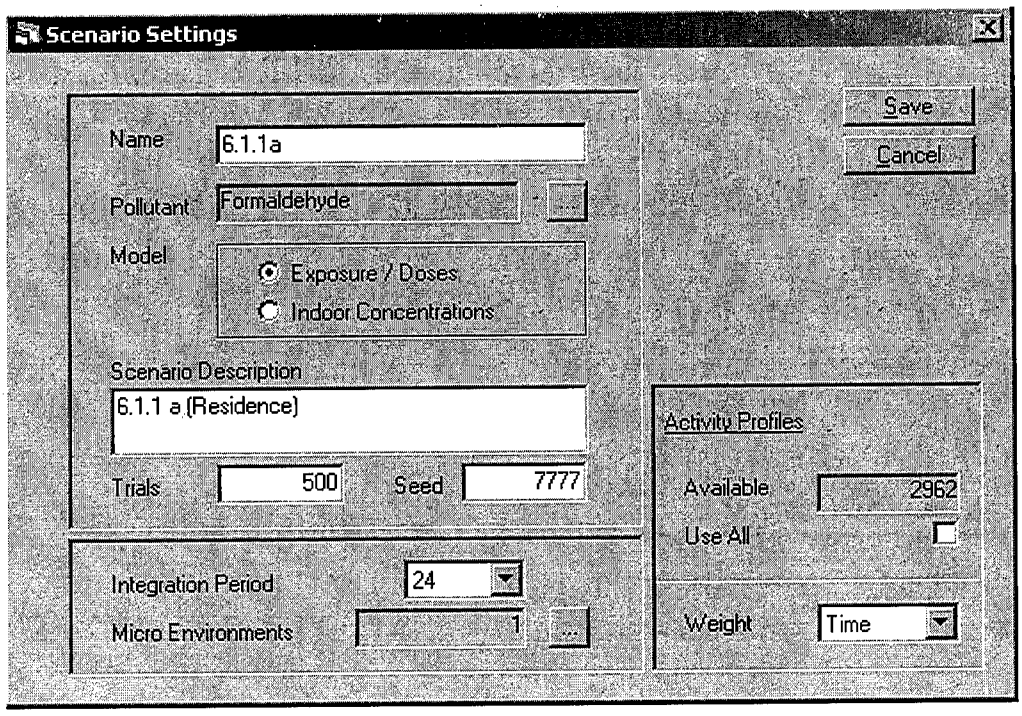

Figure 2-5 Scenario Settings dialog box with the Exposure/Doses model selected

If you select Indoor Concentrations, CPEIM will display the Scenario Settings dialog box with the following lists and boxes:

- Scenario Description
- Trials and Seed

- Indoor Sources

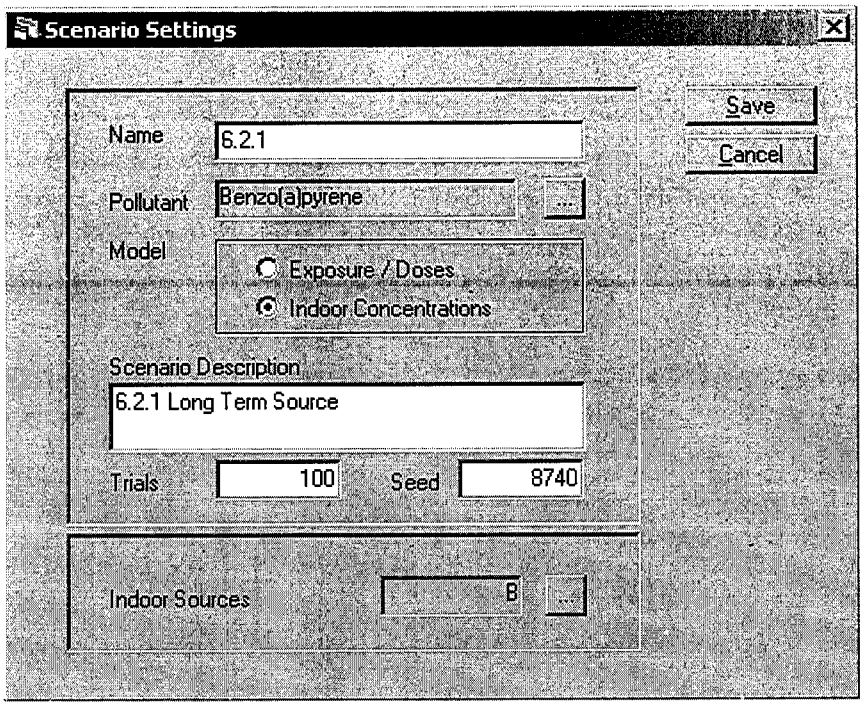

Figure 2-6 Scenario Settings dialog box with the Indoor Concentrations model select d

2.3.4. Typing a Scenario Description

You can type a description for the scenario. This description will be displayed in the list of scenarios in the Scenarios dialog box. Click in the box and type a description. You can use up to 100 alphanumeric characters.

2.3.5. Entering the Number of Trials

Trials refers to the number of times CPIEM will randomly choose an activity profile from the matched population subset and link this profile with randomly chosen concentrations for various environments. However, You can also choose to use all available profiles and instruct CPIEM to use each matching profile once, rather than sample profiles at random. To do this, select "Use All" in the Activity Profiles box. Generally you should not specify a number of trials that is more than half the number of matching profiles; otherwise, some profiles will be selected more than once.

If the chosen number of trials exceeds the number of available profiles, a warning is displayed, but you are allowed to proceed. There is a trade-off between the number of trials and the stability of estimates from the simulation, particularly for parameters such as the upper percentiles of the exposure or dose distribution—the larger the number of trials, the more stable the estimates will be. Thus, in some cases, you might want to increase the stability of parameter estimates by specifying a number of trials that is larger than the number of profiles. In this case, some activity profiles will be selected more than once. Because each randomly selected profile

is combined with a randomly chosen concentration for each environment, sampling a profile twice is essentially equivalent to monitoring an individual on two days, except that his or her activity profiles would be identical for each of those days.

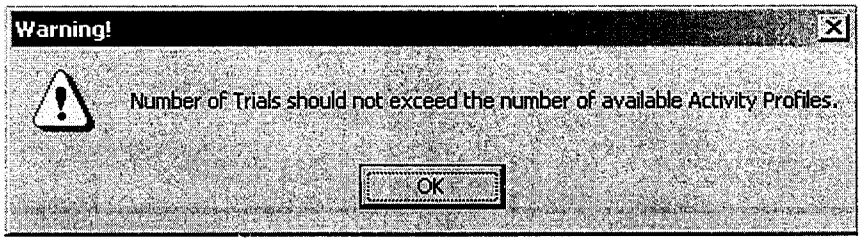

Figure 2-7 Warning: Number of trials exceeds the Number of Available Profiles

2.3.6. Specifying a Random Number Seed

You can use the Seed box to specify a random number seed that controls the sampling of activity profiles and micro-environmental concentrations for the simulation. By making repeated model runs with all inputs the same, except for the random number seed, it is possible to assess the stability of various parameters of the estimated exposure/dose distribution. For example, after making ten such runs, the user could compile a list of the ten values obtained for the 90th percentile, from which the average value (and standard deviation) for this parameter could be calculated. Although CPIEM will provide the values for such calculations, the calculations themselves must be performed outside of the model.

