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MACCS (MELCOR Accident Consequence Code System) User Guide – Version 4.0, Revision 1

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ABSTRACT

The MELCOR Accident Consequence Code System (MACCS) is used by Nuclear Regulatory Commission (NRC) and various national and international organizations for probabilistic consequence analysis of nuclear power accidents. This User Guide is intended to assist analysts in understanding the MACCS/WinMACCS model and to provide information regarding the code. This user guide version describes MACCS Version 4.0. Features that have been added to MACCS in subsequent versions are described in separate documentation. This User Guide provides a brief description of the model history, explains how to set up and execute a problem, and informs the user of the definition of various input parameters and any constraints placed on those parameters. This report is part of a series of reports documenting MACCS. Other reports include the MACCS Theory Manual, MACCS Verification Report, Technical Bases for Consequence Analyses Using MACCS, as well as documentation for preprocessor codes including SecPop, MelMACCS, and COMIDA2.

Revision 1 of the MACCS Version 4.0 User Guide was made to update the authorship and acknowledgments.

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EXECUTIVE SUMMARY

The purpose of this document is to provide a user guide and reference document for MACCS, which is used for calculating health and economic consequences from a release of radioactive materials into the atmosphere. The MACCS code suite has a diverse user base including the U.S. Nuclear Regulatory Commission (NRC), the U.S. Department of Energy (DOE), various research organizations, nuclear power plant applicants and licensees, as well as international regulators and technical support organizations.

In 2001, the NRC initiated an effort to create a Windows-based interface and framework for performing consequence analysis. This user guide describes the functions of both WinMACCS and MACCS together. For simplicity, the combined functions of MACCS and WinMACCS are often referred to as MACCS. However, WinMACCS and MACCS are separate codes and it is often useful to distinguish the functions of the two codes. This User Guide applies to version 4.0 of both MACCS and WinMACCS but is largely applicable to more recent updates.

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ACRONYMS AND ABBREVIATIONS

AT	annual threshold
CCDF	Complimentary cumulative distribution function
DCF	Dose conversion factor
DDREF	Dose and Dose Rate Effectiveness Factor
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FGR	Federal Guidance Report
GDP	Gross Domestic Product
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory model
ICRP	International Commission on Radiation Protection
LHS	Latin Hypercube Sampling
LNT	Linear No Threshold
MACCS	MELCOR Accident Consequence Code System
NOAA	National Oceanic and Atmospheric Administration
NPPs	Nuclear power plants
NRC	U.S. Nuclear Regulatory Commission
PL	piecewise linear
PRA	Probabilistic Risk Assessment
RDEIM	Regional Disruption Economic Impact Model
SecPop	Sector Population and Economic Estimator
SNL	Sandia National Laboratories
SOARCA	State-Of-the-Art Reactor Consequence Analyses project
SRS	Simple random sampling
SQA	Software quality assurance
TEDE	Total effective dose equivalent

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1. INTRODUCTION

The historical reference to the consequence code has been MACCS or MACCS2, which was related to the version number. In 2001, the NRC initiated an effort to create a Windows-based interface and framework for performing consequence analyses. This user guide describes the functions of both WinMACCS and MACCS together. For simplicity, the combined functions of MACCS and WinMACCS are often referred to as MACCS. However, WinMACCS and MACCS are separate codes and it is often useful to distinguish the functions of the two codes.

MACCS is the NRC code used to estimate the offsite consequences of potential severe accidents at nuclear power plants. The code is used to perform probabilistic health and economic consequence assessment of hypothetical releases of radioactive material. Atmospheric dispersion and transport, wet and dry deposition, probabilistic treatment of meteorology, environmental transfer, countermeasure strategies, dosimetry, health effects, and economic impacts are addressed in the code.

The lineage of development of accident consequence codes for the NRC is described as follows:

- CRAC was used in the landmark Reactor Safety Study (WASH-1400) to estimate consequences of a set of hypothetical accidents. WASH-1400 was published in 1975 but a CRAC user manual does not appear to have been published.

- CRAC2 was published in 1983 (Ritchie et al., 1984) and was most notably used to support Technical Guidance for Siting Criteria Development (Aldrich et al., 1982)

- MACCS was published in 1990 (H-N Jow, et al., 1990) and was used to perform the consequence analyses for the landmark probabilistic risk assessment (PRA) study documented in NUREG-1150 (NRC, 1989)

- MACCS2 was published in 1997 (Chanin and Young, 1997). The work to develop MACCS2 was sponsored by the DOE and was focused largely on generalizing MACCS to be used for nonreactor applications.

- WinMACCS was first released to the public in March of 2008 as Version 3.4.0. WinMACCS has been used for a large number of important studies, including the State-of-the-Art Reactor Consequence Analyses (SOARCA) (Chang et al., 2012; Bixler et al., 2013, and Sandia National Laboratories, 2013), the SOARCA uncertainty analyses for Peach Bottom, Sequoyah, and Surry (Mattie et al., 2016; Sandia National Laboratories, 2019; Ross et al., 2015), and Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor (Barto et al., 2014).

1.1 MACCS History

MACCS2 1.12 was released in April of 1997 as a batch-process code. In September 2001, version 1.13 was released to allow execution under newer operating systems and to fix several bugs in the previous version. Since 2001, a new version of MACCS has been released approximately every two years. New versions offered enhancements in addition to addressing bugs. The current version of MACCS is 4.0. A detailed chronicle of changes made to MACCS is distributed along with MACCS and can be located in the Start Menu folder and is entitled “History of MACCS.” Parallel revisions to WinMACCS are similarly documented in “History of WinMACCS” which is located in the same Start Menu folder.

1.2 Software Quality Assurance

Development of MACCS, WinMACCS, and other supporting codes in the suite of MACCS software is controlled by a set of software quality assurance (SQA) requirements in compliance with NRC requirements. The elements of the SQA requirements include QA training for the software developers, testers, and administrators; documentation of software requirements; documentation of software implementation; test plans; management of revision history and configuration control; test reports; bug tracking; and client tracking. Further documentation, such as a user manual, a verification report, theory manual, and other supporting documentation, are either currently available or in the process of being written at the time of this writing. Bug tracking for MACCS version 4.0 used Melzilla, an implementation based on Bugzilla. Currently, as of this report's publication, bug tracking for newer versions of MACCS use FogBugz. The details of the SQA plan are documented in MELCOR Accident Consequence Code System (MACCS) Software Quality Assurance Plan, Version 1.7, which is available to MACCS users upon request.

1.3 WinMACCS Overview

In 2001, the NRC initiated an effort to create a Windows-based interface and framework for performing consequence analyses. WinMACCS is developed for Windows operating systems. This effort was intended to address the following needs:

- Simplify the effort required to create or modify input files and make it more intuitive;
- Reduce the likelihood of user errors in performing consequence analyses;
- Enable the user to simply and conveniently account for uncertainties in input data; and
- Displace the original batch framework with a Windows-based framework.

The result of this development effort was the WinMACCS code. WinMACCS is currently integrated with versions of MACCS, COMIDA2, and LHS (Latin Hypercube Sampling) to perform all the required functionality. The original MACCS2 batch framework is preserved; MACCS can still be run in stand-alone fashion apart from the WinMACCS interface. However, there are significant advantages for migrating to the WinMACCS framework for running consequence calculations.

1.4 MACCS Framework

1.4.1 Software used to Develop WinMACCS

Components used to develop the WinMACCS software are described in Section 4.

1.4.2 WinMACCS Components

The components of WinMACCS are shown in Figure 1-1. WinMACCS allows one or more calculations to be run on a computer. The user can modify model input parameters and model settings and save them in the project database. The user can initiate a WinMACCS deterministic simulation or a set of simulations to evaluate uncertainty from input parameters represented by probability distributions to reflect degree of belief. To do the latter, WinMACCS uses a code called LHS to generate vectors of sampled input parameters to create a set of equally probable realizations. LHS can use either of two sampling algorithms: simple random sampling (SRS) or LHS, which is a type of stratified sampling. WinMACCS can also run three other codes: COMIDA2 to evaluate parameters affecting the food ingestion pathway, PopMod to change the number of sectors in a site file, and CombineSource to combine source terms for multiple units and/or spent fuel pools. These codes act as preprocessors for MACCS.

WinMACCS can run LHS to generate values for the uncertain parameters and to build the MACCS input files for each simulation. It runs MACCS multiple times, once for each realization. Multiple simulations can also be created using the cyclical file option. In this case, MACCS input can be modified using a set of input files that effectively act as change cards. One application of this feature is to run successive MACCS simulations using multiple source terms from MELCOR accident progression simulations. The interface utility, MelMACCS, can be used to create the input files containing the source-term data. This feature is called cyclical because it can be combined with sampling of uncertain input data and the input files are cycled if there are more simulations than input files. The user may view, export, and aggregate results of MACCS simulations in various formats, such as text, Microsoft Excel, JPEG, BMP, XML, and HTML.

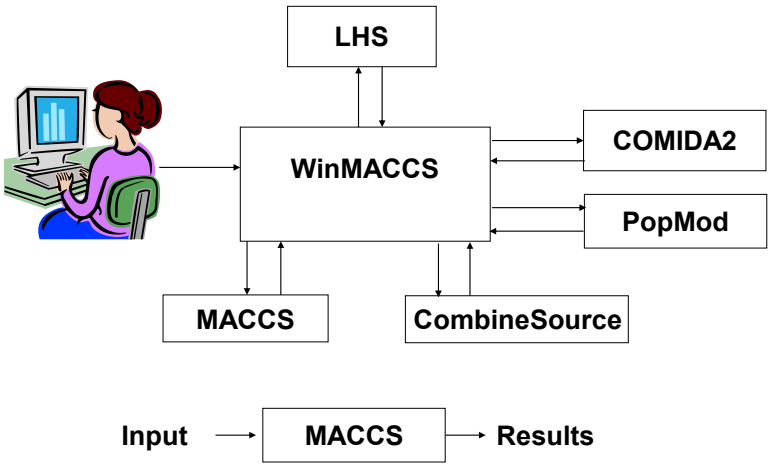


Figure 1-1 WinMACCS components

PopMod can be used with site files generated with versions of SecPop prior to 4.0 to support MACCS grids with more than 16 compass sectors. The work of PopMod is primarily interpolation and reformatting. No new information is added to the site data file that is created. With SecPop 4.0 or newer, PopMod is not needed because SecPop creates population distributions for grids with more than 16 compass sectors.

Data files managed by WinMACCS include a set of auxiliary files, such as a site file, a meteorological file, one or more COMIDA2 binary file(s), and one or more DCF file(s). Input files are created by WinMACCS using the model and input settings stored in an underlying database. These input files can include Atmos*n*.inp, Early*n*.inp, Chronc*n*.inp, Comida*n*.inp, and Lhs.inp. Here, *n* is 1 or more and denotes the simulation number. Multiple simulations are performed when evaluating uncertainty and/or using the cyclical file option discussed in this document. Output files are created by MACCS and its preprocessors (e.g., LHS and COMIDA2). A set of MACCS output files, Model*n*.out and Model*n*.bin, are normally created for each simulation. Other files may or may not be created, depending on settings chosen by the user.

An Access database file is created from a database template file, Initialize2000.mdb, when a new project is created. The project database is modified using the Microsoft DAO 3.6 library. The database contains the following information:

- Default input values and model settings,
- Input values and model settings specified by user,
- Input parameter descriptions and limits,
- Information to construct input forms,
- Information to construct input files,
- LHS results, and
- MACCS results read from binary files.

1.4.3 WinMACCS Project File Structure

A project folder contains the following files and subfolders:

- A database file (e.g., myProject\myProject.mxd). This file is an Access 2010 database file. In addition to its settings, this file contains the parameter values used to build the MACCS input files when a simulation is run.

This folder contains four subfolders as follows:

- myProject\Data\ contains user specified data files, such as the site file, the meteorological file, and the dose conversion factor (DCF) file.

- myProject\Input\ contains input files created by WinMACCS each time the user requests a MACCS simulation.

- myProject\Output\ contains output files from MACCS and other executables run by WinMACCS.

- myProject\ResultsDB\ contains results from the MACCS model execution

To move the location of the project, the user can simply move (or drag and drop) the folder myProject\, including its files and subdirectories, to a new location.

1.4.4 Parameters Tab

The parameters are organized in a tree structure to facilitate access. The highest level of the tree structure is called a main category, the second level is called a category, the third level is called a subcategory, fourth level is called a form and under a form are one or more parameters. The example in Figure 1-2, shows the main categories: *GENERAL, ATMOS, EARLY, CHRONC, DOSE COEFFICIENTS*, and *COMIDA2*. *GENERAL* contains categories named *Properties*, *File Specifications*, and *Output Options*. More information under each of the categories can be viewed if the + is clicked to display more detail. The convention used in this document is that italicized words are names or labels that appear in the WinMACCS interface.

Within the *ATMOS* main category, the *Radionuclides* category has been completed, as indicated by the solid orange diamond next to the category name. The orange color of the symbol indicates that there is at least one form in this category that is optional.

Within the *ATMOS* main category, the *Deposition* category detail is shown. The X-ed red octagon indicates that there is missing or inconsistent information in this category. The *Wet/Dry Depos Flags* and *Wet Deposition* forms have been completed consistently, as indicated by the solid green octagons. The *Dry Deposition* form needs attention, as indicated by the X-ed red octagon

next to the form name. This form contains one variable: *VDEPOS*. If the form name or the parameter is double-clicked, the corresponding parameter modification form is opened.

It is important to note that the symbols do not indicate whether input values are correct or incorrect; they only indicate whether they are consistent and within acceptable bounds imposed by WinMACCS. The user is responsible for entering and performing adequate quality assurance/control to verify that reasonable values of input parameters are entered in the interface.

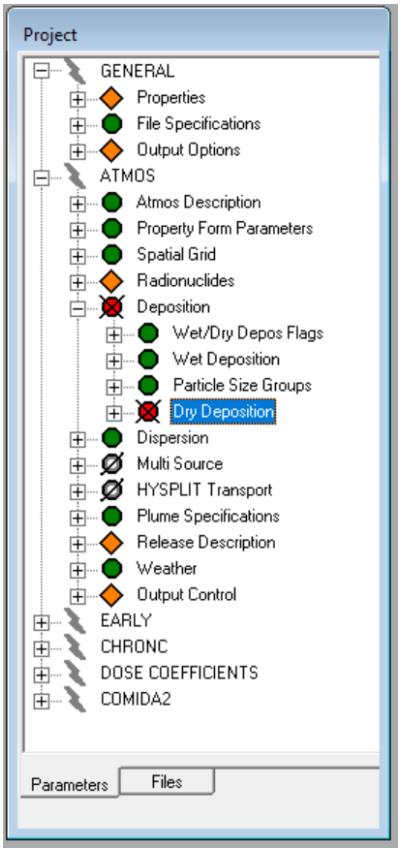


Figure 1-2 Parameters Tab Under the Project Window

Each entry in the tree shown in Figure 1-2 has a related icon. This icon reflects the state of the object. The objects and icons are as follows:

- Input associated with a main category is represented by a lightning bolt icon.

  GENERAL, *ATMOS*, *EARLY*, *CHRONC*, DOSE COEFFICIENTS, and *COMIDA2* are the main categories. The *GENERAL* category contains the links to the model settings (e.g., the weather sampling method) and the links to the auxiliary files to be used in a simulation. There are several categories within each module. These categories contain forms that are used to specify input parameters. An example of a category is *Plume Specifications*.

Icons next to category names define the underlying form states as follows:

 An X-ed red octagon indicates that the user needs to complete or correct this form before running MACCS.

 A solid green octagon indicates that the user has completed this form and that the data defined on this form are needed to perform a calculation.

 A solid orange diamond indicates that the user has completed this optional form. The values defined on all forms with a solid orange diamond are used to perform a calculation. A solid orange diamond may appear on categories and subcategories when some forms are optional, and others are required.

 An empty orange diamond indicates that the user has not completed this optional form.

 A solid X-ed orange diamond indicates that this optional form needs attention before running MACCS. This can be done by opening, clearing the form, and clicking OK or by correcting it, in which case the values on this form are conveyed to the appropriate MACCS input file.

 A solid gray octagon with a diagonal line indicates that the user has completed this form, but the values are not needed under the current model choices.

 An empty gray octagon with a diagonal line indicates that the user has not completed this form, but it is not required and can be ignored.

 A black circle indicates a parameter that is contained on a form. The parameter names are listed to facilitate navigation within WinMACCS and are given the same names as the MACCS input variables. Double-clicking on a parameter object causes the related form to open with the focus at the selected parameter value.

Double-clicking on a form or on a parameter name associated with a form causes that form to open for review and editing.

The *Properties* form found under the *GENERAL* main category and under the *Properties* category allows the user to modify model choices to be used in a subsequent MACCS calculation(s). Data entry on this form can modify the status of the categories and forms as indicated by the icons listed above. The user should generally start a new project or modify an existing project by making appropriate model choices under the *Properties* form. This defines the status of the categories and forms shown under the *Project Parameters* tab.

1.4.5 Files Tab

There are three file categories on the *Files* tab: *Data*, *Input,* and *Output*. The Data file category contains several file-type variables. Beneath the file-type parameters are links to the files currently used or defined in the project. Each of the file categories corresponds to folders stored in the project folder.

The structure emulates the folder structure displayed when the project is viewed in Windows Explorer as shown in Figure 1-3 with differences noted below in the detailed description of each of the three file categories.

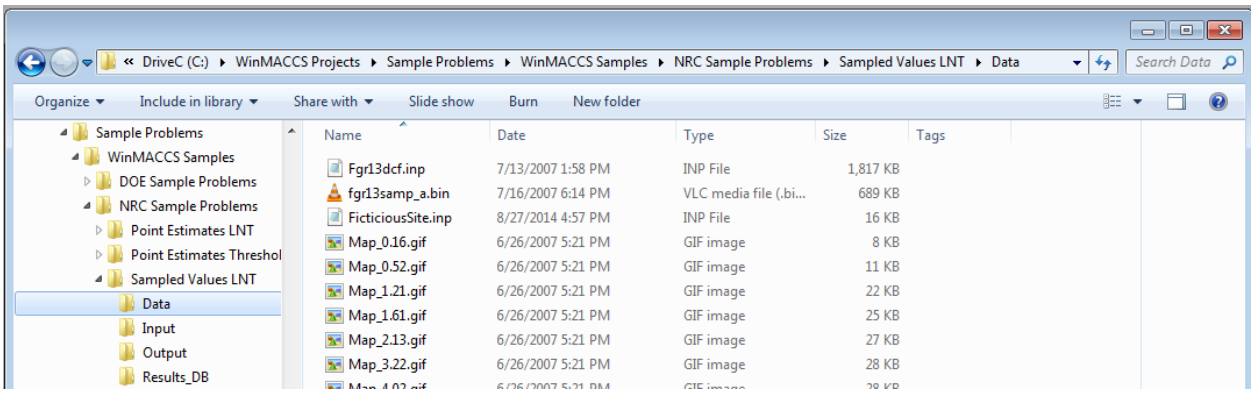


Figure 1-3 Data folder as seen from Windows Explorer

1.4.5.1 Data Files

This file category called *Data* contains data files specified by the user under the *General*/*File Specifications* category on the *Parameters* tab of the *Project* window. Double-clicking on a file link opens the selected file in Notepad for editing. This allows the user to modify the file and save it. The modified file is used when MACCS is run. Files in the Data folder, as shown in Figure 1-3, other than those in *File Specifications,* are not shown in the *Data* files category.

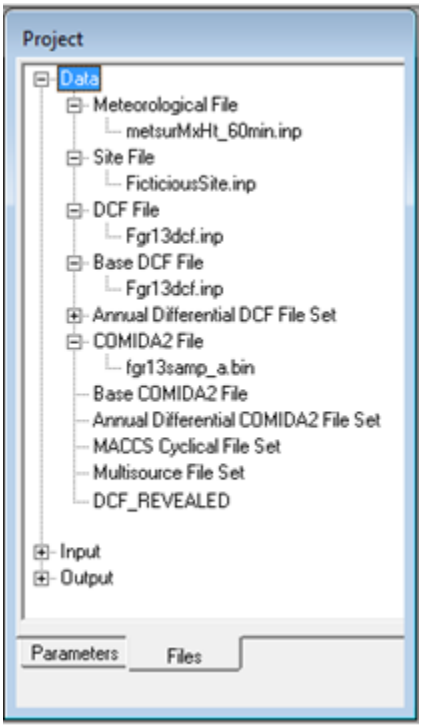


Figure 1-4 Project data folder

Not all the files shown in Figure 1-4 are necessarily used when MACCS is run. Which files are used depends on the models that have been selected on the *Properties* form. For example, if *Early Consequences* is not selected under the *Scope* tab on the *Properties* form, the DCF file is not needed for the simulation. This is indicated by the icon displayed next to *DCF File* under the *File Specifications* category.

The file links displayed in Figure 1-4 can be modified by double-clicking on the form or parameter name under the *GENERAL*/*File Specifications* category, as shown in Figure 1-5.

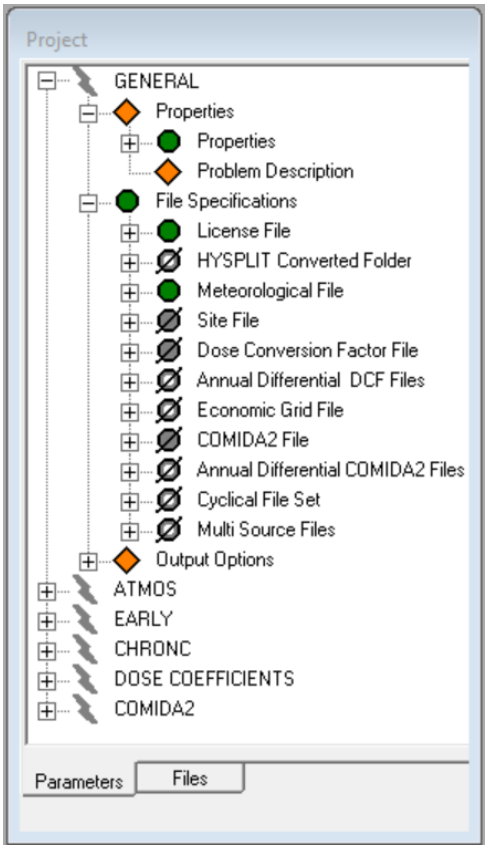


Figure 1-5 File specifications

Model settings that determine which data files are needed for a calculation are controlled with the *Project Properties* form shown in Figure 1-6.

If a user desires to include map files in order to use the network evacuation model, the map files also need to be placed in the Data folder. Map files stored in the Data folder are not shown in the *Files* tab in the *Project* form. These files need to be in Graphics Interchange Format (.gif). A utility to facilitate creating .gif files uses a stand-alone executable called MapGen (see Section 4.4.7.3). MapGen reads an interface file containing information about the spatial grid written by WinMACCS and creates a set of map files using Microsoft MapPoint. MapPoint is no longer supported by Microsoft and this capability is now largely obsolete, although Sandia retains the capability to generate these maps. Some forms use these maps as a background layer to facilitate defining evacuation model settings. These forms are located in each of the *EARLY/Emergency Cohort* categories (e.g., *EARLY/Emergency Cohort One*).

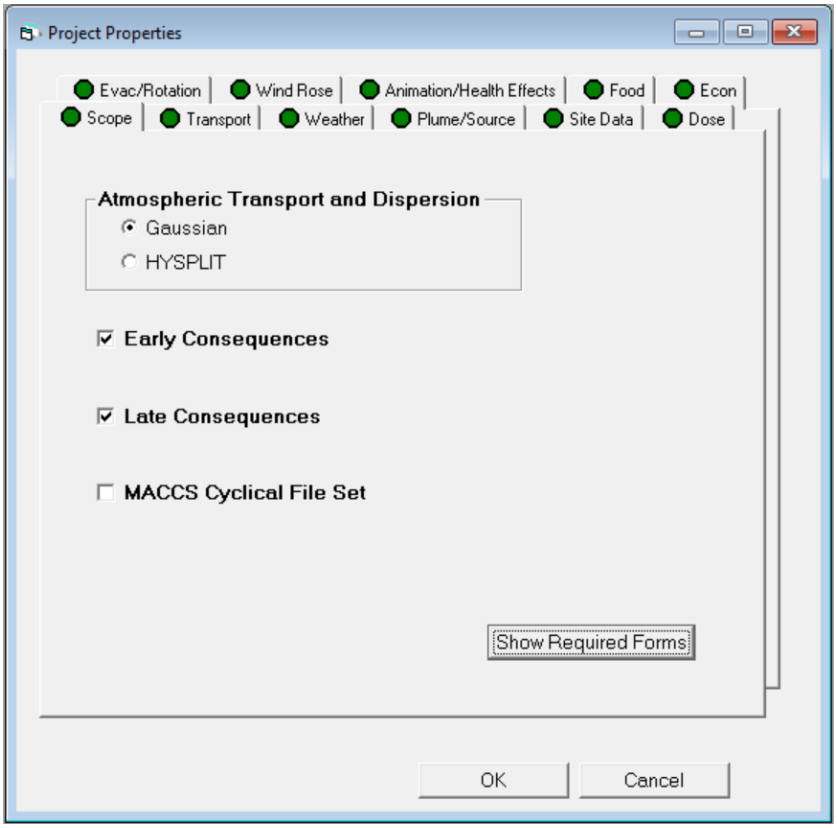


Figure 1-6 *Project Properties* form

1.4.5.2 Input Files

This category contains input files as shown in Figure 1-7 that are normally created by WinMACCS before running a MACCS simulation. If the main menu option, *Execute*→Run Models→*Create all templates* is not checked, but rather the *Create only missing templates* is checked, the template files atmosTemplate.txt, earlyTemplate.txt, chroncTemplate.txt, and comidaTemplate.txt are not recreated from the settings within WinMACCS before running a simulation. This feature allows the user to edit these files and run a simulation using the edited files. This feature was created to allow users to modify the template files manually during the implementation of new features not yet supported by WinMACCS. It is unusual to uncheck this menu option, but it could be useful in exceptional situations when the WinMACCS template file does not satisfy the user's needs. When any project is opened, regardless of the previous state of this menu option, this option is checked.

Users may also enter the *Advanced Execution Parameters* form, to select more specific disposition of each MACCS input and output file.

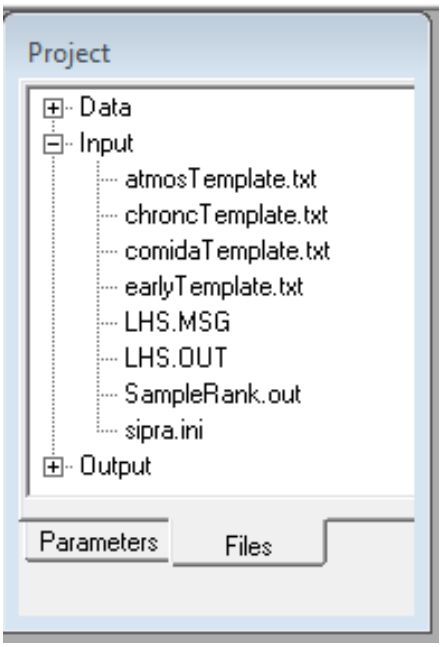


Figure 1-7 Input files

All files in Project\Input\ are shown in the *Project* window. Selecting main menu option *File→Refresh File View* causes the hard drive to be queried and refreshes the set of files shown in the *Project* window.

***WARNING*: The Input folder is not a good place to store any files that the user wants to keep! WinMACCS deletes all files in this folder when it runs MACCS. The Data (Project\Data\) and root directories (Project\) are safe places to store files because they are never deleted by WinMACCS. The user can also create additional directories for archiving files under the Project\ folder.**

The following example reflects a run with a scope of *Atmospheric Dispersion, Early Consequences*, *Late Consequences*, and *COMIDA2*. In this example, some parameters are sampled, the template files are created, and two simulations are requested.

Table 1-1 Files created in the input folder by WinMACCS during execution.

Name of file	Conditions when file Is created	Description
atmosTemplate.txt	Always created when MACCS is run.	File atmosTemplate.txt is used to create input files Atmos1.inp and Atmos2.inp. This file is used by WinMACCS
earlyTemplate.txt	*EARLY* module is selected under the *Scope* tab in the *Properties* form.	File earlyTemplate.txt is used to create input files Early1.inp and Early2.inp. This file is used by WinMACCS.
chroncTemplate.txt	*CHRONC* module is selected under the *Scope* tab in the *Properties* form.	File chroncTemplate.txt file is used to create input files Chronc1.inp and Chronc2.inp. This file is used by WinMACCS.
Atmos1.inp Early1.inp Chronc1.inp Atmos2.inp Early2.inp Chronc2.inp	Input files are created consistently with the model scope. For example, when the user has only specified *Atmospheric Dispersion* and *Early Consequences* on the *Scope* tab in the *Properties* form, Atmos1.inp, Atmos2.inp, Early1.inp, and Early2.inp are created using atmosTemplate.txt and earlyTemplate.txt. Chronc*n*.inp is not created. This example is for Late Consequences selected so that the Chronc files are created.	Files are created using the template files in conjunction with data from LHS.out relevant to each simulation. If any of the parameters are uncertain, this information is encoded in the relevant template file. The actual values used in simulation *n* correspond to realization *n* in the LHS.out file. These files are used by MACCS.
LHS.inp	Created whenever uncertain parameters are defined.	This file contains input to LHS that indicates the number of observations, probability distributions, parameter names, and correlations between sampled parameters.
Sipra.ini	Created whenever uncertain parameters are defined.	This file contains LHS settings and is copied from Program Files\WinMACCS folder into the \Project\Input\ folder. It is read by LHS.
LHS.out LHS.msg	Created whenever uncertain parameters are defined.	These files are created by LHS. LHS.msg is a detailed output file describing the run. LHS.out is used to create the input files by WinMACCS for MACCS.
comidaTemplate.txt	Created when the *Late Consequences* option is selected on the *Scope* tab in the *Properties* form and the *File Created from User Input* option is selected on the *Food* tab in the *Properties* form.	This file is like the other template files. It is used with LHS.out to create the three sets of input files required by COMIDA2, namely Comida*n*.inp, Comida*n*.par, and Comida*n*.var, where *n* is the simulation number.

Name of file	Conditions when file Is created	Description
Comida1.inp Comida2.inp	Created when the *Late Consequences* option is selected on the *Scope* tab in the *Properties* form and the *File Created from User Input* option is selected on the *Food* tab in the *Properties* form.	This is a set of one of three input files required by COMIDA2.
Comida1.var Comida2.var	Created when the *Late Consequences* option is selected on the *Scope* tab in the *Properties* form and the *File Created from User Input* option is selected on the *Food* tab in the *Properties* form.	This is a set of one of three input files required by COMDIA2. The files contain radionuclide data.
Comida1.par Comida2.par	Created when the *Late Consequences* option is selected on the *Scope* tab in the *Properties* form and the *File Created from User Input* option is selected on the *Food* tab in the *Properties* form.	This is a set of one of three input files required by COMDIA2. The files contain food-pathway data.

When the user has checked the box labeled *Delete Atmos, Early, Chronc and COMIDA2 Input Files* on the *Advanced Execution Parameters* form, the input files that aren't used as templates are deleted when the calculation is finished. In the example above, this means that Atmos1.inp, Atmos2.inp, Early1.inp, Early2.inp, Chronc1.inp, Chronc2.inp, LHS.inp, Comida1.inp, Comida2.inp, Comida1.par, Comida2.par, Comida1.var and Comida2.var are deleted. Normally, this box is checked. The user might uncheck this box when MACCS input files are needed for some other process and so need to be retained. Otherwise, the input parameters are preserved for QA purposes in the output file that is generated.

1.4.5.3 Output Files

This category contains output files created by MACCS and COMIDA2.

The entries under the file category *Output* are file names found in the user's project folder Project\Output\ excluding the binary MACCS result files, which end with a .bin extension. They are created when *Run* is selected. Select main menu option *File→Refresh File View* to query the hard drive and refresh the file list.

The Output folder is a convenient place to store files because they are listed in the file view of the project as shown in Figure 1-8.

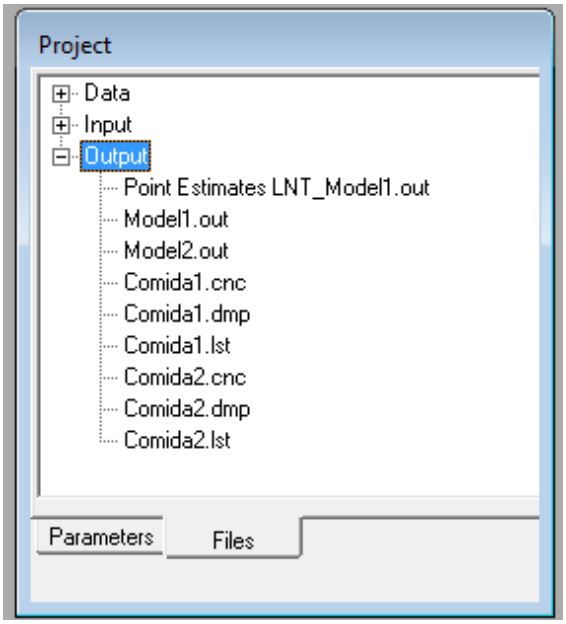


Figure 1-8 Output files

***WARNING*: Do not name any files in the output folder Model*n*.out, Model*n*.bin, Comida*n*.cnc, Comida*n*.dmp, or Comida*n*.lst. These files are deleted from the Ouput folder each time a simulation is run. Likewise, never put any files in the Project\Input\ folder. These are all deleted each time a simulation is run.**

Double-clicking on a file causes it to open in Notepad. The following example shows a simulation with a scope including *Atmospheric Dispersion*, *Early Consequences,* and *Late Consequences*. Comida2 is run to create the .bin files used for *Late Consequences*. In the example shown in Table 1-2, two simulations are requested.

Table 1-2 Output files created by MACCS and COMIDA2.

Name of file	Description
Model1.out Model2.out	These are the text output files created by MACCS corresponding to each of the LHS samples.
Model1.bin Model2.bin	These are the binary result files created by MACCS corresponding to each of the LHS samples. These files are not shown on the Project\Output\ screen.
Comida1.lst Comida2.lst Comida1.cnc Comida2.cnc Comida1.dmp Comida2.dmp	These are output created by COMIDA2 for each of the LHS samples.

When the user has checked the box labeled *Delete MACCS and COMIDA2 Text Output Files* on the *Advanced Execution Parameters* form, the text output files are deleted after each simulation. Normally, this box is unchecked as shown in Figure 1-9. The user would have this box checked if it was not necessary to directly view the output results. Results that are written to the binary file are still available in the form of plots, summary.out and custom available reporting options. These

options may be convenient when there are many simulations and it is important to conserve space on the hard drive.

Similarly, if the user has checked the box labeled *Delete MACCS and COMIDA2 Binary Result Files* the binary result files are deleted after the reports have been created. See Section 4.5.2 for more information. Normally, this box is unchecked as shown in Figure 1-9. WinMACCS imports the binary results into the project file (the .mxd file) after the simulations are complete. Having this box checked causes these files to be deleted after the data are imported into WinMACCS. This option may be useful for conserving space on the hard drive.

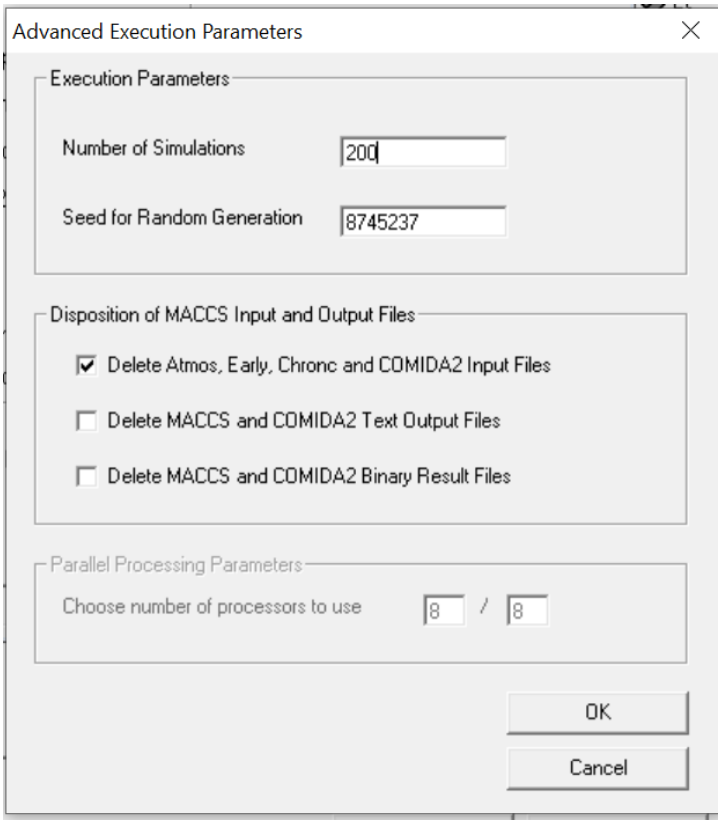


Figure 1-9 Advanced Execution Parameters

1.4.6 Results Window

The *Results* window is found at the bottom of the application window. The *Results* window communicates progress (e.g., during MACCS execution).

Results text, as shown in Figure 1-10, can be selected and copied to the Windows clipboard by using the copy and paste functions available when right clicking the mouse. Alternatively, the user can use the control-C option to copy text from this window. Error messages may be included in the text to describe an execution problem in need of resolution. For any questions regarding error messages, users are encouraged to contact wg-maccs-entity@sandia.gov for user support.

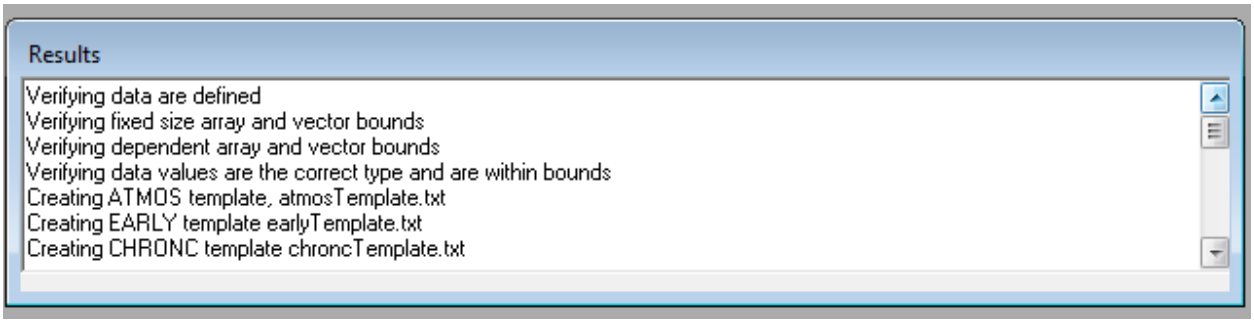


Figure 1-10 Sample results window

1.5 Main Menu Options

Figure 1-11 shows the main menu options shown at the top of the MACCS application.

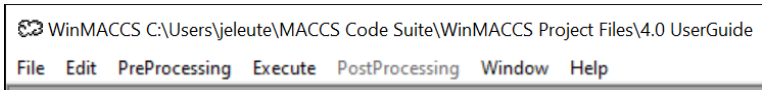


Figure 1-11 Main menu

The main menu contains the following drop-down menus:

- *File* allows projects to be managed and MACCS files to be imported, along with several other functions.
- *Edit* manages some screens, enables distributions for uncertain input parameters to be correlated, enables editing of some parameters, and allows the user to open all windows containing a specified parameter.
- *PreProcessing* allows the user to create MACCS-HYSPLIT files.
- *Execute* allows the user to run calculations and to control choices related to those calculations.
- *PostProcessing* controls the post-processing options, both graphical and tabular.
- *Window* manages screens within WinMACCS.
- *Help* provides information on the version of WinMACCS that is installed on the user's computer.

Section 4.2 describes each of these menu items in more detail.

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2. GETTING STARTED

2.1 Overview of User Interface

Instructions for WinMACCS installation are located within the ReadMe file in the installation download folder. These instructions walk the user through running the installation executable and obtaining a license key. For WinMACCS version 4.0, a computer-linked license key is required and may be obtained from Sandia National Laboratories by following the instructions in the ReadMe. Upon receiving the license key request file, Sandia National Laboratories will reply with a license key file to be linked to the user's specific computer which will allow the use of WinMACCS for one year. Users may renew this license when needed by following the same procedure.

When a project is opened using the *File→Open Project* command or a new project is created using the *File→New Project* command, *Project* and *Results* screens are also opened, as illustrated in Figure 2-1. The *Project* window is used to modify parameter values and view related project files.

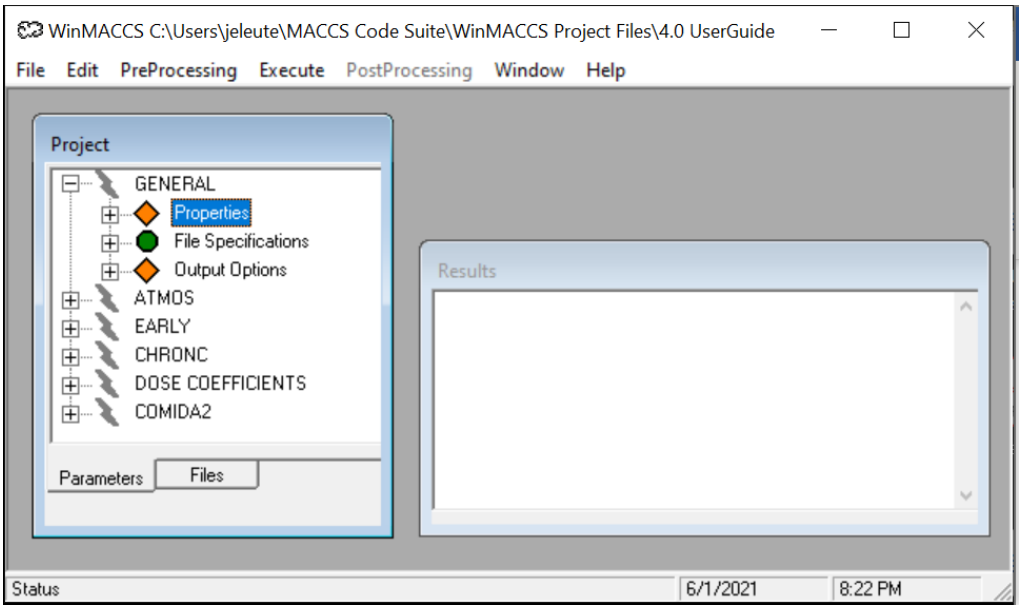


Figure 2-1 Project and results windows

The caption at the top of the window indicates the name and location of the project.

The main menu options are *File*, *Edit*, *Preprocessing*, *Execute*, *PostProcessing*, *Window*, and *Help*.

The *Project* window contains two tabs, *Parameters* and *Files*.

- The *Parameters* tab contains a list of forms that are used to select model options, modify input parameters, and create file links.
- The *Files* tab contains links to active files in the project folder displayed at the top of the window.

The *Results* window displays the progress of a user-initiated action, such as importing a file or running a simulation.

A legend automatically opens with a project, as shown in Figure 2-2. The legend defines the meaning of the icons shown next to the form names and categories in the *Parameters* tab of the *Project* window.

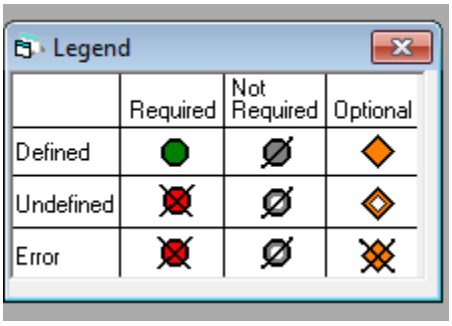


Figure 2-2 Legend

The information displayed under the *Parameters* tab is organized as follows:

- The top display level is called a main category, which includes GENERAL, ATMOS, EARLY, CHRONC, DOSE COEFFIENTS, and COMIDA2. The icon used for main categories looks like a lightning bolt and a main category can contain categories, subcategories, and forms, as defined below.

- The next level of organization below a main category is a category. For example, Radionuclides is a category under ATMOS. Several types of icons are used to represent categories, depending on whether they are required, not required, optional, defined, undefined, or have an error state. The icons corresponding to each possibility are displayed in the Legend window shown in Figure 2-2.

- The next level below a category is a subcategory. For example, Emergency Cohort Two is a subcategory under Additional Emergency Cohorts, which is a category under EARLY.

- The next level of organization below a subcategory is a form. The icons for forms are identical to those for categories and subcategories. For example, Basic Parameters is a form under Additional Emergency Cohorts.

- Each form contains one or more parameters. Parameters are denoted by black dots.

In some cases, forms are directly under categories or even main categories because the intermediate levels are not required.

2.2 Modifying a Parameter Value

A parameter can be modified by opening the form containing the parameter. This is illustrated in Figure 2-3 for the parameters associated with wet deposition.

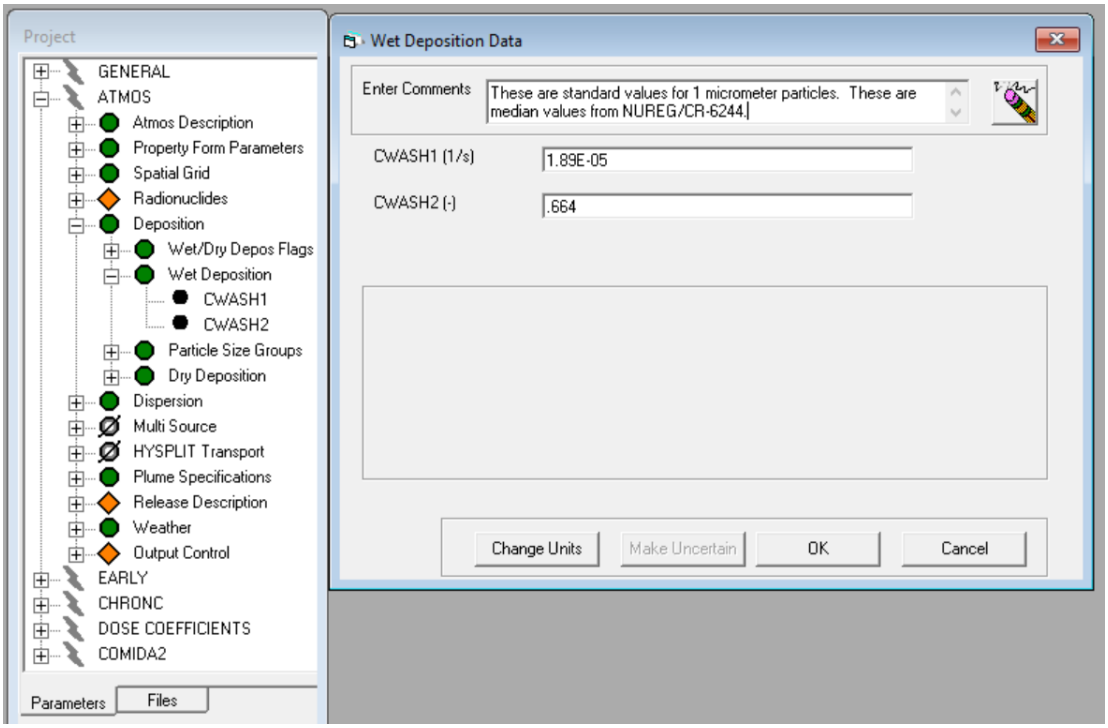


Figure 2-3 Modifying a parameter on a form

Parameter values are changed by replacing the value on the form and clicking the *OK* button. The *Make Uncertain* button allows a probability distribution to be assigned to an uncertain input parameter for sampling in an uncertainty analysis (see Section 4.4.1.3). Clicking *OK* saves all changes and closes the form; Clicking *Cancel* retains the previous values and closes the form. Clicking the pencil eraser button on the top right clears the form of all values and comments.

The user is not allowed to save values by clicking *OK* unless all values have been defined and are within the bounds specified on the form. For example, the limits on CWASH1 in Figure 2-3 are from 0.0 to 1.0, inclusive of the end points. Resetting a form to the default state is accomplished by closing the form, right clicking on the form name, and selecting *Reset to Default*. The default state may or may not be the same as clearing the form.

2.3 Specifying and Viewing Files

MACCS may require auxiliary files depending on the selections made in *Project Properties*. For example, if one of the file-sampling options was selected on the *Weather* tab of *Project Properties*, the user must provide a meteorological data file.

Under the *GENERAL/File Specifications* category, icons displayed next to the names indicate which files are required. Figure 2-4 shows an example in which the *Meteorological File* and *DCF File* are required. The DCF file was defined previously, as is indicated by the solid green octagon, but the user has not yet defined a meteorological data file, as is indicated by the red, X-ed octagon. The undefined status for this file is addressed by opening this form, clicking the *Browse* button, and selecting the desired file. The selected file is copied to the project's data folder, *ProjectName/Data,* where *ProjectName* is the name of the project. This copy is used for subsequent MACCS calculations.

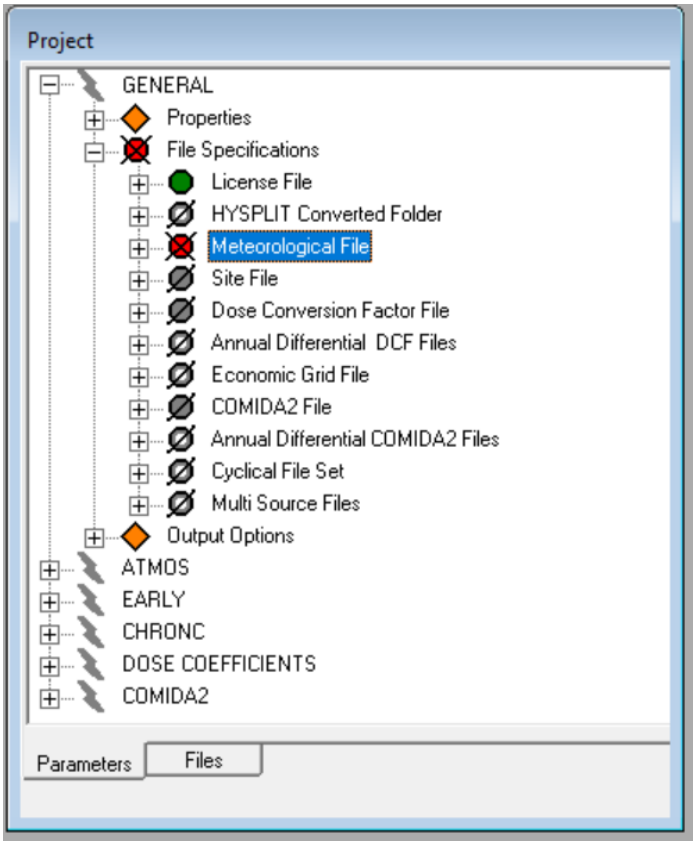


Figure 2-4 File specifications

Selecting a site file works the same way as selecting a meteorological data file. The *Site File* form contains extra functionality to allow the creation of a more finely gridded site file from an existing, more coarsely gridded one. This function is described in Section 4.4.8.

The *Annual Differential DCF Files*, *Annual Differential COMIDA2 Files,* and *Cyclical File Set* are organized to allow selection of a set of files. Copies of the files are used for a calculation, and these copies are placed in the *ProjectName/Data* folder.

Once a file has been selected, it can be viewed and edited via the *Files* tab. The *Data*, *Input,* and *Output* categories on the *File* tab correspond to files stored in the project folders named Data\, Input\, and Output\. Any of these files can be viewed and edited in Notepad by double clicking on the file name. The files in the Input\ and Output\ folders are automatically generated when a simulation is run.

2.4 Filling out a Map Form

Some forms in the interface display a polar grid. These are used to specify evacuation directions when the network evacuation model is enabled and speed multipliers when the speed multiplier option is enabled on the *Project Properties* form, *Evac/Rotation* tab, or to specify what population group is designated to that grid element.

Detailed instructions are provided in Section 4. The following notes, however, can help the user get started with these forms:

- Evacuation directions are initially set to be radially outward and the speed multiplier is set to one. The evacuation direction in each grid element is shown as an arrow. The speed multiplier is identified by an integer.

- Speed multipliers are modified on the forms named Radial Evacuation Speed and Network Evacuation Speed, depending on which model is selected on the *Properties* form. Evacuation directions are modified on the form named *Network Evacuation Direction*. There is one of these forms for each cohort. Both speeds and directions are shown on all these forms, but only one of them can be changed from that form.

- Speed multipliers are activated by clicking on the button *Modify Multipliers*.

- There are several ways to change evacuation directions on this screen. The simplest is to click on one of the grid elements, which causes the arrow to rotate clockwise to the next direction. Directions can also be changed on the *Network Evacuation Direction* form by selecting multiple radii and/or sectors and applying a direction to the selected portion of the map. The direction is selected by clicking on an entry in the table labeled *Direction;* the multiple radii and sectors are selected from the lists labeled *Radius* and *Sector.* Clicking the *Assign* button applies the direction to the selected area(s). Multiple radii and sectors can be selected by holding down either the shift or the control key for contiguous or noncontiguous selections, respectively. Similar options are available on the *Radial Evacuation Speed* and *Network Evacuation Speed* forms.

- The *SaveMap* button saves a copy of the evacuation map with the grid background as either a jpeg or Windows bit map file. This allows maps to be imported into other applications and documents.

- The sliders labeled Inner Ring Shown and Outer Ring Shown allow the user to zoom in and out and to eliminate detail at the center of the map.

- The maps forms can be resized by grabbing the corner/edge of the map and dragging it to the desired size.

2.5 Running a Simulation

Running a simulation starts by selecting *Execute→Run Models* from the main menu.

Clicking the *Run Simulation* button initiates a simulation. If there are any input inconsistencies detected by WinMACCS, forms open automatically to allow values to be corrected. However, not all input inconsistencies are caught at this stage. Some input problems are detected when MACCS is run. Errors generated at this step are described in the *Results* window.

Starting with MACCS version 4.0, parallel simulations on a local computer are now supported through the Execute menu. This feature takes advantage of the local system's processors to run multiple simulations concurrently. The number of simulations that can run in parallel is a parameter on the Advanced Execution Parameters form. When one process completes on a processor, the next process starts.

The simulation progress can be observed in the command-prompt window (Results Window) from which MACCS is initiated. The window is minimized by default but can be opened by the user.

When the simulation has completed, the command window closes and a message conveying successful completion is written to the *Results* window. At this point, results can be viewed using the following options:

- Double-clicking on Output/Model1.out found under the *Files* tab of the *Project* window to open the results file in Notepad.

- Select Post Processing/Graphical Result/Results Over All Weather Trials to view a complimentary cumulative distribution function (CCDF) over weather trials.

- When sampling is used (parameters were set to be uncertain and multiple realizations were run), the option *Post Processing/Create Custom Report* can be used to combine results. The quantiles reported can be modified on the form *GENERAL/Reporting Options.*

- If sampling was used, the option *Post Processing/Graphical Result/Statistical Summary Results* can be used to display the distributions of the results.

2.6 Running MACCS from a command line

A MACCS run can be generated by using command line parameters. The following parameters can be specified on the MACCS.exe command line in any order.

-a ATMOS input file and path

-e EARLY input file and path

-c CHRONC input file and path

-m meteorological data file and path

-s site file and path

-o output file and path. The prefix portion of the output file name is also used to name the binary output file. For example, if the output file is named model1.out, the binary file created by MACCS is named model1.bin.

-i file containing names of MACCS input files. This is the path and name of a file containing the ATMOS, EARLY, CHRONC, meteorological, site, and output file names and paths. The file must have one file name per line, and they must be listed in the order above. If one of these files is not needed for a calculation, the line must contain a dummy name or blank field defined by two consecutive double quotes. If any of these files have been specified on the command line using the -a, -e, -c, -m, -s, or -o parameter, this file is not used for any of the file names. If this -i option is not used and the files are not specified on the command line, the file names are expected to be in a file named MACCS.tmp located in the same folder as MACCS.exe.

The following example shows the contents of a sample MACCS.tmp file. Only the Atmos model is to be executed in this example. The EARLY, CHRONC, and site files are not needed, and file names do not need to be specified. A meteorological data file, Metsur.inp, is to be used. MACCS creates the output files Model1.out and Model1.bin.

C:\WinMACCSSamp\inb\Input\Atmos1.inp
""
""
C:\WinMACCSSamp\inb\Data\Metsur.inp
""
C:\WinMACCSSamp\inb\Output\Model1.out

-p is a prefix used in naming the status files. If this isn't specified, the status files are named MaxStat.log and FortErr.log by default. If it is specified, the names of the two status files are prefixed with the string following this flag. For example, "MACCS.exe -p MyRun" would create status files MyRunMaxStat.log and MyRunFortErr.log. These files are placed in the same folder as the output file specified with the -o parameter. If the -i option was used to specify the file names (instead of the -a, -e, -c, -m, -s and -o parameters), the status files are placed in the same folder as the output file specified using the -i option. If neither of these options were used, the status files are placed in the same folder as the MACCS executable file, MACCS.exe.

The status file, MaxStat.log, contains a single line with the string 'OK' if the MACCS execution was successful. If the execution is not successful, this file contains a line with the string 'NO'. If MACCS detects an error and exits, the line containing the string 'NO' is followed by a MACCS generated error message.

The FORTRAN error file, FortErr.log, is created only when MACCS aborts abnormally. It contains trace-back information and system level error messages. If this file exists before MACCS crashes, the error messages are appended to the end of the file rather than overwriting the previous contents.

When at least one of the command line parameters, -a, -e, -c, -m, -s, or -o, is present, the MACCS.tmp file is not used to define the names and paths of the required files. In this case, all the files used by MACCS must be specified on the command line.

The following example shows a case in which all files are specified on the command line.

C:\Program Files\WinMACCS> MACCS.exe -a C:\inb\Input\Atmos1.inp -m C:\inb\Data\Metsur.inp -o C:\inb\Output\Model1.out

The following example shows a case in which a file is used to specify the names of MACCS files. The file specifying the names is Maccs.tmp. Error files are named inbMaxStat.log and inbFortErr.log. These files are placed in the folder C:\inb\.

C:\ Program Files\WinMACCS> MACCS.exe -i C:\inb\Maccs.tmp –p inb

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3. WINMACCS USER GUIDE

All WinMACCS model choices and parameters are specified through the *Parameters* tab on the *Project* window. The main categories are *GENERAL*, *ATMOS*, *EARLY*, *CHRONC*, *DOSE COEFFICIENTS*, and *COMIDA2*.

This section is not intended to be a theory manual that describes the theoretical and mathematical foundations for the MACCS models; however, some equations are provided for context to help define some of the input parameters.

3.1 GENERAL Main Categories

The GENERAL main category consists of Properties, File Specifications, and Reporting Options.

The hierarchical structure in WinMACCS can be expanded or contracted by clicking on the + or – next to items on the parameters tab, respectively. For example, clicking on the + to the right of the GENERAL main category reveals three categories that belong to this main category. Clicking on the + to the left of the Properties category expands it, revealing the two forms that it contains. Finally, clicking on the + to the left of the *Properties* form reveals the set of parameters that it contains.

3.1.1 Properties

The *Properties* form is opened by double-clicking on *General/Properties/Properties* from the *Parameters* tab in the *Project* window, as illustrated in Figure 3-1.

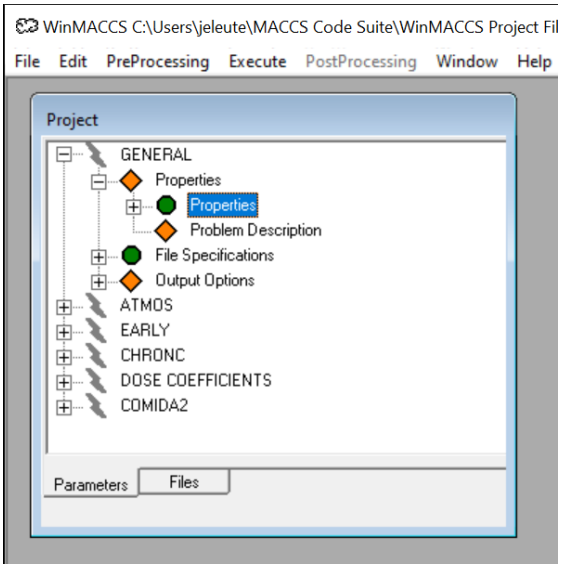


Figure 3-1 Accessing *Properties* form

A window opens that shows the scope of the calculation and related model settings, as shown in Figure 3-2. Depending on the selections made, input parameters may be or may not be required. Details describing the available models are included in this section of this document.

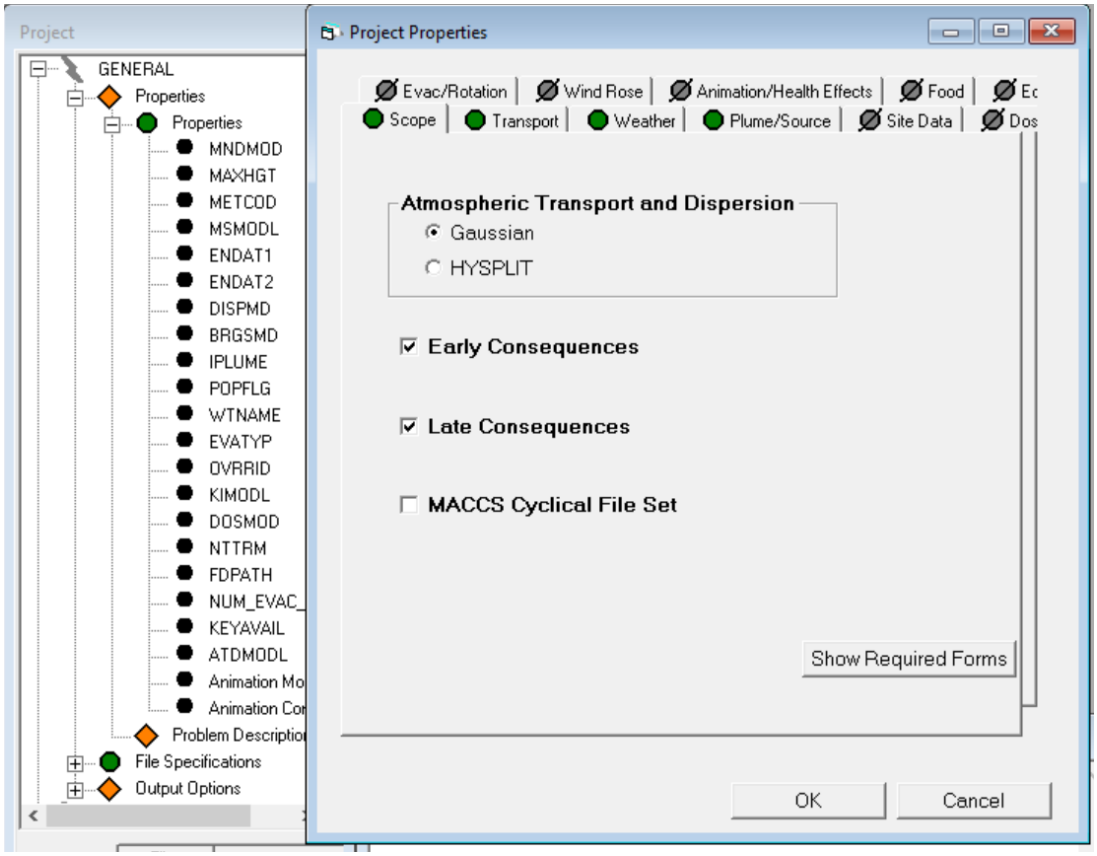


Figure 3-2 *Project Properties* Form

The following describes how modifying the scope of the calculation affects the forms that are required.

(1). Creating a new project by selecting *File→New* from the main menu causes *Project Properties* to open after the new project is created with default settings. Notice that default for *Atmospheric Transport and Dispersion* is the Gaussian model. *Early Consequences* (corresponding to the EARLY Main Category) and *Late Consequences* (corresponding to the CHRONC Main Category) are not checked by default.

(2). Clicking on the plus sign next to the *ATMOS*, *EARLY,* and *CHRONC* main categories on the *Parameters* tab causes categories to become visible, as illustrated in Figure 3-3. All the categories under *EARLY* and *CHRONC* are empty grey circles with a single slash. This means that the parameters on these forms are not defined but are not required in order to run a simulation given the model choices on the *Properties* form.

(3). Clicking the check box next to the *Early Consequences* label and clicking the button labeled *Show Required Forms* shows that some categories in the *EARLY* main category now require attention. These categories have icons consisting of an X-ed red octagon. If the *OK* button is clicked in *Properties*, the scope of the calculation changes to include early consequences.

(4). Repeating the process by adding *Late Consequences* to the scope causes an additional group of categories to require attention.

(5). Each of the selected main categories (ATMOS, EARLY, CHRONC) contains a form called *Property Form Parameters*. Opening these by double-clicking on the word *Property Form Parameters* under each of the main categories allows a user to see the parameter values that are defined on the *Project Properties* form. Note that forms titled *Property Form Parameters* cannot be updated while open. The user must close and re-open them after changing parameters on the *Properties* form.

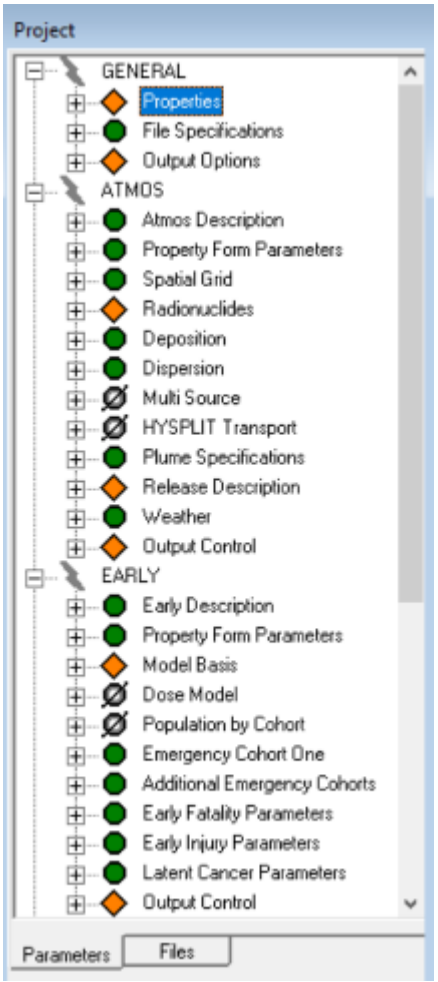


Figure 3-3 Form icons

Figure 3-4 shows the form for EARLY. The values on these forms correspond to model settings in *Project Properties*. These values can be modified by changing settings in *Project Properties (under the GENERAL* main category) but cannot be changed from the *Property Form Parameters* form, as indicated by the light gray backgrounds.

The settings on the other *Project Properties* tabs function in a similar way.

When the *Show Required Forms* is clicked on the *Project Properties* form, WinMACCS modifies the icons next to each category to indicate the ones that would be required if the change is made by clicking *OK*.

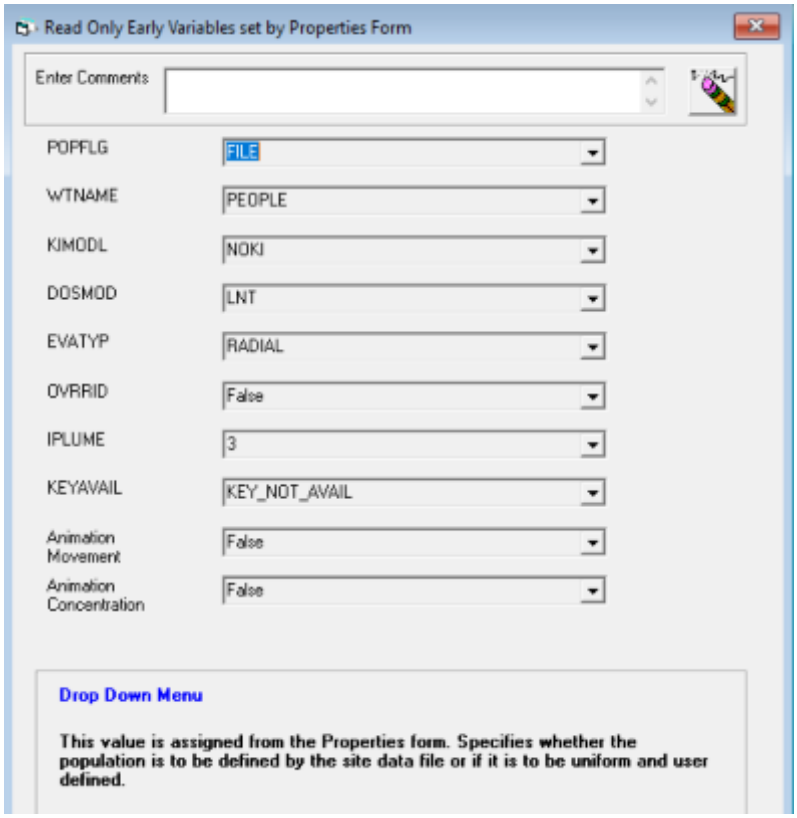


Figure 3-4 Read-only parameters on Property form under the *EARLY* main category

Scope Tab

MACCS uses parameters ENDAT1 and ENDAT2 to determine whether the simulation should run ATMOS; ATMOS and EARLY; or ATMOS, EARLY, and CHRONC. The *Scope* tab in Figure 3-5 determines the value of these variables. ENDAT1 is set to False if the EARLY model is to be run. ENDAT2 is set to False if the CHRONC model is to be run. The option to invoke the *MACCS Cyclical File Set* does not correspond to any MACCS parameters; this option is handled within the WinMACCS interface.

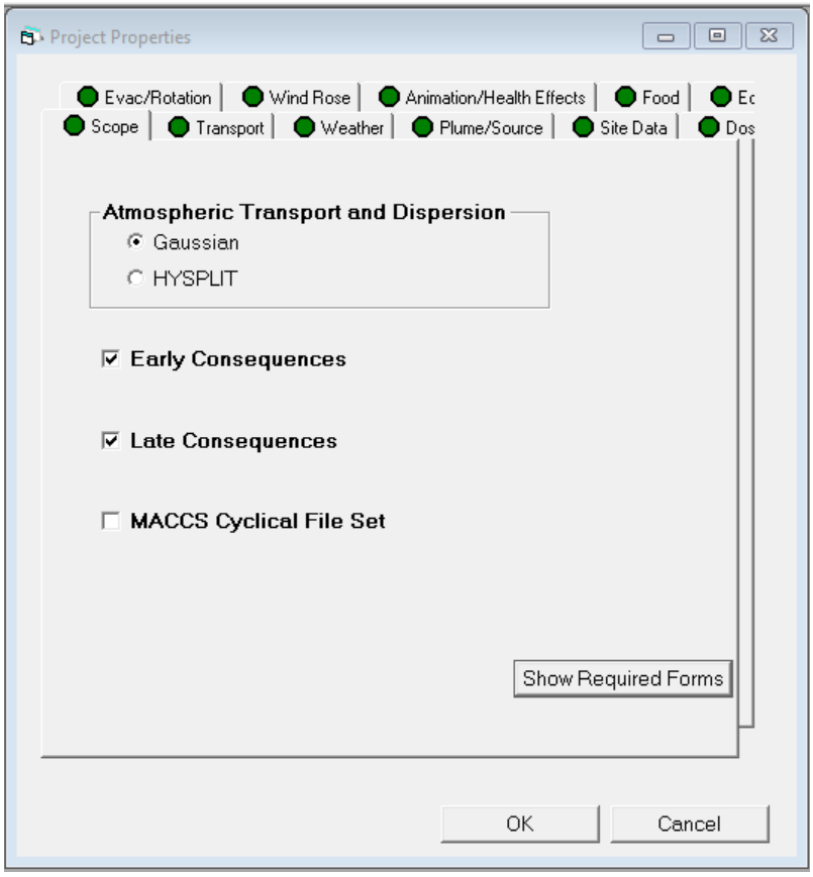


Figure 3-5 Scope Tab on the *Project Properties* Form

The *Atmospheric Transport and Dispersion* (ATMOS) box provides two options for the atmospheric transport and dispersion model used by MACCS:

- The Gaussian option selects the standard Gaussian plume segment model to be used by MACCS.
- The HYSPLIT option selects the new Hybrid Single-Particle Lagrangian Integrated Trajectory model.

Checking the *Early Consequences* Module (EARLY) box means:

- A DCF file needs to be assigned under the *File Specifications* category on the *Parameters* tab of the Project window.
- Entries on other tabs, namely *Site Data, Dose, Evac/Rotation,* and *Wind Rose* determine which other EARLY input parameters are required.

Checking the *Late Consequences m*odule (CHRONC) means:

- *Early Consequences* are automatically checked. The CHRONC module cannot be run without the EARLY module.
- Entries on the *Food* tab determine which additional CHRONC input parameters are required.

Checking the MACCS Cyclical File Set means:

- A cyclical file set needs to be assigned under the *File Specifications* category on the *Parameters* tab of the *Project* window. The function of this model choice is described in Section 4.4.6.

- *OK* saves changes made under any tab and closes the form. *Show Required Forms* shows how changes affect the form states on the *Parameters* tab window and the tab states in *Project Properties* without saving the changes.

- *Cancel* closes the form without saving any changes.

***Transport* Tab**

The contents of the *Transport* tab are shown in Figure 3-6. The user must either select power law functions or lookup tables to define the dispersion parameters.

Selecting the *Power Law Functions* means:

- Power law function parameters are required. They must be defined in the *Dispersion Function* form found in the *ATMOS/Dispersion* category in the *Parameters* tab.

- WinMACCS sets NUM_DIST to be zero when building input images for MACCS.

Selecting *Lookup Tables* means:

- Lookup table parameters are required. These must be defined in the *Dispersion Table* form found in the *ATMOS/Dispersion* category in the *Parameters* tab.

- WinMACCS sets NUM_DIST to be the value defined on the *Dispersion Table* form when building input images for MACCS.

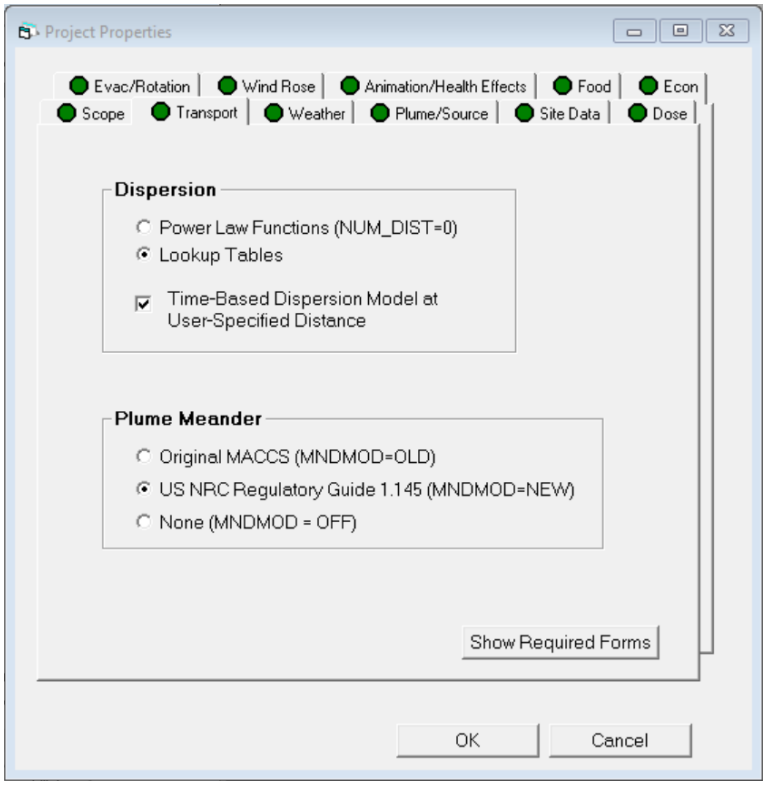


Figure 3-6 Transport tab on the *Project Properties* form

Switch to Time-Based Dispersion Model at User-Specified Distance:

- If checked, WinMACCS sets the parameter DISPMD to the value LRTIME. Parameters on the *Long-Range Time-Based Parameters* form found in the *ATMOS/Dispersion* category in the *Parameters* tab are required. Dispersion parameters are functions of time rather than distance beyond a user-specified distance.

- If not checked, DISPMD is set to the value LRDIST. The value LRDIST causes MACCS to use the original model in which dispersion parameters are functions of distance.

There are three choices for plume meander model. MACCS uses a variable, MNDMOD, to determine which plume meander model to use. The corresponding value of MNDMOD is shown parenthetically on the right of each entry on the *Properties* form.

Selecting *Original MACCS* means:

- The plume meander model is the original one in MACCS Version 1.12. This model accounts for the effect of the duration of release.

- The ATMOS/Plume Specifications/Original Meander form is required.

Selecting *U.S. NRC Regulatory Guide 1.145* means:

- The Regulatory Guide 1.145 plume meander model is used. This model assumes one-hour duration plume segments. It accounts for the effects of stability class and wind speed on plume meander. It should not be used when plume segment durations are

substantially different than one hour, especially when they are less than one hour, because this violates the assumptions of the model.

- Parameters on the form ATMOS/Plume Specifications/US NRC Reg. Guide 1.145 Meander are required.

Selecting *None* means:

- There are no required parameters.
- The plume meander model is turned off.

Weather Tab

The contents of the *Weather* tab are shown in Figure 3-7.

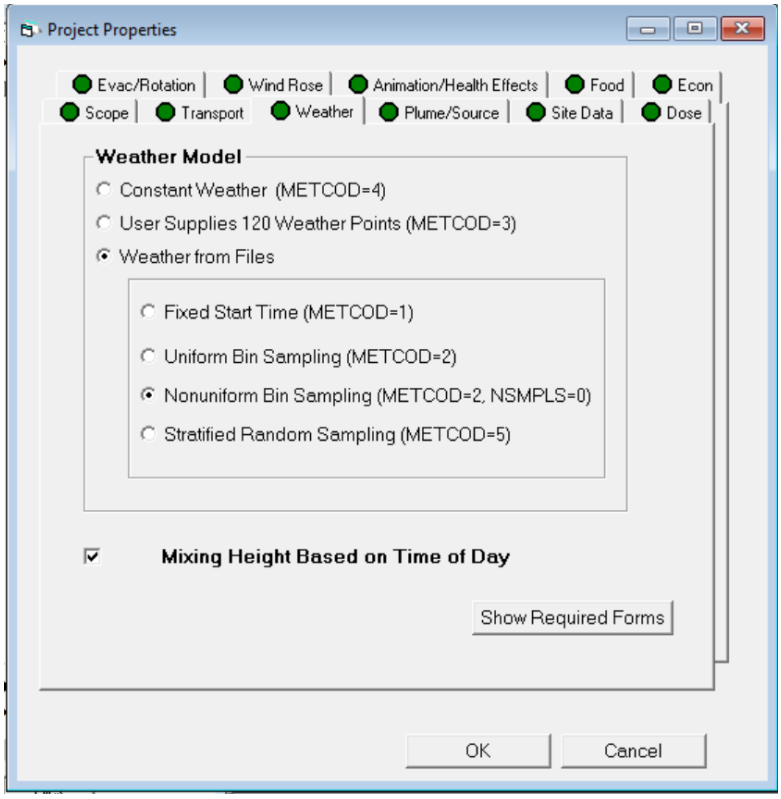


Figure 3-7 *Weather* tab on the *Project Properties* form

MACCS uses a variable, METCOD, to specify which weather sampling option to use. The corresponding value of METCOD is shown on the right of each entry.

Constant Weather means that a single weather trial is evaluated and that inputs on the following *ATMOS*/*Weather* category forms on the *Parameters* tab are required:

- Constant or Boundary Conditions
- Fixed Start Time Data

User Supplies 120 Weather Points means that a single weather trial is evaluated and that the following inputs found on the *ATMOS*/*Weather* category on the *Parameters* tab are required:

- Constant or Boundary Conditions
- Fixed Start Time Data
- User-Supplied Weather
- Boundary Limit

The fixed start time is required for these options to determine the time of year the accident occurs, which is needed for food ingestion modeling. These inputs are required even if food ingestion is not being treated but they can be set to dummy values.

The other weather options require specifying a meteorological data file. The meteorological data file allows 15-minute, 30-minute, and one-hour intervals. Only the traditional hourly weather data are supported with the *User Supplies 120 Weather Points (METCOD=3)* option described above.

When *Weather from Files* is selected, a meteorological data file is required and needs to be assigned under the *File Specifications* category. The input data requirements for the weather options are described in the subsequent paragraphs.

Fixed Start Time means that the following *ATMOS/Weather* category forms under the *Parameters* tab inputs are required:

- Constant or Boundary Conditions
- Fixed Start Time Data
- Boundary Limit

Uniform Bin Sampling means the following *ATMOS*/*Weather* category forms under the *Parameters* tab are required:

- Constant or Boundary Conditions
- Samples per Bin
- Seed
- Boundary Limit
- Rain Distances
- Rain Intensities

Nonuniform Bin Sampling means the following *ATMOS*/*Weather* category forms under the *Parameters* tab are required:

- Constant or Boundary Conditions
- Seed
- Boundary Limit
- Bins
- Rain Distances
- Rain Intensities

Stratified Random Sampling means the following *ATMOS*/*Weather* category forms under the *Parameters* tab are required:

- Constant or Boundary Conditions
- Samples per Day
- Seed
- Boundary Limit

When the *Weather from Files* is selected, an optional, mixing-height model can be chosen. MACCS uses a variable, MAXHGT, to determine which mixing height model to use.

Mixing Height Based on Time of Day means:

- WinMACCS sets the parameter MAXHGT to the value DAY_AND_NIGHT.
- Parameters in *Site Location* found on the *ATMOS/Weather* category are required.
- Both daytime and nighttime values of the mixing heights in the meteorological data file are used.
- When not checked, MAXHGT is set to the value DAY_ONLY. This causes MACCS to use the model in MACCS Version 1.12, which uses only the maximum seasonal values that normally correspond to daytime values.

Plume/Source **Tab**

The contents of the *Plume/Source* tab are shown in Figure 3-8.

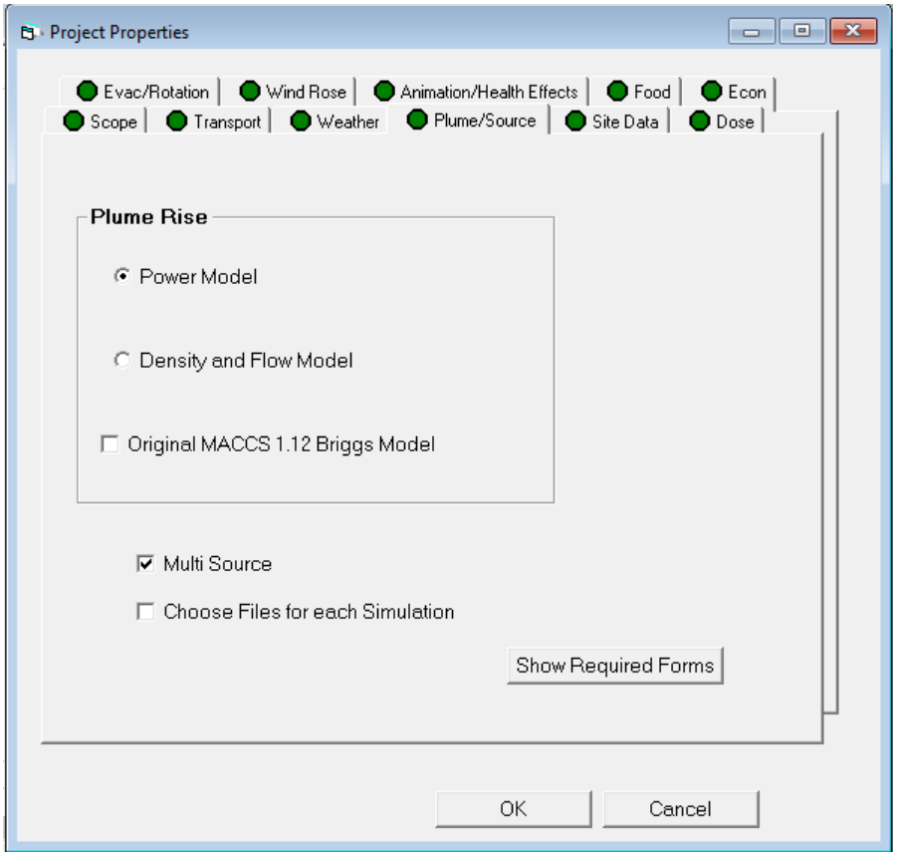


Figure 3-8 ***Plume/Source*** **Tab on the** ***Project Properties*** **form**

Choosing *Power Model* means:

- The original MACCS model is used.
- Values for rate of release of sensible heat for each plume segment must be specified in *ATMOS*/*Release Description/Heat*.

Choosing Density and Flow Model means:

- Mass flow rate and mass density are required for each plume segment. These are defined in *ATMOS*/*Release Description/Density and Flow*.

Choosing Original MACCS 1.12 Briggs Model means:

- WinMACCS sets the parameter BRGSMD to the value ORIGINAL. The original Briggs model is used to simulate plume rise. The default and recommended model is the improved one (see Bixler et al., 2020, for more information).
- When not checked, BRGSMD is set to the value IMPROVED. This causes MACCS to use the improved plume rise model.

Choosing *Multi Source Term* means:

- MACCS allows the user to use multiple source term definition.
- The user specifies these files under *File Specifications* and needs to fill out additional forms in the *ATMOS* main category.
- When *Multi Source* is selected, an optional selection to *Choose Files for each Simulation* becomes available, which allows the use of different MELCOR plot files for each simulation.

Site Data **Tab**

The contents of the *Site Data* tab are shown in Figure 3-9. This tab is required when *Early Consequences* are selected on the *Scope* tab. MACCS uses a variable, POPFLG, to define the source of the site data.

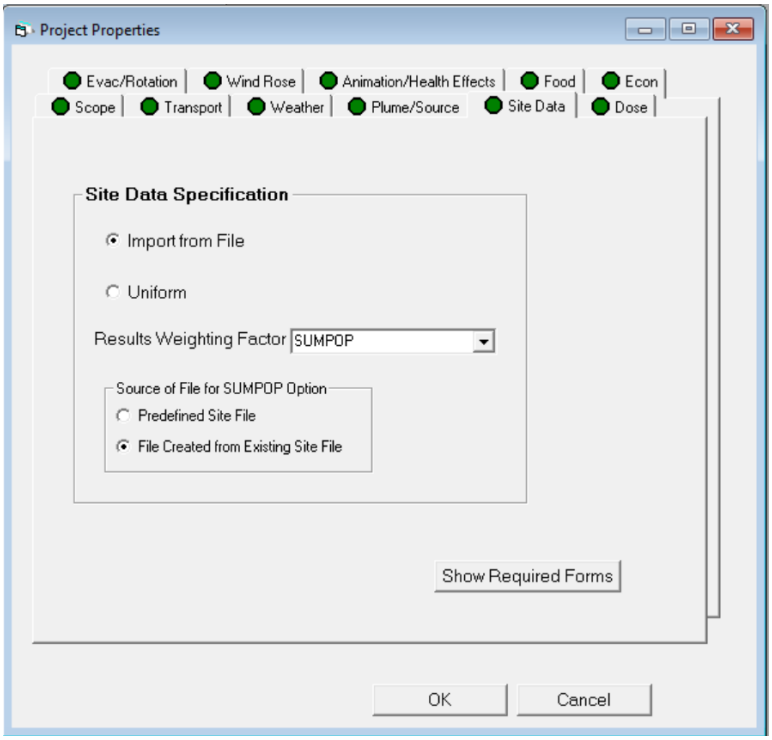


Figure 3-9 *Site Data* tab on the *Project Properties* form

Choosing *Import from File* means:

- WinMACCS sets the parameter POPFLG to the value FILE.
- A site file is required and needs to be chosen under the *File Specifications* category under the *Parameters* tab. This file can be created by a preprocessor (e.g., SecPop, to generate a file containing census and economic data for the chosen site). A sample site file, FicticiousSite.inp, is included in the WinMACCS installation. WinMACCS allows the user to increase the number of compass sectors in a site file, and this feature has been integrated into the site file specification form.
- The SUMPOP option is available under Results Weighting Factor.
- *Results Weighting Factor* determines the way multiple-cohort results are combined. Except when SUMPOP is selected, the weighting factor used for each of the cohorts is assigned by the parameter WTFRAC found under the *EARLY*/*Emergency Cohort n*/*Basic Parameters* forms, where *n* is the cohort number.
- When *SUMPOP* is selected, the site file must include a separate population distribution for each evacuation scenario. This option enables cohorts to be defined in a very general fashion.
- If *TIME* is selected, the weighting factor under each *Basic Parameters* form refers to fraction of time.
- If *PEOPLE* is selected, the weighting factor under each *Basic Parameters* form refers to fraction of people.

Choosing *Uniform* means:

- MACCS sets the parameter POPFLG to the value UNIFORM.
- Population density data are required and are specified in the *Population Data* form found under the *EARLY*/*Model Basis* category.
- The SUMPOP option is unavailable under Results Weighting Factor.

MACCS uses a variable, WTNAME, to determine the cohort weighting method. This is set to SUMPOP, TIME, or PEOPLE, depending on the choice on this form.

When *Import from File* is chosen and the *Results Weighting Factor* is set to be equal to *SUMPOP,* the user must specify the source of the site file by choosing one of two options as follows:

Choosing *Predefined Site File* means:

- The user is required to link an existing site file to the project using the *Site File* form in the *GENERAL/File Specifications* category on the *Parameters* tab. This site file should have a POPULATIONn section defined for each evacuation cohort or MACCS will fail. The n in POPULATIONn is a number corresponding to the cohort number.

Choosing *File Created from Existing Site File* means:

- The user is required to link an existing site file to the project using the *Site File* form in the *GENERAL/File Specifications* category on the *Parameters* tab. The number of POPULATION sections in this file is not relevant. In other words, a site file previously created with or without the SUMPOP option is acceptable. Most commonly, the site file is created using SecPop.
- Additional forms in the EARLY category *Population by Cohort* are required.

After a site file is linked, the total population can be viewed on the *Population from Site File* form found in the EARLY/Model Basis category within the *Parameters* tab.

Dose **Tab**

Choices under the *Dose* tab must be made when the *Early Consequences* option is selected under the *Scope* tab. The contents of the *Dose* tab are shown in Figure 3-10.

MACCS supports Federal Guidance Report (FGR-11 and -12) dose coefficient files created by a preprocessor program, FGRDCF, files created from Federal Guidance Report 13, and files created by DOSFAC2. DOSFAC2 bases its DCFs on DOE/EH-0070 (1988). Changing the type of DCF file has the effect of changing the allowed organ types on several forms and the user is required to modify these forms to be consistent with the select type of dose coefficient file. The sets of organs allowed with each dose coefficient file is hardwired in WinMACCS/MACCS version 3.10. However, a feature was added in MACCS version 3.11.2 which enables the user more flexibility in assigning organs where the user can now select any organ listed in the DCF file.

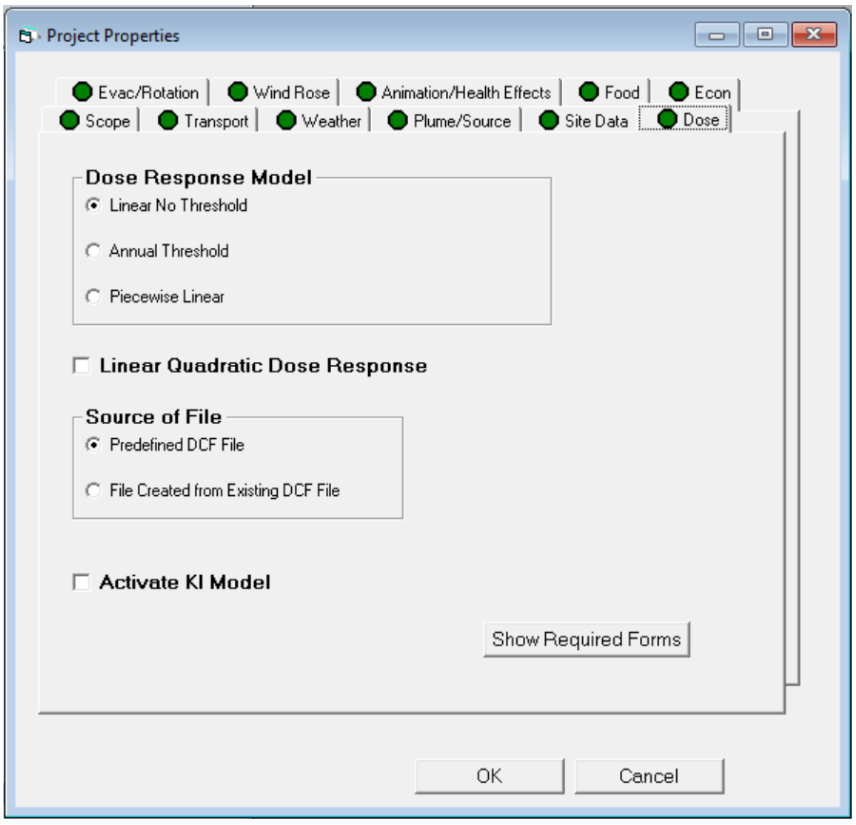


Figure 3-10 *Dose* tab on the *Project Properties* form

The user has three dose-response models to choose from. MACCS uses a variable, DOSMOD, to specify which dose-response model is to be used.

Choosing *Linear No Threshold (LNT)* means:

- The linear no-threshold dose-response model (the only option in early versions of MACCS) is used to calculate latent health effects. (MACCS continues to support a linear-quadratic dose response model under this option, although it has fallen into disuse.)
- DOSMOD is set to LNT
- *MACCS Food Model* on the *Food tab* is available.

Choosing *Annual Threshold* means:

- The *EARLY/Dose Model/Annual Threshold* form is required.
- The *EARLY/Dose Model/Lifetime Threshold* form is optional.
- DOSMOD is set to Annual Threshold.

Choosing *Piecewise Linear* means:

- The *EARLY/Dose Model/Piecewise Linear (PL)* form is required.
- DOSMOD is set to PL.

Choosing either *Annual Threshold* or *Piecewise Linear* means:

- When the *Activate KI Model* box is checked, the *EARLY/Emergency Cohort n/KI Ingestion Threshold* or *Piecewise* form must be filled out instead of the *EARLY/Emergency Cohort n/KI Ingestion LNT* form.

- Only the values 0 or 1 are valid for POPFRAC on the *KI Ingestion* form.

- On the *Food* tab the options *COMIDA2 Food Model* or *No Food Model* must be chosen.

- Files must be specified under the GENERAL/File Specifications/Annual Differential DCF Files and, when the *COMIDA2 Food Model* under the *Food tab* is selected, files must be specified under the GENERAL/File Specifications/Annual Differential *COMIDA2 Files* form.

MACCS uses a parameter named KIMODL to determine whether the KI model is to be used. When the check box *Activate KI Model* is checked, this parameter is set to *KI.* Otherwise, this parameter is set to *NOKI.*

Choosing *Predefined DCF File* means:

- The user is required to link an existing DCF file to the project using the *DCF File* in the *GENERAL/File Specifications* category on the *Parameters* tab.

- If the user has chosen *Predefined COMIDA2 File* on the *Food* tab, the COMIDA2 file chosen must have been created using the same DCF file that is specified.

Choosing *File Created from Existing DCF File* means:

- The user is required to link an existing DCF file to the project using the *DCF File* in the *GENERAL/File Specifications* category on the *Parameters* tab. This file is used to extract the list of available radionuclides. The default DCF values are the values defined in this file but can be modified by the user.

- The *COMIDA2 Food Model* is unavailable, even though it appears to be enabled in the WinMACCS interface. The reason is that MACCS requires each COMIDA2 file to be consistent with the DCF file and WinMACCS does not have the capability to create a new COMIDA2 file when the DCF file is modified.

- After the DCF file is linked to the project, the user can select radionuclides and define both deterministic and uncertain DCF values using forms in the category *DOSE COEFFICIENTS* within the *Parameters* tab.

Evac/Rotation **Tab**

Choices under this tab are required when the *Early Consequences* module is selected. The *Evac/Rotation* tab is broken up into three main areas: problem model, number of cohorts, and model activation, as shown in Figure 3-11. First, the user must choose the type of evacuation to use. The choices are *Radial, Network*, and *None*. Choosing *Radial* causes evacuees to move radially outward from each grid element to the next. *Network* evacuation models evacuation from a grid element to any of the four adjacent grid elements. Finally, *None* specifies that no evacuation occurs. Selecting *None* means all cohorts are nonevacuating.

The next action is to specify whether the *Speed Multiplier Model* and/or *Keyhole Evacuation Model* is active. Finally, the user specifies the number of cohorts represented in the problem. WinMACCS supports up to 20 cohorts. All scenarios correspond to EARLY change sets in the MACCS input files. MACCS uses a variable, EVATYP, to determine the evacuation model for each cohort. The choices for the evacuation model are automatically designated based on the selected option, *Radial*, *Network* or *None* in the *Problem Model* box. The selected choice restricts the options for all cohorts that are defined.