2.3.7. Random Number Generator Scheme Options

In CPIEM 2.0, two schemes are provided for generating random numbers. Option A which is the default setting, would allow the model to produce "repeatable" sequences for a given seed number for multiple runs as intended. However, the numbers generated in such sequence for a given seed are NOT the same as ones generated in DOS version with the same seed. This is because, the DOS application was built as separate EXE and invoking a model run was equivalent to restarting the application, therefore provisions for re-run (of the same EXE) and associated logic for the Random Number Generator were not built in. Hence, the need for Option B, which would allow you to emulate the behavior of the DOS version run while you are verifying results between the two versions. When Option B, the application should be re-started between scenario runs.

You can set the scheme by clicking on the Options menu item from the Help menu. The selected option will stay active for the session and can be change anytime during the session. It will default back to Option A at restart.

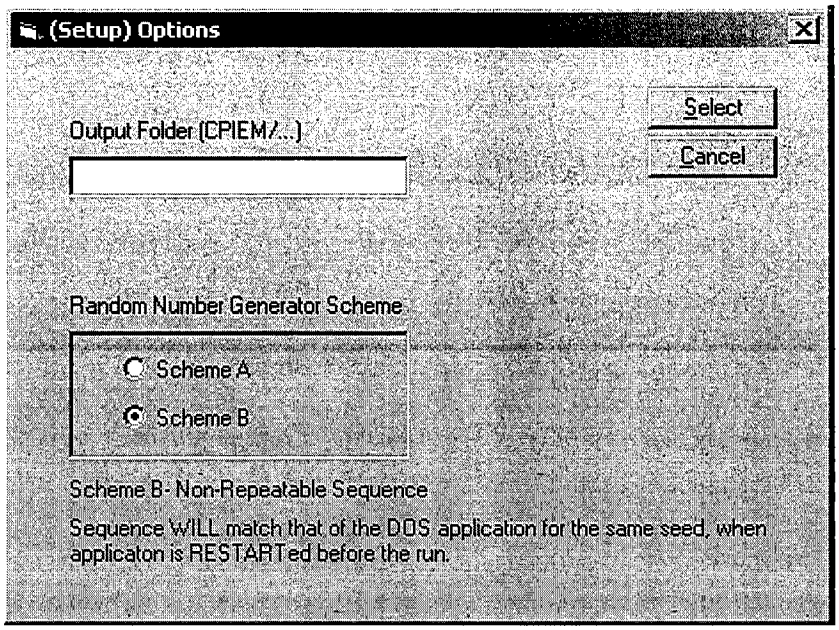

Figure 2-8 Random Number Generator Scheme Options

2.3.8. Selecting an Integration Period

This selection is only possible if Exposure/Doses has been selected as the model.

When the Exposures/Doses model is selected, you must select an integration period from the list. For the first three choices (24 hour, 12 hour daytime, and 12 hour nighttime), a daily concentration value will be combined with an activity profile for each trial of the simulation. For the last two choices (1 hour and 8 hour), 24 concentration values per day will be linked with an activity profile for each trial. Tables containing properly formatted activity profiles for each of the integration periods are provided with the model (see Section 7.1). For example, for the "12-hour daytime" option, each activity profile in the file WC_ACTAM covers the 12-hour period from 6:00 a.m. to 6:00 p.m.

For the "1 hour" option, the activity profile is segmented into 24 hourly periods (midnight to 1:00 a.m., 1:00 a.m. to 2:00 a.m., etc.). The activity profile for the "8 hour" option is segmented into 24 "running" or overlapping periods. Because activity profiles were collected for a single 24-hour period for each survey respondent, the 8-hour profile "wraps around" the midnight hour. That is, the first period is from midnight to 8:00 a.m., the second record is from 1:00 a.m. to 9:00 a.m., the 16th record is from 4:00 p.m. (1600 hours) to midnight, the 17th record is from 5:00 p.m. to 1:00 a.m. (wrapping around midnight), and the 24th record is from 11:00 p.m. to 7:00 a.m.

2.3.9. Selecting Micro Environments

This selection is only possible if Exposure/Doses has been selected as the model.

Click the continuation button ..., and CPIEM will display the Micro Environments dialog box.

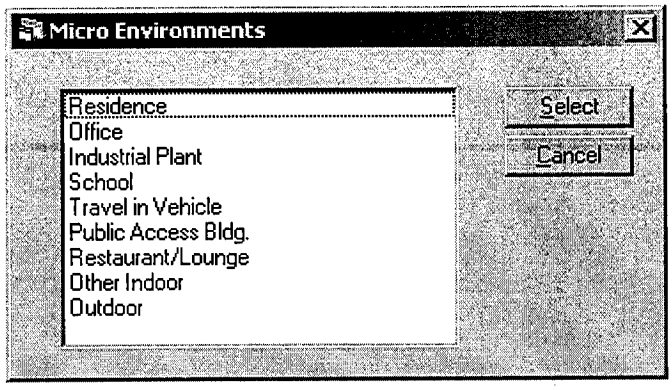

Figure 2-9 Micro Environments dialog box

You can select one or more micro environments from the list. In the list, click on a micro environment to select it, and click again to unselect it. Multiple micro environments can be selected. When you have finished, click **Select**.

The micro environments that you select will be displayed in the Scenario Settings dialog box using the codes below.

Micro Environment	Code
Residence	1
Office	2
Industrial Plant	3
School	4
Travel in Vehicle	5
Public Access Building	6
Restaurant/Lounge	7
Other Indoor	8
Outdoor	9

Table 2-1 Micro Environment Codes

2.3.10. Selecting Activity Pattern Weights

This selection is only possible if Exposure/Doses has been selected as the model.

The original CPIEM provided only a single set of weights for the population activity patterns when constructing exposure and dose distributions. In the new CPIEM 2.0 you can select a set of activity pattern weights from the following choices:

- No weights, i.e. all weights are equal. (None)
- SAMPWT, which adjusts for deliberate oversampling of certain populations. (Sample)
- TIMEWT, the original model default, which adjusts for deliberate oversampling of certain populations and day-types. (Time)

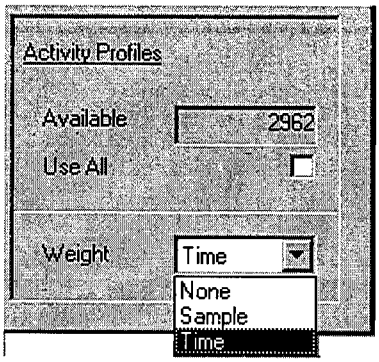

Figure 2-10 Selecting Activity Pattern Weights

The current version of CPIEM was enhanced by allowing the user to select weighting by SAMPWT as an alternative to TIMEWT, since the weekday/weekend and seasonal adjustments applied to compute TIMEWT from SAMPWT were derived using the entire database and may not be applicable for selected activity pattern subsets of interest. For example, the percentages of weekend days sampled may differ for different age groups.

Thus, TIMEWT is recommended when sampling from the entire dataset, but for activity pattern subsets it might be more appropriate to use SAMPWT it is believed that the weekday/weekend and seasonal adjustments applied to that subset would be atypical. A more detailed review of the activity pattern data would be needed to decide which weight would be best for a given application.