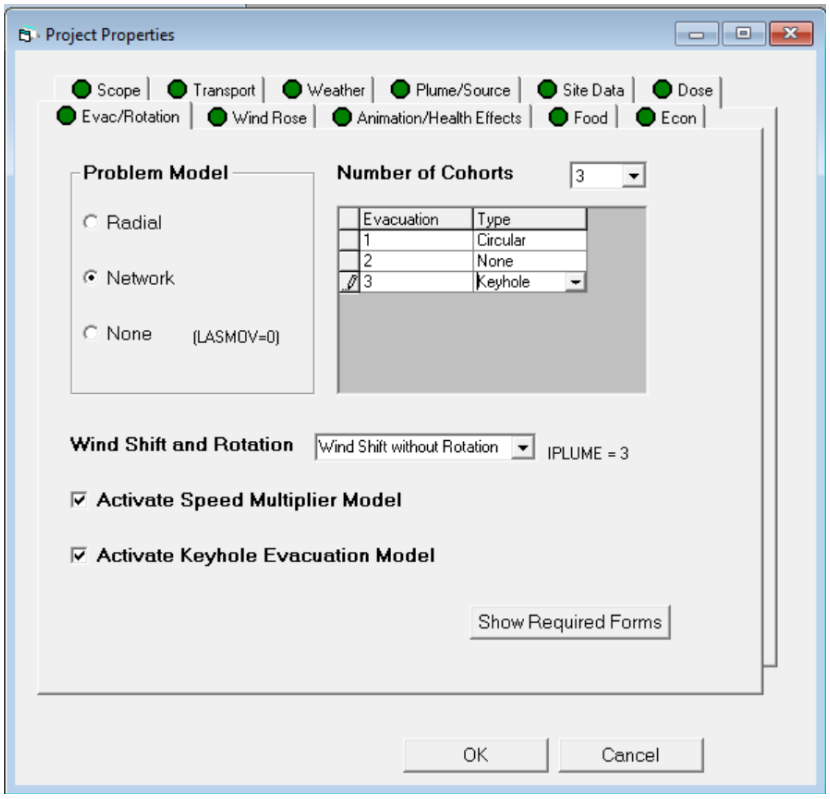


Figure 3-11 *Evac/Rotation* Tab on the *Project Properties* form

Choosing *Radial* under *Problem Model* means:

- The options for the evacuation *Type* field for all evacuation cohorts are *None* and *Circular. Keyhole* is also available when the *Activate Keyhole Evacuation Model* check box is checked.

- The options for the evacuation type for all evacuation cohorts must be entered. The first Cohort must be assigned the type *Circular* or *Keyhole* to allow *Circular* or *Keyhole* to be assigned for subsequent cohorts.

Choosing *Network* means:

- The options for the evacuation *Type* field for all evacuation cohorts are *None* and *Circular. Keyhole* is also available when the *Activate Keyhole Evacuation Model* check box is checked.

- The options for the evacuation type for all evacuation cohorts must be entered. The first Cohort must be assigned the type *Circular* or *Keyhole* to allow *Circular* or *Keyhole* to be assigned for subsequent cohorts.

- The field Wind Shift and Rotation must be set to Wind Shift without Rotation.

Choosing *None* means:

- The only option for the evacuation type field for all evacuation cohorts is *None.*
- The *Activate Speed Multiplier Model* check box cannot be activated on this form.
- The *Activate Keyhole Evacuation Model* check box cannot be activated on this form.

The user must choose the method for plume segment modeling. MACCS uses a variable, IPLUME, to specify the option that is used. The corresponding value of IPLUME is shown to the right of the drop-down box, as shown in Figure 3-11.

Choosing *No Wind Shift with Rotation* means:

- All subsequent plume segments travel in the same direction as the initial plume segment.

- When weather bin sampling is selected, a set of results is constructed for each weather trial by considering that the wind might have blown toward each compass direction. This is equivalent to rotating the results for the weather trial around the compass, one compass sector at a time. This process creates an expanded set of results for each weather trial with little additional CPU time. The total number of results generated by this process is the number of compass sectors times the number of weather trials. Probabilities for each of the rotated results are calculated by using the wind rose for the corresponding weather bin or using a user-defined wind rose, depending on the wind rose option selected by the user (see below). The wind-rose probability is assigned based on the direction taken by the first plume segment. This method may not create realistic results when more than one plume segment is modeled.

Choosing *Wind Shift with Rotation* means:

- Each plume segment moves in the direction that the wind is blowing at the time of its release. Thus, each plume segment can travel in its own direction.

- When weather bin sampling is selected, each weather pattern is rotated around the compass, creating a set of results equal to the number of compass sectors times the number of weather trials. The probability of each result is calculated using the wind rose for the weather bin or the user defined values for the wind rose, depending on the wind rose option selected by the user (see below). The wind-rose probability is assigned based on the direction taken by the first plume segment.

  Wind Shift with Rotation assumes that specific weather patterns (i.e., time dependence of wind directions relative to the initial wind direction) are independent of the initial direction and that the likelihood only depends on the wind rose probability of the initial wind direction. For example, the conditional probability of the second plume segment traveling southeast given that the first segment traveled east is the same as same as the conditional probability of the second plume segment traveling northwest given that the first segment traveled west. This option has been used in past analyses, such as NUREG-1150, where only a few plume segments were used to represent the source term. More recent analyses commonly use more than a few plume segments to represent the source term. The more plume segments that are used in an analysis, the

less likely this assumption is to be valid. As a result, this option should be avoided when more than a few plume segments are modeled.

Choosing *Wind Shift without Rotation* means:

- Each plume segment moves in the direction that the wind is blowing at the time of its release. Thus, each plume segment can travel in its own direction.

- Only the set of wind directions indicated in the meteorological file is used; no wind rotation is performed. Thus, only a single result is generated per weather trial.

Wind Shift without Rotation produces the most realistic results and is recommended for most analyses when more than a single plume segment is used. The drawback is that more weather trials may be required to achieve adequate weather statistics than are required using *Wind Shift with Rotation*. The user can evaluate the accuracy of weather statistics by comparing results for weather sampling options against the case of performing the maximum number of weather trials (e.g., 8760 weather trials when data are averaged over hourly periods) and using the *Wind Shift without Rotation* option.

Choosing *Activate Speed Multiplier Model* Means:

- When the *Network* evacuation option has been selected, the evacuation speed can be adjusted by grid element on the *Network Evacuation Speed* form.

- When the *Radial* evacuation option has been selected, the evacuation speed can be adjusted by grid element on the *Radial Evacuation Speed* form.

- Wind Shift Without Rotation must be selected.

Choosing *Activate Keyhole Evacuation Model* Means:

- Keyhole evacuation methods become available for all cohorts.
- Wind Shift Without Rotation must be selected.

When more than one cohort is specified, the user must enter the evacuation *Type* for each cohort by filling in the grid, as illustrated in Figure 3-12.

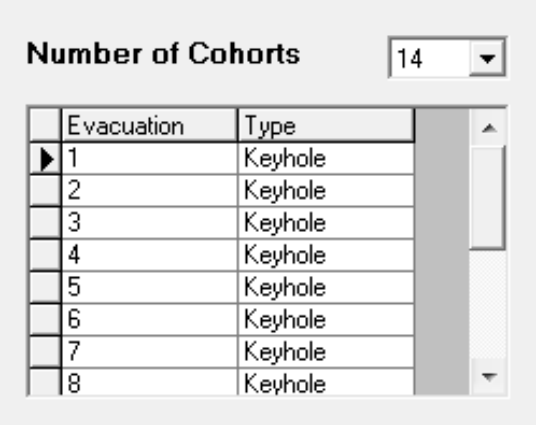


Figure 3-12 Specifying cohort evacuation types

Choosing a Circular evacuation type means people will evacuate from an entire circular region, regardless of the wind direction(s).

Choosing a Keyhole evacuation means people evacuate if they are downwind of the source, accounting for wind changes and possibly weather forecasting. In addition, people near the source evacuate regardless of direction.

Wind Rose Tab

The *Wind Rose* tab shown in Figure 3-13 is required when the *Early Consequences* module is selected.

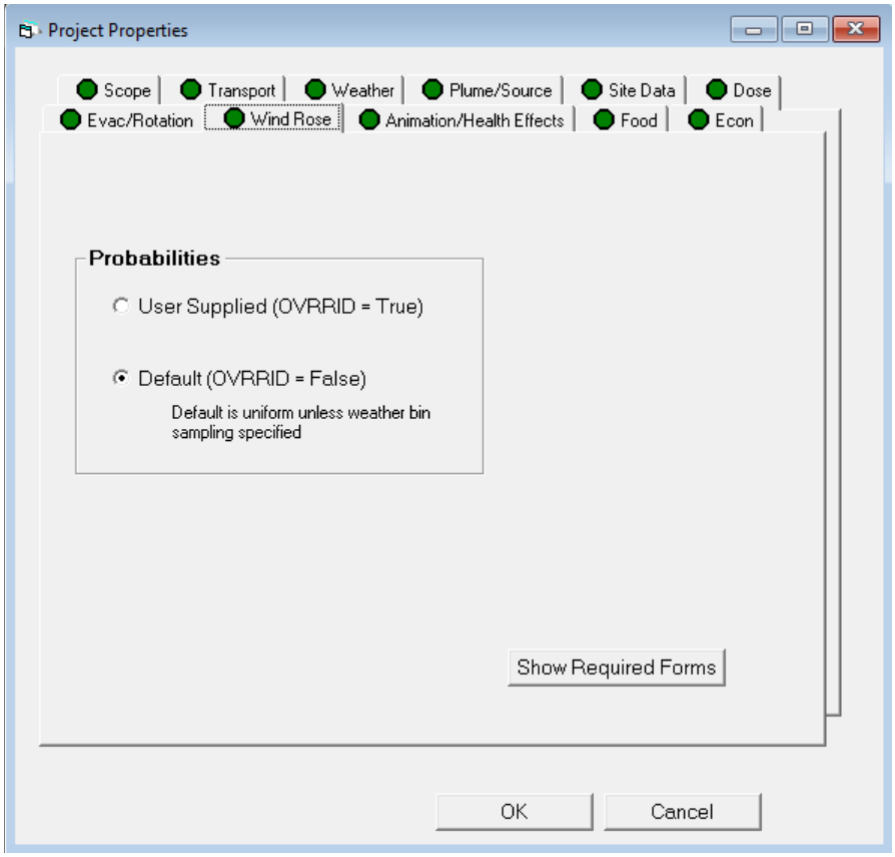


Figure 3-13 *Wind Rose* tab on the *Project Properties* form

The corresponding value of the MACCS parameter OVRRID is shown to the right of each entry.

Choosing *User Supplied* means:

- Wind rose probabilities are required. These are defined on the *Wind Rose Probabilities* form found on the *EARLY/Model Basis* on the *Parameters* tab.

- User defined wind rose probabilities are used in place of values taken from the weather file when one of the *Wind Rotation* options and one of the weather binning options are selected.

Choosing *Default* means:

- Wind rose probabilities for each weather sampling bin constructed from the meteorological data file are used if one of the bin sampling options is selected.

- Wind rose data are only used by MACCS when one of the *Wind Rotation* options and one of the weather binning options are selected.

User Supplied wind rose values are used for all weather bins, whereas the *Default* option constructs wind roses separately for each weather bin. As a result, the *User Supplied* option sacrifices some accuracy and is therefore only recommended when a weather file is only available for a nearby site, but wind rose data are available for the site to be analyzed.

Animation/Health Effects **Tab**

This Animation/Health Effects tab shown in Figure 3-14 is required when the *Early Consequences* module is selected. This form allows the user to select the animation files to be created for use in AniMACCS and for health effects to be calculated. If an FGRDCF DCF file is specified, early fatality and injury results are not available.

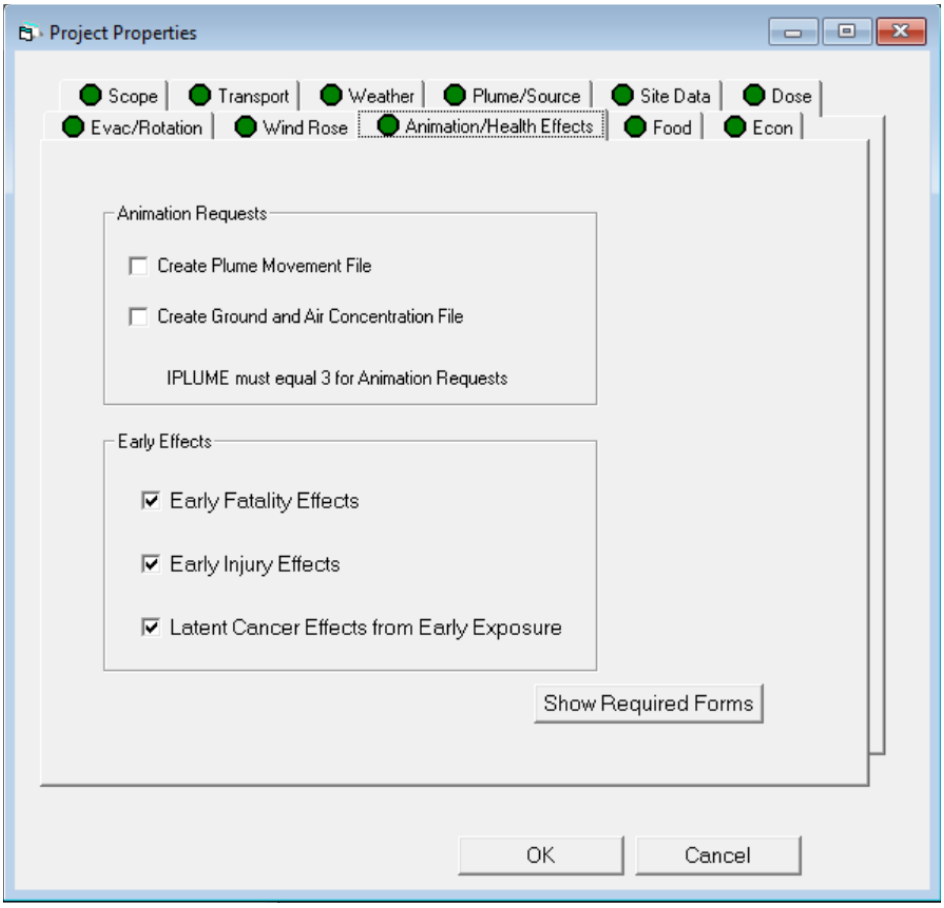


Figure 3-14 Animation/Health Effects on the *Project Properties* form

For *Animation Requests* there are two options available:

- Checking the box next to *Create Plume Movement File* generates an output file which may be used in AniMACCS to animate the plume segment movement over time.

- Checking the box next to *Create Ground and Air Concentration File* generates an output file which may be used in AniMACCS to animate the ground and air concentration of particular radionuclides over time.

Checking the box next to *Early Fatality Effects* means:

- At least one set of early fatality parameters must be defined on the *Early Fatality Parameters* form.

- The fatalities defined can be included in the output requests on the *Health-Effect Cases* form (type 1), *Early Fatality Radius* form (type 2), *Average Individual Risk* form (type 4), *Centerline Risk* form (type 7), and *Population-Weighted Risk* form (type 8). Early fatality results are unavailable when this box is not checked.

- The user must choose a dose coefficient file type that supports early health effects.

Checking the box next to *Early Injury Effects* means:

- At least one set of early injury parameters must be defined on the *Early Injury Parameters* form.

- The injuries defined can be included in the output requests on the *Health-Effect Cases* form (type 1), *Average Individual Risk* form (type 4), *Centerline Risk* form (type 7), and *Population-Weighted Risk* form (type 8). Early injury results are unavailable when this box is not checked.

- The user must choose a DCF file type that supports early health effects.

Checking the box next to *Latent Cancer Effects from Early Exposure* means:

- Latent cancer parameters must be defined on the forms found under the *Latent Cancer Parameters* category, namely those on the *Latent Cancer Parameters* and *Latent Cancer Thresholds* forms.

- The latent cancer results can be included in the output requests on the *Health-Effect Cases* form (type 1), *Average Individual Risk* form (type 4), *Centerline Risk* form (type 7) and *Population-Weighted Risk* form (type 8). Latent cancer results are unavailable when this box is not checked.

Food **Tab**

The *Food* tab shown in Figure 3-15 is required when *Long-Term Consequences* is selected on the *Scope* tab.

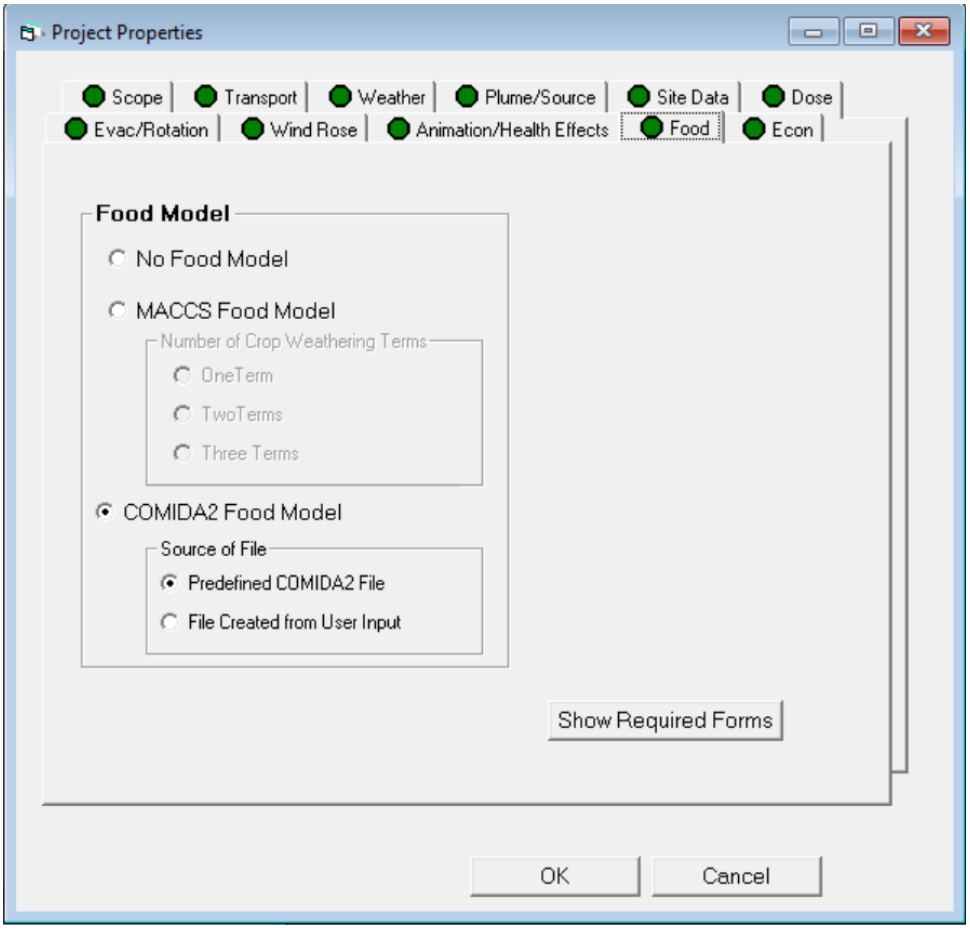


Figure 3-15 *Food* tab on the *Project Properties* form

MACCS uses a variable, FDPATH, to determine which food model to use.

Choosing the radio button next to *No Food Model* means:

- FDPATH is set to OFF.
- No food-chain doses are calculated.
- Economic consequences are disabled.

Choosing the radio button next to *MACCS Food Model* means:

- The original MACCS food-chain model is used.
- FDPATH is set to OLD.
- MACCS uses parameter NTTRM to indicate the number of crop weathering terms used when the *MACCS food model* is used. The value of NTTRM is chosen on this tab.
- A set of forms under *CHRONC/Food-Chain* are required.

This option is not available when the *Annual Threshold* or *Piecewise Linear* dose response models are chosen on the *Dose* tab

Choosing the radio button next to *Predefined COMIDA2 File* means:

- The COMIDA2 food chain model is used.
- The *Annual Threshold* and *Piecewise Linear* dose-response models are available on the *Dose* tab. When either of these models is chosen, a set of binary files created by the preprocessor, COMIDA2, and the corresponding DCF files used to create those binary COMIDA2 files must be linked to the project.
- When the *LNT* dose-response model is chosen on the *Dose* tab, a single COMIDA2 binary file must be linked to the project. The DCF file must be the same one used to create the COMIDA2 binary file.
- FDPATH is set to NEW.

File Created *from User Input*:

- The *Annual Threshold* and *Piecewise Linear* dose-response models are not available, even though they appear to be available in the WinMACCS interface.
- One or more COMIDA2 binary files are created when a simulation is run, depending on whether there are uncertain parameters defined in the COMIDA2 inputs.
- Values must be specified on the forms under the *COMIDA2* main category on the *Parameters* tab.

Econ **Tab**

The *Econ* Tab is shown in Figure 3-16 and is required when *Late Consequences* are selected in the *Scope* Tab.

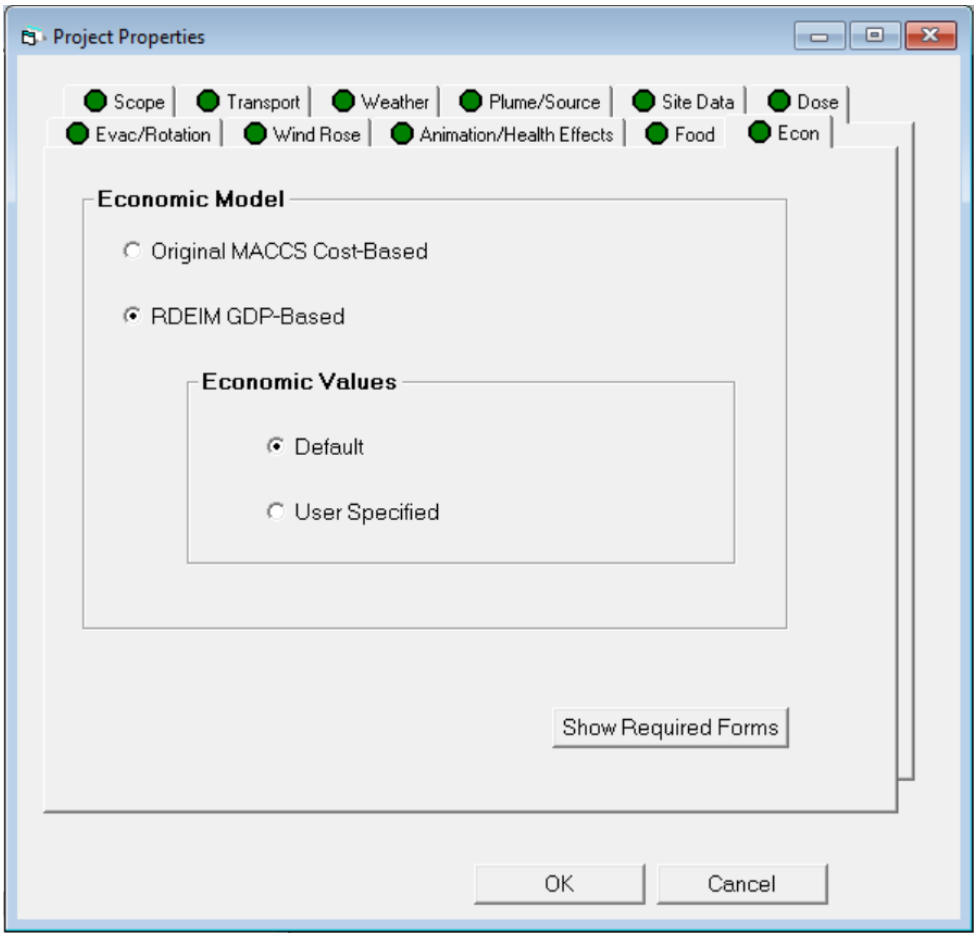


Figure 3-16 *Econ* Tab on *Project Properties* Form

Selecting Original MACCS Cost-Based means the cost-based model in MACCS will calculate the economic losses.

Selecting RDEIM GDP-Based means the new Gross Domestic Product (GDP) based economic model will be used to calculate economic losses.

3.1.2 Problem Description Form

WinMACCS provides several options for documenting a project by adding comments and other description fields. One of the options is to enter a general project description on the *General/Properties/Problem Description* form.

Comments entered anywhere within WinMACCS are echoed in the MACCS input files. MACCS echoes the comments in the input files to the output file, so comments are traceable throughout the calculation process.

3.1.3 File Specifications Category

Model settings that determine the types of files required are chosen on the *Project Properties* form. The set of files are shown as required under the *File Specifications* category. In the example shown in Figure 3-17, the meteorological, site, dose coefficient, and COMIDA2 files are required, as indicated by the icons to the left of the forms. When the required files have not been correctly specified, the icons appear as red octagons with an X over them.

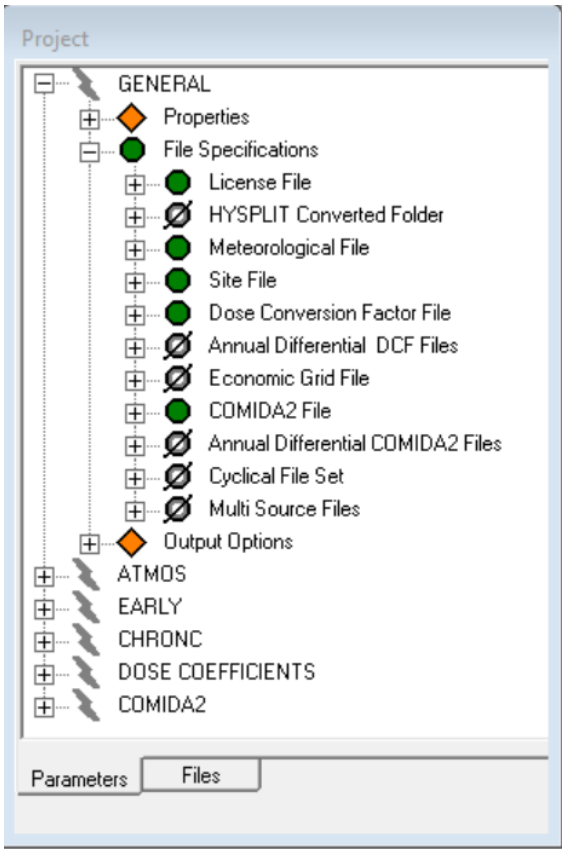


Figure 3-17 Specifying files

Table 3-2 describes the types of files that may be required, the conditions under which they are required, the tab within the *Properties* form that controls the requirement, and some sample files that are included with WinMACCS to illustrate the contents and format of the file. The interface uses icons just to the left of the form names to indicate which auxiliary files are required, depending on the project properties settings selected by the user.

License File **Form**

For WinMACCS version 4.0, a computer-linked license key is required and may be obtained from Sandia National Laboratories by following the instructions in the ReadMe.

HYSPLIT Converted Folder **Form**

MACCS-HYSPLIT files are required when the user selects *HYSPLIT* on the *Scope* tab. These are atmospheric transport files created by HyGridConvert and are linked to MACCS via the HYSPLIT Converted Folder Form. Unlike other files, these files are not copied to the data folder.

Meteorological File **Form**

A meteorological data file is required when the user selects *Weather from Files* on the *Weather* tab. WinMACCS allows the user to select any file, but a file should be selected that conforms to the format described in Section 7. The range of allowable wind directions in the meteorological file is determined by the value of the MACCS parameter NUMCOR, which is the number of compass sectors in the spatial grid.

Table 3-1 Meteorological File Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
Meteorological File	Yes	Text File	None	Any file. File is not validated by WinMACCS, but it should conform with the format described in Section 7.

Site File Form

A site file is required when the user selects *EARLY CONSEQUENCES* on the *Scope* tab and selects the *Import from File* on the *Site Data* tab. NUMCOR is the number of compass sectors in the spatial grid. Site files created by older versions of SecPop or used in earlier versions of MACCS have 16 sectors in the spatial grid. Changing the value of NUMCOR in an older site file is accomplished by clicking the button labeled *File Created from Existing Site File.* The user can browse to an existing site file and create a new site file with a modified value of NUMCOR. This operation does not add any resolution; it merely interpolates the original data onto a finer grid. The latest version of SecPop supports up to 64 sectors and should be used to create site files with more than 16 compass sectors whenever possible.

Table 3-2 Auxiliary files used by WinMACCS.

Name of form	Related *Project Properties* tab(s)	Conditions when form(s) is (are) required	Files from sample problems
License File	*N/A*	Required to use MACCS version 4.0	Supplied by Sandia after following ReadMe instructions
HYSPLIT Converted Folder	*Scope*	HYSPLIT is selected for the Atmospheric Transport and Dispersion Model on the Scope tab	Due to the large file size, these are a special request on the MACCS download site.
Meteorological File	*Weather*	Radio button next to Weather File Specified is selected.	westernsite_04.inp metsurMxHt_60min.inp
Site File	*Scope and Site Data*	EARLY Consequences is selected on Scope tab. Import from File is selected on Dose tab.	FicticiousSite.inp
Dose Conversion Factor File	*Scope and Dose*	EARLY Consequences is selected on Scope tab. LNT is selected on the Dose tab.	DosData20Organs.inp DOSD825.inp Fgr13dcf.inp Pu72.inp
Annual Differential DCF Files	*Scope, Dose, and Food*	Late Consequences is selected on Scope tab. Annual Threshold or Piecewise Linear dose-response model is selected on Dose tab. Predefined DCF File is selected on Dose tab. Either the No Food Model or the Predefined COMIDA2 File is selected on the *Food tab*.	dosdata20organs.inp dosdata20organs01.inp … dosdata20organs50.inp Fgr13dcf.inp FGR13GyEquiv_RevA.inp Fgr13dcf01.inp … Fgr13dcf50.inp

Name of form	Related *Project Properties* tab(s)	Conditions when form(s) is (are) required	Files from sample problems
Economic Grid File	*Econ*	RDEIM is selected as the economic model on the Econ tab	Available upon request to wg-maccs-entity@sandia.gov.
COMIDA2 File	*Scope and Food*	Late Consequences is selected on Scope tab. LNT is selected on the Dose tab. Predefined COMIDA2 File is selected on the *Food tab*.	samp_a20organs.inp samp_d.bin Fgr13samp_a.bin comida2
Annual Differential COMIDA2 Files	*Scope, Dose, and Food*	Late Consequences is selected on Scope tab. Annual Threshold or Piecewise Linear dose-response model is selected on Dose tab. Predefined DCF File is selected on Dose tab. Predefined COMIDA2 File is selected on the *Food tab*.	samp_a20organs.inp samp_a20organs01.inp … samp_a20organs50.inp fgr13samp_a.bin fgr13samp_a01.bin … fgr13samp_a50.bin
Cyclical File Set	*Scope*	MACCS Cyclical File Set is selected.	Case 2, 1MW.txt Case 3, 5MW.txt Case 4, 10MW.txt Case 5, 1MW, Entr.+Wake.txt Case 6, 5MW, Entr.+Wake.txt Case 7, 10MW, Entr.+Wake.txt
Multi Source Term File Set	*Plume/Source*	Multi Source Term option is selected.	

The site file is a text file containing site specific information. This file is commonly created using SecPop but may be created by a different process as long as it has the required format. See Section 4.4.8 for more information.

Table 3-3 Site File Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMCOR	Yes Click *File Created from Existing Site File* to change value	Integer	None	16, 32, 48, and 64
Site File	Yes	Text File	None	Site data is partially validated by WinMACCS.

Dose Coefficient or Dose Conversion Factor File Form

The newer term used by International Commission on Radiation Protection (ICRP) is dose coefficient, but the older term, DCF, is generally used in WinMACCS. A single DCF file is required when the user selects *Early Consequences* on the *Scope* tab and selects *LNT* on the *Dose* tab. A DCF File is an ASCII file containing a set of DCFs. Three types of DCF files are provided with MACCS. The most recent of these is based on *FGR-13*.

Table 3-4 Dose Coefficient File Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
DCF File	Yes	Text File	None	Files are provided. WinMACCS does not validate the files, but the format required by MACCS is specified in Section 8.

Annual Differential DCF Files Form

A set of DCF files are required when the user selects *Late Consequences* on the *Scope* tab and selects *Annual Threshold* or *Piecewise Linear* on the *Dose* tab. *Annual Differential DCF Files* are a set of fifty-one DCF files provided with the WinMACCS installation. These consist of a parent DCF file and a set of 50 annual DCF files, for which the 50-year dose commitment period is broken up into single years. Only the parent DCF file needs to be selected by the user; the set of annual files, with standardized nomenclature, are automatically included when the parent is selected. See Section 4.4.5 for more information.

Table 3-5 Annual Differential DCF Files Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
Annual Differential DCF File Set	Yes	Text Files	51 files	File sets are provided. WinMACCS does not validate the files, but the format required by MACCS is specified in Section 8.

COMIDA2 File Form

This form is required when the user selects *Late Consequences* on the *Scope* tab, selects *LNT* on the *Dose* tab, and selects *Predefined COMIDA2 File* on the *Food* tab. The COMIDA2 file is a binary file created by the COMIDA2 preprocessor. COMIDA2 requires a DCF file as part of its input. This DCF file must be the same as the one specified in the section above.

Table 3-6 COMIDA2 File Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
COMIDA2 File	Yes	Binary File	None	This file is not validated by WinMACCS, but it is by MACCS.

Annual Differential COMIDA2 Files Form

This form is required when the user selects *Late Consequences* on the *Scope* tab, selects *Annual Threshold* or *Piecewise Linear* on the *Dose* tab, and selects *Predefined COMIDA2 File* on the *Food* tab. *Annual Differential COMIDA2 File Set* is a set of fifty-one COMIDA2 binary files provided with the WinMACCS installation.

Table 3-7 Annual Differential COMIDA2 Files Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
Annual Differential COMIDA2 File Set	Yes	Binary Files	51 files	File sets are provided. WinMACCS does not validate the files, but they are validated by MACCS.

Cyclical File Set Form

A set of cyclical files is required when the user selects *MACCS Cyclical File Set* on the *Scope* tab. A *MACCS Cyclical File Set* is a set of files in MACCS input format. The function of this file set is described in Section 4.4.6.

Table 3-8 Cyclical File Set Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
MACCS Cyclical File Set	Yes	Text File	≥1 file	MACCS input file format. Files are read by WinMACCS.

Multi Source Term File Set Form

Using this option requires selecting *Multi Source Term* option on the *Properties* form and selecting the multi-source term files created using MelMACCS (version 2.0.1 or later) or with some other method. A software program, CombineSource, is integrated into WinMACCS and processes the set of multi-source term files specified and creates two output files. One output file, CombineSource.wmc, contains information that is directly imported into WinMACCS. The other file, CombineSource.out, contains information that is read by MACCS.

Table 3-9 Multi Source Term File Set Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
Multi Source Term File Set	Yes	Text Files	≥1 file	MelMACCS output file format

3.1.4 Output Options

Reporting Options Form

Results are calculated by WinMACCS for each quantile level on this form. If results have the Report option activated in the output request forms, results are automatically generated after model execution. The reported values are interpolated from the binned CCDF tables in the MACCS binary file. The quantile levels are also used when creating custom reports that combine results over simulations. See Section 4.6.2.3 for more information.

Table 3-10 Reporting Options Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
Probabilities	Yes	Real	≥1 file	0.0 to 1.0

***Output Units* Form**

Each time MACCS runs, an output file and a binary file is created containing the results. The units reported in the text and binary output files can be modified.

Table 3-11 Output Units Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
Activity Units	Yes	Character	None	{Bq, Ci}
Distance Units	Yes	Character	None	{km, mi}
Area Units	Yes	Character	None	{ha, km**2, mi**2}
Dose Units	Yes	Character	None	{rem, Sv}

3.2 ATMOS Input and Model Description

3.2.1 Overview of ATMOS

ATMOS performs all the calculations pertaining to atmospheric transport, including dispersion and deposition, as well as the radioactive decay and ingrowth that occurs prior to release and while the material is in the atmosphere. (Following calculation of transport within the problem domain, radioactive decay and dose modeling are performed by the EARLY and CHRONC modules of MACCS.) Beginning with MACCS version 4.0, an optional Lagrangian particle tracking model (HYSPLIT) was added to MACCS, in addition to the Gaussian plume segment model traditionally used. An overview of both models are provided in this section.

Gaussian Plume Segment Model

The Gaussian plume segment model characterizes the plume dispersion during downwind transport using a Gaussian distribution. Thus, the crosswind and vertical extent of plume segments is expressed in terms of the crosswind (σ_y) and vertical (σ_z) standard deviations of the normal concentration distributions that characterize a Gaussian plume. The Gaussian equations implemented in MACCS are derived assuming that turbulent velocities are negligible compared to the mean wind speed (Koa, 1984).

The specification of the release characteristics designating a “source term” can consist of up to 500 plume segments. ATMOS models the transport of these plume segments considering time-varying meteorological conditions. Treatment of variable meteorological conditions, referred to as weather sampling, is supported using various sampling options. If weather sampling is used, results are reported as statistical summaries and optionally as a binned CCDF. This is done for an individual MACCS run and only reflects weather variability, not uncertainty in other input parameters.

The radioactive materials released are modeled as being dispersed while being advected by the prevailing wind. During transport, deposition of particles onto the ground from dry and wet

processes can be modeled. In addition to the air and ground concentrations, ATMOS determines plume arrival time, plume departure time, and plume dimensions.

ATMOS results are used by the EARLY and CHRONC modules. Therefore, at a minimum, a MACCS calculation must include the ATMOS module. In other words, calculations of early or latent health effects of a radioactive release depend on dispersion and deposition results provided by ATMOS.

MACCS allows multiple individual source terms to be specified in the ATMOS input using a method called change records. Change records allow the user to specify new values for previously defined variables. When these are encountered, the code's calculations are rerun based on the new values for parameters defined in the set of change records and new output is generated for each specified source term and emergency response scenario.

WinMACCS does not support this feature of ATMOS, but a similar feature in EARLY that allows the specification of multiple emergency response cohorts is supported. Results for multiple source terms can be treated by WinMACCS through multiple MACCS runs using the *MACCS Cyclical File Set* option found on the *Scope* tab.

A relatively new feature of MACCS is to treat releases from multiple units and/or spent fuel pools that occur in a sequential or overlapping fashion. These releases can be associated with units having different isotopic inventories, different reactor shutdown times, and different release histories. MACCS can calculate the combined consequences of the multiple releases.

HYSPLIT Model

Starting with MACCS version 4.0 a new and more advanced atmospheric transport and dispersion (ATD) model has been enabled which uses HYSPLIT. This feature is partially supported in WinMACCS, but the user must perform several steps before running WinMACCS to use this new feature. The user needs to separately download documentation and software to use this option. Additional detail can be located in Instructions and Sample Problems for Using the MACCS/HYSPLIT Capability which is available with MACCS version 4.0 upon request to wg-maccs-entity@sandia.gov.

3.2.2 Basic Parameters

***Atmos Description* Form**

The *Atmos Description* form, as shown in Figure 3-18, contains two variables. ATNAM1 identifies the MACCS calculation and is printed in the output file. ATNAM2 identifies the name of the source term being studies. They are required input for all MACCS calculations.

Table 3-12 Atmos Description Parameter

Parameter Name	Definable	Type	Dimensions	Allowed Values
ATNAM1	Yes	Character	None	1 to 80 characters
ATNAM2	Yes	Character	None	1 to 80 characters

A more detailed description of the calculation can be entered on the *Problem Description* form under the *GENERAL/Properties* category.

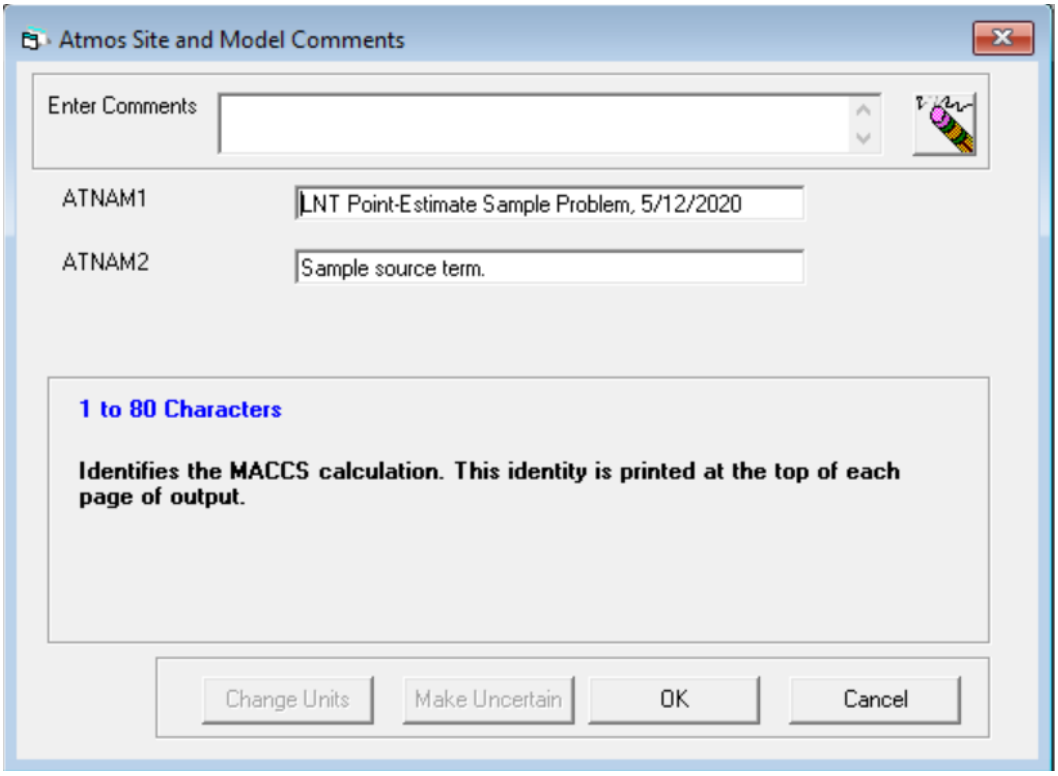


Figure 3-18 ATMOS Site and Model Description Form

***Property Form Parameters* Form**

The *Property Form Parameters* form, shown in Figure 3-19, illustrates how selections in the *Properties* form define some important parameters that are required in the ATMOS input to MACCS. The parameters are read-only and cannot be changed from this form.

ENDAT1 terminates the calculation after running ATMOS when set to True. Likewise, ENDAT2 terminates the calculation after running EARLY when set to True. ATMOS, EARLY, and CHRONC are run in sequence when both flags are set to False.

DISPMD is the long-range crosswind dispersion model flag. The value is set to LRTIME for the long-range, time-based option, in which case dispersion is calculated as a function of time. The value is set to LRDIST for the long-range, distance-based option, in which dispersion is calculated as a function of downwind distance. The distance-based model is the original MACCS2 1.12 dispersion model.

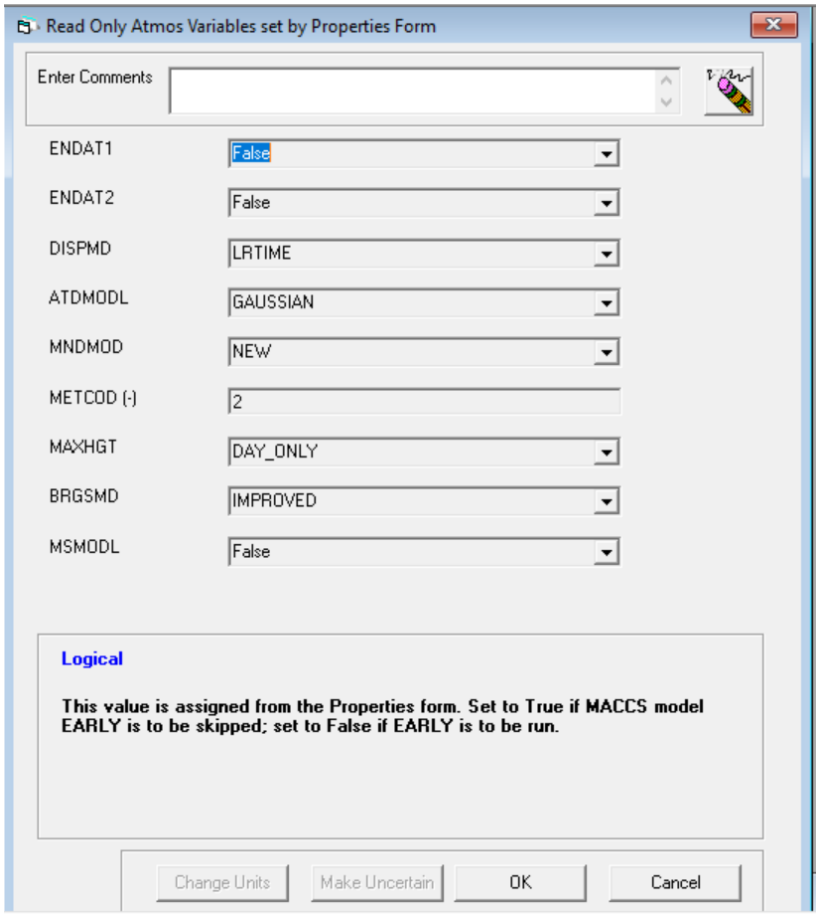


Figure 3-19 Property Form Parameters Form

ATDMODL defines which atmospheric transport and dispersion model is selected, GAUSSIAN for the Gaussian plume segment model, and HYSPLIT for the Lagrangian particle tracking model.

MNDMOD defines the algorithm used to calculate plume meander. If set to OLD, the plume meander factor is a function of release duration only. If set to NEW, plume meander factor depends on wind speed and stability class, but not on the duration of release. This model is consistent with NUREG/CR-2260 and US NRC Regulatory Guide 1.145. If MNDMOD is chosen to be NEW, the plume segments should be approximately one hour in duration. OFF means no plume meander is treated.

METCOD determines what meteorological data are used and how weather sampling is performed. When the value is set to one, two, or five, a meteorological data file is needed to supply the meteorological data.

- A value of one allows the user to choose a single starting point in the file, defined by a day and period of the day. A single weather trial is performed using this time as a starting point.
- A value of two corresponds to weather-bin sampling from the meteorological data file.
- A value of three is used for user-supplied hourly data for 120 hours.
- A value of four is used for user-supplied, constant weather.
- A value of five corresponds to stratified, random sampling from the meteorological data file.

MAXHGT determines whether only the daytime or both the daytime and nighttime mixing heights are to be used in the calculation. When DAY_AND_NIGHT is selected, the *Site Location* form is required to estimate sunrise and sunset for each day of the year. The required mixing heights are specified in the meteorological data file.

BRGSMD is the plume-rise model flag. IMPROVED is the recommended value. This recommendation is based on comparisons of several empirical models with results from the National Institute of Standards and Technology (NIST) ALOFT-FT code. ALOFT-FT solves the fundamental equations that govern the rise of hot gases into the atmosphere. ORIGINAL is the original MACCS 1.12 Briggs plume rise model. See Section 3.2.9.1 for more details.

MSMODL is the Multi Source Term model flag. When set to True, the forms under the *Multi Source Term* category are required, and MACCS calculates the combined effects of the multiple releases defined in these files. When set to False, the source term is specified directly in the WinMACCS interface.

Table 3-13 Property Form Parameter Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values	Tab where Defined on *Properties Form*
ENDAT1	Read-Only	Logical	None	True, False	*Scope* tab
ENDAT2	Read-Only	Logical	None	True, False	*Scope* tab
DISPMD	Read-Only	Character	None	LRDIST, LRTIME	*Transport tab*
MNDMOD	Read-Only	Character	None	OLD, NEW, OFF	*Transport tab*
ATDMODL	Read-Only	Character	None	GAUSSIAN, HYSPLIT	*Scope* tab
METCOD	Read-Only	Integer	None	1 to 5	*Weather* tab
MAXHGT	Read-Only	Character	None	DAY_ONLY, DAY_AND_NIGHT	*Weather* tab
BRGSMD	Read-Only	Character	None	ORIGINAL, IMPROVED	*Plume/Source* tab
MSMODL	Read-Only	Logical	None	True, False	*Plume/Source* tab

Spatial Grid Form

The region potentially affected by a release is represented by polar coordinates, (r, θ). The radius, r, represents distance from the release point, which is always at $r = 0$. The angle, θ, is the angle measured clockwise from north. The user must specify a set of radial endpoints (i.e., the outer radii for the grid elements), as shown in Figure 3-20. Up to 35 radii may be defined, extending out to a maximum distance of 9999 km. The number of angular divisions, or compass sectors, used to define the spatial grid can be 16, 32, 48, or 64. If the spatial grid is divided into 16 sectors, each sector is 22.5˚ wide. In all cases the sectors are equally spaced. The first sector is always centered on north.

NUMCOR is the number of sectors in the spatial grid. If a site file is used, it must be consistent with the number of sectors in the grid.

NUMRAD is the number of radial spatial intervals. The value of this parameter is automatically determined in WinMACCS by the number of entries in vector SPAEND. The number of radial intervals and the radial locations must be consistent with the site file, if one is used.

SPAEND defines the radial boundaries in the spatial grid. If a site data file is being used, these values are optionally updated when the site file is selected. This update ensures consistency between the site file and the MACCS input. The first radius must be at least 0.05 km. The minimum spacing between adjacent radii is 0.1 km.

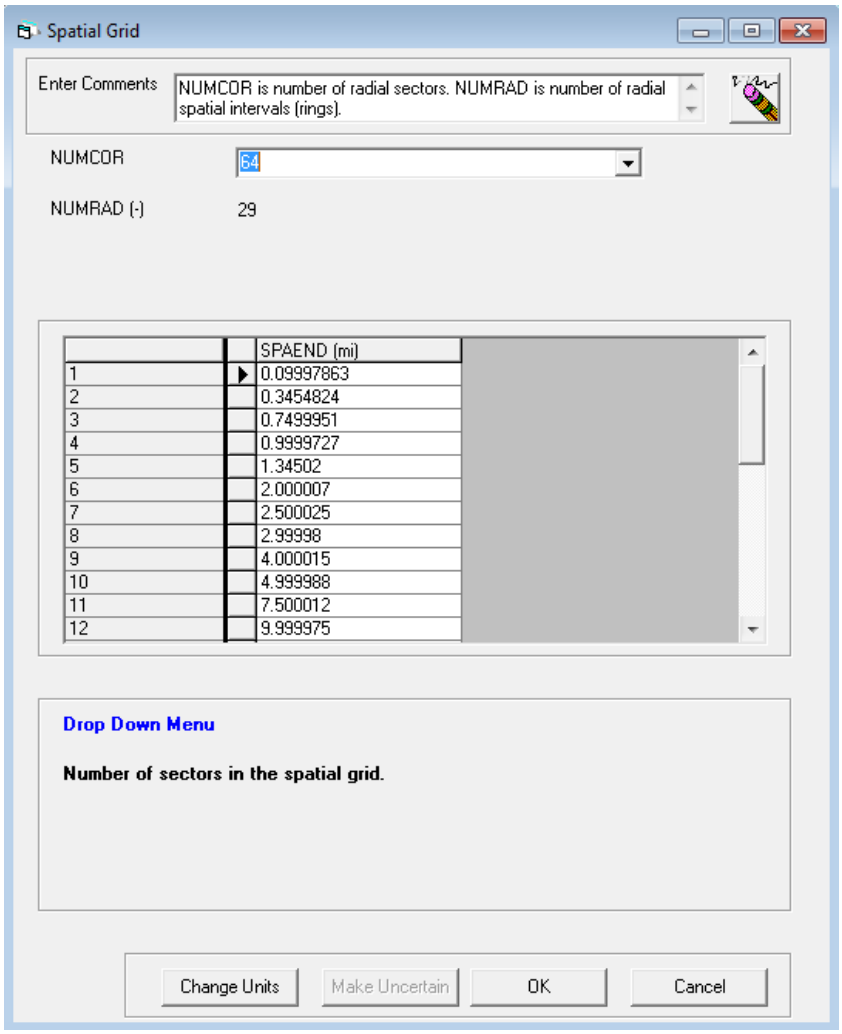


Figure 3-20 Spatial Grid Form

Table 3-14 Spatial Grid Form Parameter Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMCOR	Yes	Integer	None	16, 32, 48, 64
NUMRAD	Linked	Integer	None	2 to 35
SPAEND	Yes	Real	NUMRAD	0.05 to 9999.0, spacing ≥ 0.1 km

3.2.3 Radionuclides

This section defines the radionuclide classes (groups) and the radionuclides that are modeled. The radioactive decay data (half-life and decay chains) are provided to MACCS by the file INDEXR.DAT, which is from the Radiation Shielding Information Center as part of the FGR-DOSE/DLC-167 data package. This file is part of the WinMACCS installation and is transparent to the user.

3.2.3.1 Radionuclide Descriptions

Radionuclide names are case sensitive. Names of chemical elements follow the usual convention that the first letter is capitalized, and the second letter is lower case. The element names are followed by a hyphen and the atomic mass of the radionuclide to define the radionuclide name.

Each decay chain is limited to a maximum of six generations. Each decay chain is independent of the others. The MACCS output file lists the chains that are being used in the calculations.

Decay chains can be terminated in two ways. They are automatically terminated when the decay product is a stable isotope. In some cases, it is desirable to terminate a decay chain with a decay product that is not stable. This is commonly done when the decay product has a very long half-life or contributes very little to the overall dose. Terminating a decay chain in this way is done by adding the radionuclide to the pseudostable isotope list.

For example, Cs-135 is formed by beta-decay of Xe-135. It decays to Ba-135 from low-energy beta decay with a half-life of 2.3×10^6 years. Because of the long half-life and low energy beta produced by its decay, it has little effect on doses and is often included as a decay-chain terminator in MACCS calculations by including it as a pseudo-stable isotope.

In some older calculations, decay products were added implicitly by adding the DCFs for the progeny to the parent and including the progeny in the list of pseudostable radionuclides. This simplification was done to reduce memory and CPU requirements. It works when the half-life for the progeny is much shorter than the one for the parent so that the progeny decays almost immediately once the parent decays. This practice somewhat disguises the set of radionuclides that are being treated in a problem and reduces flexibility. Since computer memory is at much less of a premium now than when MACCS was initially developed, this practice of implicitly including progeny in a calculation is now discouraged. With the latest DCF file based on FGR-13, all progeny must be included in a calculation if their doses are to be included.

If an input error occurs because an unstable decay product is omitted, MACCS exits with an error message that lists the isotope or isotopes that are missing. The missing decay products must either be added to the radionuclide list or to the pseudostable isotope list. A radionuclide cannot be included on both lists. When one or more decay chain branches exist, the decay products in all the active branches must be included in one of the two lists.

3.2.3.2 *Radionuclide*s Forms and Parameters

Chemical Names Form

The *Chemical Names* form is required when *Multi Source Term* is not selected on the *Plume/Source* tab. Each radionuclide to be modeled is assigned to a chemical class. Traditionally, the term chemical class has been used in MELCOR applications to identify a set of chemically similar elements that are assumed to behave identically within the radionuclide package of MELCOR. For example, all noble gases are generally assigned to the Xe class. In MACCS, the dry deposition characteristics and release fractions are assigned by chemical group,

where group is commonly used instead of class. Thus, all isotopes assigned to a chemical group are assumed to act similarly in terms of release fraction and deposition behavior. The user is required to assign a name for each chemical group, which is used as a label in the forms for RELFRC and DRYDEP.

MAXGRP is the number of chemical groups. The value is linked to the number of entries in the vector GRPNAM.

GRPNAM is a vector of character strings used to identify each of the radionuclide classes. This parameter is used for labeling within WinMACCS and appears in the ATMOS input file created by WinMACCS.

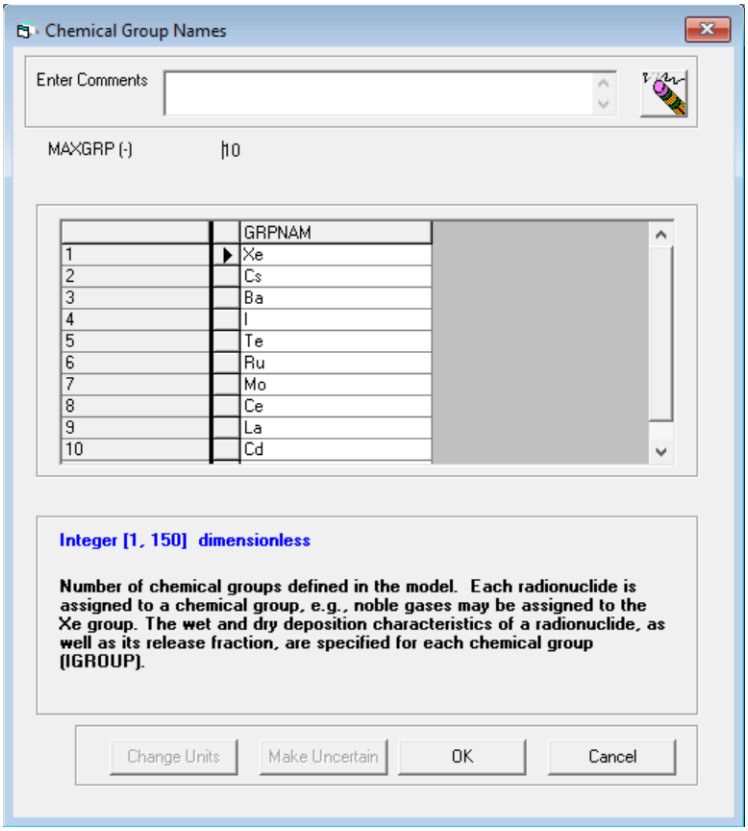


Figure 3-21 Chemical Group Names Form

Table 3-15 Chemical Names Form Parameter Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
MAXGRP	Linked	Integer	None	1 to 150
GRPNAM	Yes	Character	MAXGRP	1 to 15 characters

Radionuclides Form

The *Radionuclides* form is required when *Multi Source Term* is not selected on the *Plume/Source* tab.

The *Radionuclides* form specifies the number of radionuclides treated in the WinMACCS calculation, the names of the radionuclides, the core inventory of each of the radionuclides, and the chemical group to which each one is assigned. The names of the radionuclides must correspond to those in the DCF file associated with the WinMACCS project. (In their latest documents, ICRP uses "dose coefficients" in place of "dose conversion factors." These names are used interchangeably in this document.)

Three types of DCF files are distributed with MACCS. The oldest of these was created by the program DOSFAC2. This file, named dosdata20organs.inp, contains 60 radionuclides. It includes DCFs for estimating acute and latent health effects. In addition to the 60 radionuclides, 11 decay products are implicitly included in this DCF file. This is done by summing the DCFs for the parent and progeny. This simplification was done to reduce CPU time and is appropriate when the progeny's half-life is very short compared with the parent's half-life. All implicit decay products must be included on the pseudostable isotope list when using this DCF file.

The two other types of DCF files are based on FGR-11, -12, and -13. The DCFs for the external pathways are common to both and are from FGR-12. DCFs for the internal pathways are from FGR-11 in one case and from FGR-13 in the other case. Both files contain extensive lists of radionuclides (825); however, treatment of implicit progeny is different in the two files. The older file, based on FGR-11 and -12, includes several implicit progenies (e.g., Ba-137m is included with Cs-137). Thus, Ba-137m should not be treated directly using this file or it would be double counted. On the other hand, the newer DCF file based on FGR-12 and -13 does not include any implicit progeny, so both Cs-137 and Ba-137m must be explicitly included. This allows more flexibility in the treatment of decay products. For example, with the older DCF file, a calculation could include either Cs-137 or Ba-137m in the inventory. Including both would lead to double counting most of the Ba-137m dose. The newer DCF file allows either Cs-137, Ba-137m, or both to be included in the inventory. The newer file also includes DCFs for estimating both acute and latent health effects; the older file only includes DCFs for latent health effects.

NUMISO defines the number of radionuclides. It is linked to the number of entries in the NUCNAM vector.

NUCNAM is a vector of radionuclide names. Each radionuclide name must be in the decay-chain definition file, INDEXR.DAT, as well as the DCF file used in the calculation.

CORINV defines the inventory of each radionuclide in the facility at the time of reactor shutdown. The unit, Bq, or Becquerel, is equivalent to disintegrations/second. This inventory can be scaled by modifying parameter CORSCA found on form *ATMOS/Release Description/Inventory Scale Factor*.

IGROUP identifies the chemical group to which the radionuclide is assigned. The radionuclides should be grouped according to their physical/chemical properties. All members of a chemical group have the same deposition characteristics and release fractions. The assignment into chemical groups or classes is often taken from MELCOR, especially when the source term was calculated using MELCOR.

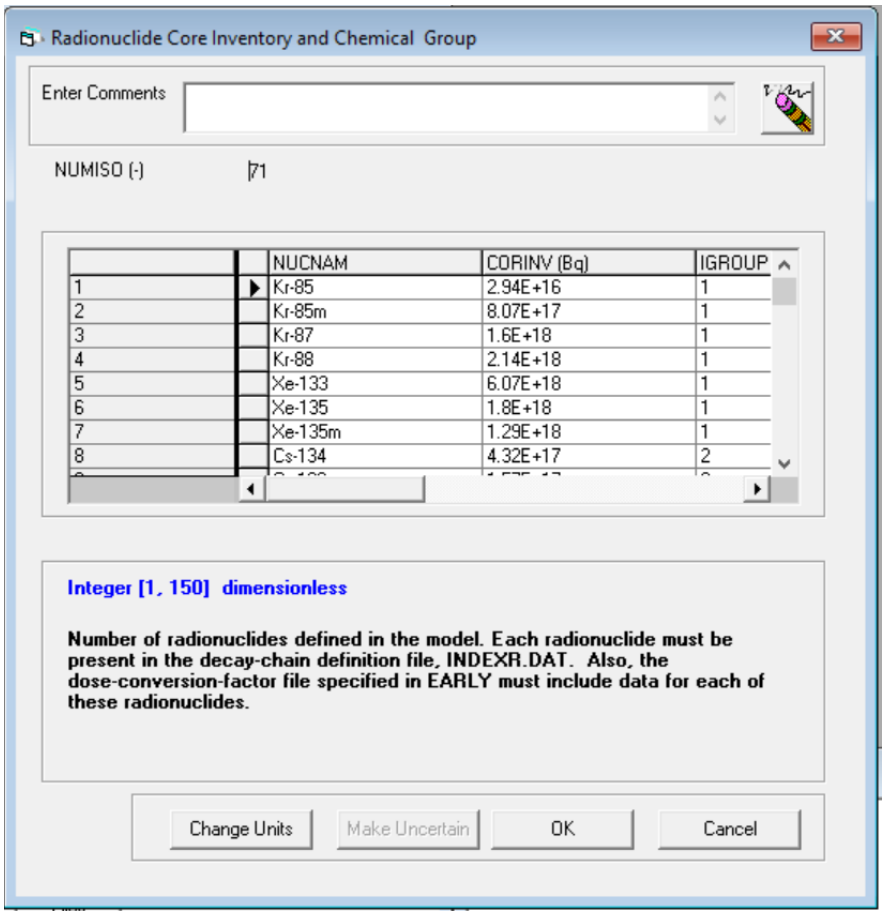


Figure 3-22 Radionuclides Form

Table 3-16 Radionuclides Form Parameter Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMISO	Linked	Integer	None	1 to 150
NUCNAM	Yes	Character	NUMISO	3 to 8 characters
CORINV	Yes	Real	NUMISO	0 to 10^{25} Bq
IGROUP	Yes	Integer	NUMISO	1 to MAXGRP

Pseudostable Radionuclides Form

The *Pseudostable Radionuclides* form is available when *Multi Source Term* is not selected on the *Plume/Source* tab. The *Pseudostable Radionuclides* form is optional, although it is almost always used in practice. This form specifies the name and number of pseudostable radionuclides, as described above.

NUMSTB is the number of pseudostable radionuclides. The value is determined by the number of entries in vector NAMSTB.

NAMSTB contains a set of decay-chain terminators. Each radionuclide must also be present in the decay-chain definition file, INDEXR.DAT. These entries and their decay products are excluded from dose calculations. Radionuclide names cannot appear in both NUCNAM and NAMSTB.

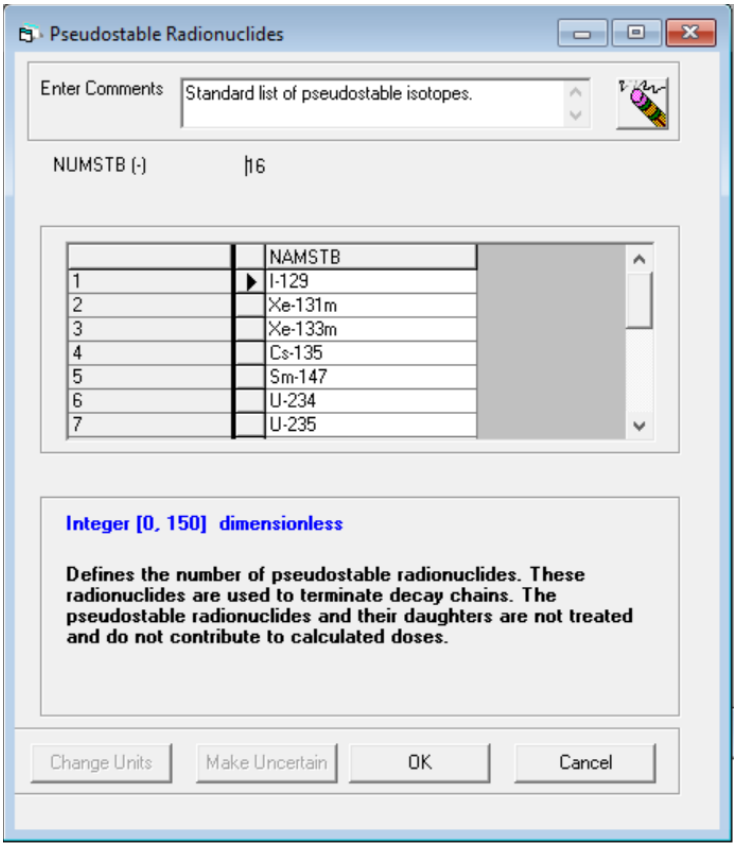


Figure 3-23 Pseudostable Radionuclides Form

Table 3-17 Pseudostable Radionuclides Form Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMSTB	Linked	Integer	None	1 to 150
NAMSTB	Yes	Character	NUMSTB	3 to 8 characters

3.2.4 Deposition

3.2.4.1 Deposition Model Description

The wet deposition model estimates how much material is deposited during episodes of precipitation. Wet deposition is treated as a function of both precipitation duration and intensity. The fraction of aerosols that remains suspended after wet deposition is calculated from the following equation (Brink and Vogt, 1981):

$$\frac{Q}{Q_0} = C_1 \cdot exp\left[-t_r \cdot \left(\frac{I_r}{I_0}\right)^{C_2}\right] \quad \textbf{(3-1)}$$

Where

Q = Quantity of suspended aerosols after rain event (Bq)

Q_0 = Quantity of suspended aerosols before event (Bq)

C_1 = linear washout coefficient, corresponding to MACCS input variable, CWASH1 (dimensionless)

$\mathrm{t_r}$ = duration of precipitation (s)

$\mathrm{I_r}$ = intensity of precipitation (mm/hr)

$\mathrm{I_0}$ = unit rain intensity, 1 mm/hr

$\mathrm{C_2}$ = exponential washout coefficient, corresponding to MACCS input variable, CWASH2 (dimensionless)

Dry deposition is modeled using the source depletion method. This method makes use of the simplifying assumption that deposition onto the ground does not significantly affect the air concentration near the ground. That is, removal by deposition is assumed to be much slower than dispersion in the air. This assumption allows the plume to be treated as Gaussian when deposition occurs. This is generally an excellent assumption because turbulent advection is generally on the order of 0.5 m/s while deposition velocities are typically a few cm/s or less.

The concentration of monodisperse aerosols at a location on the ground is the product of the integrated ground-level air concentration there times the deposition velocity. In the general case, multiple aerosol sizes each with a different deposition velocity, the ground concentration is the sum over the set of aerosol sizes of the products of the time-integrated air concentrations and the deposition velocities.

The material in each chemical group can be distributed among several particle-size groups (up to 20), with each chemical group having a different distribution of activity among the particle-size groups. The particle-size distribution of each chemical group is specified in the release description data. Because each particle size can deposit at a different rate, both the size distribution and the relative amounts of chemical groups can vary with downwind distance. For example, consider a release containing noble gases, which do not deposit (deposition velocity is zero) and iodine, which does deposit. As a result, the ratio of noble gases to iodine increases with downwind distance because iodine deposits while the noble gases do not. Further, consider that the iodine is represented by two aerosol bins, each with its own deposition velocity. The activity in the bin that deposits faster is depleted more rapidly than the other bin as the plume travels downwind. Thus, both the chemical composition and size distribution of a plume can change with time and distance.

3.2.4.2 Deposition Forms and Parameters

Wet/Dry Depos Flags

The *Wet/Dry Depos Flags* form is required. DRYDEP is defined for each of the chemical groups. This flag indicates whether the chemical group is subject to dry deposition. Setting the flag to False ensures that the deposition velocity is zero for this radionuclide class. WETDEP is also defined for each of the chemical groups. This flag indicates whether the radionuclide class is subject to wet deposition.

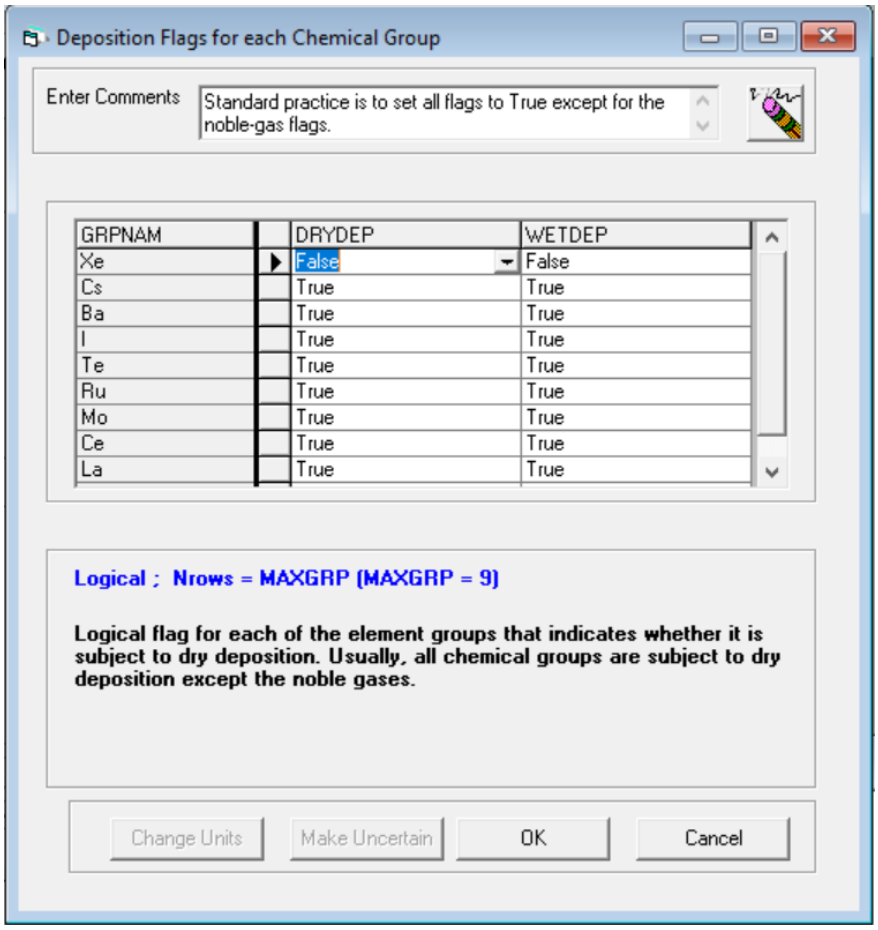


Figure 3-24 Wet/Dry Depos Flags Form

Table 3-18 Wet/Dry Depos Flags Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
DRYDEP	Yes	Logical	MAXGRP	True, False
WETDEP	Yes	Logical	MAXGRP	True, False

The chemical group representing the noble gases, which do not form aerosols and are highly inert, is generally assigned deposition flags of False for both wet and dry deposition. Other chemical groups are generally assigned deposition flags of True for both wet and dry deposition.

Wet Deposition

CWASH1 is the linear coefficient in the washout function shown in Equation (3-1).

CWASH2 is the exponential coefficient in the washout function shown in Equation (3-1).

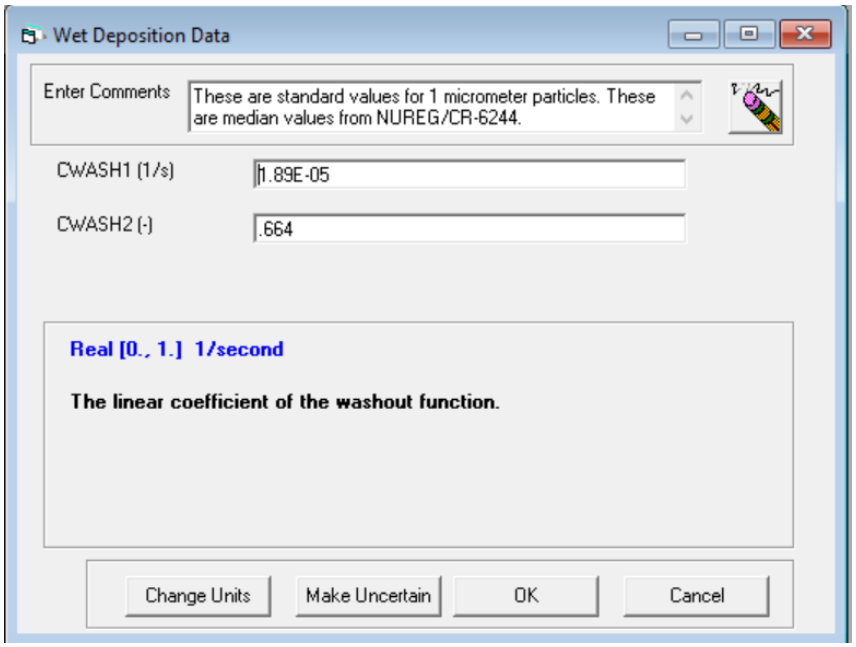


Figure 3-25 Wet Deposition Form

Table 3-19 Wet Deposition Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
CWASH1	Yes	Real	None	0.0 to 1.0
CWASH2	Yes	Real	None	0.0 to 1.0

Particle Size Groups

NPSGRP is the number of particle size groups, determined by the number of entries in vector VDEPOS.

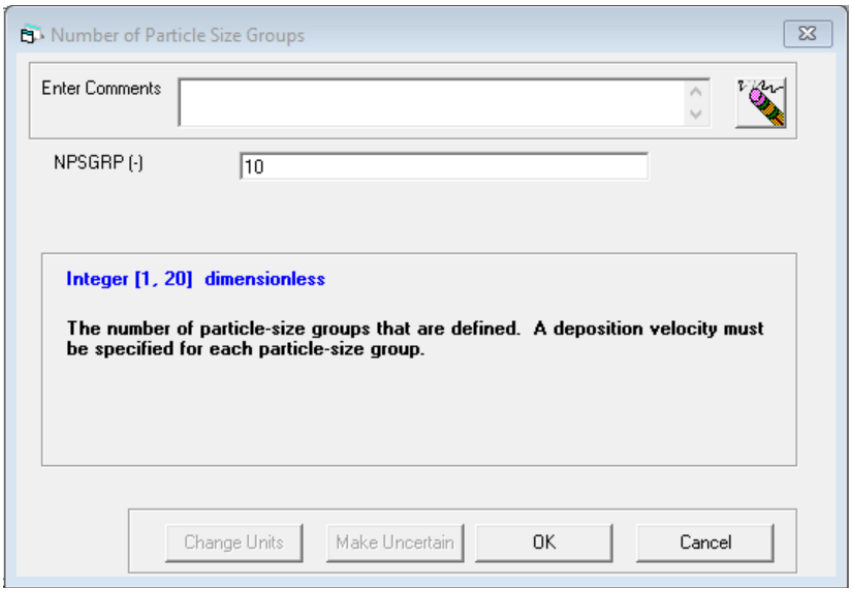


Figure 3-26 Particle Size Groups Form

Table 3-20 Particle Size Group Parameter Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
NPSGRP	Linked	Integer	None	1 to 20

Dry Deposition

VDEPOS is the set of dry deposition velocities corresponding to the set of particle size groups.

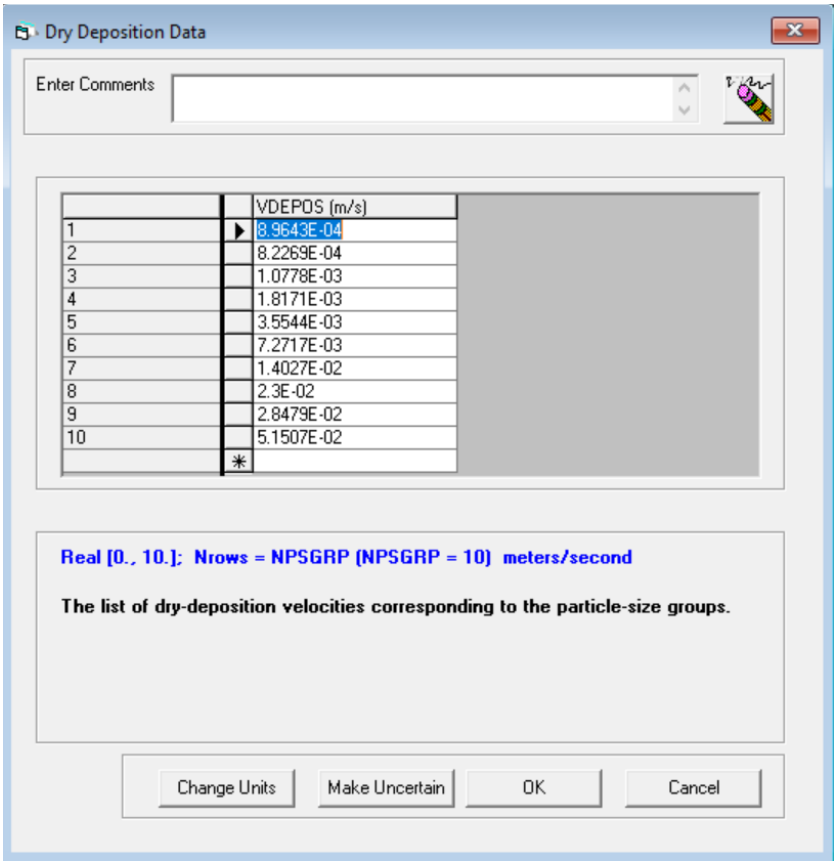


Figure 3-27 Dry Deposition Form

Table 3-21 Dry Deposition Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
VDEPOS	Yes	Real	NPSGRP	0.0 to 10.0 m/s

3.2.5 Dispersion

3.2.5.1 Dispersion Model Description

The Gaussian plume segment model of atmospheric dispersion optionally uses spatially dependent dispersion parameters, σ_y and σ_z. (A subsequent section describes an option to switch to time-based dispersion at a user-specified distance downwind of the source.) The dispersion

parameters can be supplied in two different ways as functions of distance: as power-law functions or in the form of a lookup-table. The choice of which of the two models to use is made on the *Transport* tab on the *Properties* form.

Gaussian Plume Equations

MACCS models plume dispersion during downwind transport using a Gaussian plume segment model. Thus, the crosswind and vertical extent of plume segments is expressed in terms of the crosswind (σ_y) and vertical (σ_z) standard deviations of the normal concentration distributions that characterize a Gaussian plume. The Gaussian equations implemented in MACCS are derived assuming that turbulent velocities are negligible compared to the mean wind speed (Koa, 1984). Accordingly, MACCS assumes that the initial length of plume segments is unaffected by dispersion during downwind transport (i.e., plume segment lengths are constant once release of that plume segment is complete). Furthermore, MACCS assumes that concentration profiles have a sharp leading and trailing edge (i.e., the profile is a step function in x at these locations).

During downwind transport, atmospheric turbulence causes plume segments to expand in all directions with the rate of expansion increasing when atmospheric turbulence increases. Vertical expansion of the plume is increased by surface roughness and constrained by the ground and by the temperature structure of the atmosphere (location of inversion layers). Crosswind spreading of the plume along the y-direction is unconstrained. The effective crosswind dimensions of a plume segment are increased by lateral meander of the plume about its centerline trajectory. Because turbulent velocities are almost always very small compared to the mean wind speed that transports the bulk plume, expansion in the wind direction can be neglected (Turner, 1970).

Because they are simple and computationally efficient, Gaussian plume models are commonly used to model atmospheric dispersion in reactor accident risk assessments (see for example the PRA Procedures Guide, NRC, 1983b). Gaussian plume models assume that the dispersion of gas molecules and aerosol particles in the plume during its downwind transport can be modeled as a random walk that generates a normal distribution for air concentration in all directions. Because wind speed and temperature vary significantly with height near the ground, vertical and crosswind plume distributions can differ significantly and must be calculated separately. Since the distribution in the wind direction does not appear in the Gaussian plume equations implemented in MACCS, only the vertical and crosswind distributions are calculated.

The size of a Gaussian plume in the vertical and crosswind directions is defined by the standard deviations (σ_y and σ_z) of the normal distributions of material concentrations in the vertical and crosswind directions. When not constrained by the ground or by inversion layers, the Gaussian plume equation has the following form (Turner, 1970):

$$\chi(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] exp\left[-\frac{1}{2}\left(\frac{z-h}{\sigma_z}\right)^2\right] \quad \textbf{(3-2)}$$

Where

$\chi(x,y,z)$ = time-integrated air concentration (Bq·s/m^3) at downwind location (*x*, y, *z*)

Q = released activity (Bq)

u = mean wind speed (m/s)

σ_y = lateral dispersion parameter representing the standard deviation of a Gaussian distribution (m)

σ_z = vertical dispersion parameter representing the standard deviation of a Gaussian distribution (m)

h = stabilized height of the plume centerline (m)

Once a plume has expanded sufficiently in the vertical dimension so that further vertical expansion is constrained by the ground and/or the capping inversion layer, Equation (3-4) is no longer applicable. To treat restricted growth in the vertical dimension, the ground and the inversion layer are treated as impenetrable, reflecting boundaries. Mathematically, reflection is accomplished by the addition of mirror image sources above the inversion layer and below the plane of the ground. This produces the following equation, which is used in MACCS to calculate both the time-integrated, plume-centerline, air concentration, $\chi\,(x,\, y = 0,\, z = h)$, and time-integrated, ground-level, air concentration under the plume centerline, $\chi\,(x,\, y = 0,\, z = 0)$, from the time a plume segment is released until the vertical distribution of the segment becomes uniform between the ground and capping inversion layer (becomes well mixed in the vertical dimension):

$$\chi(x,y,z) = \frac{Q}{2\pi u\sigma_y\sigma_z} exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \sum_{n=-\infty}^{\infty} \left\{exp\left[-\frac{1}{2}\left(\frac{z-h+2nH}{\sigma_z}\right)^2\right] + exp\left[-\frac{1}{2}\left(\frac{z+h+2nH}{\sigma_z}\right)^2\right]\right\} \quad \textbf{(3-3)}$$

Where

H = height (m) of the capping inversion layer (i.e., the height of the mixing layer)

At each spatial interval along the plume's trajectory, MACCS tests for the occurrence of a uniform concentration distribution in the vertical direction (well-mixed plume between the ground and the capping inversion layer). Once a uniform vertical distribution is attained, Equation (3-5) approximately reduces to the following equation:

$$\chi(x, y = 0, z) = \frac{Q}{\sqrt{2\pi}\sigma_y uH} exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \quad \textbf{(3-4)}$$

MACCS switches from Equation (3-5) to Equation (3-6) when $H/\sigma_z < 0.03$. This criterion approximately corresponds to the requirement that the results of the two equations agree within 1%. Because Equation (3-6) is independent of σ_z, this value is not calculated once the transition from Equation (3-5) to Equation (3-6) is made.

Dispersion Values

The rate at which materials disperse in the atmosphere depends strongly on atmospheric turbulence, which varies greatly with stability class. Therefore, the rate of expansion of a plume during downwind transport also varies with stability class.

The growth of plume dimensions during downwind transport to short distances (1 km) has been experimentally determined (Haugen, 1959) over flat terrain covered by prairie grass (surface roughness length z_0 = 3 cm) for short plumes (10 min release durations) released during stable, neutral, and unstable atmospheric conditions. Pasquill (1961) used these data to develop curves that depict the increase of plume dimensions (σ_y and σ_z values) with downwind distance for each

of the six Pasquill-Gifford Stability Classes A through F. Although measurements had only been made to 1 km, Pasquill extrapolated the curves to 100 km. These curves, as later modified by Gifford (1975, 1976), are presented in Figure 3-28.

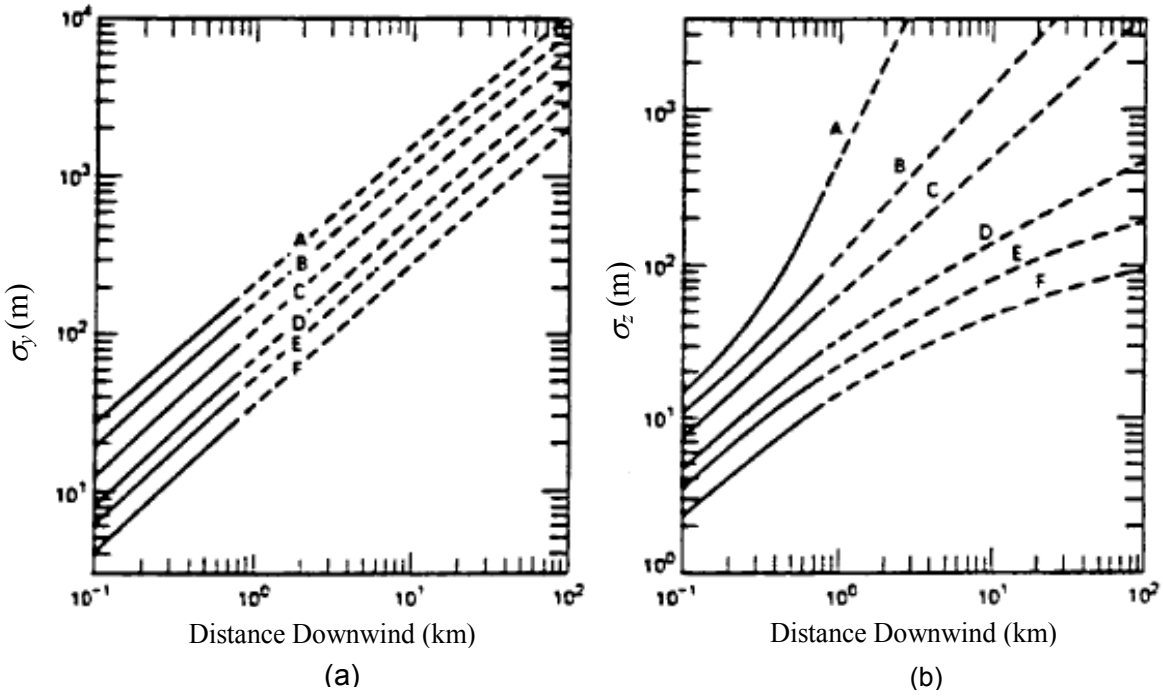


Figure 3-28 Dependence of σ_y and σ_z on distance for the six Pasquill-Gifford stability classes, A through F

Solid lines depict the range of the experimental data; dashed lines are extrapolations. Tadmor and Gur (1969) constructed power-law fits to the Pasquill-Gifford (P-G) curves. The coefficients are provided in Table 3-22. Technical guidance for selecting a parameterization to represent dispersion can be found in *Technical Bases for Consequence Analyses Using MACCS* (Bixler et al., 2020).

Table 3-22 Tadmor and Gur coefficients for σ_y and σ_z for Equation(3-2).

Stability Class		Constant*			
P-G	i	a_i	b_i	c_i	d_i
A	1	0.3658	0.9031	0.00025	2.125
B	2	0.2751	0.9031	0.0019	1.6021
C	3	0.2089	0.9031	0.2	0.8543
D	4	0.1474	0.9031	0.3	0.6532
E	5	0.1046	0.9031	0.4	0.6021
F	6	0.0722	0.9031	0.2	0.6020

*The values of these constants reflect correction of typographical errors identified by Dobbins (1979).

As used in MACCS, the values of the dispersion parameters, σ_y and σ_z, in Equation (3-2) must change in a piecewise continuous fashion. Discontinuous changes in slope occur when stability class changes. Since stability class changes discretely, the source distance x in the dispersion parameter equation (Equation (3-2) must be changed to some new value that causes dispersion parameter growth to be continuous. The value of the source distance, when it differs from the actual source distance, is called the virtual source distance, and generally has a different value for σ_y and for σ_z. It is calculated as follows.

Let i be the stability class before the change in atmospheric conditions, j the stability class after the change, and x_{yi} and x_{zi} be the source distances under the old conditions (the downwind distances to the virtual source just before the stability class changes). Let x_{yj} and x_{zj} be the source distances under the new conditions (i.e., the new virtual source distances). To ensure continuity, σ_{yi} must be equal to σ_{yj} and σ_{zi} must be equal to σ_{zj}. Thus,

$$\begin{aligned} a_i\left(x_{y_i}\right)^{b_i} &= \sigma_{y_i} = \sigma_{y_j} = a_j\left(x_{y_j}\right)^{b_j} \\ c_i\left(x_{z_i}\right)^{d_i} &= \sigma_{z_i} = \sigma_{z_j} = c_j\left(x_{z_j}\right)^{d_j} \end{aligned} \qquad \textbf{(3-5)}$$

These equations can be solved explicitly for the virtual source locations to produce the following result:

$$\begin{aligned} x_{y_j} &= \left[\frac{1}{a_j} a_i\left(x_{y_i}\right)^{b_i}\right]^{\frac{1}{b_j}} = \left[\frac{\sigma_{y_i}}{a_j}\right]^{\frac{1}{b_j}} \\ x_{z_j} &= \left[\frac{1}{c_j} c_i\left(x_{z_i}\right)^{d_i}\right]^{\frac{1}{d_j}} = \left[\frac{\sigma_{z_i}}{c_j}\right]^{\frac{1}{d_j}} \end{aligned} \qquad \textbf{(3-6)}$$

This same approach can be used in conjunction with the lookup table option described above. This assumes that the inverse functional dependence for the lookup table can be evaluated (i.e., that given a dispersion value, a unique value of x can be determined). For the lookup table, the requirement of monotonically increasing values in the table ensures uniqueness. Performing the inverse function is done by interpolation in the same way as for the function itself.

Although new "virtual source" distances for σ_y and σ_z are calculated every time stability class changes, these distances are used only to calculate growth of σ_y and σ_z. Plume locations are always expressed relative to the release point that is the center point of the polar-coordinate computational grid.

For a given spatial element, the average values of σ_y and σ_z are used to calculate air and ground concentrations for the entire spatial element. The average values of σ_y and σ_z are the arithmetical means of the initial and final values of these two parameters as a plume segment traverses the spatial element.

Scaling Factors

MACCS allows the user to input a separate scaling factor for σ_y and σ_z. These scale factors can be used to account for phenomena that would tend to increase or decrease the plume dimensions. There are two such phenomena that are commonly included in plume modeling: plume broadening caused by meander (wind direction fluctuations) and increase in the vertical plume dimension caused by surface roughness. Separate options exist to account for plume meander,

as described in a subsequent subsection, so the scale factor for σ_y is usually set to 1.0. However, MACCS does not contain a separate model to account for surface roughness, so most commonly the vertical scale factor is set to a value other than unity.

The Pasquill-Gifford curves depicted in Figure 3-28 are appropriate for transport over flat terrain covered by prairie grass (surface roughness length z_0 = 3 cm). But plume transport is usually over areas characterized by surface roughness lengths greater than 3 cm. Figure 3-29 presents some approximate surface roughness lengths for different surfaces based on the values in (Lettau, 1969; Briggs, 1984; Randerson, 1984).

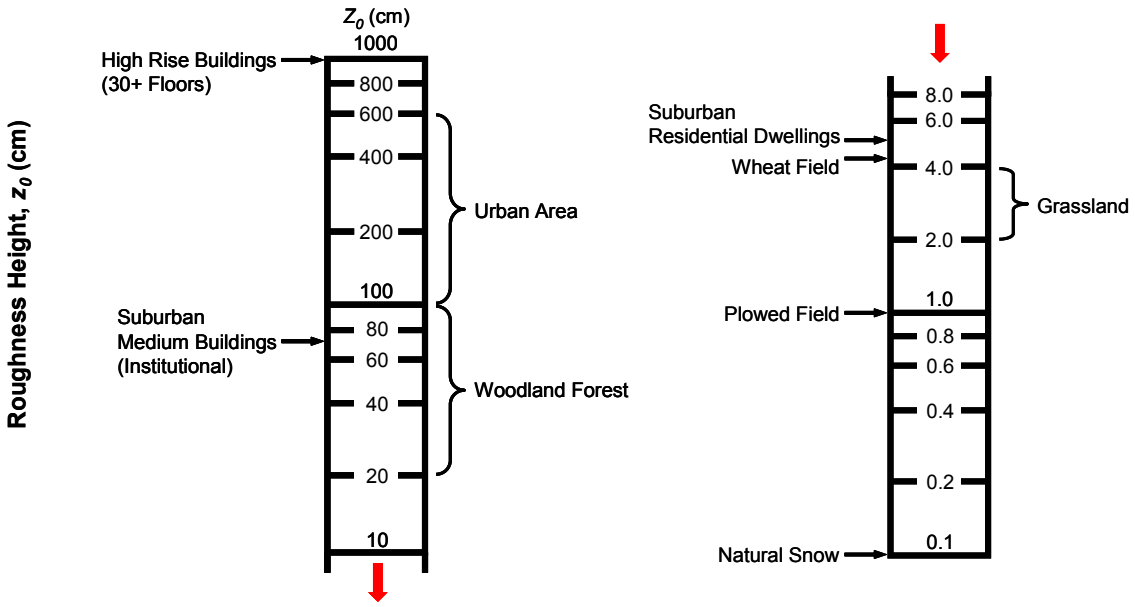


Figure 3-29 Approximate surface roughness lengths (z_0) for various surfaces (from Figure 7.3 in Whelan et al., 1987)

Figure 3-29 suggests that a roughness length greater than 3 cm, at least 5 cm and possibly as much as 1000 cm, is more likely typical of populated areas. Surface roughness principally affects vertical dispersion and thus σ_z values. The following formula (AMS, 1977) can be used to correct Pasquill-Gifford values of $\sigma_{z,P-G}$, which are appropriate for $z_{0,P-G}$ = 3 cm, for the effects of smoother or rougher surfaces:

$$\sigma_{z,r} = \sigma_{z,P-G}\left[\frac{z_0}{z_{0,P-G}}\right]^{0.2} \qquad \textbf{(3-7)}$$

Where the subscript *P–G* refers to the Pasquill-Gifford formulation for dispersion parameters and subscript r refers to the scaled dispersion accounting for the actual surface roughness, z_0.

Dispersion Function Parameters

The MACCS power-law functions for σ_y and σ_z have the form:

$$\sigma_{yi} = a_i \cdot (x/x_0)^{b_i}$$
$$\sigma_{zi} = c_i \cdot (x/x_0)^{d_i} \qquad \textbf{(3-8)}$$

Where

σ_{yi} = lateral (crosswind) dispersion parameter for stability class, *i*. This parameter is the standard deviation of a Gaussian distribution (m).

σ_{zi} = vertical dispersion parameter for stability class, *i*. This parameter is the standard deviation of a Gaussian distribution (m).

x = downwind distance (m)

a_i, b_i = linear and exponential coefficients in the power-law expressions for crosswind dispersion. Subscript, *i*, represents stability class. Units for these coefficients are m and dimensionless, respectively.

c_i, d_i = linear and exponential coefficients in the power-law expressions for vertical dispersion. Subscript, *i*, represents stability class. Units for these coefficients are m and dimensionless, respectively.

x_0 = unit of length, 1 m

The user should ensure that the categorization scheme used to define the stability classes for the meteorology is consistent with the values of the dispersion coefficients.

Lookup-Table Parameters

The lookup-table option allows the user to define a lookup table in place of power-law functions for σ_y and σ_z. This code option uses an interpolation algorithm that avoids the numerical instabilities observed with cubic spline fits. The calculational approach uses a Hermite cubic approach from Kahaner, Moler, and Nash (1989). This lookup-table algorithm can be used to implement alternative dispersion parameterizations or to use fits to site-specific tracer data.

This feature was implemented to allow the use of parameterizations other than simple power laws (*e.g.,* the Briggs formulas). Also, if tracer experiments are available for a site, it may be possible to process the data into tables of horizontal and vertical standard deviations (σ_y and σ_z). A caution to the user is that the algorithms associated with the lookup tables do not allow for extrapolation, either to smaller values than the first entry or to larger values than the last entry in the table. If, for example, the initial value of one of the dispersion parameters is smaller than the first value in the table for a specific stability class, the initial value in the table is used. If a larger value of the dispersion parameter is needed than the final value in the table for a specific stability class, the dispersion parameter is held fixed until the stability class changes.