In addition, the enhanced CPIEM allows the user to specify that no weights be used at all, which is equivalent to weighting each activity pattern equally. This option is particularly useful if the user wants to fit statistical models to the CPIEM results, so that the statistical model specifications can do the job of the weights. For example, if the user wants to fit statistical regression models to the exposure distribution outputs as a function of the population characteristics (e.g. age, gender, region), then the no weight option is appropriate.

In general, for most applications of the model, TIMEWT is recommended.

The original weights, which reflect the population structure at the time the activity surveys were taken, are provided in the default file, POP.mdb. However, a second file of activity patterns has been provided with post-stratification values for TIMEWT and SAMPWT (POP_NEW.mdb). The age and gender post-stratification adjustments were computed using California Department of Finance year 2000 projected population counts. Age groups were chosen as 0-4, 5-11, 12-17, 18-29, 30-39, 40-49, 50-65, and 66 or greater. The user may substitute this file of more recent

data for POP.mdb by re-naming it as POP.mdb. (To avoid overwriting the original POP.mdb, first save it under another name.) In addition, the user is now able to supply his or her own set of weights by providing a properly formatted file in the same subdirectory and re-naming it to POP.mdb.

2.3.11. Selecting Indoor Sources

This selection is only possible if Indoor Concentrations has been selected as the model.

To select a type of indoor source, click the continuation button ... CPIEM will display the Indoor Sources dialog box.

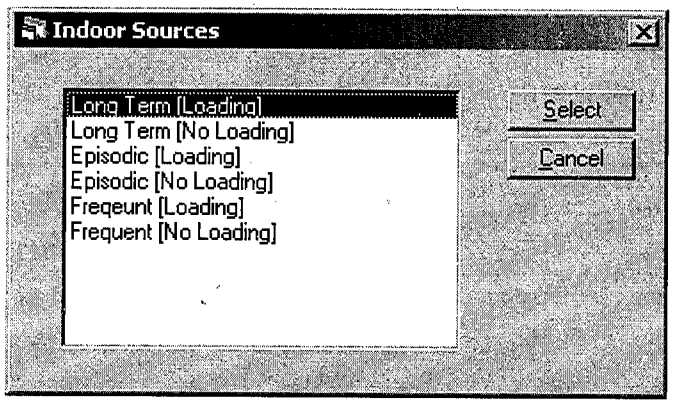

Figure 2-11 Indoor Sources dialog box

You can select any of the types of indoor sources. To select more than one type of indoor source, press the control key and click on the type of indoor source that you want. When you are finished, click **Select**. The type(s) of indoor source will be displayed in the Indoor Sources box in the Scenario Settings dialog box according to the following codes:

Indoor Source	Code
Long Term [Loading]	A
Long Term [No Loading]	B
Episodic [Loading]	C
Episodic [No Loading]	D
Frequent [Loading]	E
Frequent [No Loading]	F

Table 2-2 Indoor Source Codes

Indoor source types including "Loading" and "No Loading" are discussed in detail in section 4.1.

2.4. Completing a Scenario

When you have finished specifying settings in the Scenario Settings dialog box, click **Save**. CPIEM will display the Scenarios dialog box. You can add, edit, or delete other scenarios, or select a scenario to use for a run. To select a scenario for a run, click **Select**.

You must now select parameters for a specific run. This will be described in Chapter 3 for Exposure/Doses and Chapter 4 for Indoor Concentrations.

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3. Inputs for Exposure/Doses

The Exposure/Doses menu will be displayed when you select Exposure/Doses in your scenario. The menu items are shown in Figure 3-1. Inputs are required for Population Subgroups, Indoor Concentrations and Breathing Rates. Each of these submenus is discussed separately in the subsections that follow. The menu contains selections for:

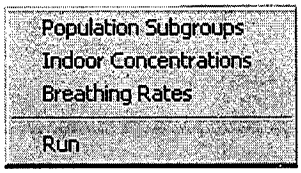

Figure 3-1 Pull down menu for Exposure/Doses

The submenus do not need to be accessed in any specific order; but you must select one set of inputs under each submenu for the model to produce meaningful results. The CPIEM application will prompt the user if required input is not provided prior to running the model, but will not check for the sensibility of the provided data.

3.1. Population Subgroups

The Population Subgroups dialog box allows the user to add, edit, and then select a case, that is a set of activity profiles, that will be linked with pollutant-concentration data for selected environments to estimate an indoor exposure/dose distribution. By default, a total of 2,962 activity profiles, gathered through ARB-sponsored surveys of adults, adolescents, and children can be used.

Any combination of criteria (age, gender, etc.) can be used as a basis for creating a case. However, having too many conditions (for example, young males in low-income households during the winter) may result in a relatively low number of matching activity profiles.

When you have finished added and edited the criteria for a case, clicking Select will cause CPIEM to locate and store all matching profiles and will report the number of matches on the status bar at the bottom of the screen.

It is recommended that the number of matching profiles be at least 100 for a meaningful run of the scenario. Use of a subgroup with fewer than about 100 cases is undesirable because a small sample is unlikely to be sufficiently representative of the entire California population for that age, gender, and region subgroup. For example, if you had 100 people and a significant factor for the exposure or dose estimation was the percentage of the group spending more than 50 % of their hours at work, you can only estimate that factor within a 95 % confidence interval of plus or minus 10 %, and the uncertainty of the percentage would be even greater for subgroups with fewer than 100 cases.

From the **Exposure/Doses** menu, select **Population Subgroups.**

CPIEM will display the Population Subgroups dialog box.

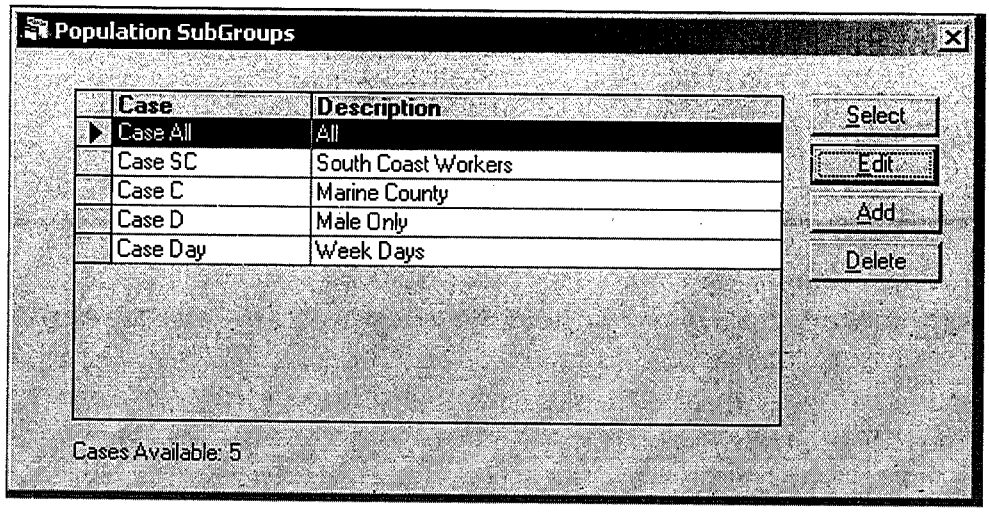

Figure 3-2 Population Subgroups dialog box

By default, there is a preloaded case that contains for which all parameters in all categories are selected. You can use this overall case, or add a new case or edit the criteria for another existing case.