Time-Based Dispersion

A time-based dispersion model can be enabled as an option. This is done on the *Transport* tab on the *Properties* form.

Hanna (2002) recommends that plume dispersion beyond 30 km be based on time, not on distance. This model allows the user to implement Hanna's recommendation. The basis for the recommended distance, 30 km, is that nearly all measurements upon which dispersion tables are based have a limit of about 30 km. The time-based dispersion model is closer to the treatment used in some Gaussian puff codes. In the MACCS implementation, the user must select the downwind distance at which the code switches from distance-based dispersion to time-based dispersion. The user must also select a linear coefficient for the time-based dispersion model. Hanna recommends a value of 0.5 m/s, which is used as a default (see Bixler et al., 2020, for more information). The virtual source concept is used to ensure that there is no discontinuity in switching from distance-based to time-based dispersion. The following equation describes the time-based model:

$$\sigma_y = \begin{cases} a\left(\frac{x}{x_0}\right)^b & x < x_c \\ a_c t & x \geq x_c \end{cases} \quad \textbf{(3-9)}$$

Where

σ_y = Value of crosswind dispersion (m)

a = Linear coefficient for distance-based, crosswind dispersion (m). The subscript i is omitted but it is implied that the coefficient is for a specific stability class.

x = Downwind distance from the virtual source (m)

b = Exponential parameter for distance-based, crosswind dispersion (dimensionless). The subscript i is omitted but it is implied that the coefficient is for a specific stability class.

x_c = Distance from the source (m) at which dispersion model switches from distance- to time-based (CYDIST in MACCS)

a_c = Linear coefficient for time-based, crosswind dispersion (m/s) (CYCOEF in MACCS)

t = Time since the plume was released from the virtual source (s)

When the time-based dispersion model is enabled, time-based dispersion is implemented at distances greater than or equal to x_c in Equation (3-3). However, distance-based dispersion is always applied within the first ring, regardless of the value of CYDIST. Either a power-law function, as illustrated in Equation (3-3), or a lookup table can be used to define the dependence of dispersion on downwind distance at distances less than CYDIST.

3.2.5.2 Dispersion Forms and Parameters

***Dispersion Function* Form**

The *Dispersion Function* form is required when the user selects *Power Law Functions* on the *Transport tab*. Values entered on this form correspond to the parameters used to calculate dispersion when using the six Pasquill–Gifford stability classes (classes A through F). The user must supply six values for each parameter defined on this form, one value for each stability class in the order A through F.

CYSIGA is the linear coefficient of the expression for σ_y.

CYSIGB is the exponential coefficient of the expression for σ_y.

CZSIGA is the linear coefficient of the expression for σ_z.

CZSIGB is the exponential coefficient of the expression for σ_z.

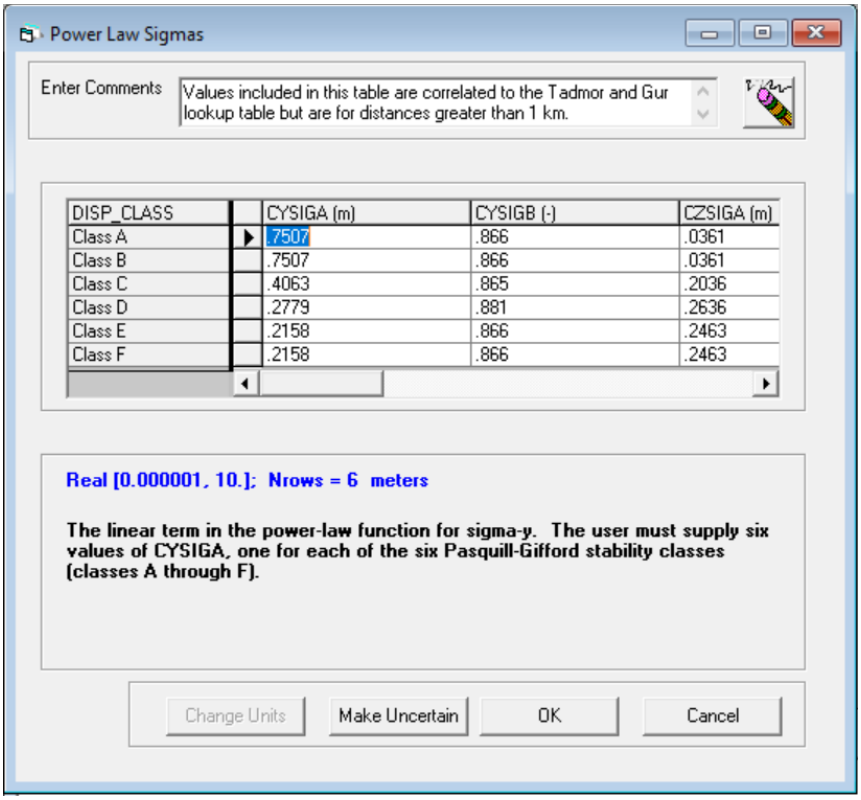


Figure 3-30 Power Law Sigmas Form

Table 3-23 Dispersion Function Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
CYSIGA	Yes	Real	6	1×10^{-6} to 10.0 m
CYSIGB	Yes	Real	6	1×10^{-6} to 10.0
CZSIGA	Yes	Real	6	1×10^{-6} to 10.0 m
CZSIGB	Yes	Real	6	1×10^{-6} to 10.0

Dispersion Table Form

The *Dispersion Table* form is required when the user selects *Lookup Tables* on the *Transport* tab. NUM_DIST is the number of distances in the lookup table and its value is determined by the number of rows entered in the grid containing the dispersion table. DISTANCE is the set of downwind distances corresponding to sigma-y and sigma-z values. Distances must be monotonically increasing. SIGMA_Y and SIGMA_Z values need to be provided on this form for each stability class, A, B, C, D, E, and F, and these values must be monotonically increasing.

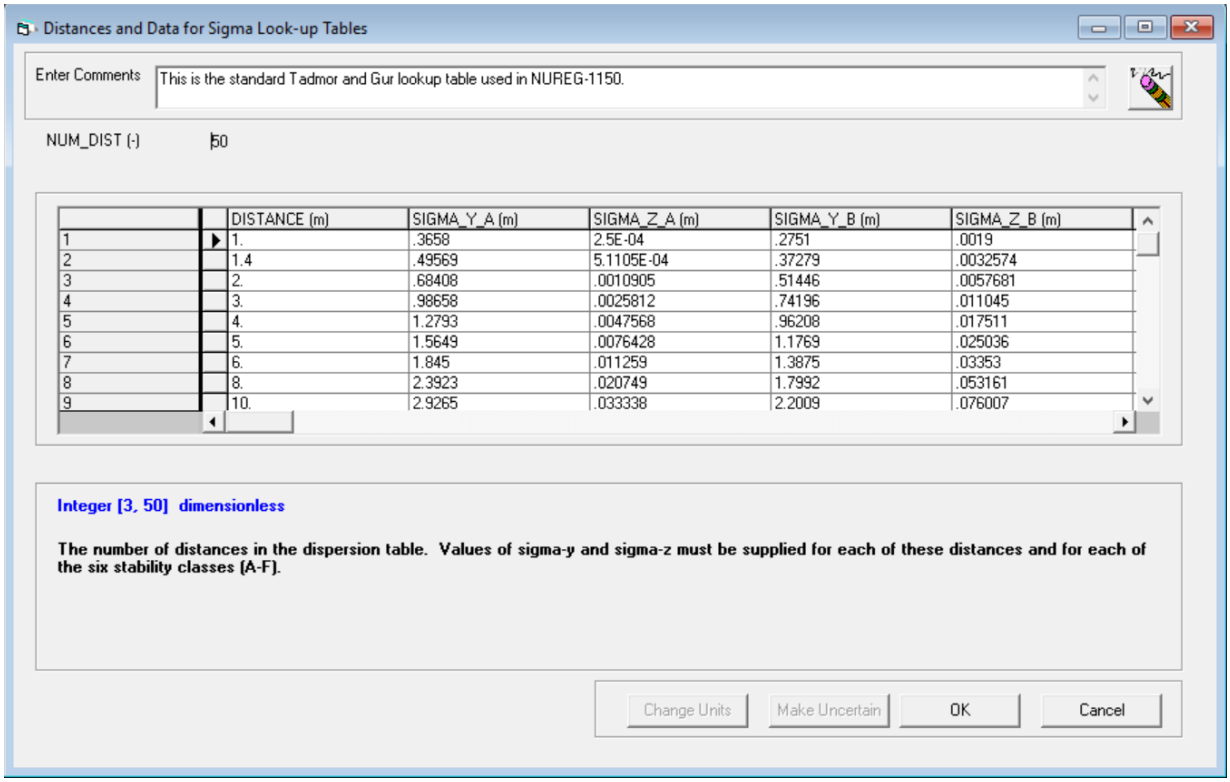


Figure 3-31 Dispersion Table Form

Table 3-24 Dispersion Table Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM_DIST	Linked	Integer	None	3 to 50
DISTANCE	Yes	Real	NUM_DIST	1.0 to 1×10^{8} m
SIGMA_Y_A	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Z_A	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Y_B	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Z_B	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Y_C	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Z_C	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Y_D	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Z_D	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Y_E	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Z_E	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Y_F	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m
SIGMA_Z_F	Yes	Real	NUM_DIST	1×10^{-6} to 1×10^{20} m

Scaling Factors

MACCS allows linear scaling of σ_y and σ_z by means of the input parameters, YSCALE and ZSCALE. These scaling factors are used to multiply the values of σ_y and σ_z that have been defined for each of the six stability classes. YSCALE is the linear scaling factor that is applied to the formula for σ_y. This modifies all the calculated σ_y values by a constant multiplicative factor for either the power-law or lookup-table options. YSCALE is normally set to 1.0. ZSCALE is the linear scaling factor that is applied to the formula for σ_z. It is commonly used to account for surface roughness. This factor modifies all the σ_z values by a constant multiplicative factor for either the power-law or lookup-table options. ZSCALE is normally set to a value greater than 1.0.

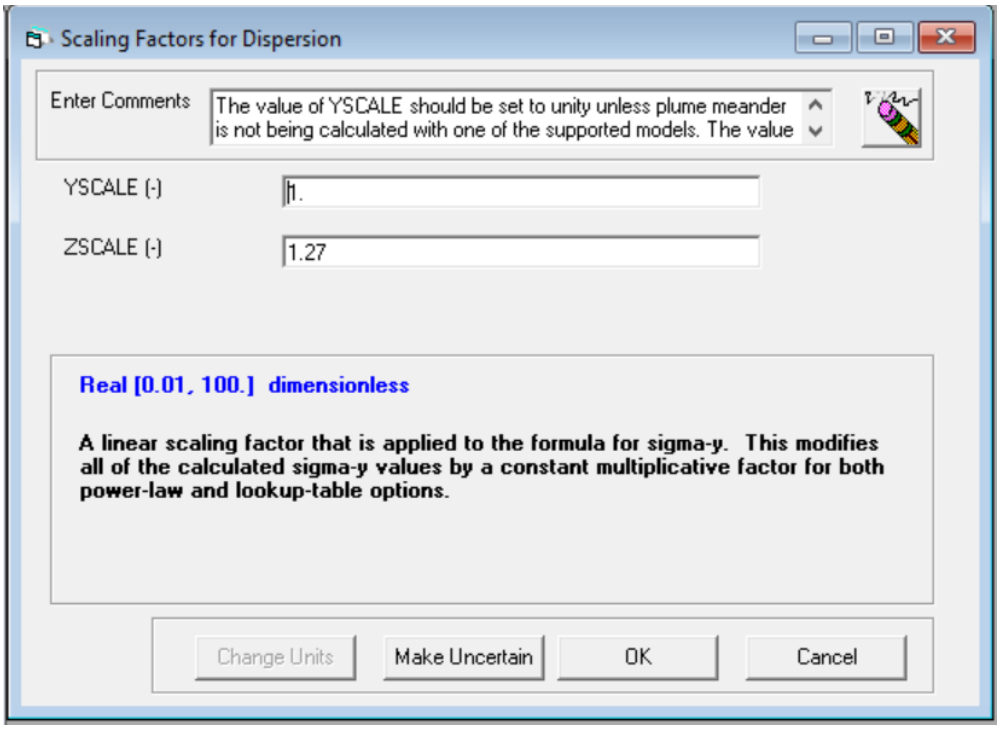


Figure 3-32 Scaling Factors Form

Table 3-25 Scaling Factors Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
YSCALE	Yes	Real	None	0.01 to 100.0
ZSCALE	Yes	Real	None	0.01 to 100.0

Long-Range Parameters

The *Long-Range Parameters* form is required when the user selects the option, *Switch to Time-Based Dispersion Model at User-Specified Distance*, on the *Transport tab*. CYDIST is the distance for switching from distance-based to time-based crosswind dispersion model. The distance-based dispersion model is always used within the first radial interval. The default value for this parameter is 30,000 m (see Bixler et al., 2020, for more discussion). CYCOEF is the linear coefficient for the time-based, crosswind dispersion model. The default value for this parameter is 0.5 m/s. Both default values are based on a recommendation by Hanna (2002).

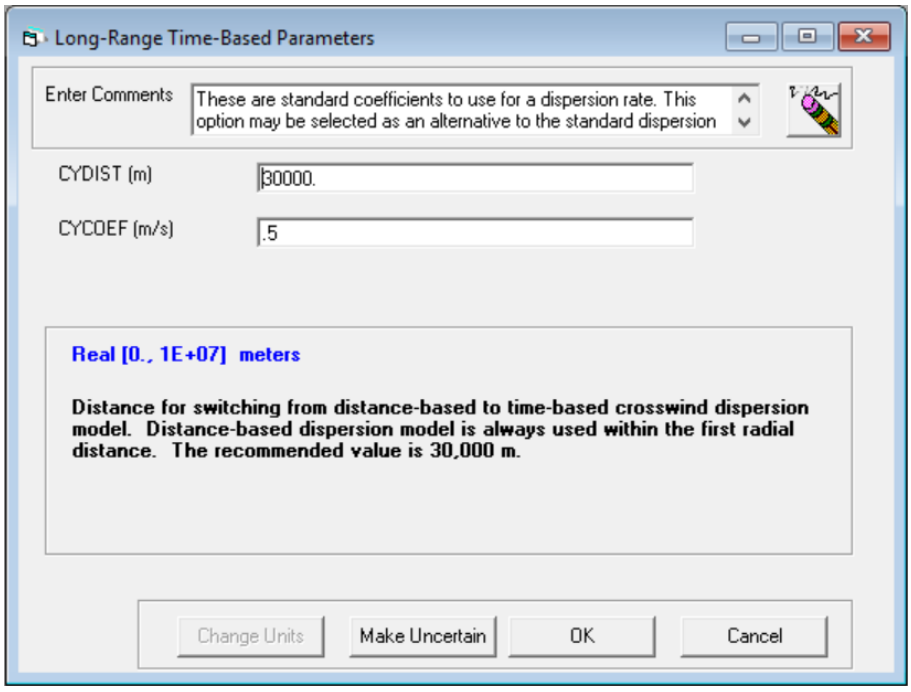


Figure 3-33 Long-Range Parameters Form

Table 3-26 Long Range Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
CYDIST	Yes	Real	None	0.0 to 1×10^{7} m
CYCOEF	Yes	Real	None	1×10^{-6} to 2.0 m/s

3.2.6 Multi-Source Option

3.2.6.1 Multi-Source Model Description

MelMACCS is the interface tool that allows MELCOR plot files to be post-processed to create MACCS source term data that can be imported directly into WinMACCS using the *Import MACCS Input File* option discussed in Section 4. In the past, the process has only been able to address single-unit source terms. Starting with WinMACCS 3.10, there is the capability to merge several source terms to create a multi-unit source term. Furthermore, MELCOR and MelMACCS have been modified to create multiple source terms from a single MELCOR plot file, provided this feature is activated in the MELCOR input. This feature allows the user to create a source term file for each ring in the MELCOR analysis. Multiple rings are generally used in MELCOR analyses to define annular portions of the reactor core in a polar coordinate system. Similarly, rings in the MELCOR analysis of a spent fuel pool are generally used to represent different regions of the fuel. This feature is especially advantageous for analyses of spent fuel pools, where each spent-fuel ring can represent a different age of spent fuel. This allows different ages of fuel to be assigned different isotopic inventories in performing the MACCS analysis. MelMACCS 2.0 (and later) is compatible with the multi-source model and allows the user to assign an inventory for a selected ring. One source term file is created for each ring processed by the user.

Source term files can be merged to create a multi-unit source term, as described subsequently in this section. Details of how to use MelMACCS are provided in Appendix A. Details of how to use the multi-source model is provided in Section 4.4.10.

3.2.6.2 Multi-Source Forms and Parameters

Chemical Names Form

The values on this form are read from the multi-source files and are not changeable.

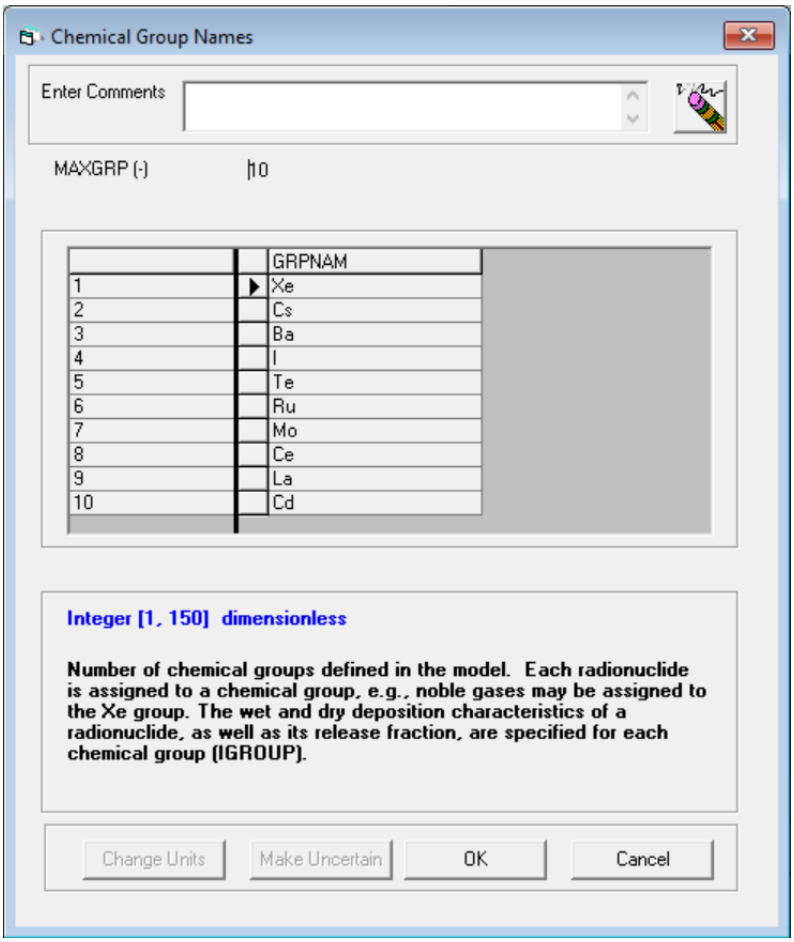


Figure 3-34 Chemical Names Form

Table 3-27 Chemical Names Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
MAXGRP	No	Integer	None	1 to 150
GRPNAM	No	Character	MAXGRP	1 to 15 characters

Radionuclides Form

The values on this form are read from the multi-source files and are not changeable.

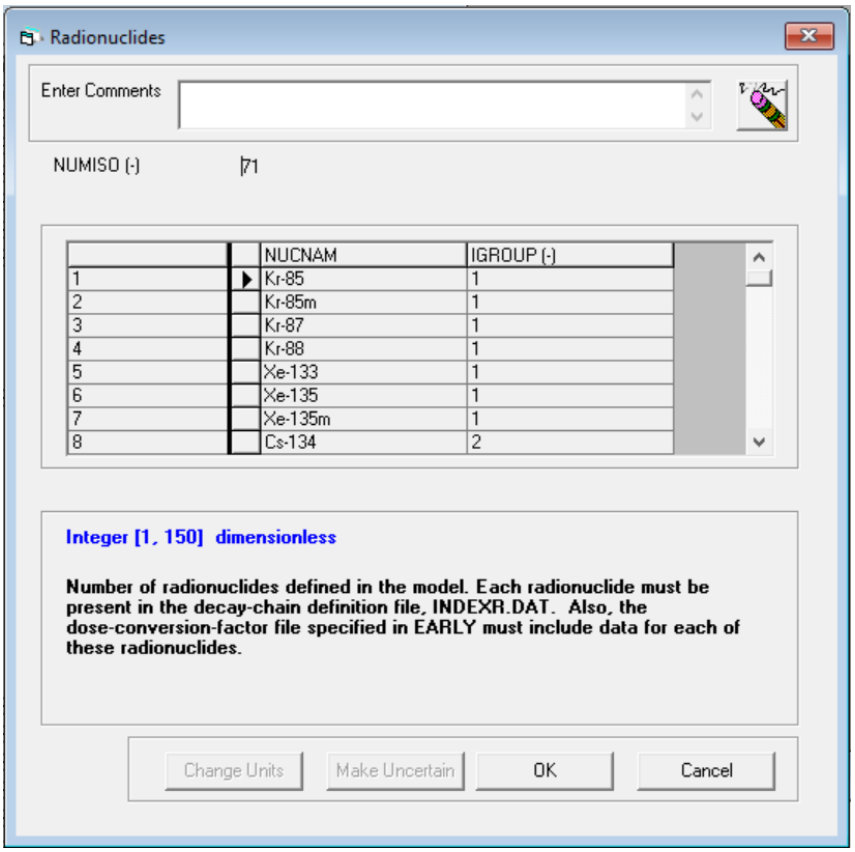


Figure 3-35 Radionuclides Form

Table 3-28 Radionuclides Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMISO	No	Integer	None	1 to 150
NUCNAM	No	Character	NUMISO	3 to 8 characters
IGROUP	No	Integer	NUMISO	1 to MAXGRP

Plume Segments Form

The values on this form are read from the multi-source files and are not changeable. Each row in the grid identifies a plume segment that is defined on one of the multi-source files.

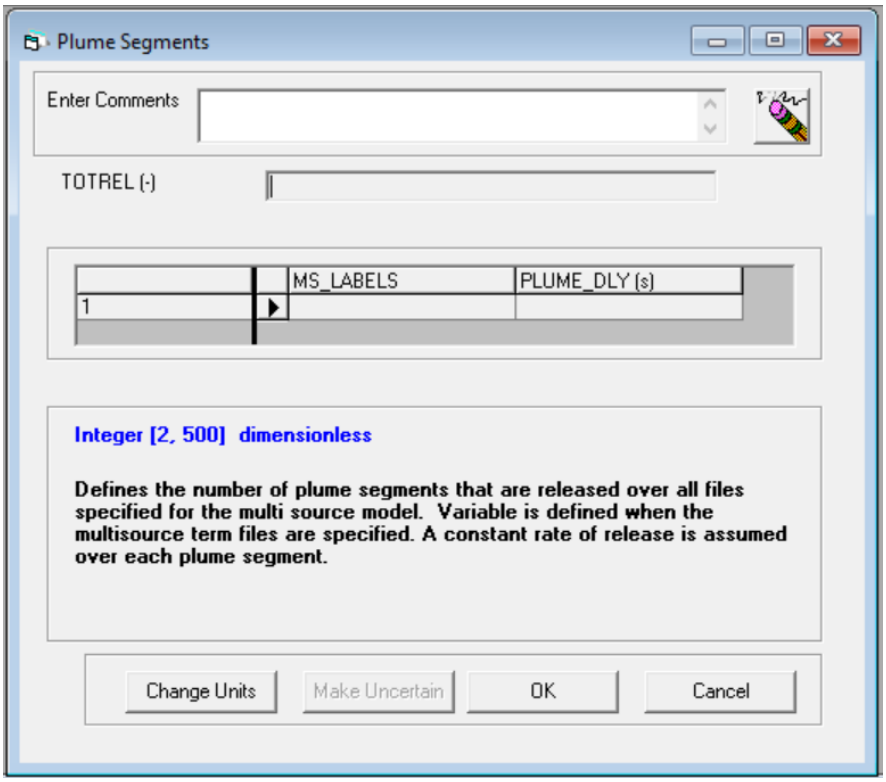


Figure 3-36 Plume Segments Form

Table 3-29 Plume Segments Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
TOTREL	No	Integer	None	2 to 9999
MS_LABELS	No	Character	TOTREL	1 to 255 characters
PLUME_DLY	No	Integer	TOTREL	0 to 2.592×10^6 s (30 days)

Time Offsets Form

A time offset can be associated with each of the multi-source files to account for different accident initiation times for each of the sources. Time offsets define the times associated with the inventories in each of the files. This information allows MACCS to adjust its calculation of radioactive decay for each unit or source.

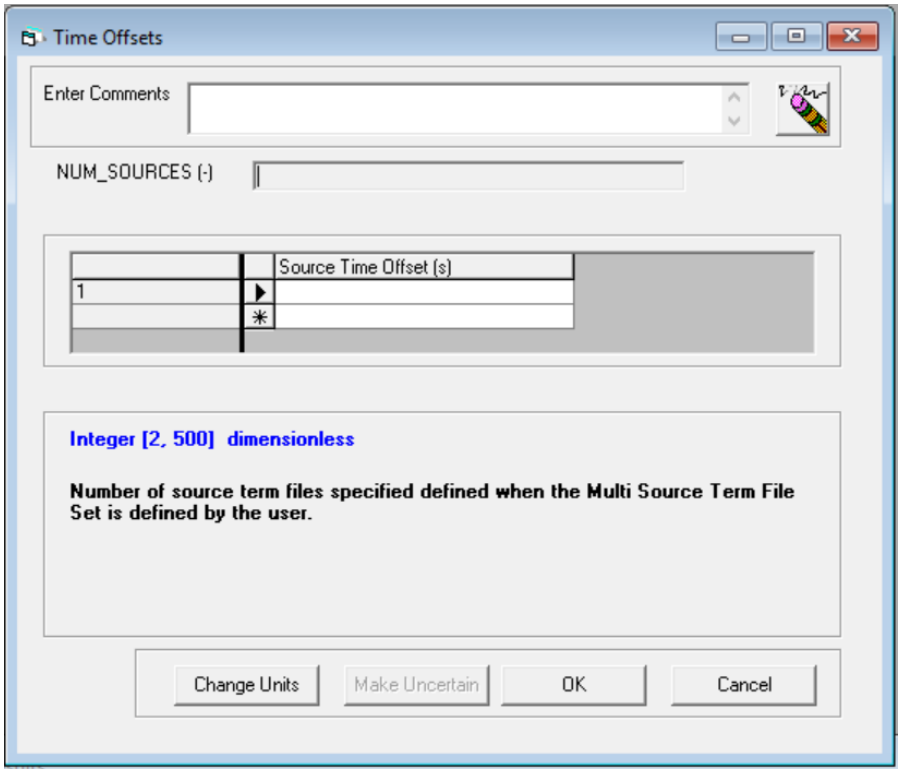


Figure 3-37 Time Offsets Form

Table 3-30 Time Offsets Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM_SOURCES	No	Integer	None	2 to 500
Source Time Offset	Yes	Real	NUM_SOURCES	0 to 2.592×10^6 s (30 days)

Number of MS Simulation Form

Multiple multi-source simulations may be run, where each simulation may use a different set of multi-source files. The number of simulations are specified on this form.

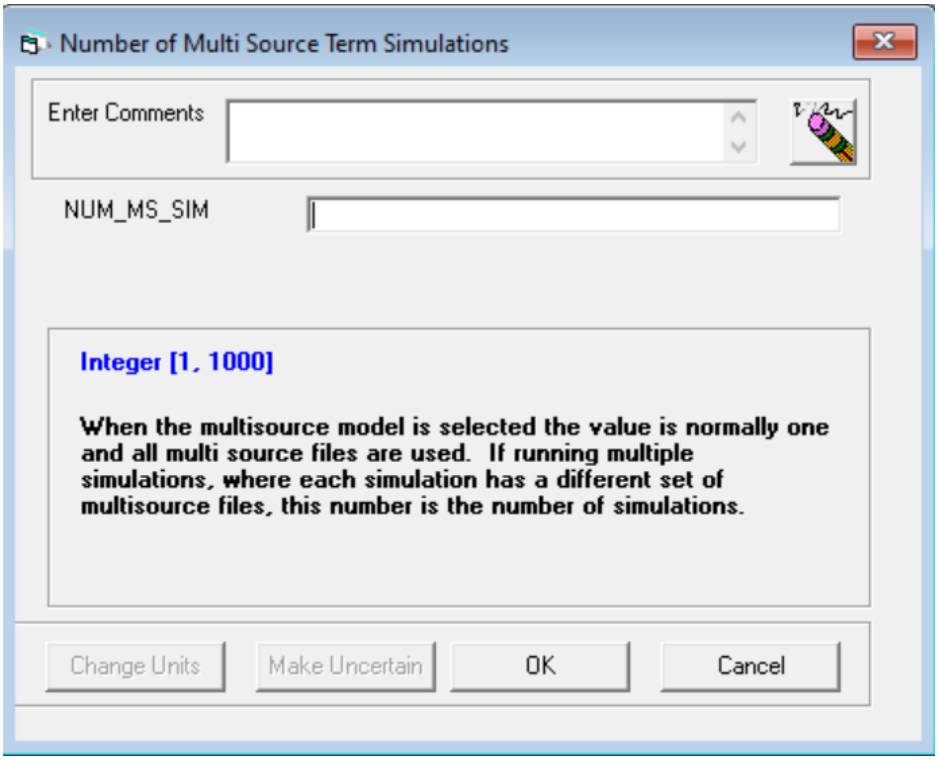


Figure 3-38 Number of Multi-Source Term Simulations Form

Table 3-31 Number of Multi-Source Term Simulations Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM_MS_SIM	Yes	Integer	None	1 to 1000

Files for Multiple Simulations Form

When multiple simulations are run, the user may select which source term files are used for each simulation.

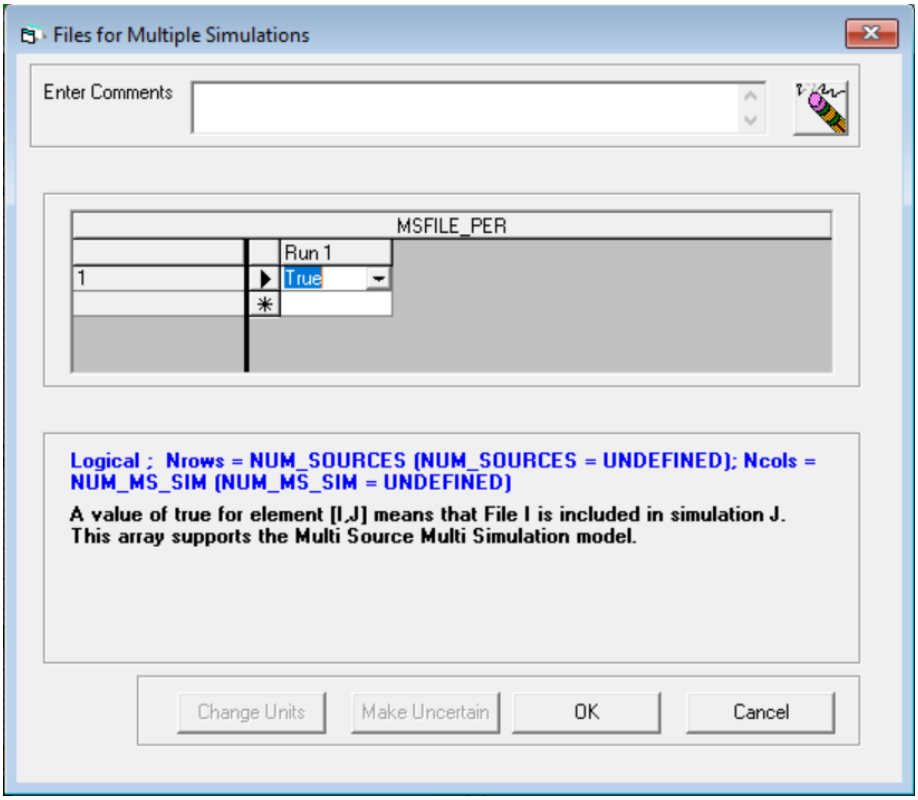


Figure 3-39 Files for Multiple Simulations Form

Table 3-32 Files for Multiple Simulations Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
MSFILE_PER	Yes	Logical	NUM_SOURCES x NUM_MS_SIM	True, False

Time Offsets for Multiple Simulations

When multiple simulations are run, the user may specify time offsets between each source term file used in each simulation.

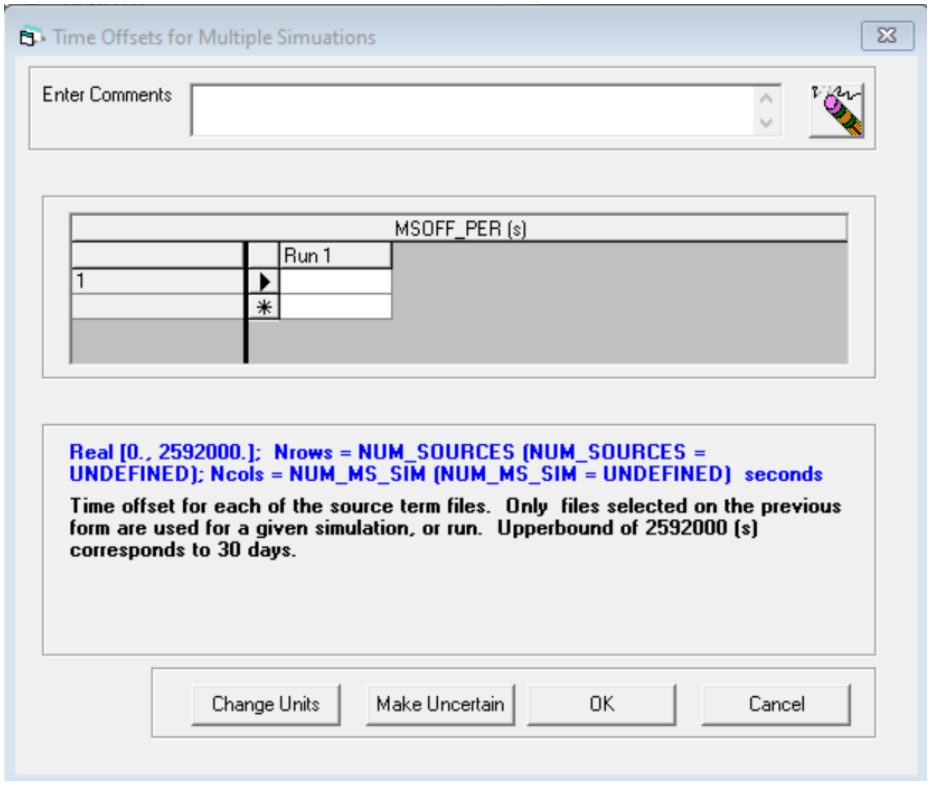


Figure 3-40 Time Offsets for Multiple Simulations Form

Table 3-33 Time Offsets for Multiple Simulations Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
MSOFF_PER	Yes	Real	NUM_SOURCES x NUM_MS_SIM	0 to 2.592×10^6 s (30 days)

3.2.7 HYSPLIT Transport

3.2.7.1 HYSPLIT Model Description

HYSPLIT is a Lagrangian particle tracking atmospheric transport and dispersion code developed by NOAA, which has been coupled to MACCS starting in version 4.0. The details of this model implementation are covered in *Instructions and Sample Problems for using the MACCS/HYSPLIT Capability*, which is provided to MACCS 4.0 users upon request.

A high-level overview of the process is as follows:

- Meteorological files and the HYSPLIT executable plus supporting software are first downloaded. This process is detailed in a separate document organized as a tutorial, *Sample Problem for Generating HYSPLIT Files for MACCS*.

- WinMACCS utilities are used to convert the HYSPLIT output files to files compatible with the spatial grid defined in the WinMACCS project. Details are documented in a separate document, *Using the HYSPLIT Model with WinMACCS.*

- Once these files are created either outside of WinMACCS or using the *Preprocessing/Create MACCS-HYSPLIT files* from the WinMACCS main menu, they are linked to the WinMACCS project by completing the form *GENERAL/File Specifications/HYSPLIT Converted Folder*.

3.2.7.2 HYSPLIT Forms and Parameters

File Extensions and Lower Bounds Form

When running the HYSPLIT model, users may specify up to ten HYSPLIT file sets using the *File Extensions and Lower Bounds* Form. For HY_PREFIX, prefixes are specified by either the release height (Hxxx, where height = xxx*10m) or the power level (Pxxx, where power = xxx*.01MW). HY_LOWER corresponds to the minimum height or power level associated with that file set.

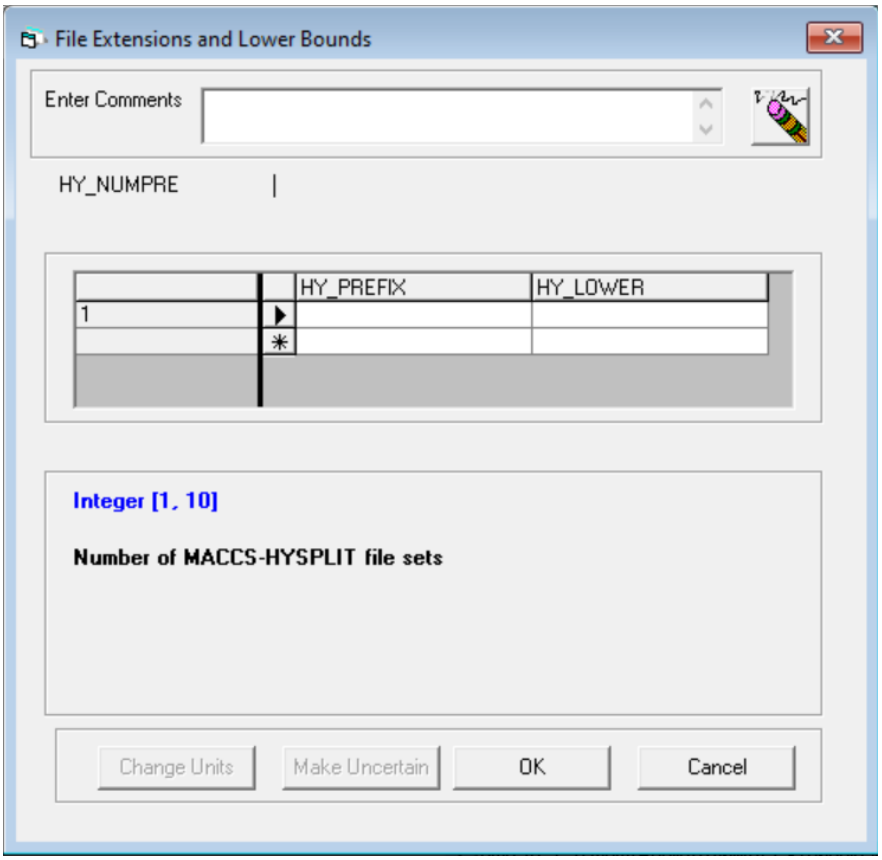


Figure 3-41 File Extensions and Lower Bounds Form

Table 3-34 File Extensions and Lower Bounds Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
HY_NUMPRE	Yes	Integer	None	1 to 10
HY_PREFIX	Yes	Character	HY_NUMPRE	Hxxx or Pxxx
HY_LOWER	Yes	Real	HY_NUMPRE	0 to $1x10^5$ m or MW

Fixed Start Time Form

The start time (date and hour) when the weather sequence begins is specified in the *HYSPLIT Fixed Start Time Data* Form. The starting date is specified by HY_FIXED in MM/DD/YYYY format, and the starting hour is specified by an integer, HY_HOUR, which can be 1 to 24.

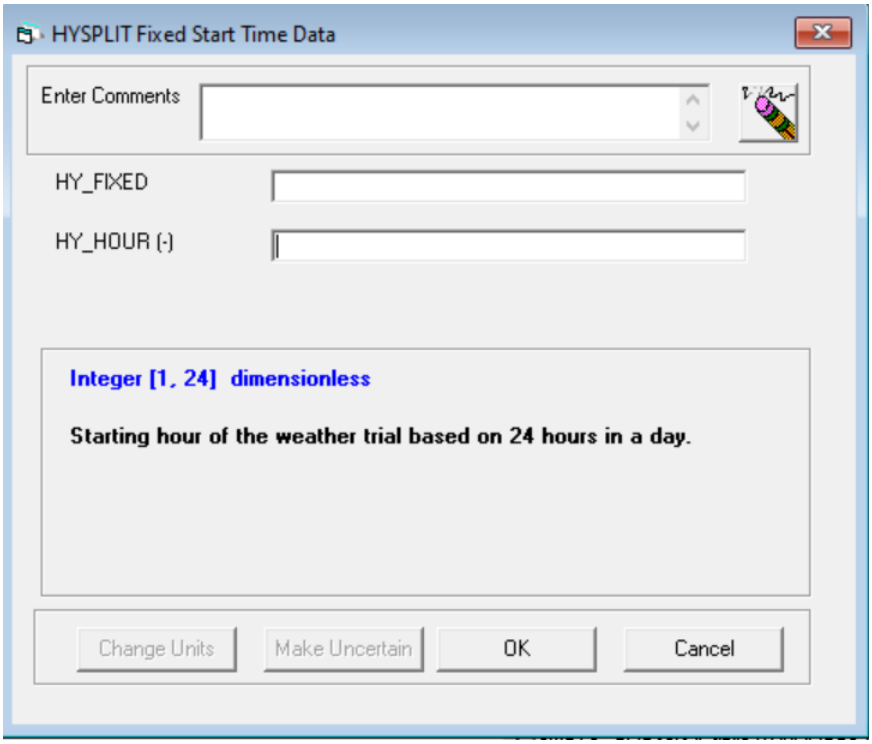


Figure 3-42 HYSPLIT Fixed Start Time Data Form

Table 3-35 HYSPLIT Fixed Start Time Data Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
HY_FIXED	Yes	Character	1	MM/DD/YYYY format
HY_HOUR	Yes	Integer	1	1 to 24 hrs

Transport Dates

The transport start and end dates are specified in the *HYSPLIT Transport Dates* Form. The starting date is specified by HY_START and the ending date is specified by HY_END. Both are in MM/DD/YYYY format.

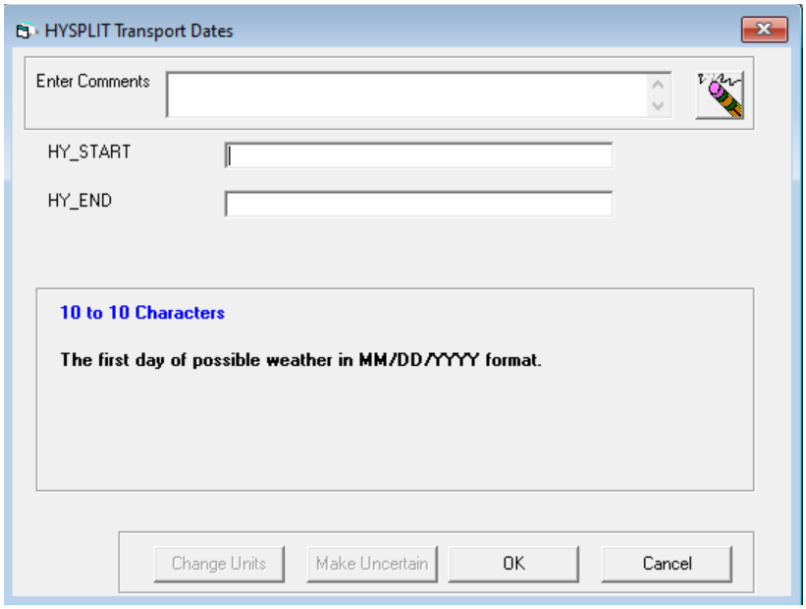


Figure 3-43 HYSPLIT Transport Dates Form

Table 3-36 HYSPLIT Transport Dates Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
HY_START	Yes	Character	None	MM/DD/YYYY format
HY_END	Yes	Character	None	MM/DD/YYYY format

Extended Time

Users may specify time before the start time and time after the end time. This extended time is specified in the *Extended Time* Form.

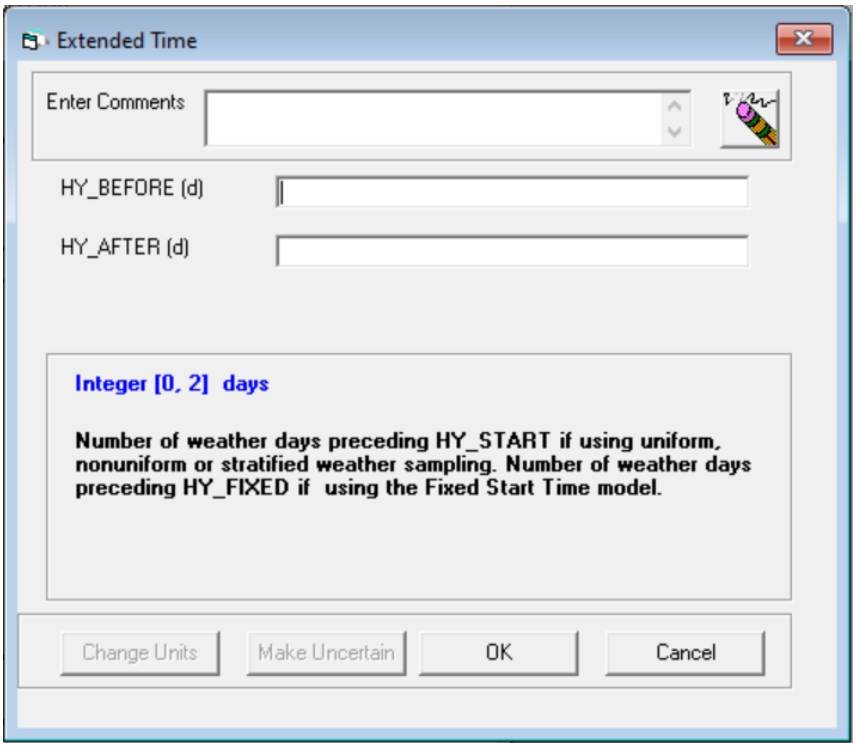


Figure 3-44 Extended Time Form

Table 3-37 Extended Time Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
HY_BEFORE	Yes	Integer	None	0 to 2 days
HY_AFTER	Yes	Integer	None	0 to 40 days

Building Height

Building height defines the height of the facility building and is used to determine whether a buoyant plume is entrained in the turbulent wake of the building. A value is specified for each release in the *HYSPLIT Building Height* Form.

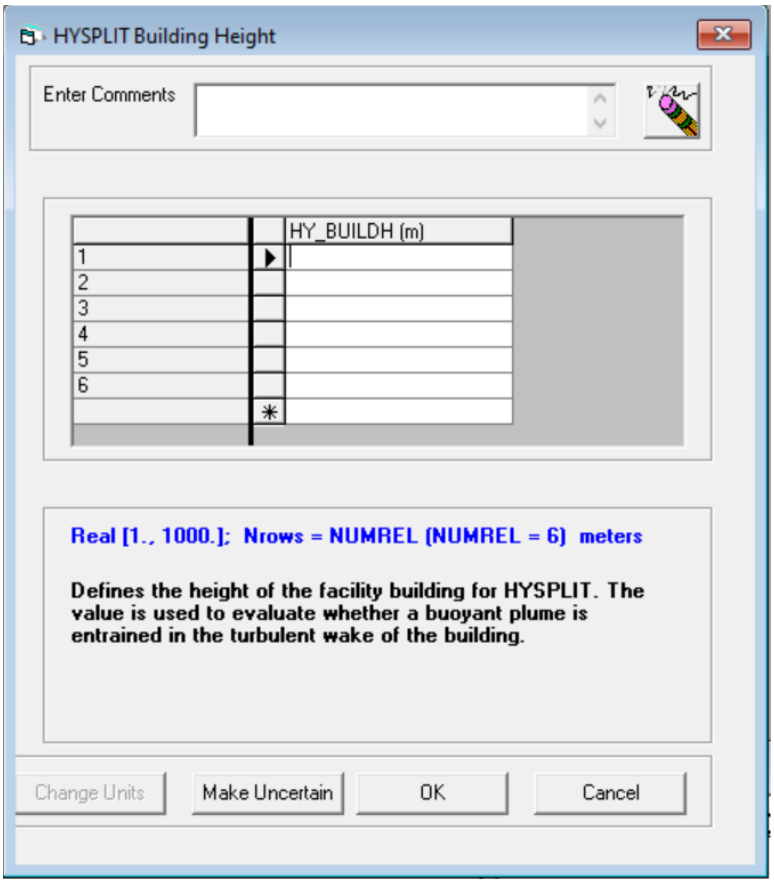


Figure 3-45 HYSPLIT Building Height Form

Table 3-38 HYSPLIT Building Height Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
HY_BUILDH	Yes	Real	NUMREL	1 to 1000 meters

3.2.8 Plume Specification

3.2.8.1 Plume Meander Model Descriptions

WinMACCS version 4.0 allows three choices for plume meander model on the *Transport tab* shown in Figure 3-6. Namely, the original MACCS model, a model based on Reg Guide 1.145 (NRC, 1983a), and an option to turn off plume meander. Plume meander accounts for the tendency of wind direction to vary over time. The amount of plume meander depends on wind speed, stability class, and the observation period. For the purposes of MACCS, observation period generally translates to the duration of release for a plume segment.

Original MACCS Plume Meander Option

The original MACCS model accounts for the effect of meander during transport of a plume segment by using a meander factor. This factor, f_m, serves to broaden the plumes in the cross-wind dimension. It acts as a linear factor on σ_y, which affects the calculation of χ/Q. The expansion factor is defined as follows:

$$
\begin{aligned}
f_m &= 1 && \Delta t_{release} \le \Delta t_0 \\
f_m &= (\Delta t_{release}/\Delta t_0)^{F_1} \quad \text{if} && \Delta t_0 < \Delta t_{release} \le \Delta t_1 \\
f_m &= (\Delta t_{release}/\Delta t_0)^{F_2} && \Delta t_1 < \Delta t_{release} \le 10
\end{aligned}
\qquad \textbf{(3-10)}
$$

Where

$\Delta t_{release}$	=	release duration for the plume segment (s)
Δt_0	=	release duration for the P–G data (s), which was 600 s
Δt_1	=	breakpoint in release duration (s), usually chosen to be 3600 s (the default value)
F_1	=	exponent for time dependence below the breakpoint (dimensionless), usually chosen to be 0.2 (the default value)
F_2	=	exponent for time dependence above the breakpoint (dimensionless), usually chosen to be 0.25 (the default value)

Bixler et al. (2020) provides more discussion on dispersion modeling and related recommendations. The duration of each plume segment should be limited to 10 hours when using this meander model because the formula is not intended to be used above that value. If a plume segment exceeds 10 hours, a nonfatal warning is given in the output file and the expansion factor is calculated as though the plume duration were 10 hours.

Plume Meander Model Based on *U.S. NRC Regulatory Guide 1.145*

MACCS now contains a plume meander model based on Regulatory Guide 1.145 (NRC, 1983a) and supporting document NUREG/CR-2260. The Regulatory Guide 1.145 plume meander model differs from the original model in MACCS in that it accounts for the effects of wind speed and stability class. The original model in MACCS accounts for the duration of the release; the new model is calibrated for 1-hour release durations. The plume meander model described below would lead to an over prediction of peak doses for release durations significantly longer than 1 hour; it would under predict peak doses for release durations that are significantly shorter than 1 hour. Enforcement of this model restriction is left to the user; WinMACCS and MACCS do not restrict the duration of plume segments to be approximately 1 hour when this model is selected. The MACCS implementation of the Reg. Guide 1.145 plume meander model treats plume meander in a similar manner as an area source. The meander occurs in the first 800 m downwind, creating a broader plume at that distance. Beyond 800 m, the plume gradually approaches the size that it would have had if meander had not occurred, just like the effect of an area source.

The plume meander model in Regulatory Guide 1.145 is described as follows:

$$\sigma_{ym} = f_m \cdot \sigma_y(x) \qquad \textbf{(3-11)}$$

Where

$\sigma_y(x)$	=	lateral dispersion not accounting for plume meander (m)
f_m	=	meander factor (dimensionless)
σ_{ym}	=	lateral dispersion accounting for plume meander (m)
x	=	downwind distance measured from the virtual source (m)

Lateral dispersion, σ_y, can be defined in terms of a power-law equation or as a look-up table. The meander factor is defined as follows:

$$f_m = m \cdot f(u) \quad \textbf{(3-12)}$$

Where

m	=	1.0 for stability classes A through C 2.0 for stability class D 3.0 for stability class E 4.0 for stability class F
$f(u)$	=	a function of wind speed and is defined in Equation (3-13) below
u	=	wind speed (m/s)

$$f(u) = 1 \quad u \le 2$$
$$f(u) = \frac{1}{m} * \exp\left[\left(1 - \frac{\ln(u) - \ln(2)}{\ln(6) - \ln(2)}\right) * \ln(m)\right] \quad 2 < u \le 6$$
$$f(u) = 1/m \quad 6 < u \quad \textbf{(3-13)}$$

The above equations are valid for distances within 800 m of the source. Beyond 800 m downwind, Equation (3-11) is modified as follows:

$$\sigma_{ym} = (f_m - 1) \cdot \sigma_y(800) + \sigma_y(x) \quad \textbf{(3-14)}$$

The MACCS model is like the model described above except that it is more general and uses a different approach at distances greater than *D* (*D* = 800 m in Equation (3-14)). The equations used in MACCS are as follows:

$$f(u) = 1 \quad u \le u_1$$
$$f(u) = \frac{1}{m} * \exp\left[\left(1 - \frac{\ln(u) - \ln(u_1)}{\ln(u_2) - \ln(u_1)}\right) * \ln(m)\right] \quad u_1 < u \le u_2$$
$$f(u) = 1/m \quad u_2 < u \quad \textbf{(3-15)}$$

D is the location beyond which the plume meander factor is no longer used. At this distance, the location of the virtual source is adjusted to ensure continuity in the value of σ_{ym}. Beyond MNDIST (the MACCS name corresponding to D), the meander factor is set to unity and the effect of the plume meander is treated in just the same way as an area source (i.e., by using an appropriate value for the virtual source location).

The MACCS plume meander model closely matches the Reg. Guide 1.145 model when [MNDFAC(i)] = [1, 1, 1, 2, 3, 4], WINSP1 = 2 m/s, WINSP2 = 6 m/s, and MNDIST = 800 m. These are the default values, as discussed in Bixler et al. (2020).

3.2.8.2 Plume Forms and Parameters

Original Meander Form

The *Original Meander* form is required when the user selects *Original MACCS (MNDMOD=OLD)* in the *Select Plume Meander Model* group on the *Transport tab*. TIMBAS is the release duration associated with the Prairie Grass tests upon which the Pasquill-Gifford dispersion curves are based. BRKPNT is the time breakpoint in the formula used to calculate the plume meander expansion factor. When the release duration is less than or equal to this value but greater than TIMBAS, the second formula is used in Equation (3-10). When the release duration exceeds the value of BRKPNT, the third expression is used in Equation (3-10). XPFAC1 is the exponential factor used to calculate the plume meander expansion factor for releases having durations that are less than or equal to BRKPNT. XPFAC2 is the exponential factor used in calculating the plume meander expansion factor for releases having durations that are greater than BRKPNT.

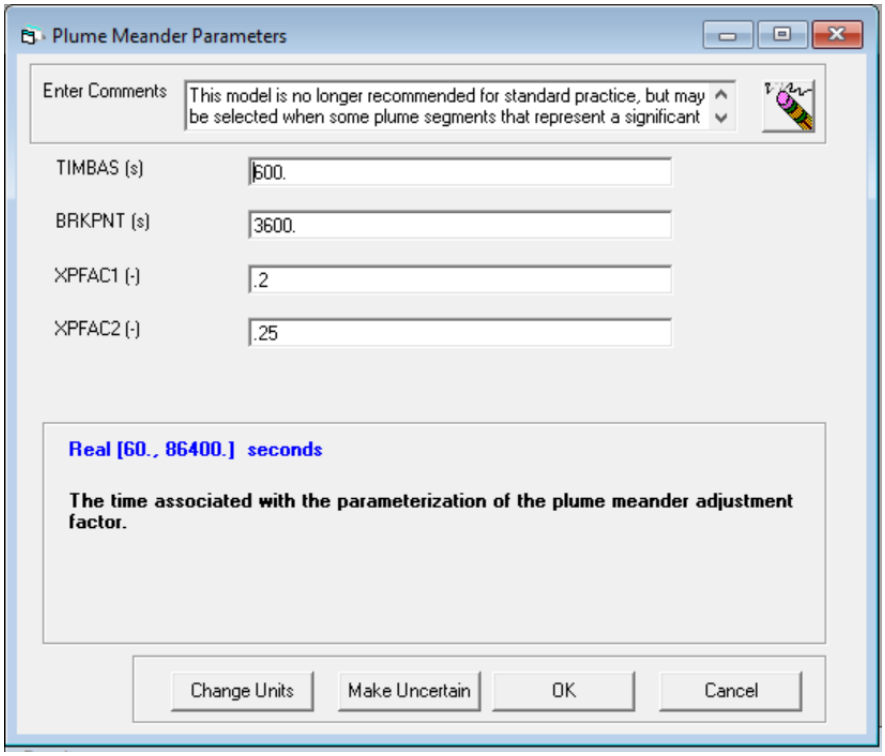


Figure 3-46 Plume Meander Form

Table 3-39 Plume Meander Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
TIMBAS	Yes	Real	None	60.0 to 86400.0 s
BRKPNT	Yes	Real	None	60.0 to 86400.0 s
XPFAC1	Yes	Real	None	0.01 to 1.0
XPFAC2	Yes	Real	None	0.01 to 1.0

US NRC Reg. Guide 1.145 Meander Form

The *U.S. NRC Reg. Guide Meander* form is required when the user selects U.S. NRC Regulatory Guide 1.145 (MNDMOD=NEW) in the Select Plume Meander Model group on the Transport tab.

WINSP1 is the wind speed where the meander factor changes from a constant value to a decreasing function of the wind speed. Meander factor decreases log-linearly from the value specified by MNDFAC(n) to one at WINSP2. The index n represents the atmospheric stability class.

WINSP2 is the wind speed where the meander factor reaches one for all stability classes. Meander factor decreases log-linearly from the value specified by MNDFAC(n) at WINSP1 to one at WINSP2. The index n represents the atmospheric stability class.

MNDIST is the downwind distance where the effect of meander begins to diminish. MNDIST is a breakpoint in the formula for calculating sigma-y.

MNDFAC is the plume meander factor used to calculate sigma-y described in the NRC Regulatory Guide 1.145. MNDFAC(1) corresponds to atmospheric stability class A, MNDFAC(2) to stability class B, and MNDFAC(6) to stability class F.

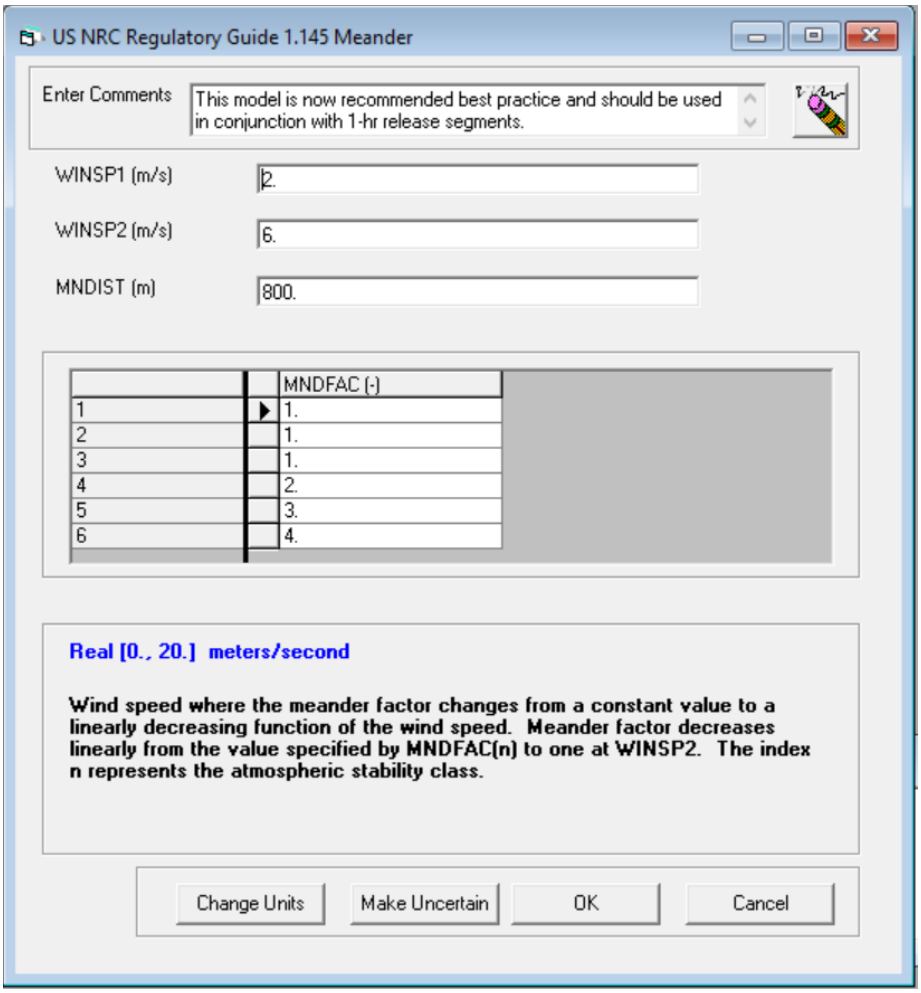


Figure 3-47 U.S. NRC Regulatory Guide 1.145 Meander Form

Table 3-40 U.S. NRC Regulatory Guide 1.145 Meander Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
WINSP1	Yes	Real	None	0.0 to 20.0 m/s
WINSP2	Yes	Real	None	0.0 to 20.0 m/s
MNDIST	Yes	Real	None	0.0 to 10,000.0 m
MNDFAC	Yes	Real	6	1.0 to 10.0

Plume Rise Scale Factor

SCLCRW is a linear scaling factor on the critical wind speed used to determine whether buoyant plumes are trapped in the turbulent wake of the facility building complex. Parameter values less than unity make plume rise less likely to occur because plume liftoff occurs only when the ambient wind speed at the time of release is less than the calculated critical wind speed; values greater than unity make plume rise more likely to occur.

SCLADP is the linear scaling factor on the plume rise formula used to determine the amount of plume rise that occurs when the atmosphere is unstable or neutrally stable (stability classes A through D).

SCLEFP is the linear scaling factor on the plume rise formula used to determine the amount of plume rise that occurs when atmospheric conditions are stable (stability classes E and F).

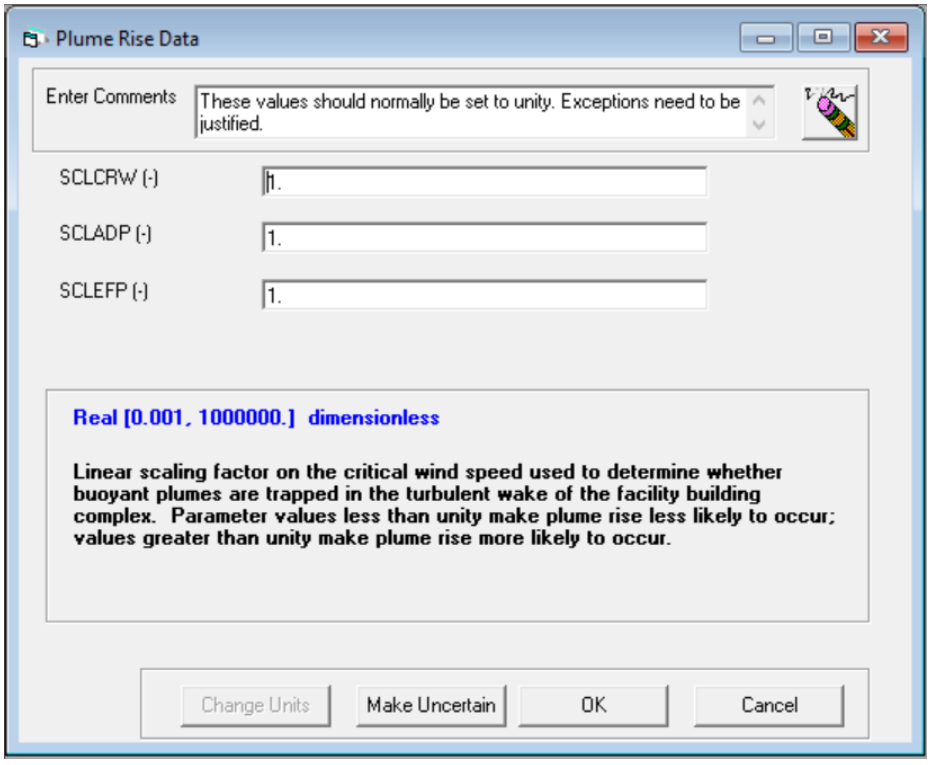


Figure 3-48 Plume Rise Scale Factor Form

Table 3-41 Plume Rise Scale Factor Parameters Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
SCLCRW	Yes	Real	None	0.001 to $1x10^6$
SCLADP	Yes	Real	None	0.01 to 100.0
SCLEFP	Yes	Real	None	0.01 to 100.0

3.2.9 Release Description

3.2.9.1 Release Model Description

Release Description

ATMOS can handle multiple plume segments to treat a source term that has a time-varying composition and release rate. The plume segments that describe a release can be separated with a time gap, can directly follow each other, or can overlap. Different release heights, heat contents, starting times, release durations, release fractions, and initial values for σ_y and σ_z can be assigned to each plume segment. Only one initial particle-size distribution can be assigned to each chemical group. Thus, the effective, initial, particle-size distribution can vary from one plume segment to another only as a function of the relative release fractions of the radionuclide classes. However, the aerosol size distribution of a plume segment changes with time (i.e., downwind location as the plume segment travels through the grid) when there are multiple particle sizes with different deposition velocities.

Initial Plume Dimensions

Mixing of the plume into the wake of a building from which a release occurs generally determines the initial dimensions of the plume. For the purpose of initializing plume dimensions, the common assumption is that the plume centerline is at ground level and in the middle of the downwind face of the building.

If plume concentrations at the sides and roofline of the building from which the release occurs are assumed to be 10% of plume centerline concentrations (building edges are 2.15 sigma from the plume centerline), initial values of the horizontal and vertical standard deviations of the Gaussian plume are given by

$$\sigma_y(x=0) = W_b / 4.3 = 0.23 W_b$$
$$\sigma_z(x=0) = H_b / 2.15 = 0.47 H_b \qquad \textbf{(3-16)}$$

Where

W_b = Width of the building from which release occurs (m)
H_b = Height of the building from which release occurs (m)

Choosing the height and, especially, the width of the building from which the release occurs is not always straightforward. In many cases, the reactor complex is comprised of a set of buildings, which may be connected or disconnected. The heights of the buildings in this complex may vary. Usually, the containment or reactor building is used to define the building height, but this may not be appropriate in all cases. Determining the width is more problematic because the complex is

generally rectangular or irregular in footprint. Thus, the apparent width depends on the direction of the wind. Fortunately, the effect of the initial size of the plume is quickly lost as the plume moves downwind of the plant. While the initial plume dimensions can have a significant effect on the maximum dose at the exclusion area boundary, they usually have little effect on doses multiple kilometers from the plant.

Plume Rise Models

There are three basic components of the plume rise models in MACCS: (1) liftoff of buoyant plumes from a building wake, (2) plume rise under unstable and neutral atmospheric conditions (stability classes A to D), and (3) plume rise under stable conditions (stability classes E and F). Each of these components is described in this section.

When wind speeds are sufficiently high, a buoyant plume segment that is released into a building wake is unable to escape from the wake. In MACCS, escape of a buoyant plume segment from a building wake is governed by a liftoff criterion (Equation (3-17) below), which was originally proposed by Briggs (1973) and validated by experiments performed at the Warren Spring Laboratory in Great Britain (Hall and Waters, 1986). The criterion states that plume rise occurs only when the wind speed upon release of the segment is less than a critical wind speed (u_c) that is calculated using the following formula:

$$u_c = \left[\frac{9.09F}{H_b}\right]^{\frac{1}{3}} \qquad \textbf{(3-17)}$$

Where

H_b = the height of the building from which the plume is escaping (m)

F = the buoyancy flux (m^4/s^3), which under standard atmospheric conditions is = $8.79 \cdot 10^{-6}\dot{Q}$

$\dot{Q}$ = the sensible heat release rate of the plume (W) (i.e., the sensible heat content of the plume divided by its release duration). Sensible heat is measured relative to ambient temperature.

This equation indicates that there is little or no possibility of plume liftoff when the sensible heat release rate is less than 10^5 W for a typical, 50-m high, reactor or containment building. Even when the rate of release of sensible heat is 1 MW, the plume only lifts off when wind speed is less than approximately 1.2 m/s. Larger release rates of sensible heat, like 10 MW, produce lift off under a significant set of weather conditions for most sites.

Plume rise, when atmospheric conditions are neutral or unstable (stability classes A through D), is treated using the “two thirds” law for bent over plumes of Hanna et al. (1982):

$$\Delta h(x) = \frac{1.6F^{\frac{1}{3}}x^{\frac{2}{3}}}{\bar{u}} \qquad \textbf{(3-18)}$$

Where

h = height of the plume centerline (m)

$\Delta h(x)$ = plume rise (m) as a function of x measured from the initial release height

$\bar{u}$ = wind speed (m/s) averaged between the initial release height and the final rise height (h)

Buoyant plume rise is terminated when any of the following conditions occur:

(1). $\Delta h(x)$ reaches a final rise height, Δh, as defined below,

(2). the height of the plume centerline reaches the mixing height (height of the capping inversion layer), or

(3). one hour has elapsed since release of the plume segment began.

In the original MACCS plume rise model, the following equation recommended by Briggs (1975) was used to determine the final rise height for stability classes A to D:

$$\Delta h = 300F/\bar{u}^3 \qquad \textbf{(3-19)}$$

In the currently recommended, improved MACCS plume rise model, a different formula is used, also based on the work of Briggs (Hanna, 1982):

$$\Delta h = \frac{38.7F^{0.60}}{\bar{u}} \quad F \geq 55$$
$$\text{when}$$
$$\Delta h = \frac{21.4F^{0.75}}{\bar{u}} \quad F < 55 \qquad \textbf{(3-20)}$$

In the original MACCS model, plume rise under stable atmospheric conditions (stability classes E and F) is calculated using the Briggs equation for the final rise (Δh) Hanna (1982):

(3-21)

In the improved MACCS model, plume rise under stable atmospheric conditions (stability classes E and F) is calculated using a slightly modified version of the above equation:

$$\Delta h = 2.4\left[\frac{F}{\bar{u}S}\right]^{\frac{1}{3}} \qquad \textbf{(3-22)}$$

In Equations (3-21) and (3-22), the stability parameter, *S*, is defined as follows:

S = stability parameter (s^{-2}) defined by the following equation:

$$S = \frac{g}{T_a}\left[\frac{\partial T_a}{\partial z} + \frac{g}{c_p}\right] \qquad \textbf{(3-23)}$$

Where

g = acceleration due to gravity (9.8 m/s^2)
T_a = ambient temperature (K)
$\frac{\partial T_a}{\partial z}$ = ambient temperature lapse rate (K/m)
c_p = heat capacity of air at constant pressure (J/kg/K)
$\frac{g}{c_p}$ = dry adiabatic lapse rate (0.98 K/100 m = 0.0098 K/m)

For E and F stability cases with small final rise height downwind distances, the plume is assumed to behave identically to the model for unstable condition.

When atmospheric conditions are stable (stability classes E or F), the final plume rise height, Δh_{final}, in the improved Briggs model depends on the downwind distance x_f when the plume reaches its final rise height, which in turn depends on the buoyancy flux *F*. The downwind distance x_f when the plume levels off is given by the following equation:

$$\begin{aligned} x_f &= 119F^{0.4} \\ x_f &= 49F^{0.625} \end{aligned} \quad \text{if} \quad \begin{aligned} F &\geq 55\, m^4/s^3 \\ F &< 55\, m^4/s^3 \end{aligned} \qquad \textbf{(3-24)}$$

If $x_f \leq 1.84 \frac{\bar{u}}{\sqrt{S}}$, then MACCS assumes the plume behaves identically to the improved Briggs model for unstable conditions

Regulatory Guide 1.23 (NRC, 1972) specifies ranges for temperature lapse rates $(\partial T_a/\partial z)$ for the six atmospheric stability classes A through F. The values of the stability parameter S used in MACCS were derived using midpoint values for these lapse-rate ranges. The lapse rate ranges specified for Stability Classes E and F are -0.5 K/100 m to 1.5 K/100 m and 1.5 K/100 m to 4.0 K/100 m. Thus, Class E has a lapse rate range midpoint of 0.5 K/100 m and Class F a midpoint of 2.75 K/100 m. Substitution of these midpoint values and the International Civil Aviation Organization standard atmosphere (West, 1972) value of 288.16 K (15°C) into Equation (3-13) results in values of 5.04 × 10-4 s-2 and 1.27 × 10-3 s-2 for the stability parameter S for Stability Classes E and F, respectively.

Because near-surface wind speeds generally increase with altitude, Equations (3-19) through (3-22) overestimate plume rise if surface wind speeds are used to calculate ∆h. Since this could underestimate radiation exposures, for purposes of calculating plume rise, wind speeds aloft are estimated from surface wind speeds using the following equation (Hanna, 1982):

$$u = u_0 \left(\frac{h}{h_r}\right)^p \qquad \textbf{(3-25)}$$

Where

u_0 = surface wind speed measured at the reference height, h_r (usually 10 m above ground level)

p = exponential coefficient (dimensionless), which depends on stability class and surface roughness. Values are provided in Table 3-42.

Table 3-42 Values of exponential coefficient, p, in Equation (3-25) for six stability classes.

Stability class	A	B	C	D	E	F
Urban Surfaces	0.15	0.15	0.20	0.25	0.40	0.60
Rural Surfaces	0.07	0.07	0.10	0.15	0.35	0.55

To calculate plume rise, the weather conditions that characterize the time at which release of the plume segment begins are used to calculate the entire rise of the segment. In other words, transitions in stability class and wind speed are not considered for the purpose of plume rise (e.g., a buoyant plume segment released at 1:59 PM would have its entire rise calculated using 1:00 PM weather).

In MACCS, plume rise is calculated in three steps. First, the surface wind speed u_0 and one of the Equations (3-19) through (3-22), as appropriate, are used to make a first-order estimate of the final centerline height (h) of the plume segment after plume rise has taken place ($h = h_0 + \Delta h$), where h_0 is the initial release height of the plume segment. Then the wind speed u at the height h is calculated using Equation (3-25). Finally, an average wind speed over this range is estimated by averaging u_0, the reference wind speed, and u, the wind speed at the first-order estimate of the final height of the plume centerline. This average value of u is used in Equations (3-19) through (3-22) to make a second-order estimate of the amount of plume rise, Δh, which is used to evaluate the final plume centerline height of the plume segment, h.

The individual numerical coefficients used by these models are fixed in the code with no provision for their convenient modification by the user. While it is not possible for the user to vary the individual coefficients used by the three components of the plume rise model, it is possible to modify the end results by specifying linear scaling factors, SCLCRW, SCLADP, and SCLEFP.

Two optional sets of inputs are available in MACCS to determine plume buoyancy. When *Power Model* is selected on the *Plume/Source* tab (specified via the MACCS parameter PLMMOD), the plume buoyancy is calculated using the rate of release of sensible heat content in a plume ($\dot{Q}$ in the equations above). In some cases, it is simpler for the user to estimate the rate of mass release and the density of a plume segment rather than the rate of release of sensible heat. The second option, the *Density and Flow Model*, allows these values to be specified in place of the rate of release of sensible heat. The required values, plume density and mass flow rate, are related to the buoyancy flux, *F,* by the following formula:

$$F = \frac{g}{\pi}\left(1 - \frac{\rho}{\rho_a}\right)\frac{\dot{m}}{\rho} \qquad \textbf{(3-26)}$$

Where

g	=	acceleration due to gravity (9.8 m/s^2)
ρ	=	mass density of the plume (kg/m^3)
ρ_a	=	mass density of surrounding air at ambient conditions (1.178 kg/m^3 for standard atmospheric conditions)
$\dot{m}$	=	mass flow rate of the plume (kg/s)

Equation (3-26) can be used to account for release of gases that are lighter than air, such as hydrogen and steam, as well as releases at elevated temperatures. Generally, the presence of aerosols can be neglected when plume density and flow rate are calculated.

3.2.9.2 Release Description

Plume of Maximum Risk Form

The *Plume of Maximum Risk* form is required when *Multi Source Term* is not selected on the *Plume/Source* tab.

MAXRIS specifies which plume segment is to be considered risk dominant. The selection of this plume segment is usually based on its potential for causing early fatalities. Selecting a value is not always obvious, but the user should select a plume segment with relatively large release fractions that occurs early in the overall release timing. Release of the risk-dominant plume is aligned with the first hour of the selected weather sequence. The upper limit on this parameter, NUMREL, is defined below.

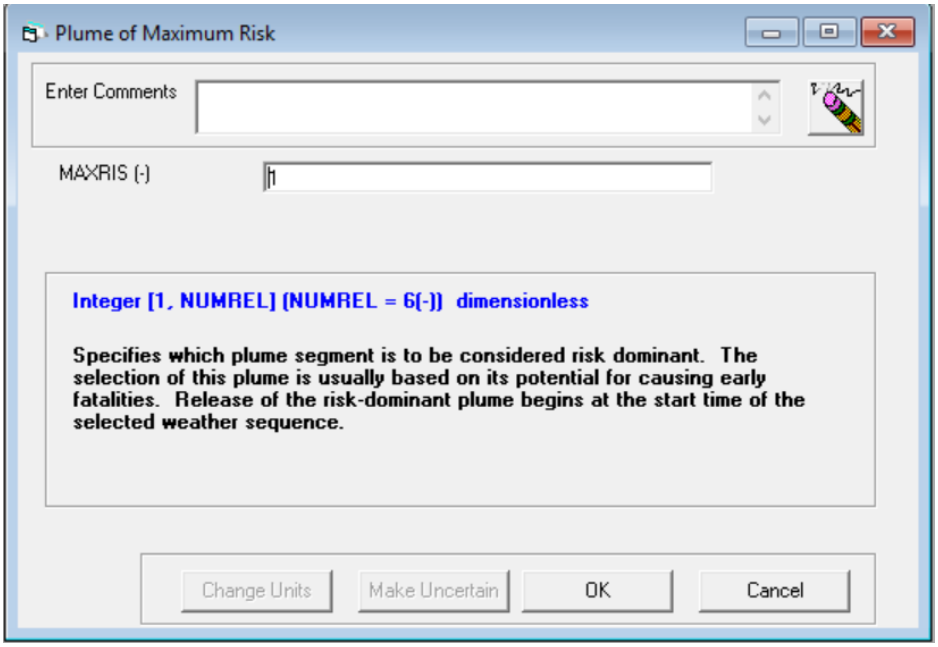


Figure 3-49 Plume of Maximum Risk Form

Table 3-43 Plume of Maximum Risk Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
MAXRIS	Yes	Integer	None	1 to NUMREL

Plume Parameters Form

The *Plume Parameters* form is required when *Multi Source Term* is not selected on the *Plume/Source* tab. It contains four parameters that define the timing of plume segments and the initial release height.

NUMREL defines the number of plume segments that are released. This value is determined by the number of rows in the grid containing values of PDELAY, PLHITE, REFTIM, and PLUDUR.

PDELAY specifies the start time of each plume segment from the time of reactor scram, which is usually the time of accident initiation. Sequential, overlapping, and gaps between plume segments are allowed.

PLHITE specifies the height above ground level at which each plume segment is released.

REFTIM specifies the representative location for each plume segment (e.g., 0.0 = leading edge, 0.5 = midpoint, 1.0 = trailing edge). This parameter allows the user to locate the contents of the plume in a bucket of material situated at some point along the plume segment. Radioactive decay,

dry deposition, and dispersion are all calculated as if the entire contents of the plume segment were located at this point. The choice of this parameter has no impact on the wet deposition calculations since those are performed as if the entire contents of the plume are uniformly distributed along its length.

PLUDUR specifies the duration of each plume segment.

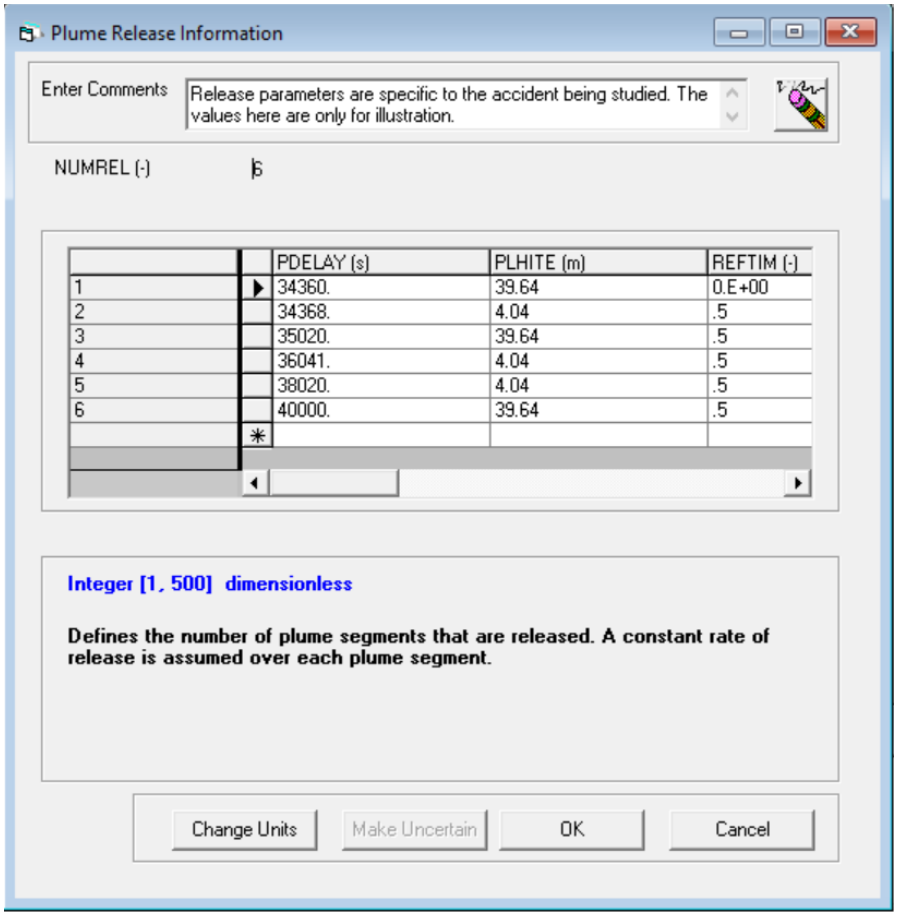


Figure 3-50 Plume Parameters Form

Table 3-44 Plume Parameters Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMREL	Linked	Integer	None	1 to 500
PDELAY	Yes	Real	NUMREL	0.0 to 2,592,000 s (30 d)
PLHITE	Yes	Real	NUMREL	0.0 to 1000.0
REFTIM	Yes	Real	NUMREL	0.0 to 1.0
PLUDUR	Yes	Real	NUMREL	60.0 to 86,400.0 s (1 min to 1 d)

Particle Size Distribution Form

The *Particle Size Distribution* form is required when *Multi Source Term* is not selected on the *Plume/Source* tab. It defines the aerosol-size distribution for each chemical group in the analysis.

PSDIST defines the fraction of the released material allocated to each of the particle-size (deposition-velocity) groups. The initial particle-size distribution for a chemical group is the same for all plume segments. The deposition velocity (VDEPOS) is shown as the column header. There are NSPGRP columns (taken from the number of particle size groups in the *Dry Deposition* form) and MAXGRP rows (taken from the number of chemical groups in the *Chemical Names* form). The fractions across a row (over the set of size groups) must sum to approximately 1.0.

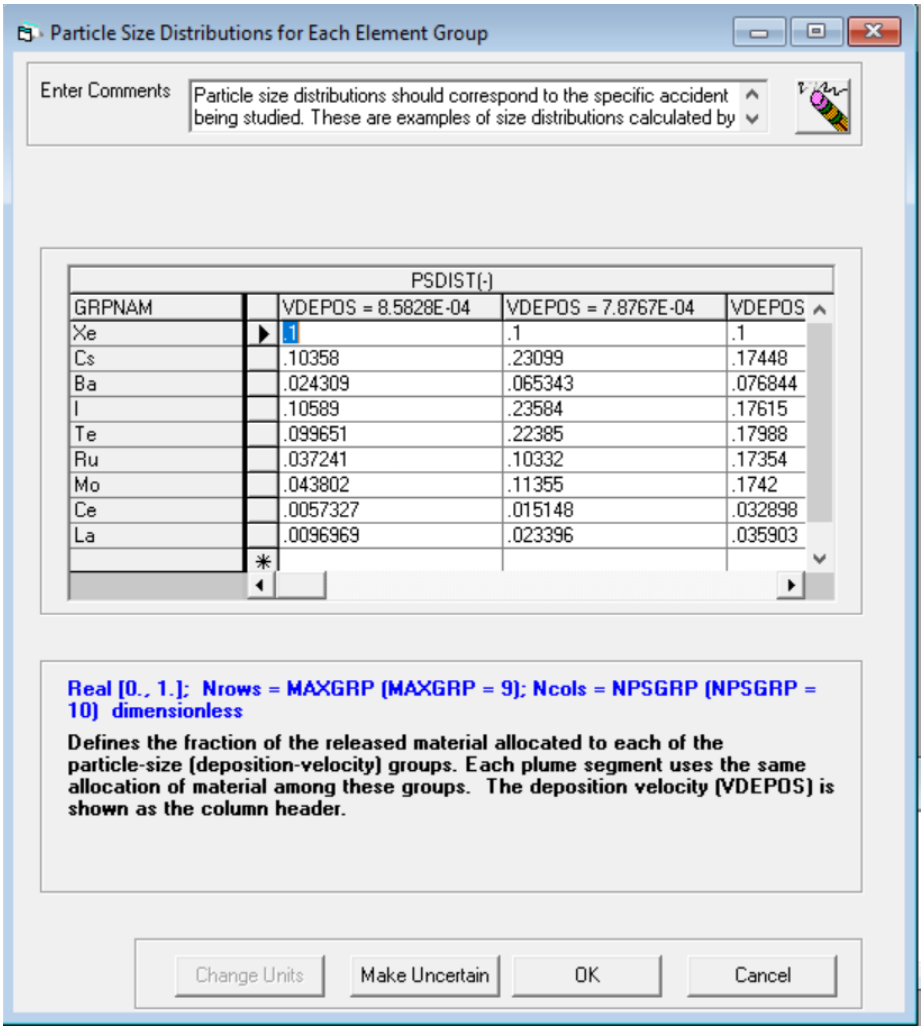


Figure 3-51 Particle Size Distribution Form

Table 3-45 Particle Size Distribution Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
PSDIST	Yes	Real	MAXGRP by NSPGRP	0.0 to 1.0

Inventory Scale Factor Form

The *Inventory Scale Factor* form is required when *Multi Source Term* is not selected on the *Plume/Source* tab. CORSCA, the only parameter on this form, is a linear scaling factor that can be used to adjust the inventory of all the radionuclides defined in the model. This factor is useful for modeling similar reactors with different power ratings.

It is preferable to obtain new sets of inventory values when studying reactors with different power ratings, fuel burnup levels, or fuel management histories, but this is not always practical. When facility-specific inventories are not available, a representative inventory may be obtained by linear scaling of the inventory of a similar reactor having a different thermal power level. The scale factor is usually chosen to be the ratio of the two reactors' thermal power levels.

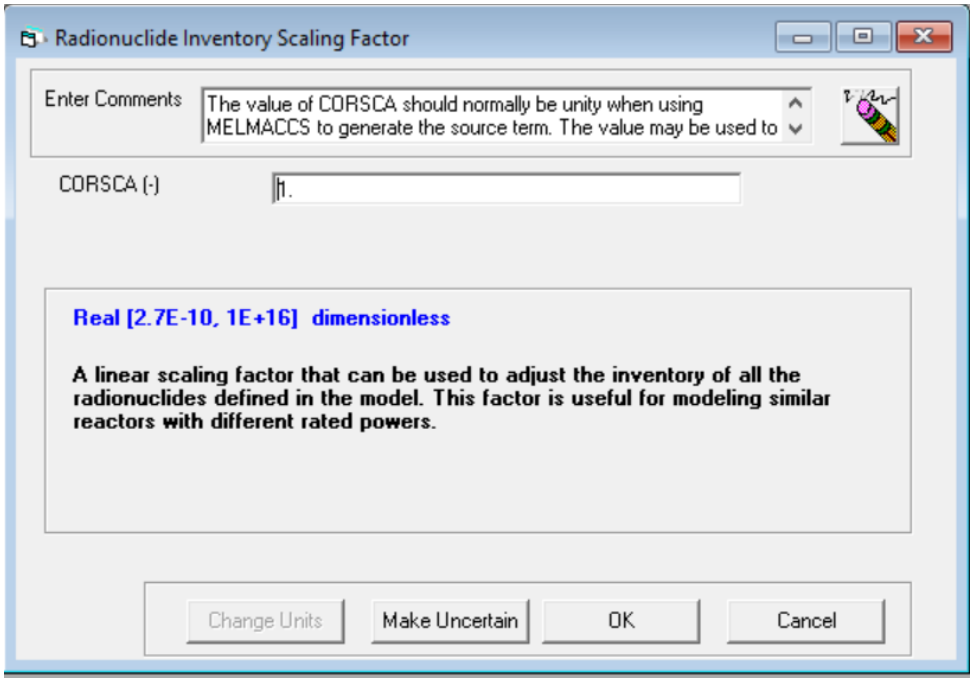


Figure 3-52 Inventory Scale Factor Form

Table 3-46 Inventory Scale Factor Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CORSCA	Yes	Real	None	2.7×10^{-10} to 10^{16}

Daughter Ingrowth Flag Form

The *Daughter Ingrowth Flag* form is required when *Multi Source Term* is not selected on the *Plume/Source* tab. APLFRC, the only parameter on this form, specifies how release fractions are applied to decay products. PARENT indicates that decay products formed after reactor shutdown are released in the same fraction as their parent; PROGENY indicates decay products formed after reactor shutdown are released according to their own chemical group. PARENT is preferred when using MELCOR data because MELCOR does not account for radioactive decay and ingrowth.



Figure 3-53 Daughter Ingrowth Flag Form

Table 3-47 Daughter Ingrowth Flag Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
APLFRC	Yes	Character	None	PARENT, PROGENY

Release Fractions Form

The *Release Fractions* form is required when *Multi Source Term* is not selected on the *Plume/Source* tab. RELFRC defines the release fraction for each of the plume segments and for each chemical group. Each row represents one of the plume segments declared on the *Plume Parameters* form. All radionuclides in a chemical group are released from the facility in the same fraction. Normally, the values of RELFRC summed over the set of plume segments should not exceed 1.0, but this requirement is not imposed by either WinMACCS or MACCS.

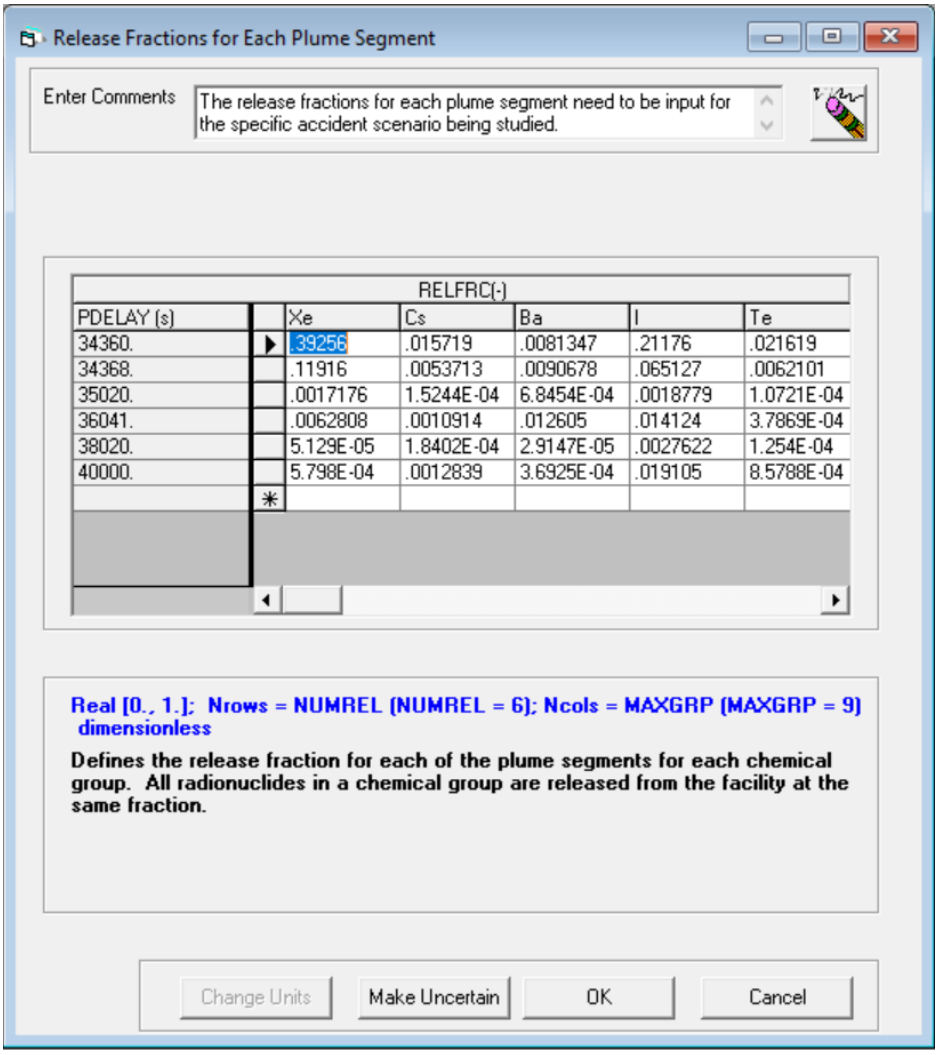


Figure 3-54 Release Fractions Form

Table 3-48 Release Fractions Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
RELFRC	Yes	Real	NUMREL by MAXGRP	0.0 to 1.0

Scale Factors for Release Fractions Form

The Scale Factors for Release Fractions Form is used to scale release fractions for each radionuclide defined in the model.

NUMISO defines the number of radionuclides. It is linked to the number of entries in the NUCNAM vector.

NUCNAM is a vector of radionuclide names. Each radionuclide name must be in the decay-chain definition file, INDEXR.DAT, as well as the DCF file used in the calculation.

IGROUP identifies the chemical group to which the radionuclide is assigned. The radionuclides should be grouped according to their physical/chemical properties. All members of a chemical group have the same deposition characteristics and release fractions. The assignment into chemical groups or classes is often taken from MELCOR, especially when the source term was calculated using MELCOR.

NUCSCA assigns a scaling factor to a particular radionuclide defined in the model. NUCSCA is similar to CORSCA, but instead of defining a scaling factor for the whole reactor, it is defined for each radionuclide individually.

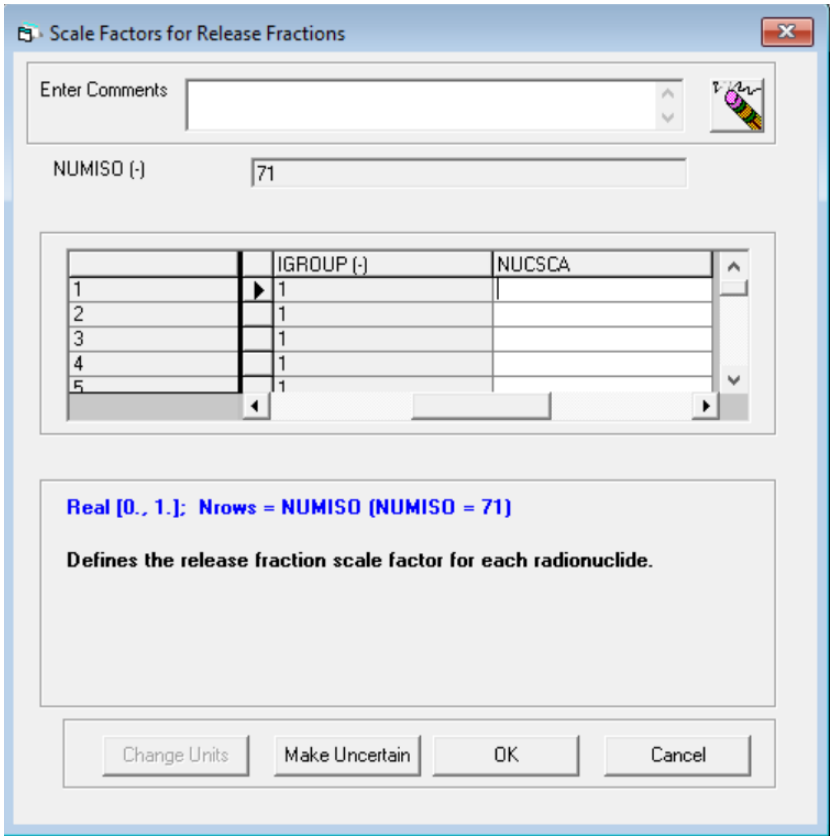


Figure 3-55 Scale Factors for Release Fractions Form

Table 3-49 Scale Factors for Release Fractions Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMISO	No	Integer	None	1 to 150
NUCNAM	No	Character	NUMISO	3 to 8 characters
IGROUP	No	Integer	NUMISO	1 to MAXGRP
NUCSCA	Yes	Real	NUMISO	0 to 1

Wake Effect Data Form

The *Wake Effect Data* form is required when *Multi Source Term* is not selected on the *Plume/Source* tab. BUILDH defines the height of the facility building or building complex. This

value is used to evaluate whether a buoyant plume is entrained in the turbulent wake of the building based on Equation (3-17).