3.1.1. Adding a Case

To add a new case, click **Add**. CPIEM will display a new line with a default name. To select criteria to be use for this case, select that new line and then click **Edit**.

You can change the default name and description by selecting each in turn and typing a new name and description.

Follow the procedures below to select the criteria for the new case.

3.1.2. Editing a Case

To edit the criteria for any case, select the case and click **Edit**. CPIEM will display the Population Subgroup Case Detail dialog box.

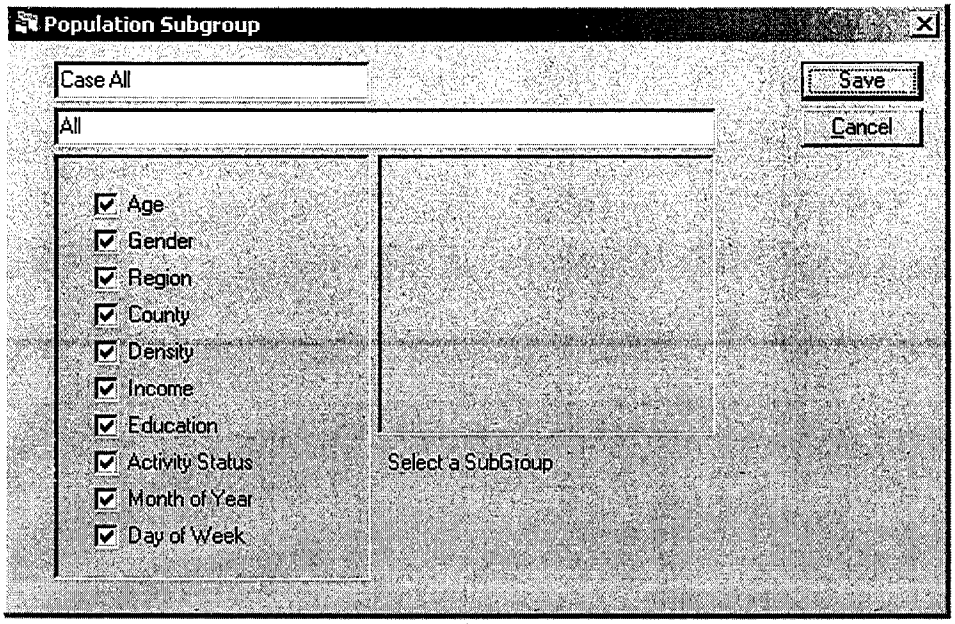

Figure 3-3 Population Subgroup Case Detail

You can select any subgroup or set of subgroups. When you select each of the subgroups in the list, boxes or lists are displayed for you to select or enter the desired criteria for the subgroup.

When you select **Age**, for example, boxes will be displayed for the entry of the desired age range. Type the lowest age that you want included in the box on the left, and type the highest age that you want included in the box on the right.

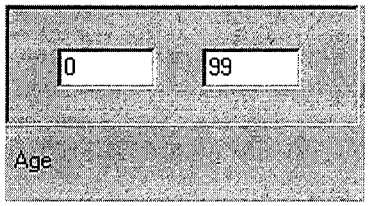

Figure 3-4 Age Subgroup boxes

For the following lists, one, several, or all criteria in the lists can be selected. Click on each criterion to select it. If you click the Select All button +++, all criteria in the list will be selected. If you click the Clear All button ---, all criteria in the list will be cleared.

When **Gender** is selected, CPIEM will display criteria of Male and Female.

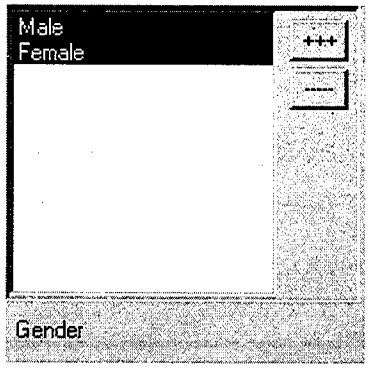

Figure 3-5 Gender subgroup list

When **Region** is selected, CPIEM will display criteria of South Coast, San Francisco (SF) Bay Area, and Other California.

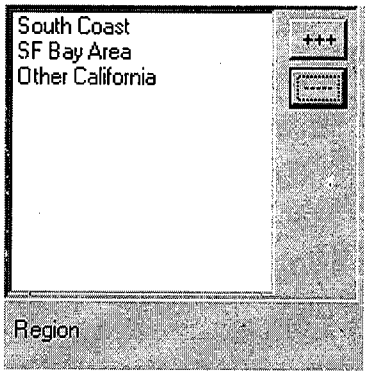

Figure 3-6 Region subgroup list

When **County** is selected, CPIEM will display a list of the 58 counties in California.

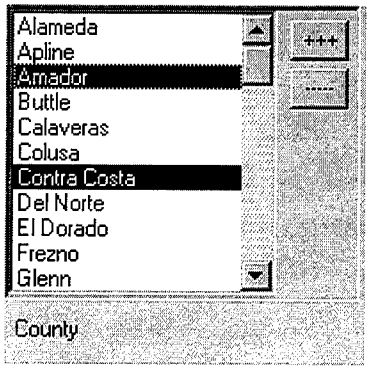

Figure 3-7 County subgroup list

When **Density** is selected, CPIEM will display criteria of Rural, Suburb, and City.

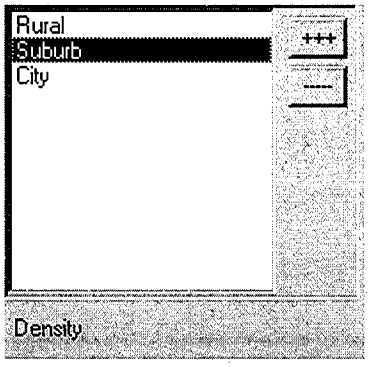

Figure 3-8 Density subgroup list

When **Income** is selected, CPIEM will display annual household income criteria in 10,000 dollar (10K) increments. You can select an exact amount, such as 30K, or a range. Ranges can be either very specific, such as 10-20K, or more open, such as less than (<) 10K, or greater than (>) 30K.

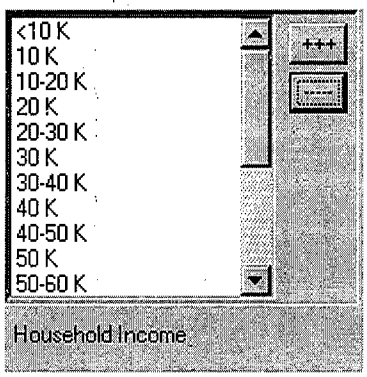

Figure 3-9 Household Income subgroup list

When **Education** is selected, CPIEM will display criteria for level of education completed by adults: Some High School, High School Graduate, Some College, and College Graduate. There are also criteria for children: Teen (ages 12 to 17) and Youth (age less than 12).

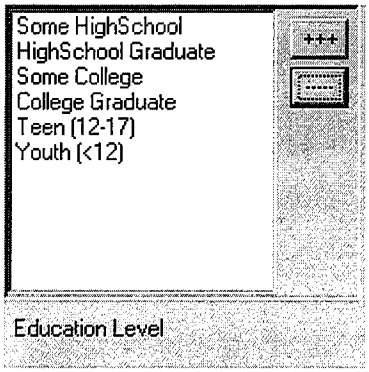

Figure 3-10 Education Level subgroup list

When **Activity Status** is selected, CPIEM will display criteria for adults of Working, Unemployed, Retired, adults currently in School, Keep House, and Other. There are also criteria for children: Teen (ages 12 to 17) and Youth (age less than 12).

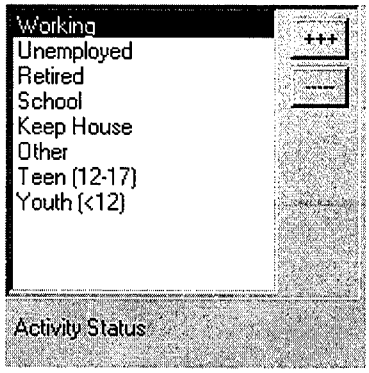

Figure 3-11 Activity Status subgroup list

When **Month of Year** is selected, CPIEM will display the months of the year. If you want to select seasons, select the following months:

Winter: December, January, February

Spring: March, April, May

Summer: June, July, August

Fall/Autumn: September, October, November

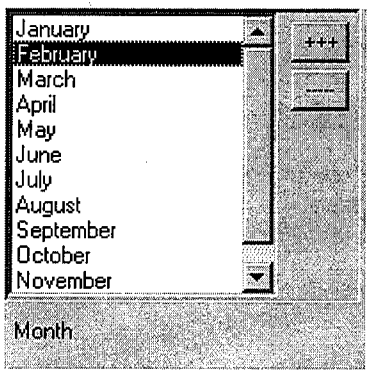

Figure 3-12 Month subgroup list

When **Day of Week** is selected, CPIEM will display the days of the week. If you want to select weekdays, select Monday through Friday. If you want to select weekends, select Saturday and Sunday.

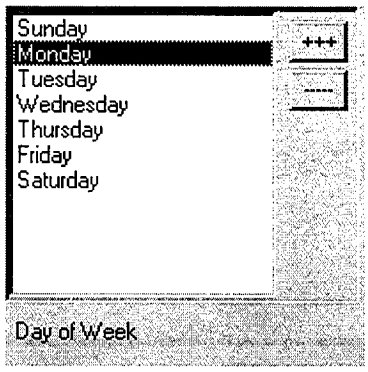

Figure 3-13 Day of Week subgroup list

When you have finished selecting criteria for the case, click **Save**. CPIEM will save the criteria for the case and again display the Population Subgroup dialog box.

3.1.3. Generating a Population Subgroup Case

The population subgroup case file (wc_act.act) must be re-generated every time there is a change in the subgroup criteria, between scenario runs. This is because, the same internal file is used to store and retrieve the activity profile information.

To re-generate the activity file, select the desired case and click **Select**.

CPIEM invoke the Population subgroup module that will search all available profiles that match the given criteria and store the corresponding records into its internal activity file (wc_act.act). At the end of this process, CPIEM will display the number of matches that have been found and stored in the status bar.

3.2. Indoor Concentrations

The Indoor Concentrations dialog box provides concentration inputs for the exposure/doses calculations as a case or cases. A case is a way of saving a distribution with parameters.

Concentration inputs can be provided for any of the nine environments that you selected under Micro Environments while creating your scenario:

- Residence
- Office
- Industrial Plant
- School
- Travel in Vehicle
- Public Access Building
- Restaurant/Lounge
- Other Indoor
- Outdoor

You can create distribution/concentration options only for the micro environments that you have selected for this scenario.

From the **Exposure/Doses** menu, select **Indoor Concentrations.**

CPIEM will display the Micro Environments dialog box.

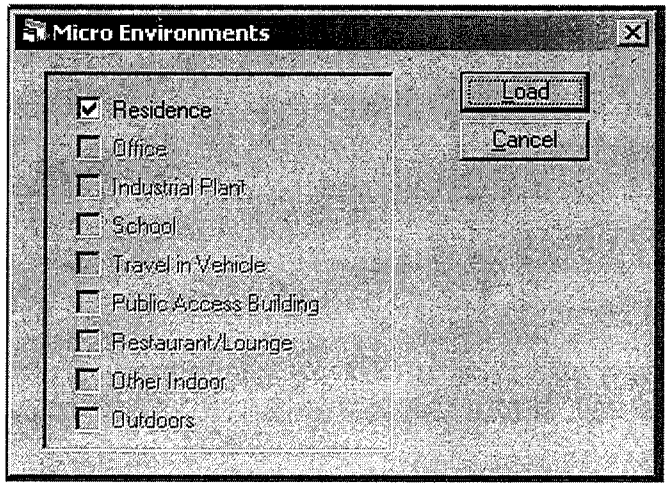

Figure 3-14 Micro Environments dialog box

You must enter case information for one environment at a time. Select an environment and click **L ad.**

CPIEM will display the Micro Environment Cases dialog box. Note that the dialog box will be named by the micro environment specified, for example Residence Cases.

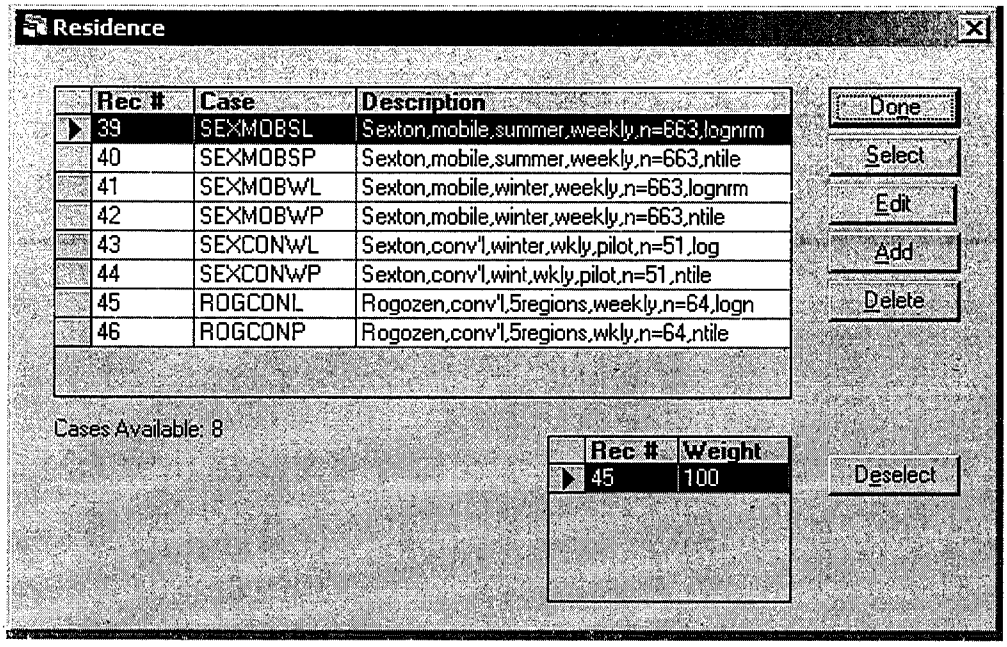

Figure 3-15 Micro Environment Cases dialog box

You can use the Micro Environment Cases dialog box to add or edit a case, then select the cases that you want to run in the scenario and assign them weights.

3.2.1. Adding a Case

To add a new case, click **Add**. CPIEM will display a new line with a default name. To select criteria to be use for this case, select that new line and then click **Edit**.