SIGYINIT defines the initial value of sigma-y for each plume segment released.

SIGZINIT defines the initial value of sigma-z for each plume segment released.

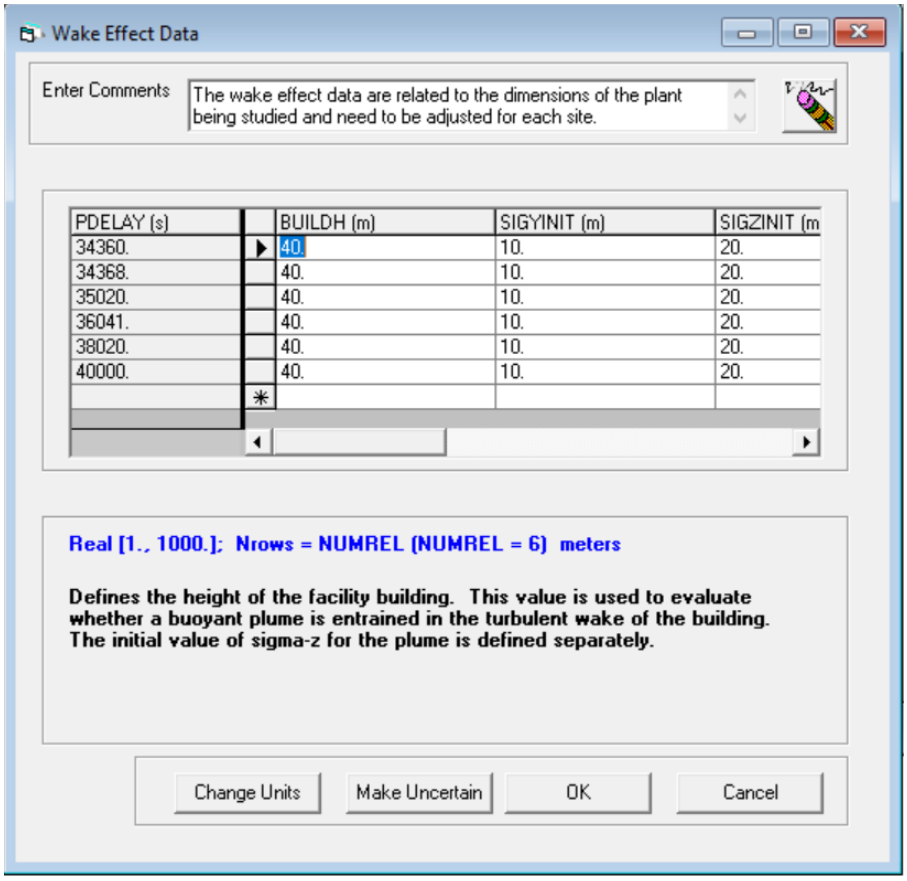


Figure 3-56 Wake Effect Data Form

Table 3-50 Wake Effect Data Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
BUILDH	Yes	Real	NUMREL	0 to 1000.0 m
SIGYINIT	Yes	Real	NUMREL	0.1 to 1000.0 m
SIGZINIT	Yes	Real	NUMREL	0.1 to 1000.0 m

Heat Form

The *Heat* form is required when the *Power Model* is selected on the *Plume Rise* tab and *Multi Source Term* is not selected on the *Plume/Source* tab. The values are used to determine buoyant plume rise.

PLHEAT specifies the rate of release of sensible heat in each plume segment. This quantity is traditionally calculated based on the difference between the plume and ambient temperatures, the heat capacity of air, and the flow rate of the plume. This value is used to determine the amount of buoyant plume rise.

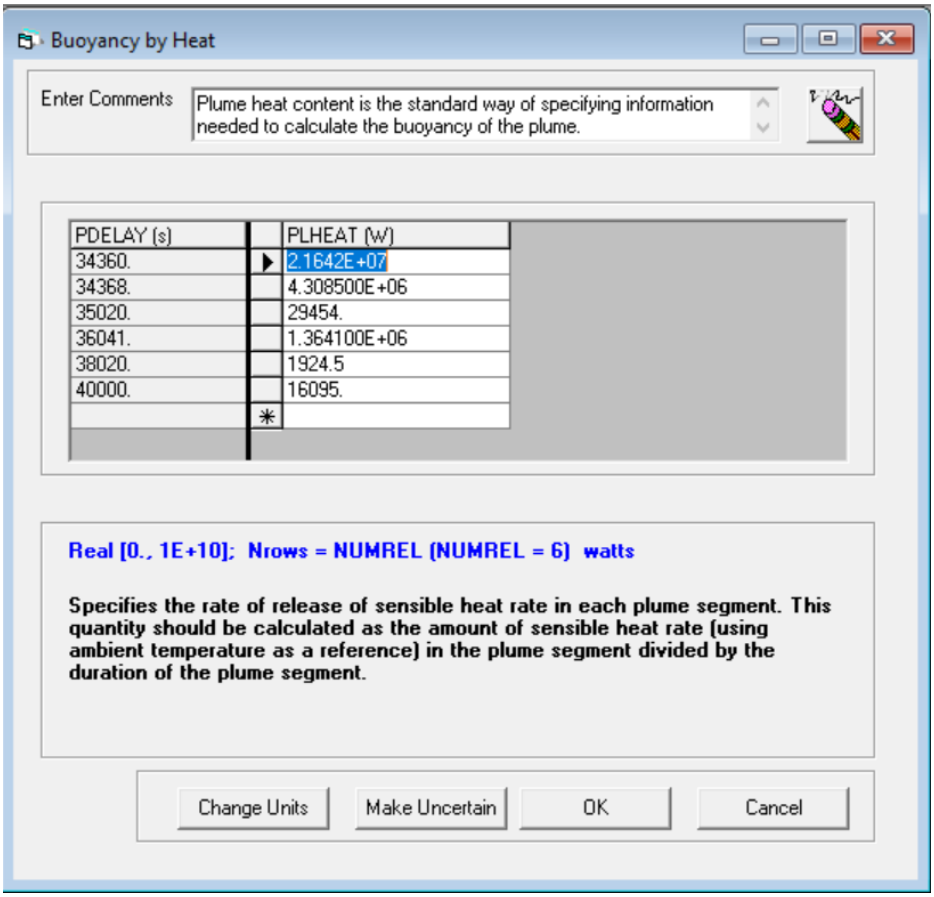


Figure 3-57 Buoyancy by Heat Form

Table 3-51 Buoyancy by Heat Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
PLHEAT	Yes	Real	NUMREL	0.0 to 10^{10} W

Density and Flow Form

The *Density and Flow* form is required when the *Density and Flow Model* is selected on the *Plume Rise* tab and the *Multi Source Term* is not selected on the *Plume/Source* tab. The values on this form are used to determine the amount of buoyant plume rise. This formulation is more general and sometimes more convenient than specifying rate of release of sensible heat, although these values are ultimately converted to buoyancy fluxes and those values are used in the same way as buoyancy fluxes derived from PLHEAT in calculating plume rise. This implies that one could derive values of PLHEAT that are exactly equivalent to the values from the density and flow model.

PLMFLA is the average mass flow rate for a plume segment.

PLMDEN is the average gas density for a plume segment.

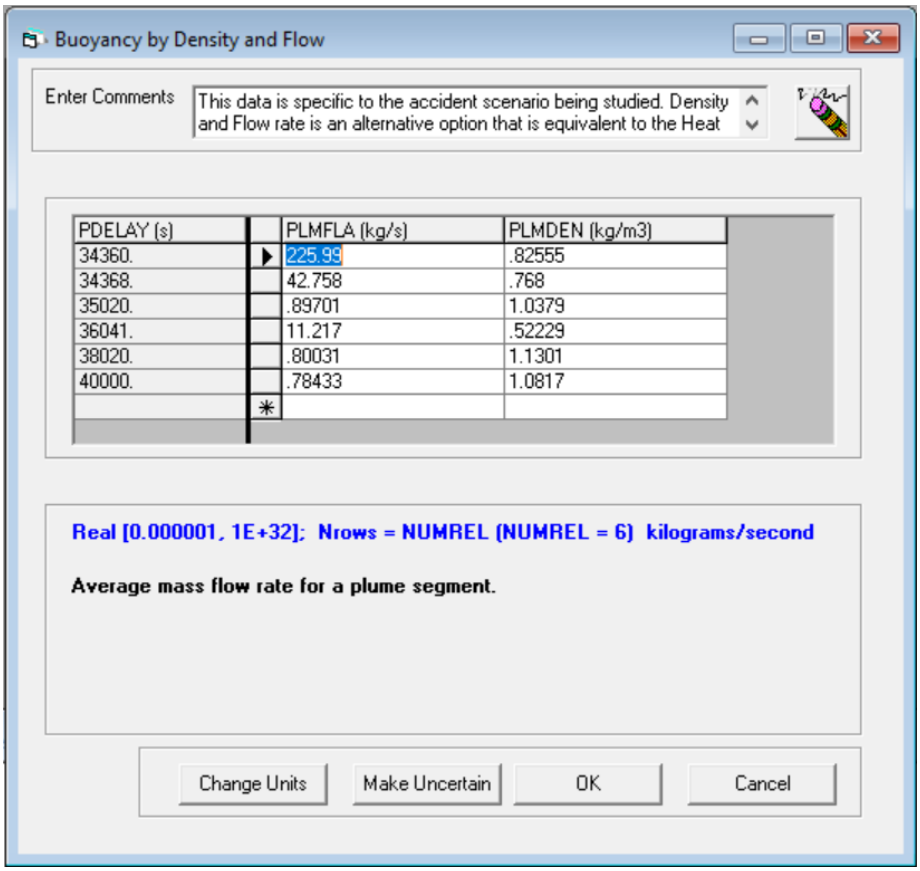


Figure 3-58 Buoyancy by Density and Flow Form

Table 3-52 Buoyancy by Density and Flow Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
PLMFLA	Yes	Real	NUMREL	10^{-6} to 10^{32} kg/s
PLMDEN	Yes	Real	NUMREL	0.02 to 5.0 kg/m^3

3.2.10 Weather

3.2.10.1 Weather Model Description

There are five options available to the user for specifying the weather data that are used by ATMOS. MACCS can run either a single weather sequence or multiple weather sequences, as described in the following paragraphs.

When a single weather sequence is desired, there are three ways to specify the weather data. The user can (1) specify data for 120 hr, (2) specify a starting day and time period in the weather data file, or (3) specify constant weather conditions.

For the specified starting day and time period option, weather data are taken from the meteorological data file beginning at the specified day and time. A file of weather data covering a period of 365 days (8760 hr) is required. The file can be defined to have 15 min, 30 min, or 1 hr time periods.

The two methods of weather sampling are (1) a modified version of the weather bin sampling method used in CRAC2 (Ritchie et al., 1984) and (2) a stratified, random sampling approach. The weather bin sampling method sorts weather sequences into categories and assigns a probability for each category, depending on the number of data points that fit into that category. The categories (i.e., bins) are defined by ranges of wind speeds paired with stability class or by the occurrence of rain. The rain bins depend on rain intensity as well as the downwind distance at which rain begins. The user is required to supply the parameters that define the rain bins as part of the ATMOS input file. The definitions of the weather bins that depend on stability class and wind speed are fixed in the code and are defined in the output file.

The stratified random sampling method allows the user to sample weather from each day of the year. For each day, a user-defined number of samples are selected randomly. Because of the way the samples are selected, each weather sequence has the same probability of occurrence, that is, P = 1/(number of samples).

3.2.10.2 Mixing Height Option

Daytime and nighttime values for mixing height are specified for each of the four seasons in the last line of the meteorological data file. An option is available in MACCS to account for night-to-day transitions in mixing height. This is activated by checking the box *Adjust mixing height based on time of day* on the *Weather* tab. This option only applies when a meteorological file is used (i.e. METCOD = 1, 2, or 5).

The meteorological file contains 2 sets of 4 values for mixing height at the end of the file. The first set is the morning mixing height values for each of the four seasons. The second set is afternoon mixing height values for each of the four seasons.

If *Mixing height based on time of day* is unchecked, only the afternoon mixing heights are used. That is, the mixing height only depends on the season for which the calculation is performed, not on time of day.

When *Mixing height based on time of day* is selected, mixing height is adjusted depending on time of day. This model uses both the morning and afternoon values. When the start time is between sunset and sunrise, the morning value for the appropriate season is used until the first hour after sunrise. At the first hour after sunrise and until the hour of sunset, the maximum mixing height is calculated by linearly interpolating between the morning value and the afternoon value for that season. Once the first sunset in the simulation is reached, the afternoon mixing height is used until the end of the weather trial. The mixing height is never allowed to decrease in the MACCS treatment because that would violate the second law of thermodynamics.

Calculations based on time of day require the user to supply the latitude and longitude of the accident site. This is done on the form labeled *Site Location*. Sunrise and sunset are calculated according to the site latitude. No adjustments are made to account for the east/west location of a site within a time zone or for switching to daylight savings time. Thus, the current version does not use the longitude value in the mixing height model.

3.2.10.3 *Weather* Forms and Parameters

Constant or Boundary Conditions Form

The *Constant or Boundary Conditions* form is required. This form allows the user to specify constant weather (METCOD = 4) or boundary weather conditions (METCOD = 1, 2, 3, or 5). Boundary weather is implemented when the radial interval greater than the value specified by LIMSPA is entered by a plume segment. Boundary weather allows the user to prescribe simple, constant weather conditions (in place of measured or simulated weather conditions taken from the meteorological data file) in the outer portion of the computational grid. This has traditionally been used to implement boundary rain, one purpose of which is to prevent the aerosols from escaping the grid. Using boundary rain tends to force a conservative result. A more realistic result can be obtained by setting LIMSPA = NUMRAD so that real weather data are used all the way to the edge of the grid. A second reason to use boundary weather is that the mean time between precipitation events is on the order of 10 days, so precipitation is likely to occur during the transport of a plume through a MACCS grid when the grid is large (e.g., 1600 km). At longer distances, precipitation may not be correlated with precipitation at the origin of the MACCS grid. Boundary weather can be used to force precipitation to occur before plume segments exit the grid.

BNDMXH is the mixing layer height that is used for the constant weather conditions (METCOD = 4). Mixing height is determined separately for all other values of METCOD and this value is not used.

IBDSTB is the stability class that is used for constant and boundary weather conditions. The integers 1 through 6 represent Pasquill-Gifford stability classes A through F, respectively.

BNDRAN is the rain rate that is used for the constant and boundary weather conditions.

BNDWND is the wind speed that is used for constant and boundary weather conditions.

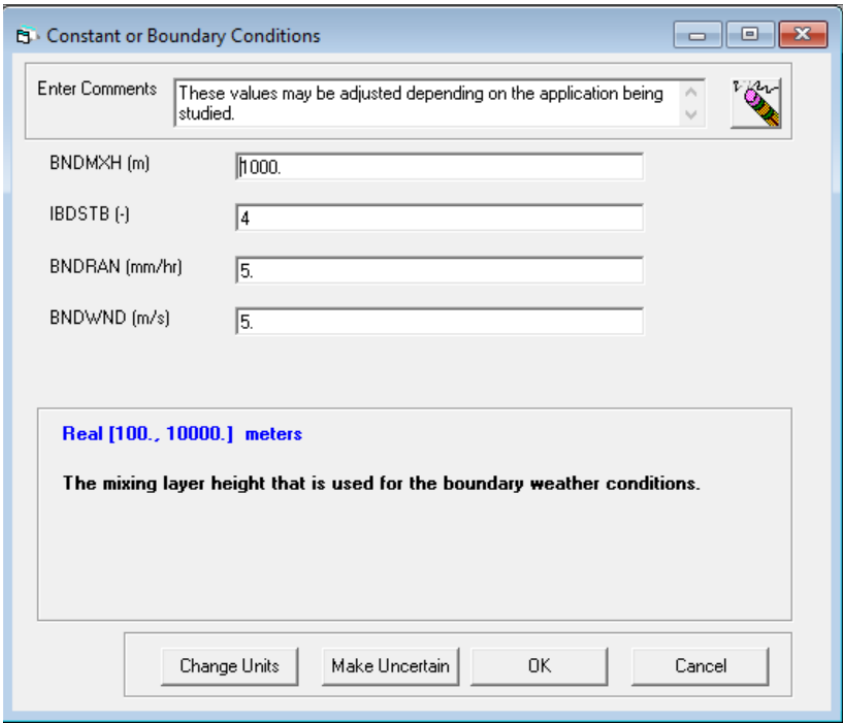


Figure 3-59 Constant or Boundary Conditions Form

Table 3-53 Constant or Boundary Conditions Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
BNDMXH	Yes	Real	None	100.0 to 10,000.0 m
IBDSTB	Yes	Integer	None	1 to 6
BNDRAN	Yes	Real	None	0.0 to 99.0 mm/hr
BNDWND	Yes	Real	None	0.5 to 30.0 m/s

Fixed Start Time Data Form

The *Fixed Start Time Data* form is required when *Constant Weather*, *User Supplies 120 Weather Points,* or *Fixed Start Time* is selected on the *Weather* tab. For the first option, the start time is only used in conjunction with the COMIDA2 food-chain model. However, MACCS requires these input parameters even when the COMIDA2 food-chain model is not used.

ISTRDY is the day of the year when the weather sequence begins.

ISTRHR is the starting time period of the weather trial. A 24-hour day is divided into 15-, 30-, or 60-minute time periods in the meteorological file, depending on the value of PERIOD in the meteorological data file. These divisions correspond to 96 time periods per day, 48 time periods per day, or 24 time periods per day, respectively. Table 3-54 contains the ranges of ISTRHR enforced by MACCS.

Table 3-54 ISTRHR Allowable Ranges

Allowed Range of ISTRHR	Data Interval	Third line of meteorological file
1 to 24	60 minutes	/PERIOD 60 (default)
1 to 48	30 minutes	/PERIOD 30
1 to 96	15 minutes	/PERIOD 15

Additionally, the food pathway calculations of the CHRONC module depend on the day the accident occurs when the COMIDA2 food-chain model is used. If the user has chosen the *Fixed Start Time* option, the values of ISTRDY and ISTRHR specify the starting day and time period in the weather file of the single weather trial that is performed. This time point in the weather file is aligned with the release of the MAXRIS plume segment.

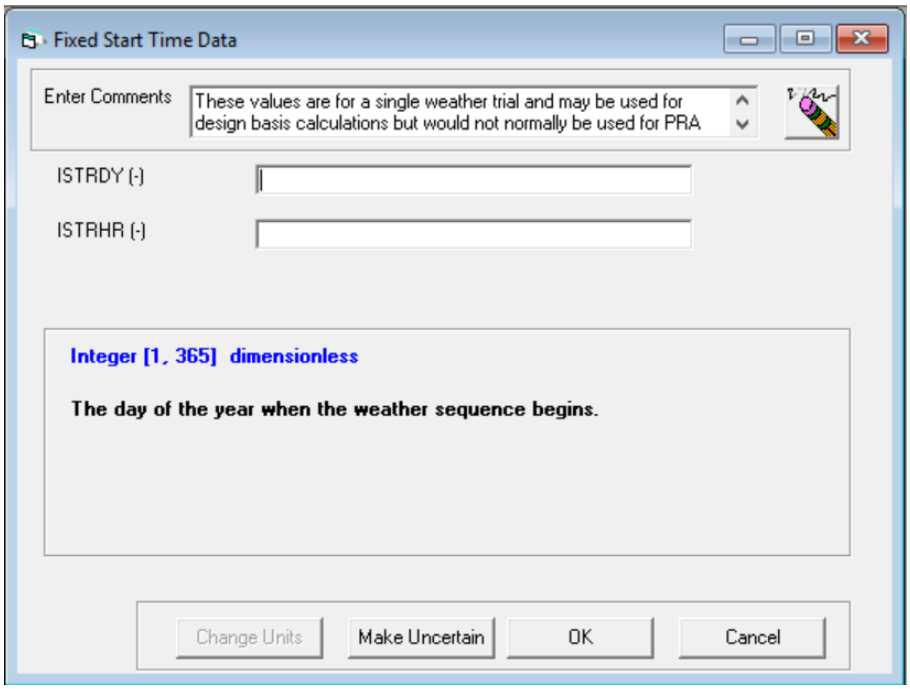


Figure 3-60 Fixed Start Time Data Form

Table 3-55 Fixed Start Time Data Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
ISTRDY	Yes	Integer	None	1 to 365
ISTRHR	Yes	Integer	None	1 to 96

User-Supplied Weather Form

The *User-Supplied Weather* form is required when *User Supplies 120 Weather Points* is selected on the *Weather* tab. There must be one data record for each hour of weather in the sequence. Shorter time periods for meteorological data are not supported on this form.

HRMXHT is the set of mixing layer heights that is used. The user can provide mixing heights in a general fashion in the input, but MACCS only allows HRMXHT to increase in the implementation of the Gaussian model to avoid unphysical plume behavior (i.e., to allow air concentration to increase at some downwind location). The user must supply 120 values, one per hour.

IHRSTB defines the list of stability classes that are used. The integers 1 through 6 represent the Pasquill-Gifford stability classes A through F, respectively. The user must supply 120 values, one per hour.

HRRAIN defines the list of rain rates that are used. The user must supply 120 values, one per hour.

HRWNDV defines the list of wind speeds that are used. The user must supply 120 values, one per hour.

IHRDIR defines the list of wind directions that are used. They are given as integers corresponding to each of the compass directions starting with north (1) and ending with the direction just to the west of north. The user must supply 120 values, one per hour.

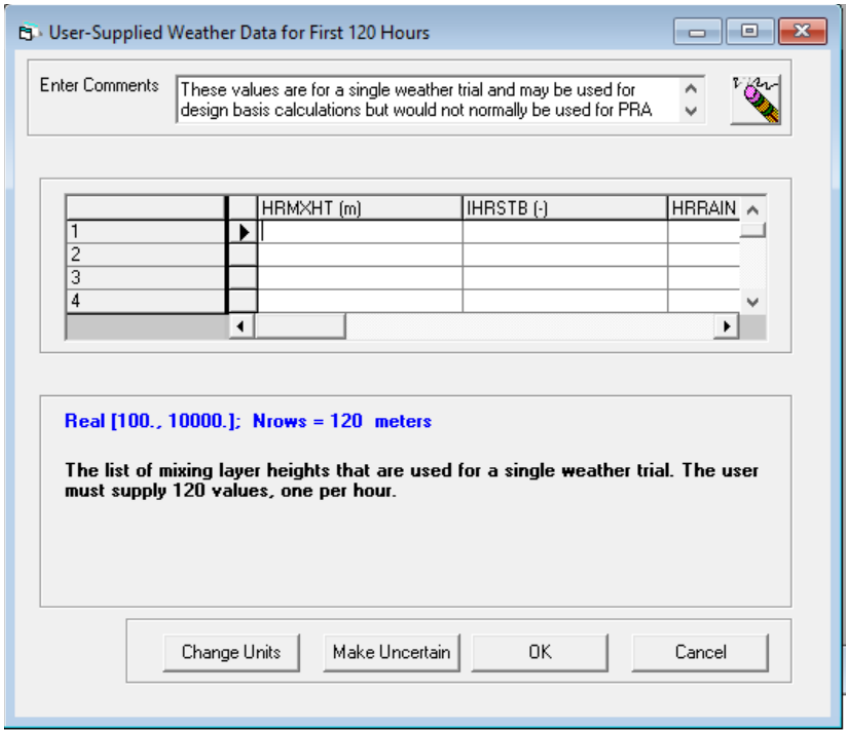


Figure 3-61 User-Supplied Weather Form

Table 3-56 User-Supplied Weather Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
HRMXHT	Yes	Real	120	100.0 to 10,000.0 m
IHRSTB	Yes	Integer	120	1 to 6
HRRAIN	Yes	Real	120	0.0 to 99.0 mm/hr
HRWNDV	Yes	Real	120	0.5 to 30.0 m/s
IHRDIR	Yes	Integer	120	1 to NUMCOR

Site Location Form

The *Site Location* form is required when *Adjust mixing height based on time of day* is selected on the *Weather* tab. The user must also specify the latitude and longitude of a site when map files need to be generated with MapGen, which allows maps to be displayed behind speed multiplier and network evacuation forms.

The latitude and longitude of a site can be found on a site file generated by SecPop as a comment line; however, this information must be entered manually because WinMACCS does not read this comment line from a site file. These values are used to calculate the time of sunrise and sunset.

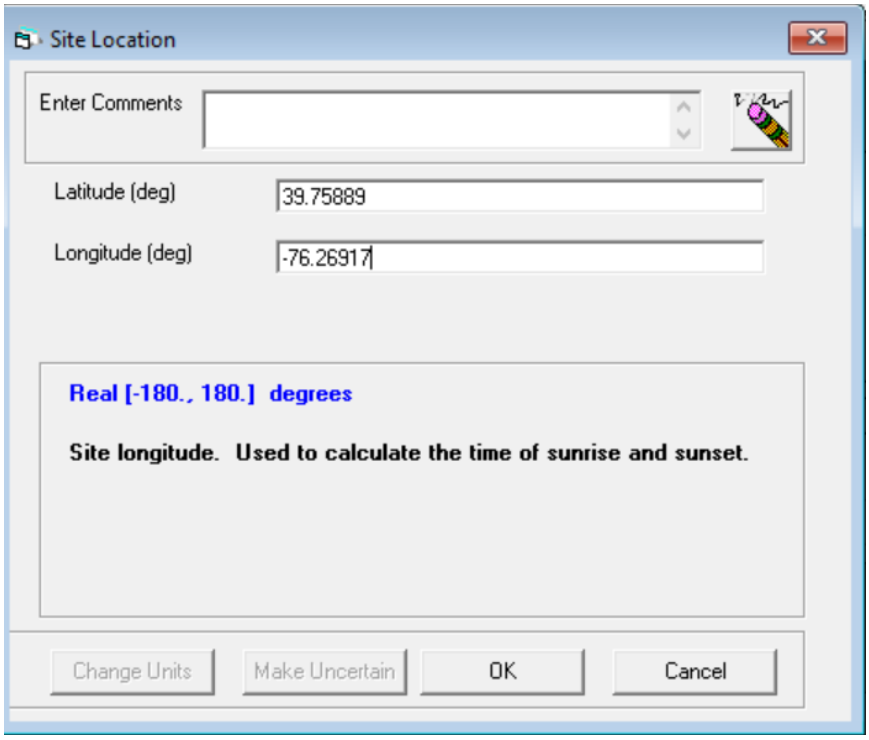


Figure 3-62 Site Location Form

Table 3-57 Site Location Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
Latitude (deg)	Yes	Real	None	-180.0 to 180.0
Longitude (deg)	Yes	Real	None	-180.0 to 180.0

Samples per Bin Form

The *Samples per Bin* form is required when *Uniform Bin Sampling (METCOD=2)* is selected on the *Weather* tab. The bins are defined to represent rain conditions at different distance intervals downwind from the accident site together with 16 bins for initial conditions organized by stability class and wind speed. The rain intensities and distance intervals that define the rain bins are chosen by the user. These values are specified on forms *Rain Distances* and *Rain Intensities.*

The total number of weather bins is determined by the number of rain intensities, NRINTN, and the number of rain distances, NRNINT. These are set in the *Rain Distances* and *Rain Intensities* forms, respectively. The total number of weather bins is NRNINT•(NRINTN+1)+16. The total number of bins can range from 28 to 40, depending on the number of rain distances and intensities supplied by the user. The 16 initial weather bins are fixed in MACCS according to the definitions given in Table 3-58.

Table 3-58 Definition of the 16 standard weather bins in MACCS.

Bin number	Stability Class	Wind Speed
1	A/B	0 m/s < u ≤ 3 m/s
2	A/B	3 m/s < u
3	C/D	0 m/s < u ≤ 1 m/s
4	C/D	1 m/s < u ≤ 2 m/s
5	C/D	2 m/s < u ≤ 3 m/s
6	C/D	3 m/s < u ≤ 5 m/s
7	C/D	5 m/s < u ≤ 7 m/s
8	C/D	7 m/s < u
9	E	0 m/s < u ≤ 1 m/s
10	E	1 m/s < u ≤ 2 m/s
11	E	2 m/s < u ≤ 3 m/s
12	E	3 m/s < u
13	F	0 m/s < u ≤ 1 m/s
14	F	1 m/s < u ≤ 2 m/s
15	F	2 m/s < u ≤ 3 m/s
16	F	3 m/s < u

NSMPLS defines the number of weather sequences to be chosen from each of the individual bins. The more samples that are taken, the better is the statistical representation of the results. The actual number of samples taken from a weather bin is the minimum of the number of time periods in the bin and the number of NSMPLS.

Table 3-59 Range of Weather Sequence Samples

Range for NSMPLS (365 x number time periods per day)	Weather Data Time Interval	Third Line of Meteorological File
1 to 8760	60 minutes	/PERIOD 60 (default)
1 to 17520	30 minutes	/PERIOD 30
1 to 35040	15 minutes	/PERIOD 15

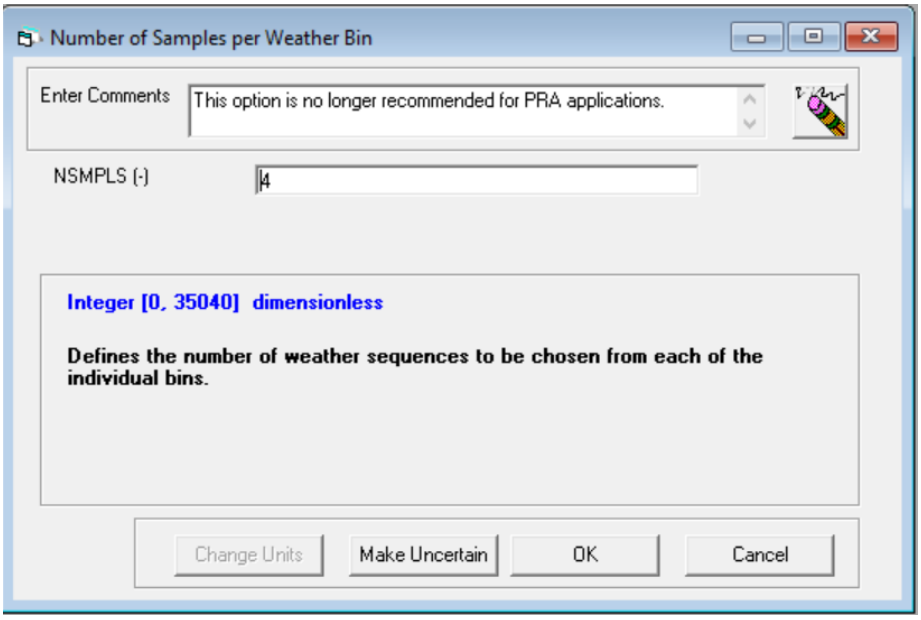


Figure 3-63 Samples per Bin Form

Table 3-60 Samples per Bin Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NSMPLS	Yes	Integer	None	0 to 35040

Samples per Day Form

Samples per Day is required when Stratified Random Sampling (METCOD=5) is selected on the Weather tab.

NSMPLS defines the number of weather sequences to be chosen from each day of the year. Table 3-61 contains the range of NSMPLS informed by MACCS.

Table 3-61 Range of Weather Sequences

Range for NSMPLS	Data Interval	Third Line of Meteorological File
1 to 24	60 minutes	/PERIOD 60 (default)
1 to 48	30 minutes	/PERIOD 30
1 to 96	15 minutes	/PERIOD 15

Although not enforced by MACCS or WinMACCS, NSMPLS should be set to be a factor of 24 when the meteorological data are hourly (i.e., 1, 2, 3, 4, 6, 8, 12, or 24), a factor of 48 when there is one record of data for every 30 minutes, or a factor of 96 when there is one record of data for every 15 minutes. This is because the sampling algorithm begins by dividing each day up into NSPLS time intervals. One sample is selected randomly from each time interval. For example, if NSPLS is 4 and hourly weather data are specified, each day is divided into 4 6-hr intervals. MACCS selects a single random starting time from each of these 4 intervals. Because the duration of each of the intervals is the same, each of the trials is equally probable. Selecting an integer that is not a factor causes some of the time intervals to be longer than others and leads to a bias in the sampling algorithm.

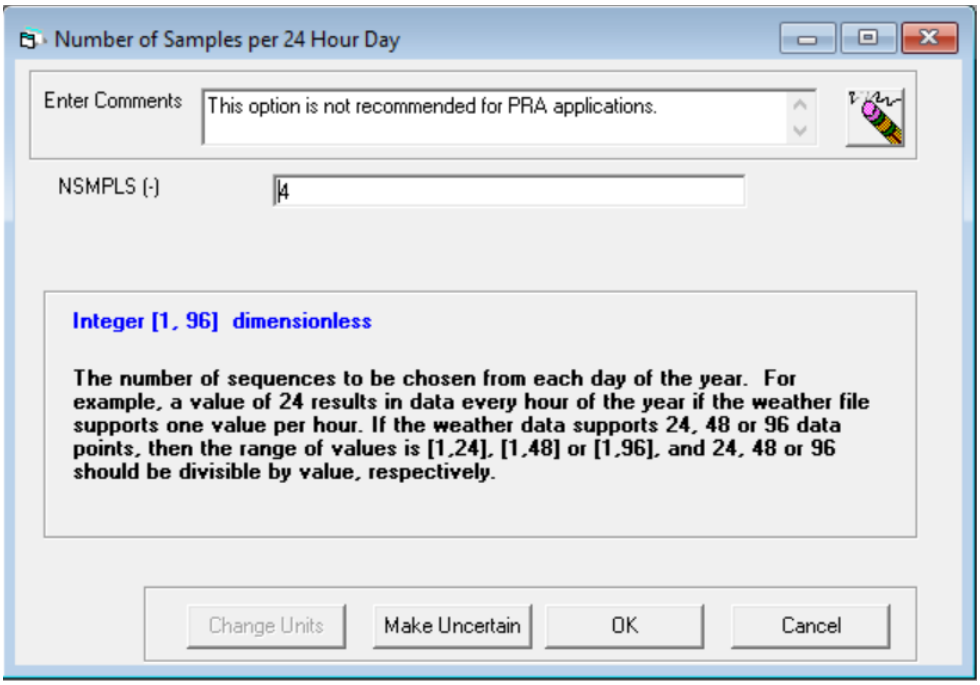


Figure 3-64 Samples per Day Form

Table 3-62 Samples per Day Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NSMPLS	Yes	Integer	None	1 to 96

Seed Form

Seed is required when any of the sampling options (METCOD=2 or 5) is selected on the *Weather* tab.

IRSEED defines the seed of the random number generator. Changes to this value cause different weather trials to be selected.

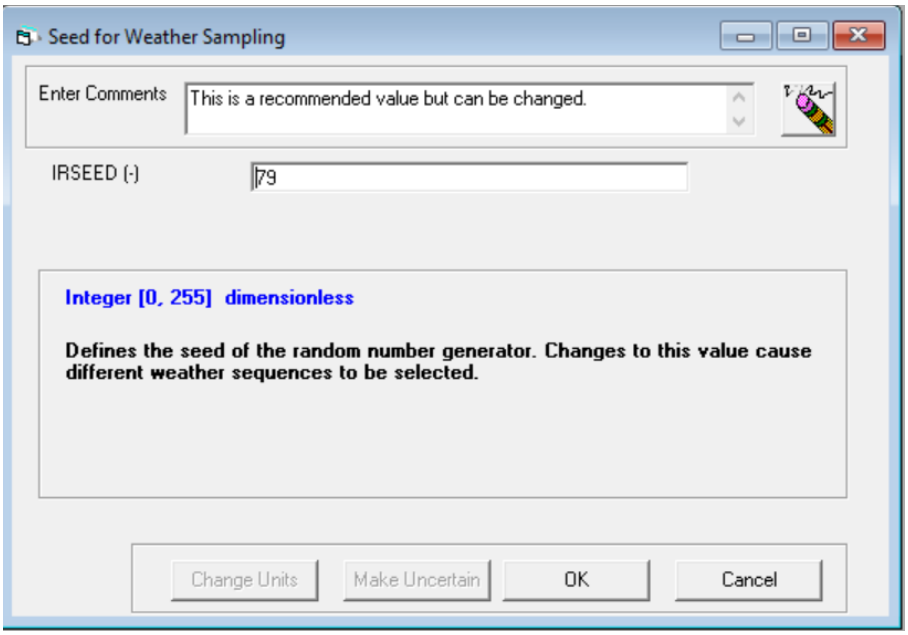


Figure 3-65 Seed for Weather Sampling Form

Table 3-63 Seed for Weather Sampling Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
IRSEED	Yes	Integer	None	0 to 255

Boundary Limit **Form**

The *Boundary Limit* form is required when anything but *Constant Weather* (METCOD=4) is selected on the *Weather* tab.

LIMSPA is the limiting spatial interval for using recorded weather data. Spatial intervals greater than with this value use the boundary weather conditions specified on form *Constant or Boundary Conditions*. Boundary weather conditions are applied to all spatial intervals when a value of 0 is specified for this parameter. No boundary weather is employed when LIMSPA = NUMRAD.

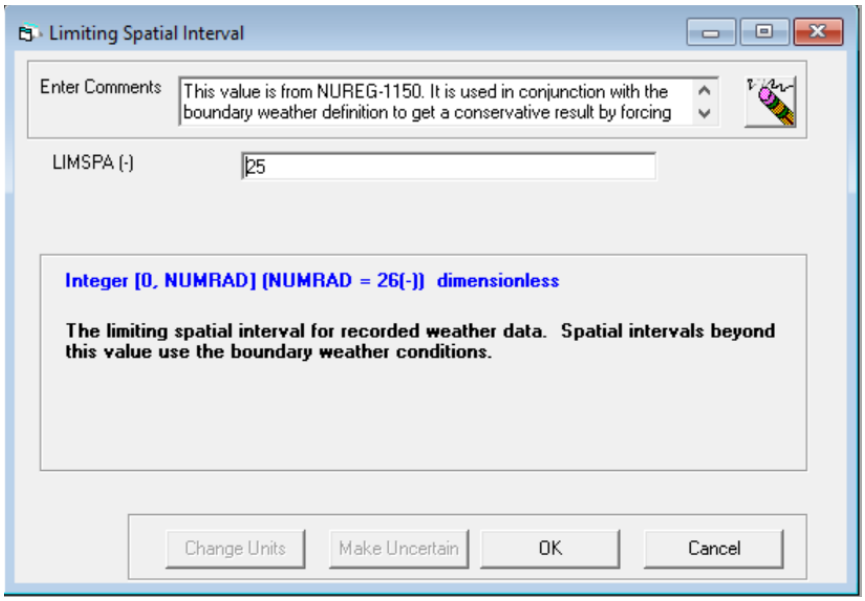


Figure 3-66 Limiting Spatial Interval Form

Table 3-64 Limiting Spatial Interval Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
LIMSPA	Yes	Integer	None	0 to NUMRAD

Bins Form

The *Bins* form is required when *Nonuniform Bin Sampling (METCOD=2, NSMPLS=0)* is selected on the *Weather* tab. Sampling a subset of all the weather bins allows the effects of weather type to be examined. This is accomplished by setting INWGHT to zero for one or more of the bins. Another option for examining the importance of various weather bins is to set the RISCAT flag to True, as described below in the section on EARLY.

NSBINS defines the number of bins from which weather sequences are to be chosen. Its value is determined by the number of rows in the grid containing values of INDXBN and INWGHT. However, the user should ensure that the number of bins is consistent with the value of NRNINT•(NRINTN+1) +16. WinMACCS does not perform a consistency check on NSBINS, but MACCS does perform this check and issues an error message when it is inconsistent.

INDXBN defines the list of bins from which weather sequences are to be selected when nonuniform bin sampling is chosen. Indices are reported in the MACCS output under METEOROLOGICAL BIN SUMMARY. MACCS requires that the range of values is $1 \leq$ value $\leq$ NSBINS. The total number of bins depends on the rain distances and intensities supplied by the user, as described above.

INWGHT defines the number of weather sequences to be selected from each weather bin. If this number exceeds the number of sequences in the specified bin, the code selects all the sequences in that bin. To find the index number for a rain bin, refer to the output titled METEOROLOGICAL BIN SUMMARY. MACCS requires that the sum of the values of INWGHT must be greater than or equal to one. Table 3-65 contains the range of INWGHT enforced by MACCS.

Table 3-65 Ranges for INWGHT

Range for INWGHT	Data Interval	Third line of meteorological file
1 to 8760	60 minutes	/PERIOD 60 (default)
1 to 17520	30 minutes	/PERIOD 30
1 to 35040	15 minutes	/PERIOD 15

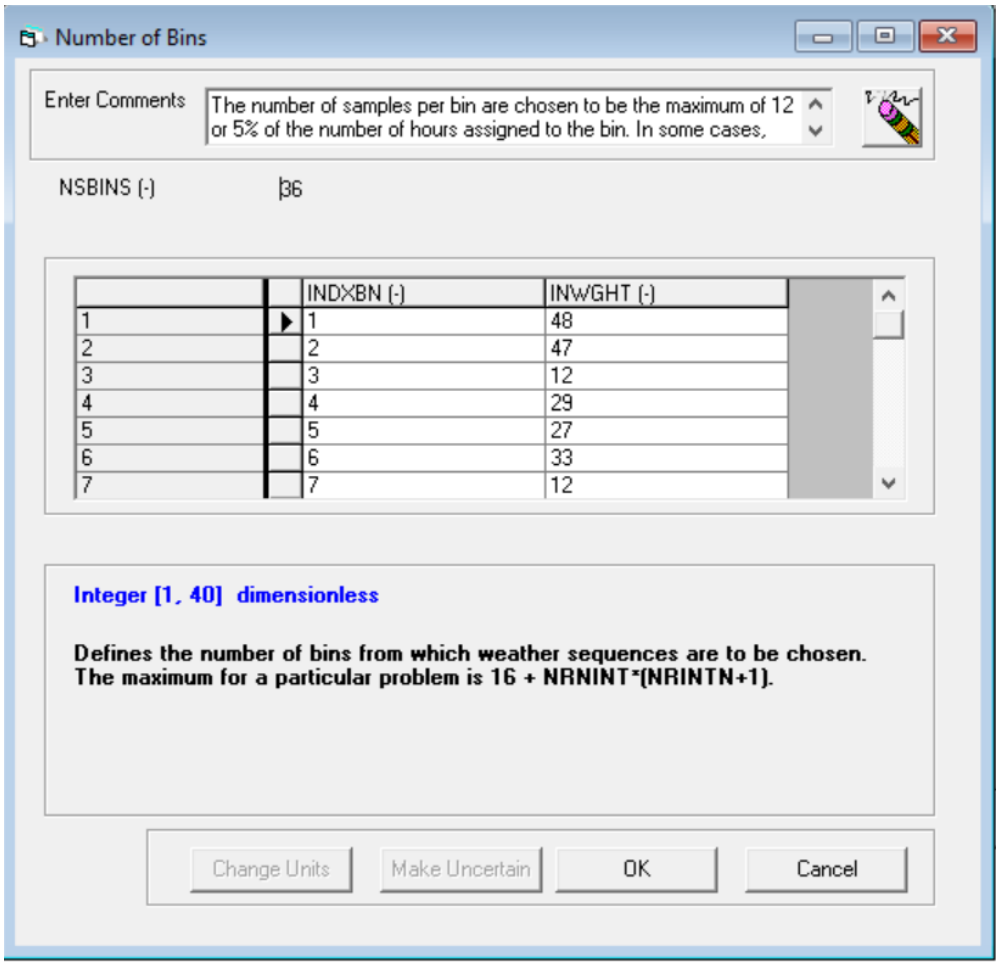


Figure 3-67 Bins Form

Table 3-66 Bins Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NSBINS	Linked	Integer	None	1 to 40
INDXBN	Yes	Integer	NSBINS	1 to 40
INWGHT	Yes	Integer	NSBINS	0 to 35040

Rain Distances Form

The Rain Distances form is required when either Uniform Bin Sampling (METCOD=2) or Nonuniform Bin Sampling (METCOD=2, NSMPLS=0) is selected on the Weather tab.

NRNINT defines the number of rain distance intervals used for weather binning. The value is determined by the number of entries in vector RNDSTS.

RNDSTS defines the rain distance interval endpoints used for the weather binning. MACCS requires that each of these distances lie within 10% of one of the spatial-interval endpoint distances, SPAEND, and that the user supply unique values in ascending order.

For example, if the user specifies 2, 4, 8, and 16 km, these values define the following four rain distance intervals:

(1). 0 km ≤ distance of first rain occurrence ≤ 2 km
(2). 2 km < distance of first rain occurrence ≤ 4 km
(3). 4 km < distance of first rain occurrence ≤ 8 km
(4). 8 km < distance of first rain occurrence ≤ 16 km.

Rain that occurs beyond 16 km in this example is not categorized as being in a rain bin. These weather sequences are categorized under the 16 bins defined in Table 3-58.

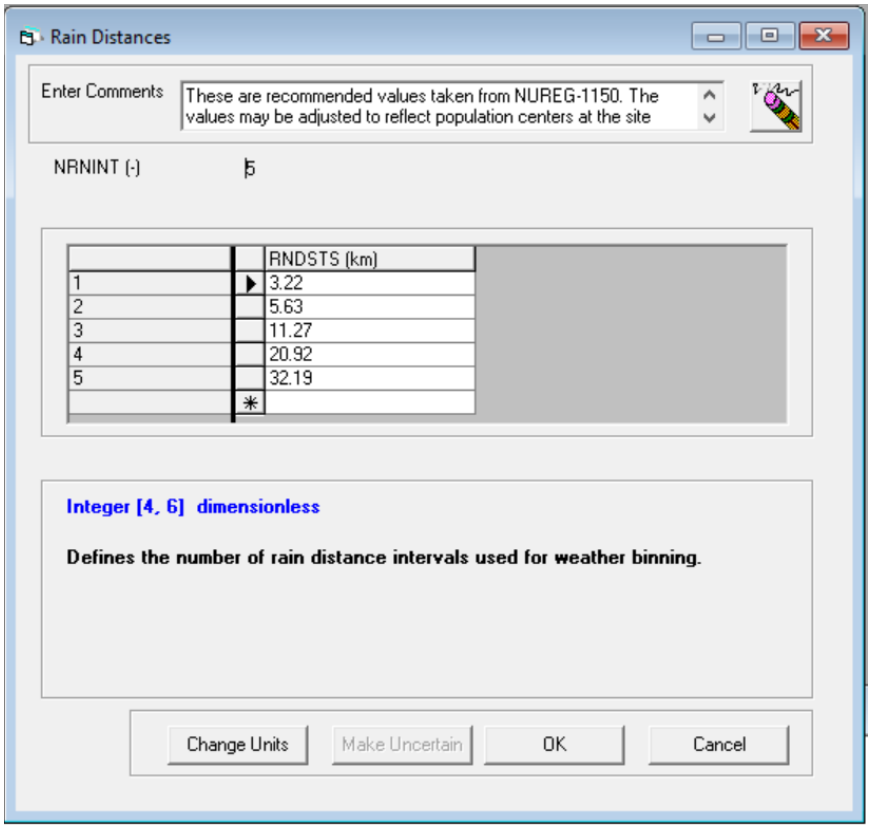


Figure 3-68 Rain Distances Form

Table 3-67 Rain Distances Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NRNINT	Linked	Integer	None	4 to 6
RNDSTS	Yes	Real	NRNINT	0.001 to 99.9 km

Rain Intensities Form

The *Rain Intensities* form is required when either *Uniform Bin Sampling (METCOD=2)* or *Nonuniform Bin Sampling (METCOD=2, NSMPLS=0)* is selected on the *Weather* tab. The user must specify either two or three rain intensities that are used as breakpoints in the categorization of precipitation rate. For example, if the user specifies two rain intensity breakpoints of 1 and 4 mm/hr, the following three rain intensity intervals, where *x* is the rain intensity, are used:

(1). 0 mm/hr < $x \leq$ 1 mm/hr

(2). 1 mm/hr < $x \leq$ 4 mm/hr,

(3). 4 mm/hr < x.

NRINTN defines the number of rain intensity breakpoints to be used for weather binning.

RNRATE defines the rain intensity breakpoints. MACCS requires that unique values are supplied in ascending order.

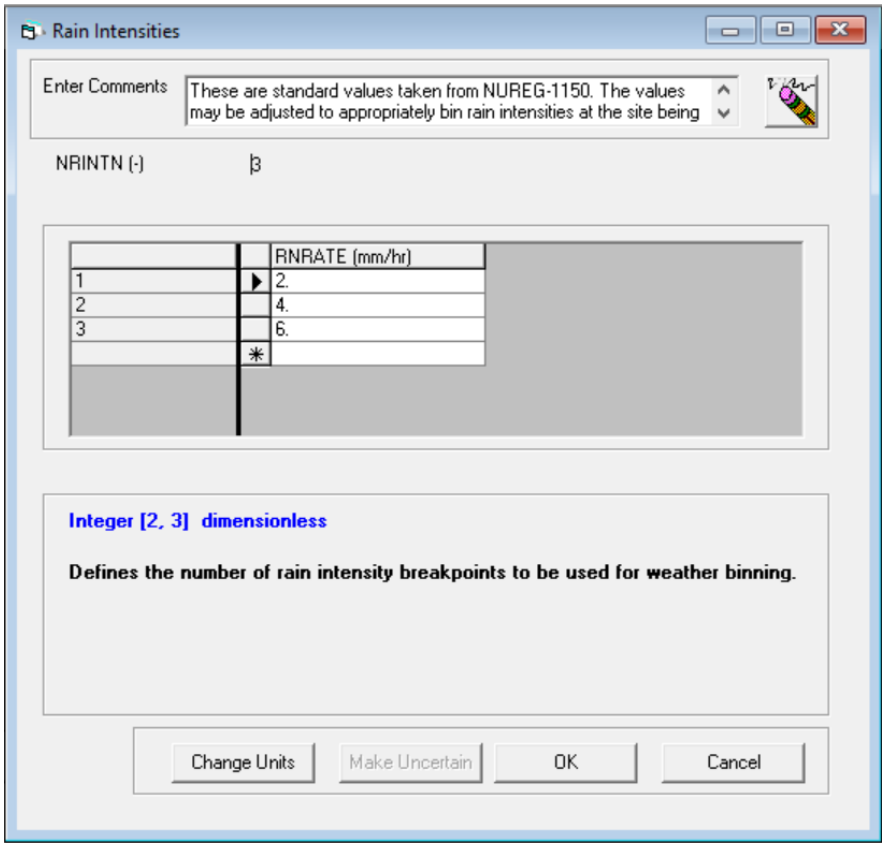


Figure 3-69 Rain Intensities Form

Table 3-68 Rain Intensities Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NRINTN	Linked	Integer	None	2 to 3
RNRATE	Yes	Real	NRINTN	0.001 to 100.0 mm/hr

3.2.11 Output Control

When requested by the user, the ATMOS module generates outputs for ten atmospheric modeling results for user-specified distances and plume segments, as listed in Table 3-69. Air and ground concentrations are reported for the radionuclide specified by the parameter NUCOUT. In addition, the total activity on the ground (from all radionuclides) is reported. Within a single run of the code, there is no provision for generating CCDFs of air and ground concentrations for multiple individual radionuclides. When such outputs are needed, separate MACCS runs are required to produce results for each radionuclide.

Table 3-69 Results available from ATMOS in statistical form.

Selected Radionuclide Centerline Air Concentration (Bq·s/m^3)
Selected Radionuclide Ground-Level Air Concentration (Bq·s/m^3)
Selected Radionuclide Centerline Ground Concentration (Bq/m^2)
Total Centerline Ground Concentration (Bq/m^2)
Ground-Level χ/Q Dispersion Factor (s/m^3) (Undepleted)
Selected Radionuclide Adjusted Source Strength, Q_a (Bq)
Plume σ_y, Crosswind Dispersion Parameter (m)
Plume σ_z, Vertical Dispersion Parameter (m)
Plume Centerline Height (m)
Plume Arrival Time at CenterPoint (s)

In the Gaussian plume equations, Q is commonly used to represent the amount released activity. When material decays or is deposited onto the ground during transport, the effective source strength for downwind distances is reduced. This is treated in MACCS through the definition of an adjusted source strength, Q_a, which is reduced by deposition and radioactive decay that occur over plume trajectory up to the current location. Note that all the concentration results shown in this table account for plume depletion; however, the value for χ/Q does not. This quantity simply represents the normalized concentration (s/m^3) from dispersion at a downwind distance.

3.2.11.1 Output Forms and Parameters

Output Control Form

The *Output Control* form is required. The user has the option of printing tables of dispersion data for all the trials that are performed. This information includes air and ground concentrations, σ_y and σ_z values, arrival time, and time overhead for each plume segment at each spatial interval. These data are written to the output file.

The following parameters can be written to the output file using the parameter IDEBUG.

Table 3-70 Additional ATMOS output information.

NUCNAM	name of the radionuclide for which results are reported
DISTANCE	distance from the point of release to the center of the spatial interval (m)
GL AIRCON	centerline ground-level time-integrated air concentration from this plume segment averaged over the spatial interval ($Bq \cdot s/m^3$)
GRNCON	centerline ground concentration after passage of this plume averaged over the spatial interval (Bq/m^2)
GL χ/Q	centerline ground-level χ/Q, the ratio of time-integrated air concentration (χ) to source strength (Q), averaged over the spatial interval (s/m^3). Values reported do not account for plume depletion by deposition or radioactive decay.
WETREM	fraction of material remaining in the plume segment after wet deposition along the plume trajectory up to the current location (dimensionless)
DRYREM	fraction of material remaining in the plume segment after dry deposition along the plume trajectory up to the current location (dimensionless)
REMINV	adjusted source strength of the plume accounting for losses over the plume trajectory from radioactive decay and wet and dry deposition (Bq)
PLSIGY	crosswind dispersion parameter, σ_y, at the current location (m)
PLSIGZ	vertical dispersion parameter, σ_z, at the current location (m)
WEATHER	indices to the first and last hours of the weather sequence used for determining atmospheric conditions during transport across each spatial interval
HTFCTR	ratio of the centerline ground-level air concentration ($z=0$) to the plume centerline air concentration ($z=H$), (dimensionless)
AVGHIT	average height (H) of the plume as it traversed the spatial interval (m)
TIMCEN	time after reactor shutdown at which the leading edge of the plume arrived at the current location (s)
TIMOVH	duration for which the plume was overhead at the current location (s)
MXMIXH	mixing height during plume passage through the current location (m)

IDEBUG specifies the quantity of debug output to be printed. For normal runs, IDEBUG should be set to 0 and no debug output is printed. If IDEBUG is set to 1 or 2, detailed results for atmospheric transport are generated for each weather trial and each plume segment. If IDEBUG is set to a value of 3 or more, the meteorological data used for each weather trial are also printed.

NUCOUT specifies which radionuclide is reported in the dispersion results. Debug results are only reported if IDEBUG is greater than zero. The specified radionuclide name must be in the previously defined list of radionuclides.

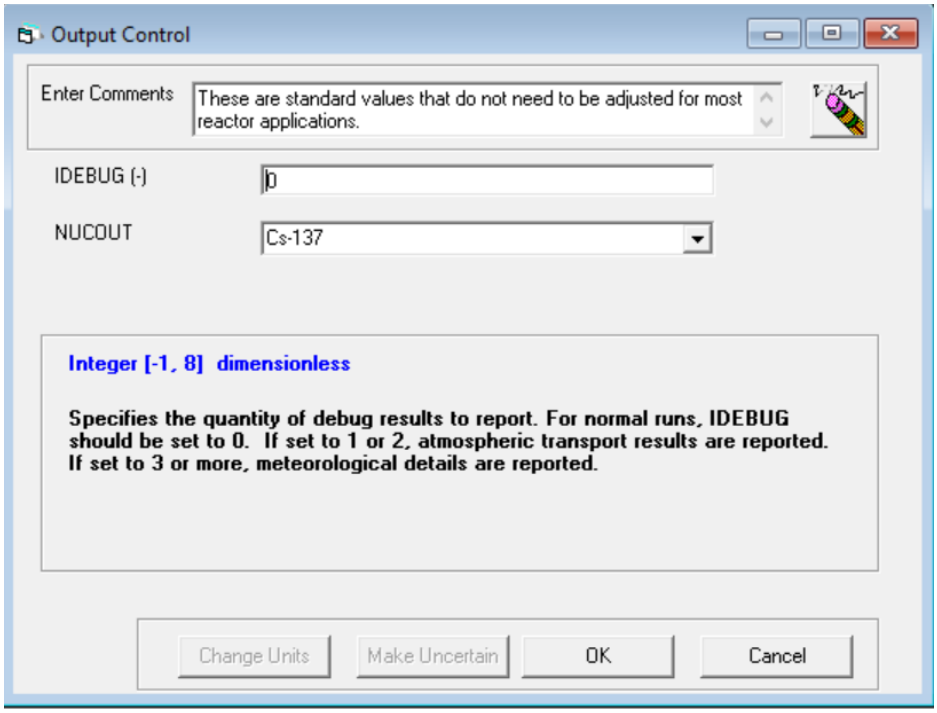


Figure 3-70 ATMOS Output Control Form

Table 3-71 ATMOS Output Control Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
IDEBUG	Yes	Integer	None	-1 to 8
NUCOUT	Yes	Character	None	Must be a radionuclide defined in vector NUCNAM

Spatial Intervals for Output Form

There are two *Spatial Intervals for Output* forms. The first one is used if *Multi Source Term* is not selected in the *Properties* form. The second one is used if *Multi Source Term* is selected. The *Spatial Intervals for Output* form is optional.

NUM0 specifies the number of results. For each request, a set of ten results describing atmospheric transport and dispersion is reported. The value of NUM0 is determined by the number of rows in the grid containing values of vectors INDREL, INDRAD, and Report Options.

INDREL specifies the index of the plume segment for which results are to be reported.

INDRAD specifies the index of the radial grid element for which results are to be reported. The reported values are evaluated at the radial midpoint of the grid element by averaging the results at the grid boundaries.

When Report Options are set to CCDF or CCDF & REPORT, the complementary cumulative distribution function data are reported in the MACCS output file. When set to REPORT or CCDF & REPORT, WinMACCS automatically generates a report over all realizations based on the quantile values specified on the *Reporting Options* form.

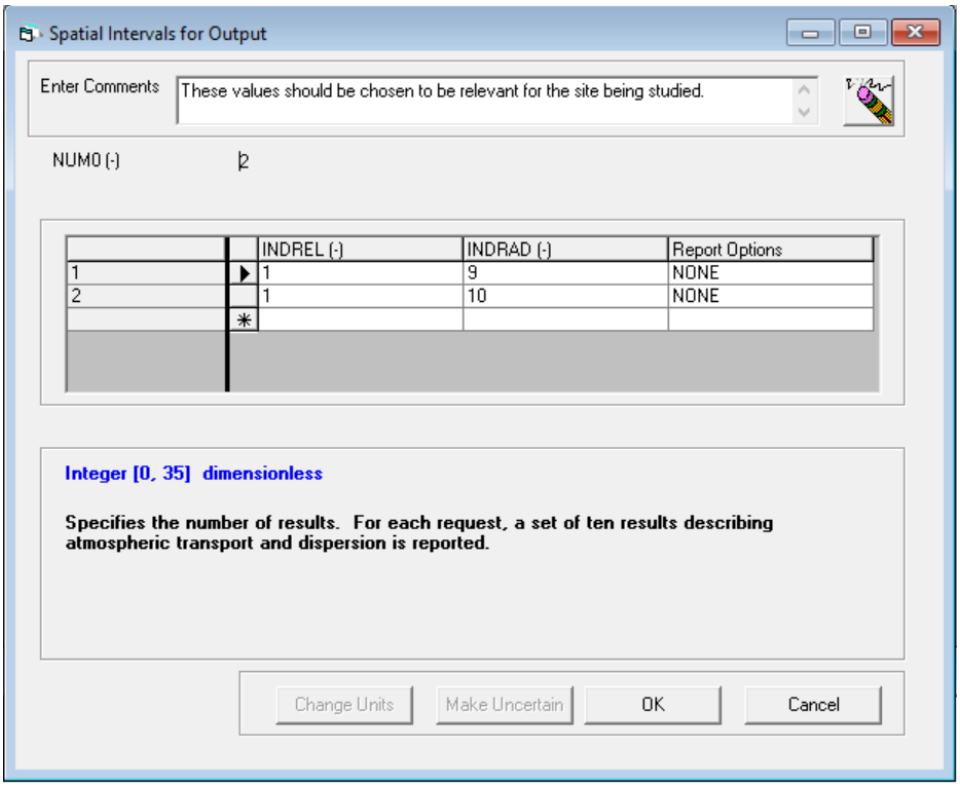


Figure 3-71 Spatial Intervals for Output Form

Table 3-72 Spatial Intervals for Output Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM0	Linked	Integer	None	0 to 999
INDREL	Yes	Integer	None	1 to NUMREL
INDRAD	Yes	Integer	NUM0	1 to NUMRAD
Report Options	Yes	Character	NUM0	CCDF, NONE, REPORT, CCDF & REPORT

3.3 EARLY Input and Model Description

3.3.1 Overview of EARLY

The EARLY module models the period starting with accident initiation. This period is commonly referred to as the emergency phase. It may extend up to 40 days after the arrival of the first plume segment at any downwind spatial interval. The subsequent intermediate and long-term phases are treated by CHRONC.

In the EARLY module the user may specify emergency response scenarios that include evacuation, sheltering, and dose-dependent relocation. The EARLY module has the capability to combine results from one to twenty different emergency response cohorts. The number of cohorts is specified on the *Evac/Rotation* tab found on the *GENERAL* main category under *Properties* in WinMACCS.

Results are output for each of the user-defined emergency response cohorts and for a weighted sum of the cohorts. Cohorts may be combined by assigning time fractions (frequencies of occurrence) to each cohort, population fractions (fraction of the population engaging in the specified behavior) to each cohort, or by a simple summation of the results for each emergency response cohort (when a unique population distribution is defined for each cohort). The weighting method is specified from the *Project/Site Data* tab.

CCDFs calculated for emergency response cohorts combined based on time fractions are a function of the probability for each meteorological trial/wind direction multiplied by the time fraction applied to the emergency response cohort. This assumes that all the population behaves like each of the cohorts some fraction of the time. Emergency response cohorts combined using population fractions are a function of the consequence calculated for each meteorological trial/wind direction multiplied by the fraction of people assigned to the cohort. This assumes that the population is divided into a set of responses, but those responses apply all of the time. The approach selected (fraction of people or fraction of time) affects the shape of the CCDF but does not affect the mean consequences.

For results that are calculated by both EARLY and CHRONC, such as population dose and cancer cases, the consequence calculated by CHRONC is added to the value of the same consequence measure produced by EARLY to generate the overall combined results. When more than one EARLY emergency response cohort is being run, these results are combined according to the weighting fractions supplied for each scenario parameter WTFRAC. The weighted sum is combined with the CHRONC result to produce the overall result. MACCS models the entire population as behaving the same in the CHRONC module, so only one CHRONC cohort exists. Whenever multiple cohorts are defined, the output file lists the overall combined results as well as results for each of the individual cohorts.

3.3.2 Dose Calculation

The calculation of radiation doses from early exposure considers five pathways: (1) direct external exposure to radiation from the plume (cloudshine), (2) exposure from inhalation of radionuclides in the cloud (cloud inhalation), (3) exposure to radioactive material deposited on the ground (groundshine), (4) inhalation of resuspended material (resuspension inhalation), and (5) skin dose from radionuclides deposited onto the skin.

Two kinds of doses are calculated: (1) acute doses used for estimating occurrences of early fatalities and injuries and (2) lifetime doses used for estimating occurrences of cancers resulting from the early exposure. The accumulation of radiation doses from early exposure is strongly dependent on the assumed emergency response (i.e., evacuation, sheltering, and relocation). Cloudshine and cloud inhalation exposures are limited to the time of cloud passage. Groundshine and resuspension inhalation doses from early exposure (emergency phase) are limited to the duration of the emergency phase.

In general, the dose equation for an early exposure pathway in each spatial element is the product of the following quantities: radionuclide concentration, usage factor, duration of exposure, DCF, and shielding or protection factor. The quantities used in the dose equations depend on the exposure pathway. For example, for the cloud inhalation exposure pathway, these quantities are the ground-level air concentration within a spatial element, breathing rate, duration of inhalation, inhalation DCF, and inhalation protection factor.

The DCFs for all exposure pathways are provided in the DCF files distributed with WinMACCS. However, the user can modify any of these factors by defining constant or uncertain values in WinMACCS.

DCFs are selected to be used with MACCS in one of the following three ways:

- A single, predefined file. In this case, the LNT model is selected on the *Properties/Dose* tab. Files based on DOSFAC2, FGR-11 and -12, and FGR-13 are distributed with WinMACCS. The user selects a file from the WinMACCS *GENERAL* main category under *File Specifications/Dose Conversion Factor File*.

- A set of 51 predefined files, a base file and a file for each of the 50 years of dose commitment. In this case, the PL or AT model is selected. Files of this type based on DOSFAC2 and FGR-13 are distributed with MACCS. The user selects a base file, e.g., FGR13DCF.INP, on the form found in the WinMACCS *GENERAL* main category under *File Specifications/Annual Differential DCF Files*.

- A single file or 51 files created by WinMACCS based on user input values. In this case, a predefined DCF file or files are used as the basis. The source of the DCF file is set to *File Created from Existing DCF File* on the *Properties/Dose* tab. Values in the DCF file are modifiable for nuclides selected on the *DOSE COEFFICIENTS/Reveal Nuclides* form.

A MACCS user has some flexibility in the selection of a DCF file. Files based on (1) DOSFAC2, a pre-processer using data from DOE/EH-0070 and tissue weighting factors from ICRP-26 and -60; (2) based on Federal Guidance Reports 11 and 12, and (3) files based on Federal Guidance Report 13 (FGR-13). The DCF set based on FGR-13 is the most complete and current and is recommended for most consequence analyses.

As a side note, the ICRP traditionally used the term DCFs to refer to coefficients that convert activity levels for an exposure pathway to doses. The newer ICRP term is dose coefficients. In this document and in the WinMACCS interface, the two terms are used interchangeably.

The list of organs that can be used in a calculation depends on which DCF file is selected, with WinMACCS 4.0 supporting all organs in specified DCF file. WinMACCS forms show organ doses with an A- or an L- prefix. Organ doses beginning with A- (e.g., A-SKIN) are used for acute exposure doses in the EARLY module; organ names beginning with L- (for example L-THYROID) are lifetime, 50-year doses that are used in both the EARLY and CHRONC modules. Acute internal doses from inhalation are calculated over a much shorter commitment period than lifetime doses. Because of the shorter commitment period, acute doses are less than or equal to lifetime doses for the same organ. The method used to construct the acute doses accounts for dose protraction by weighting internal doses received after the first day less heavily than doses received during the first day.

The DCF files do not use the A- or L- prefix for the organ names. They contain columns of data, some of which correspond to acute doses, some to lifetime doses, and some are used for both. The DCFs for acute or lifetime exposures depend on exposure pathway.

Though SKIN is listed as an organ in the FGRDCF DCF file, the numbers for SKIN in the DCF file are not used in the acute exposure calculation for A-SKIN. Dose to the skin is calculated directly in MACCS based on beta energy depositing in the skin from radionuclides that have deposited onto the skin. This is different than the long-term skin dose (L-SKIN), which is calculated using values in the FGRDCF file. To make this distinction clear, the lifetime organ dose is labeled L-SKIN(FGR).

When a COMIDA2-generated input file is used in a MACCS run, MACCS must use the same DCF file as the one used to generate the COMIDA2 file. The first two header records of the DCF files

used by MACCS and COMIDA2 are read and compared to ensure that the two sets of calculations used the same DCF file. This is important when predefined COMIDA2 files are used.

The duration of exposure depends on the exposure pathway and the emergency response at a spatial element and is calculated based on user-supplied data. The shielding factor is a dimensionless quantity used to reduce the radiation dose as a result of shielding protection provided by a given protective action for a given exposure pathway. Shielding factors for the various exposure pathways (cloudshine, inhalation, groundshine, and skin dose) and for three different groups of people (evacuees, people continuing normal activity, and people taking shelter) are specified by the user.

The evacuation model incorporates two delay times that affect the timing of evacuation: one is a delay to shelter and the second is a delay to evacuate. Different shielding factors and breathing rates can be used while people continue normal activity, take shelter, or evacuate.

The EARLY calculation accumulates the radiation doses for an evacuating population by adding the doses they receive during normal activity, sheltering, and evacuation. This is done until the evacuees reach a user-defined distance where they are assumed to avoid further exposure. Evacuees can return to their residences during the emergency phase, depending on user inputs, only when no additional radiation exposure would be received.

The CHRONC module allows the user to define dose projection criteria that determine whether evacuees return to their original locations during the intermediate and long-term phases. Additional radiation doses are calculated in the CHRONC module.

Before a population shelters, the members of the population are assumed to be carrying out normal activities. Shielding factors (cloudshine, groundshine, inhalation, and skin) for normal activity apply to them during this period. When the members take shelter, shielding factors for sheltering apply. After they begin to evacuate, shielding factors for evacuation apply. The user defines the durations of each of these activities; a null period is possible (e.g., no time duration for sheltering).

The plume transport model assigns the plume a finite length calculated by using the assigned release duration and wind speed(s) during the release. The length of a plume segment is constant following the release (i.e., the front and back of the plume travel at the prevailing wind speed), and the concentration of radioactive material is assumed to be uniform over the length of a segment. The radial position of evacuating persons, before or during evacuation, is compared with the positions of the front and back of the plume as a function of time to determine the period of exposure to airborne radionuclides.

3.3.3 Model Basis

3.3.3.1 Basic Model Description

Grid Subdivisions

The basic nodalization used in MACCS is defined above in the description of the spatial grid in the ATMOS section. In addition to this basic grid, a more refined grid, called the fine grid, is used in EARLY to calculate off-centerline doses. The fine grid is used both for calculation of early and latent health effects during the early (i.e., emergency) phase.

Each one of the compass sectors is further subdivided into several fine grid divisions. The number of fine grid divisions is specified by the user and can be 3, 5, or 7.

The off-centerline correction factor of a fine spatial element for the cloudshine pathway is calculated in a different manner than the correction factors for the other exposure pathways during the emergency phase. For the cloudshine pathway, the off-centerline correction factor within a fine spatial element is the finite cloud correction factor discussed below. This factor considers both the total distance to the plume centerline and the size of the plume. It accounts for the geometrical view factor between the plume and the receptor.

For cloud inhalation, groundshine, resuspension inhalation, and skin exposure pathways during the emergency phase, the Gaussian crosswind distribution is evaluated at the CenterPoint of each fine grid. The outermost extent of the plume is taken to be the azimuthal location where the Gaussian distribution falls to one-tenth of its peak, i.e., the outermost fine grid that contains the point where the crosswind distance (measured around a circular arc) is ($2.15 \times \sigma_y$) from the plume centerline.

Weather Sampling and Wind Rose Probabilities

One of the basic options in MACCS that affects weather sampling is chosen under the Evac/Rotation tab. This choice defines the MACCS parameter, IPLUME. These options capture two independent concepts for weather sampling: wind shift and rotation.

Wind shift carries the idea of variations in wind direction. Wind shift only matters when a release is divided into multiple plume segments. The simplest Gaussian plume methods do not allow any variations in wind conditions. These methods treat the entire plume as following along a single direction, at a single speed, with a single stability class. The MACCS implementation of the Gaussian plume model is much more general. One of the generalizations is that plume segments can travel in different directions, depending on the directions indicated in the weather data that are being used. For example, suppose the wind blows toward the north in the first hour and toward the east in the second hour. When two plume segments are modeled, each with release duration of one hour, the first plume segment travels north. The direction of the second plume segment depends on whether wind shift is included in the calculation or not. When it is, the second plume segment travels in the direction that the weather data indicate, to the east. When wind shift is not included, both plume segments travel in the same direction, to the north.

Rotation is a numerical convenience for squeezing more information out of a set of results without significantly increasing the computational time required. Rotation uses wind-rose probabilities to expand a result for a single weather trial into a set of NUMCOR results, where NUMCOR is the number of compass directions treated in the calculation. For example, suppose MACCS performs a weather trial for which the initial wind direction is to the north. When rotation is not used, this is the only result that is computed. When rotation is used, NUMCOR results are constructed. These results are based on the probabilities that the wind might have blown in each of the compass directions, given that other weather conditions (e.g., stability class and wind speed, are within the same bin (weather binning is described previously)). As a simple example, suppose the probability of the wind blowing in each compass direction is 1/NUMCOR. For this case, MACCS constructs the consequences assuming the initial wind direction was toward each of the compass sectors and assigns each result a probability of 1/NUMCOR times the probability of the original weather trial selected from one of the weather bins. The rotation option is only available when the weather bin option for constructing a set of weather trials. The wind rose probability for each result is the value for the wind direction and the weather bin (i.e., a wind rose is calculated for each weather bin and used for weather trials belonging to that bin).

The assumption that the conditional probability of a weather trial occurring in any compass direction is the same as the wind rose probability for that direction is perfectly reasonable when only a single plume segment is modeled. Even when two plume segments are treated, the

underlying assumption becomes somewhat questionable. The larger the number of plume segments modeled in a calculation, the more dubious this assumption becomes. This is because the underlying assumption is that the entire pattern of wind shifts that define a weather trial can be rotated in any direction around the compass, and that the likelihood only depends on the wind-rose probability of the initial wind direction for that weather trial. Thus, for extended releases modeled with more than a few plume segments, modeling plume transport without rotation is the preferred option.

There are three options allowed by MACCS, which are defined as follows:

- **No Wind Shift with Rotation.** In this case, all plume segments follow the same direction as the first plume segment. However, for each weather trial, results are constructed as though the wind had blown in each compass direction. The relative probability of the wind blowing in each compass direction is taken from wind rose data, usually constructed from the weather file. Optionally, the user can specify a wind rose in the input.

- **Wind Shift with Rotation.** In this case, all plume segments follow the direction indicated by the weather data when the plume segment begins to be released. Depending on the weather data, each plume segment can travel in a different direction than the other plume segments. Wind rose probabilities are used to construct N different results where the wind shift pattern is preserved for each of these results. For example, suppose that in the initial calculation, plume segment 1 travels toward compass sector 1 (north) and plume segment 2 travels toward compass sector 2. In the first rotation, plume segment 1 travels toward compass sector 2 and plume segment 2 travels toward compass sector 3. This pattern continues for each possible compass direction.

- **Wind Shift without Rotation.** In this case, wind shift is performed but wind rotation is not. This is the only option that is allowed when the network evacuation model is selected or either the speed multiplier or keyhole evacuation model is activated. This is because the symmetry assumptions required for rotation to be valid are violated with these options. This is the preferred option when multiple plume segments are treated.

MACCS supports six choices for selection of one or more weather trials. Three of these are single weather-trial options; the remaining three support random sampling from annual data. These weather sampling options are described in this section. Specifically, the interaction between wind rose data and sampling option is described.

- **Constant Weather.** Conditions are specified on the *Constant or Boundary Conditions* form. However, the user is not allowed to specify wind direction. When wind rotation is not included, wind direction is always to the north. When wind rotation is included, wind directions are assumed to be distributed uniformly around the compass. Wind shift has no affect since wind directions are constant for each weather trial.

- **User Supplies 120 Weather Points.** Weather conditions are specified on the *User-Supplied Weather* form. This form allows the user to specify hourly wind directions. When wind rotation is used, the wind rose is assumed to be uniform around the compass. When wind shift is used, the direction taken by each plume segment is defined by the user-specified wind direction at the time it is released.

- **Fixed Start Time.** This option works the same as the User Supplies 120 Weather Points option except that the weather data are extracted from the weather file, beginning with the day and time period specified under the *Fixed Start Time Data* form. When weather

data are read from the weather file, however, 1200 hours of data are extracted rather than only 120 hours to represent temporal weather variations.

- **Uniform Bin Sampling.** Weather data, including wind direction, are taken from the weather file. When wind rotation is performed, the default is that a separate wind rose is constructed within MACCS for each weather bin. Therefore, the wind rose varies from weather trial to weather trial, depending on which weather bin the trial is taken from. When OVRRID = True, the data on the *Wind Rose Probabilities* form are used for all weather trials, regardless of which weather bin they are taken from. 1200 hours of data are extracted from the weather file to represent temporal weather variations for each weather trial.

- **Nonuniform Bin Sampling.** This option works the same as Uniform Bin Sampling, except that the user defines the number of weather trials to be sampled from each weather bin. 1200 hours of data are extracted from the weather file to represent temporal weather variations for each weather trial.

- **Stratified Random Sampling.** No weather binning is performed for this option. Instead, a user-specified number of weather trials are selected randomly from each weather day. Because weather bins are not created, MACCS does not assemble wind rose data and, thus, each weather trial is handled similarly as in the *User Supplies 120 Weather Points* option. When wind rotation is not used, wind directions are taken directly from the weather file. When wind rotation is used, the wind rose is assumed to be uniform around the compass. 1200 hours of data are extracted from the weather file to represent temporal weather variations for each weather trial.

Relocation Model Description

Relocation is a post-accident protective measure designed to limit radiation exposure and is implemented in MACCS following plume arrival. The model provides four alternatives for relocation, including hot-spot relocation during the emergency phase, normal relocation during the emergency phase, relocation during the intermediate phase, and relocation during the long-term phase. During the emergency phase, relocation occurs at a user-specified time after plume arrival, conditional on a projected dose from cloudshine, groundshine, cloud inhalation, and resuspension inhalation that exceeds a user-specified limit.

MACCS includes the ability to simulate relocation of residents from areas of elevated dose rate through the hotspot and normal relocation parameters. The user can specify a hotspot relocation criterion and a normal relocation criterion. For both relocation criteria, the user specifies a dose limit, a dose projection period, the critical organ for the dose limit, and a relocation time. MACCS requires that the dose for hotspot relocation be greater than or equal to the dose for normal relocation and the delay time for hotspot relocation be less than or equal to the delay time for normal relocation. The concept is that the segment of the public that would receive larger doses would be relocated more urgently than those who would receive smaller doses. However, the two criteria can be collapsed into a single criterion by specifying all the parameters to be the same for the two relocation types.

To evaluate the need for relocation during the emergency phase, the dose received from the sum of the following dose pathways is considered: cloudshine, inhalation of the cloud during plume passage, groundshine, and inhalation of resuspended contamination. These doses are assessed beginning with the arrival of the first plume segment for the dose-projection period. They are based on lifetime doses.

The relocating population is assumed to be in normal activity before relocation. Thus, the shielding factors for normal activity are used. Once the population is relocated, no further dose is calculated for them during the emergency phase. Additional doses could be calculated in the CHRONC module for the intermediate and long-term phases. The criterion for determining whether they return to their original spatial element depends on dose projections. The dose projection criterion used for relocation during the long-term phase is commonly referred to as the habitability criterion.

Emergency Phase Resuspension

The resuspension model in MACCS is the following:

$$C = G \cdot RESCON \cdot 2^{-t/RESHAF} \quad \textbf{(3-27)}$$

Where

C = Air concentration at ground level from resuspension (Bq/m^3)
G = Concentration on ground (Bq/m^2)
t = Time measured from the time of deposition (s)

RESCON is the initial value of the resuspension coefficient (m^{-1}) and RESHAF is the resuspension coefficient half-life (s), which accounts for weathering.

Keyhole Model

The standard MACCS evacuation model assumes that the evacuation region is a circular area. With keyhole evacuation, the evacuation area is a keyhole-shaped area (i.e., a circular area surrounding the site and an odd number of consecutive sectors projecting out to a larger radius), as illustrated in Figure 3-72. The region is defined by the radius of the inner, circular area, the number of sectors to evacuate beyond the circular area, and the outer radius of the evacuation area.

Initially, the keyhole is centered on the wind direction, as shown by the yellow and purple portions of the keyhole in Figure 3-72. The keyhole is expanded as the wind direction changes in subsequent hours, as illustrated by the green and orange portions of the keyhole. The purple and orange sectors are in the downwind directions before and after the wind shift, respectively.

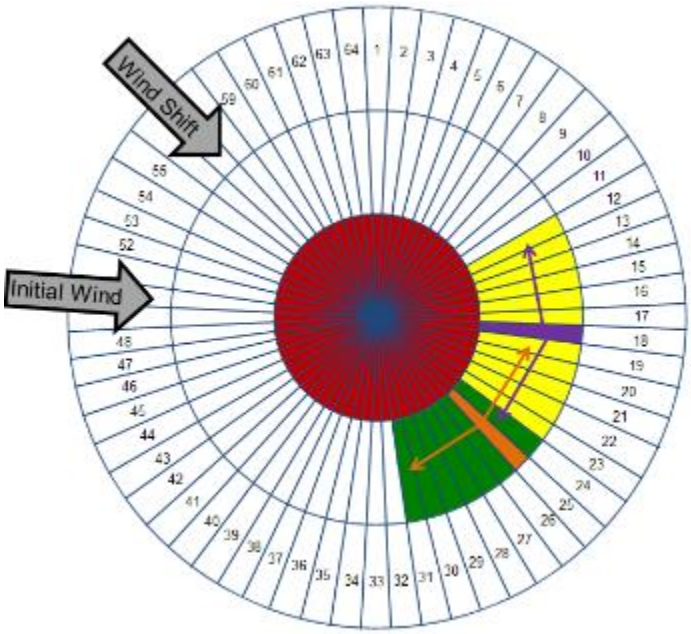


Figure 3-72 Illustration of the MACCS keyhole evacuation model

An additional concept employed with the keyhole model is to allow the keyhole to be expanded in advance of an actual wind shift to account for weather forecasting. The parameter in WinMACCS to accomplish this is named KEYFORCST. The user must specify the number of hours of weather forecasting to use in the model. When the number of hours is four, for example, the model considers the wind directions that occur over the next four hours and expands the size of the keyhole accordingly. The MACCS implementation inherently assumes that wind shifts are forecasted with 100% accuracy for KEYFORCST hours, so this value should be considered in this light.

3.3.3.2 Basic Early Forms and Parameters

Early Description Form

The *Early Description* form has one parameter that contains a brief description of the early model. This description is printed in the output file. This form is required when *Early Consequences* are selected on the *Properties/Scope* tab.

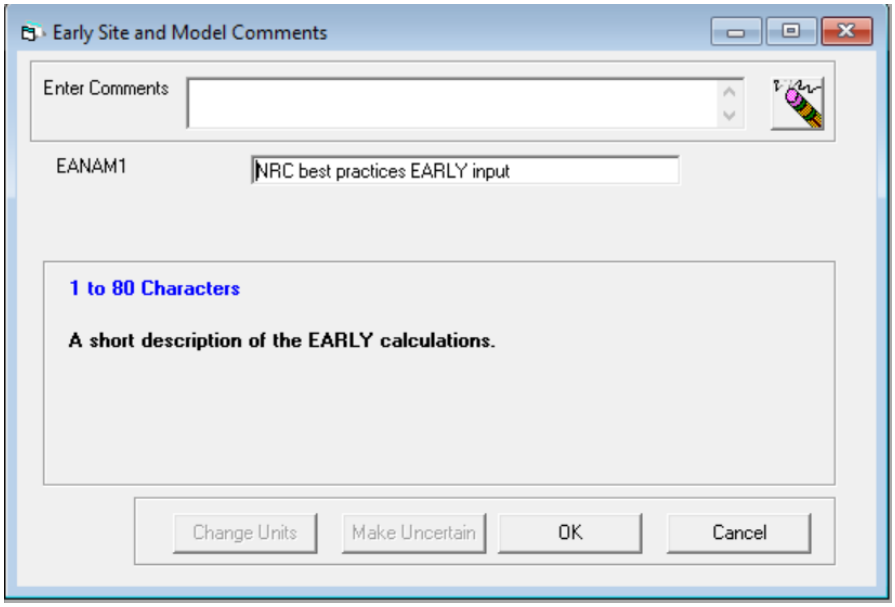


Figure 3-73 Early Site and Model Description Form

Table 3-73 Early Site and Model Description Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
EANAM1	Yes	Character	None	1 to 80 characters

Property Form Parameters Form

The *Property Form Parameters* form shows how selections under the *Properties* form define some important parameters that are required in the EARLY input to MACCS. The parameters cannot be changed from this form; they are read only. Details about these parameters are provided in the following paragraphs.

POPFLG determines the source of population data. The value is set to FILE when the population is provided by a file either generated by the preprocessor, SecPop, or separately. POPFLG is set to UNIFORM when the population is to be treated as uniformly distributed on the grid.

WTNAM determines the method used for combining results from different cohorts when generating overall results. When PEOPLE or TIME is selected, the weighting factor for each cohort is determined by the value of WTFRAC. Results from CHRONC are included as a single, separate cohort, and are simply added to the weighted results from EARLY. When WTNAM is set to SUMPOP, the population for each cohort is present in the site file under headings POPULATION1, POPULATION2, etc., for each cohort. Such a site data file can be created by hand or by using a relatively new feature of WinMACCS described below. When this option is used, the values of WTFRAC are not needed to combine results from the EARLY cohorts.

KIMODL determines whether consequence calculations consider potassium iodide (KI) ingestion. The value is set to KI when the effect of KI is to be included or to NOKI when it is not to be included in a calculation. When included, parameters regarding the percentage of the population ingesting KI and its efficacy at reducing thyroid dose must be defined, as explained below.

DOSMOD determines which model is used for calculating dose. The choices are LNT, Annual Threshold (AT), or piecewise linear (PL). The simplest and traditional choice is the LNT model,

for which only one DCF file is required. That file contains internal dose coefficients for a 50-year commitment period. Other choices require additional user input for threshold values and a set of 51 dose coefficient files. The additional 50 files break down the dose-commitment period of 50 years into annual periods.

EVATYP determines the evacuation model. The choices are NONE, RADIAL, or NETWORK. When RADIAL or NETWORK is chosen, further user input to define evacuation behavior is required. RADIAL models evacuation as being radially outward within each sector. NETWORK allows evacuees to travel from one grid element to any of the four adjacent grid elements.

OVRRID is a flag set to either True or False. This flag allows the user to override the default values used for wind rose probabilities. When either uniform or nonuniform weather bin sampling is selected, the wind rose probabilities are usually calculated from the weather file; when OVRRID is set to True, the default wind rose probabilities are replaced by user-specified values. When weather binning is not selected, equal probabilities (1/NUMCOR) are assumed for each compass direction regardless of the value of OVRRID. OVRRID can be set to True when a meteorological file is not available for the actual site being studied but wind rose data are available for the site. This option allows local wind rose characteristics to replace those contained in a meteorological data file. It assumes that other weather characteristics of the site are like those in the file. Wind rose data are only needed when rotation is chosen (IPLUME = 1 or 2); otherwise, wind directions are taken directly from the weather file and wind rose probabilities are not used.

IPLUME defines two characteristics regarding plume transport. When set to 1, no wind shift is modeled; when set to 2 or 3, wind shift is modeled. No wind shift means that all plume segments travel in the same direction; wind shift means that each plume segment can travel in its own direction, depending on the wind direction at the time of its release. The second characteristic is rotation. When IPLUME is set to 1 or 2, rotation is used; when IPLUME is set to 3, no rotation is used. These two concepts, wind shift and rotation, are discussed in more detail above.

KEYAVAIL determines whether the keyhole evacuation model can be chosen for evacuation. When KEYAVAIL is equal to KEY_NOT_AVAIL, the choices for the cohort evacuation are circular or none. When KEYAVAIL is equal to KEY_AVAIL, the choices for the cohort evacuation are circular, none, or keyhole. When set to KEY_AVAIL, the only choice is IPLUME = 3.

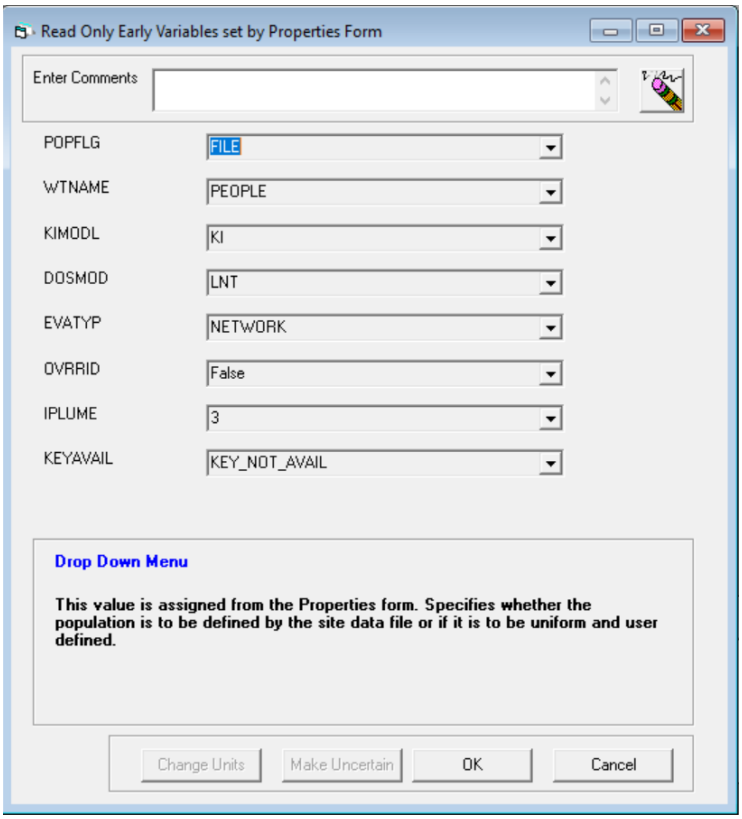


Figure 3-74 Property Form Parameters Form

Table 3-74 Property Form Parameters Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values	Defined on Form
POPFLG	Read Only	Character	None	FILE, UNIFORM	*Site Data* tab on *Properties*
WTNAME	Read Only	Character	None	PEOPLE, TIME, SUMPOP	*Site Data* tab on *Properties*
KIMODL	Read Only	Character	None	KI, NOKI	*Dose* tab on *Properties*
DOSMOD	Read Only	Character	None	LNT, AT, PL	*Dose* tab on *Properties*
EVATYP	Read Only	Character	None	RADIAL, NETWORK, NONE	*Evac/Rotation* tab on *Properties*
OVRRID	Read Only	Logical	None	True, False	*Wind Rose* tab on *Properties*
IPLUME	Read Only	Integer	None	1 to 3	*Evac/Rotation* tab on *Properties*
KEYAVAIL	Read Only	Character	None	KEY_AVAIL, KEY_NOT_AVAIL	*Evac/Rotation* tab on *Properties*
Animation Movement	Read Only	Logical	None	True, False	*Animation/Health Effects tab* on *Properties*
Animation Concentration	Read Only	Logical	None	True, False	*Animation/Health Effects tab* on *Properties*

3.3.3.3 Basic Model Forms

Grid Subdivisions Form

The *Grid Subdivisions* form is required. NUMFIN is the number of fine-grid subdivisions used by the model. The fine grid is used to improve the resolution of doses in EARLY. This is especially important for non-linear dose responses such as early health effects. Each of the grid elements is subdivided into NUMFIN fine-grid elements in the azimuthal direction. NUMFIN is used in the calculations performed by EARLY to improve resolution for consequences that behave nonlinearly with dose, e.g., early health effects. Values in CHRONC are averaged over the fine grid at the course grid level because the consequences evaluated for the intermediate and long-term phases behave relatively linearly with dose.

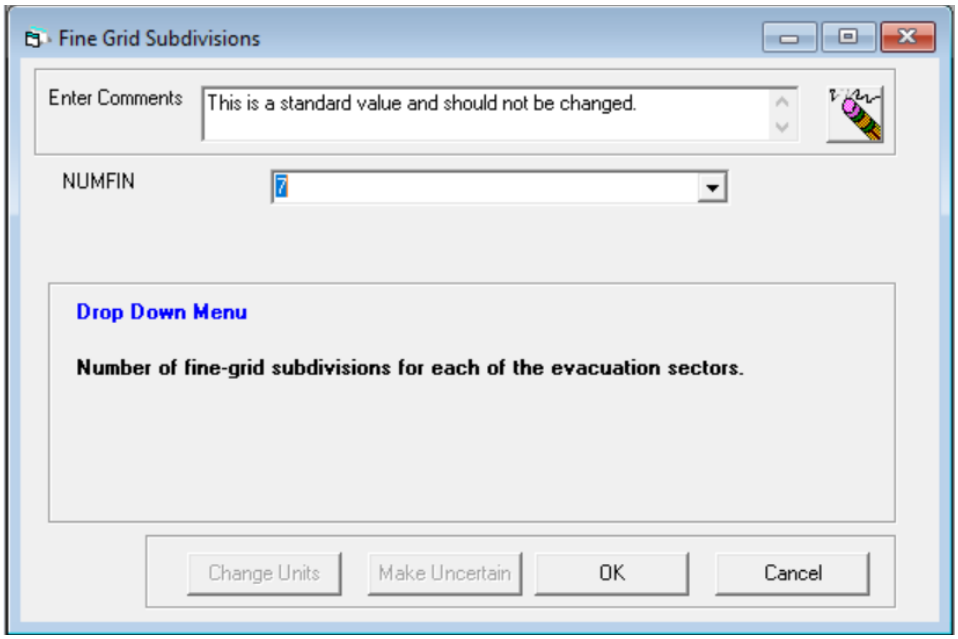


Figure 3-75 Grid Subdivisions Form

Table 3-75 Organs of Risk Fine Grid Subdivisions Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMFIN	Yes	Character	None	3, 5, 7

Wind Rose Probabilities Form

The *Wind Rose Probabilities* form is required when the user selects *User Supplied* on the *Wind Rose* tab.

WINROS contains the probabilities of the wind blowing from the site toward each of the compass sectors. Values are listed clockwise starting with the value for north. When these values do not approximately sum to unity, MACCS validation fails and generates an error message.

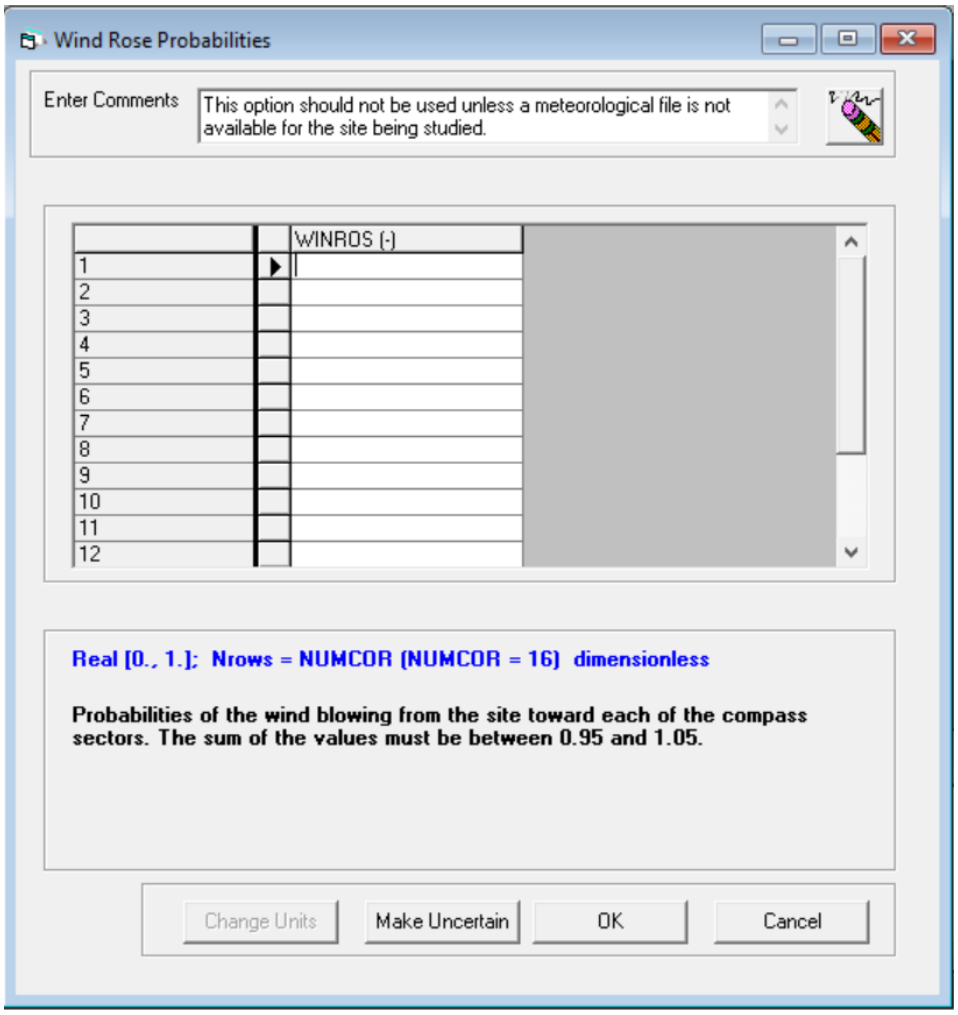


Figure 3-76 Wind Rose Probabilities Form

Table 3-76 Wind Rose Probabilities Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
WINROS	Yes	Real	NUMCOR	0.0 to 1.0

Uniform Site Data Form

The *Uniform Site Data* form is required when the user selects *Uniform* on the *Site Data* tab of the *Properties* form. This information is required when a site data file is not used.