You can change the default name by selecting it and typing a new name.

Follow the procedures below to select the criteria for the new case.

3.2.2. Editing a Case

Click **Edit**.

CPIEM will display the Micro Environment Case Details dialog box. Note that the dialog box will be named by the micro environment specified, for example Residence Case Details.

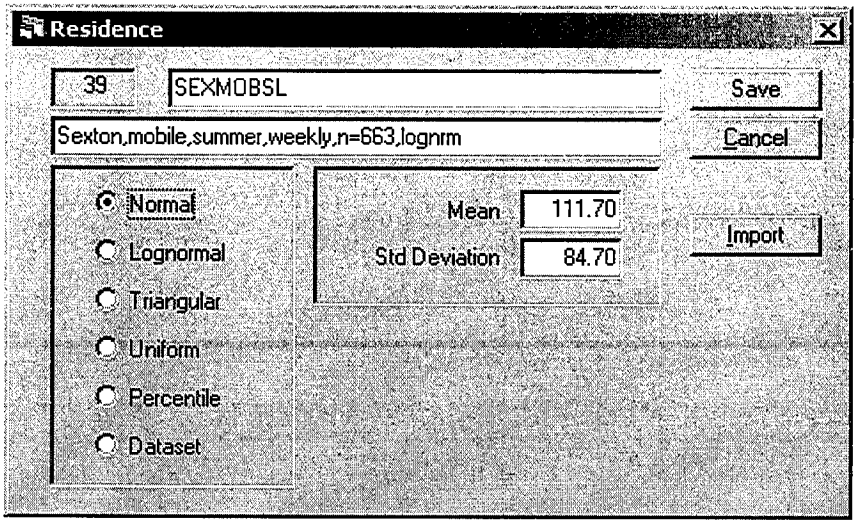

Figure 3-16 Micro Environment Case Details dialog box

You can select one of the concentration distributions. You must then enter the parameters for the distribution you selected. The type of parameter you must provide depends on the type of distribution you select. The following table shows types of concentration distributions that are available for the scenario and the input parameters that are required for each.

Type of Distribution	Input Parameters
Normal	Mean, standard deviation
Lognormal	Mean, standard deviation
Triangular	Minimum, mode, maximum
Uniform	Minimum, maximum
Percentile	Up to 12 pairs of percentiles and associated values
Dataset	Name of file, Microsoft Access (.mdb)

Table 3-1 Types of Concentration Distributions and Associated Input Parameters

3.2.3. Selecting a Distribution Type

If you select **Normal**, you must then provide the arithmetic mean and standard deviation. Enter a standard deviation that is a third or less of the magnitude of the mean. If you specify a standard deviation with a magnitude approaching that of the mean, then negative values could theoretically be sampled. If a negative value is selected, CPIEM re-samples form the specified distribution until a positive value is selected. The resulting distribution of selected values will have a higher expected mean than that specified by the user, and this could introduce upward bias in the CPIEM results.

If you select **Lognormal**, you must provide the arithmetic mean and standard deviation, *not* the geometric mean and standard deviation. The concentration values randomly selected by CPIEM for the run of the scenario will follow the shape of a lognormal, rather than normal, distribution.

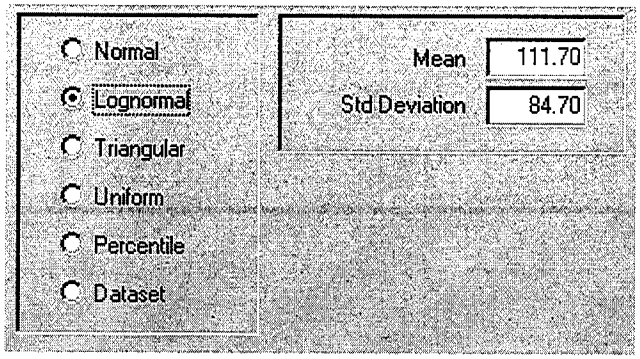

Figure 3-17 Mean and Standard Deviation are choices for both Normal and Lognormal

Both the DOS version of CPIEM and CPIEM 2.0 characterize a lognormal distribution according to the arithmetic mean and arithmetic standard deviation. However, in the literature a lognormal distribution is more often characterized by the geometric mean and geometric standard deviation. If you want to enter a lognormal distribution, but know only the geometric mean and geometric standard deviation parameters, you may use the following relationships to derive the equivalent arithmetic mean and arithmetic standard deviation parameters.

Assume Y is lognormal with geometric mean of "M " and geometric standard deviation of "S". This is the same as assuming ln(Y) is normal with mean ln(M) and standard deviation ln(S).

Then, the arithmetic mean of $Y = M * \exp(0.5 * \{\ln(S)\}^2)$

And the standard deviation of $Y = M * \sqrt{[\exp(\{\ln(S)\}^2) * \{ \exp(\{\ln(S)\}^2) - 1\}]}$

If you select **Triangular**, you must provide the minimum, mode, and maximum. This particular distribution can provide a reasonable approximation for many other types of distributions, including normal and lognormal. For example, a triangular distribution with the mode equidistant from the maximum and minimum would approximate a normal distribution.

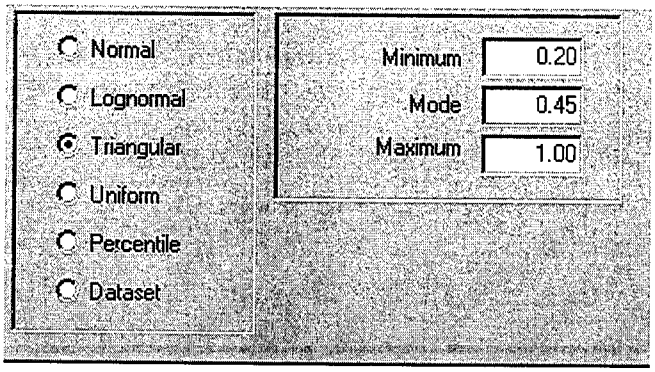

Figure 3-18 Minimum, Mode, and Maximum are choices for a Triangular distribution

If you select **Uniform**, you must provide just the minimum and maximum values; however, concentration distributions typically do not follow this shape.

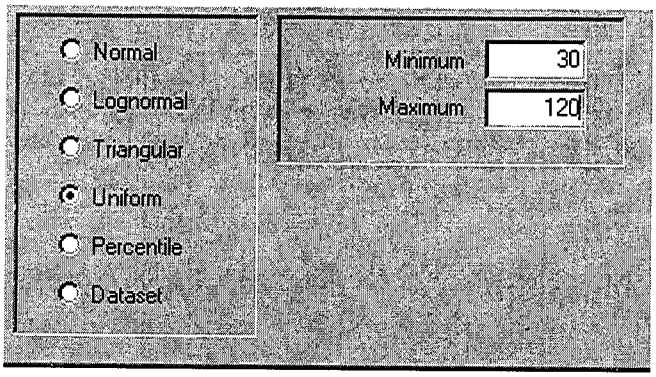

Figure 3-19 Minimum and Maximum are choices if Uniform is selected

If you select **Percentile**, you must provide up to 12 pairs of percentiles and associated concentration values. You must list these in ascending order, typically starting with the minimum (0th percentile) and ending with the maximum (100th percentile). In many cases, particularly when the shape of the distribution is unknown (although lognormal would be a reasonable assumption), percentile would be the best choice. Ideally, you should provide the following nine percentiles: 0, 5, 10, 25, 50, 75, 90, 95, and 100.