IBEGIN specifies the spatial interval beyond which the population begins. Inside the radius corresponding to IBEGIN, the assumption is that there is no population. This can be used to represent the exclusion area.

POPDEN specifies the uniform population density of the region.

FRACLD specified the average fraction of the region that is land.

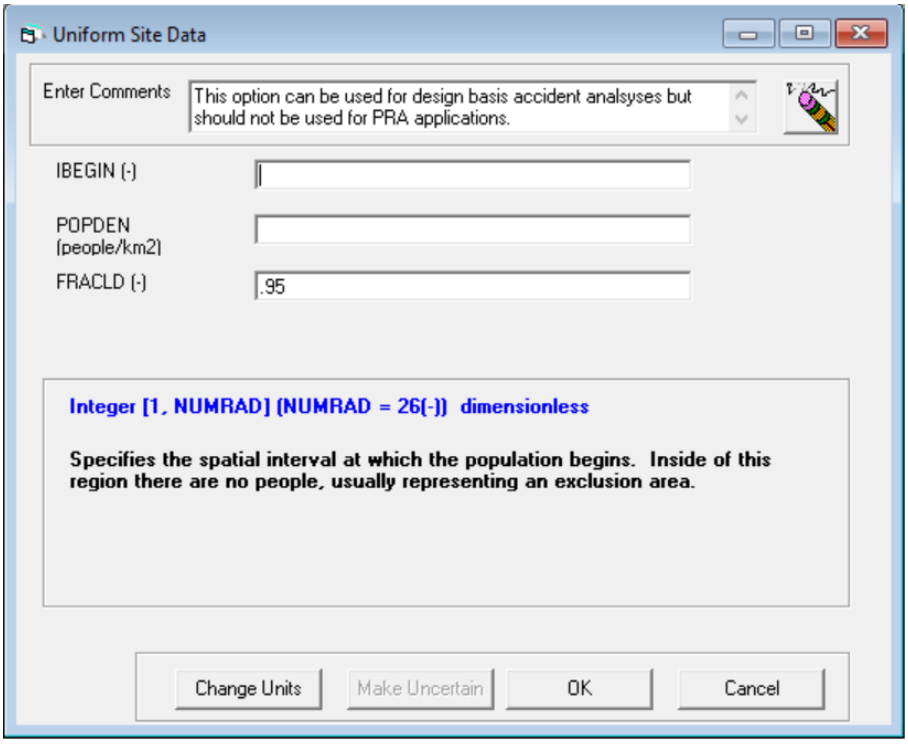


Figure 3-77 Uniform Site Data Form

Table 3-77 Uniform Site Data Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
IBEGIN	Yes	Integer	None	1 to NUMRAD
POPDEN	Yes	Real	None	0 to 1,000,000 people/km^2
FRACLD	Yes	Real	None	1×10^{-6} to 1.0

Population from Site File Form

The *Population from Site File* form is active when the user selects "*Import from File*" on the *Site Data* tab of the *Properties* Window. The *Population from Site File* form contains a table with columns for the set of compass sectors and rows labeled with values of SPAEND (radial distance). The table contains the total population in each grid element read from the site file.

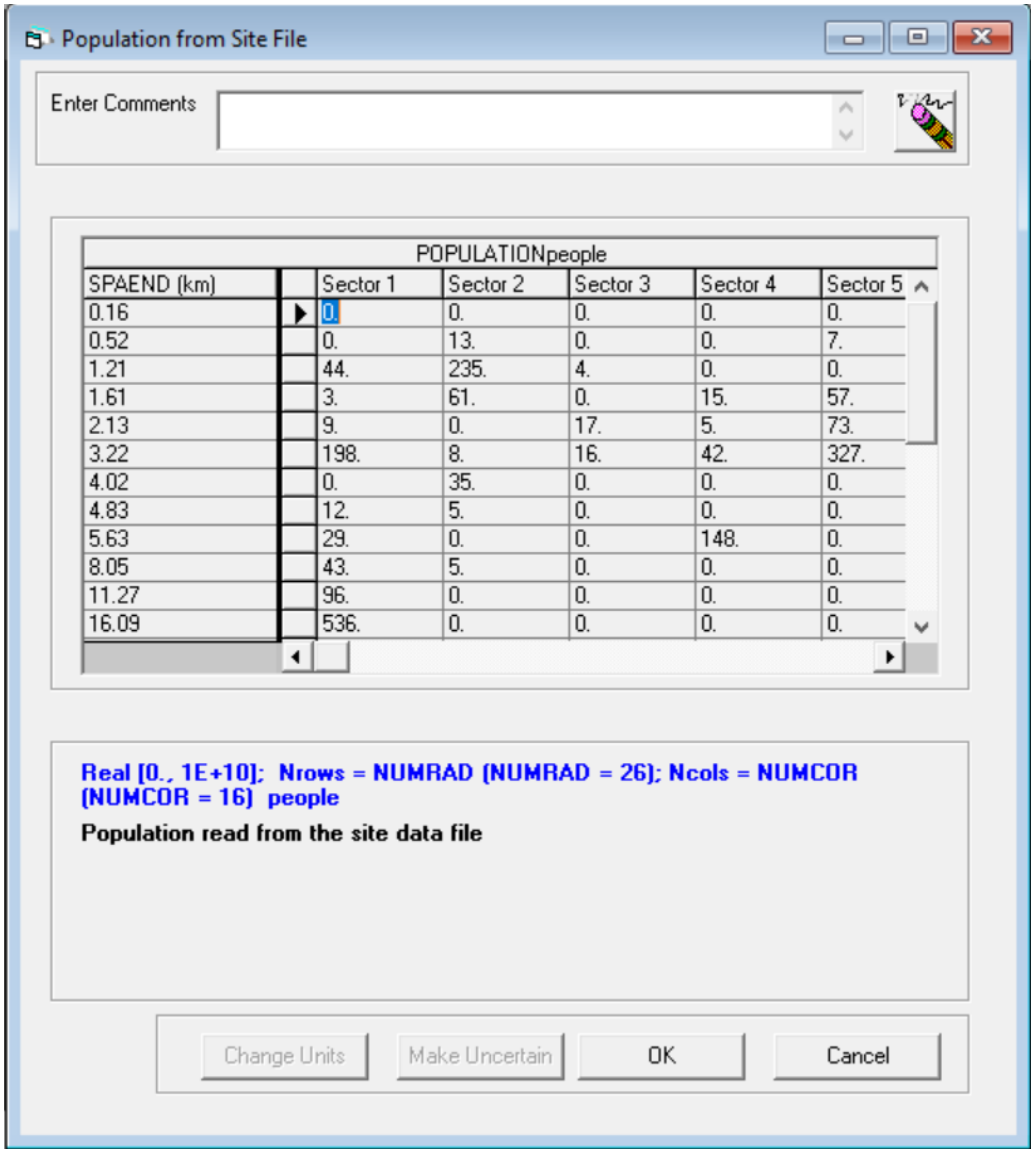


Figure 3-78 Population from Site File Form

Organs of Risk Form

The *Organs of Risk* form is required when the user selects *Predefined DCF File* on the *Dose* tab. This form allows all organs in the specified DCF file to be selected for health effects calculations. Organs predefined in the DCF file are prepopulated in the left column. Users may select organs to be included in calculations by placing them in the right column using the arrows. The first organ selected is always A-Skin, independent of the dose conversion file. A-Skin cannot be deselected because it is calculated in MACCS independently of values in the DCF file. Once the DCF file is defined, organs on this form can be selected.

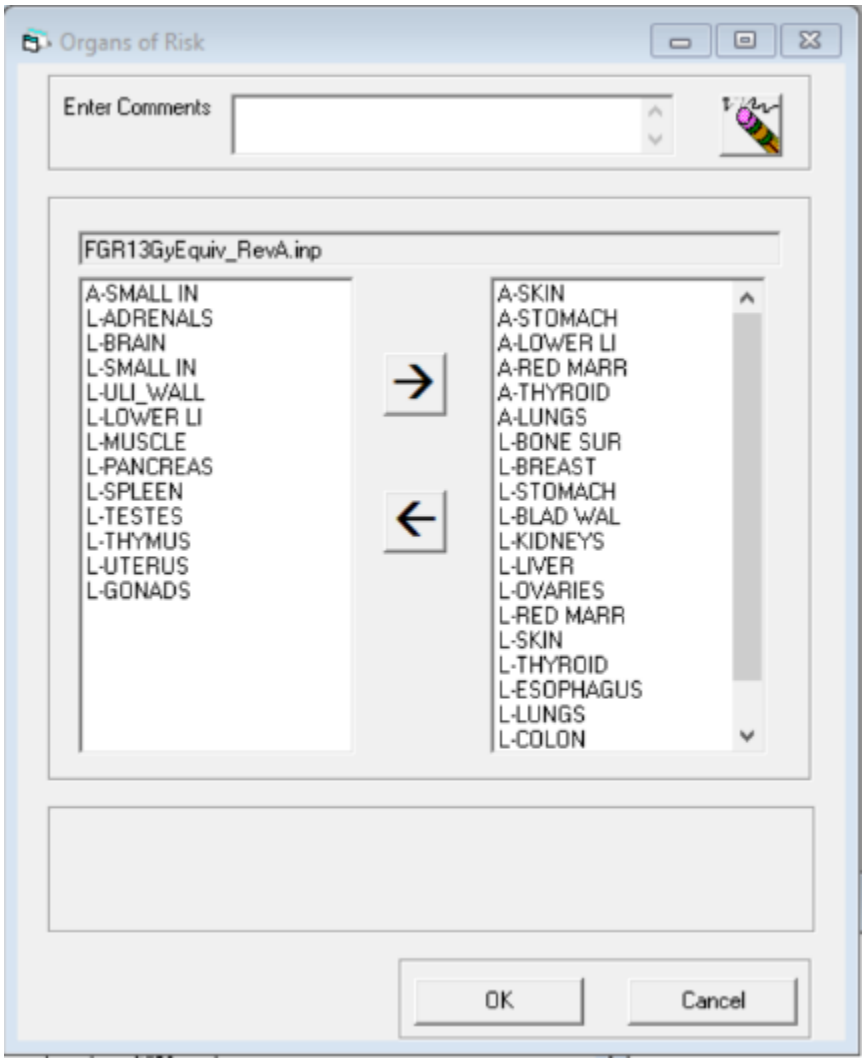


Figure 3-79 Organs of Risk Form

Thyroid Organs **Form**

The *Thyroid Organs* form is required when the user selects *Activate KI Model* on the *Dose* tab. Both the effective organ and up to three organs affected by the KI model can be selected for the KI model.

KI_EFF defines the effective organ affected by the ingestion of KI.

NUMKIORG defines the number of thyroid organs affected by the ingestion of KI.

KINAME provides a drop-down menu to select the organ names affected by the KI model.

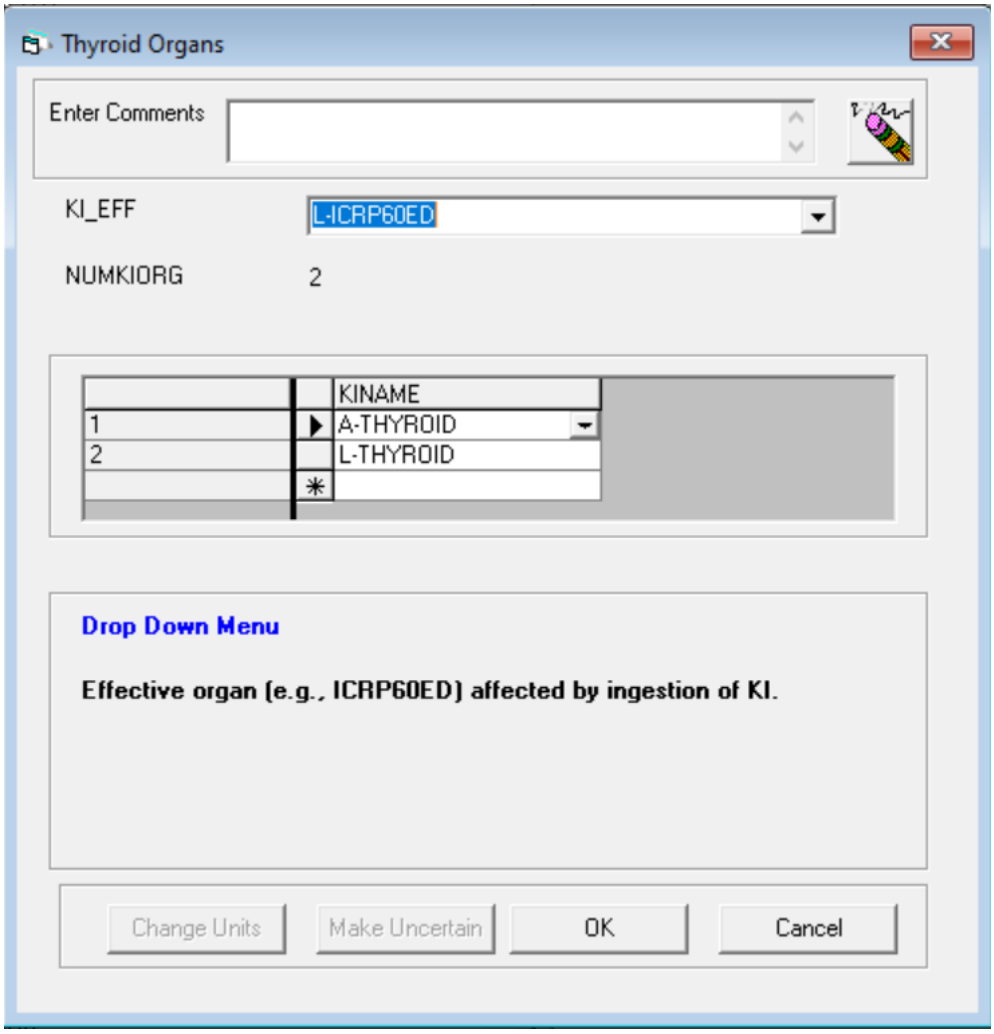


Figure 3-80 Thyroid Organs Form

Table 3-78 Thyroid Organs Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
KI_EFF	Yes	Character	None	Based on DCF File
NUMKIORG	Yes	Integer	None	1 to 3
KINAME	Yes	Character	NUMKIORG	Based on DCF File

Duration of Early Phase Form

The Duration of Early Phase form is required.

ENDEMP defines the duration of the emergency phase. Calculation of doses in each grid element start with the arrival of the first plume segment at that location and continue for the period defined by ENDEMP. This period should normally be chosen to be large enough so that all plume segments have time to exit the problem domain. The allowed range is 1 to 40 days.

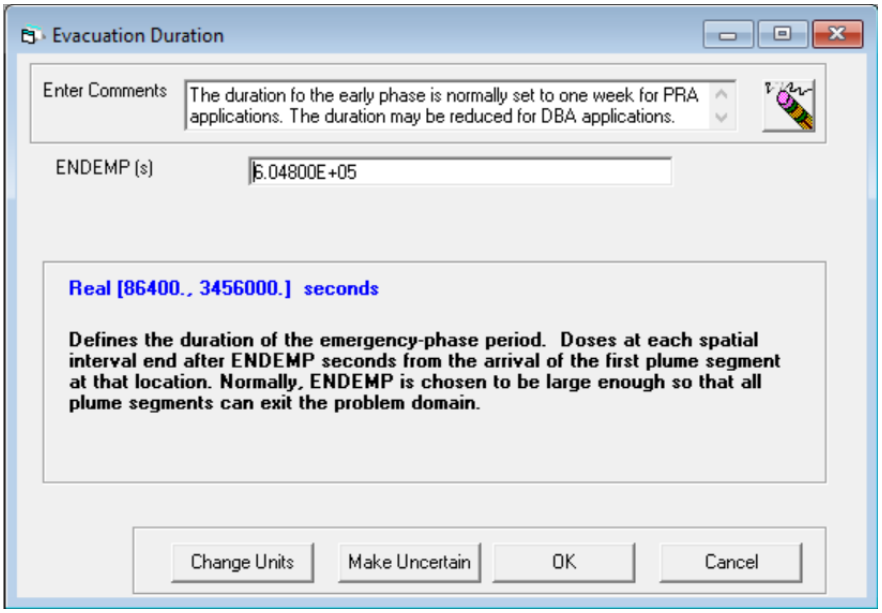


Figure 3-81 Duration of Early Phase Form

Table 3-79 Duration of Early Phase Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
ENDEMP	Yes	Real	None	86,400 to 3,456,000 s

Evacuee Return Time Form

The *Evacuee Return Time* is an optional form. When this form is not used, MACCS assumes the value of TIMRTN is the same as the value specified for ENDEMP.

TIMRTN defines the elapsed time between the time of evacuation and return to the home for an evacuee whose location on the grid is not affected by any contamination. In previous versions of MACCS, this value was assumed to be the duration of the emergency phase. This value only affects the time used to evaluate economic losses.

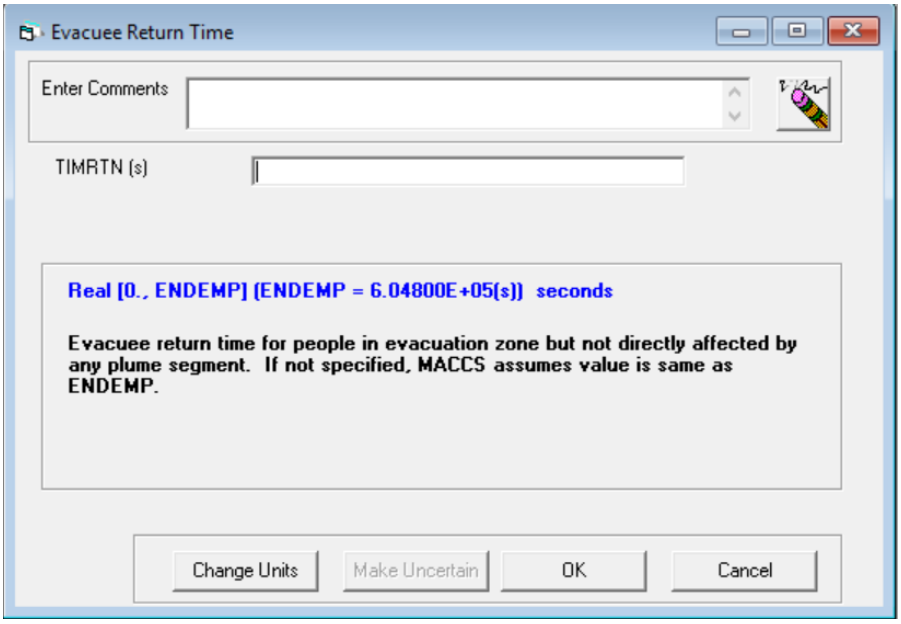


Figure 3-82 Evacuee Return Time Form

Table 3-80 Evacuee Return Time Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
TIMRTN	Yes	Real	None	0 to ENDEMP

Normal Relocation Form

The *Normal Relocation* form is required.

TIMNRM defines the normal relocation action time measured from plume arrival. Normal relocation applies to everyone who does not evacuate; it does not apply to evacuees. Normal relocation is based on a dose projection criterion to determine the need to relocate. TIMNRM must be greater than or equal to TIMHOT and less than or equal to ENDEMP. The value of TIMNRM can account for the fact that the initial priority may be to evacuate the public within the emergency planning zone, for time needed to evaluate releases and project doses to the public, and for time needed for the public to receive notification and begin to relocate. Relocation is modeled as being instantaneous, so TIMNRM may also account for some portion of a realistic relocation time.

The normal relocation dose, DOSNRM, along with the critical organ and dose projection period, determines where relocation is required. When total projected dose commitment exceeds DOSNRM, people in an area are relocated at the normal relocation time, TIMNRM. DOSNRM cannot exceed DOSHOT, which is described below.

The dose used to evaluate normal relocation is the dose commitment projected for an individual who remains in place for the dose projection period (defined below) while engaging in normal activity. The dose pathways used to calculate the projected dose commitment are cloudshine, groundshine, direct inhalation, and resuspension inhalation. Any individuals relocated due to normal relocation receive no additional dose during the emergency phase.

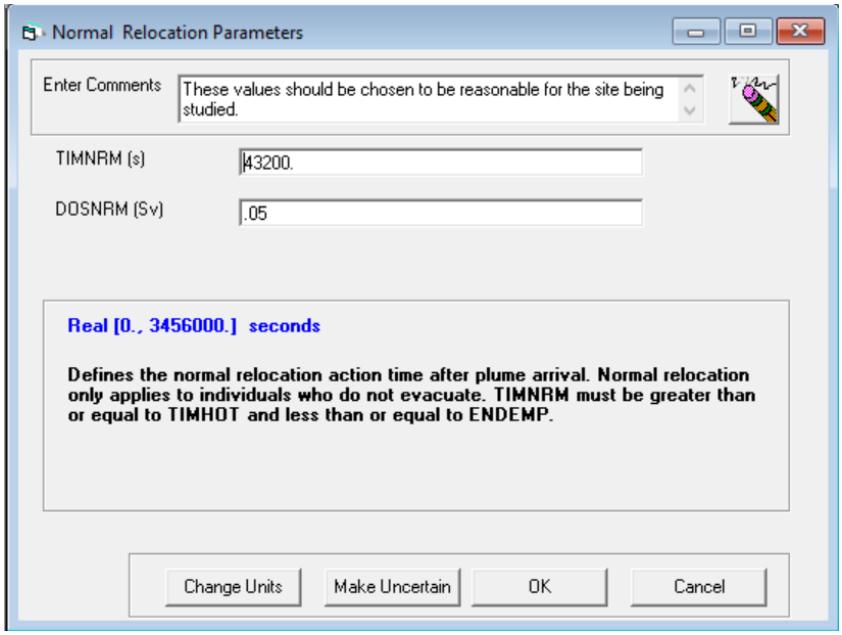


Figure 3-83 Normal Relocation Form

Table 3-81 Normal Relocation Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
TIMNRM	Yes	Real	None	0 to 3,456,000 s (0 to 40 d)
DOSNRM	Yes	Real	None	0 to 10^{10} Sv

Hot Spot Relocation Form

The *Hot Spot Relocation* form is required when *EARLY* is selected on the *Scope* tab.

TIMHOT defines the hot-spot relocation action time after plume arrival. Hot-spot relocation applies to everyone who does not evacuate; it does not apply to evacuees. Hot-spot relocation works similarly to normal relocation but is used to prioritize relocation of the population at higher risk. TIMHOT must be less than or equal to TIMNRM and less than or equal to ENDEMP. The same time elements described for defining TIMNRM also apply to TIMHOT.

The hot-spot relocation dose (DOSHOT) is intended to trigger relocation beyond the evacuation area, although it also applies to nonevacuees who reside within the evacuation area. Areas identified for hotspot relocation usually take priority once evacuation is completed or well along and occur before normal relocation. When dose projections for individuals exceed DOSHOT, they are relocated at the hot-spot relocation time (TIMHOT).

The dose used to evaluate hotspot relocation is the dose projected for an individual who remains in place for the dose projection period while engaging in normal activity. The dose pathways used to calculate the dose commitment are cloudshine, groundshine, direct inhalation, and resuspension inhalation. Any individuals relocated due to hot-spot relocation receive no additional dose during the emergency phase.

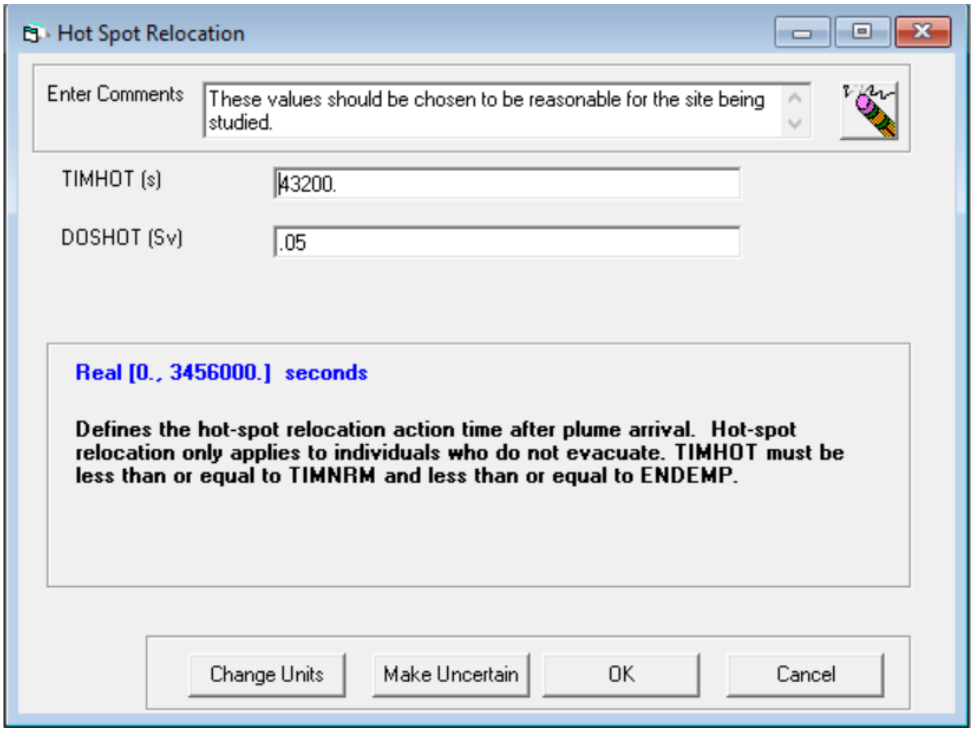


Figure 3-84 Hot Spot Relocation Form

Table 3-82 Hot Spot Relocation Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
TIMHOT	Yes	Real	None	0 to 3,456,000 s (0 to 40 d)
DOSHOT	Yes	Real	None	0 to 10^{10} Sv

Dose Projection Form

The *Dose Projection* form is an optional form. When it is not used, MACCS assumes the value of DPPEMP is the same as the value specified for ENDEMP.

DPPEMP is the dose-projection period for the emergency phase. It defines the dose projection period used for normal and hot-spot relocation. A full definition of the dose projection criteria for normal and hot-spot relocation includes the dose level (DOSNRM and DOSHOT, respectively), the target organ (CRIORG, defined below), the dose projection period (DPPEMP), the commitment period for the dose (standard value of 50 years for internal doses), and the set of dose pathways that are included, which are cloudshine, groundshine, direct inhalation from the plume, and inhalation of resuspended aerosols. The dose projection period begins with plume arrival and ends after the time interval specified by DPPEMP. Older versions of MACCS used ENDEMP for the dose projection period.

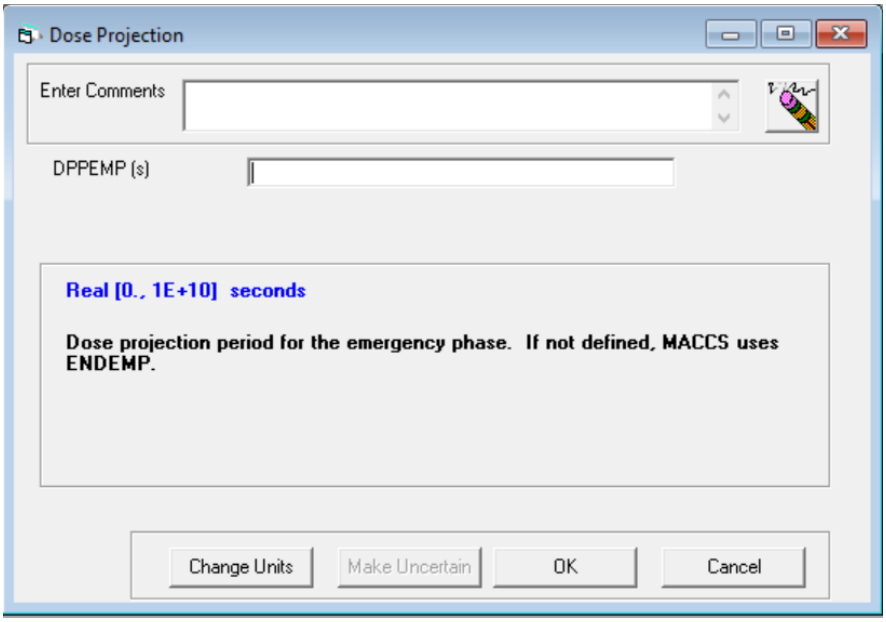


Figure 3-85 Dose Projection Form

Table 3-83 Dose Projection Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DPPEMP	Yes	Real	None	0 to ENDEMP

Emergency Phase Resuspension Form

The *Emergency Phase Resuspension* form is required. Resuspension can be excluded from a calculation by setting RESCON to be zero.

RESCON is the linear factor for the emergency phase resuspension concentration factor.

RESHAF is the emergency phase resuspension concentration weathering half-life.

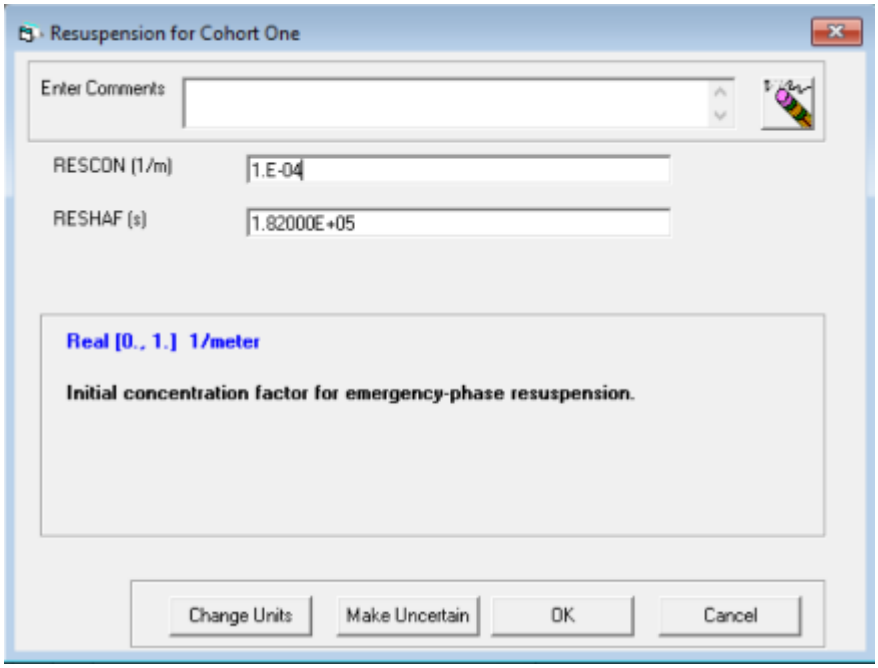


Figure 3-86 Emergency Phase Resuspension Form

Table 3-84 Emergency Phase Resuspension Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
RESCON	Yes	Real	None	0 to 1 m^{-1}
RESHAF	Yes	Real	None	1 to 10^{10} s

Keyhole Forecast Form

The *Keyhole Forecast* form is required when *Activate Keyhole Evacuation Mode*l is checked on the *Evac/Rotation* tab.

KEYFORCST defines the advance time for which wind shifts can be reliably forecast by weather forecasters (e.g., the National Weather Service). The model expands the number of sectors included in a keyhole evacuation, as illustrated in Figure 3-72, KEYFORCST hours before a wind shift occurs. This model is currently implemented as if the forecasting were infallible (i.e., it uses wind shifts from the recorded meteorological data and these are correct 100% of the time). Real weather forecasting is less than 100% reliable, but that is not accounted for in the current model. To compensate for the assumption of perfect forecasting, this value should normally be chosen to be a relatively small number of hours.

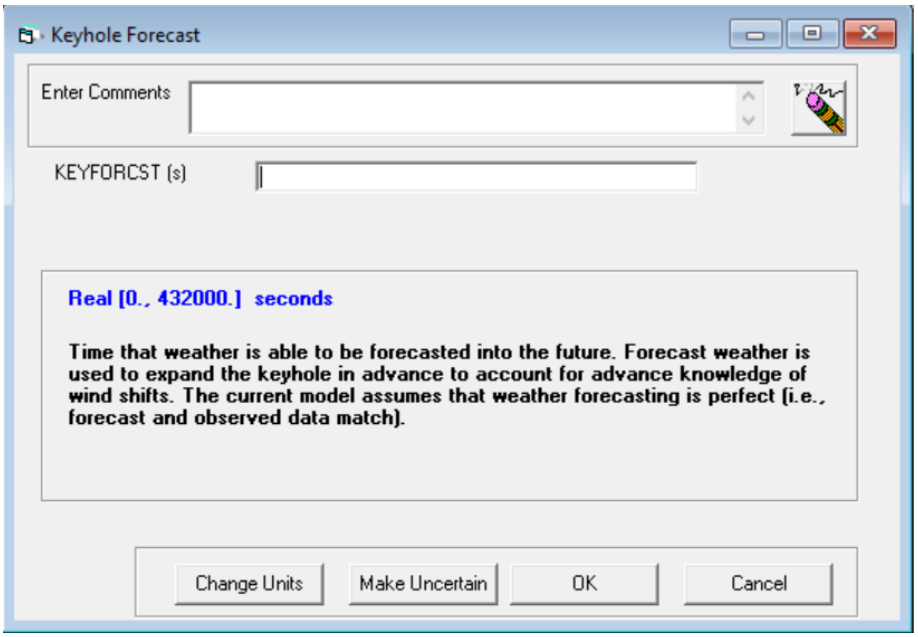


Figure 3-87 Keyhole Forecast Form

Table 3-85 Keyhole Forecast Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
KEYFORCST	Yes	Real	None	0 to 432,000 s (5 d)

Cohort Units Form

The *Cohort Units* form is required, but it contains a set of default units and the user is not required to reset these units.

The default units in MACCS are SI units. This form allows the user to change the units for a set of cohort parameters for all the cohorts. Units can be changed on this form for delays, phase durations, breathing rate, and evacuation speeds. To avoid confusion when entering input values for individual cohorts, these units are applied to all cohorts.

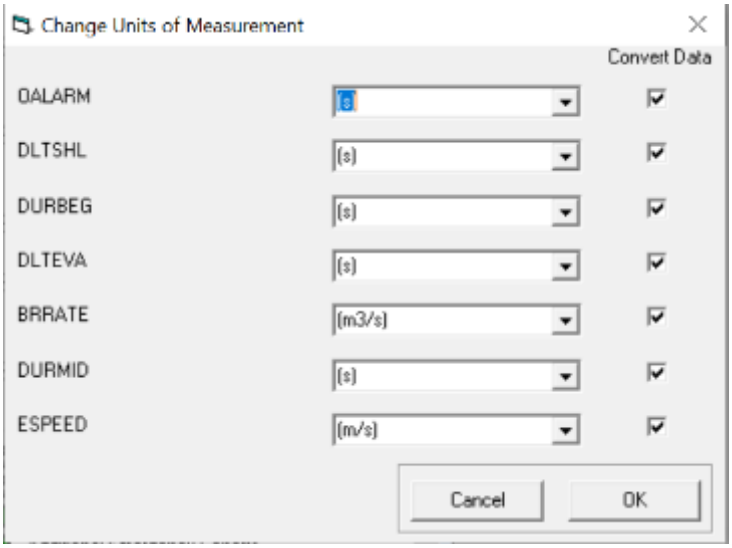


Figure 3-88 Cohorts Unit Form

Table 3-86 Cohorts Units Form Allowable Units

Parameter Name	Allowed Units for Variable
OALARM	(s), (min), (hr), (day), (yr)
DLTSHL	(s), (min), (hr), (day), (yr)
DURBEG	(s), (min), (hr), (day), (yr)
DLTEVA	(s), (min), (hr), (day), (yr)
BRRATE	(m^3/s), (l/s), (l/day), (m^3/day), (m^3/yr)
DURMID	(s), (min), (hr), (day), (yr)
ESPEED	(m/s), (cm/s), (km/hr), (mi/hr), (in/hr), (mm/hr)

3.3.4 Dose-Response Models

3.3.4.1 Dose-Response Model Description

Three optional dose-response models are available to calculate latent-cancer injuries and fatalities. The three types of models are illustrated in Figure 3-89.

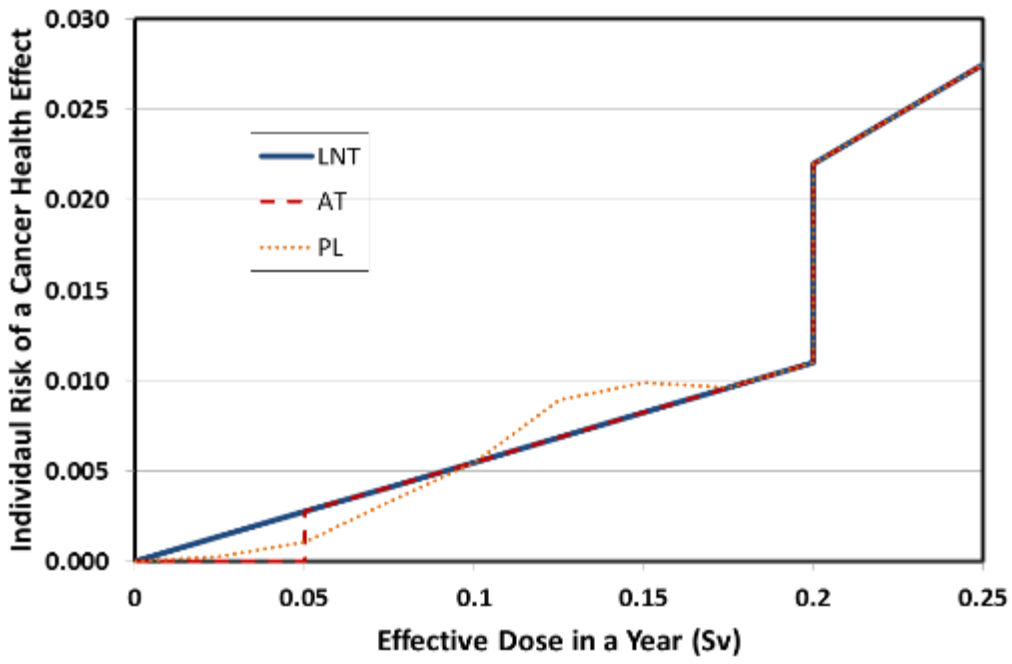


Figure 3-89 Three types of dose-response models for latent cancer health effects supported by MACCS

The first uses the standard, LNT hypothesis. This was the only model available in earlier versions of MACCS. In the linear, no-threshold model, the relationship between dose and health effects is linear in the low-dose range, even for infinitesimal doses. However, the LNT dose-response model implemented in MACCS includes a discontinuity and has a change in slope at a threshold dose, as shown in Figure 3-89. In the MACCS model, for latent health effects, doses are divided by a dose and dose-rate effectiveness factor (DDREFA) for dose levels below the threshold but not for doses above the threshold. MACCS uses the standard implementation of the LNT model in which internal doses over an exposure period are calculated as 50-year doses and it combines internal and external doses to estimate a total organ dose, including the effective pseudo organ. This total organ dose is compared with the dose threshold to determine whether to divide by DDREFA. Doses after the emergency phase are assumed to stay below the threshold, so they are always divided by DDREFA.

Figure 3-89 illustrates the simplified situation where all doses are delivered to an individual during the first year (i.e., internal doses from inhalation and ingestion have diminished to zero by the end of the first year). This allows all three dose-response models to be compared on the same basis. Furthermore, the figure shows a typical dose response when radiation is assumed to be uniformly distributed over the body, although this assumption is not essential to the illustration. For example, effective dose could be replaced by equivalent dose to a specific organ and latent cancer health effects could represent just the cancers associated with that organ. The figure shows typical values of 0.2 Sv for the threshold and a value of 2.0 for DDREFA. The solid curve in Figure 3-89 shows the individual risk of a cancer fatality using typical values for cancer induction and the LNT dose-response model.

Effective dose is the term used by ICRP when the weighted sum of equivalent organ doses is calculated using ICRP 60 tissue weighting factors. An equivalent organ dose accounts for biological damage using a radiation weighting factor, which is generally unity for beta and gamma radiation and 20 for alpha radiation. Effective dose is the same in concept as the older term of

total effective dose equivalent (TEDE). Technically, TEDE is based on older tissue weighting factors from ICRP 26. (The latest tissue weighting factors from ICRP are in ICRP 103, but these are not currently used in the MACCS dose coefficient files.)

The second option for dose-response model is called the AT model. In this model, the user can specify one or more thresholds, up to one for each year of the exposure period. The thresholds are specified in terms of effective dose. When the predicted effective dose is below an AT, there are no contributions to any latent cancer health effects for that year; when the predicted effective dose exceeds the AT, contributions to health consequences are calculated in the same way as with the LNT model. Contributions to health effects are summed over all exposure years. This dose response model is illustrated in Figure 3-89 for the case that the AT is 0.05 Sv (5 rem). To compare with the threshold, internal doses are calculated as annual doses rather than 50-year committed doses. The process for doing this in MACCS is described a few paragraphs below.

The third option for dose-response model is called the PL model. In this model, the user can construct a series of line segments that define the functional dependence of health effects on annual dose, as illustrated in Figure 3-89. The line segments are required to form a continuous curve. To define the PL function, the user defines a multiplicative factor that is applied to the LNT model as a function of annual dose. This model can be used to approximate a dose threshold, to create a sublinear dose-response model, or to create a supra-linear dose-response model. It cannot be used to construct a hormesis model because MACCS does not allow beneficial health effects (negative risk) from radiation exposure. Figure 3-89 illustrates a PL model that is sublinear below 0.1 Sv (10 rem) and supra-linear between 0.1 Sv and 0.175 Sv (17.5 rem). Above 0.175 Sv, the PL model is identical to the LNT model in this illustration. The PL model operates on annual doses in the same way as the AT model described in the previous paragraph.

For the general case where exposures occur over many years and internal dose pathways potentially deliver a dose over the 50-yr dose commitment period, the model is somewhat more complicated than it is for the LNT model. For the two non-LNT models discussed above, AT and PL, annual doses are estimated for each year during the exposure and commitment periods. The models depend on the actual dose delivered to an individual during a one-year period, referred to as an annual dose. Annual doses account for external radiation received during the year and the first year of the commitment period for all internal exposures during the year. They also account for the current year of dose commitment for internal exposures in all previous years. Once the annual doses are calculated for an individual, the latent cancer risk is the sum of the risks over the relevant set of years. In other words, the risk illustrated in Figure 3-89, which is for a single year, is summed over all the years for which doses are received by that individual. Years in which the annual doses are below the dose threshold are assumed not to contribute to latent health effects in the AT model. Similarly, annual doses contribute based on the PL factor using the PL model.

Even when radiation is not distributed uniformly over the body, the effective dose is still used to determine whether an AT is exceeded. When the threshold is exceeded, equivalent organ doses are used to estimate the contributions to cancer risks for each type of cancer. Total cancer risks are summations of the cancer types considered in the consequence analysis. In Figure 3-89, nonuniform radiation could increase or decrease the cancer risks, depending on the radio sensitivity of the organs receiving larger and smaller doses.

The AT model allows for an optional lifetime threshold, which is also based on effective dose. When the lifetime threshold is exceeded, the health effects are calculated to be identical to those for the LNT model. In that case, dose contributions to health effects are counted for all years, no matter how small the dose in any of the years.

3.3.4.2 Dose Model Forms and Parameters

***Annual Threshold* Form**

Annual Threshold is required when the user selects *Late Consequences* on the *Scope* tab and *Annual Threshold* on the *Dose* tab.

DTHNUM is the number of annual dose threshold values. This value is determined from the number of entries for DTHANN.

DTHANN is a vector containing the annual dose threshold for latent cancer models. The first entry corresponds to year one, the second to year two, etc. When calculated annual effective dose per person is below the specified threshold for a year, all latent health consequences are calculated to be zero for that year. The value specified for the last year is used for all subsequent years. When a single value is listed, it applies to every year of the exposure period.

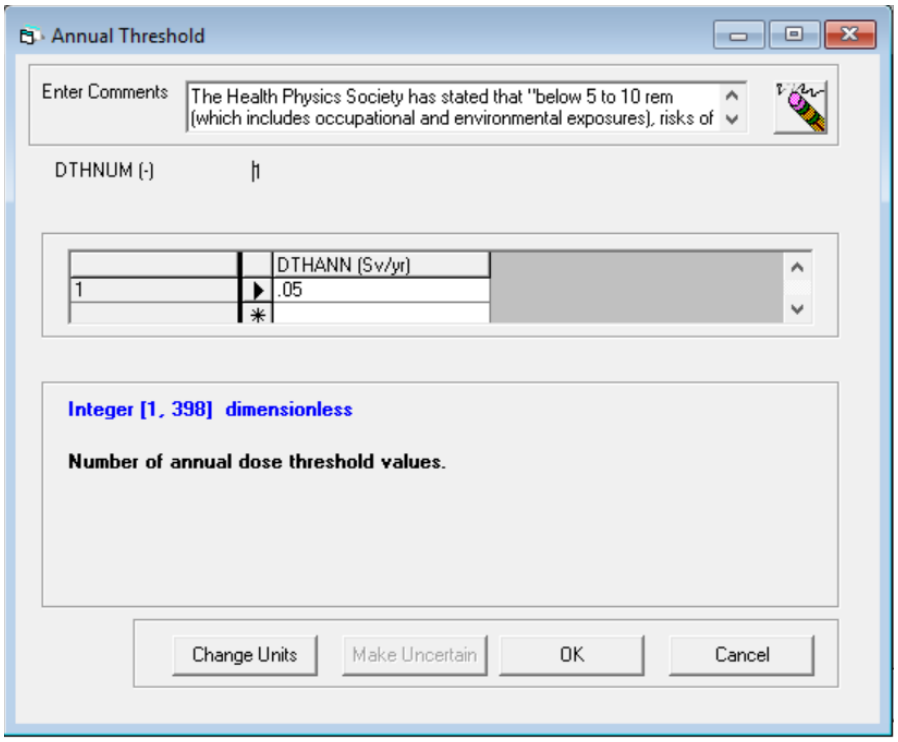


Figure 3-90 Annual Threshold Form

Table 3-87 Annual Threshold Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DTHNUM	Linked	Integer	None	1 to 398
DTHANN	Yes	Real	DTHNUM	0 to 10^{30} Sv/yr

Lifetime Threshold Form

Lifetime Threshold is optional when the user selects *Annual Threshold* on the *Dose* tab.

DTHLIF is the lifetime dose restriction. When this dose is exceeded, all doses are used to estimate health effects the same as with the LNT model, regardless of AT values.

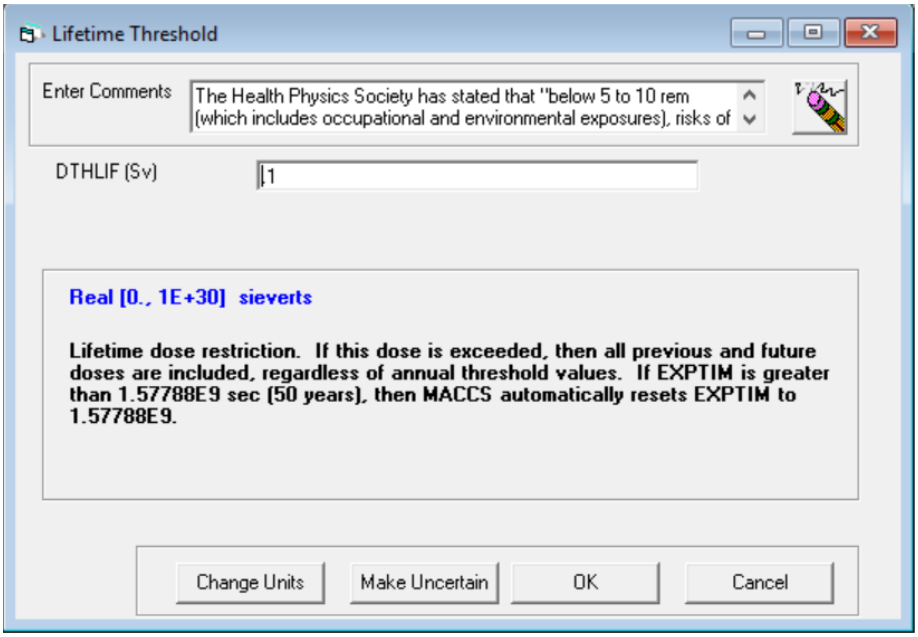


Figure 3-91 Lifetime Threshold Form

Table 3-88 Lifetime Threshold Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DTHLIF	Yes	Real	DTHNUM	0 to 10^{30} Sv

Piecewise Linear Form

The *Piecewise Linear* form is required when the user selects *Late Consequences* on the *Scope* tab and *Piecewise Linear* on the *Dose* tab.

PWLNUM is the number of piecewise dose values entered by user. Its value is determined by the number of values of PWLDOS and PWLFAC entered by the user.

PWLDOS is the effective dose associated with multiplier, PWLFAC. Values of PWLDOS must be specified in ascending order. Linear interpolation is used to calculate a multiplicative factor for an annual effective dose between those supplied by the user. Health consequences are calculated for each annual effective dose using the multiplicative factor calculated from this model as a multiplier on the LNT model. The health effects are summed for all the annual dose contributions, accounting for the number of exposure years and the commitment period for each exposure year, as described above.

PWLFAC is a multiplicative factor associated with PWLDOS. The last value in vector PWLFAC must be one. Above the last dose specified on this form, the LNT model is used.

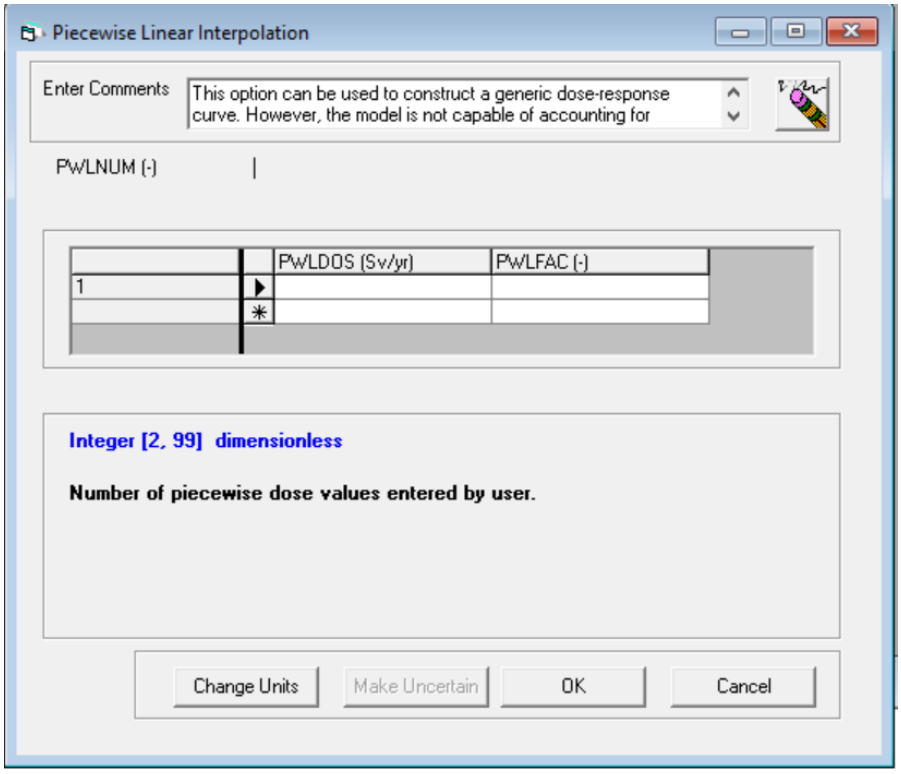


Figure 3-92 Piecewise Linear Form

Table 3-89 Piecewise Linear Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
PWLNUM	Linked	Integer	None	2 to 99
PWLDOS	Yes	Real	PWLNUM	10^{-10} to 10^{30} Sv/year
PWLFAC	Yes	Real	PWLNUM	0 to 1×10^{30}

3.3.5 Population by Cohort

The characteristics of each evacuation cohort are assigned on the Emergency Cohorts forms. The forms in the Population by Cohort category enable assigning portions of the population to different evacuation cohorts for each spatial grid element. Each cohort should represent a segment of the population that displays a distinct evacuation behavior (e.g., the general populace vs. people with special needs). First, populations are defined on the *Populations* forms, where a population is defined by a set of cohort fractions. Next, populations are assigned to spatial grid elements. This defines the population fraction of each evacuation cohort that belongs to that grid element. The total population per grid element is defined in the site data file. See Section 4.4.7.2 for more guidance.

Populations Form

The *Populations* form is required when the user assigns SUMPOP to the *Results Weighting Factor* and selects *File Created from Existing Site File* on the *Site Data* tab.

N_POP_DIST is the number of population distributions entered by the user.

POP_DIST defines the population distributions to be assigned to the grid. One distribution is entered per row. The cohort fractions on each row should sum to one. Each column of the grid is associated with a cohort.

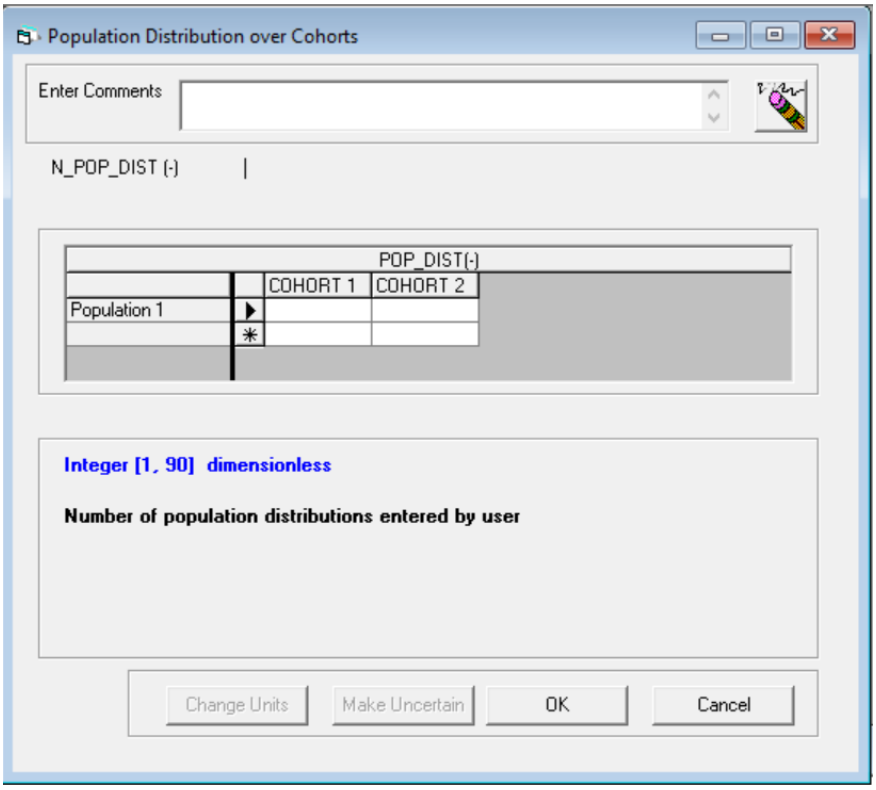


Figure 3-93 Populations Form

Table 3-90 Populations Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
N_POP_DIST	Linked	Integer	None	1 to 90
POP_DIST	Yes	Real	N_POP_DIST by NUM_EVAC_SCEN	0 to 1.0

Population Labels Form

The *Population Labels* form is required when the user assigns SUMPOP to *the Results Weighting Factor and selects File Created from Existing Site File on the Site Data* tab.

DIST_SYMB is a single character that is used to assign a population to a grid element in the spatial grid form.

DIST_LABEL is a descriptive label associated with the population.

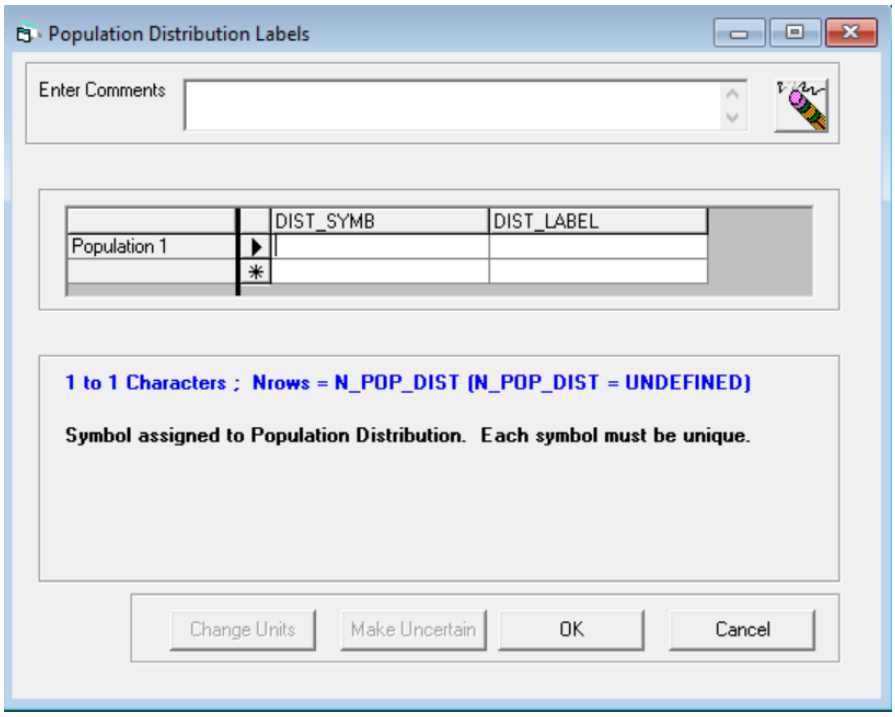


Figure 3-94 Population Labels Form

Table 3-91 Population Labels Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DIST_SYMB	Yes	Character	N_POP_DIST	1 character
DIST_LABEL	Yes	Character	N_POP_DIST	1 to 20 characters

Populations Assigned Form

The *Populations Assigned* form is required when the user assigns SUMPOP to the *Results Weighting Factor* and selects *File Created from Existing Site File.* Both are specified on the *Site Data* tab of the *Properties* form

The *Populations Assigned* form allows the user to assign populations, identified by the symbol, DIST_SYMB, defined on the *Population Labels* form, to grid elements. After this form is saved, each *Population* form for each cohort in the calculation is updated to show the population by grid element. Before the MACCS simulation is run, a new site file is constructed with the populations shown on the *Populations* forms for each cohort. The site file is created to be compatible with the MACCS SUMPOP option and includes a section defining the population for each cohort.

POP_DIST is defined on the *Populations* form.

DIST_SYMB associates a population distribution with a symbol.

DIST_LABEL is a descriptive label associated with a population.

COHORT_POP3D is an array defining the population assigned to each of the spatial grid elements.

COHORT_POP is the population array associated with a cohort.

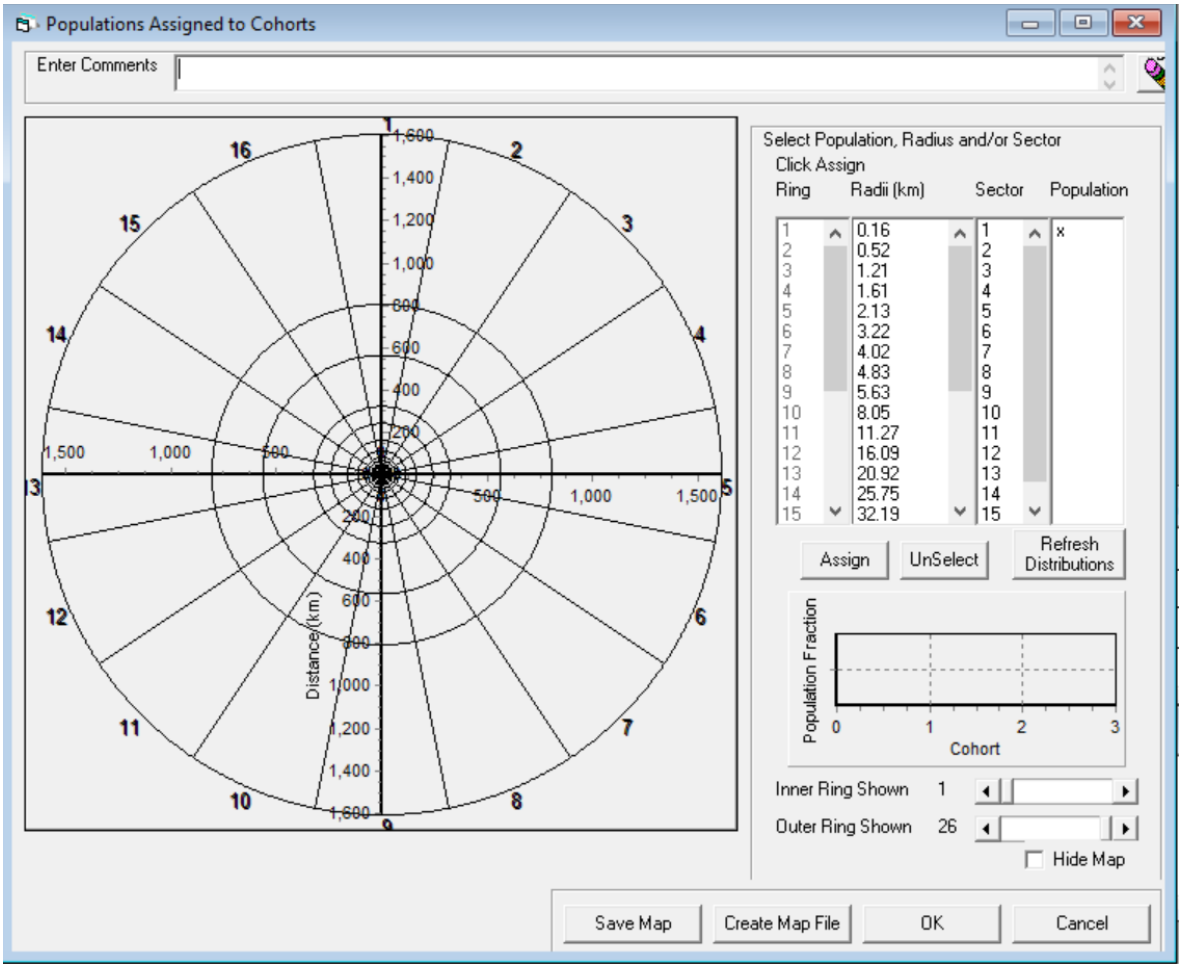


Figure 3-95 Populations Assigned Form

Table 3-92 Populations Assigned Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values	Defined on Form
POP_DIST	No	Real	N_POP_DIST by NUM_EVAC_SCEN	0 to 1.0	Populations
DIST_SYMB	No	Character	N_POP_DIST	1 character	Population Labels
DIST_LABEL	No	Character	N_POP_DIST	1 to 20 characters	Population Labels
COHORT_ POP3D	Yes	Character	NUMRAD by NUMCOR	1 character	Populations Assigned
COHORT_POP	Yes	Real	NUMRAD by NUMCOR	0 to 1×10^{9}	Populations Assigned

3.3.6 Emergency Response Cohorts

WinMACCS supports up to twenty emergency cohorts. The number of cohorts is defined on the *Evac/Rotation* tab. Several cohort forms must be defined under the *Emergency Cohort One* category. When there is more than one cohort, additional, identical, forms must be defined under the *Additional Emergency Cohorts* category. The form names and parameters are the same for each cohort. For example, a critical organ can be specified for each cohort on the *Critical Organ* form. Each form must be filled out for set of cohorts defined in the model. However, data entry can be reduced by selecting *Edit/Auto Propagate Cohort Values* on the main menu as described in Section 4.2.2.

3.3.6.1 Emergency Cohort Model Description

For the purposes of accounting for dose and health effects, the dose received by an evacuee is attributed to the location in which the evacuee originates. Evacuees travel from the center of one grid element to the center of another in discrete steps. The transit time for an evacuee to move from one grid element to another is determined by several input values. Dose calculations are performed as though the evacuee is located at the center of one grid element for a period then suddenly moves to the center of the next grid element along the path of evacuation. The top-hat approximation for concentration is used to calculate doses for evacuees. The top hat approximates the Gaussian profile as a constant concentration over a width of $3 \cdot \sigma_y$, as shown in Figure 3-96.

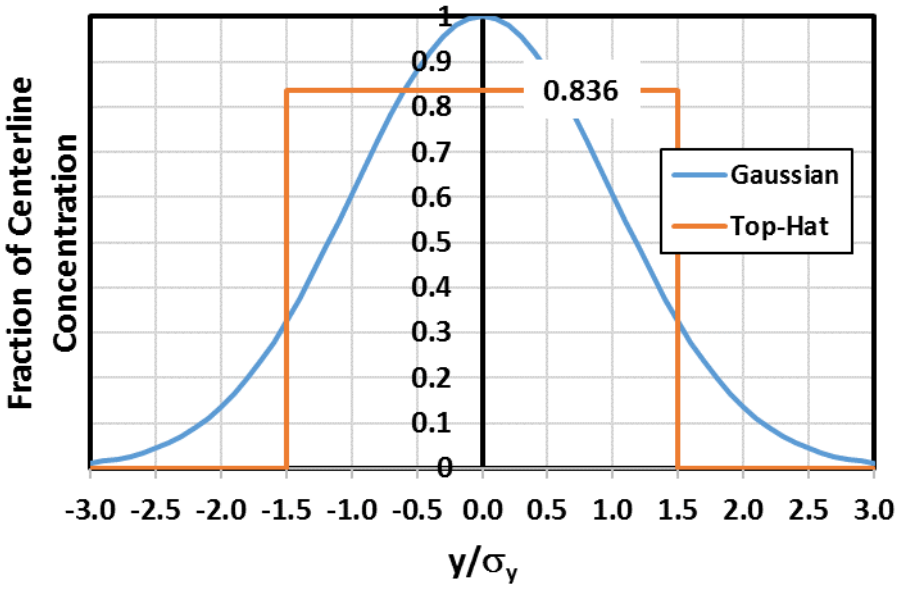


Figure 3-96 Top-hat approximation for plume concentration used for evacuees

The starting point for all evacuees is the center of the element in which they begin. The transit time to arrive at the center of the next grid element depends on the choice of the parameter, TRAVELPOINT. When this parameter is equal to BOUNDARY, the evacuee is in the next grid element upon crossing the grid boundary; when equal to CENTERPOINT, the evacuee is considered to be in the next grid element upon arrival at the center of the destination grid element. The following formulae are used in the case when TRAVELPOINT = BOUNDARY:

- when the evacuee moves radially and resides in the current grid element

$$T_{t,n} = (r_n - r_{n-1})/(2 \cdot V) \quad \textbf{(3-28)}$$

- when the evacuee moves radially and does not reside in the current grid element

$$T_{t,n} = (r_n - r_{n-1})/V \quad \textbf{(3-29)}$$

- when the evacuee moves around the compass and resides in the current grid element

$$T_{t,n} = \pi \cdot (r_n + r_{n-1})/(2 \cdot N_\theta \cdot V) \quad \textbf{(3-30)}$$

- when the evacuee moves around the compass and does not reside in the current grid element

$$T_{t,n} = \pi \cdot (r_n + r_{n-1})/(N_\theta \cdot V) \quad \textbf{(3-31)}$$

The following formulae are used in the case when TRAVELPOINT = CENTERPOINT:

- when the evacuee moves radially outward

$$T_{t,n} = (r_{n+1} - r_{n-1})/(2 \cdot V) \quad \textbf{(3-32)}$$

- when the evacuee moves radially inward

$$T_{t,n} = (r_n - r_{n-2})/(2 \cdot V) \quad \textbf{(3-33)}$$

- when the evacuee moves around the compass

$$T_{t,n} = \pi \cdot (r_n + r_{n-1})/(N_\theta \cdot V) \quad \textbf{(3-34)}$$

Where

$T_{t,n}$ = transit time to move from the current to the next grid element. For dose calculations, this value is used as the residence time at the center point of the element. The evacuee jumps instantaneously from the center point of one element to the next.

r_n = the outer radius of grid element n

V = the speed at which an evacuee moves through an element. This value is given by the equation $V = ESPEED \cdot ESPGRD$ when no precipitation is occurring and by $V = ESPEED \cdot ESPMUL \cdot ESPGRD$ when precipitation is occurring. ESPGRD corresponds to ESPGRD_RAD or ESPGRD_NET, depending on whether radial or network evacuation is selected, respectively. The values of ESPEED and ESPMUL depend on the phase of the evacuation period, as described below. The value of ESPGRD depends on the grid element through which the evacuee travels.

N_θ = number of compass sectors in the grid, i.e., 16, 32, 48, or 64.

The evacuee's location as a function of time is compared with the location of the head and tail of the plume. For periods of time when the evacuee is located within the plume, the doses from

direct exposure pathways are accumulated (i.e., cloudshine, direct inhalation of the plume, and skin deposition). Doses from groundshine are always accounted for when the evacuee is at a location where the ground is contaminated. Resuspension inhalation is only considered once the plume segment has exited the grid element.

3.3.6.2 Emergency Cohort Forms and Parameters

***Basic Parameters* Form**

Basic Parameters are required for each *Emergency Cohort* category.

EVAKEY determines the algorithm used in evacuation. CIRCULAR implies all sectors are subject to evacuation. KEYHOLE limits the number to NSECTR sectors beyond an inner circular region. NONE means that there is no evacuation. The evacuation type is defined for each cohort under the *Project Properties/Evac Rotation* tab.

EANAM2 is a name that identifies each cohort.

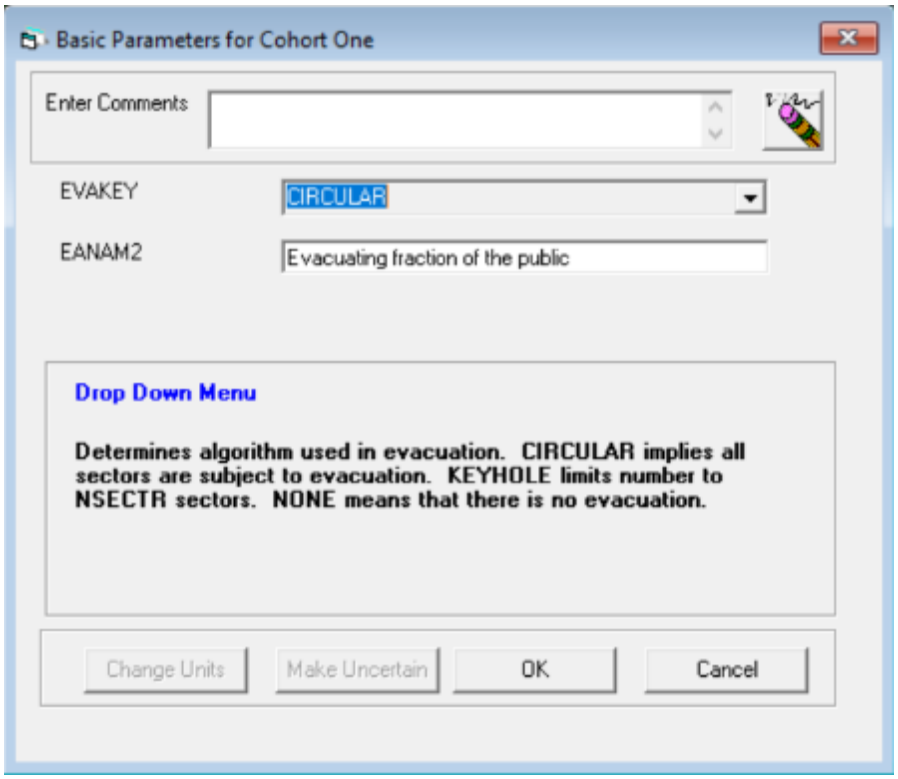


Figure 3-97 Basic Parameters Form

Table 3-93 Basic Parameters Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
EVAKEY	No	Character	None	NONE, CIRCULAR, KEYHOLE
EANAM2	Yes	Character	None	1 to 80 characters

Cohort Fraction Form

WTFRAC is a weight fraction to be applied to results from each emergency response cohort. The value is used when combining results for the overall weighted sum over all evacuation cohorts. The meaning depends on the value of the *Results weighting factor* as follows:

- PEOPLE – WTFRAC represents the fraction of the population that belongs to this cohort. With this option, a fraction of the population follows each cohort definition all the time.
- TIME – WTFRAC represents the fraction of the time or probability that this cohort is applicable. With this option, the entire population follows each cohort definition a fraction of the time.
- SUMPOP – WTFRAC must be defined but isn't used by MACCS. Instead, weighting information is based on population distributions read from the site data file.

MACCS requires that the sum of values of WTFRAC over all evacuation scenarios must add up to 1.0 within a tolerance of 0.001. WinMACCS does not enforce this requirement.

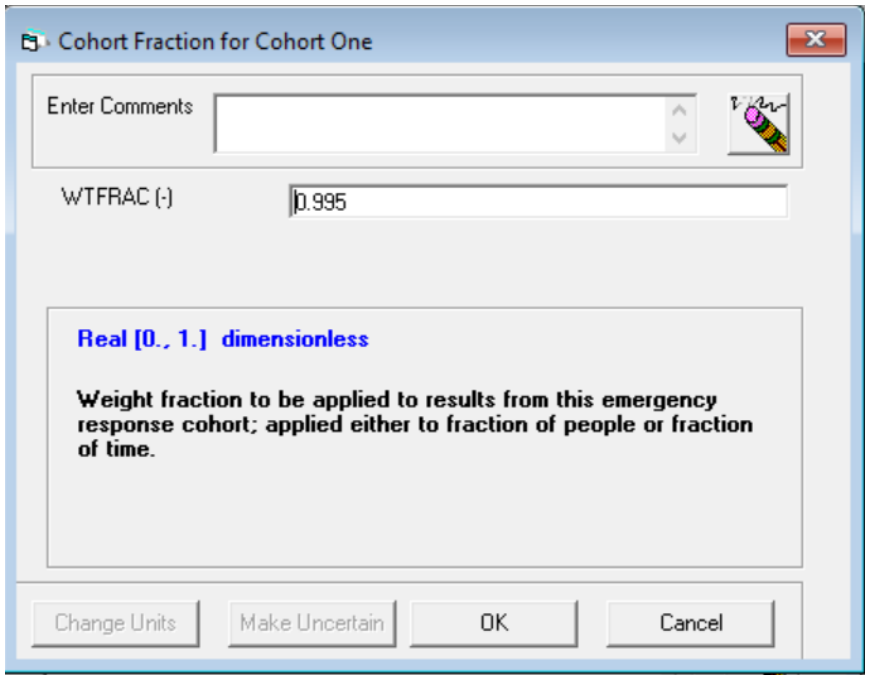


Figure 3-98 Cohort Fraction Form

Table 3-94 Cohort Fraction Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
WTFRAC	Yes	Real	None	0.0 to 1.0

Phase Durations and Speeds Form

This form is required for *Emergency Cohort One* and any subsequent cohorts when the evacuation type is circular or keyhole.

The evacuation phase is divided into three subphases defined by DURBEG, DURMID, and the remainder of the emergency phase. The purpose for the evacuation subphases is to allow evacuation speed parameters to vary over time.

REFPNT defines the reference time point for actions in the evacuation and sheltering zone. The user may choose to have the reference time be alarm time (ALARM), which is established by the value of OALARM, or first plume arrival (ARRIVAL) at each grid element. With keyhole evacuation, ALARM is the only legal choice for this variable.

TRAVELPOINT determines whether evacuees move from a spatial element when they cross the boundary between the two elements (BOUNDARY) or when they reach the center point of the destination element (CENTERPOINT).

DURBEG is the duration of the initial subphase of evacuation. This phase starts when the cohort in the shelter and evacuation region begins to evacuate, which is defined by the minimum over all radial distances (i) of DLTSHL(i) + DLTEVA(i) after the time designated by REFPNT. The evacuation speed used during this phase is the initial value of ESPEED.

DURMID defines the duration of the middle subphase of evacuation. The evacuation speed used during this subphase is the middle value of ESPEED. The evacuation speed used during the final subphase, which extends until evacuation is complete or until the end of the emergency phase, is the third value of ESPEED.

The evacuation phase begins when the first individual begins to travel out of the region. The durations of the initial and middle subphases of evacuation are defined by input parameters DURBEG and DURMID. The late phase of evacuation extends until all individuals complete their travel or until the end of the emergency phase, whichever is sooner. Normally, all evacuation should be complete by the end of the emergency phase.

Vectors ESPEED and ESPMUL contain a set of values that correspond to each of the three evacuation phases.

ESPEED is the travel speed of the evacuees. Three values are required, one for each of the evacuation (travel) subphases: initial, middle and late. MACCS requires that all three values be the same when TRAVELPOINT is set to BOUNDARY. They can be different when TRAVELPOINT is set to CENTERPOINT.

ESPMUL is a multiplicative factor that affects ESPEED during adverse weather, i.e., when precipitation is occurring. The occurrence of precipitation is determined from HRRAIN, BNDRAN, or the meteorological file, depending on the weather option. The value of evacuation speed in an element is calculated with the following formulae, where ESPGRD is the grid-level speed multiplier ESPGRD_NET or ESPGRD_RAD (supplied on another form):

Evacuation Speed = ESPEED * ESPMUL * ESPGRD when precipitation is occurring

Evacuation Speed = ESPEED * ESPGRD when no precipitation is occurring

ESPEED is defined for each of the three subphases (initial, middle, and late) of evacuation, but is independent of grid elements. ESPGRD, a speed multiplier defined on the forms *Radial Evacuation Speed* or *Network Evacuation Speed*, is independent of subphase, but is defined for each grid element. When ESPGRD is not defined because *Activate Speed Multiplier Model* has not been selected on the *Project Properties/Evac Rotation* tab, a value of one is assumed.

Three values of ESPEED are required, one for each of the evacuation (travel) phases as follows: initial, middle, and late. MACCS requires that all three values must be the same when TRAVELPOINT is equal to BOUNDARY.

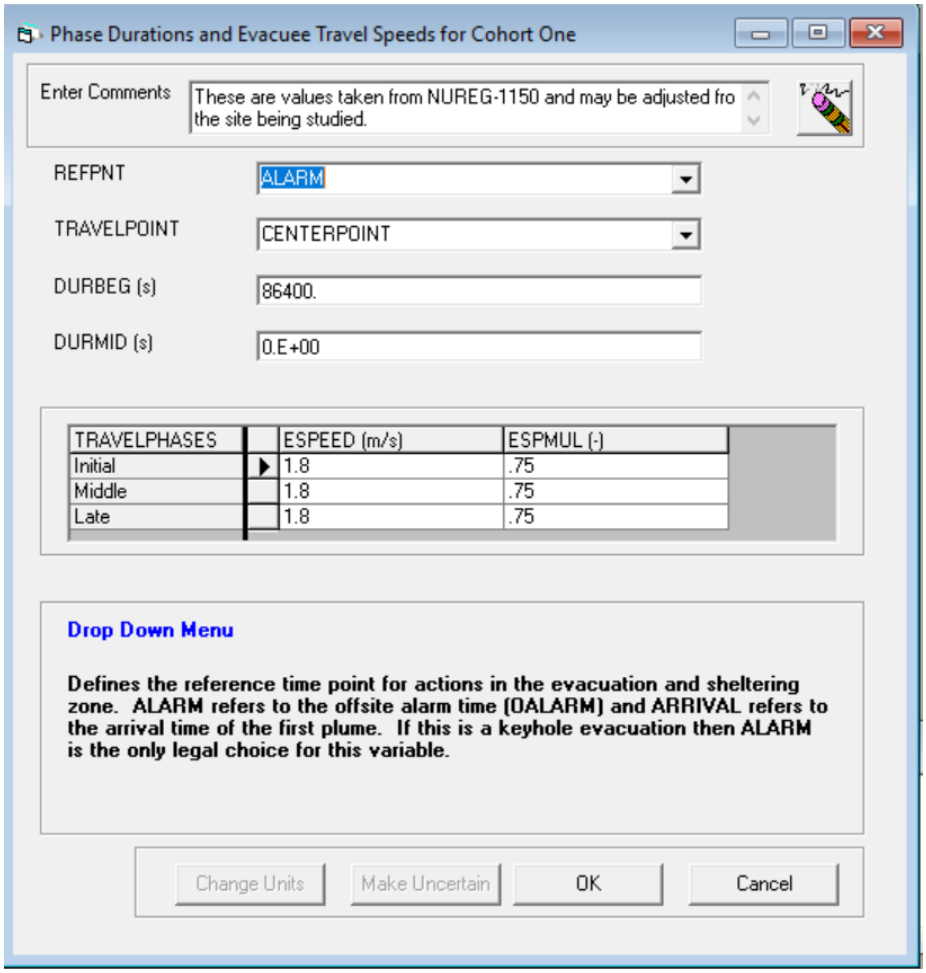


Figure 3-99 Phase Duration and Speeds Form

Table 3-95 Phase Duration and Speeds Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
REFPNT	Yes	Character	None	ALARM, ARRIVAL
TRAVELPOINT	Yes	Character	None	BOUNDARY, CENTERPOINT
DURBEG	Yes	Real	None	0.0 to 86400.0 s
DURMID	Yes	Real	None	0.0 to 86400.0 s
ESPEED	Yes	Real	3	10^{-6} to10^{6} m/s
ESPMUL	Yes	Real	3	0.0 to 1.0

Critical Organ Form

This form is required for *Emergency Cohort One* and any additional cohorts.

CRIORG is the critical organ for relocation decisions during the emergency phase. People remain in the grid element when the projected total dose to the critical organ is less than the values that trigger relocation.

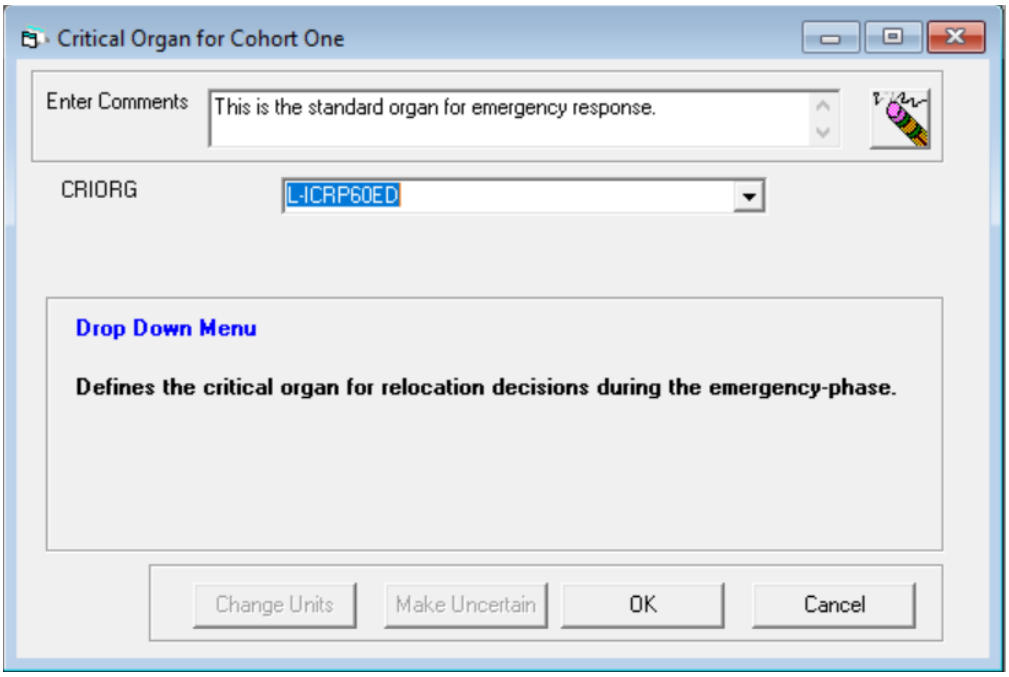


Figure 3-100 Critical Organ Form

Table 3-96 Critical Organ Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CRIORG	Yes	Character	None	Must select an Organ name. Choice depends on DCF file.

KI Ingestion Linear No Threshold Form

This form is required for *Emergency Cohort One* and any subsequent cohorts when the *LNT* dose-response model and the *Activate KI Model* are selected on the *Dose* tab of the *Properties* form.

The KI ingestion model accounts for potential reduction in uptake of inhaled radioiodine by the thyroid gland. The ingested KI saturates the thyroid gland so that the effect of inhaling iodine from a plume can be significantly diminished. The KI ingestion model allows the user to specify a population fraction that ingests KI and an associated efficacy factor. The efficacy factor defines the fractional dose reduction to the thyroid gland from inhaled radioiodine. The efficacy factor depends on the relative timing between KI ingestion and exposure to radioiodine.

POPFRAC is the fraction of a cohort that ingests KI. A fraction of the population ingesting KI is allowed when the LNT dose-response model is used; it must be 0 or 1 when a non-LNT option is chosen, as described below.

EFFACY is a factor used to reduce the dose to the thyroid from inhalation of radioiodine. The dose to a population is modified by a factor of (1 - EFFAC) × POPFRAC.

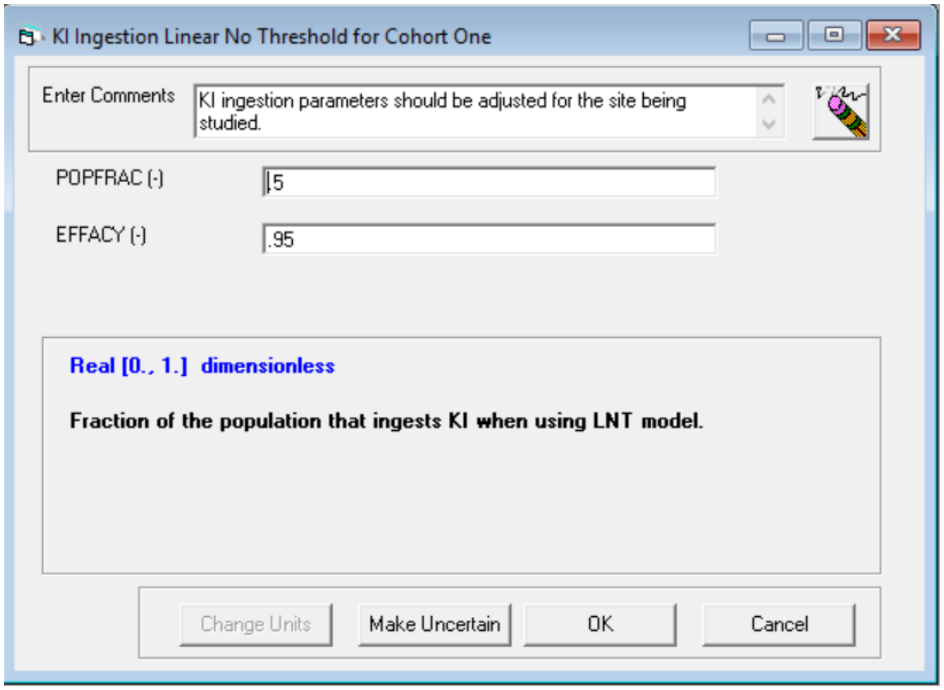


Figure 3-101 KI Ingestion Linear No Threshold Form

Table 3-97 KI Ingestion Linear No Threshold Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
POPFRAC	Yes	Real	None	0 to 1
EFFACY	Yes	Real	None	0 to 1

KI Ingestion Threshold or Piecewise Form

This form is required for *Emergency Cohort One* and any subsequent cohorts when the *Annual Threshold* or *Piecewise Linear* dose-response model and the *Activate KI Model* are selected on the *Dose* tab.

POPFRAC is the fraction of the population that ingests KI. When the PL or AT dose-response model is used, either all the population or none of the population ingest KI. A cohort can be split into two cohorts, one that takes KI and one that does not to accommodate this restriction.

EFFACY is a factor used to reduce the dose to the thyroid from inhalation of radioactive iodine. The dose to a population is modified by a factor of (1 - EFFAC) when the population ingests KI.

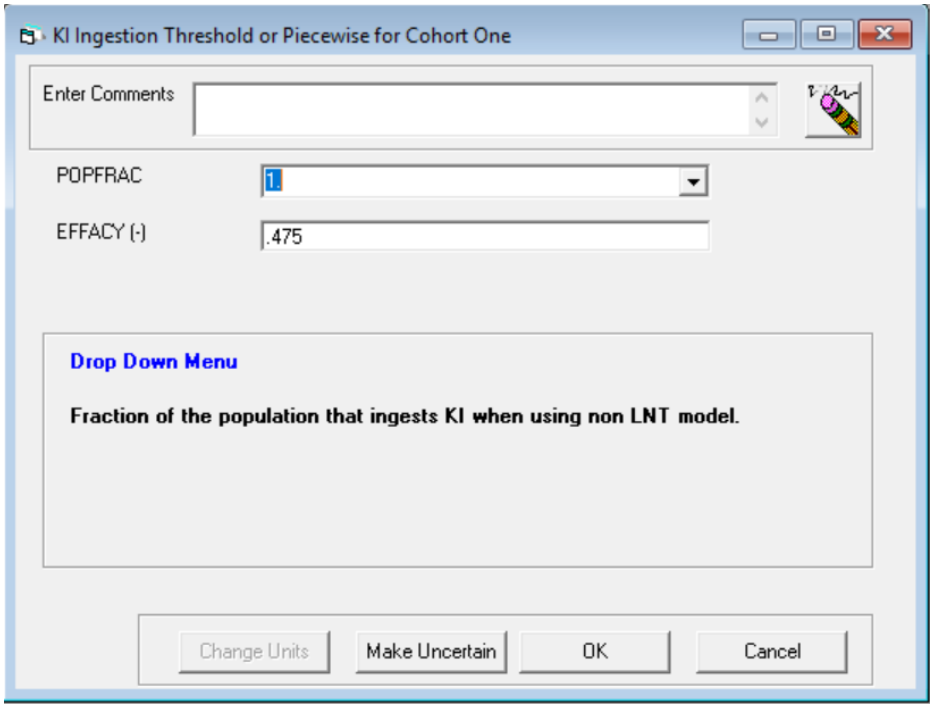


Figure 3-102 KI Ingestion Threshold or Piecewise Form

Table 3-98 KI Ingestion Threshold or Piecewise Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
POPFRAC	Yes	Real	None	0 or 1
EFFACY	Yes	Real	None	0 to 1

Sheltering and Evacuation Boundary Form

This form is required for Emergency Cohort One and any additional cohorts when the evacuation type is circular or keyhole. When the Radial Evacuation Speed, Network Evacuation Direction, or the Network Evacuation Speed forms are used for any of the additional Emergency Cohort categories, this form must be completed first to define distances on those forms.

LASMOV indicates the outer boundary at which evacuees are assumed to disappear from the early health effects model and receive no further dose. MACCS requires that the value be greater than or equal to NUMEVA and less than or equal to NUMRAD.

NUMEVA defines the outer boundary of the sheltering and evacuation region (often the same as the emergency planning zone). MACCS requires that NUMEVA be no larger than LASMOV.

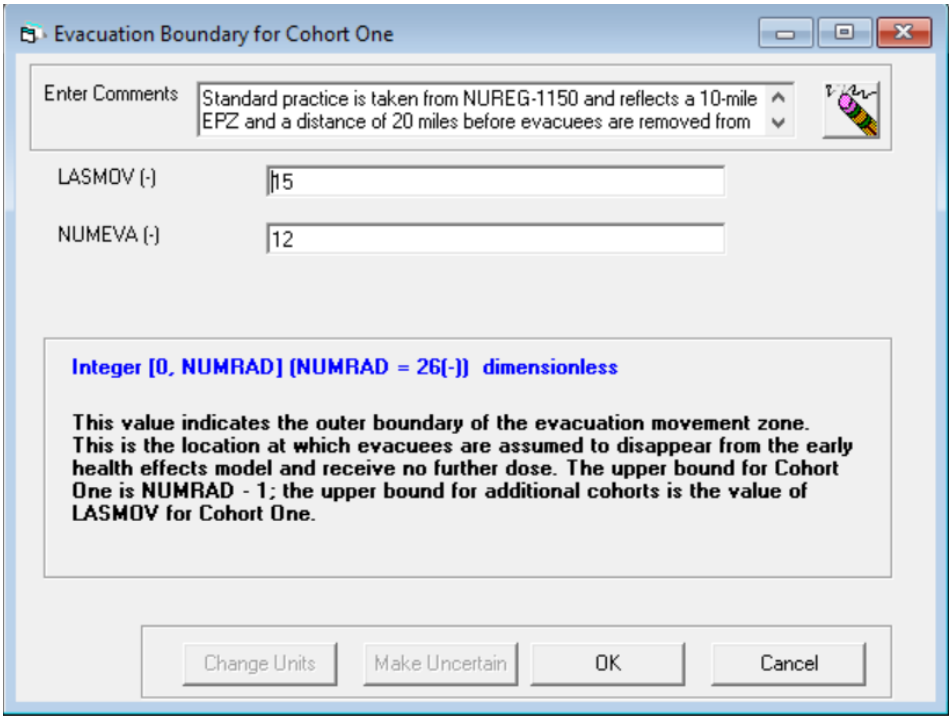


Figure 3-103 Sheltering and Evacuation Boundary Form

Table 3-99 Sheltering and Evacuation Boundary Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
LASMOV	Yes	Integer	None	1 to NUMRAD
NUMEVA	Yes	Integer	None	1 to NUMRAD, but MACCS requires 1 to LASMOV

Shielding and Exposure Form

This form is required for *Emergency Scenario One* and for each additional *Emergency Scenario* category.

This section defines the shielding factors for exposure to cloudshine, groundshine, inhalation, and deposition onto skin for three types of activities: normal activity, evacuation, and sheltering. A breathing rate is also specified for each type of activity. Normal activity values are used throughout the emergency phase for nonevacuating cohorts.

CSFACT is cloudshine shielding factor. This value is used as a multiplier on the value of cloudshine dose that would have been received if the person were standing outside in an unshielded location. A value of 0 indicates complete shielding; a value of 1 indicates no shielding.

PROTIN is inhalation protection factor. This value is used as a multiplier on the value of inhalation dose that would have been received if the person were standing outside. A value of 0 indicates complete protection from inhalation of radioactive materials; a value of 1 indicates no protection.

BRRATE is average breathing rate for the specified cohort and activity.

SKPFAC is skin protection factor. This value is used as a multiplier on the value of skin dose that would have been received if the person were standing outside. A value of 0 indicates complete protection from aerosol deposition onto the skin; a value of 1 indicates no protection.

GSHFAC is groundshine shielding factor. This value is used as a multiplier on the value of groundshine dose that would have been received if the person were standing outside in an unshielded location and the ground were a perfectly flat surface. A value of 0 indicates complete shielding from groundshine; a value of 1 indicates no protection.

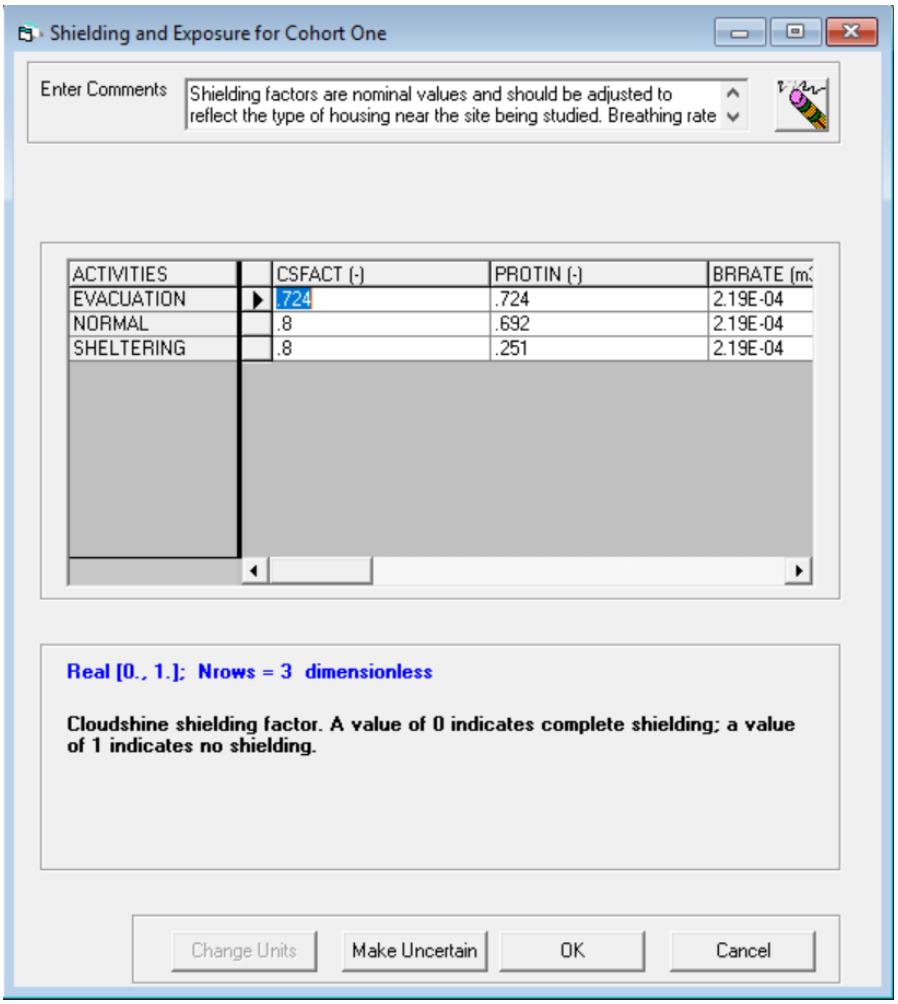


Figure 3-104 Shielding and Exposure Form

Table 3-100 Shielding and Exposure Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CSFACT	Yes	Real	3	0.0 to 1.0
PROTIN	Yes	Real	3	0.0 to 1.0
BRRATE	Yes	Real	3	0.0 to 1.0 m^3/s
SKPFAC	Yes	Real	3	0.0 to 1.0
GSHFAC	Yes	Real	3	0.0 to 1.0

Notification Delay Form

Starting with MACCS version 4.0, notification delays can be set for each individual cohort, which is done via the *Notification Delay* Form for each cohort. OALARM is the parameter that specifies the notification delay and is defined as the elapsed time between accident initiation to notification of the public to take protective actions. OALARM represents declaration of a site emergency, a general emergency, or some other notification time used to trigger emergency response.

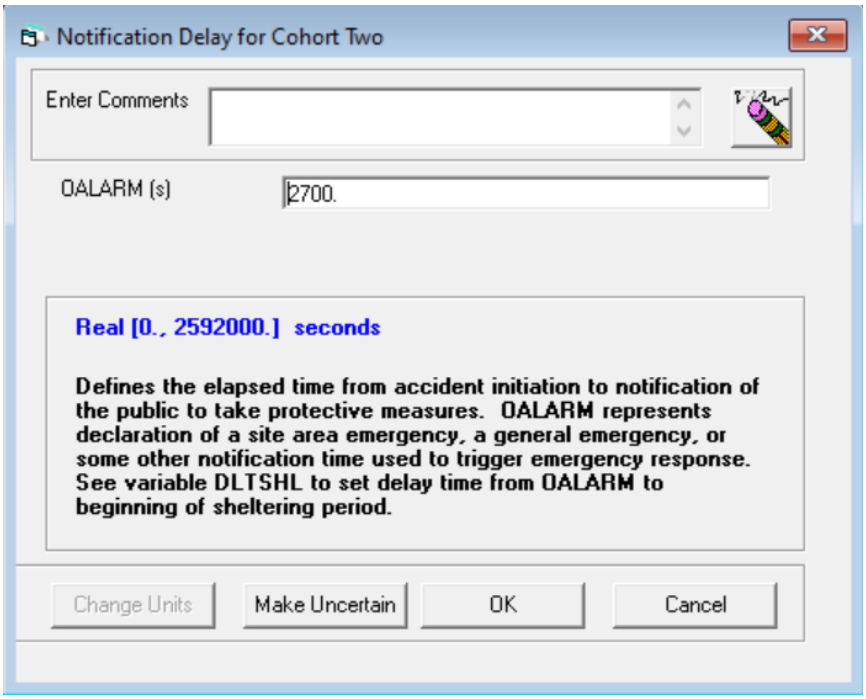


Figure 3-105 Notification Delay Form

Table 3-101 Notification Delay Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
OALARM	Yes	Real	None	0.0 to 2.592 x 10^6 sec

Response Delays Form

This form is required for *Emergency Scenario One* and for each additional *Emergency Cohort* category.

This form defines the delay from the time indicated by REFPNT until the beginning of sheltering and the delay from the beginning of sheltering until the beginning of evacuation.

DLTSHL defines the delay from the time represented by REFPNT to the start of sheltering. Normal activity shielding factors are used during this delay. Sheltering shielding factors are used following this delay. One value of DLTSHL must be supplied for each ring in the sheltering/evacuation region.

DLTEVA defines the delay from the beginning of the sheltering period to the beginning of evacuation. Sheltering is assumed during this delay. Evacuation shielding factors are used following this delay. One value must be supplied for each ring in the sheltering/evacuation region.

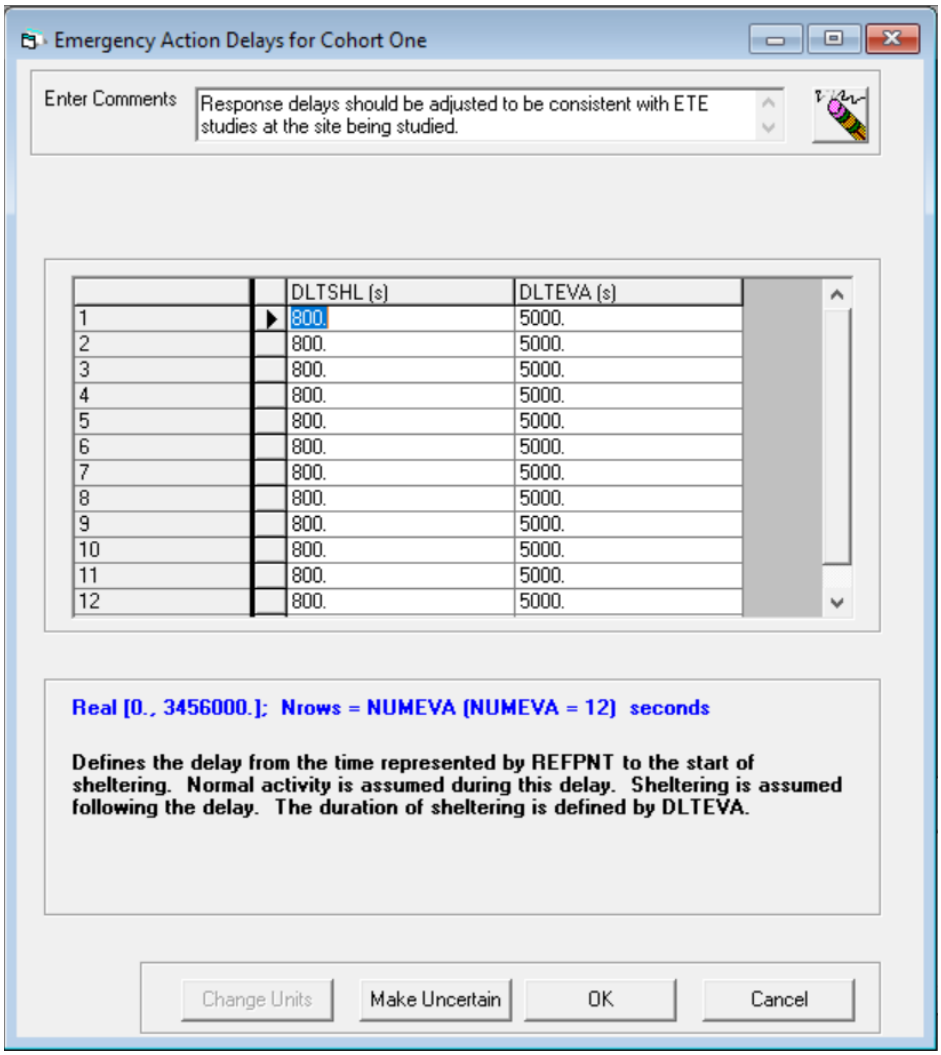


Figure 3-106 Emergency Actions Delays Form

Table 3-102 Emergency Actions Delays Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DLTSHL	Yes	Real	NUMEVA	0 to 3.456 x 10^6 s or 40 days
DLTEVA	Yes	Real	NUMEVA	0 to 3.456 x 10^6 s or 40 days

Radial Evacuation Speed Form

This form is required for *Emergency Cohort One* when the *Problem Model* is *Radial* and *Activate Speed Multiplier Model* is selected on the *Project Properties/Evac Rotation* tab. This form is required for each additional *Emergency Cohort* category when evacuation type is circular or keyhole and *Activate Speed Multiplier Model* is selected.

ESPGRD_RAD defines the speed multiplier for each grid element where evacuation is treated. This includes all grid elements from the center to the outer boundary of evacuation movement, defined by LASMOV. A value of one indicates the speed is the same as the value of ESPEED. The ranks of these numbers are shown in the interface. See Section 4.4.7 for more information.

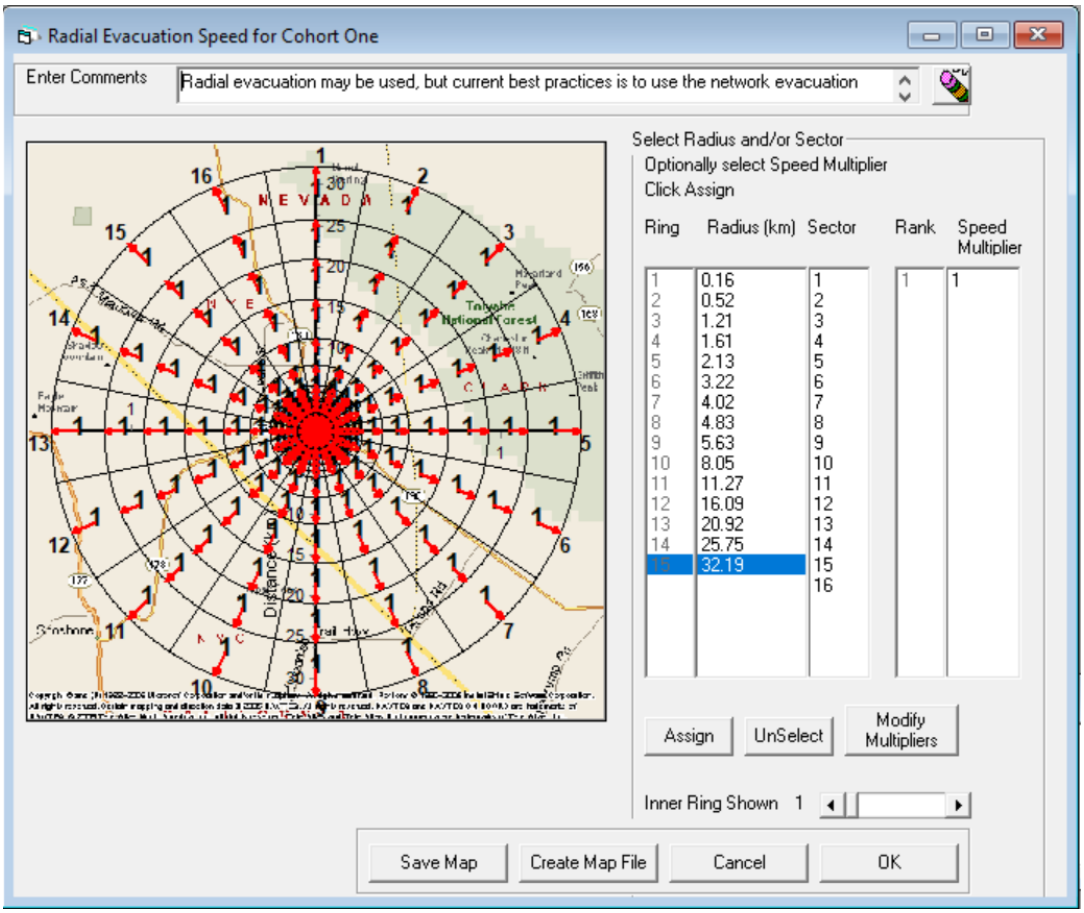


Figure 3-107 Radial Evacuation Speed Form

Table 3-103 Radial Evacuation Speed Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
ESPGRD_RAD	Yes	Real	LASMOV by NUMCOR	0.001 to 1000.0

Network Evacuation Direction Form

This form is required for *Emergency Scenario One* when the *Problem Model* is chosen to be *Network* on the *Project Properties/Evac Rotation* tab. This form is required for each additional *Emergency Cohort* category when evacuation type is circular or keyhole.

ESPGRD_NET is a read-only parameter on this form and is defined on the form *Network Evacuation Speed*. When this parameter is undefined, a value of 1 is used for both the rank and the value of the speed multiplier.

IDIREC defines the evacuation direction. A value of one indicates an outward evacuation to the next grid element, two indicates clockwise evacuation, three indicates inward evacuation, and four indicates counterclockwise evacuation. These numbers are input in the interface as arrows that can be clicked to change the evacuation direction.

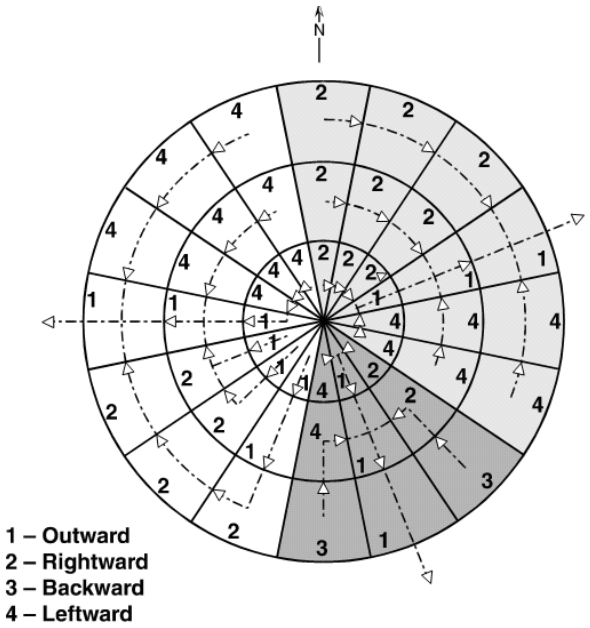


Figure 3-108 IDIREC values in network evacuation grid

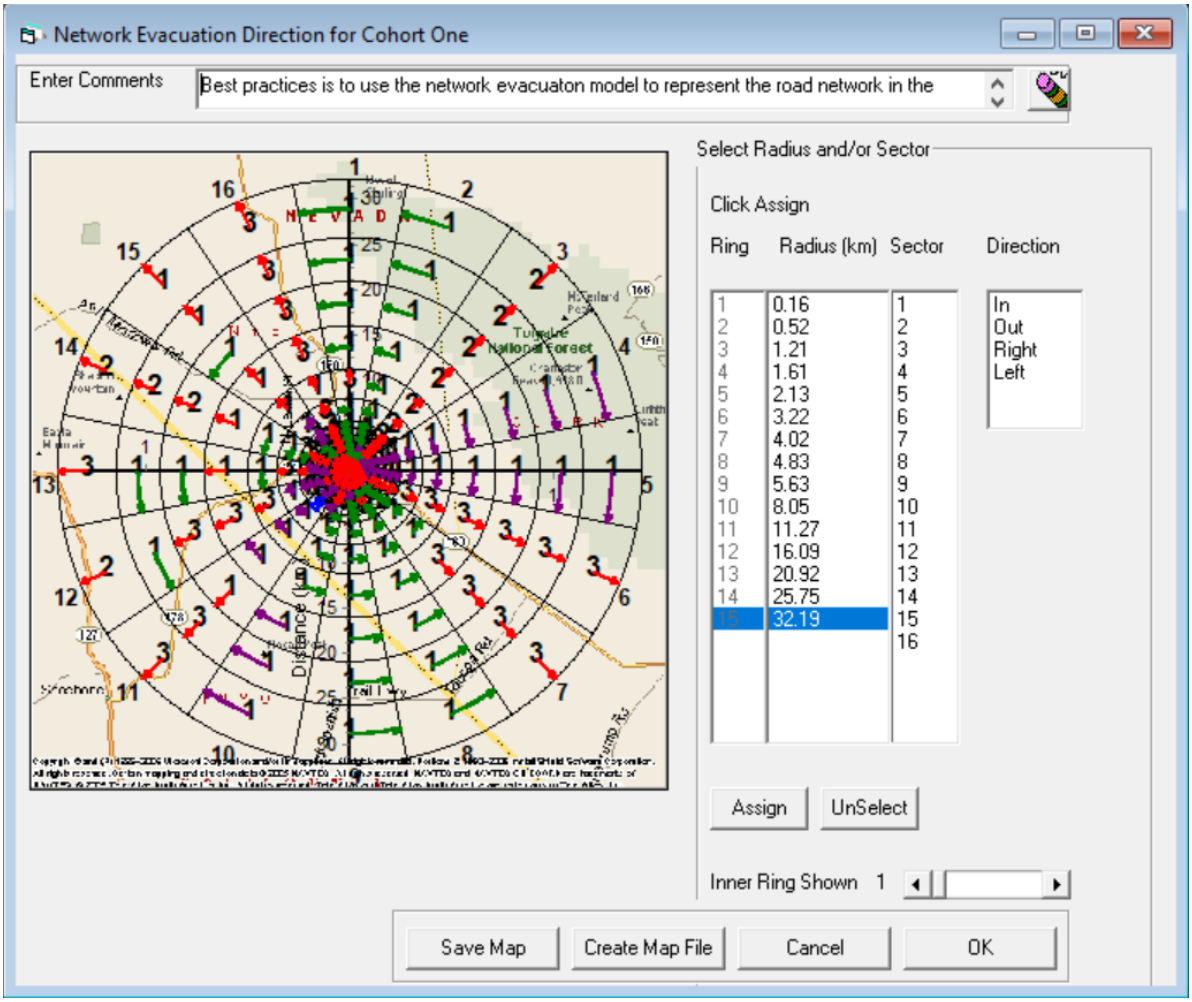


Figure 3-109 Network Evacuation Direction Form

Table 3-104 Network Evacuation Direction Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values	Defined on Form
ESPGRD_NET	No	Real	LASMOV by NUMCOR	0.001 to 1000.0	Network Evacuation Speed
IDIREC	Yes	Integer	LASMOV by NUMCOR	1 to 4	Network Evacuation Direction

Network Evacuation Speed Form

This form is required for *Emergency Cohort One* when the *Problem Model* is *Network* and *Activate Speed Multiplier Model* is selected on the *Project Properties/Evac Rotation* tab. This form is required for each additional *Emergency Cohort* category for which the evacuation type is keyhole or circular. This set of parameters is useful for adjusting speeds to account for bottlenecks in the road network or for areas of freely flowing traffic.

ESPGRD_NET defines the speed multiplier for each grid element where evacuation is treated. This includes all grid elements from the center to the outer boundary of the evacuation movement, defined by LASMOV. A value of one indicates the speed is the same as the value of ESPEED. The ranks of these numbers are shown in the interface. See Section 4.4.7 for more information.

IDIREC is a read-only parameter on this form and is defined on the form *Network Evacuation Direction.* A value of one indicates an outward evacuation to the next grid element, two indicates clockwise evacuation, three indicates inward evacuation, and four indicates counterclockwise evacuation. These numbers are shown in the interface as arrows that display the direction of evacuation.

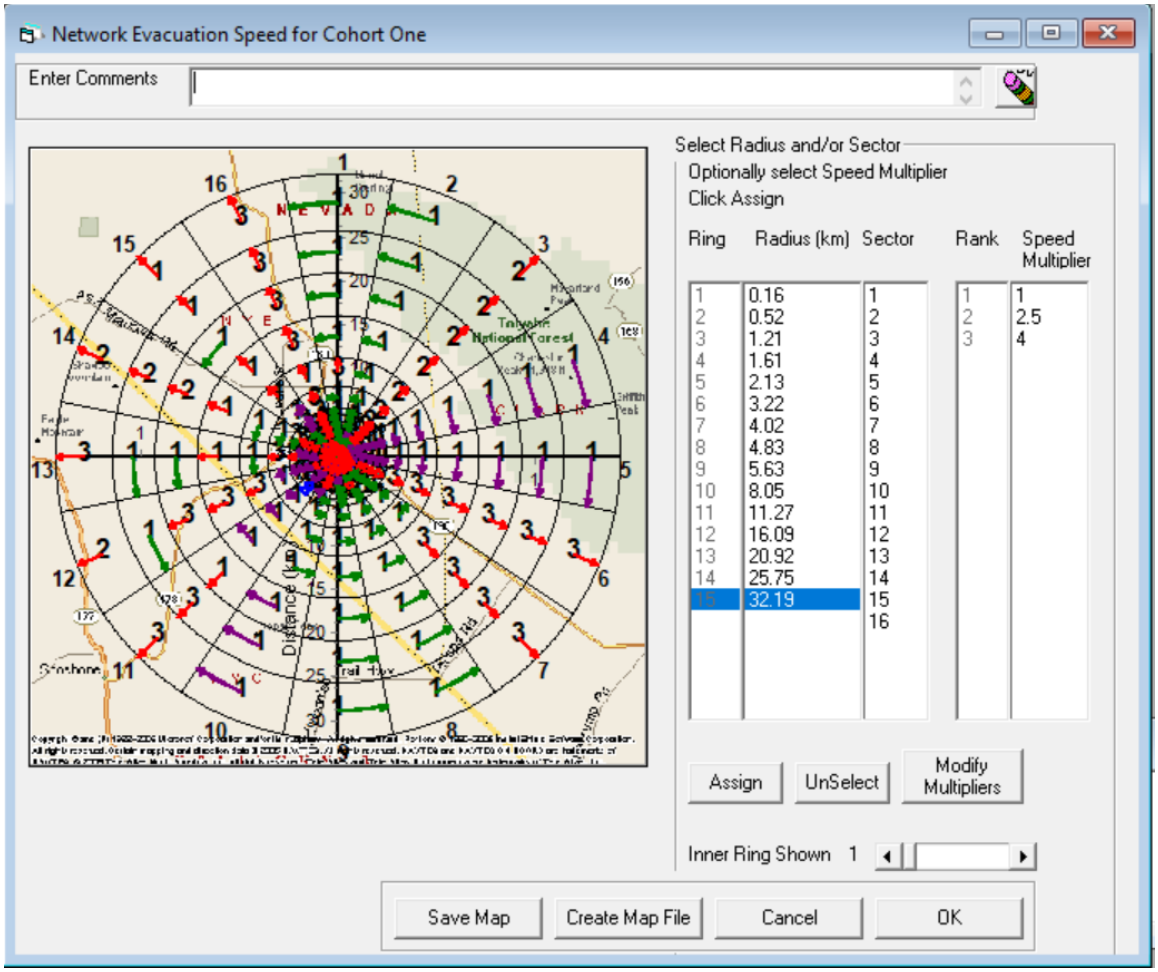


Figure 3-110 Network Evacuation Speed Form

Table 3-105 Network Evacuation Speed Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values	Defined on Form
ESPGRD_NET	Yes	Real	LASMOV by NUMCOR	0.001 to 1000.0	Network Evacuation Speed
IDIREC	No	Integer	LASMOV by NUMCOR	1 to 4	Network Evacuation Direction

Population Form

The *Population* form is relevant for each emergency cohort when the user chooses SUMPOP as the *Results Weighting Factor* and selects *File Created from Existing Site File* on the *Site Data* tab. When the *Populations Assigned* form is completed or modified, the *Population* form is updated. The values shown are the number of people assigned to each spatial grid element for the given cohort.

COHORT_POP defines the number of people associated with each spatial grid element for a cohort.

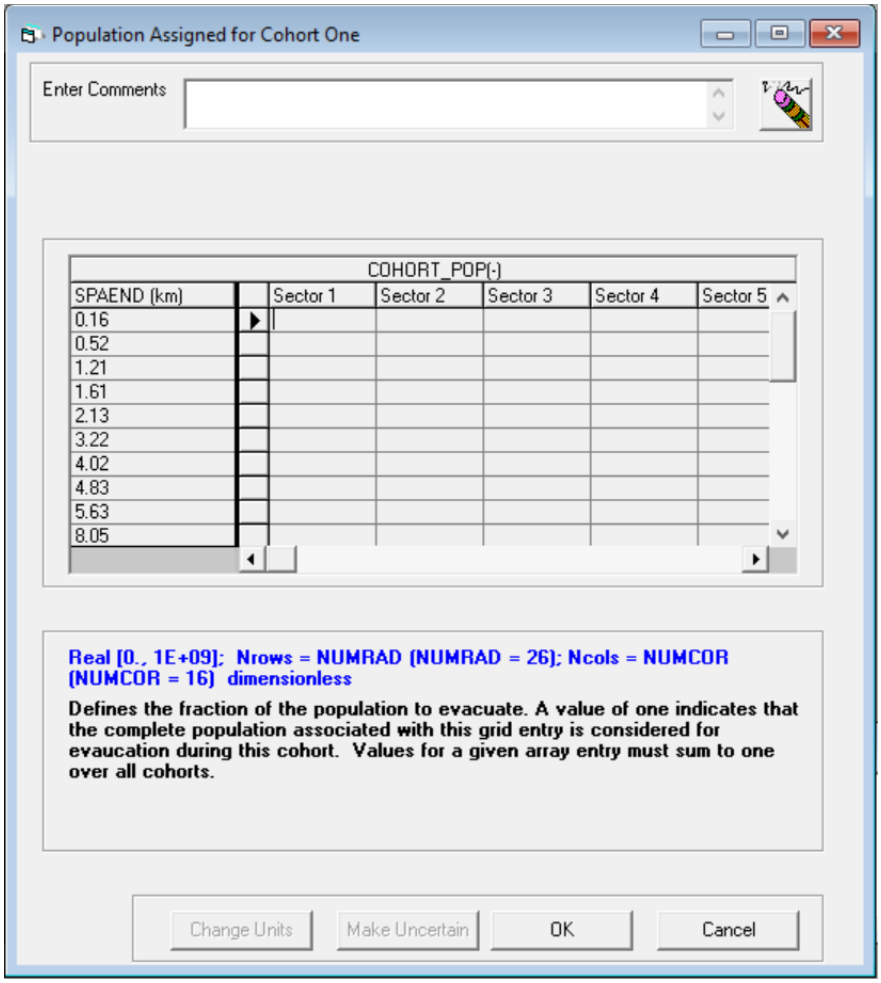


Figure 3-111 Population Form

Table 3-106 Population Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values	Defined on Form
COHORT_POP	No	Real	NUMRAD by NUMCOR	0 to 10^9	Populations Assigned

Keyhole Definition Form

The *Keyhole Definition* form is required when the evacuation *Type* field is set to *Keyhole.*

NSECTR defines the number of sectors to be considered in keyhole evacuation. This number should not exceed NUMCOR/2 – 1. If it does, the evacuation model defaults to a circular one.

KEYDIS is the radius of the circular portion of the keyhole. KEYDIS is the index of a radius in SPAEND. The outer radius of the evacuation region is defined by NUMEVA. Setting KEYDIS to zero eliminates the circular portion of the keyhole. Setting KEYDIS to NUMEVA eliminates the key portion of the keyhole.

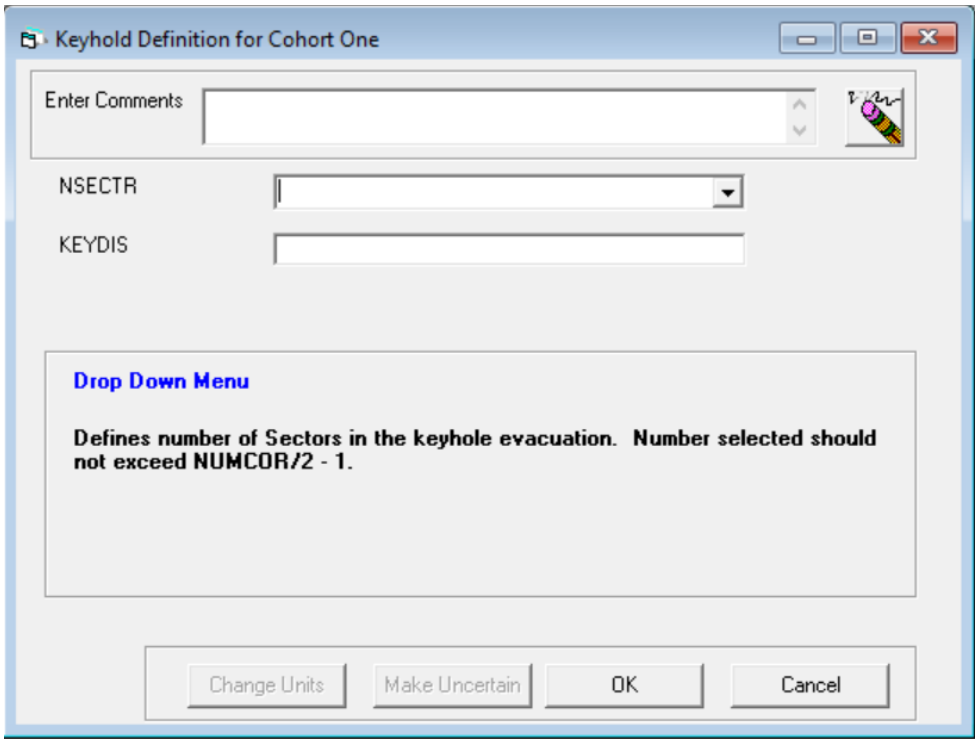


Figure 3-112 Keyhole Definition Form

Table 3-107 Keyhole Definition Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NSECTR	Yes	Integer	None	1, 3, 5, 7, …, 31
KEYDIS	Yes	Integer	None	0 to NUMEVA

3.3.7 Early Fatality and Injury Parameters

3.3.7.1 Fatality Model Description

The individual risk of early fatality is modeled in MACCS using a two-parameter Weibull function, termed a hazard function (Evans, Moeller, and Cooper, 1985). The hazard function is used to sum the cumulative risk from several potential types of damage as follows:

$$RISK = 1 - e^{-\sum_i H_i} \quad \textbf{(3-35)}$$

Where

$$H_i = 0.693 \left(\frac{DOSE_i}{EFFACA_i} \right)^{EFFACB_i}$$

$\mathrm{DOSE_i}$ = effective acute dose to organ i (described later),

$\mathrm{EFFACA_i}$ = the alpha (LD_{50}) parameter in the hazard function (Evans, Moeller, and Cooper, 1985, p. II-8) for organ i, and

$\mathrm{EFFACB_i}$ = the beta or exponential parameter in the hazard function that defines the steepness of the dose-response function for organ i.

In addition to the two Weibull parameters, a dose threshold is incorporated into the early fatality model. When the dose to any organ is below the user-specified threshold (see EFFTHR below), the hazard function (H_i) for that organ is set to 0.

When radioactive material is inhaled and retained in the respiratory system, an individual may continue to receive a radiation dose for extended periods of time after the material was inhaled. Depending on particle size and chemical form, clearance mechanisms may remove the material from the body or transport it from the respiratory system to other organs of the body. Acute radiation doses represent doses delivered to an organ over a relatively brief period. The concept of lifetime dose commitment is widely used in radiation protection (Eckerman, Wolbarst, and Richardson 1989), but is not appropriate for estimating acute health effects.

As applied in MACCS, lifetime dose refers to the dose received over a 50-year commitment period following inhalation by a standard reference person who is 30 years old. Lifetime doses are used to determine the need for mitigative actions and to estimate cancers occurrences and population doses.

Implementation of the Evans, Moeller, and Cooper (1985) early health effects model requires a calculation method that takes account of dose protraction for radioactive material inhaled and retained in the respiratory system. The assumption is that the exposure occurs on the first day, but that dose is received by an organ over a period of time. MACCS applies dose reduction factors to protracted doses that contribute to early health effects. Dose reduction factors are derived from LD_{50} or D_{50} values that apply to a sequential set of time periods of fixed length. In addition, for the calculation of early fatalities and injuries in MACCS, a new measure of dose was defined to reduce the computational demands of the calculations. This dose is termed an effective acute dose. This dose is different than the effective dose defined by ICRP.

The effective acute dose, D_e, is the dose, which if it were delivered entirely in one day, would induce the same health effects as an actual dose delivered over many days. Thus,

$$H = log_2\left(\frac{D_e}{\alpha_1}\right)^{\beta} = log_2\left(\sum_t \frac{D_t}{\alpha_t}\right)^{\beta} \quad \textbf{(3-36)}$$

Where

D_e = $C \cdot F_e$

D_t = $C \cdot F_t$

C = the amount of material inhaled from the plume,

F_e = the effective acute DCF,

F_t = the DCF for the actual dose, D_t, delivered over time t.

α_t = the LD_{50} or D_{50} delivered over time t.

α_1 = the LD_{50} or D_{50} delivered over 1 day.

Substitution yields the following result:

$$F_e = \sum_t \left(\frac{\alpha_1}{\alpha_t} F_t\right) \quad \textbf{(3-37)}$$

Effective acute DCFs are supplied only for the organs used for calculating early health effects. The acute dose commitment period from inhaled and internally deposited radionuclides is from one week to one year, depending on the organ. The organs in the DCF file for which effective acute dose coefficients have not been assessed are assigned values of -1.0, which prevents their inadvertent use since any resulting doses would be negative. The dose reduction factors (*i.e.*, α_1/α_t) that underly the acute values in the dose coefficient files supplied with WinMACCS are shown in the table below. The values in this table are taken from Evans, Moeller, and Cooper (1985) and are also documented in H-N Jow et al. (1990).

Table 3-108 Effective Acute Dose Reduction Factors Used to Construct Acute Dose Coefficients for Inhalation in MACCS DCF Files.

	Period after Initial Exposure (Days)					
	0–1	**1–7**	**7–14**	**14–30**	**30–200**	**200–365**
Organ Name	**Effective Acute Dose Reduction Factors (α_1/α_t) (Dimensionless)**					
RED MARR	1.0	0.5	0.5	0.25		
LUNGS	1.0	0.0625	0.0625	0.027	0.027	0.0109
THYROID	1.0	0.2	0.2	0.2		
STOMACH	1.0	0.37				
LOWER LI	1.0	0.43				
SMALL IN	1.0	0.43				

For early fatalities (with supportive treatment) for bone marrow irradiation, Evans, Moellen, and Cooper (1985) show LD_{50} values of 4.5 Gy for the 0- to 1-day period, 9 Gy for the 1- to 14-day period, and 18 Gy for the 14- to 30-day period. Instead of calculating three different red marrow doses and applying the three different values of LD_{50} to calculate risk, a single red marrow dose is calculated using the effective acute DCF, as described above. The result is the same as the one that would have been obtained if doses over all three periods had been obtained and Equation (3-36) had been used directly.

In the MACCS model, exposure via the inhalation pathway is assumed to occur on the first day, and this exposure results in committed doses for each of the periods listed in the table. To illustrate use of the above table, effective acute red marrow dose from inhaling a contaminant is 100% of the first day's committed dose, 50% of the next 13 days' committed dose, plus 25% of the subsequent 16 days' committed dose. The effective acute dose from inhalation is added to doses from external sources to get a total acute dose. The external exposures are also assumed to occur in the first day, so they are applied with a dose reduction factor of one. The total effective acute dose is used in the risk equation with the LD_{50} for the 0- to 1-day period to evaluate the hazard function for bone marrow.

The current implementation of the early health effect models does not distinguish between cloudshine, groundshine, and the 0- to 1-day inhalation dose commitment. These pathways are considered in this model to be equally effective in causing damage. Finally, the radiation weighting factor used for acute alpha radiation is 10 instead of the conventional value of 20 used for lifetime DCFs, which corresponds to the fact that the endpoint of the damage for early and latent health effects is different (i.e., the former corresponds to cell death and the latter to chromosome damage).

The error introduced by attributing the entire direct exposure dose to the first day is usually small and is in the direction of overestimating the hazard function and resulting value of risk of an early fatality. In most cases, emergency plans should ensure that no individuals are permitted to remain in a contaminated area for much longer than one day when dose levels are high enough to pose a risk of early health effects.

This section describes the MACCS models used to estimate early health effect cases and individual risks. Results to be processed (*e.g.,* total cases of early fatalities, average individual risk of early fatalities, and centerline risk vs. distance of early fatalities) are described in later sections of this document. To produce early fatality results, the early fatality model must be activated on the *Properties* form.

3.3.7.2 Injury Model Description

The individual risk of each type of early injury is modeled in MACCS using an approach analogous to the one used for early fatality risk (Evans, Moller and Cooper 1985). The early injury risk model differs from the early fatality model in that, instead of summing the damage from more than one organ, only a single organ is evaluated at a time. The early injury risk function is as follows:

$$RISK = 1 - e^{-\sum_i H_i} \quad \textbf{(3-38)}$$

Where

$$H_i = 0.693 \left(\frac{DOSE_i}{EIFACA_i} \right)^{EIFACB_i}$$

$\mathrm{DOSE_i}$ = effective acute dose (described in Section 3.3.7.1) to organ i,

$\mathrm{EIFACA_i}$ = the alpha (D_{50}) parameter in the hazard function (Evans, Moller and Cooper 1985, p. II-8) for a one-day dose to organ i, and

$\mathrm{EIFACB_i}$ = the beta or exponential parameter in the hazard function that defines the steepness of the dose-response function for organ i.

In addition to the two Weibull parameters, a dose threshold is incorporated into the early injury model. When the dose to any of the target organs is below the user-specified threshold (see EITHRE in the following discussion), the hazard function for this type of early injury is set to 0, which results in the risk being zero.

In addition to the values described above, the user must specify the fraction of the population that is susceptible to the injury, EISUSC. Results to be processed (*e.g.,* total cases of a given injury, average individual risk, and centerline risk vs. distance of a given injury) are described in later sections. To produce early injury results, early injuries must be activated on the *Properties* form.

3.3.7.3 Latent Cancer Model Description

The cancer risk model included in the first public release version of MACCS was based on a linear-quadratic risk model. In response to recommendations presented in an NRC-sponsored reassessment of cancer risk models published in 1991 and referred to as LMF-132 (Abrahamson *et al.* 1991), the cancer risk model was updated in MACCS version 1.5.11.1 (Chanin *et al*. 1993) to include a linear, no-threshold dose-response function. The capability to exercise the linear-quadratic risk model was retained although it is not typically used at present for calculation of cancer-induction risk.

Linear-Quadratic Dose-Response Model

The linear-quadratic dose-response model assumes that risk, *R*, increases linearly with increases in dose, *D*, at low doses and that risk increases quadratically with respect to dose at higher dose levels. The linear-quadratic dose-response function has the form (ICRP, 1991):

$$R(D) = D \cdot (a + \beta D) \quad \textbf{(3-39)}$$

The implementation of the linear-quadratic dose-response model in MACCS is based on the recommendations of NRC-sponsored work (Evans 1990) and is described as follows. In the period modeled by EARLY, a quadratic dose-response relationship is used when dose to the target organ is less than a user-specified limit (MACCS ACTHRE input parameter). The dose-response function used in this case has the form:

$$R(DOSE) = DOSE \bullet CFRISK \bullet (DOSEFA + DOSE \bullet DOSEFB) \bullet ACSUSC \quad \textbf{(3-40)}$$

Where

DOSE	=	50-year lifetime dose commitment to the target organ,
CFRISK	=	lifetime risk factor for cancer injury,
DOSEFA	=	the linear factor, α, of the dose dependence,
DOSEFB	=	the quadratic factor, β, of the dose dependence, and
ACSUSC	=	fraction of the population susceptible to the latent cancer.

When dose to the target organ is greater than the dose limit *ACTHRE*, the upper-bound linear dose-response relationship is used:

$$R(D) = DOSE \bullet CFRISK \bullet (DOSEFA + ACTHRE \bullet DOSEFB) \bullet ACSUSC \quad \textbf{(3-41)}$$

The change from Equation (3-40) to Equation (3-41) at the threshold value causes a discontinuity in the slope but not of the risk factor itself.

During the long-term phase modeled by CHRONC, it is assumed that exposure of the population is limited to low levels by mitigative actions and therefore the quadratic term of the risk equation is ignored. Cancer risk is calculated using only the linear term, $R(D) = \alpha D$, of the quadratic dose response function. Cancer risk from all pathways (groundshine, resuspension inhalation, and ingestion) is modeled with the linear dose-response function given below:

$$R(D) = DOSE \bullet CFRISK \bullet DOSEFA \bullet ACSUSC \quad \textbf{(3-42)}$$

The meaning of DOSE and CFRISK depends on whether individual risk (groundshine and resuspension) or collective risk (also including ingestion and decontamination worker doses) is being calculated.

The quadratic form of the dose-response relationship is deactivated by assigning zero to the ACTHRE input parameter.

Dose and Dose-Rate Effectiveness Factor

In response to recommendations presented in LMF-132, the MACCS cancer risk model was updated in MACCS version 1.5.11.1 to include a dose and dose-rate effectiveness factor in the dose-response function as follows:

$$R(D) = \alpha \cdot \frac{D}{DDREF} \qquad \text{D < 0.2 Gy or 0.1 Gy per hour} \qquad \textbf{(3-43)}$$

$$R(D) = \alpha \cdot D \qquad \textit{D} > \text{0.2 Gy or 0.1 Gy per hour}$$

This function is shown as the LNT curve in Figure 3-89. DDREF is the dose and dose rate effectiveness factor. The LMF-132 report states that the DDREF is to be applied "when the total dose is less than 0.2 Gray, and for higher doses when the dose rate is less than 0.1 Gray per hour." This guidance for the application of the DDREF is identical to the recommendations provided in ICRP 60. The DDREF is given a value of 2 in LMF-132 for central estimates of most cancer types; for central estimates of breast and thyroid cancers, DDREF is assigned a value of 1 in LMF-132. In current modeling with FGR-13 dose coefficient files, DDREF is generally chosen to be 2 for all organs but breast, which is assigned a value of 1.

The user defines the lifetime dose commitment, input parameter DDTHRE, below which the DDREFA is applied to cancer risk calculations for emergency-phase exposures. MACCS applies DDREFA to all the dose calculations in the CHRONC module because doses should always be less than 0.2 Gy after the end of the emergency phase.

3.3.7.4 Injury and Fatality Forms and Parameters

***Early Fatality Parameters* Form**

The *Early Fatality Parameters* form is not used when the DCF file FGRDCF is selected on the *Project Properties/Dose* tab or when *Early Fatality Effects* is not checked on the *Project Properties/Early Effects* tab. It is required when either of the other DCF file types is selected and *Early Fatality Effects* is checked.

NUMEFA is the number of early fatality effects to be included in the total risk of early fatality.

ORGNAM is an organ name. The possible values depend on the DCF file chosen. Possibilities are limited to supported acute organs (ones beginning with A-).

EFFACA is the Alpha factor (LD50) in the hazard function for the target organ.

EFFACB is the beta factor (shape parameter) in the hazard function for the target organ.

EFFTHR is the threshold dose below which the risk of a fatality is zero.

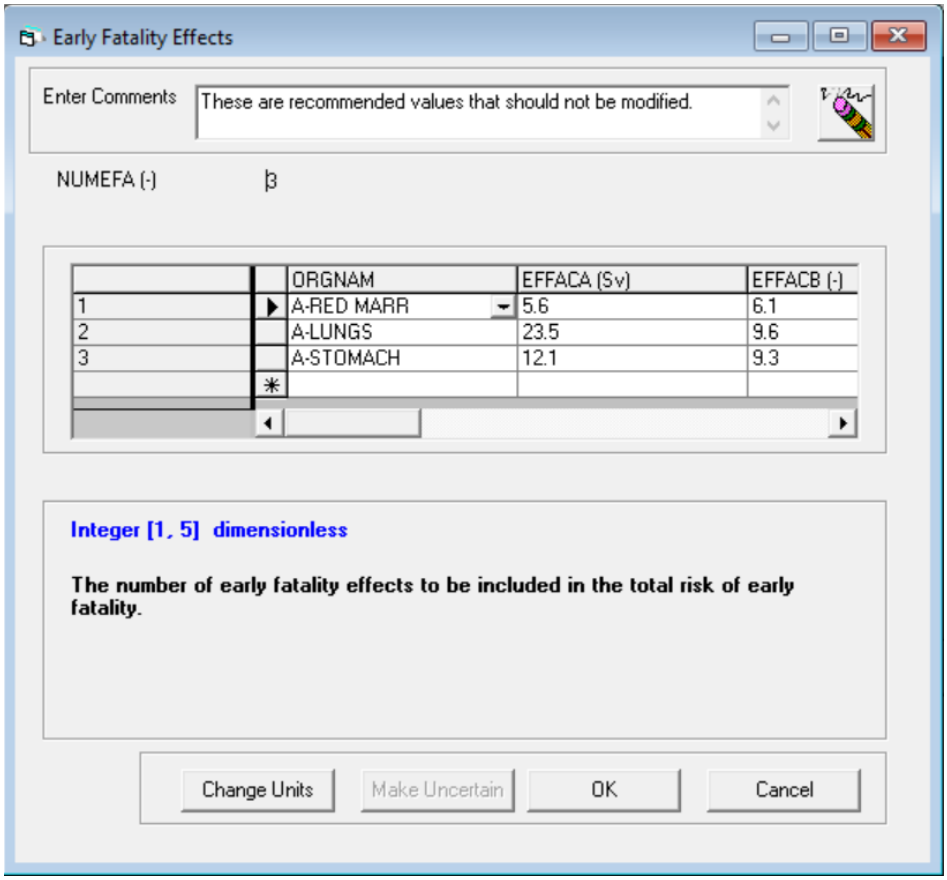


Figure 3-113 Early Fatality Parameters Form

Table 3-109 Early Fatality Parameters Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMEFA	Linked	Integer	None	1 to 10
ORGNAM	Yes	Character	NUMEFA	Acute Organ name from DCF File
EFFACA	Yes	Real	NUMEFA	1.0 to 100. Gy
EFFACB	Yes	Real	NUMEFA	1.0 to 100.
EFFTHR	Yes	Real	NUMEFA	0.0 to 100. Gy

Early Injury Parameters Form

The *Early Injury Parameters* form is not used when the DCF file FGRDCF is selected on the *Project Properties/Dose* tab or when *Early Injury Effects* is not checked on the *Project Properties/Early Effects* tab. It is required when either of the other DCF file types is selected and *Early Injury Effects* is checked.

NUMEIN is the number of early injury types that are to be calculated.

EINAME is the name of each type of early injury. This is a user-defined label.

ORGNAM is an organ name. The possible values depend on the DCF file chosen. Possibilities are limited to organs with acute dose coefficients (ones beginning with A-).

EISUSC is the fraction of the population that is susceptible to the type of early injury.

EITHRE is the threshold dose below which risk of the injury is zero.

EIFACA is the alpha factor (D50) in the hazard function for the injury.

EIFACB is the beta (shape) factor in the hazard function for the injury.

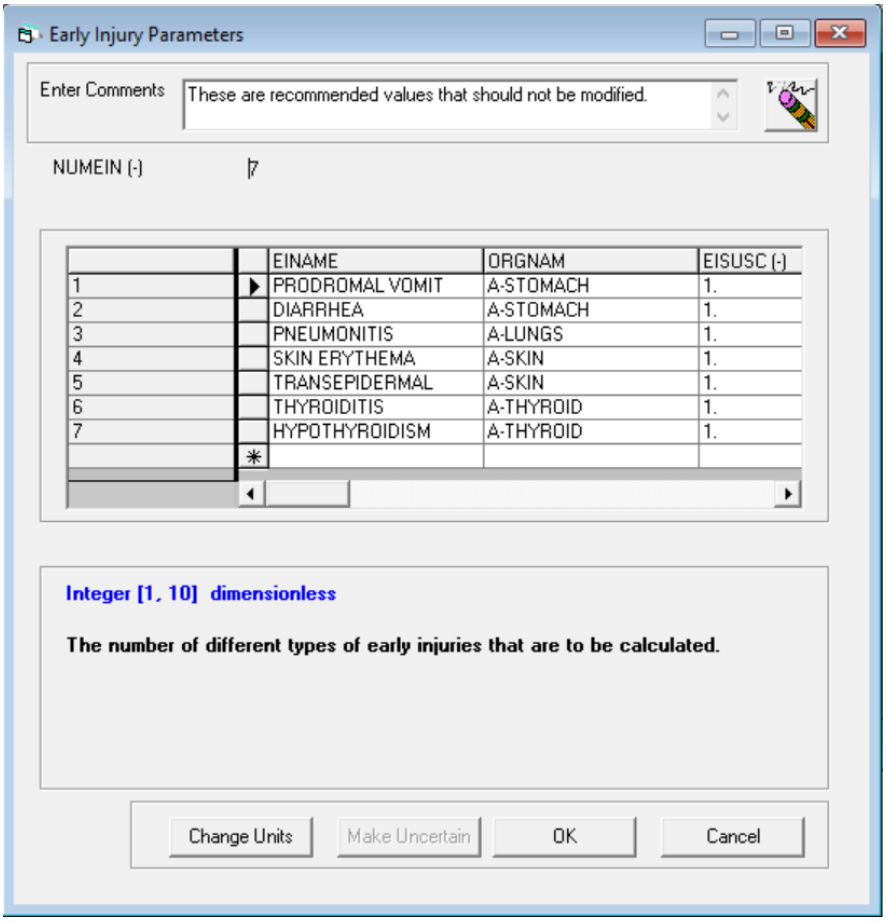


Figure 3-114 Early Injury Parameters Form

Table 3-110 Early Injury Parameters Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMEIN	Linked	Integer	None	1 to 10
EINAME	Yes	Character	NUMEIN	1 to 16 characters
ORGNAM	Yes	Character	NUMEIN	Acute Organ name from DCF File
EISUSC	Yes	Real	NUMEIN	0.0 to 1.0
EITHRE	Yes	Real	NUMEIN	0.0 to 1000.0 Gy
EIFACA	Yes	Real	NUMEIN	0.0 to 1000.0 Gy
EIFACB	Yes	Real	NUMEIN	0.0 to 100.0

Latent Cancer Parameters Form

The *Latent Cancer Parameters* form is required when Latent Cancer Effects is checked on the Project Properties/Early Effects tab.

NUMACA is the number of latent cancers that are to be calculated.

DDTHRE is the threshold dose for applying the dose and dose-rate effectiveness factor DDREFA. When the lifetime dose commitment incurred during the EARLY exposure period is less than DDTHRE, the risk of cancer from irradiation of that organ is reduced by dividing by DDREFA.

ACNAME is the name of each type of latent cancer.

ORGNAM is the name of the target organ for each type of latent cancer effect. The possible values offered depend on the DCF file. Possibilities are limited to supported latent organs (ones beginning with L-).

ACSUSC is the fraction of the population that is susceptible to the latent cancer.

DOSEFA defines the linear factor, alpha, of the dose dependence in the cancer risk model.

DOSEFB defines the quadratic factor, beta, of dose dependence in the cancer risk model. It is used in EARLY, but not in CHRONC. The quadratic factor is used when dose to an organ is below ACTHRE. The user should assign a value of zero to deactivate the quadratic portion of the linear-quadratic risk model.

CFRISK is the lifetime risk factor for a cancer fatality. This parameter has units of risk/Sievert.

CIRISK is the lifetime risk factor for a cancer incidence (injury). This parameter has units of risk/Sievert.

DDREFA is the dose and dose-rate effectiveness factor. When the lifetime dose commitment to an organ during the EARLY exposure period is less than DDTHRE, the risk of cancer for that organ is divided by DDREFA. Doses calculated in CHRONC are always divided by DDREFA because the doses are assumed to be below DDTRHE.

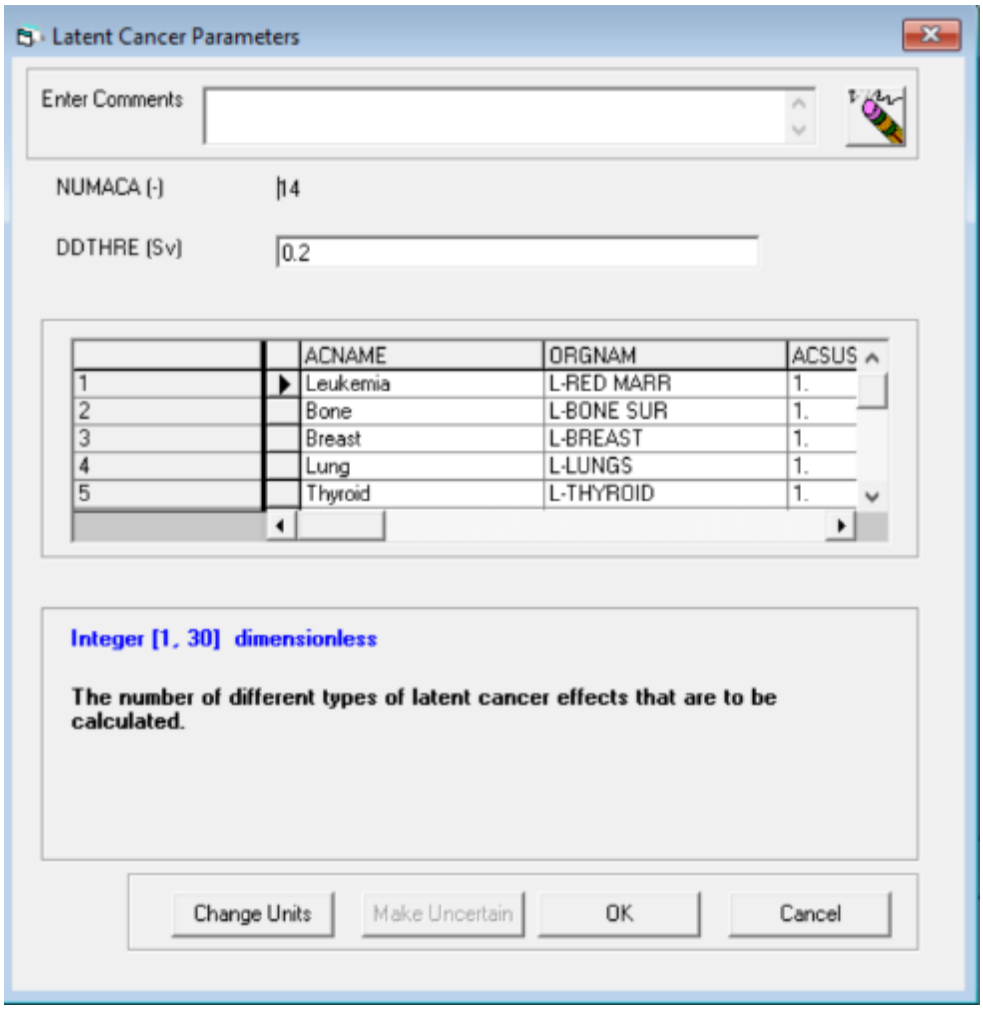


Figure 3-115 Latent Cancer Parameters Form

Table 3-111 Latent Cancer Parameters Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMACA	Linked	Integer	None	1 to 30
DDTHRE	Yes	Real	None	0 to 1 Sv
ACNAME	Yes	Character	NUMACA	1 to 10 characters
ORGNAM	Yes	Character	NUMACA	Lifetime Organ name from DCF File
ACSUSC	Yes	Real	NUMACA	0.0 to 1.0
DOSEFA	Yes	Real	NUMACA	0.0 to 2.0
DOSEFB	Yes	Real	NUMACA	0.0 to 2.0
CFRISK	Yes	Real	NUMACA	0.0 to 1.0 per Sv
CIRISK	Yes	Real	NUMACA	0.0 to 1.0 per Sv
DDREFA	Yes	Real	NUMACA	1.0 to 10.0

Latent Cancer Linear Quadratic Form

The Linear-Quadratic Dose Response check box on the *Project Properties Dose* determines whether parameters are required for the linear quadratic dose response model. If this box is checked, then the quadratic coefficients, ACTHRE, DOSEFA, and DOSEFB, are required input. When not checked, ACTHRE, DOSEFA, and DOSEFB are automatically set to 0., 1., and 0., respectively, for each organ in the EARLY input file.

ACTHRE is the dose limit for the linear-quadratic dose-response relationship. For doses less than ACTHRE, a quadratic relationship is used. This parameter should be assigned a value of zero when the user wishes to deactivate the linear-quadratic risk model in favor of a linear relationship. This parameter might better be described as a breakpoint in the dose-response curve and its use is distinct from the model for a threshold in the dose-response function described in Section 3.3.4.

DOSEFA defines the linear factor, alpha, of the dose dependence in the cancer risk model.

DOSEFB defines the quadratic factor, beta, of dose dependence in the cancer risk model. It is used in EARLY, but not in CHRONC. The quadratic factor is used when dose to an organ is below ACTHRE. The user should assign a value of zero to deactivate the quadratic portion of the linear-quadratic risk model.

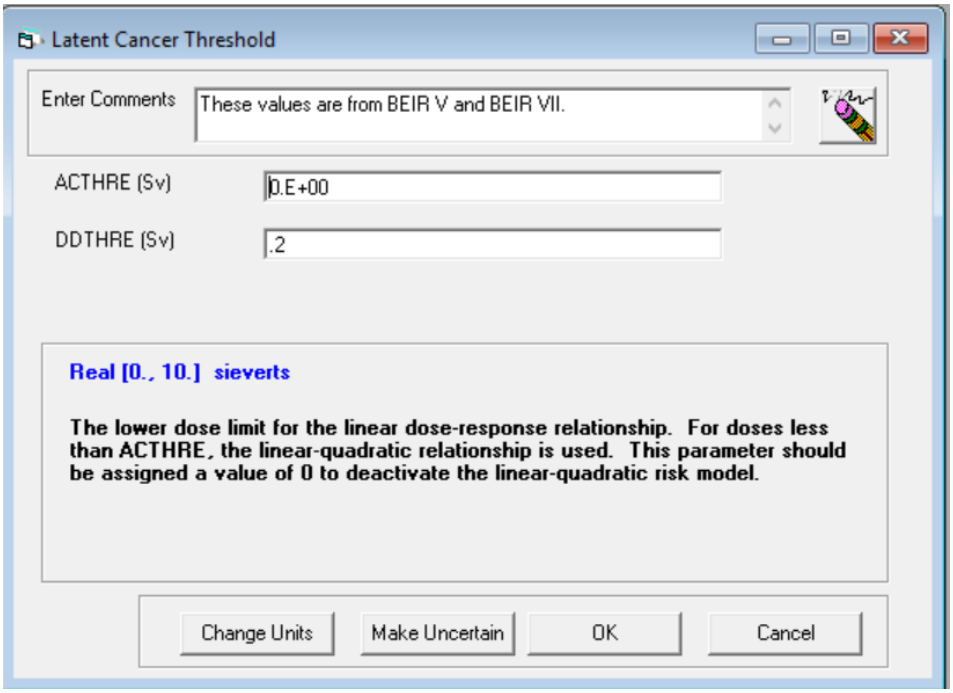


Figure 3-116 Latent Cancer Linear Quadratic Form

Table 3-112 Latent Cancer Linear Quadratic Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
ACTHRE	Yes	Real	None	0.0 to 10.0 Sv
DOSEFA	Yes	Real	NUMACA	0.0 to 2.0
DOSEFB	Yes	Real	NUMACA	0.0 to 2.0

3.3.8 Output Control

3.3.8.1 Output Control Forms and Parameters

***Debug Options* Form**

IPRINT specifies the quantity of debug output that is desired. The higher the value, the more output that is printed. Normal runs should use a value of zero.

Normally, centerline doses can be selected when IPLUME = 1 from the *Centerline Dose* form under *EARLY/Output Control*. An alternative method for evaluating centerline doses from EARLY is to set the output control variable, IPRINT, to a value greater than zero. When this is done, a listing of dose vs. distance for all the organs is included in the output. Since this is written for each weather trial, this option is normally used for single weather trial runs.

For various values of IPRINT, the output file contains some intermediate results. These are described below.

IPRINT ≥1: This option produces skin DCFs, centerline doses for all organs (when IPLUME=1), Gaussian histogram and cloudshine correction factors, and return code values (RETCOD).

IPRINT ≥2: This option produces final groundshine dose rate for each organ and each plume segment.

IPRINT ≥4: This option produces total acute dose for organs 2 and 3, early fatality, early injury, and cancer risk values for each spatial element.

IPRINT ≥8: This option produces acute dose to organs 2 and 3 after completion of subroutine RELZON, acute dose to organs 2 and 3 after completion of subroutine ESTAT.

When RISCAT is set to True and weather bin sampling is selected, the relative contribution of each of the weather-category bins to the mean consequence value is included in the MACCS output.

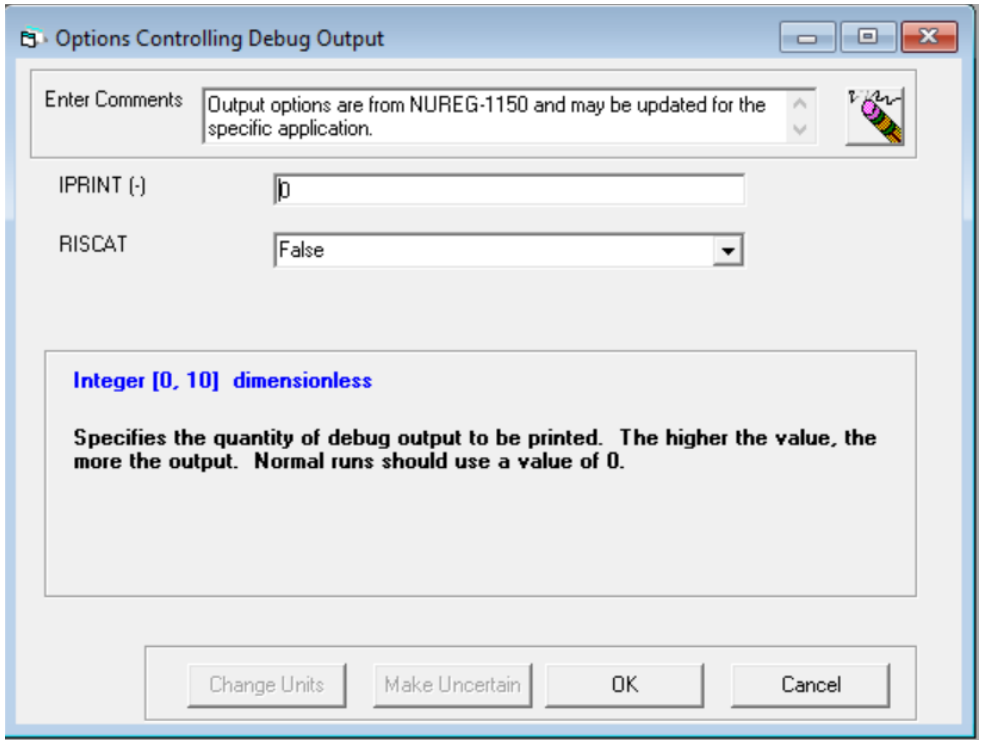


Figure 3-117 Debug Options Form

Table 3-113 Debug Option Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
IPRINT	Yes	Integer	None	0 to 10
RISCAT	Yes	Logical	None	True, False

Health-Effect Cases Form

The *Health Effect Cases* form is optional. Cancer results requested from this form are automatically produced by CHRONC so that the results can be combined in the output. In the results calculated by CHRONC, the cancer results include the following dose pathways: (1) groundshine to the residents, (2) inhalation of resuspended aerosols by the residents, (3) consumption of food and water produced in the region (not necessarily by the residents), and (4) groundshine exposure to workers required to decontaminate the area.

NUM1 specifies the number of results. The value is determined by the number of rows in the grid containing values of vectors *NAME, I1DIS1, I2DIS1,* and *Report Options*.

NAME indicates the type of result desired. Choices for this are presented by WinMACCS, and depend on the values of parameter EINAME, which represents the types of early injuries, and ACNAME, which represents the types of latent cancers. Totals for early fatalities and cancer fatalities are also available.

I1DIS1 defines the inner spatial interval of the region of interest. The distance corresponds to the inner boundary of this ring.

I2DIS1 defines the outer spatial interval of the region of interest. The distance corresponds to the outer boundary of this ring. MACCS requires that the value must be greater than or equal to I1DIS1.

Report Options determine whether CCDF data are written to the MACCS output file and whether the results are to be included in the WinMACCS summary report. WinMACCS reports can also be generated on demand and independently of the choice of Report Options.

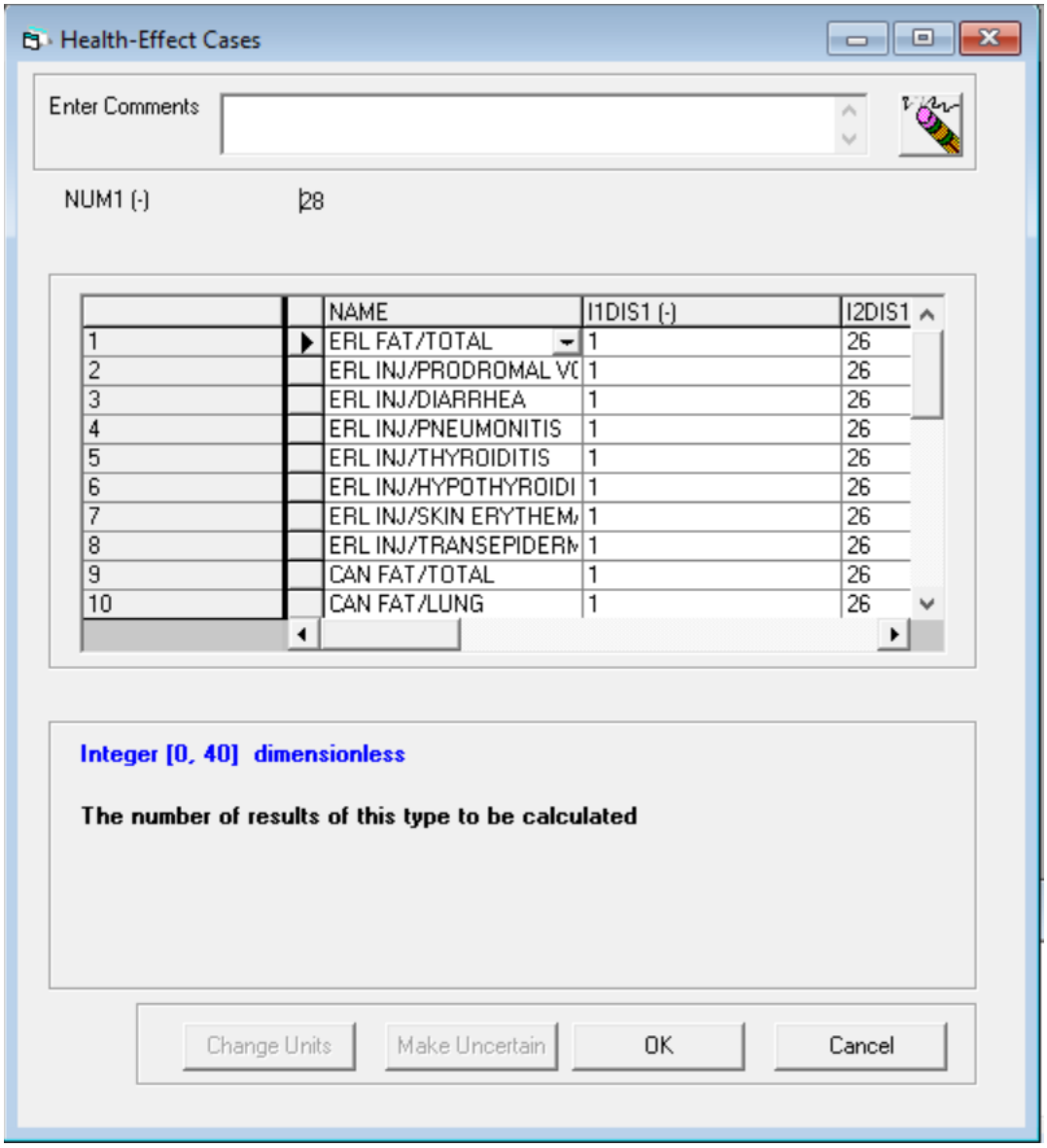


Figure 3-118 Health-Effect Cases Form

Table 3-114 Health-Effect Cases Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM1	Linked	Integer	None	0 to 999
NAME	Yes	Character	NUM1	ERL FAT/TOTAL, ERL INJ/[EINAME], CAN FAT/[ACNAME], CAN FAT/TOTAL, CAN INJ/[ACNAME], CAN INJ/TOTAL
I1DIS1	Yes	Integer	NUM1	1 to NUMRAD
I2DIS1	Yes	Integer	NUM1	1 to NUMRAD (MACCS requires I2DIS2 ≥ I1DIS1)
Report Options	Yes	Character	NUM1	CCDF, NONE, REPORT, CCDF & REPORT

Early-Fatality Radius Form

The *Early-Fatality Radius* form is optional. This result type is unavailable when *Federal Guidance Report FGRDCF* is selected on the *Dose* tab of the *Properties* form or when *Early Fatality Effects* is not selected under the *Early Effects* tab of the *Properties*.

NUM2 specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors RISTHR and Report Options.

RISTHR defines the risk threshold used for calculating the fatality radius. It estimates the maximum distance at which a specified level of early fatality risk is exceeded. The user can obtain information about the size of the region in which early fatalities may possibly occur by setting this parameter to zero.

Report Options determine whether additional CCDF data are written to the MACCS output file and whether the results are to be included in the WinMACCS summary report.

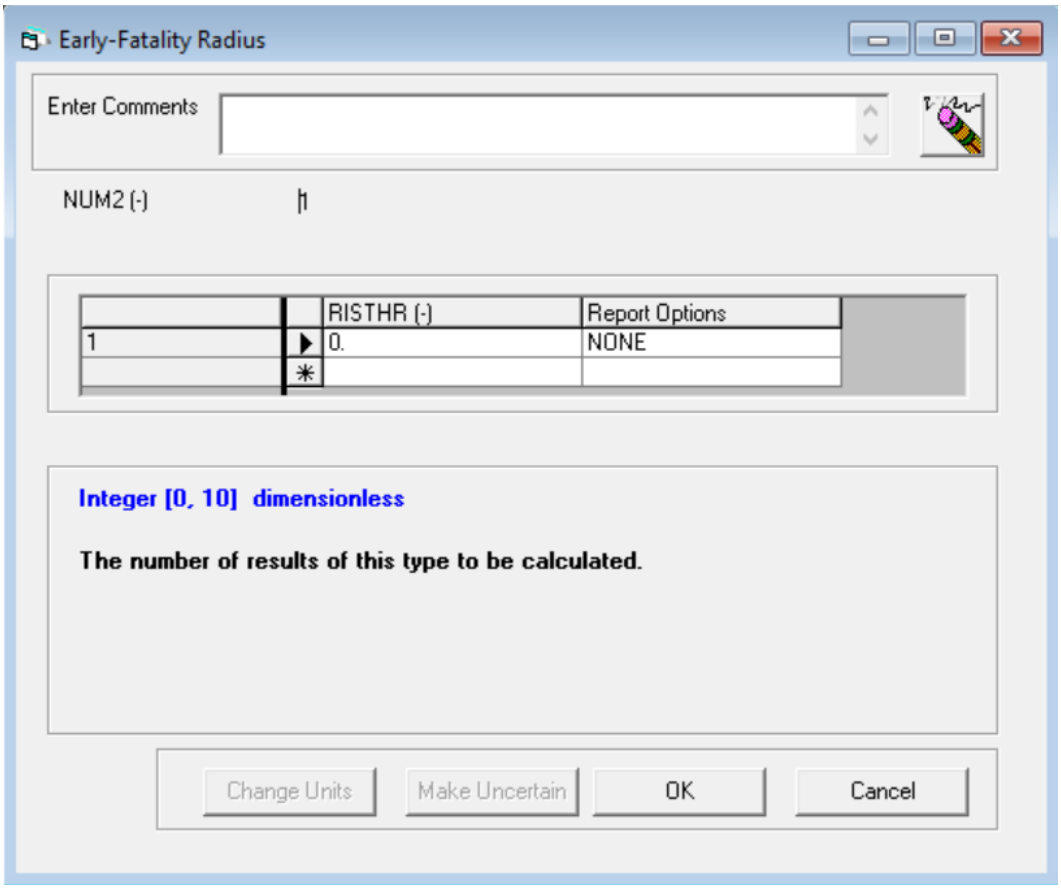


Figure 3-119 Early-Fatality Radius Form

Table 3-115 Early-Fatality Radius Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM2	Linked	Integer	None	0 to 999
RISTHR	Yes	Real	NUM2	0.0 to 1.0
Report Options	Yes	Character	NUM2	CCDF, NONE, REPORT, CCDF & REPORT

Population Exceeding Threshold Form

The *Population Exceeding Threshold* form is optional.

This output type provides an estimate of the number of people who receive acute or lifetime doses exceeding a user-definable level. This consequence measure is for doses calculated in the EARLY module. There is no analogous capability for doses estimated in CHRONC or for combined doses estimated in EARLY and CHRONC.

NUM3 specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors NAME, DOSTH3 and Report Options.

NAME defines the name of the organ to which the dose threshold applies.

DOSTH3 defines the dose threshold that is used for counting the population.

Report Options determine whether CCDF data are written to the MACCS output file and whether they are included in the WinMACCS summary report.

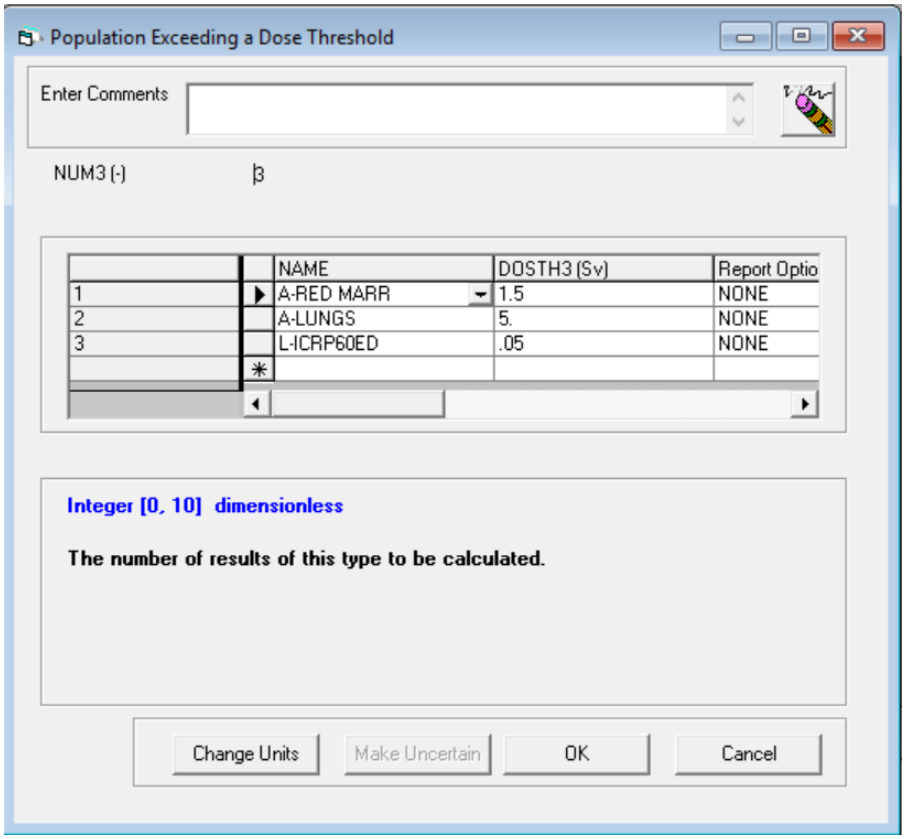


Figure 3-120 Population Exceeding Threshold Form

Table 3-116 Population Exceeding Threshold Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM3	Linked	Integer	None	0 to 999
NAME	Yes	Real	NUM3	Organ name from DCF File
DOSTH3	Yes	Real	NUM3	0.0 to 1000.0 Gy or Sv
Report Options	Yes	Character	NUM3	CCDF, NONE, REPORT, CCDF & REPORT

Average Individual Risk Form

The *Average Individual Risk* form is optional. Average individual risk is obtained by taking the sum of the risk values in all sectors at a given distance and dividing it by the number of sectors. The result is based on a phantom person residing in each grid element and does not depend on site data (i.e., population distribution).

Cancer results are automatically produced by CHRONC so that the results can be combined in the MACCS output. When this result is produced by CHRONC, it is only a measure of the risk

from the dose pathways of groundshine and inhalation of resuspended aerosols. The risk presented in this result does not include doses from ingestion of food and water by the population or doses to workers required to decontaminate the region. The reason these doses are excluded is that they cannot necessarily be attributed to the same population that resides in the area being evaluated.

NUM4 specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors I1DIS4, NAME, and Report Options.

I1DIS4 specifies outer spatial boundary. For example, when I1DIS4 is two, the associated average risk is calculated from the center of the grid to the value of SPAEND(2).

NAME indicates the type of result desired. Choices are contained in a dropdown menu and depend on the values of parameter EINAME, which are the types of early injuries, and ACNAME, which are the types of latent cancers. Totals for early fatalities and cancer fatalities are also available.

Report Options determine whether CCDF data are written to the MACCS output file and whether they are included in the summary report.

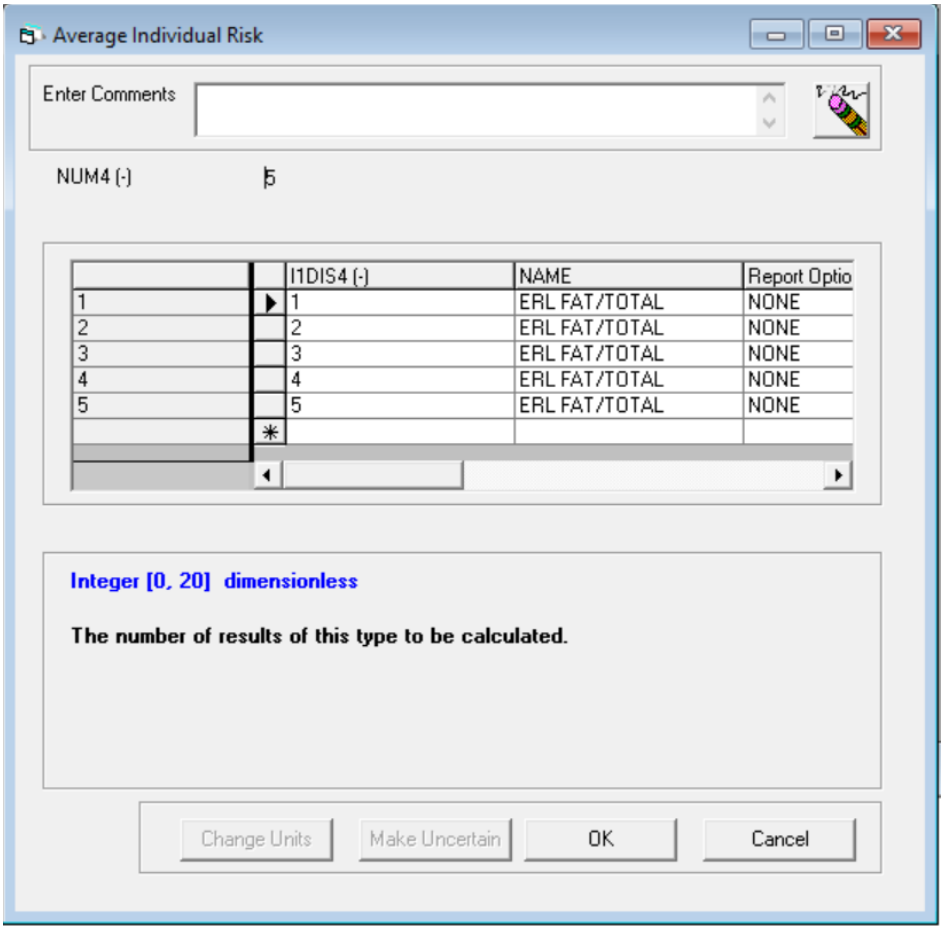


Figure 3-121 Average Individual Risk Form

Table 3-117 Average Individual Risk Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM4	Linked	Integer	None	0 to 999
I1DIS4	Yes	Integer	NUM4	1 to NUMRAD
NAME	Yes	Real	NUM4	ERL FAT/TOTAL, ERL INJ/[EINAME], CAN FAT/[ACNAME], CAN FAT/TOTAL, CAN INJ/[ACNAME]
Report Options	Yes	Character	NUM4	CCDF, NONE, REPORT, CCDF & REPORT

Population Dose Form

The *Population Dose* form is optional. This form requests that population dose to a given organ be reported. The user must supply the name of the target organ as well as the inner and outer spatial intervals of the region of interest. When only the EARLY module is run, this result reflects only the pathways considered by EARLY. When both EARLY and CHRONC are run, the population dose from all pathways is included in the calculation. The CHRONC pathways include (1) groundshine dose to the population, (2) inhalation of resuspended aerosols by the population, (3) food and water ingestion doses resulting from deposition within the region (not necessarily ingested by the population within the region), and (4) doses to workers decontaminating the region.

NUM5 specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors NAME, I1DIS5, I2DIS5, and Report Options.

NAME is the name of the target organ for the dose calculation. The possible values offered depend on the DCF file chosen and include only lifetime doses.

I1DIS5 defines the inner spatial interval of the region of interest. The distance is the inner radius of the specified ring.

I2DIS5 defines the outer spatial interval of the region of interest. The distance is the outer radius of the specified ring. MACCS requires that its value must be greater than or equal to I1DIS5.

Report Options determine whether CCDF data are written to the MACCS output file and whether they are included in the summary report.

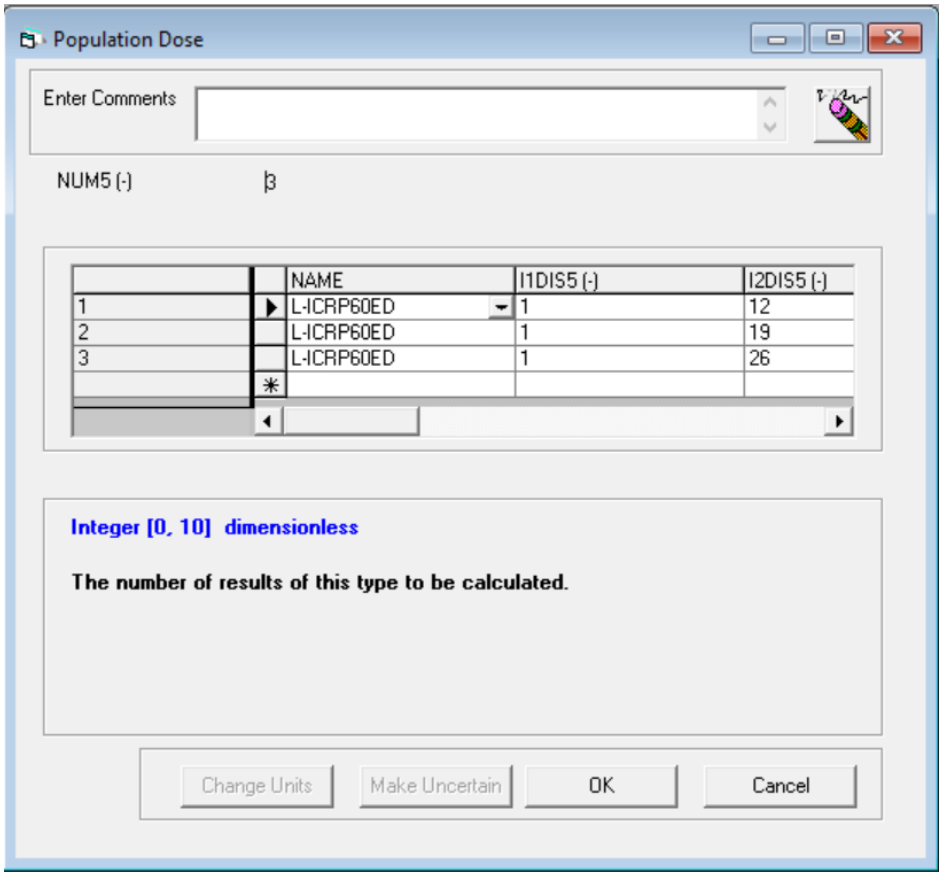


Figure 3-122 Population Form Dose

Table 3-118 Population Form Dose Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM5	Linked	Integer	None	0 to 999
NAME	Yes	Character	NUM5	Organ name from DCF File
I1DIS5	Yes	Integer	NUM5	1 to NUMRAD
I2DIS5	Yes	Integer	NUM5	1 to NUMRAD (MACCS requires I2DIS5 ≥ I1DIS5)
Report Options	Yes	Character	NUM5	CCDF, NONE, REPORT, CCDF & REPORT

Centerline Dose Form

The *Centerline Dose* form is optional. This form is available when *No Wind Shift with Rotation (IPLUME=1)* is selected on the *Evac/Rotation* tab on the *Properties* form. In this case, MACCS reports the centerline dose between a range of distances for a set of dose pathways and for acute and lifetime doses.

The following pathways/dose types are supported:

Pathway	Description	Calculation
CLD	cloudshine dose	EARLY
GRD	groundshine dose	EARLY, CHRONC
INH ACU	acute dose from inhalation of the passing plume	EARLY
INH LIF	lifetime dose from inhalation of the passing plume	EARLY, CHRONC
TOT ACU	total acute dose from all direct exposure pathways	EARLY
TOT LIF	total lifetime dose from all direct exposure pathways	EARLY, CHRONC
RES ACU	acute dose from inhalation of resuspended material after plume passage	EARLY
RES LIF	lifetime dose from inhalation of resuspended material after plume passage	EARLY, CHRONC

Depending on the exposure pathways and dose types requested, the results are calculated by EARLY and/or CHRONC. When both EARLY and CHRONC are being run, CHRONC automatically produces all the results for the pathways it includes. When pathways 'GRD', 'INH LIF', 'RES LIF', or 'TOT LIF' are chosen, those results are automatically produced by CHRONC. The other pathway values are only produced by EARLY.

An alternative method to request centerline doses from EARLY is to set the output control variable, IPRINT, to a value greater than 0. When this is done, a listing of dose vs. distance for all organs or risk are included in the output.

NUM6 specifies the number of centerline dose results to be reported. Its value is determined by the number of rows in the grid containing vectors ORGNAM, PATHNM, I1DIS6, I2DIS6, and Report Options.

ORGNAM is the name of the target organ for the dose calculation. The possible values offered depend on the DCF file chosen.

PATHNM indicates the pathway/dose type to be used for the calculation. The pathway name is ignored when 'A-SKIN' is specified as the target organ because direct dry deposition is the only exposure pathway considered for skin.

I1DIS6 defines the inner spatial interval of the region of interest. The distance is the inner boundary of the specified ring.

I2DIS6 defines the outer spatial interval of the region of interest. The distance is the outer boundary of the specified ring. MACCS requires that the value must be greater than or equal to I1DIS6.

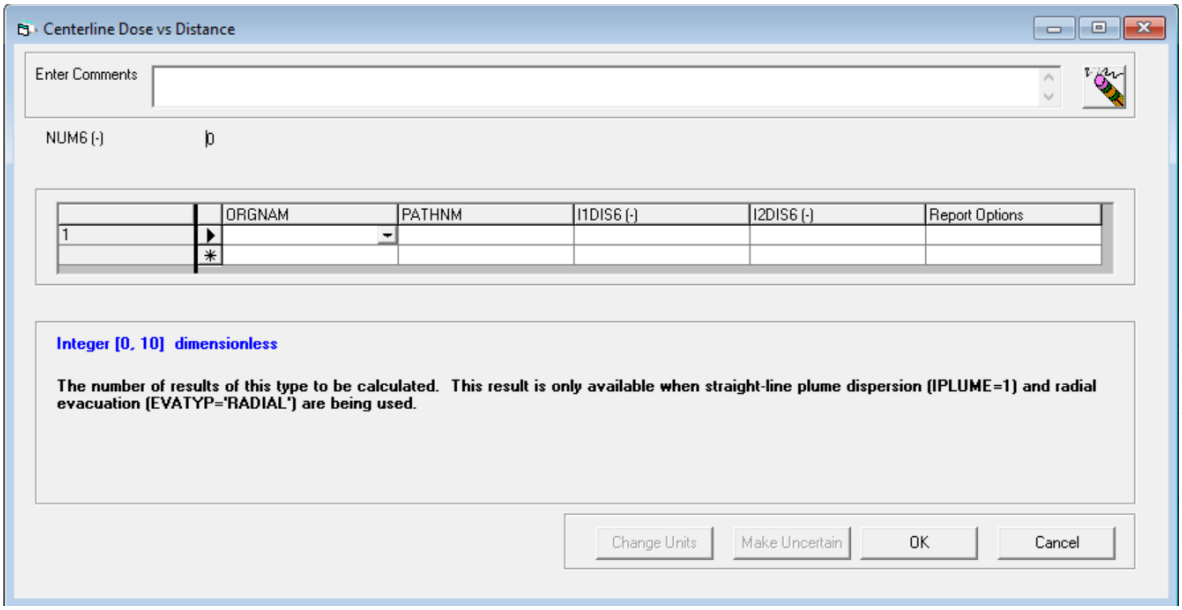


Figure 3-123 Centerline Dose Form

Table 3-119 Centerline Dose Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM6	Linked	Integer	None	0 to 999
ORGNAM	Yes	Character	NUM6	Organ name from DCF File
PATHNM	Yes	Character	NUM6	CLD, GRD, INH ACU, INH LIF, TOT ACU, TOT LIF, RES LIF, RES ACU
I1DIS6	Yes	Integer	NUM6	1 to NUMRAD
I2DIS6	Yes	Integer	NUM6	1 to NUMRAD (MACCS requires I2DIS6 ≥ I1DIS6)
Report Options	Yes	Character	NUM6	CCDF, NONE, REPORT, CCDF & REPORT

Centerline Risk Form

The *Centerline Risk* form is optional. This form is available when Wind Shift and Rotation is set to No Wind Shift with Rotation (IPLUME=1) on the *Evac/Rotation tab* on the *Properties* form.

Centerline risk is calculated for phantom individuals located directly under the plume centerline who are exposed to air and ground concentrations. The centerline risk at each distance in the region is treated as a separate result and MACCS generates a distribution of the consequence measure for each of the spatial intervals within the specified range.

Cancer results are automatically produced by CHRONC. The CHRONC values represent risk from groundshine and inhalation of resuspended aerosols. This risk does not include doses from ingestion of food and water or doses to workers decontaminating the area.

NUM7 specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors NAME, I1DIS7, I2DIS7, and Report Options.

NAME indicates the type of health effect requested. Choices are listed in a dropdown menu and depend on the values of parameter EINAME, the types of early injuries, and ACNAME, the types of latent cancers.

I1DIS7 defines the inner spatial interval of the region of interest. The distance is the inner boundary of this ring.

I2DIS7 defines the outer spatial interval of the region of interest. MACCS requires that the value must be greater than or equal to I1DIS7. The distance is the outer boundary of this ring.

Report Options determine whether CCDF data are written to the output file and whether the data are included in the report generated after simulations are completed.

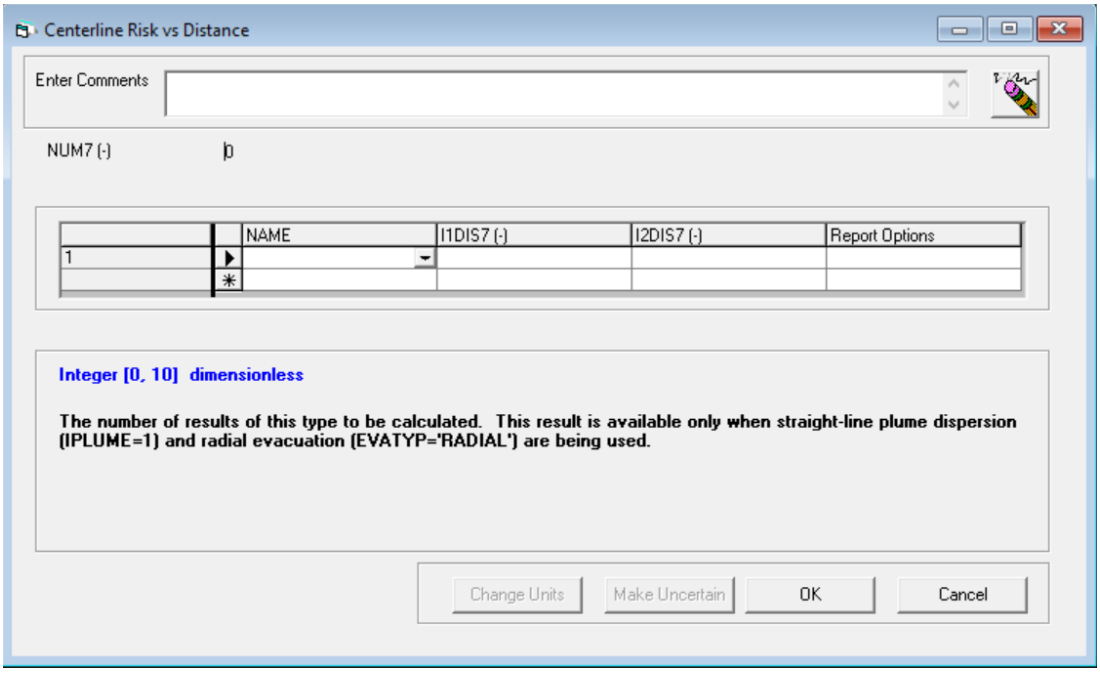


Figure 3-124 Centerline Risk Form

Table 3-120 Centerline Risk Form

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM7	Linked	Integer	None	0 to 999
NAME	Yes	Character	NUM7	ERL FAT/TOTAL, ERL INJ/[EINAME], CAN FAT/[ACNAME], CAN FAT/TOTAL, CAN INJ/[ACNAME], CAN INJ/TOTAL
I1DIS7	Yes	Integer	NUM7	1 to NUMRAD
I2DIS7	Yes	Integer	NUM7	1 to NUMRAD (MACCS requires I2DIS7 ≥ I1DIS7)
Report Options	Yes	Character	NUM7	CCDF, NONE, REPORT, CCDF & REPORT

Population Weighted Risk Form

The *Population Weighted Risk* form is optional. Population-weighted health effect risk is obtained by calculating the number of cases of a health effect within a region and dividing by the total population of that region. It accounts for the population distribution.

Cancer results are automatically produced by CHRONC. CHRONC risks include the exposure pathways of groundshine and inhalation of resuspended aerosols.

The population-weighted risk in CHRONC is calculated by estimating the number of cancer cases and dividing that value by the population of the region. The risk presented in this result does not include the societal pathways of (1) ingestion of contaminated food and water or (2) doses to workers decontaminating the area.

NUM8 specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors NAME, I1DIS8, I2DIS8, and Report Options.

NAME indicates the type of health effect desired. Choices depend on the values of parameter EINAME, the types of early injuries, and ACNAME, the types of latent cancers.

I1DIS8 defines the inner radius of the region of interest. The radius is the inner boundary of this ring.

I2DIS8 defines the outer boundary of the region of interest. The radius is the outer boundary of this ring. MACCS requires that the value must be greater than or equal to I1DIS8.

Report Options determine whether CCDF data are written to the output file and whether they are included in the MACCS report generated after simulations are completed.