A value for the 100th percentile (the maximum) must be provided.

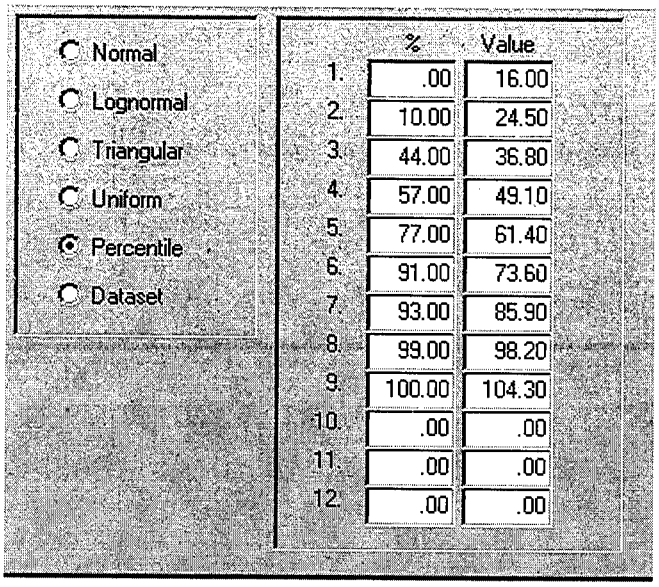

Figure 3-20 Up to 12 pairs of percentiles and associated concentration values

Concentration results from a number of field studies (primarily in residences) are provided. However, many of these results apply to a specific region of the state and/or a specific time of year (such conditions are noted in the case-name descriptions for each distribution). Ideally, the criteria for selecting a population subgroup should be consistent with the region/time of the chosen concentration distribution(s).

The final choice for type of distribution is an actual **Dataset** containing concentration values to be sampled (Figure 3-15). Such data sets must be provided in a dBase-compatible format (.dbf) and contain an index number (1, 2, 3, etc.) for successive records as the first field. The file format must be compatible with the chosen integration period (see Section 2.2). For 12-hour and 24-hour integration periods, a single concentration value for each record comprises the second (and only other) field. For 1-hour and 8-hour periods, 24 ordered fields follow the index field (for example, for the 1-hour period, the first of these 24 fields is a concentration value from midnight to 1:00 a.m., the second is a value from 1:00 to 2:00 a.m., etc.). The user must provide the name of the .dbf file. Instructions for creating an .dbf in the required format are given in Section 7.0.

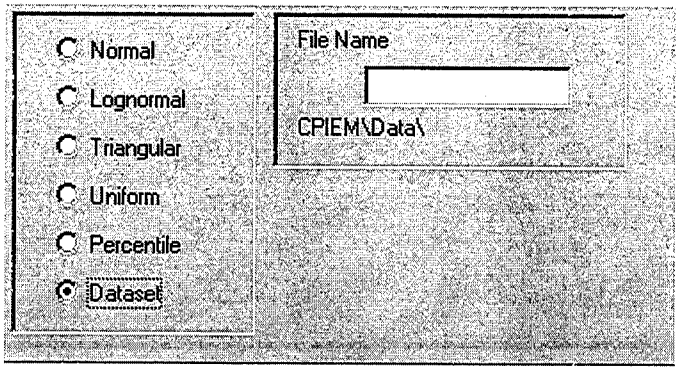

Figure 3-21 Dataset

For 1-hour and 8-hour integration periods, Dataset is the only option for concentration distributions (all other choices are grayed out and unavailable). CPIEM does not use distributional information as input for these integration periods because 24 concentration values are required for each trial in the simulation, as opposed to one value per trial when a 24-hour or 12-hour integration period is used.

You can also **Import** data files containing summary statistics that have been generated from an Indoor Concentrations (Level 3) model run. These can be used to estimate a concentration distribution for one environment. The name of the file containing the summary statistics, with an extension of .stc, must be provided by the user in the same subdirectory as the CPIEM executable. (This is the default location of Indoor Concentration [level 3] model run output files, if not re-directed.) **Select** CPIEM will retrieve statistics from the file that are appropriate for the type of distribution chosen by the user. Specifically, if the user chooses either normal or lognormal distributions the mean and standard deviation from the .stc file are retrieved to populate the corresponding parameters. For a triangular distribution, geometric mean is used for the mode, and for a percentile distribution the 5^{th}, 10^{th}, 25^{th}, 75^{th}, 90^{th}, 95^{th} percentiles in addition to the minimum and maximum values are used to populate the corresponding values.

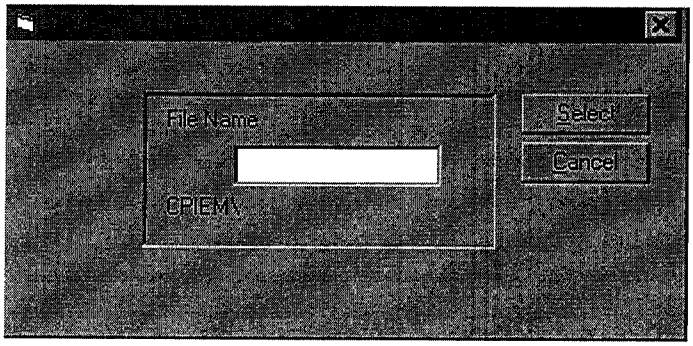

Figure 3-22 Import Data File dialog box

When you have finished selecting the type of distribution and entering information for it, click **Save**. CPIEM will again display the Micro Environment Cases dialog box.

3.2.4. Selecting Cases to Run and Assigning Weights

Concentration distributions can be saved for later access. All saved cases are linked to a pollutant and integration period. You can use more than one case for a run of the scenario by using weights; these weights must sum to 100. When you use more than one distribution for a given environment, CPIEM will randomly access one of the distributions for each trial; the probability of choosing a specific distribution will be proportional to its assigned weight.

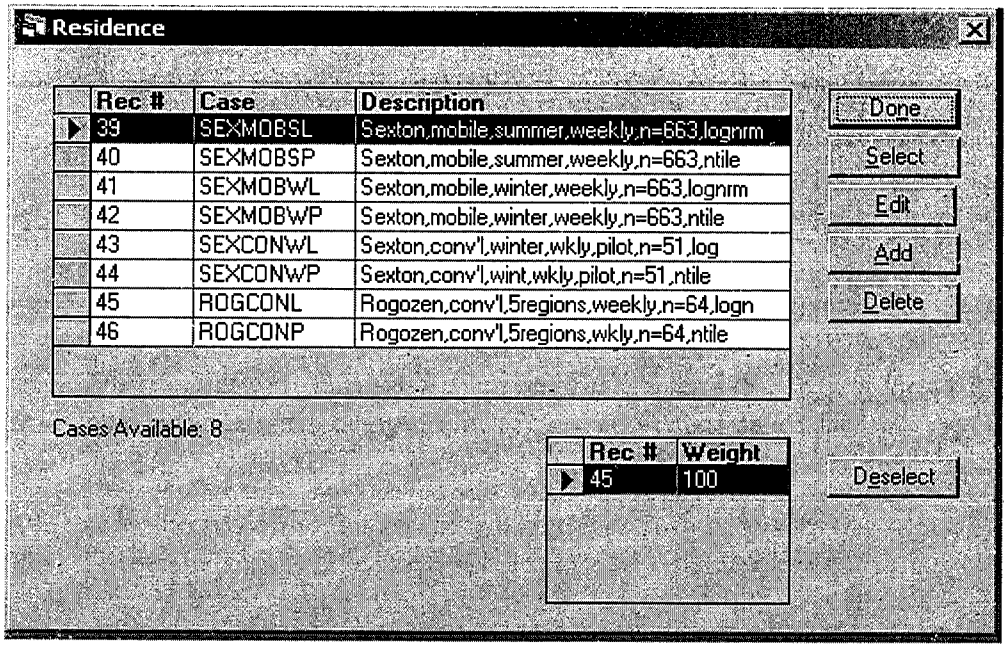

Figure 3-23 Micro Environment cases

You can select a single case or multiple cases to run in a scenario. Select the cases that you want to run and click **Select** after each. CPIEM will display each, by record number, in the Weight box at the bottom of the dialog box.