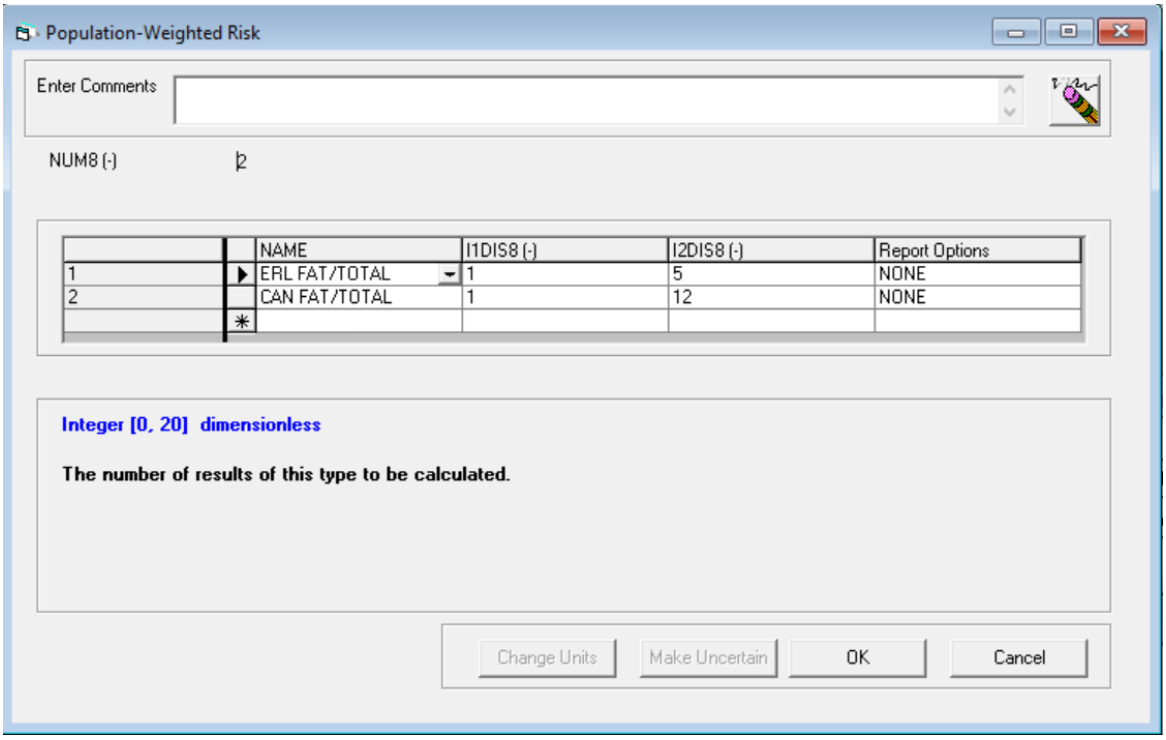


Figure 3-125 Population Weighted Risk Form

Table 3-121 Population Weighted Risk Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM8	Linked	Integer	None	0 to 999
NAME	Yes	Character	NUM8	ERL FAT/TOTAL, ERL INJ/[EINAME], CAN FAT/[ACNAME], CAN FAT/TOTAL, CAN INJ/[ACNAME], CAN INJ/TOTAL
I1DIS8	Yes	Integer	NUM8	1 to NUMRAD
I2DIS8	Yes	Integer	NUM8	1 to NUMRAD (MACCS requires I2DIS8 ≥ I1DIS8)
Report Options	Yes	Character	NUM8	CCDF, NONE, REPORT, CCDF & REPORT

Peak Dose Form

The *Peak Dose* form is optional. Results are based on the dose at each distance for a range of distances, analogous to centerline dose results. Reporting of centerline doses is not an option when wind shift is considered because a centerline does not exist when multiple plume segments each travel in their own direction. Peak dose is more general than centerline dose because it calculates the maximum dose around the compass for any of the plume transport options. The implementation of this result differs from centerline dose in two ways: (1) there is no option to report a breakdown of individual doses by pathway and (2) peak dose represents an average dose over the width of a fine grid and is not a point value like centerline dose.

Peak doses are produced for each emergency response cohort. The doses depend on the definition of that cohort in terms of evacuation and relocation. When the CHRONC module is exercised, this result is automatically produced by CHRONC as well. However, the peak dose is calculated on the fine grid level in EARLY but only on the course grid level in CHRONC.

The overall results represent the combination of doses calculated by EARLY and CHRONC. However, the overall results may be misleading because peak doses for the various cohorts may occur at different angular locations. Summation of these values may be questionable when multiple plume segments travel in different directions (*i.e.,* when NUMREL is greater than 1 *and* IPLUME is 2 or 3).

NUMA specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors NAME, I1DISA, I2DISA, and Report Options.

NAME is the name of the target organ for the dose calculation. The possible values depend on the choice of DCF file.

I1DISA defines the inner radius of the region of interest. The radius is the inner boundary of this ring.

I2DISA defines the outer radius of the region of interest. The radius is the outer boundary of this ring. MACCS requires that the value must be greater than or equal to I1DISA.

Report Options determine whether CCDF data are written to the output file and whether they are included in the summary report.

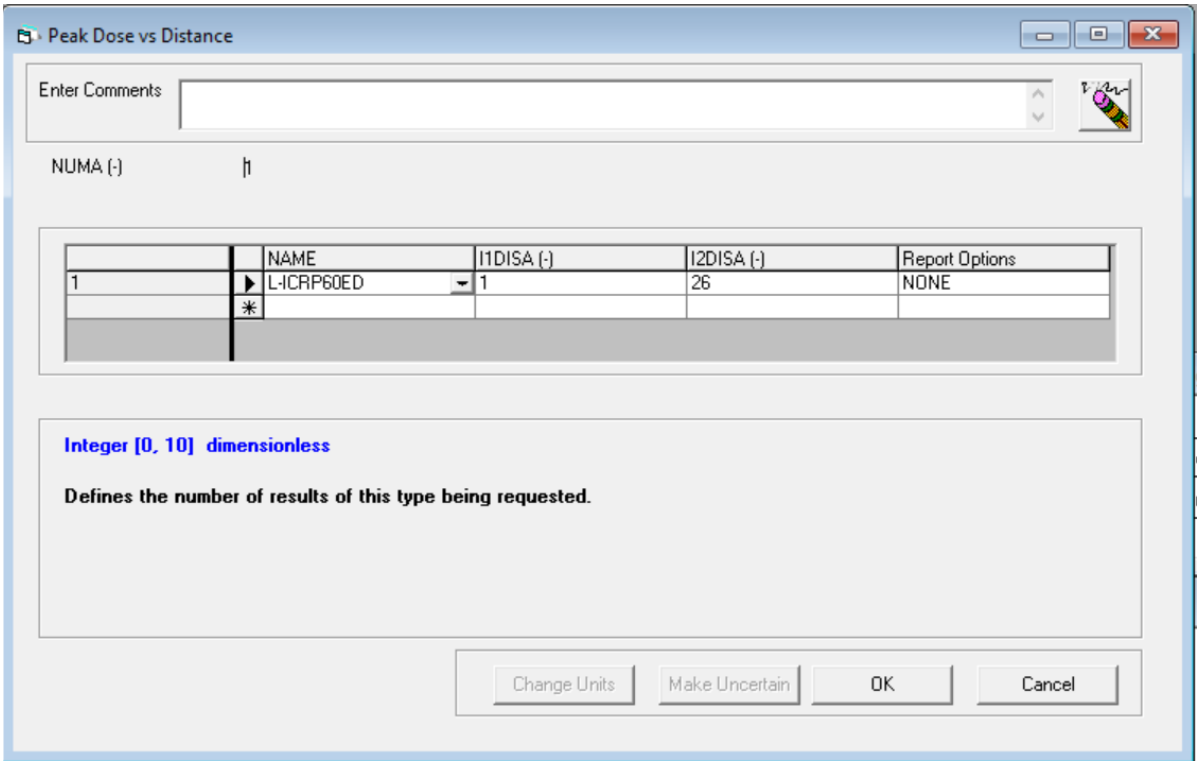


Figure 3-126 Peak Dose Form

Table 3-122 Peak Dose Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMA	Linked	Integer	None	0 to 999
NAME	Yes	Character	NUMA	Organ name from DCF File
I1DISA	Yes	Integer	NUMA	1 to NUMRAD
I2DISA	Yes	Integer	NUMA	1 to NUMRAD (MACCS requires I2DISA ≥ I1DISA)
Report Options	Yes	Character	NUMA	CCDF, NONE, REPORT, CCDF & REPORT

Peak Dose Polar Form

The *Peak Dose Polar* form is optional. In this output type, the peak dose is calculated for a user-specified (r,θ) grid location. Individual doses at locations other than directly under the plume(s) are reported with this option. There is no option to report individual doses by dose pathway.

When CHRONC is used, these results are generated by CHRONC as well as by EARLY. The total dose is estimated for a representative individual assumed to be at a (r,θ) grid location. The dose depends on the definition of that cohort in terms of evacuation and relocation. Exposures resulting from the ingestion of contaminated food and water are not included because this in an individual dose and ingestion dose is not attributed to a specific individual.

The location for which this result is to be calculated is specified as a radial index (which can range from 1 to NUMRAD) and an angular index (which can range from 1 to NUMCOR). Following the convention used throughout MACCS, an angular index of 1 represents a compass sector centered to the north of the release point. Numbering of compass sectors increases in the clockwise direction from north.

NUMB specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors NAME, IRAD_B, IANG_B, and Report Options.

NAME is the name of the target organ for the dose calculation. The possible values depend on the DCF file chosen.

IRAD_B defines the radial interval of the grid element for which this result is calculated.

IANG_B defines the angular index of the grid element for which this result is calculated.

Report Options determine whether CCDF data are written to the MACCS output file and whether they are included in the summary report.

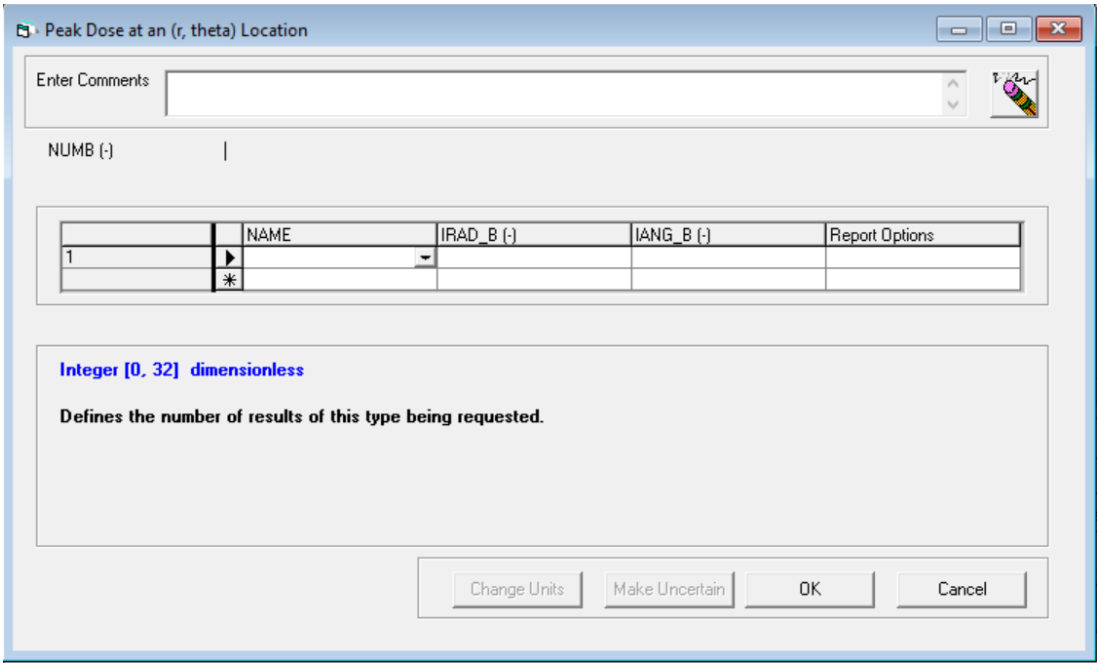


Figure 3-127 Peak Dose Polar Form

Table 3-123 Peak Dose Polar Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMB	Linked	Integer	None	0 to 999
NAME	Yes	Character	NUMB	Organ name from DCF File
IRAD_B	Yes	Integer	NUMB	1 to NUMRAD
IANG_B	Yes	Integer	NUMB	1 to NUMCOR
Report Options	Yes	Character	NUMB	CCDF, NONE, REPORT, CCDF & REPORT

Land Area Exceeding Dose Form

The *Land Area Exceeding Dose* form is optional. The land area that exceeds a user-specified dose level to an organ is reported. Optionally, dose values for all grid elements and selected organ can be displayed.

NUMC specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors ORGNAM, ELEVDOSE, and PRINT_FLAG_C.

ORGNAM is the name of the target organ for the dose calculation. The possible values depend on the DCF file chosen.

ELEVDOSE is the threshold dose value for calculating land contamination areas. Land area that is contaminated above the threshold dose level is reported in the output. The dose level is calculated a representative individual in a grid element who evacuates or relocates according to the parameters defining a cohort. Results are provided for each cohort.

PRINT_FLAG_C set to True means that the output includes dose levels to the specified organ for each grid element. Otherwise, these results are suppressed.

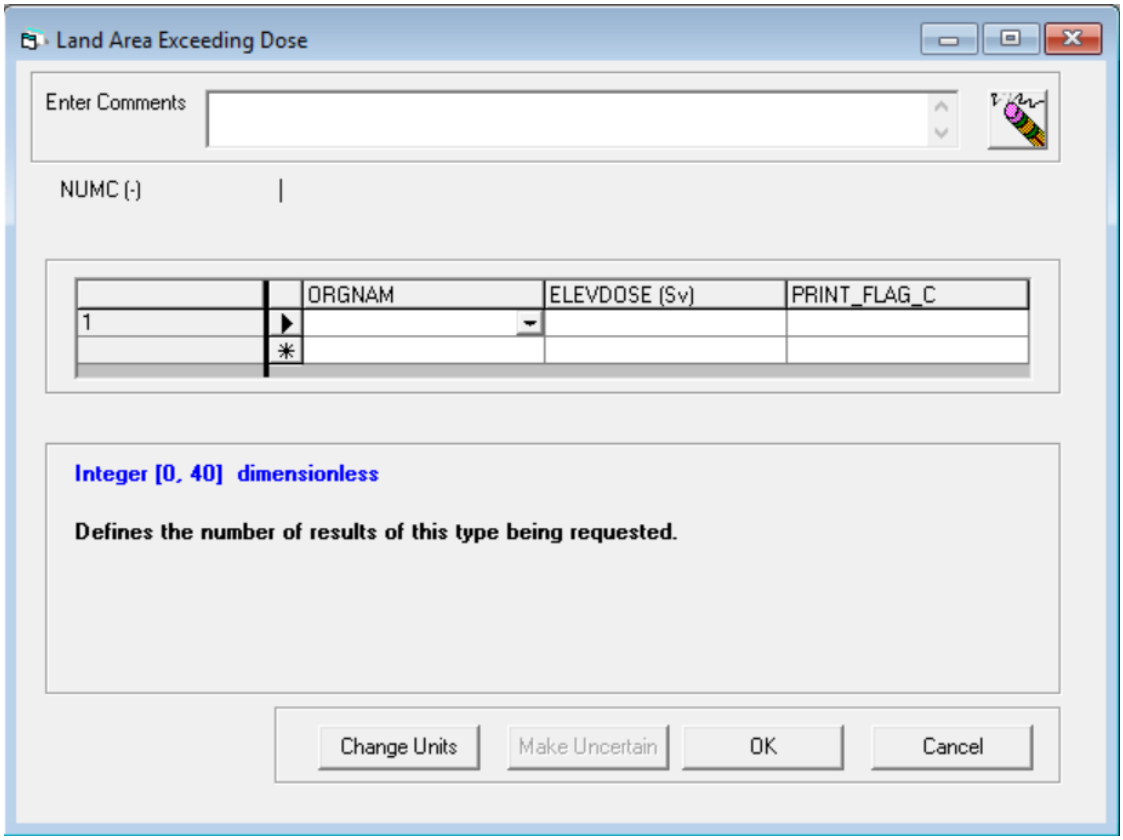


Figure 3-128 Land Area Exceeding Dose Form

Table 3-124 Land Area Exceeding Dose Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMC	Linked	Integer	None	0 to 999
ORGNAM	Yes	Character	NUMC	Organ name from DCF File
ELEVDOSE	Yes	Real	NUMC	0.0 to 10^{12} Gy or Sv
PRINT_FLAG_C	Yes	Logical	NUMC	True, False

Land Area Exceeding Concentration Form

The *Land Area Exceeding Concentration* form is optional. This output type provides the land area that exceeds a user-specified ground concentration for a specified radionuclide. Optionally, the user can request ground concentrations and time-integrated, ground-level, air concentrations be reported for every grid element.

NUMD specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors I1DISD, NUCLIDE, ELEVCONC, and PRINT_FLAG_D.

I1DISD is the outer spatial interval bounding the region of interest. The radius corresponds to the outer radius of the specified ring. The area in the calculation is from a radius of zero to the outer spatial interval.

NUCLIDE is the radionuclide of interest. The value must be an element of vector NUCNAM.

ELEVCONC is the threshold value for calculating the land contamination area. The land area that is contaminated above this threshold value is reported in the output.

PRINT_FLAG_D set to True means that the output includes ground and ground-level air concentrations for each grid element. Otherwise, this output is suppressed.

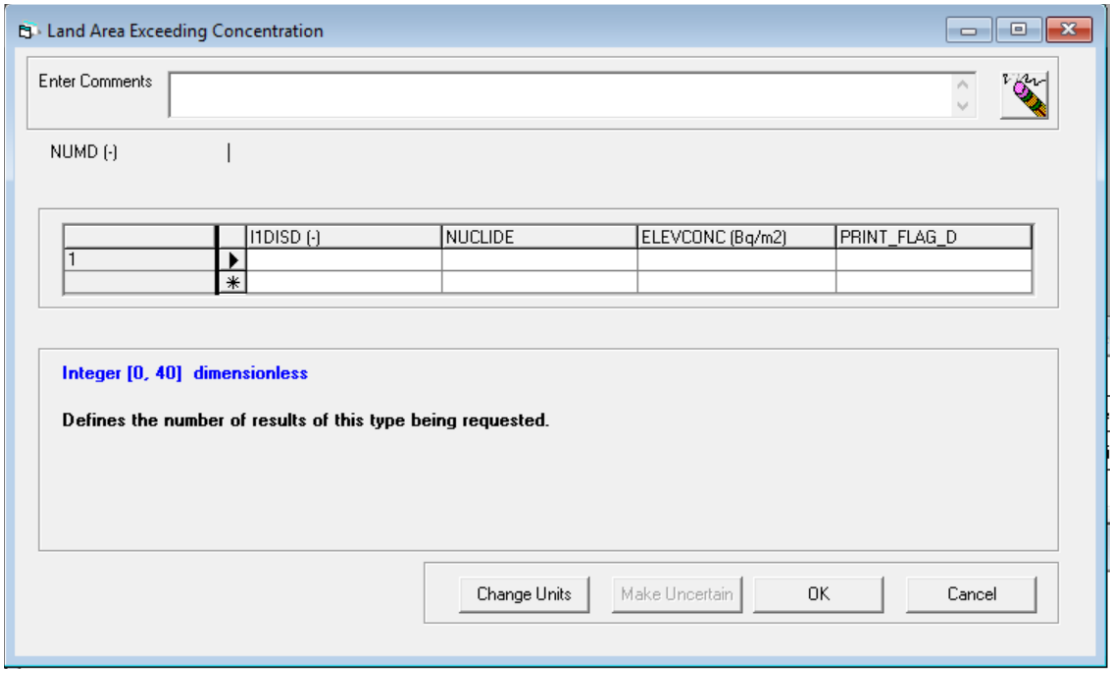


Figure 3-129 Land Area Exceeding Concentration Form

Table 3-125 Land Area Exceeding Concentration Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMD	Linked	Integer	None	0 to 999
I1DISD	Yes	Integer	NUMD	1 to NUMRAD
NUCLIDE	Yes	Character	NUMD	Must select a radionuclide from NUCNAM
ELEVCONC	Yes	Real	NUMD	0.0 to 10^{12} Bq/m^2
PRINT_FLAG_D	Yes	Logical	NUMD	True, False

Population Movement Form

The model reports the fraction of each cohort and of the total population that has left the circular boundary corresponding to the I1DISE radial distance. The output reports the result at the time interval specified by TIMDIVE if the fraction has changed since the previous time interval. For the case that the network evacuation model is used and some portion of the population exits the boundary then later returns into the circular region defined by the boundary, only the first crossing of the boundary is considered by the model.

NUME specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors I1DISE, TIMDIVE, and Report Options.

I1DISE specifies the radial index for which results are to be reported. The region is defined by the outer boundary of the specified radial grid element. The fraction of the population within this boundary exiting the region as a function of time is reported in the output.

TIMDIVE is the time interval for reporting.

Report Options determine whether CCDF data are written to the output file and whether they are included in the summary report.

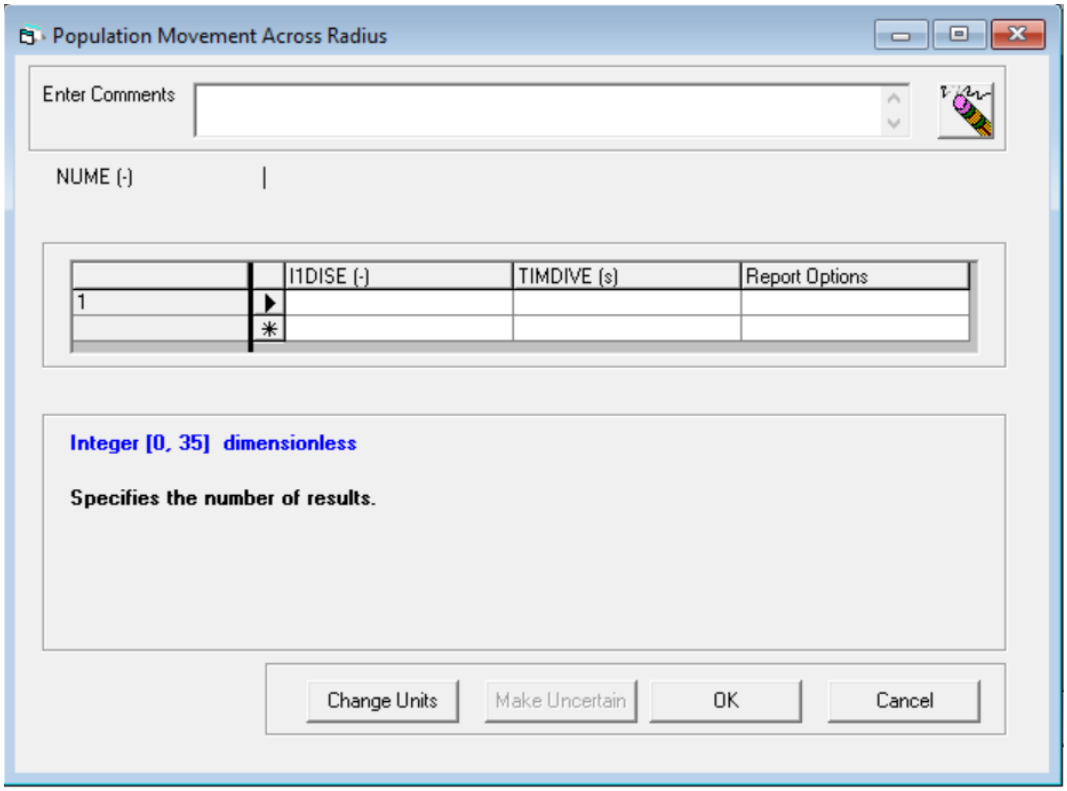


Figure 3-130 Population Movement Form

Table 3-126 Population Movement Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUME	Linked	Integer	None	0 to 999
I1DISE	Yes	Integer	NUME	1 to LASMOV
TIMDIVE	Yes	Integer	NUME	60 to 86400 s
Report Options	Yes	Character	NUME	CCDF, NONE, REPORT, CCDF & REPORT

3.4 CHRONC Input and Model description

3.4.1 Overview of CHRONC

The CHRONC module simulates the events that occur following the emergency phase modeled by EARLY. Various long-term protective actions can be taken during this period to limit radiation doses to acceptable levels.

CHRONC calculates the individual health effects that result from both external and internal dose pathways. CHRONC also calculates the economic costs of the long-term protective actions as well as the cost of the emergency response actions that were modeled in the EARLY module.

Three long-term exposure pathways are modeled to predict the radiation exposures from accidental radiological releases: groundshine, resuspension inhalation, and ingestion of contaminated food and water. The models used to predict the doses from these three pathways

are described individually in the following sections. The dose from each of the long-term pathways is evaluated for each spatial element surrounding the accident site. For the intermediate phase, only the groundshine and resuspension inhalation exposure pathways are treated. The implicit assumption is that contaminated food and water would not be ingested during the intermediate phase.

The radiation dose for the exposure pathways of the intermediate and long-term phases is calculated for each of the coarse spatial elements using the initial ground concentration under the plume centerline calculated by the ATMOS module. Like the early exposure pathways, MACCS uses centerline and off-centerline concentrations to estimate the initial ground concentration for any spatial element. By contrast with EARLY, which estimates deposition at the fine grid level, CHRONC only resolves deposition at the course grid level. The Gaussian distribution is averaged over the width of a compass sector to estimate a ground concentration for each grid element.

CHRONC incorporates calculations for two distinct periods of time, the intermediate phase and the long-term phase. These phases are described in the following subsections.

3.4.1.1 Intermediate Phase

The intermediate phase begins immediately after the emergency phase. The user can define the duration of the intermediate phase to be zero (i.e., no intermediate phase) or up to thirty years, but is usually modeled as one year.

The only response considered during the intermediate phase is continued relocation for areas that are too heavily contaminated for the population to return. The criterion for relocation during the intermediated phase is based on a user-defined dose projection and dose level. The dose projection is defined in terms of an exposure period and a target organ. The user also specifies the maximum acceptable dose level. When the intermediate-phase dose criterion is satisfied, which is that the projected dose is less than the maximum acceptable dose, the residential population of a grid element is assumed to be present and subject to radiation exposure from groundshine and resuspension inhalation for the entire intermediate phase. When the criterion is exceeded, the population is assumed to be relocated to uncontaminated areas for the entire intermediate phase, with a corresponding per-capita economic cost defined by the user through the input parameter POPCST.

3.4.1.2 Long-Term Phase

The long-term phase follows the intermediate phase or directly follows the emergency phase when the duration of the intermediate phase is set to zero. A set of protective actions are implemented during the long-term phase, which are decontamination, interdiction, and condemnation of land that exceeds the habitability level set by the user.

Decisions on mitigative actions during the long-term phase are based on two independent criteria as follows:

- Decisions are made relating to whether land at a specific location and time is suitable for human habitation. This criterion is often called the habitability criterion.
- Decisions are made relating to whether land at a specific location and time is suitable for agricultural production. This criterion is often called the farmability criterion.

In addition to these two criteria on usability of land for its intended purpose, MACCS also considers cost effectiveness of decontamination. If it is not cost effective to decontaminate (plus additional interdiction when required to reach habitability), then land is condemned.

3.4.1.3 Division Between Farm and Population

The long-term phase incorporates a fundamental distinction between the consequences associated with agricultural uses of land (denoted FARM-DEPENDENT in the code output) and habitation of land by humans (denoted POP-DEPENDENT in the code output).

3.4.1.4 Habitability Decision Making

Habitability decision making determines whether land is immediately habitable, land is habitable after decontamination, land is habitable after a combination of decontamination and additional interdiction, or land is condemned.

The first step in the decision-making regarding habitability is to determine whether, in the absence of any mitigative actions, the land in a grid element is suitable for habitation during the long-term exposure period. This is done by comparing the projected, lifetime, individual dose to the target organ (CRTOCR) for the long-term dose projection period (TMPACT) against the user-specified dose for long-term exposure (DSCRLT). When the projected individual dose does not exceed DSCRLT, the land is considered immediately habitable, and no further tests regarding habitability are made. Residents are assumed to return to the grid element and no further costs are tallied.

When the land is not immediately habitable, a progressive series of actions are evaluated, beginning with decontamination for the various user-defined decontamination levels. The influence of decontamination is twofold:

- Doses are reduced by a dose reduction factor (DRF, input parameter DSRFCT), which is a scaling factor by which the doses are reduced.

- Doses are also reduced by weathering and radioactive decay during the decontamination period.

The influence of these two factors is independent. That is, when the user specifies a DRF of 3 and a decontamination period of one year, the doses to the population after decontamination are generally less than one-third of the doses before decontamination because decontamination, weathering, and radioactive decay all work to reduce subsequent doses.

The first level (smallest DRF) of decontamination is considered first. When this DRF plus weathering and decay is enough to meet the habitability criterion immediately after decontamination, this level of decontamination is performed, and the population is assumed to return. When the first level of decontamination is not sufficient, higher levels of decontamination are considered. MACCS allows up to three levels.

When the highest level of decontamination is insufficient to restore habitability, MACCS evaluates whether performing this level of decontamination plus additional interdiction would restore habitability. MACCS allows up to 30 years of interdiction when it performs this calculation. However, decontamination plus additional interdiction is usually not cost effective when the required interdiction period is significantly less than 30 years.

MACCS declares land to be condemned under two conditions:

- Habitability cannot be restored after decontaminating at the highest level plus additional interdiction.

- The total cost to restore habitability is greater than the cost to condemn the land.

Under either of these conditions, the land is condemned immediately at the beginning of the long-term phase; the model assumes that decontamination is not performed and that the population never returns. Thus, MACCS calculates the corresponding long-term food and population doses to be zero for the condemned land and assesses an economic cost for condemnation of the property equal to the value of the land plus the cost of permanent relocation.

The effect of weathering and decay over the interdiction period is calculated with an interpolation technique that uses doses for predefined interdiction periods of 1, 5, and 30 years. These three predefined interdiction periods all begin at the conclusion of the maximum-level decontamination effort, which is a user-specified duration that can extend up to 30 years. So, the three dose projections are calculated at starting times of 1, 5, and 30 years after the maximum level of decontamination would be complete.

For the two land uses, farm and population, mitigative actions are chosen to yield the lowest-cost approach to satisfying the applicable criteria. For farms, the criteria define acceptable levels of foodstuff contamination; for populations, the criteria define acceptable levels of radiation exposures to individuals. The maximum duration of temporary farmland interdiction is 8 years; as previously discussed, the corresponding maximum duration for populated areas is 30 years. It is likely that neither of these limiting cases would be applied in practice because the cost of decontamination and interdiction would normally exceed the cost of condemnation before these time limits are reached.

3.4.1.5 Primacy of Habitability over Farmability Decisions

For both food-chain model options, farm production can occur only when the environmental contamination levels are sufficiently low to allow habitation. The implicit assumption is that people cannot work on land that is not habitable. When farmland is not habitable, it is treated the same as described in the previous subsection on habitability decision making.

3.4.1.6 Farmability Decision Making

As described in the previous subsection, the decision on whether farmland can be used for agriculture is based first on evaluations of its suitability for human habitation. When farmland is immediately habitable or is restored to being habitable, it is next evaluated for farmability, which means that contamination levels of the agricultural products are low enough to be consumed. The criterion for farmability is specified through a set of maximum allowable food doses, which are input parameters DOSEMILK, DOSEOTHR, and DOSELONG. These parameters are discussed below.

Most often the farmability criterion is stricter than the habitability criterion, so it is not unusual that farmland is habitable but not farmable. Decontamination is only implemented in MACCS to restore habitability, not farmability. Land that is initially habitable but not farmable is either interdicted without decontamination or condemned.

3.4.2 Basic Parameters

3.4.2.1 Basic Forms and Parameters

***Chronc Description* Form**

The *Chronc Description* form contains one variable, which is a brief description of the CHRONC model used in the calculation. This form is required.

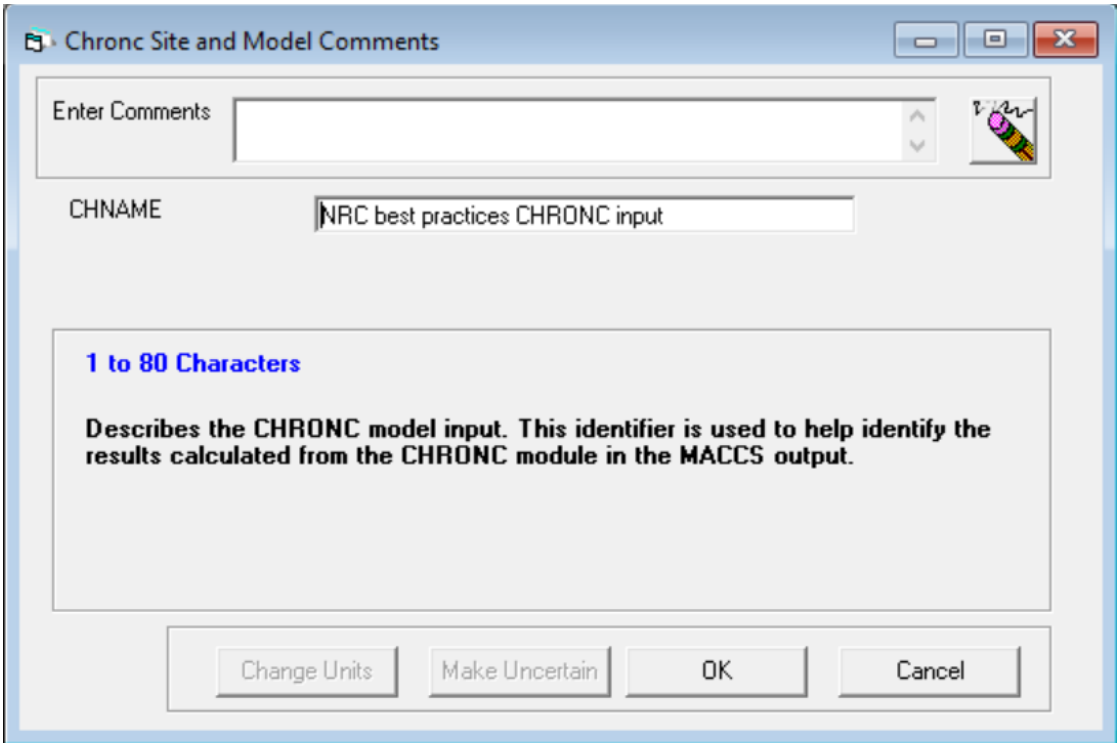


Figure 3-131 Chronc Site and Model Description Form

Table 3-127 Chronc Site and Model Description Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CHNAME	Yes	Character	None	1 to 80 characters

***Property Form Parameters* Form**

This form allows the user to observe how the choices made on the *Properties* form define some important parameters that are required in the CHRONC input. The parameters on this form are read-only and cannot be changed from this form. Details about the effect of these parameters are provided in the subsections below.

FDPATH determines the food-chain model used. When this parameter is set to OLD the food-chain model developed for MACCS 1.5 is used. NEW means the COMIDA2 food-chain model is used. When this parameter is set to OFF, no food-chain model is used.

NTTRM is the number of terms used in the growing crop retention model. This parameter is only relevant when FDPATH is set to OLD.

ECON_MODL defines which economic model is used for the economic consequence calculation. Original uses the original MACCS cost-based model, and RDEIM uses the new GDP-based economic model.

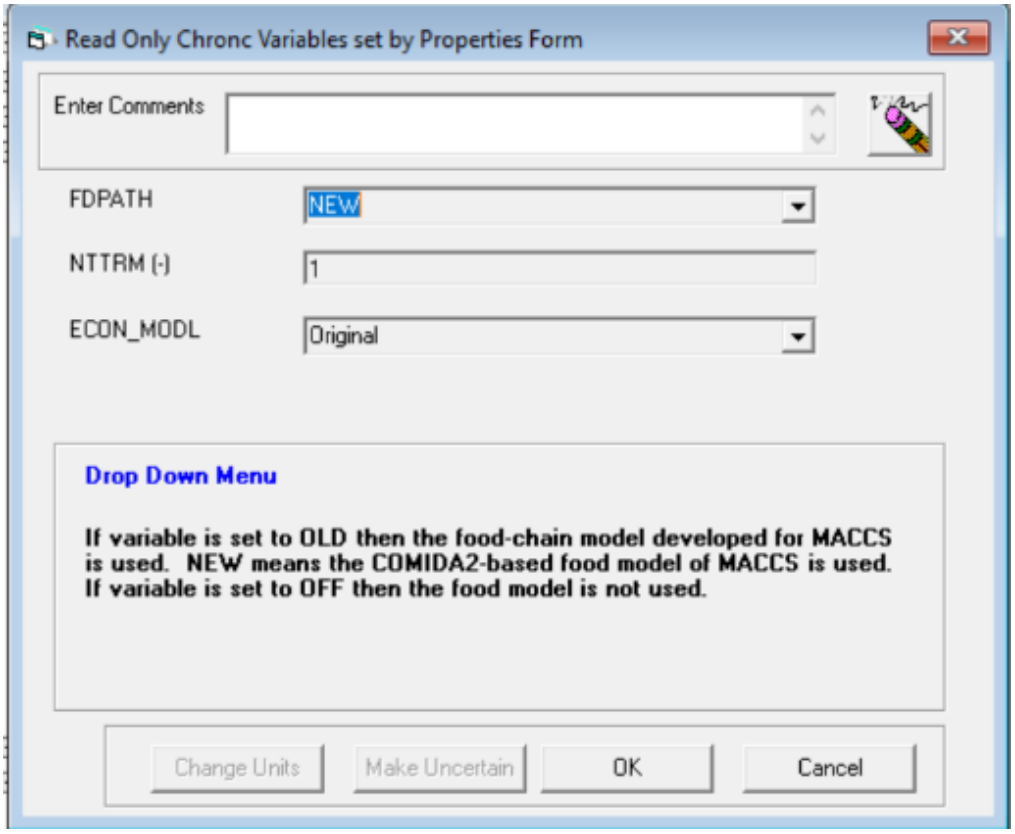


Figure 3-132 Property Form Parameters Form

Table 3-128 Property Form Parameters Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values	Defined on Form
FDPATH	Read Only	Character	None	NEW, OFF, OLD	*Food* tab on *Properties* form
NTTRM	Read Only	Integer	None	1 to 3	*Number of Crop Weathering Terms* found on *Food* tab of the *Properties* form
ECON_MODL	Read Only	Character	None	Original, RDEIM	*Econ* tab on *Properties* form

3.4.3 Shielding and Exposure

3.4.3.1 Shielding and Exposure Model Description

Shielding and exposure factors are specified separately for EARLY and CHRONC but serve the same purpose. These factors account for long-term behavior of the public and for the shielding offered by structures in which people dwell, work, and spend time.

Older versions of MACCS assumed that the long-term shielding and exposure factors in the intermediate and long-term phases are identical to those for normal activity during the emergency phase. This is still a reasonable assumption and is commonly used. However, there are some reasons why the factors could be different for these phases. The main reason is potential equilibration of contamination levels between the exterior and interior of buildings after an extended period. The usual assumption in estimating these factors for the emergency phase is that the exterior is contaminated but the interior is relatively clean. This may be a reasonable assumption for the short term but may be less reasonable for the long term. Even for the short term, air exchange between the interior and exterior of a building can cause some level of contamination on the interior. Filtered air exchange between the atmosphere and a control room is generally included when assessing doses to control-room workers for design-basis accidents. Similarly, ventilation systems in a home or other building would gradually introduce contaminants into the interior, which in turn would affect the shielding and exposure factors. After a long time, it is possible that the interior and exterior of a building would equilibrate. In other words, the contamination level of the interior of a building would be lower but proportional to the contamination level of the exterior of the building. By allowing a distinction between short-term and long-term shielding and exposure factors, MACCS can be used to evaluate possible longer-term influences on these factors.

3.4.3.2 Shielding and Exposure Forms and Parameters

***Shielding and Exposure* Form**

The *Shielding and Exposure* form is required.

LPROTIN is the long-term inhalation protection factor. A value of 0 indicates complete protection from inhalation of radioactive materials; a value of 1 indicates no protection and corresponds to a person standing outdoors with no protection from the surrounding atmosphere.

LBRRATE is the long-term breathing rate. There is a range of breathing rates that can be assigned based on level of activity and other factors. This value should reflect a long-term average that is consistent with the exposure period used for the long-term phase.

LGSHFAC is the long-term groundshine shielding factor. This value is used as a multiplier on the value of groundshine dose that would have been received if the person were standing outside and the ground were a perfectly flat surface. A value of 0 indicates complete shielding from groundshine; a value of 1 indicates no protection. A typical surface roughness of the ground affords some shielding, which is typically taken to be 0.7. Other shielding from houses and building would be expected to reduce this factor below 0.7.

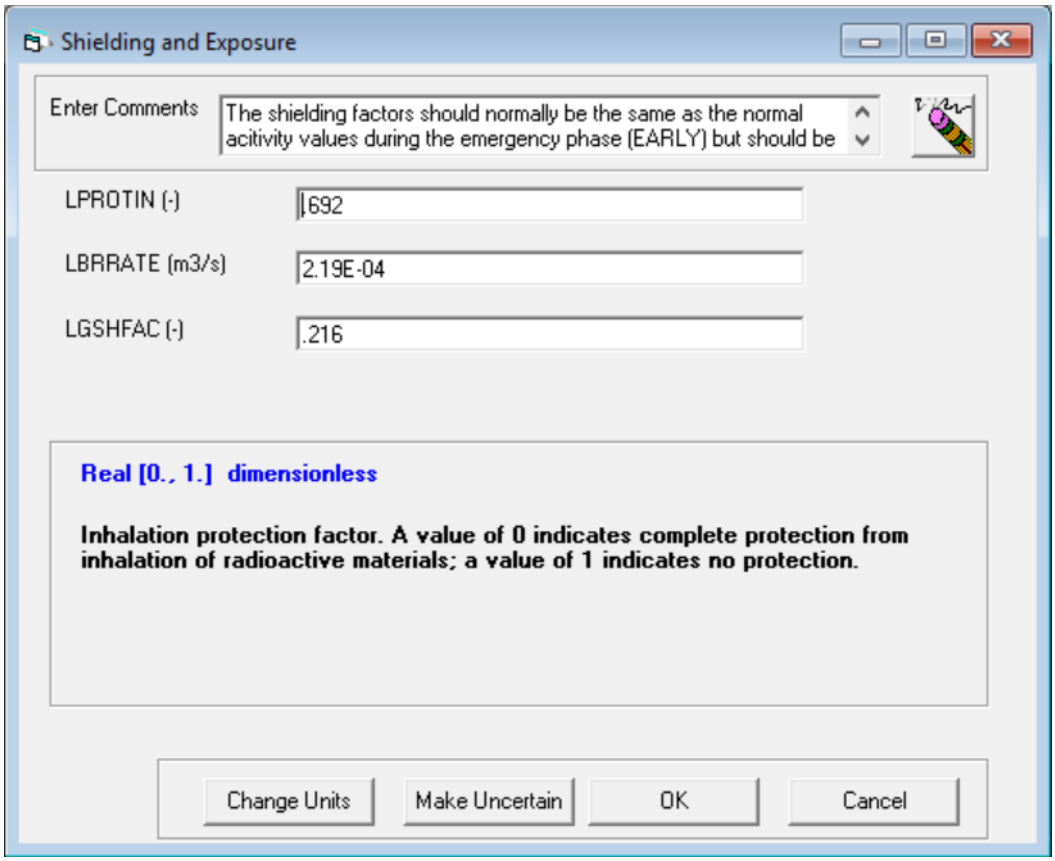


Figure 3-133 Shielding and Exposure Form

Table 3-129 Shielding and Exposure Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
LPROTIN	Yes	Real	None	0.0 to 1.0
LBRRATE	Yes	Real	None	0.0 to 1.0 m^3/s
LGSHFAC	Yes	Real	None	0.0 to 1.0

3.4.4 Dose Projection Model Description

Dose projection is used to determine the need for relocation during the intermediate phase and to determine habitability during the long-term phase. Dose projection is defined by an exposure period and a critical organ for the dose. It is used to estimate a dose that would occur if no protective action were taken. The purpose is to protect the population by ensuring that the projected dose is small enough; otherwise a protective action is taken to eliminate or reduce the projected dose.

The dose criterion for habitability is discussed in a subsequent subsection. The dose criterion for relocation during the intermediate phase is based on a dose projection period defined by DPP_INTERPHAS, and a target organ, CRTOCR. The criterion is that the projected dose is less than a user input dose defined by parameter DSCRTI. These parameters are discussed in this and subsequent subsections.

Dose Projection Form

The *Dose Projection* form is optional. It contains a single parameter that defines the exposure period for dose projection used in the relocation criterion for the intermediate phase.

DPP_INTERPHAS is the dose projection period for relocation during the intermediate phase.

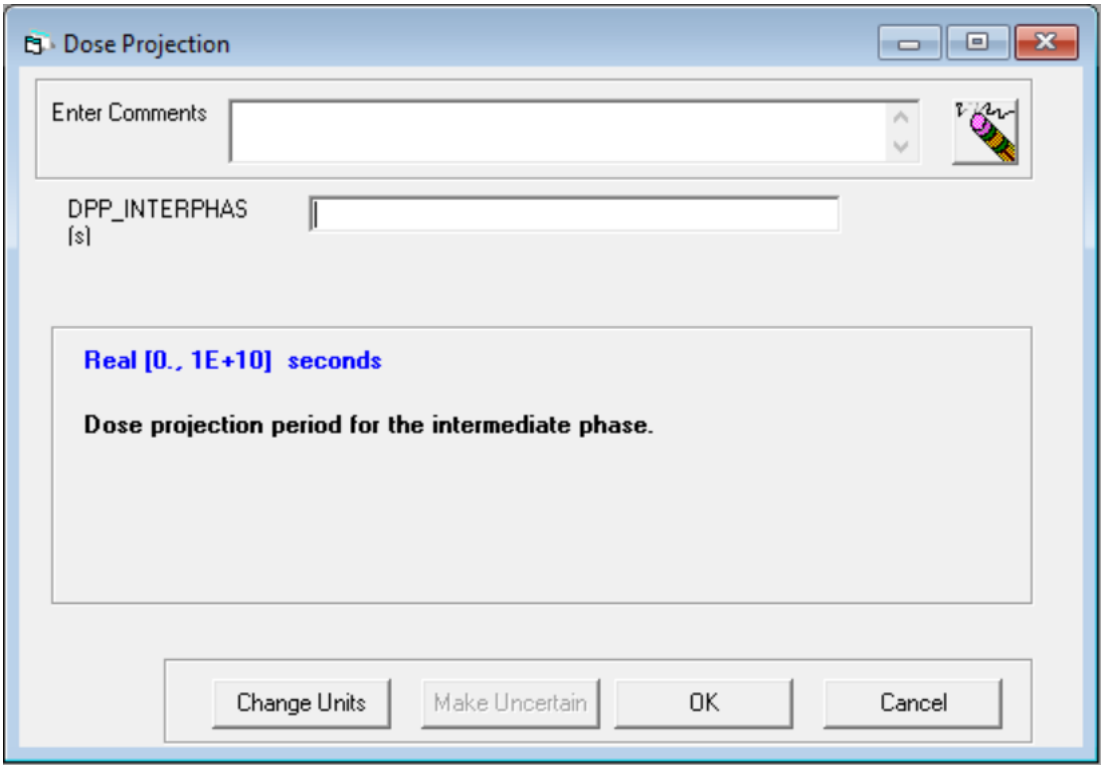


Figure 3-134 Dose Projection Form

Table 3-130 Dose Project Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DPP_INTERPHAS	Yes	Real	None	0.0 to 10^{10} s

3.4.5 Evacuation/Relocation Cost Model Description

The evacuation and relocation costs describe the expected compensation for people who take these protective actions. Evacuation only occurs during the emergency phase. It is triggered by an emergency declaration at a nuclear plant or facility (e.g., declaration of a general emergency).

Relocation of individuals can occur during the emergency or intermediate phases. It can also occur during the long-term phase but is commonly referred to as interdiction in that case.

In the presentation of economic cost results, the costs associated with the emergency phase (*i.e.,* for evacuation and short-term relocation) are reported separately from the costs associated with the intermediate phase (*i.e.,* for relocation) and the long-term phase (i.e., decontamination, interdiction, condemnation, loss of use, and permanent relocation costs).

3.4.5.1 Emergency Response Cost Forms and Parameters

***Compensation Costs* Form**

The *Compensation Costs* form is required.

Some of the compensation parameters are for actions taken during the emergency phase. Nonetheless, these parameters are CHRONC inputs because the costs of these actions are only tallied when CHRONC is run.

EVACST defines the daily cost of compensation for evacuees and short-term relocatees who are removed from their homes during the emergency phase. MACCS does not impose any specific set of costs for this parameter; it is entirely up to the user to determine which costs should be included. The value usually includes food, housing, and transportation costs. It can optionally include lost income when this cost is not included in other cost inputs.

RELCST defines the daily cost of compensation for individuals relocated from their homes during the intermediate phase of CHRONC. MACCS does not impose any specific set of costs for this parameter; it is entirely up to the user to determine which costs should be included. This value usually includes food, housing, and transportation costs. It can optionally include lost income and lost personal property when these are not included in other input parameters.

POPCST defines the per-capita, one-time relocation cost for temporary or permanent relocation of population and businesses in a region rendered uninhabitable during the long-term phase. This cost is assessed when any of the following actions are required: decontamination alone, decontamination followed by interdiction, or condemnation. This value can account for personal and corporate income losses for a transitional period and/or moving expenses.

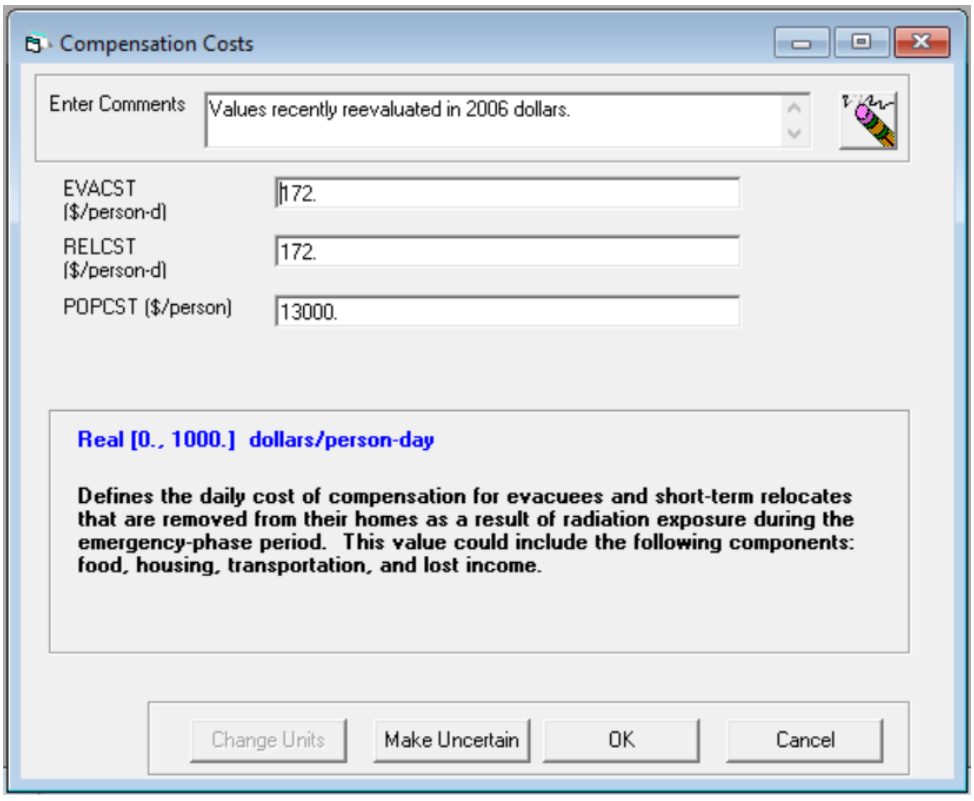


Figure 3-135 Compensation Costs Form

Table 3-131 Compensation Costs Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
EVACST	Yes	Real	None	0 to 1000 $/person-day
RELCST	Yes	Real	None	0 to 1000 $/person-day
POPCST	Yes	Real	None	10^{-6} to 10^{6} $/person

3.4.6 Long-Term Protective Action Model Description

The long-term protective action parameters define the intermediate and long-term action time periods as well as the maximum doses that people can receive during these periods. The maximum allowable doses defined here are used to determine the need for relocation, decontamination, interdiction, and condemnation.

3.4.6.1 Long-Term Protective Action Forms and Parameters

***Long-Term Exposure Period* Form**

The *Long-Term Exposure Period* form is required.

DUR_INTPHAS is the duration of the intermediate phase. This phase follows the emergency phase. In the MACCS model, each phase is distinct and contiguous. The U.S. Environmental Protection Agency (EPA) definition allows for some overlap between the emergency and intermediate phases and of the intermediate and long-term phases (EPA, 2013). While this distinction should be recognized, it has little or no effect on the consequence results estimated by MACCS.

TMPACT is the long-term dose projection period corresponding to the long-term dose limit, DSCRLT, which is described below. The dose projection is performed at the beginning of the long-term phase for the target organ specified by CRTOCR (also discussed below) to determine whether land is immediately habitable. The combination of these three parameters establishes the criterion commonly referred to as the habitability criterion. When habitability is not met at the beginning of the long-term phase, a set of actions are evaluated to determine whether habitability can be restored later, as described in Section 3.4.1.

EXPTIM is the long-term exposure period. It begins when people return to their property. For example, when the code estimates that 5 years of interdiction are needed at a specific location to satisfy the habitability criterion and EXPTIM is 30 years, doses to the resident population is calculated for an exposure period that begins at the beginning of year 6 and ends at the end of year 35 of the long-term phase.

The accrual of doses from food and water ingestion is not affected by the user-specified value of EXPTIM. This accrual is not strictly associated with the population from which the contaminated food and water originate. The ingestion of contaminated food and water is estimated as a societal dose to an unspecified population. However, the ingestion dose is accounted for in the grid element from which the food and water originate.

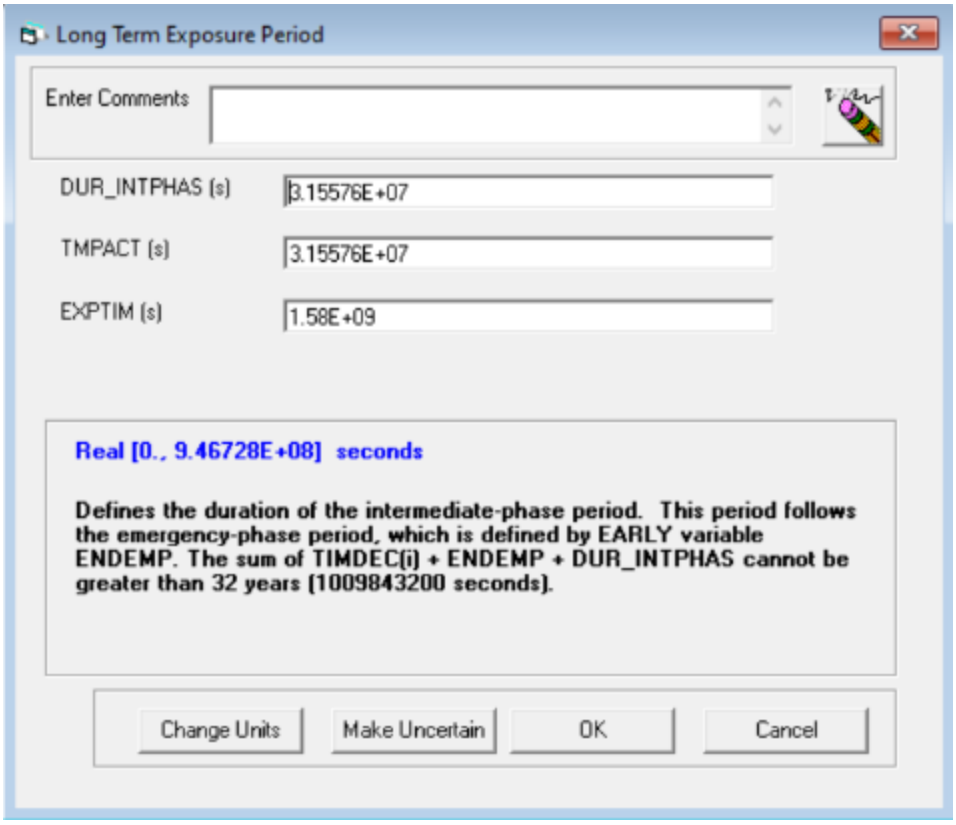


Figure 3-136 Long-Term Exposure Period Form

Table 3-132 Long-Term Exposure Period Form Input

Parameter Name	Definable	Type	Dimensions	Allowed Values
DUR_INTPHAS	Yes	Real	None	0 to 9.46×10^{8} s (30 yrs)
TMPACT	Yes	Real	None	0 to 10^{10} s
EXPTIM	Yes	Real	None	0 to 10^{10} s

Long-Term Dose Criterion Form

The *Long-Term Dose Criterion* form is required.

DSCRTI is the maximum allowable dose commitment to the long-term critical organ (CRTOCR) over the intermediate-phase dose projection period (DPP_INTERPHAS). The exposure pathways considered in the dose projection are groundshine and resuspension inhalation. When the intermediate-phase dose criterion (DSCRTI) is exceeded within a grid element, the population there is relocated for the entire intermediate phase.

DSCRLT is the maximum allowable dose commitment to the long-term critical organ (CRTOCR) during the long-term dose-projection period (TMPACT). These three parameters establish the habitability criterion. The exposure pathways considered in the dose projection are groundshine and resuspension inhalation. When the long-term-phase dose criterion (DSCRLT) is exceeded within a grid element, the population there is relocated until the habitability criterion can be met.

When it is not possible to reduce doses to the level specified by this criterion in a cost-effective manner, the property is condemned, and the resident population is permanently relocated. When this occurs, no doses are accrued during the long-term phase.

CRTOCR defines the critical organ that is used for both the intermediate and long-term phases.

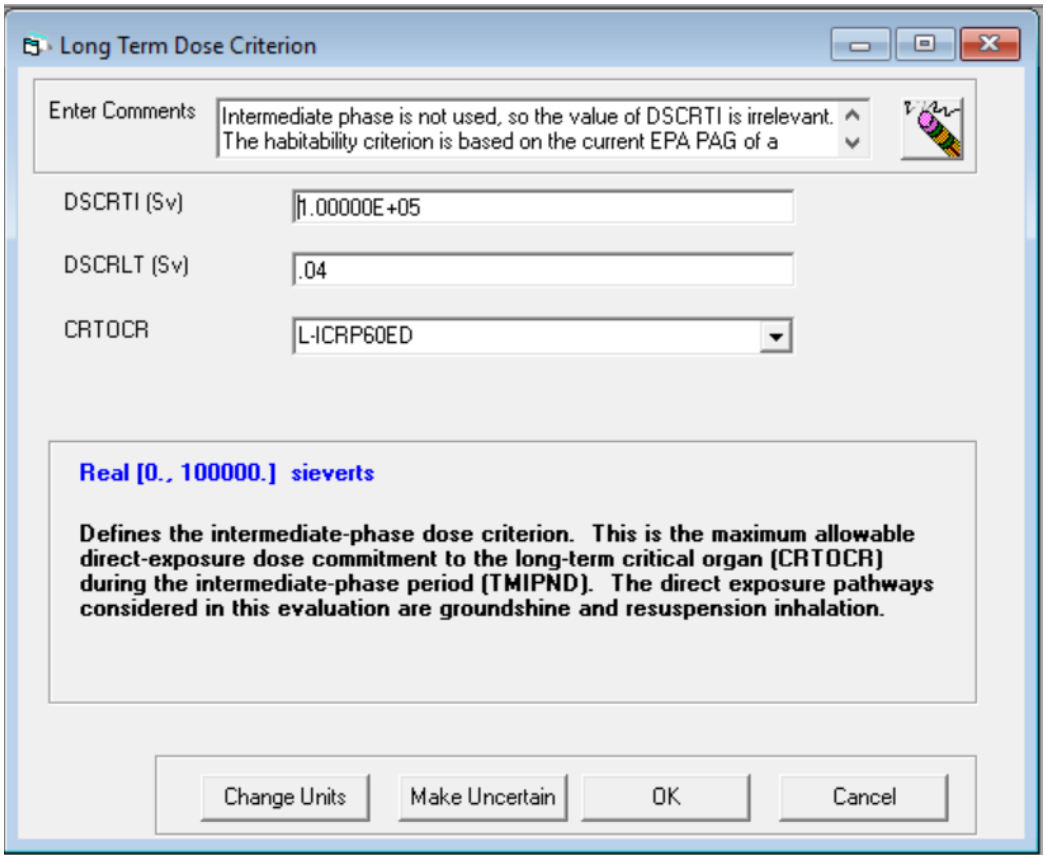


Figure 3-137 Long-Term Dose Criterion Form

Table 3-133 Long-Term Dose Criterion Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DSCRTI	Yes	Real	None	0 to 10^5 Sv
DSCRLT	Yes	Real	None	10^{-20} to 10^5 Sv
CRTOCR	Yes	Character	None	Organ names from DCF File

3.4.7 Decontamination Plan

The decontamination plan data block defines the decontamination actions that may be taken during the long-term period to reduce doses to acceptable levels. Each decontamination level represents an alternative strategy that would reduce the projected long-term groundshine and resuspension doses by a factor called the *dose reduction factor*.

3.4.7.1 Decontamination Plan Model Description

The objective of decontamination is to reduce projected doses below the long-term dose criterion in a cost-effective manner. When the maximum decontamination level is insufficient to restore an area to immediate habitability, a period of temporary interdiction following the maximum decontamination level is considered to reduce doses through radioactive decay and weathering. When the property cannot be made habitable within 30 years or when the cost of reclaiming the property exceeds the cost of condemning it, the property is condemned and permanently withdrawn from use.

Decontamination cost is divided into two categories and these two types of cost are calculated separately. Farm-dependent decontamination cost represents the cost of farmland decontamination in a grid element. Farm-dependent decontamination cost is a function of the area of the grid element devoted to agriculture. Population-dependent decontamination represents the cost of non-farmland decontamination. Population-dependent decontamination cost is a function of the population residing in the grid element. The strategy of decontamination within a grid element is largely independent of the type of area being decontaminated, with the exception that farmland can be decontaminated to restore habitability but not to restore farmability, as explained above.

For a given decontamination level, the same decontamination time and effectiveness apply to both farmland and non-farmland, but the two costs are unique and are assigned independently for each type of decontamination. Owing to the requirement that the recovery of property must be cost-effective, it is possible that non-farmland is decontaminated and restored to use but farmland is instead condemned within the same grid element.

Decontamination of a grid element serves to reduce the dose level in that element by the dose reduction factor associated with the decontamination effort being applied. Everything else being equal, a decontamination factor of 10 causes the integrated dose over any exposure period to be reduced by a factor of 10 of what it would have been without decontamination. Dose reduction factors are presented in Table 3-134.

Table 3-134 Decontamination factors.

Dose Reduction Factor	Percent of Dose Reduction
2	50%
3	66.7%
5	80%
10	90%
15	93.3%
20	95%

During the decontamination period, which is assumed to begin at the start of the long-term phase, the population is relocated from areas that are decontaminated.

While engaged in cleanup efforts, decontamination workers are assumed to wear respiratory protection devices. Therefore, they accumulate only groundshine doses. These doses contribute to the population dose tabulated in the MACCS output.

Decontamination reduces direct exposure doses (both groundshine and resuspension) caused by contamination of land and buildings. Some decontamination processes reduce groundshine and resuspension doses by washing surface contamination down into the ground. These processes do not eliminate contamination from the area, but they do reduce doses to the population by adding shielding. Since these processes may not move contamination out of the root zone, the WASH-1400-based economic cost model of MACCS assumes that farmland decontamination reduces direct exposure doses to farmers without reducing uptake of radioactivity by root systems. Thus, decontamination of farmland does not reduce the ingestion doses produced by consumption of crops that are contaminated by root uptake. Therefore, decontamination is not considered for restoring farmability. Nonetheless, contamination levels from produce, meat, and dairy products drops significantly in the second year because edible surfaces can be contaminated by direct deposition only in the first year of the accident.

3.4.7.2 Decontamination Plan Forms and Parameters

***Number of Plan Levels* Form**

The *Number of Plan Levels* form is required.

LVLDEC is the number of decontamination levels that can be used. Each decontamination level represents an alternative strategy to reduce the projected long-term groundshine and resuspension inhalation doses.

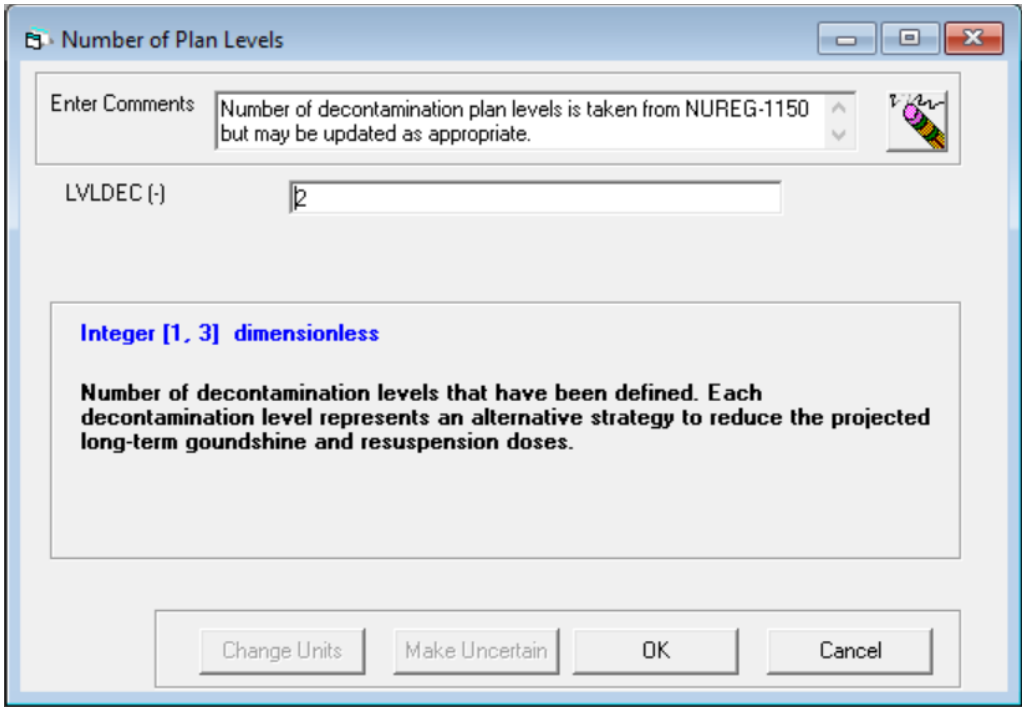


Figure 3-138 Number of Plan Levels Form

Table 3-135 Number of Plan Levels Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
LVLDEC	Yes	Integer	None	1 to 3

Plan Definition Form

The *Plan Definition* form is required.

DLBCST is the labor cost of a decontamination worker.

TIMDEC defines the time required for completion of each level of decontamination. Decontamination begins at the end of the intermediate phase (TMIPND). The values must be monotonically increasing when there is more than one decontamination plan.

DSRFCT defines the effectiveness of the various decontamination levels for reducing dose. A dose reduction factor of 3 means that the resulting population dose at that location is reduced to one-third of what it would have been without decontamination. The values must be monotonically increasing when there is more than one plan.

TFWKF defines the fraction of the decontamination period (TIMDEC) that a farmland decontamination worker spends in the contaminated area for each level of decontamination.

TFWKNF defines the fraction of the decontamination period (TIMDEC) that a non-farmland decontamination worker spends in the contaminated area during the decontamination period for each level of decontamination.

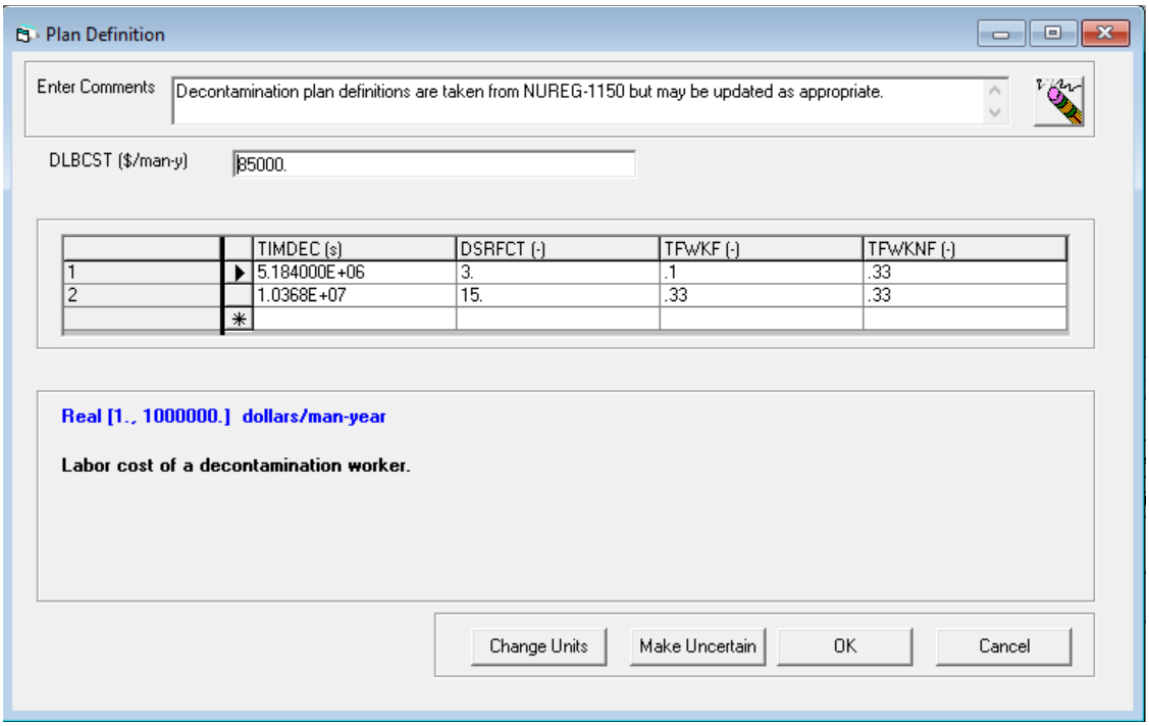


Figure 3-139 Plan Definition Form

Table 3-136 Plan Definition Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DLBCST	Yes	Real	None	1.0 to 10^6 $/person-yr
TIMDEC	Yes	Real	LVLDEC	10^{-6} to 9.46×10^8 s (30 yrs)
DSRFCT	Yes	Real	LVLDEC	1.01 to 100.0
TFWKF	Yes	Real	LVLDEC	0.0 to 1.0
TFWKNF	Yes	Real	LVLDEC	0.0 to 1.0

Farmland Costs Form

The *Farmland Costs* form is required.

CDFRM defines the farmland decontamination costs for each level of decontamination. Values must be monotonically increasing when more than one plan is defined.

FRFDL defines the fraction of the farmland decontamination cost that is due to labor for each level of decontamination.

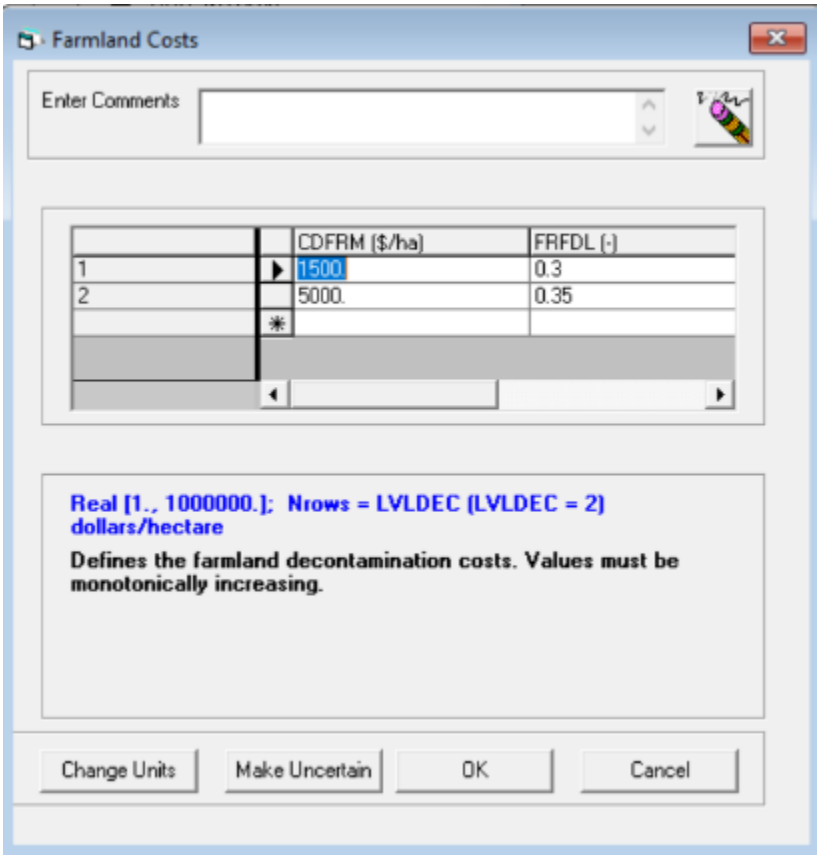


Figure 3-140 Farmland Costs Form

Table 3-137 Farmland Costs Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CDFRM	Yes	Real	LVLDEC	1.0 to 10^6 $/ha
FRFDL	Yes	Real	LVLDEC	0.0 to 1.0

NonFarmland Costs Form

The *Non-Farmland Costs* form is required.

CDNFRM defines the non-farmland decontamination costs for each level of decontamination. Values must be monotonically increasing when more than one plan is defined.

FRNFDL defines the fraction of the non-farmland decontamination cost that is due to labor for each level of decontamination.

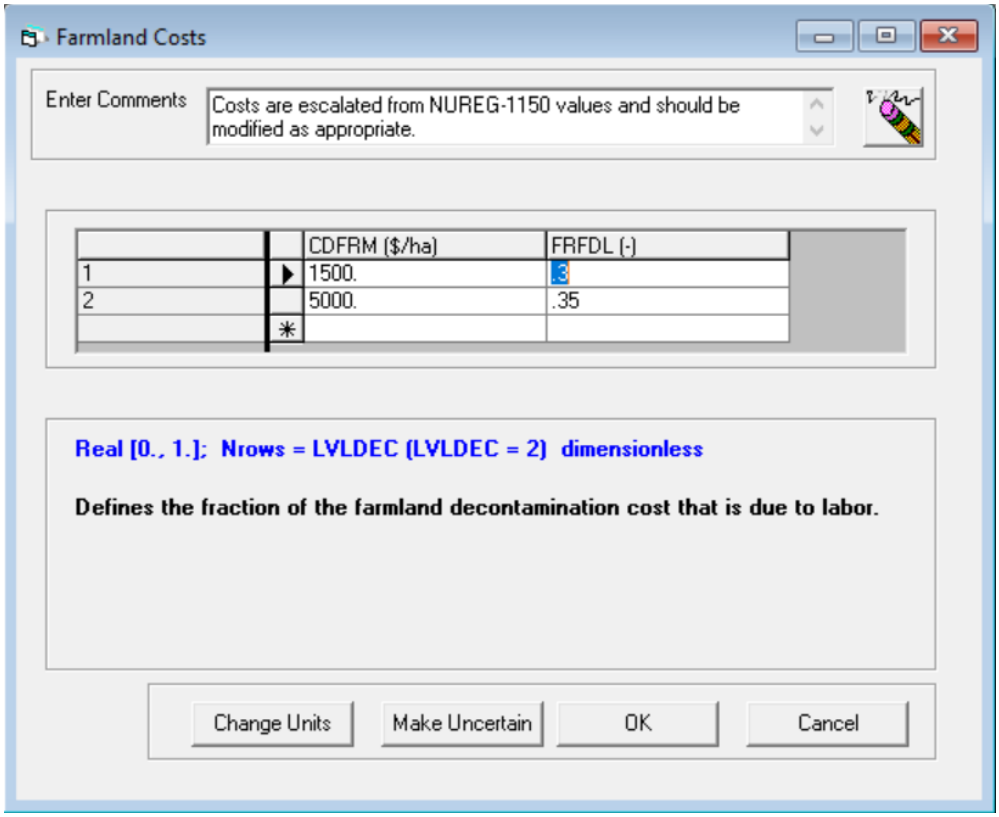


Figure 3-141 NonFarmland Costs Form

Table 3-138 NonFarmland Costs Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CDNFRM	Yes	Real	LVLDEC	1.0 to 10^6 $/person
FRNFDL	Yes	Real	LVLDEC	0.0 to 1.0

3.4.8 Interdiction Costs

The interdiction plan cost data block defines the parameters needed to calculate the cost of interdiction. The values supplied here are combined with values in the site data file (if one is used) and the regional characteristics data to estimate losses.

3.4.8.1 Interdiction Cost Model Description

The model used in MACCS for assessing the cost of interdiction is based on the model described in WASH-1400, Appendix 6. It is currently used to calculate the economic cost from depreciation and loss of use during both decontamination and temporary interdiction periods.

3.4.8.2 Interdiction Cost Forms and Parameters

***Interdiction Costs* Form**

The *Interdiction Costs* form is required.

DPRATE defines the depreciation rate that applies to property improvements during a period of interdiction. This depreciation rate is intended to account for the loss of value of buildings and other improvements resulting from a lack of habitation and maintenance. Depreciation losses are compounded continuously.

DSRATE defines the expected rate of return from land, buildings, equipment, etc. It also used for discounting losses that occur in future years. Losses are compounded continuously.

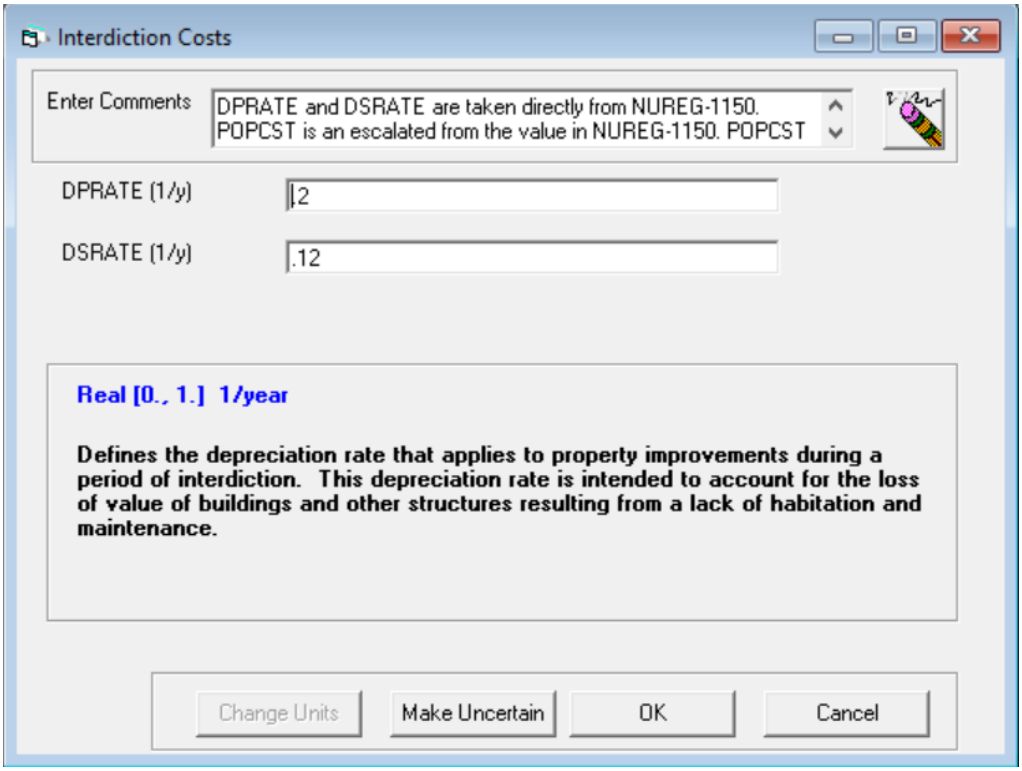


Figure 3-142 Interdiction Costs Form

Table 3-139 Interdiction Costs Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DPRATE	Yes	Real	None	0.0 to 1.0 yr^{-1}
DSRATE	Yes	Real	None	0.0 to 1.0 yr^{-1}

3.4.9 GDP Economic Parameters

3.4.9.1 RDEIM Model Overview

RDEIM (Regional Disruption Economic Impact Model) is an economic model that estimates the impact on direct, indirect, and induced GDP, for a disrupted geographic area. Indirect GDP losses are calculated using national RIMS II (Regional Input-Output Modeling System) multipliers.

The result of the RDEIM model are direct, indirect, and induced GDP losses, for each industry in the grid. This is accomplished by aggregating the RDEIM county-level results to a grid-level result that accounts for full and partial counties affected by an accident.

RDEIM uses state-of-practice input-output (I-O) economics to develop estimates of economic impact due to business disruption resulting from an atmospheric radioactive release. The modeling process considers multiple types of impacts in its estimations: direct losses are losses to the affected region in which the business disruption occurs; indirect losses are to the remainder of the US economy; and induced losses correspond to the lost spending power from income of impacted workers. These categories are described more precisely below:

- Direct impacts result from a loss of final demand of a product/service due to the supplier firm of that product or service being in the affected region.

- Indirect impacts result from the lack of demand for indirect goods/services within the directly affected area. These can be thought of as supplier firms outside the directly affected region that are no longer supplying those persons/companies/areas within the affected region. This excludes any geographic areas that are contained within the disrupted region.

- Induced impacts result from the spending by workers whose incomes were affected/interrupted by the disruption. This loss applies to both the directly and indirectly affected regions.

Direct impacts occur in a known geographic area, unlike indirect impacts, which may occur throughout the nation. Additionally, suppliers may exist within the actual affected area, introducing an opportunity for double counting these suppliers as both direct (based on geographic location) and indirect (based on who the supplier supplies) impact contributions. Additional complexity is introduced in the induced impacts where workers lost wages cannot be wholly attributed to lost economic stimulus (sales) within the affected region. Those workers may spend none, some, or all their income in the affected region with the remainder being spent outside of that region.

RDEIM estimates these losses for both the regional and national economies. Additionally, independent recovery schedules for local and national markets are permitted, under the premise that the national recovery timeframe is always shorter than that of the regional economic recovery.

Two regions are naturally defined for the RDEIM. *Intra-* is defined as the area affected directly by contamination to the extent that the land is labeled as currently unusable. This area may change over time due to remediation efforts and natural processes that diminish dose rates. The second region, *extra-*, includes the locations where indirect impacts occur and encompasses the contiguous United States less the *intraregional* area.

Multipliers are used to estimate national losses. Two types of multipliers are used: Type I and Type II. Type I account for direct plus indirect GDP losses; Type II account for direct, indirect, and induced GDP losses. Direct losses are estimated by calculating the number of affected workers per industry and multiplying by the value added by each worker in that industry. Total direct losses are estimated by summing losses for all industries and over the affected set of grid elements. Direct plus indirect losses are calculated using the sum of the products of losses by industry and the Type I multipliers. Indirect losses are estimated by taking the difference between direct + indirect and direct losses. Direct, indirect, and induced losses are calculated using the sum of the products of losses by industry and the Type II multipliers. Induced losses are estimated from the difference between the losses using Type II and Type I multipliers.

The multipliers are based on Industry-by-Industry Total Requirement (TRII) tables. For Type I, the TRII tables without households is used. For Type II, households are included. These multipliers are adjusted to be valid for regional and national data for each industry.

The results of RDEIM aim to provide the user with a comprehensive view of the economic effect following a disruption. This is done by including most of the previous economic model's cost-based valuations with the GDP losses. Economic losses for evacuation/relocation, long-term relocation, decontamination costs, depreciation on property improvements, condemned property, and disposal of contaminated crop and dairy products are calculated the same way in both the cost- and GDP-based models. GDP losses replace expected return on investment in the original, cost-based model.

An additional component to the GDP-based model is the inclusion of losses of tangible wealth. A criticism of including tangible wealth is the potential for double counting losses (counted once in GDP losses and again in the tangible wealth losses). However, not including losses of tangible wealth loss estimates could lead to undercounting. Double counting is considered preferable to undercounting and therefore used in the implementation of RDEIM.

Input-Output (I-O) modeling uses a framework of inputs and outputs for different types of industries and areas of the economic sector. An output from one industry may serve as input for a different industry. Using this modeling system, a national economic network can be established, and it is possible to measure the far-reaching economic effects suffered by the loss of a single industry or region.

The process for determining losses (or loss of value additions) involves comparing a baseline GDP scenario and a disruption scenario. Direct GDP is the GDP produced in a region if it were open for business (the baseline case). Direct GDP loss assumes the area is shut down for a period specified in the disruption scenario, as calculated by MACCS, and considers GDP of the affected area to be lost.

MACCS uses a set of weather trials to obtain a distribution of impact results for various weather events. These results are analyzed producing standard statistical outputs, such as mean, median, and 90^{th} percentile economic losses.

MACCS uses a grid structure. Grid elements may contain 1 or more partial or full counties. MACCS determines if the grid element should be condemned due to radiological contamination

and if/when the element recovers. The area is also modeled in terms of industry, where all industries within a grid element are assumed to be non-operable for some (MACCS calculated) period (not longer than the user-defined "Maximum Duration of Local Economic Impact" parameter).

Data are available for the number of workers in each industry for each county in the continental U.S. Since grid elements are not necessarily full counties, the value for a partial county is found by multiplying the number of employees within the entire county by the fraction of land area or fraction of the population affected for each industry and summing the results. For industries that are based on land (e.g., farming), the fraction of affected land area is used to determine the fraction of a county within a grid element. Conversely, for industries where labor is the primary factor (e.g., manufacturing), the fraction of the county population affected is used to determine the fraction of an industry within a grid element. A table of industries and how partial counties are apportioned is shown below:

Table 3-140 Method for Apportioning County in a Grid Element for Each Industry Treated by RDEIM

Industry	By Area	By Population
Agriculture, forestry, fishing, and hunting	X	
Mining	X	
Utilities	X	
Construction		X
Wholesale trade		X
Retail trade		X
Transportation & Warehousing	X	
Information		X
Finance & Insurance		X
Manufacturing		X
Real estate & rental leasing		X
Professional, scientific, and technical services		X
Management of companies & Enterprises	X	
Administrative & Waste management services	X	
Educational services		X
Health care & Social assistance		X
Arts, entertainment & recreation		X
Accommodations & food services		X
Other services, except government		X
Federal government		X
State & local government		X

For each industry that exists in a grid element, a value added to GDP by each worker per year is used to estimate the direct impact of affected workers. Multipliers are used to address Type I and Type II impacts. Disruptions for each grid element are summed to provide GDP losses.

A significantly more detailed discussion of the RDEIM model can be found in a document that is located in the WinMACCS/References folder titled “Economic Model for Estimation of GDP Losses in the MACCS Offsite Consequence Analysis Code.”

3.4.9.2 RDEIM Model Forms and Parameters

Default Gross Domestic Product Parameters Form

This form contains the default values that are used when “Default” economic values are selected on the Project Properties form. These values may be updated when the RDEIM is updated, but current values are shown in the table below.

ECON_DEF_DRT is the default social discount rate over the economic impact duration as a fraction.

ECON_DEF_GRT is the default gross domestic product (GDP) growth rate over the economic impact duration as a fraction.

ECON_DEF_AYR is the year that an accident is assumed to occur. The default is that the accident year is the same as the RDEIM year, which is currently 2011.

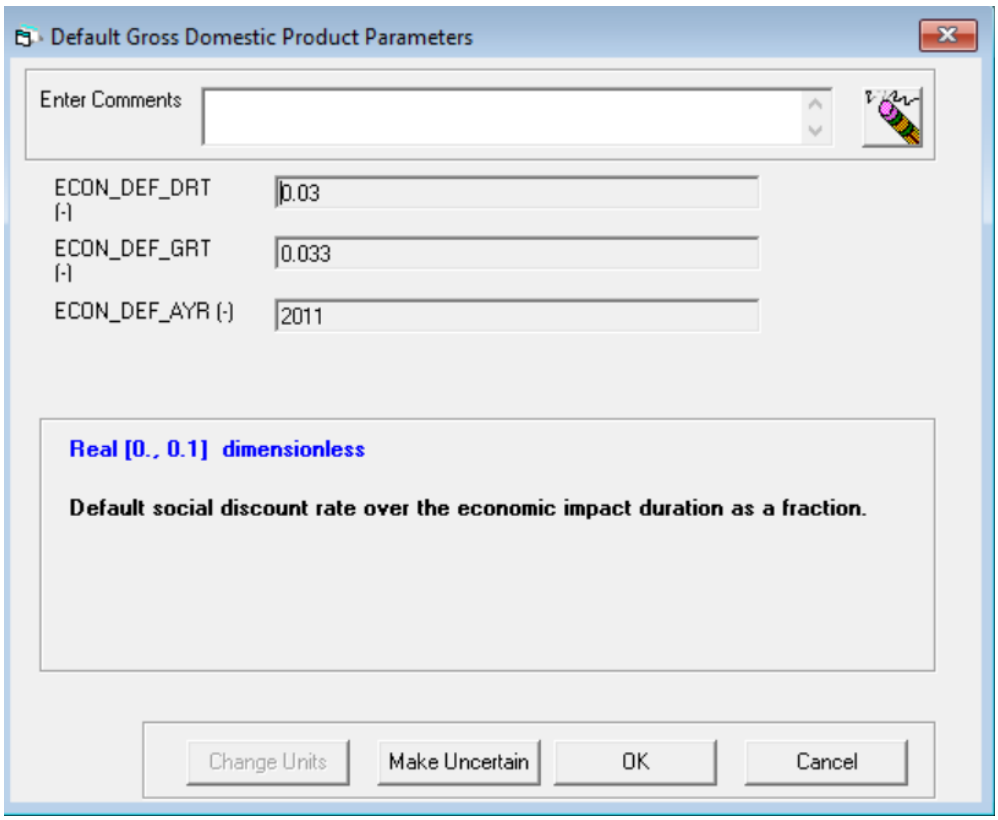


Figure 3-143 Default Gross Domestic Product Parameters Form

Table 3-141 Default Gross Domestic Product Parameters Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
ECON_DEF_DRT	No	Real	None	0 to 0.1
ECON_DEF_GRT	No	Real	None	0 to 0.1
ECON_DEF_AYR	No	Integer	None	1980 to 2050

Model Basis Form

This form is required when RDEIM is selected.

ECON_RGDR is the duration of regional economic disruption.

ECON_NTDR is the duration of national economic disruption. This should not exceed ECON_RGDR.

ECON_MULT is the land condemnation factor. This parameter multiplies the value of the land in the inequality that determines whether decontamination is cost beneficial.

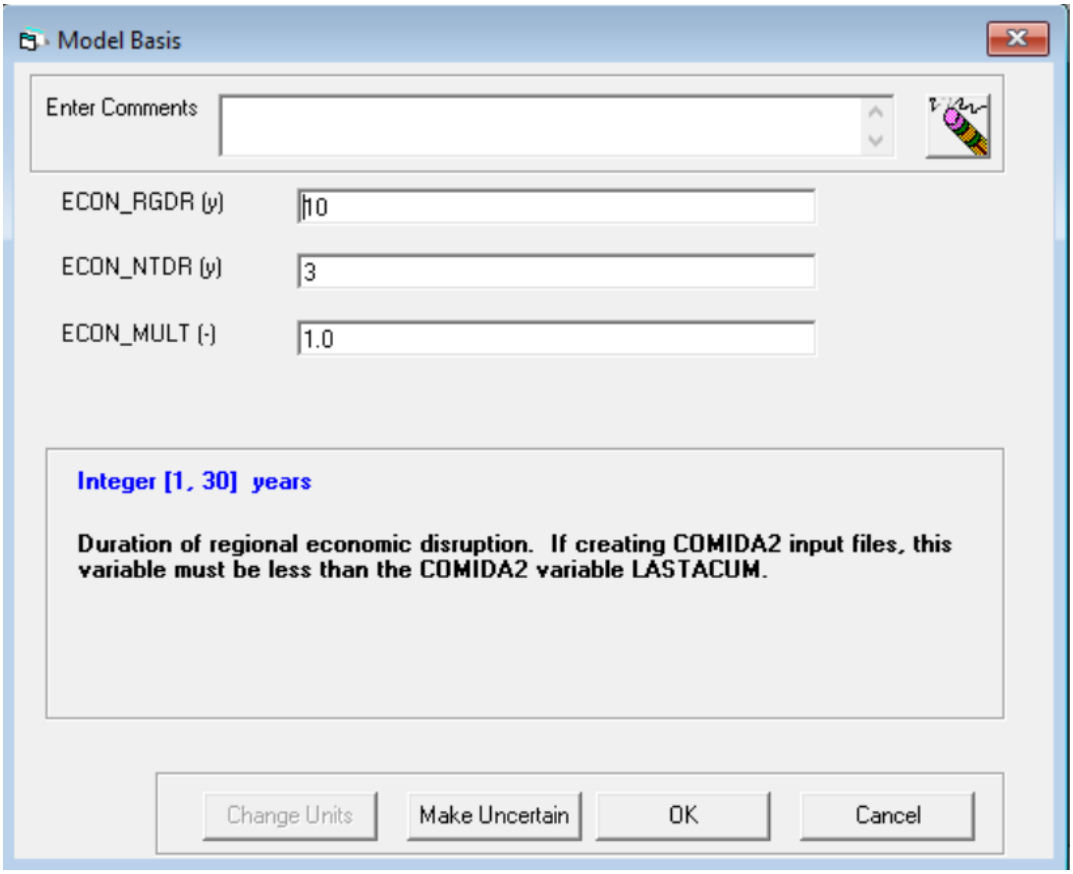


Figure 3-144 Model Basis Form

Table 3-142 Model Basis Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
ECON_RGDR	Yes	Integer	None	1 to 30 year
ECON_NTDR	Yes	Integer	None	1 to 10 year
ECON_MULT	Yes	Real	None	0.0 to 1000.0

Model Basis Form

This form is used when the User Specified option is selected on the *Project Properties* form under the *Econ* tab.

ECON_DRT is the annual social discount rate over the economic impact duration specified as a fraction.

ECON_GRT is the annual gross domestic product (GDP) growth rate over the economic impact duration specified as a fraction.

ECON_AYR is the year the accident occurs. GDP values are adjusted to be consistent with the accident year using the GDP growth rate.

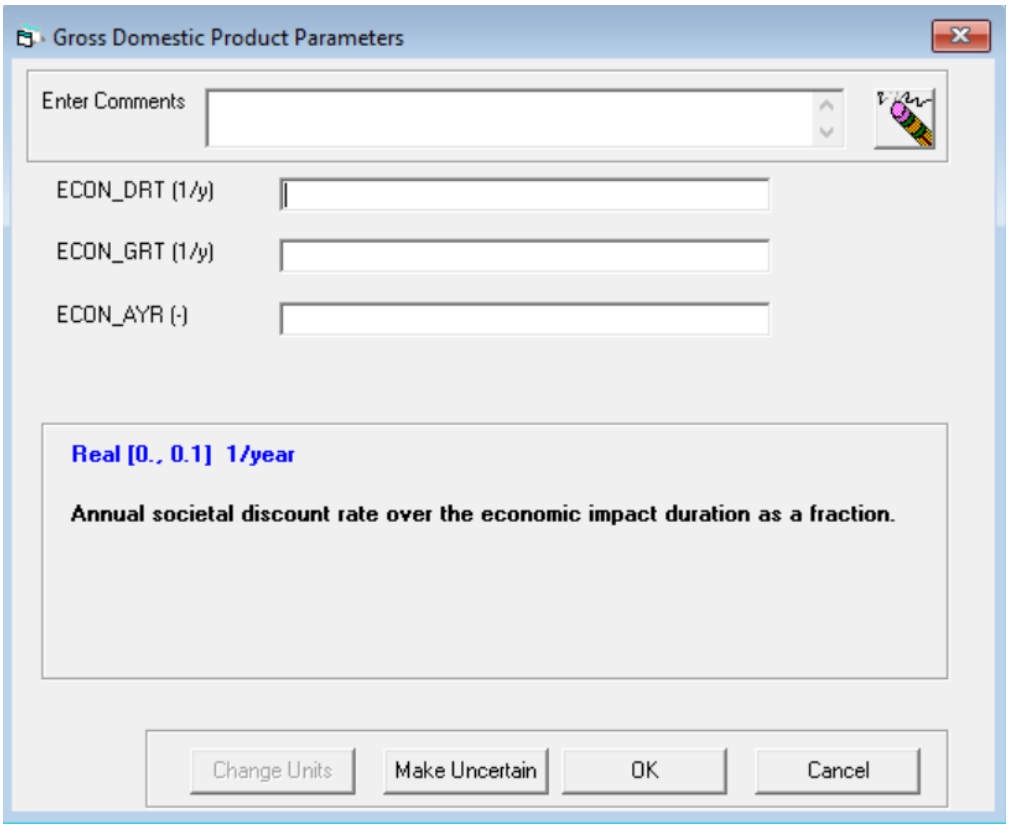


Figure 3-145 GDP Economic Parameters Form

Table 3-143 GDP Economic Parameters Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
ECON_DRT	Yes	Real	None	0.0 to 0.1 per year
ECON_GRT	Yes	Real	None	0.0 to 0.1 per year
ECON_AYR	Yes	Integer	None	1980 to 2050

3.4.10 Weathering

3.4.10.1 Weathering Model Description

The groundshine weathering relationship from Gale, Miller, and Fisher (1964) is described as follows:

$$GW(t) = GWCOEF(1) \bullet \exp[-\ln(2) \bullet t/TGWHLF(1)] + GWCOEF(2) \bullet \exp[-\ln(2) \bullet t/TGWHLF(2)] \quad \textbf{(3-44)}$$

Where

GW(*t*) represents groundshine weathering factor at time *t*, given the weathering coefficients, GWCOEF(i), and the weathering half-lives, TGWHLF(i).

The resuspension weathering relationship is defined as:

$$RW(t) = RWCOEF(1) \bullet \exp[-\ln(2) \bullet t/TRWHLF(1)] + RWCOEF(2) \bullet \exp[-\ln(2) \bullet t/TRWHLF(2)] + RWCOEF(3) \bullet \exp[-\ln(2) \bullet t/TRWHLF(3)] \quad \textbf{(3-45)}$$

Where

RW(*t*) represents the resuspension weathering at time *t*, given the weathering coefficients, RWCOEF(i), and the weathering half-lives, TRWHLF(i).