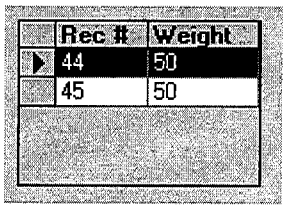

Figure 3-24 Weight box

If you select a single case, its weight will be 100. When you select multiple cases, their combined weights must add to 100. When you have selected all the cases that you want to run, select each case in the weight box, by record number, and type in a percentage for weight. The percents must add to 100. **NOTE:** When the user clicks on a weight values to edit it, the format of the weight box will shift so that the Rec # column is no longer displayed. To return to Rec # display format, use the leftward directional arrow key on the keyboard while any weight value entry is selected.

Once the input describing a concentration distribution has been saved, it is available for subsequent runs by selecting it; the input needs to be saved only once.

3.3. Breathing Rates

The Breathing Rates dialog box provides one of the inputs to dose calculations. The potential inhaled dose for each micro environment is calculated by multiplying the airborne concentration in that environment by the amount of time spent in the environment by an individual and his/her breathing rate. A sampled activity profile provides the information on time spent in each environment and associated activity level(s), from which breathing rates are assigned. The units for breathing rate are cubic meters per hour (m^3/h).

From the **Exposure/Doses** menu, select **Breathing Rates**.

CPIEM will display the Breathing Rate Cases dialog box.

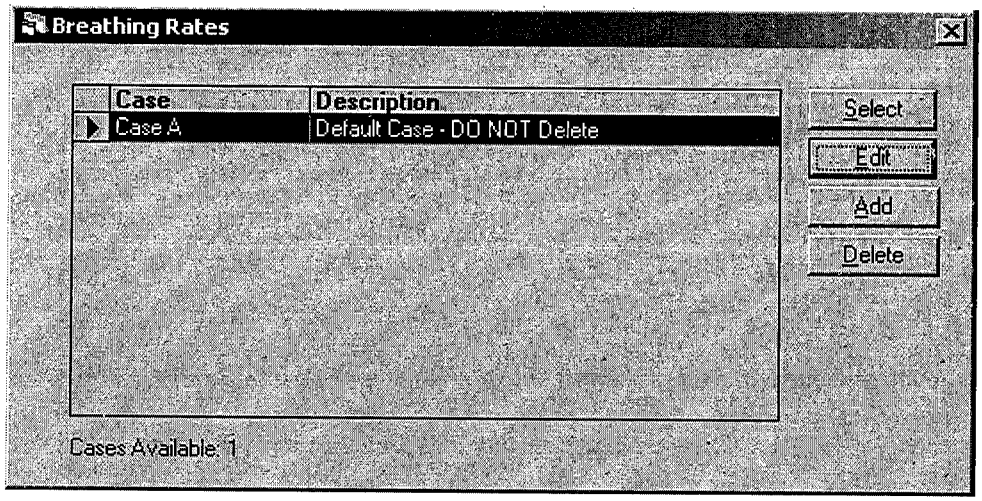

Figure 3-25 Breathing Rate Cases dialog box

CPIEM will display a list of breathing rate cases. There is a default case that can be used as an example and should not be deleted.

You can use the Breathing Rate Cases dialog box to add a new case or edit an existing case. You can select the case you want to use for this run of the scenario.

3.3.1. Adding a Breathing Rates Case

To add a new case, click **Add**. CPIEM will display a new line with a default name. To select criteria to be use for this case, select that new line and then click **Edit**.

You can change the default name and description by selecting each in turn and typing a new name and description.

Follow the procedures below to select the criteria for the new case.

3.3.2. Editing a Breathing Rates Case

Click **Edit**, and CPIEM will display the Breathing Rate Case Detail dialog box.

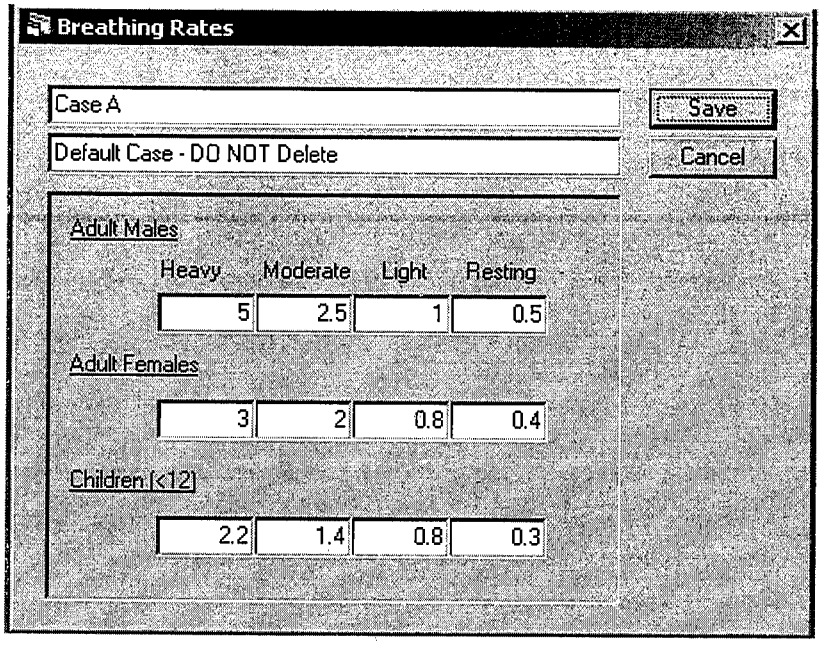

Figure 3-26 Breathing Rate Case Detail dialog box

You can use the Breathing Rate Case Detail dialog box to assign breathing rates. Breathing rates can be assigned to four activity levels: heavy, moderate, light, and resting for each of three age/sex classes: adult males, adult females, and children under 12 years of age. The default values provided were determined by staff in ARB's Research Division and are recommended for use until such time as future research indicates more appropriate values.

As with inputs for population subgroup, sets of alternative values can be used. Only one set of breathing rates can be used for a given run of the scenario. If the user is concerned only with estimating time-integrated exposure, which does not require breathing rates for calculations, then you do not need to use this dialog box.

When you have finished making your additions or edits, click **Save**. CPIEM will again display the Breathing Rate Cases dialog box. Select the case you want to use for this run and click **Sel ct**.

You can now run the scenario. For information on running the scenario, see Chapter 5, Executing Model Calculations.

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