The values are defined under the *Weathering* category in the WinMACCS interface.

3.4.10.2 Weathering Forms and Parameters

***Groundshine Weathering Terms* Form**

The *Groundshine Weathering Terms* form is required.

NGWTRM defines the number of terms in the groundshine weathering relationship.

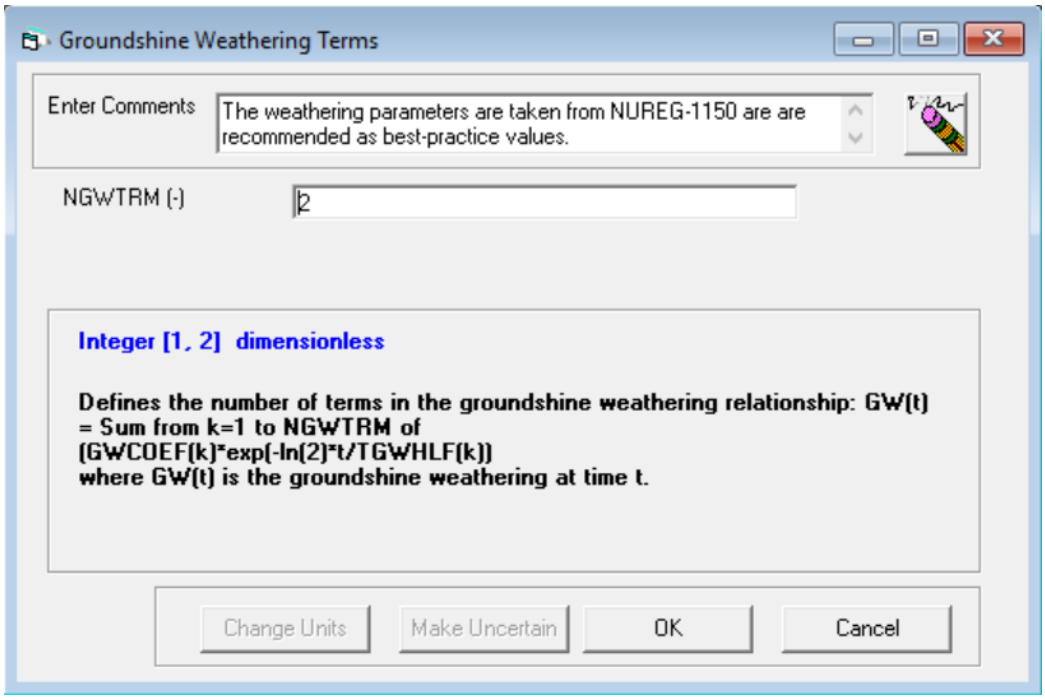


Figure 3-146 Groundshine Weathering Terms Form

Table 3-144 Groundshine Weathering Terms Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NGWTRM	Yes	Integer	None	1 or 2

Groundshine Weathering Coefficient Form

The *Groundshine Weathering Coefficient* form is required.

GWCOEF is the set of linear coefficients in the groundshine weathering equation.

TGWHLF is the set of half-lives in the groundshine weathering equation.

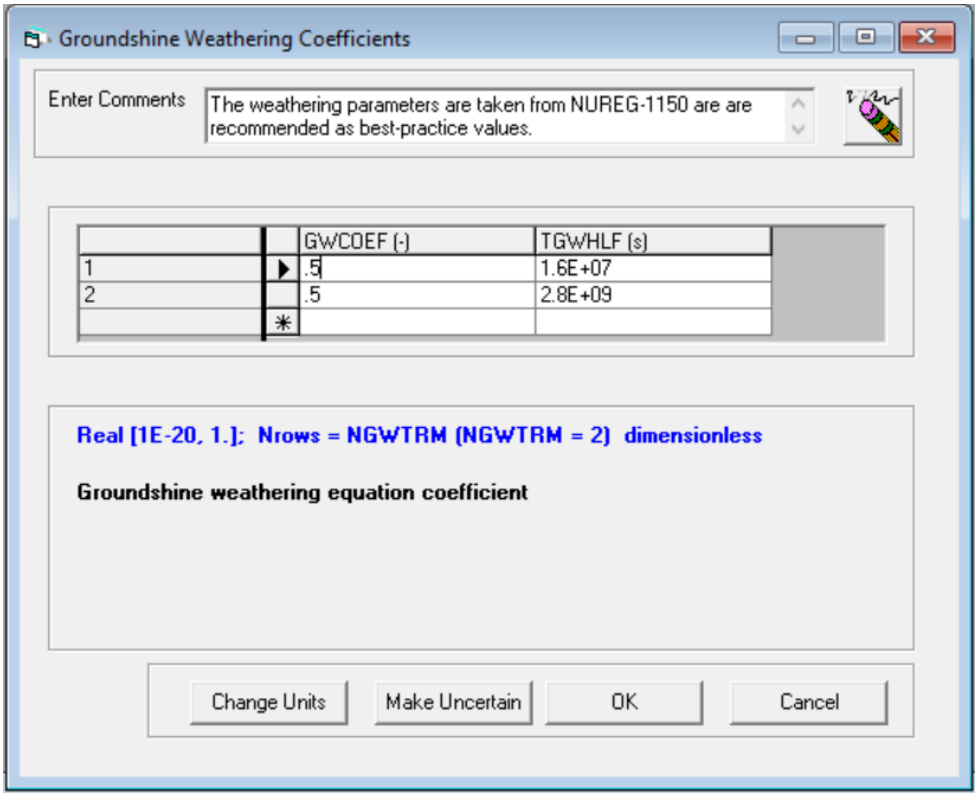


Figure 3-147 Groundshine Weathering Coefficients Form

Table 3-145 Groundshine Weathering Coefficients Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
GWCOEF	Yes	Real	NGWTRM	10^{-20} to 1.0
TGWHLF	Yes	Real	NGWTRM	10^{-6} to 10^{12} s

Resuspension Weathering Terms Form

The *Resuspension Weathering Terms* form is required.

NRWTRM defines the number of terms in the resuspension weathering relationship.

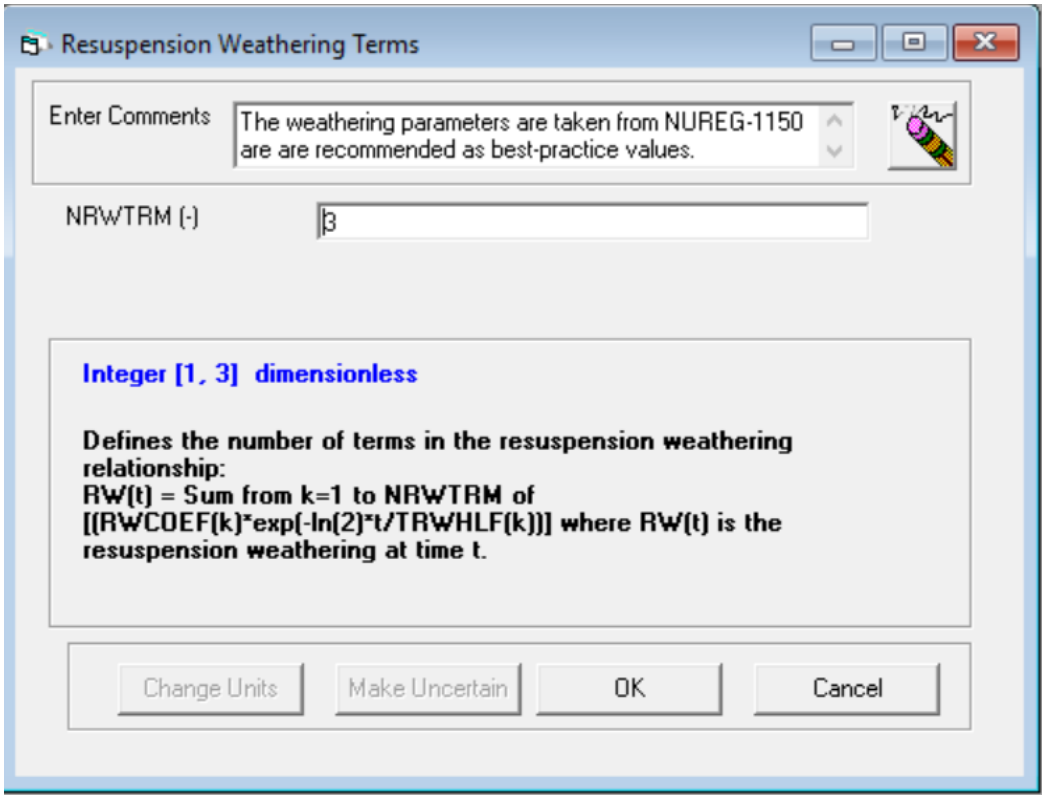


Figure 3-148 Resuspension Weathering Terms Form

Table 3-146 Resuspension Weathering Terms Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NRWTRM	Yes	Integer	None	1 to 3

Resuspension Weathering Coefficient Form

Resuspension Weathering Coefficient is required.

RWCOEF is the set of linear coefficients in the resuspension weathering equation.

TRWHLF is the set of resuspension weathering half-lives.

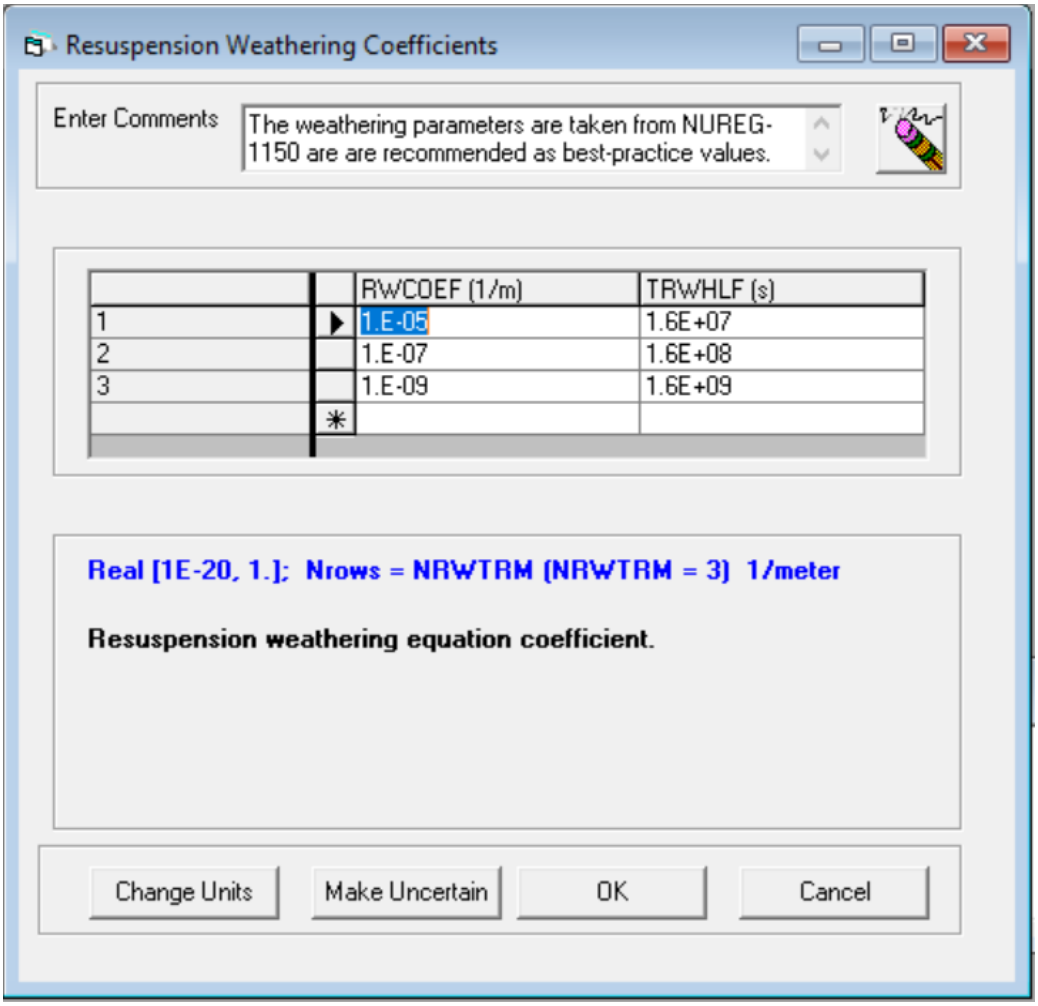


Figure 3-149 Resuspension Weathering Coefficients Form

Table 3-147 Resuspension Weathering Coefficients Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
RWCOEF	Yes	Real	NRWTRM	10^{-20} to 1.0 m^{-1}
TGWHLF	Yes	Real	NRWTRM	10^{-6} to 10^{12} s

3.4.11 Regional Characteristics

The regional characteristics data block defines the average economic and agricultural characteristics of the area surrounding the accident site.

3.4.11.1 Regional Characteristics Model Description

When mitigative actions are needed to restore habitability or farmability, the regional characteristic values are used to evaluate the cost-effectiveness of those actions. For instance, when the average property values supplied here indicate that decontaminating a piece of land costs more than condemning it, the land is condemned.

To implement the rotation strategy when the user has chosen the option of *No Windshift with Rotation* (IPLUME=1) or *Windshift with Rotation* (IPLUME=2), the result of the cost-effectiveness test must be the same in any direction. Thus, instead of using actual property values from the site file, uniform values defined in the following section are used to make the decision on whether it is cost effective to decontaminate. When no site file is supplied by the user, land values are assumed to be uniform over the grid and so the regional characteristic values are also used to calculate economic losses.

3.4.11.2 Regional Characteristic Forms and Parameters

Property Improvements Form

FRNFIM defines the fraction of nonfarm wealth in the region due to improvements. This value includes buildings and infrastructure, such as roads and utilities, as well as any nonrecoverable equipment or machinery.

FRFIM defines the fraction of farm wealth in the region due to improvements. This value includes farm buildings and nonrecoverable machinery as well as any infrastructure, such as silos and irrigation that exclusively support farming.

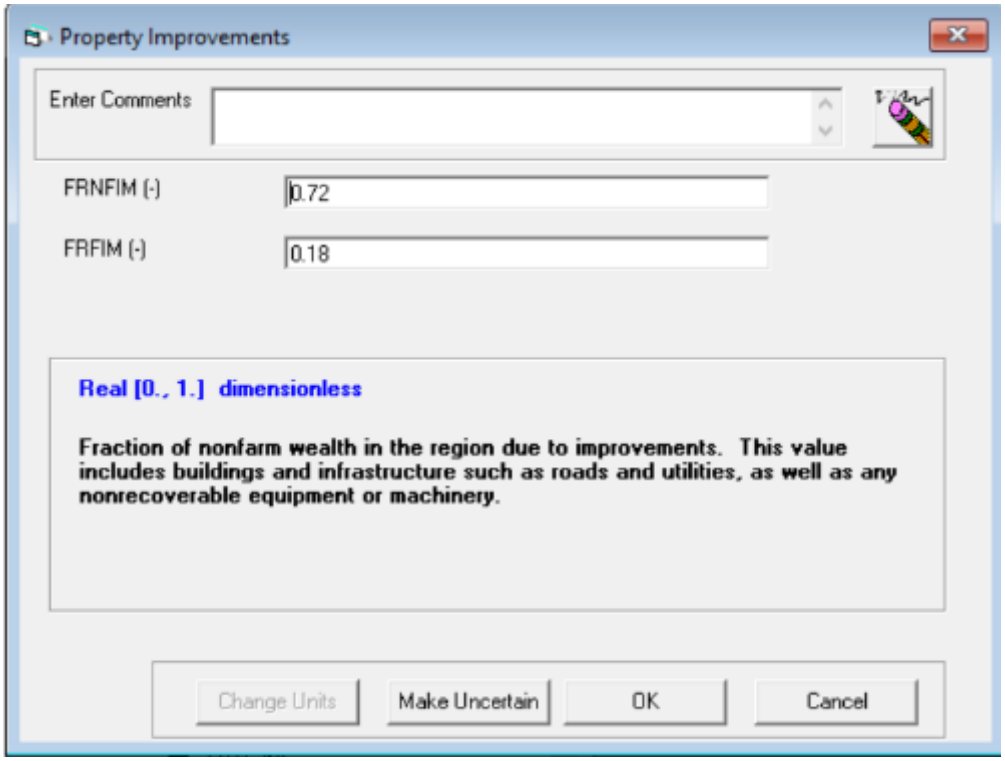


Figure 3-150 Property Improvements Form

Table 3-148 Property Improvements Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
FRNFIM	Yes	Real	None	0.0 to 1.0
FRFIM	Yes	Real	None	0.0 to 1.0

Property Values Form

VALWNF defines the value of the nonfarm wealth in the region. Nonfarm wealth includes all public and private property not associated with farming that would be unusable while the region is uninhabitable. This value should include the cost of land, buildings, infrastructure, and the cost of any nonrecoverable equipment or machinery. A corresponding value (VNFRM) is calculated for each economic region by SecPop. The SecPop value is not averaged over the entire region, so it is able to represent variations in non-farmland wealth within the computation grid. When a site file is used in a calculation, the actual losses are estimated from the site file values (VNFRM) rather than the input value (VALWNF).

VALWF defines the average value of farm wealth in the region. This value should include both publicly- and privately-owned grazing lands, farmland, farm buildings, and nonrecoverable farm machinery, as well as any publicly owned infrastructure serving the farm industry in the region. A corresponding value (VFRM) is calculated for each economic region by SecPop. The SecPop value is not averaged over the entire region, so it is able to represent variations in farmland wealth within the computation grid. When a site file is used in a calculation, the actual losses are estimated from the site file values (VFRM) rather than the input value (VALWF).

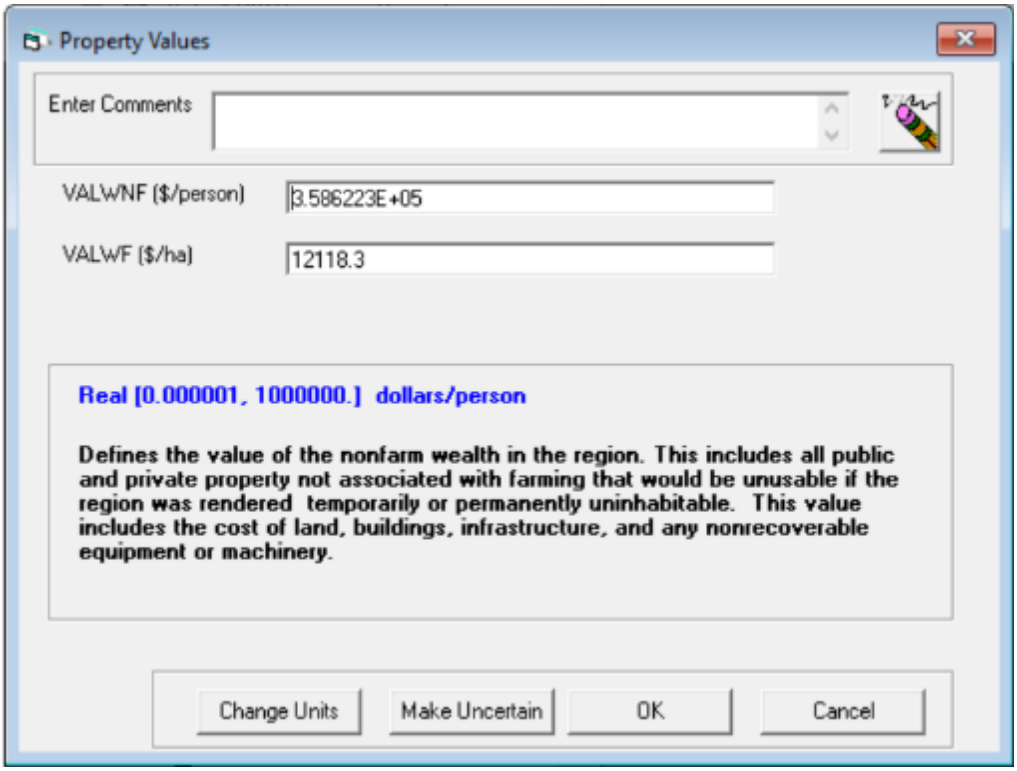


Figure 3-151 Property Values Form

Table 3-149 Property Values Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
VALWNF	Yes	Real	None	10^{-6} to 10^{6} $/person
VALWF	Yes	Real	None	10^{-6} to 10^{6} $/ha

Land Usage Form

Land Usage is required when *Uniform* is selected on the *Site Data* tab on the *Properties* form. When *Import from File* is selected on the *Site Data* tab, the values needed in the calculation are taken from the site data file.

FRCFRM defines the average fraction of land in the region devoted to agriculture. The land area devoted to agriculture is calculated as follows:

$$\text{agricultural area} = \text{total area} \bullet \text{FRACLD} \bullet \text{FRCFRM} \qquad \textbf{(3-46)}$$

FRMPRD defines the value of the average annual farm production (gross sales) in the region.

DPFRCT defines the fraction of annual farm production (gross sales) in the region resulting from dairy production.

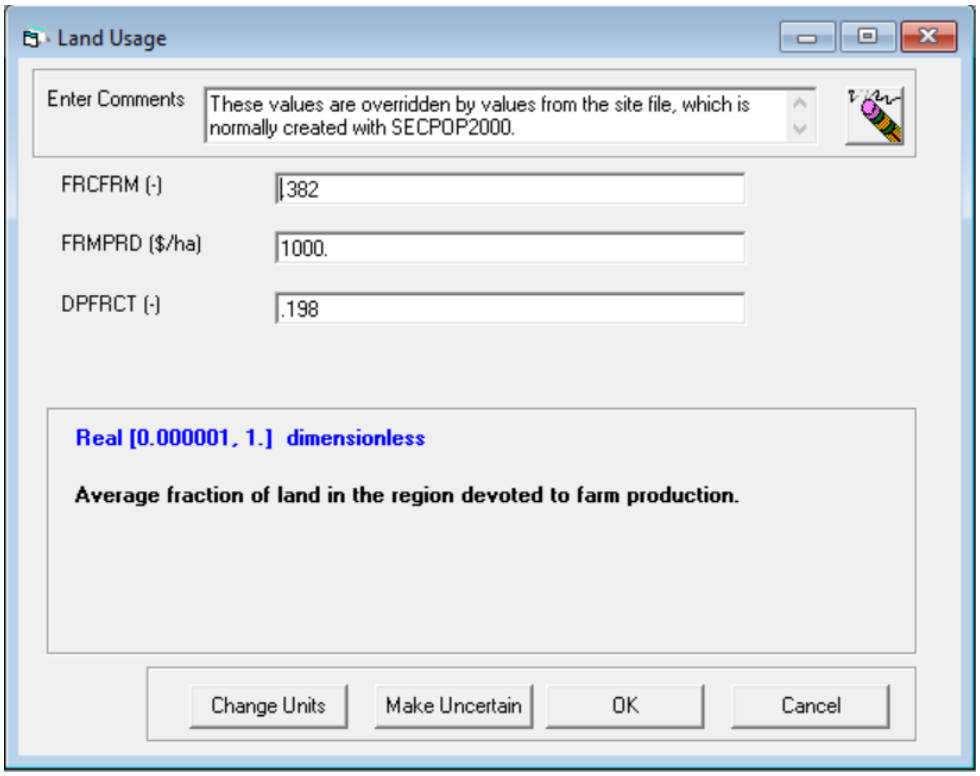


Figure 3-152 Land Usage Form

Table 3-150 Land Usage Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
FRCFRM	Yes	Real	None	10^{-6} to 1.0
FRMPRD	Yes	Real	None	0 to 10^{5} $/ha
DPFRCT	Yes	Real	None	0.0 to 1.0

3.4.12 Food Chain

MACCS incorporates three optional food-ingestion models as follows:

- the food-ingestion model from the original MACCS code, as used in NUREG-1150
- the COMIDA2 food ingestion model
- no food-ingestion model.

The MACCS food ingestion model is based on the principle that the long-term dose produced by any radionuclide to an organ via the food-ingestion pathway is the product of the ground concentration of the radionuclide, the integrated transfer factor for the radionuclide to human intake for the pathway, and the ingestion DCF.

There are several limitations in the MACCS food-ingestion model. A main drawback is that the integrated transfer factors for food pathway radionuclides not included in the MACCS sample problems must be derived externally. Calculation of the transfer factors is difficult and error prone. A second limitation is that it is not capable of distinguishing the effects of contamination at different times during the growing season. The difference is substantial, depending on whether deposition occurs directly onto standing crops or not.

By contrast, the COMIDA2 ingestion model is based on a preprocessor that can be exercised by the user, with consideration of site-specific data, when such data are available. Alternatively, the user can use a COMIDA2 file distributed with the code that provides typical values for the U.S. The COMIDA2 model considers a set of times during the growing season, so variations in food contamination over the growing season are automatically treated.

The user has a choice of using one of two food-chain models or specifying that food-chain doses should not be treated. These choices are made on the *Food* tab of the *Properties* form. When the user selects *No Food Model* on the *Food* tab, user input is not required in this section; otherwise, some input is required. When the *MACCS Food Model* is chosen on the *Food* tab, all the inputs to the food-chain model are contained in this section. When the COMIDA2 food-chain model is used, MACCS uses a binary data file created by the preprocessing program, COMIDA2, that contains the results of the COMIDA2 food-chain modeling calculations.

When *Predefined COMIDA2 File* is specified, the user must specify the COMIDA2 binary file to be used. The name of the files is specified on the *COMIDA2 File* form found under the *GENERAL/File Specifications* category. Additionally, the same DCF file used to create the user supplied COMIDA2 file must be specified as the DCF file on the *GENERAL/File Specifications/ Dose Conversion Factor File* form.

When *Create COMIDA2 File* is specified, the user must complete the forms found in the main model category titled COMIDA2. In this case, when the model is executed, the COMIDA2 pre-processor is run first. This pre-processor uses the DCF file specified and creates a binary file to be used by MACCS. One purpose for using this option is that uncertainty in food-chain parameters can be included in MACCS calculations.

When one of the dose threshold models is used, either *Annual Threshold* or *Piecewise Linear*, creating COMIDA2 binary files is not supported. Also, the MACCS food-chain model is not compatible with these choices.

3.4.12.1 Food-Chain Model Descriptions

Modeling of Agricultural Countermeasures

LASTACUM, a COMIDA2 input parameter, specifies the maximum duration of the ingestion dose period. MACCS calculates the accumulated societal dose starting with the year that the land satisfies the human consumption criteria specified by DOSEMILK, DOSEOTHR, and DOSELONG, with the exposure period ending in the LASTACUM year after the accident. The allowable range for the LASTACUM parameter is from 1 to 50 years. The value of the LASTACUM parameter is defined in the COMIDA2 user input file. It is communicated to MACCS as part of the header information on the .bin file written by COMIDA2.

Consistent with the MACCS interdiction model, the maximum farmland interdiction period considered is eight years. Land that cannot be returned to production after eight years is condemned. MACCS condemns land that cannot be returned to production within LASTACUM years when the COMIDA2 model is used and the LASTACUM input parameter is assigned a value less than 9.

To preserve the functionality of the MACCS food-chain model, agricultural countermeasures are always subordinate to the code's evaluation of habitability. That is, when land is uninhabitable because projected groundshine and resuspension doses exceed the long-term dose criterion, DSCRLT, agricultural production at that location is not allowed.

Furthermore, when the resident population is never allowed to return, either because of a failure to meet the dose criterion or because the costs to restore habitability exceed the value of the property, farmland is also assumed to be condemned, irrespective of the projected doses from food ingestion. When the farmland is condemned, none of the additional tests described below are performed. The costs associated with the condemnation of the farmland are based on the value of the property.

Milk and crop disposal during the year of the accident are triggered when the habitability criterion (DSCRLT) is exceeded. Milk and crop disposal costs are calculated only for the year of the accident. When DSCRLT does not lead to milk and nonmilk crop disposal, the maximum dose levels for the first year's milk production (DOSEMILK) and the first year's nonmilk crops (DOSEOTHR) are examined separately to find whether either is exceeded. The first-year dose criteria are evaluated using the consumption rates specified by the COMIDA2 input parameter CONSUM_RATES. Crop or milk disposal is triggered when the corresponding dose level is exceeded. Beginning with the second year following the accident, year 2, the long-term ingestion dose criterion (based on DOSELONG) is evaluated. The disposal of milk and/or nonmilk crops is triggered when the projected ingestion dose for food and milk combined exceeds DOSELONG.

When the projected individual dose for a year does not exceed the dose level DOSELONG, agricultural production for that year and all subsequent years is allowed. Implicit in the model is the assumption that the food doses resulting from successive years of production do not increase with time. Also, just as with the MACCS food-chain model, the long-term interdiction of farmland applies to *all* crop categories; there is no provision for long-term interdiction of a subset of the crops.

When the projected individual dose from the second year of agricultural production exceeds the dose criterion, the projected doses for up to eight successive annual periods are each examined to determine whether production can be resumed within the first nine years after the accident.

When the projected doses in each of years two through nine exceed DOSELONG, no further tests are performed and the farmland is condemned. When farmland is condemned, the associated

cost is the market value of the farmland, VALWF, with dollar values reported on the output listing as FARM DEPENDENT CONDEMNATION COST.

When the projected doses for one of the years satisfies the long-term dose criterion, agricultural production is assumed to resume in that year. Societal ingestion doses are assessed for the period ending with the LASTACUM year.

For example, when DOSELONG is satisfied in year three, and LASTACUM has a value of 9, societal doses are accrued for the period denoted as years three to nine. Since agricultural production was not allowed in the first and second years, economic costs for two years of interdiction are assessed for farmland. The model calculates the cost of temporary interdiction as the loss of return on investment on the land and improvements (see parameters VALWF and FRFIM) and accounts for depreciation on the improvements.

First-Year Crop Disposal Cost

The economic cost of milk and/or nonmilk crop disposal during year one is modeled based on the economic costs assessed for the loss of sales. The two crop disposal cost calculations, however, consistent with CRAC2, are treated differently, as follows.

When the disposal of the first year's milk production is triggered because the dose criterion DOSEMILK is exceeded, milk disposal costs are assessed as 0.25 of annual milk sales (see parameters FRMPRD and DPFRCT). The 0.25 adjustment factor assumes that cows would be taken off pasture and fed uncontaminated feed, allowing dairy production to resume after one-quarter of a year. To maintain consistency with the MACCS food-chain model, the application of the fixed 0.25 adjustment factor on milk disposal costs is also implemented for the COMIDA2 food-chain model.

It is noted that the model implemented in MACCS for crop disposal costs, and the 0.25 factor for lost dairy sales, is not based on WASH-1400 because WASH-1400 did not account for crop disposal costs. CRAC2, in contrast to WASH-1400, *did* implement separate milk and nonmilk crop disposal costs, providing the technical basis for the MACCS model to assess such costs. CRAC2, however, in assessing the costs of milk and nonmilk crop disposal, assessed a milk disposal cost based on the full year's dairy sales.

Water Ingestion Model

When radioactive material is deposited on the ground, it is expected that some fraction of this material makes its way into drinking water that is consumed by humans (Helton, Muller, and Bayer, 1985). MACCS models this uptake into drinking water as two separate paths: (1) deposition of contaminants directly onto freshwater bodies and (2) deposition of contaminants onto land with subsequent wash off into freshwater bodies.

The water ingestion model assumes that the area surrounding the site is divided into two categories: water and land. The radioactive material deposited on a spatial element is initially apportioned between water and land according to the fraction of the region covered by land. For coastal sites, where both fresh water and ocean water need to be treated, the user can manually edit the site data file to account for more than one watershed. A site data file can define up to four watersheds. One or more of those watersheds (*e.g.,* ocean) can be defined to have no uptake fraction.

The parameters described below are used to define the behavior of the single watershed; however, the discussion is easily extended to multiple watersheds where the parameter values

depend on grid element. The user specifies which radionuclides are to be included with the water ingestion pathway.

Of the activity deposited directly onto water or transferred from land to water, the fraction represented by WINGF determines how much of that deposited activity is eventually consumed by humans. Once the activity is transferred to the water body, there is no adjustment to account for radioactive decay.

Of the activity that is initially deposited on land, some fraction makes its way through runoff into the freshwater supply over a relatively brief period following deposition. This fraction is specified by the value of WSHRTI. The remainder of the material deposited on land is assumed to be washed off to the freshwater supply at a constant fractional rate over the time from t=0 to t=infinity. The rate at which this subsequent wash off occurs is specified by the value of the rate constant WSHRTA.

The model uses the values of the two variables, WSHRTI and WSHRTA, and evaluates the integral of the wash off fraction in a way that takes account of radioactive decay of the material deposited on land surfaces. The model is described by Helton, Muller, and Bayer (1985). The evaluation of this integral produces a numerical value, F, that represents the fraction of activity falling on land that is eventually transferred to surface water bodies that supply drinking water.

With the value of F, the uptake fraction of activity deposited on land can be calculated, which is WINGF • F. The input parameter WINGF is the ratio of the total amount of a radionuclide consumed via the drinking-water pathway (*i.e.,* by the entire population of the region surrounding the facility) and the amount entering potable surface-water bodies. Ideally, a value for WINGF should be derived from a model for radionuclide transport through the surface-water system of the surrounding region.

The models used to determine WINGF can vary in complexity from the very simple (*e.g.,* a single uniformly mixed cell) to the very complex (*e.g.,* three-dimensional fluid transport with temporal and spatial variability). The value of WINGF supplied with the sample problems was derived in a very simple manner. See Bixler et al. (2020) for a more extensive discussion of the water ingestion parameters, including WINGF.

MACCS Food-Chain Model

When the MACCS food-chain model is selected, MACCS performs food and water ingestion calculations in the same manner as the original MACCS code used in NUREG-1150.

When radioactive material is deposited on land, some fraction of this material may make its way through the food chain and ultimately be consumed by humans in the form of contaminated food or drinking water. The ingestion pathway is modeled in MACCS as a series of transfer processes that the material must undergo between the time of deposition and the consumption of the contaminated food products by humans; these processes decrease the amount of material passed on to the next step in the food chain.

To calculate the population dose resulting from the accumulated contamination of an area, it is necessary to know the efficiency of the entire food chain for transferring material from the ground to man. MACCS calculates the overall efficiency of two ingestion sources (food and water) by multiplying all the individual transfer factors that are described in Section 3.4.12.2, yielding an overall weighted sum representing the effectiveness of the pathway in transferring contaminants from the ground to human consumption.

When an accident occurs during the growing season, part of the radioactive material deposited on farmland is retained on plant surfaces and the remainder falls on the ground. Between the time of deposition and the time of harvest, radioactive material can be lost from plant surfaces due to weathering, radioactive decay, translocation to interior portions of the plant, and the harvesting process.

The fraction of radioactive material that is removed from the air due to dry and wet deposition that ends up in edible portions of the harvested plant is referred to as the growing crop retention factor. Specifically, this factor is defined to be the ratio between the amount of a radionuclide present in the crop at harvest and the total amount of material initially deposited onto the land used for producing that crop.

For all crops except pasture, harvesting occurs at the end of the growing season. The harvesting of pasture differs from other crops in that it assumed to be continuous. In MACCS it is assumed that grazing takes exactly one growing season to harvest the year's entire production of the pasture crop. The numerical integration used in the pasture dose calculations is therefore different from that used for the other crop categories. The type of integration performed by the code is determined by the name given to the crop categories. Crop names beginning with PASTURE are treated differently from the rest.

For crops where the edible portion of the plant is exposed to the environment, weathering losses over the period from deposition to harvesting decreases the activity of radionuclides retained as a function of time. That is, the longer the time between deposition and harvesting, the lower the resulting dose.

Crops such as grains and legumes, which have the edible portions internal to the plant, may show the opposite behavior, with material being absorbed into the plant over time. Since this is a slow process and data on translocation rates are hard to obtain, the user should try to define an average retention factor appropriate for deposition onto crops that is independent of time during the growing season, and not use the weathering model for these types of crops. The situation is further complicated by the fact that available data suggest that total retention for grains is greatest when the deposition occurs near the middle of the growing season rather than at the end of it.

Both types of crops are modeled with a weathering equation that can have up to three exponential terms, each with a different weathering rate. For the types of crops not subject to weathering losses (that is, grains and legumes), a very long half-life can be specified for the weathering rate as a way of replacing the weathering function with a constant transfer fraction.

In MACCS the removal of radioactivity from plant surfaces by weathering is treated as a sum of terms that have the following form:

$$\text{CTCOEF} \cdot \exp(-\lambda \cdot t),$$

Where CTCOEF represents the fraction of material deposited on a cultivated field that is removed by weathering with a decay rate of $\lambda = 0.693 / \text{CTHALF}$.

CTCOEF equals the product of two quantities: the interception fraction and the availability fraction. The interception fraction is the fraction of material deposited onto a field that is intercepted by crop surfaces and the availability fraction is the fraction of material deposited onto crop surfaces that remains after weathering, with the half-life CTHALF.

When CTCOEF includes the effects of weathering, as suggested above, the exponential part of the weathering decay expression associated with this empirical value for CTCOEF is reduced to

unity by setting CTHALF to the maximum allowable value, 3.15×10^{13} s (10^6 yr). Because translocation from the plant surface to interior portions influences the retention of radioactivity for grains, legumes, and root crops, the weathering model can be modified to provide a transfer factor that is nearly constant in time.

Since long-term uptake is treated separately from the growing-season portion of the model, this may cause the long-term uptake dose from grains and legumes to be double counted in the first growing season. However, since root uptake in a single season is typically small relative to the contamination resulting from direct deposition, the potential impact of such a double counting is unlikely to be significant.

The number of terms in the weathering equation is defined in on the *Food* tab. Up to three terms are supported.

In the unlikely event of an accident at a nuclear facility, an assessment of the accident's impact on agricultural production in the surrounding region can be performed with MACCS. Based on a projected dose to an individual consuming locally produced food products, the local authorities determine whether local agricultural products are safe to eat. When the food product is judged to be unsafe, two kinds of actions can be taken: disposal of current-year crops and long-term restriction of agricultural production in subsequent growing seasons.

The MACCS food-chain model divides agricultural activities into four components representing two sets of binary pairs:

- MILK DIRECT-DEPOSITION
- CROP DIRECT-DEPOSITION
- MILK ROOT-UPTAKE
- CROP ROOT-UPTAKE

This terminology is defined as follows. MILK refers to fresh milk and dairy products, such as cheese and butter. CROP refers to all other foodstuffs. DIRECT-DEPOSITION refers to doses that result when an accident occurs during the growing season and the doses are incurred in the single annual period following the accident. When an accident occurs outside of the growing season, the code does not evaluate the need for disposal of crops, and the corresponding doses from DIRECT-DEPOSITION are reported as zero. By contrast, ROOT-UPTAKE refers to food doses that result regardless of whether the accident occurs during the growing season, and these are calculated over an infinite period. For accidents that occur during the growing season, first-year doses are from *both* direct-deposition and root-uptake in the MACCS food-chain model.

The stringency (degree of protection) for both types of mitigative actions is specified by the user through input parameters. These parameters are specified in terms of allowable ground concentration and are referred to as "action guides."

3.4.12.2 Food Chain Forms and Parameters

Maximum Food Ingestion Dose Form

The *Maximum Food Ingestion Dose* form is required when the *COMIDA2 Food Model* is selected on the *Food* tab. When it is not acceptable to produce milk or crops, production is interdicted for up to LASTACUM–1 or 8 years, whichever is smaller, until farmability is restored. When the allowed years of interdiction are insufficient to restore farmability, farmland is condemned.

CM2EFF selects the effective organ name to be used with the COMIDA2 food model.

CM2THY selects the lifetime thyroid organ name to be used with the COMIDA2 food model.

DOSEMILK, DOSEOTHR, and DOSELONG are vectors of size two. The first entry corresponds to a limit on effective dose; the second corresponds to a limit on thyroid dose. These parameters define the allowable individual food doses that determine farmability.

DOSEMILK is the maximum allowable food ingestion dose from milk products during the year of the accident. For dairy to be allowed in the first year after an accident, individual milk doses must be below this limit. In addition, second-year individual doses from milk products plus crops must not exceed DOSELONG. DOSEMILK is intended to fulfill a purpose like that served by the parameter PSCMILK of the MACCS food-chain model.

DOSEOTHR is the maximum allowable food ingestion dose from non-milk crops during the year of the accident. For crops to be produced in the first year after an accident, individual doses from consumption of crops must be below this limit. In addition, second-year doses from milk plus crops must not exceed DOSELONG. This parameter is intended to fulfill a purpose like that served by the parameter PSCOTHR of the MACCS food-chain model.

DOSELONG is the maximum allowable "long-term" annual dose to an individual from ingestion of the combination of milk and non-milk crops. These parameter values are used for determining whether agricultural production is suitable for consumption in years after the year of the accident.

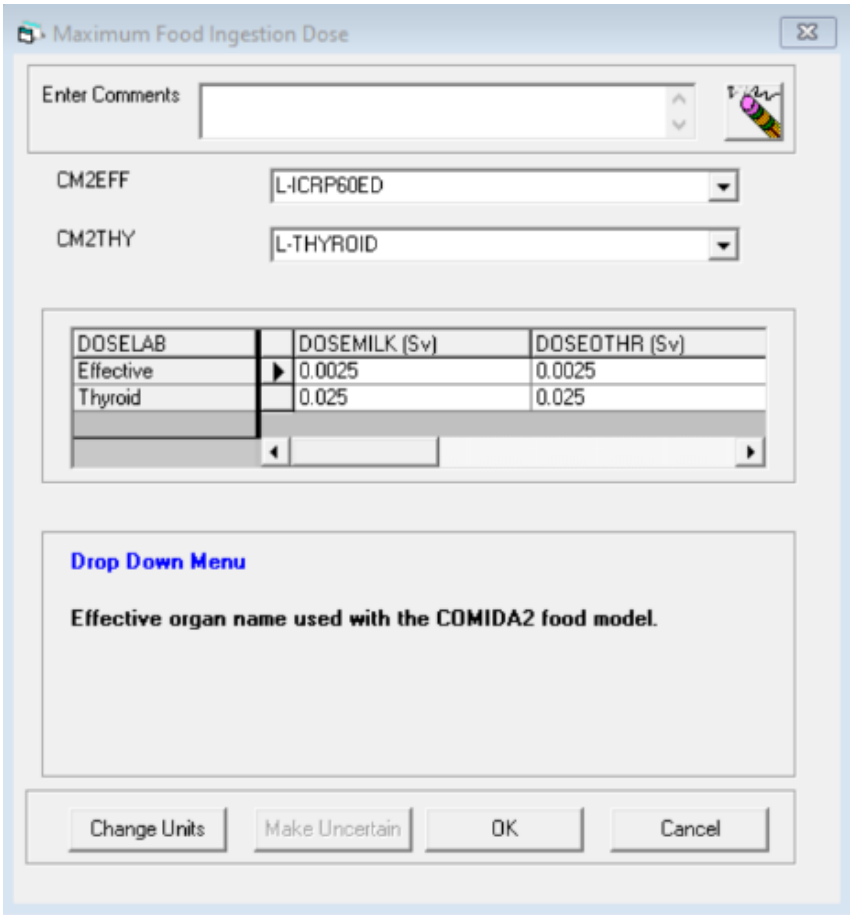


Figure 3-153 Maximum Food Ingestion Dose Form

Table 3-151 Maximum Food Ingestion Dose Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CM2EFF	Yes	Character	None	Based on DCF File
CM2THY	Yes	Character	None	Based on DCF File
DOSEMILK	Yes	Real	2	0.0 to 10^{10} Sv
DOSEOTHR	Yes	Real	2	0.0 to 10^{10} Sv
DOSELONG	Yes	Real	2	0.0 to 10^{10} Sv

Radionuclides Form

The *Radionuclides* form is required when *MACCS Food Model* is selected on the *Food* tab. This model does not account for the food ingestion doses from decay products of the food pathway radionuclides defined in NAMIPI when radioactive decay occurs before consumption. Dose coefficients implicitly account for decay products of a parent radionuclide when the decay occurs after consumption.

NFIISO defines the number of radionuclides for the food-ingestion pathway.

NAMIPI defines the set of radionuclides used in the food-pathway model. This list must include all the radionuclides that are specified for the drinking water pathway, and they must appear in the same order as in NAMWPI.

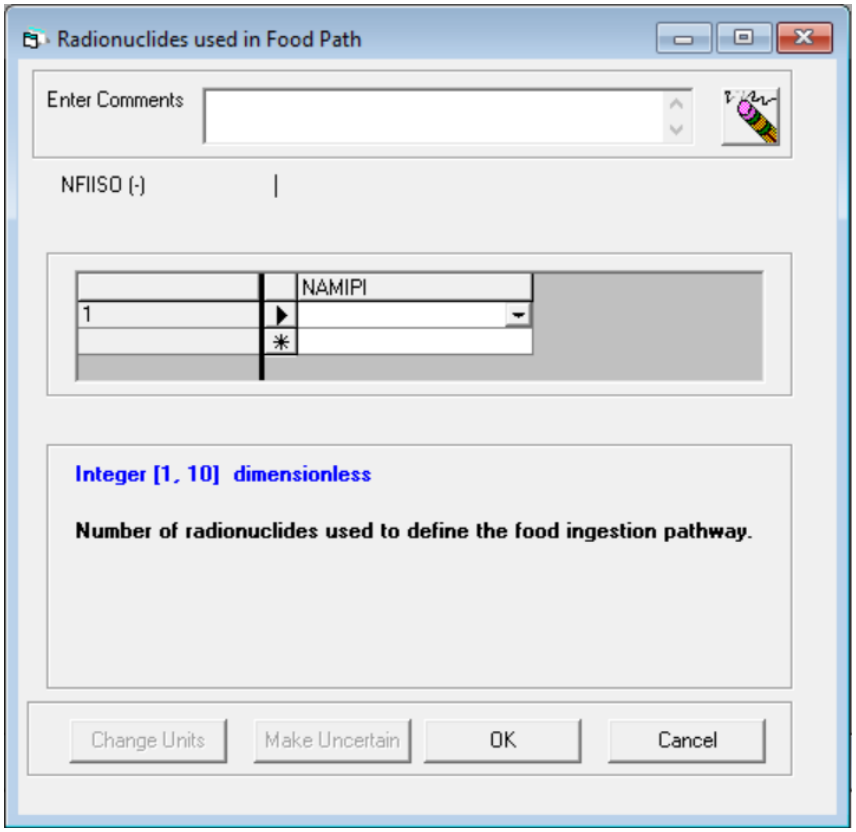


Figure 3-154 Radionuclides used in Food Path Form

Table 3-152 Radionuclides used in Food Path Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NFIISO	Linked	Integer	None	1 to 10
NAMIPI	Yes	Character	NFIISO	Radionuclides defined in ATMOS parameter NUCNAM

Crop Ingestion Form

The *Crop Ingestion* form is required when the *MACCS Food Model* is selected on the *Food* tab.

NFICRP defines the number of crop categories that are used by the food-pathway model.

NAMCRP defines the name of a crop category used in the food-pathway model. MACCS distinguishes between two types of crops: those harvested at the end of the growing season, and those harvested continuously over the entire growing season. The first seven letters of the crop names supplied here are used to distinguish between these two types of crops. When a crop's name begins with 'PASTURE', it is harvested continuously; when it doesn't, it is harvested at the end of the growing season.

FRCTCH specifies the fraction of the edible portion of the harvested crop that is consumed by humans. The user must supply NFICRP values for this parameter in column 2 of the data block.

FRCTCM specifies the fraction of the edible portion of the harvested crop that is consumed by milk-producing animals.

FRCTCB specifies the fraction of the edible portion of the harvested crop that is consumed by meat-producing animals.

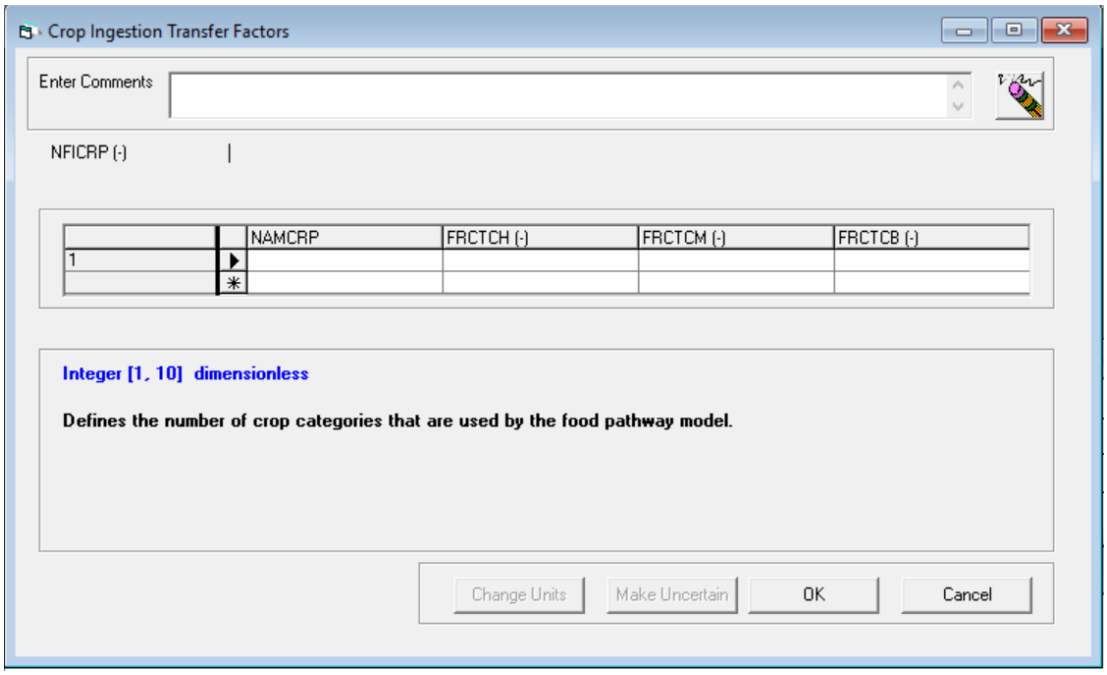


Figure 3-155 Crop Ingestion Form

Table 3-153 Crop Ingestion Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NFICRP	Linked	Integer	None	1 to 10
NAMCRP	Yes	Character	NFICRP	6 to 20 characters
FRCTCH	Yes	Real	NFICRP	0.0 to 1.0
FRCTCM	Yes	Real	NFICRP	0.0 to 1.0
FRCTCB	Yes	Real	NFICRP	0.0 to 1.0

Meat/Milk Ingestion Form

The *Meat/Milk Ingestion* form is required when the *MACCS Food Model* is selected on the *Food* tab.

DCYPMH is the transfer factor describing the processing losses and radioactive decay that occur between the production and the consumption of milk products. Specifically, it is the ratio of the amount of a radionuclide in milk products at the time of consumption to the amount in the milk at the time of its production (milking). The values are multiplied by the values of TFMLK to define the efficiency of the milk-to-man food pathway.

DCYPBH is the transfer factor describing the processing losses and radioactive decay that occur between the production and the consumption of meat products. It is the ratio of the amount of a radionuclide in meat products at the time of consumption to the amount of that radionuclide in the meat at the time of its production (slaughter). The values given here are multiplied by the values given for TFBF in order to define the efficiency of the meat-to-man pathway.

TFMLK is the transfer factor describing how much of a radionuclide ingested by milk-producing animals ends up in milk products at the time of their production (milking). It is the ratio of the amount of a radionuclide in fresh milk to the amount of the radionuclide consumed by milk-producing animals. It accounts for biological transport within the animal as well as radioactive decay. The values are multiplied by the values of DCYPMH to define the efficiency of the milk-to-human food pathway.

TFBF is the transfer factor describing how much of the material ingested by meat-producing animals is in meat products at the time of their production. It is the ratio of the amount of a radionuclide in edible meat at the time of slaughter to the amount of the radionuclide that was consumed by the meat-producing animals. It takes account of biological transport within the animals as well as radioactive decay. The values are multiplied by the values of DCYPBH to define the efficiency of the meat-to-man food pathway.

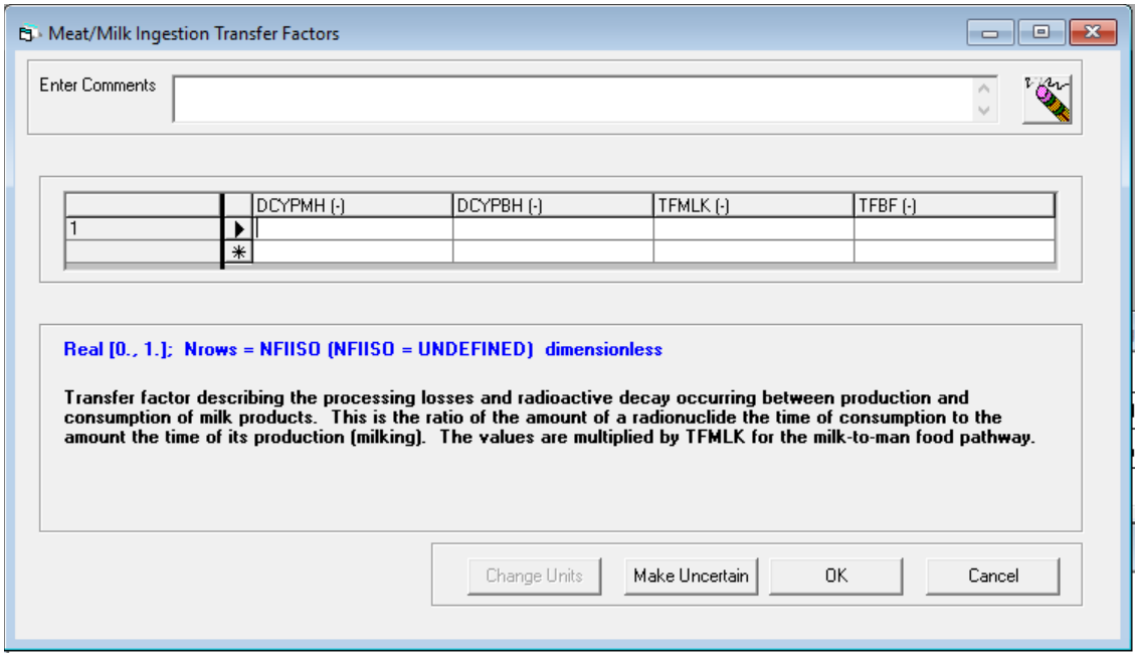


Figure 3-156 Meat/Milk Ingestion Form

Table 3-154 Meat/Milk Ingestion Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DCYPMH	Yes	Real	NFIISO	0.0 to 1.0
DCYPBH	Yes	Real	NFIISO	0.0 to 1.0
TFMLK	Yes	Real	NFIISO	0.0 to 1.0
TFBF	Yes	Real	NFIISO	0.0 to 1.0

Soil to Edible Crops Form

The *Soil to Edible Crops* form is required when *MACCS Food Model* is selected on the *Food* tab.

TCROOT defines the transfer factor for long-term transfer of radionuclides from soil to edible crops. This is the ratio of the amount of a radionuclide taken up from soil into edible portions of a crop to the amount that was deposited onto the soil. The long-term transfer of radionuclides from soil to plants occurs principally by uptake (sorption) by plant root systems. Transfer to plant surfaces by rain up splash and by deposition of materials resuspended from surface soil can also contribute to this pathway.

The values of TCROOT supplied in the data block should be calculated by integrating the overall uptake rate over the period from t=0 to infinity. In other words, TCROOT incorporates the total uptake over time after the initial deposition. Since radionuclides are removed from the soil compartment not only by root uptake but also by radioactive decay, percolation, and irreversible chemical binding, these processes should be incorporated into the derivation of TCROOT.

The annual rate at which the material is made unavailable by these processes is specified by the input parameter QROOT.

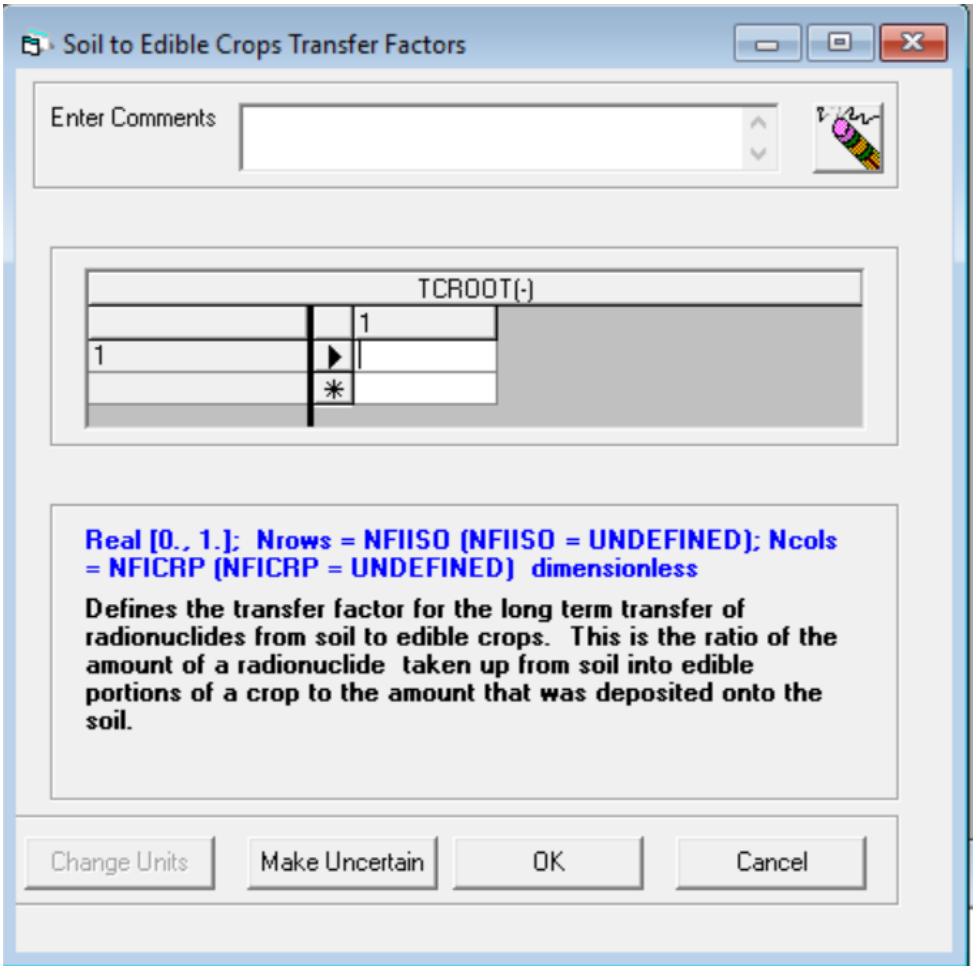


Figure 3-157 Soil to Edible Crops Form

Table 3-155 Soil to Edible Crops Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
TCROOT	Yes	Real	NFIISO by NFICRP	0.0 to 1.0

Crop Radioactive Decay Loss Form

The *Crop Radioactive Decay Loss* form is required when *MACCS Food Model* is selected on the *Food* tab.

DCYPCH is the ratio of the amount of a radionuclide present in a crop at the time of consumption and the time of harvest, accounting for losses due to radioactive decay. The values are used to calculate ingestion doses arising from both direct deposition onto growing crops and the long-term uptake processes of subsequent growing seasons. It is only applied to crops that are directly consumed by humans (e.g., grains, vegetables, and legumes). Values supplied for crops not consumed by humans have no impact on the calculations. The values are multiplied by the corresponding values of FPLSCH, which characterizes processing losses, to obtain the overall transfer factor for this part of the food chain. Values of DCYPCH must be specified for each crop category for all radionuclides treated by the food pathway model (*i.e.,* for all possible radionuclide/crop combinations).

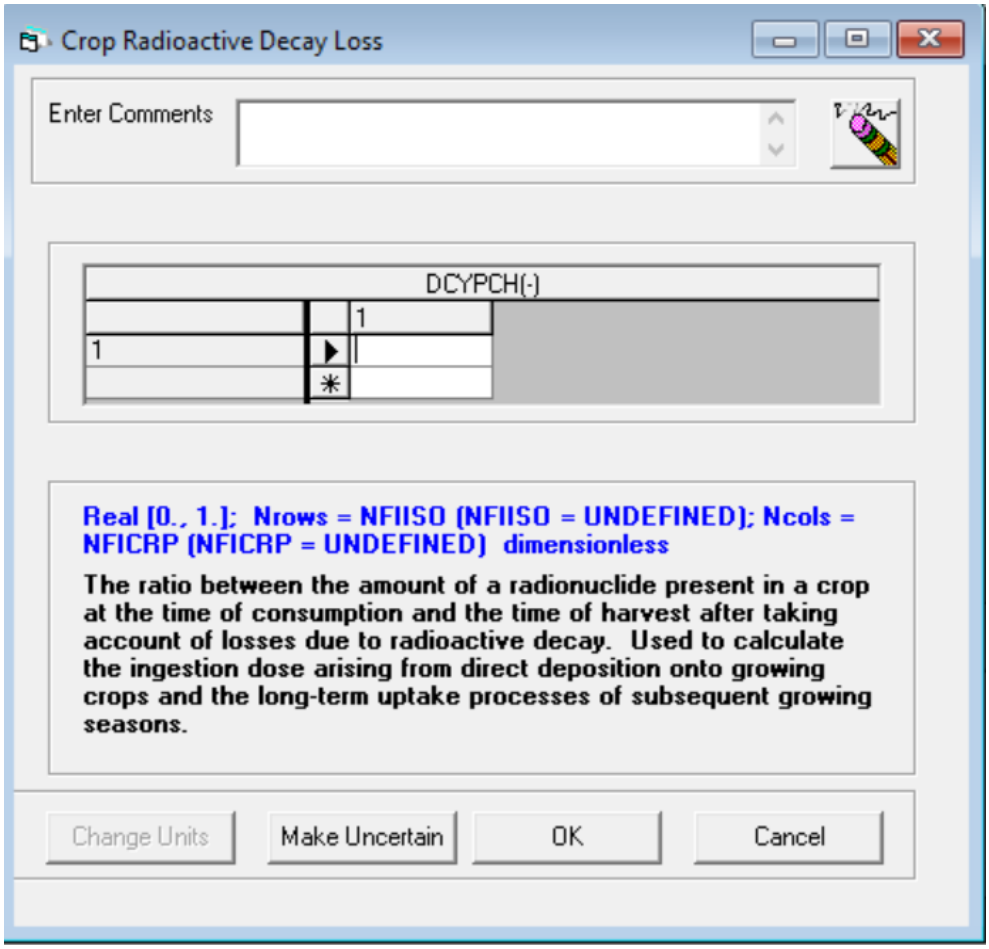


Figure 3-158 Crop Radioactive Decay Loss Form

Table 3-156 Crop Radioactive Decay Loss Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DCYPCH	Yes	Real	NFIISO by NFICRP	0.0 to 1.0

Meat/Milk Radioactive Decay Loss Form

The *Meat/Milk Radioactive Decay Loss* form is required when *MACCS Food Model* is selected on the Food tab.

DCYPCM is the ratio of the amount of a radionuclide in the crop at the time of its consumption to the amount at the time of harvest. The values are used to calculate ingestion dose arising from both direct deposition onto growing crops and the long-term uptake processes of subsequent growing seasons. It is applied only to crops that are directly consumed by milk-producing animals (e.g., pasture and forage). Any values supplied for crops not consumed by milk-producing animals have no impact on the calculations.

For pasture crops, harvest and consumption are simultaneous and so DCYPCM should be set to 1.0 for the pasture crop categories. Values of DCYPCM must be specified for each crop category for all radionuclides treated by the food pathway model (i.e., for all possible radionuclide-crop combinations).

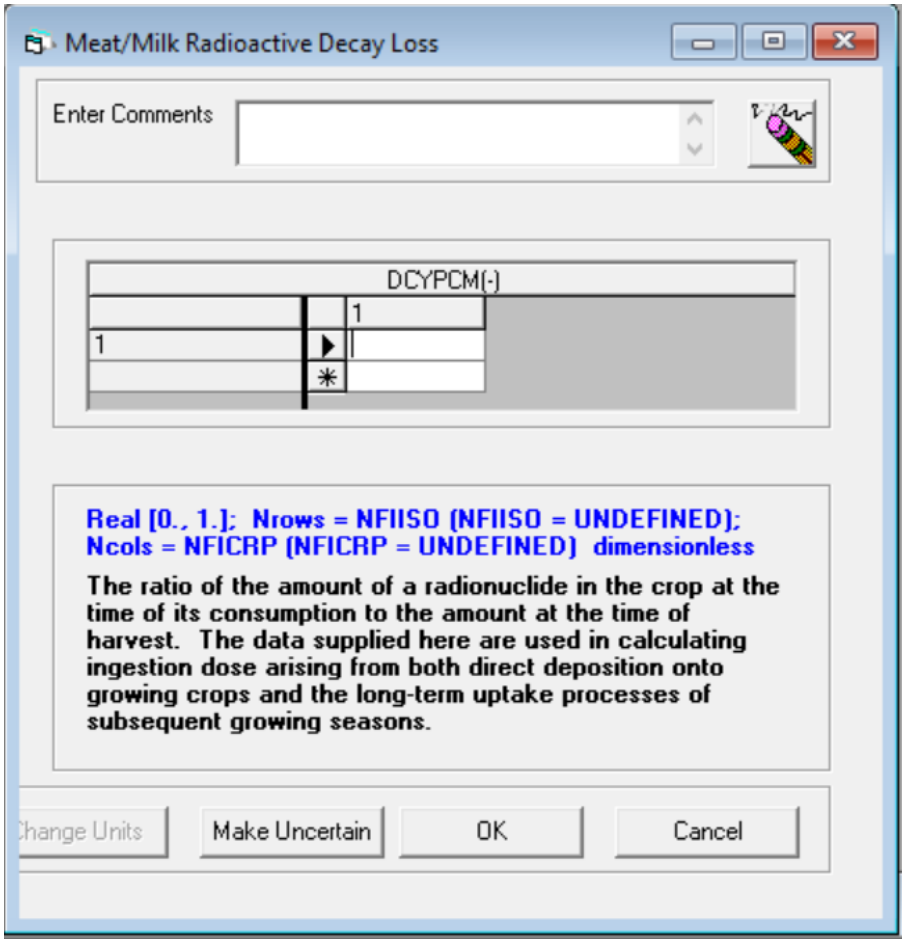


Figure 3-159 Meat/Milk Radioactive Decay Loss Form

Table 3-157 Meat/Milk Radioactive Decay Loss Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DCYPCM	Yes	Real	NFIISO by NFICRP	0.0 to 1.0

Crop Radioactive Retention Form

The *Crop Radioactive Retention* form is required when the *MACCS Food Model* is selected on the *Food* tab.

FPLSCH is the ratio of the amount of a radionuclide in the crop after it has been processed for human consumption to the amount before processing. The retention factor reflects the fraction of radioactive material in the edible portion of the plant that is retained after washing, peeling, or cooking. The values apply only to crops that are directly consumed by humans. Values specified for crops such as pasture have no impact on calculations.

Values of FPLSCH must be specified for each crop category for all radionuclides treated by the food pathway model (i.e., for all possible radionuclide-crop combinations). The values are multiplied with the corresponding values of DCYPCH to obtain the overall transfer factor for this part of the food chain.

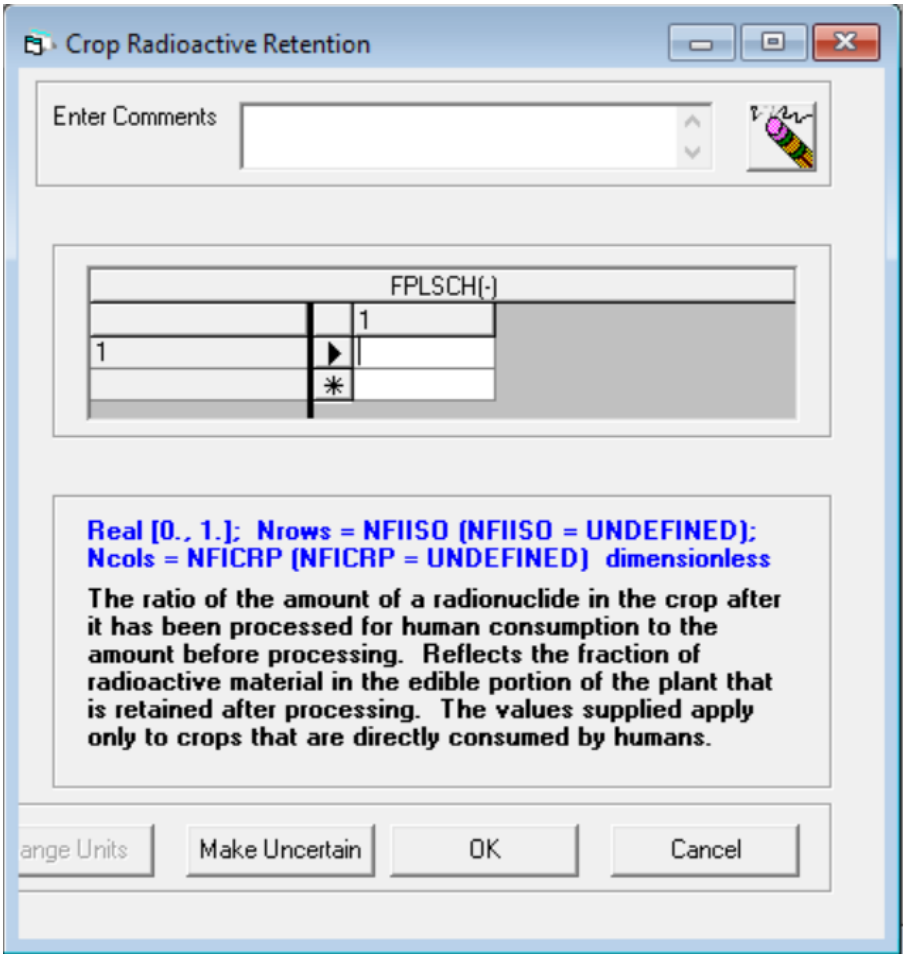


Figure 3-160 Crop Radioactive Retention Form

Table 3-158 Crop Radioactive Retention Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
FPLSCH	Yes	Real	NFIISO by NFICRP	0.0 to 1.0

Meat/Milk Radioactive Retention Form

The *Meat/Milk Radioactive Retention* form is required when *MACCS Food Model* is selected on the *Food tab*.

DCYPCB is the ratio of the amount of a radionuclide in the crop at the time of its consumption to the amount of that radionuclide in the crop at the time of harvest. This factor is only applied to crops that are directly consumed by meat producing animals (e.g. pasture and forage). Values supplied for crops not consumed by meat-producing animals have no impact on the calculations.

Values of DCYPCB must be specified for each crop category for all radionuclides treated by the food pathway model (i.e., for all possible radionuclide-crop combinations).

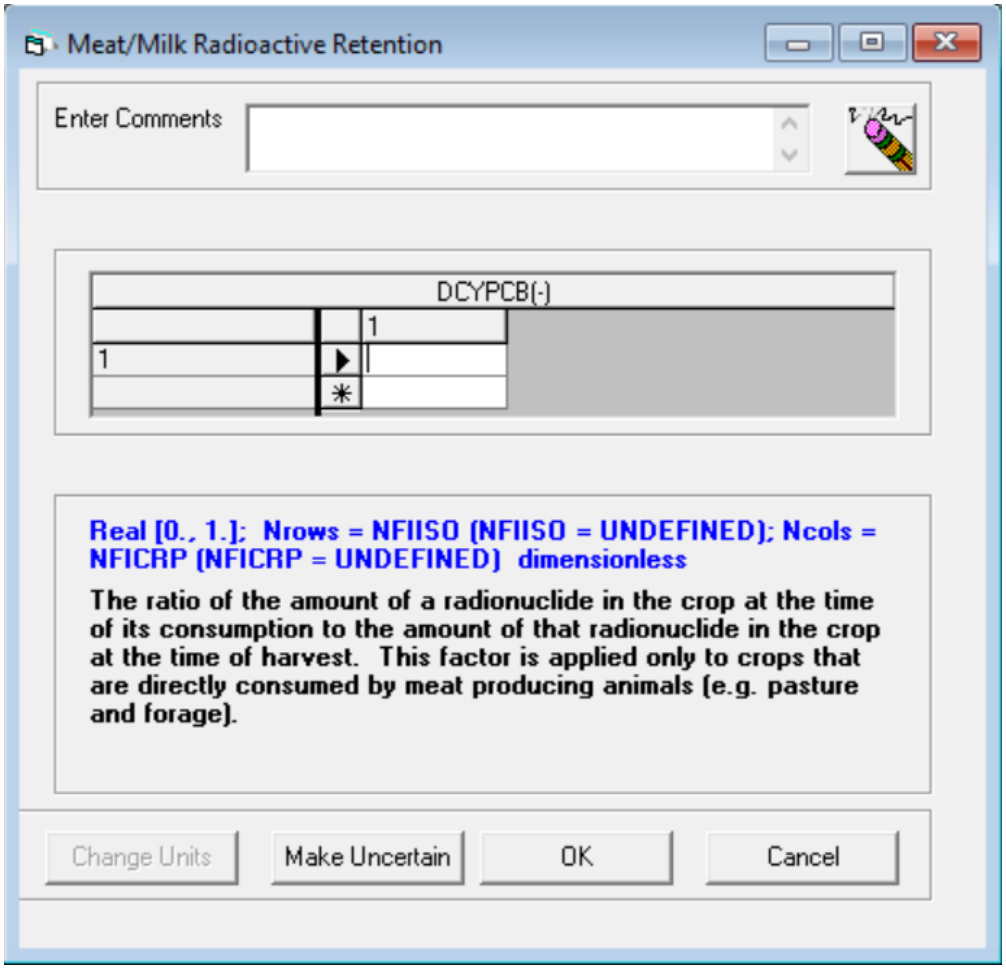


Figure 3-161 Meat/Milk Radioactive Retention Form

Table 3-159 Meat/Milk Radioactive Retention Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
DCYPCB	Yes	Real	NFIISO by NFICRP	0.0 to 1.0

Term One CTCOEF for Weathering Form

The *Term One CTCOEF for Weathering* form is required when *MACCS Food Model* is selected on the *Food tab.*

CTCOEF corresponds to the constant multiplier of the first term in the weathering equation, as described in Subsection 3.4.12.1. This parameter defines the product of the interception fraction and the availability fraction for each term in the weathering model for crops with exposed edible portions. For plants with edible portions internal to the plant, this defines the combined transfer fraction for interception, weathering, and translocation averaged over an entire growing season. Values of CTCOEF must be specified for each crop category and for all radionuclides treated by the food pathway model.

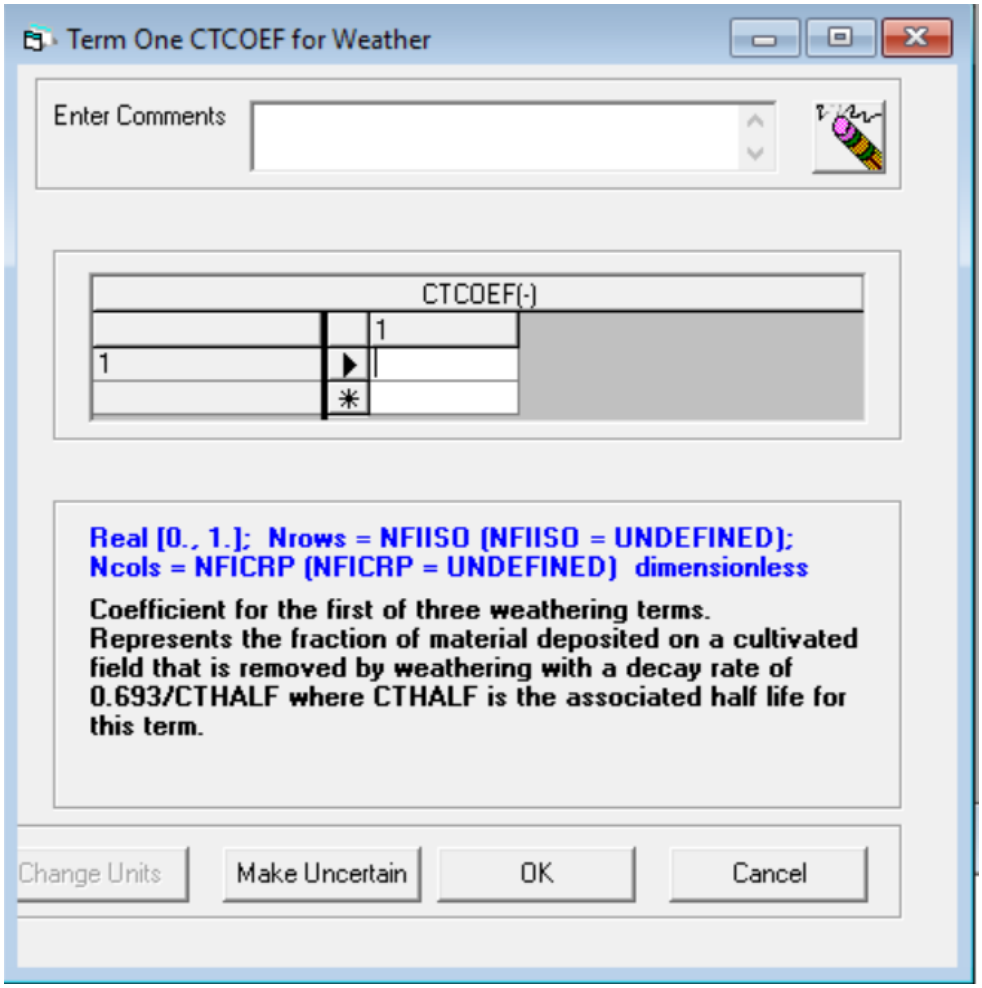


Figure 3-162 Term One CTCOEF for Weather Form

Table 3-160 Term One CTCOEF for Weather Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CTCOEF	Yes	Real	NFIISO by NFICRP	0.0 to 1.0

Term One CTHALF for Weathering Form

The *Term One CTHALF for Weathering* form is required when *MACCS Food Model* is selected on the *Food tab*.

CTHALF corresponds to the half-life value of the first term in the weathering equation, as described in Subsection 3.4.12.1. The values supplied for CTHALF must be properly paired with the corresponding values of CTCOEF defined in the previous form. Values of CTHALF must be specified for each crop category for all radionuclides treated by the food pathway model.

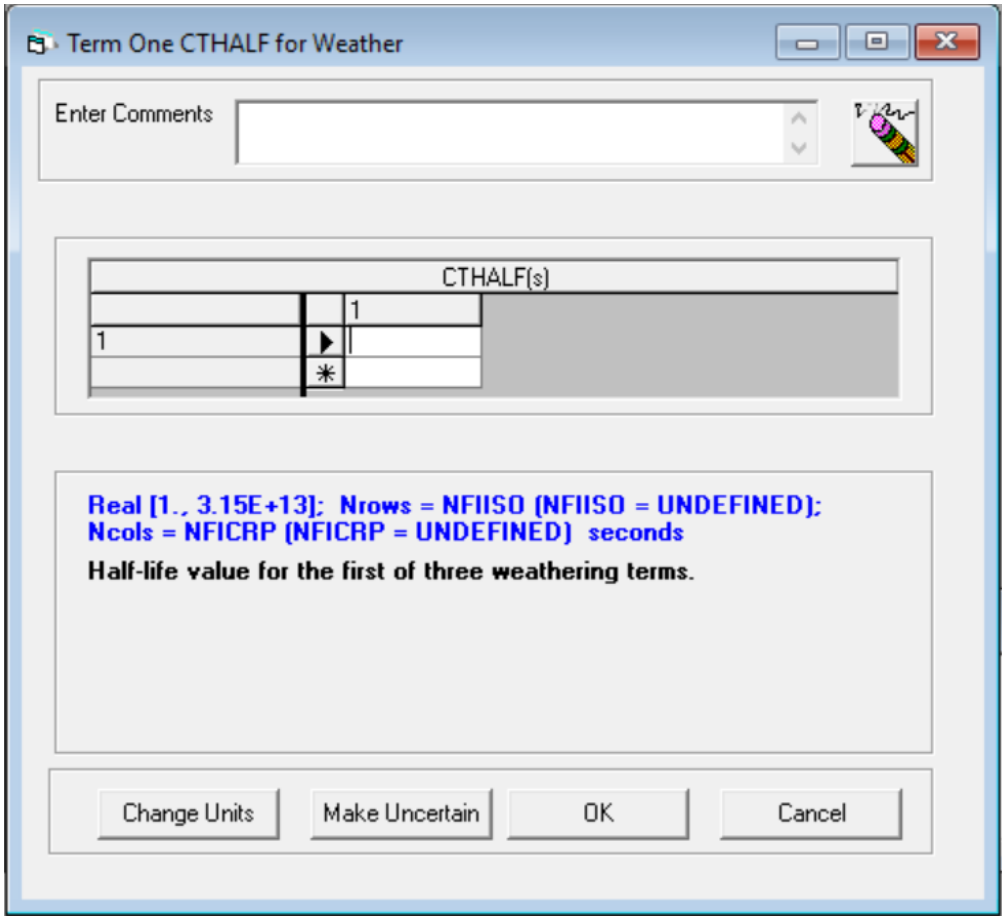


Figure 3-163 Term One CTHALF for Weathering Form

Table 3-161 Term One CTHALF for Weathering Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CTHALF	Yes	Real	NFIISO by NFICRP	1 to 3.15×10^{13} s

Term Two CTCOEF for Weathering Form

The *Term Two CTCOEF for Weathering* form is required when *MACCS Food Model* is selected on the *Food tab* and the *Number of Crop Weathering Terms* is set to *Two Terms* or *Three Terms*.

CTCOEF corresponds to the constant multiplier of the second term in the weathering equation, as described in Subsection 3.4.12.1. It defines the product of the interception fraction and the availability fraction for each term in the weathering model for crops with exposed edible portions. For plants with edible portions internal to the plant, it defines the combined transfer fraction for interception, weathering, and translocation to seeds averaged over an entire growing season. Values of CTCOEF must be specified for each crop category and for all radionuclides treated by the food pathway model.

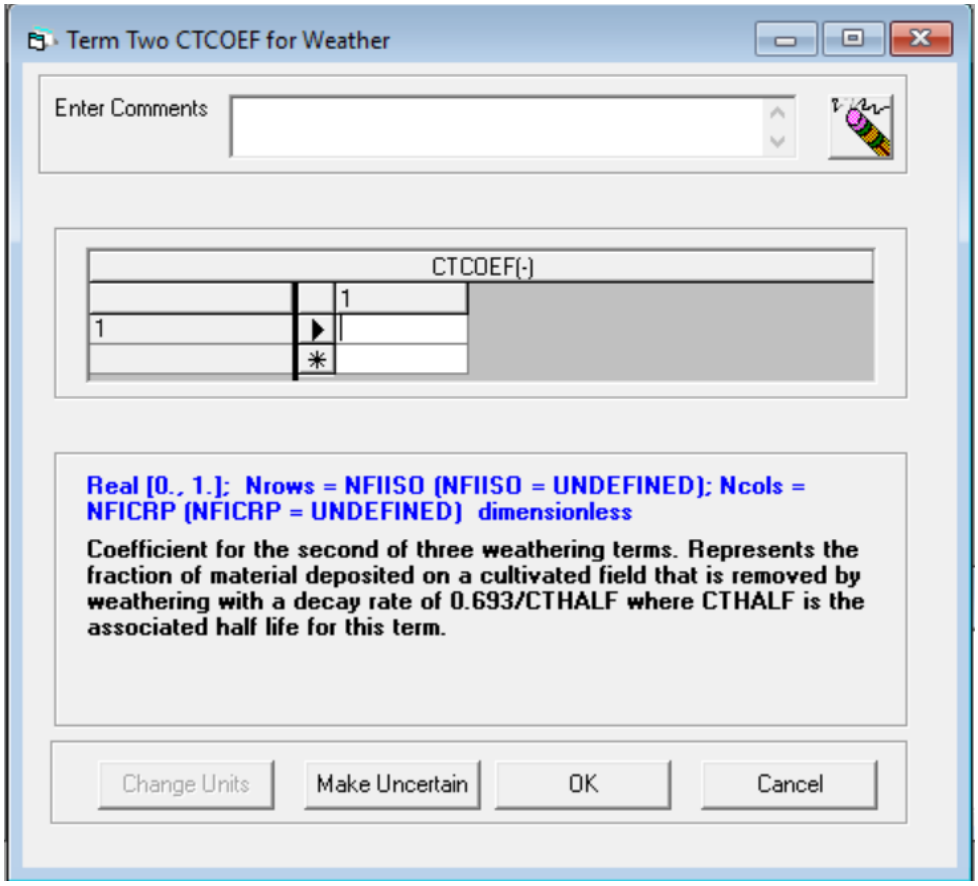


Figure 3-164 Term Two CTCOEF for Weathering Form

Table 3-162 Term Two CTCOEF for Weathering Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CTCOEF	Yes	Real	NFIISO by NFICRP	0.0 to 1.0

Term Two CTHALF for Weathering Form

The *Term Two CTHALF for Weathering* form is required when *MACCS Food Model* is selected on the *Food tab* and the *Number of Crop Weathering Terms* is set to *Two Terms* or *Three Terms.*

CTHALF corresponds to the half-life value of the second term in the weathering equation, as described in Subsection 3.4.12.1. Values must be specified for each crop category for all radionuclides treated by the food pathway model.

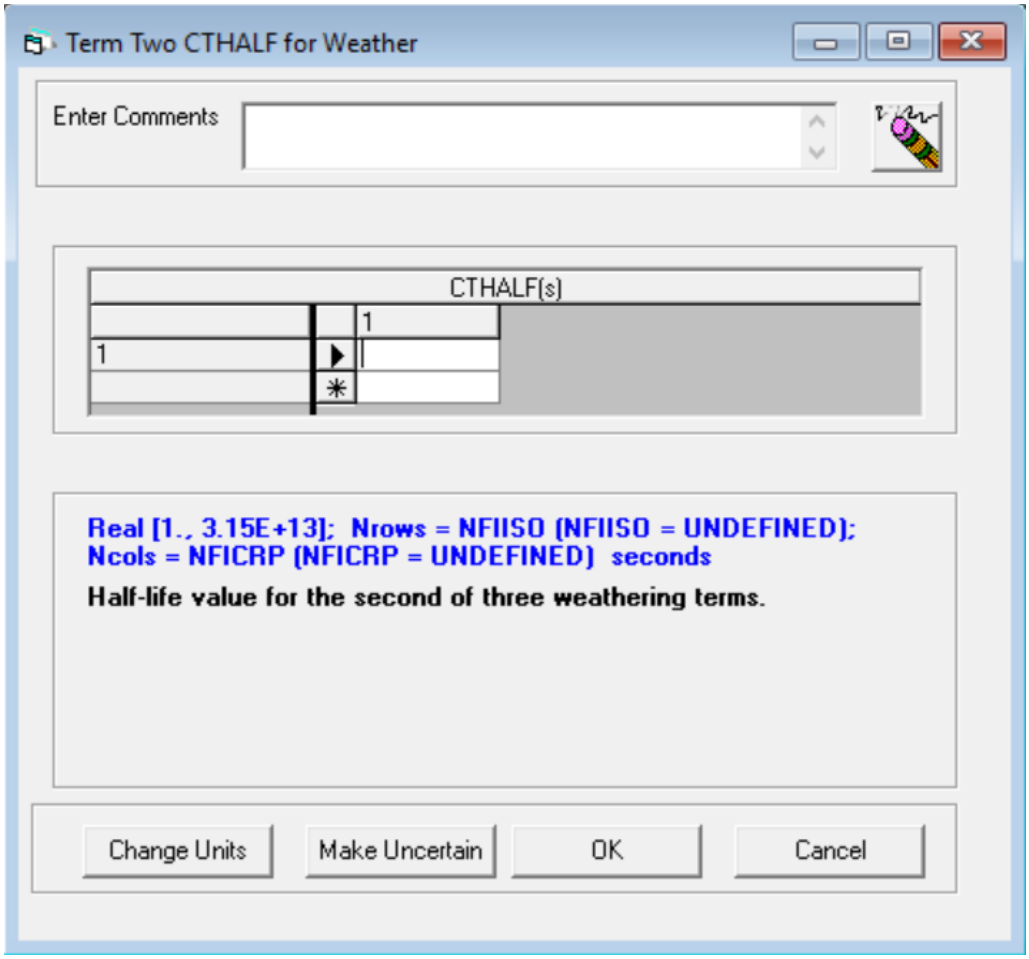


Figure 3-165 Term Two CTHALF for Weathering Form

Table 3-163 Term Two CTHALF for Weathering Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CTHALF	Yes	Real	NFIISO by NFICRP	1.0 to 3.15×10^{13} s

Term Three CTCOEF for Weathering Form

The *Term Three CTCOEF for Weathering* form is required when *MACCS Food Model* is selected on the *Food* tab and the *Number of Crop Weathering Terms* is set to *Three Terms.* In this case, parameter NTTRM is set to three.

CTCOEF corresponds to the constant multiplier of the third term in the weathering equation, as described in Subsection 3.4.12.1 This parameter defines the product of the interception fraction and the availability fraction for each term in the weathering model for crops with exposed edible portions. For plants with edible portions internal to the plant, this defines the combined transfer fraction for interception, weathering, and translocation averaged over an entire growing season.

Values of CTCOEF must be specified for each crop category and for all radionuclides treated by the food pathway model.

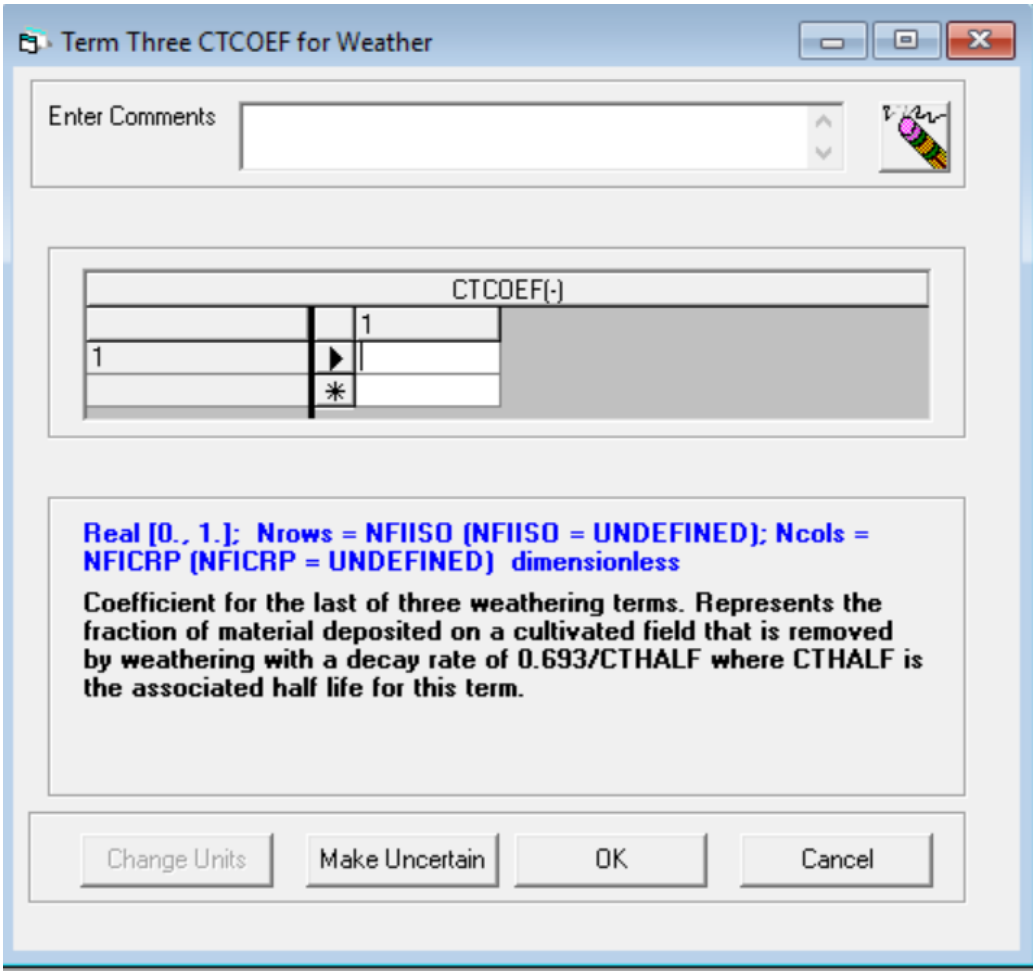


Figure 3-166 Term Three CTCOEF for Weathering Form

Table 3-164 Term Three CTCOEF Weathering Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CTCOEF	Yes	Real	NFIISO by NFICRP	0.0 to 1.0

Term Three CTHALF for Weathering Form

The *Term Three CTHALF for Weathering* form is required when *MACCS Food Model* is selected on the *Food* tab and the *Number of Crop Weathering Terms* is set to *Three Terms.* In this case, parameter NTTRM is set to three.

CTHALF corresponds to the half-life value of the third term in the weathering equation, as described in Subsection 3.4.12.1. The values supplied for CTHALF must be properly paired with the corresponding values of CTCOEF defined in the previous form.

Values of CTHALF must be specified for each crop category for all radionuclides treated by the food pathway model.

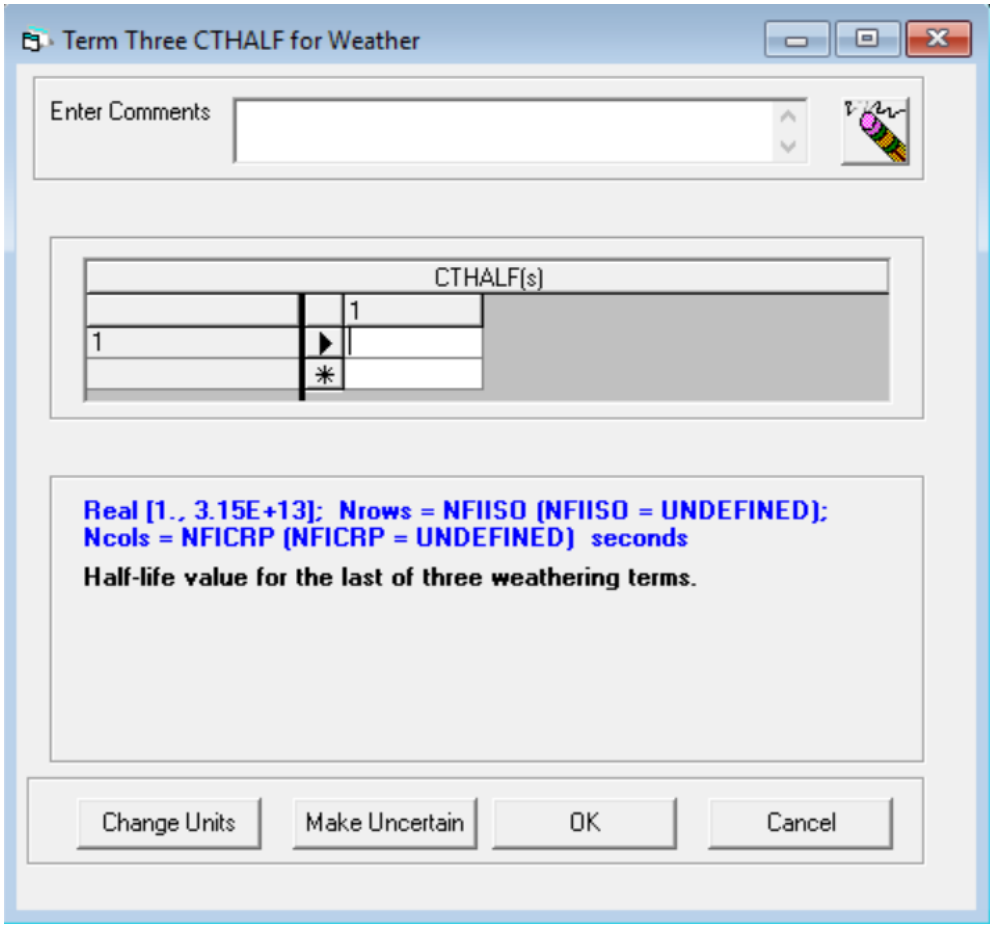


Figure 3-167 Term Three CTHALF for Weathering Form

Table 3-165 Term Three CTHALF for Weathering Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
CTHALF	Yes	Real	NFIISO by NFICRP	1.0 to 3.15×10^{13} s

Crop Share and Growing Season Form

The *Crop Share and Growing Season* form is required when the *MACCS Food Model* is selected on the *Food* tab and the *Site Data Specification* is set to *Uniform* on the *Site Data* tab. Values are taken from the site file when *Import from File* is chosen on the *Site Data* tab.

TSGBEG defines the start of the growing season for the named crop category in terms of Julian day (January 1 is day 1; December 31 is day 365 for a non-leap year).

TGSEND defines the end of the growing season for the named crop category in terms of Julian day.

FRCTFL defines the fraction of cultivated farmland that is used to grow the named crop category.

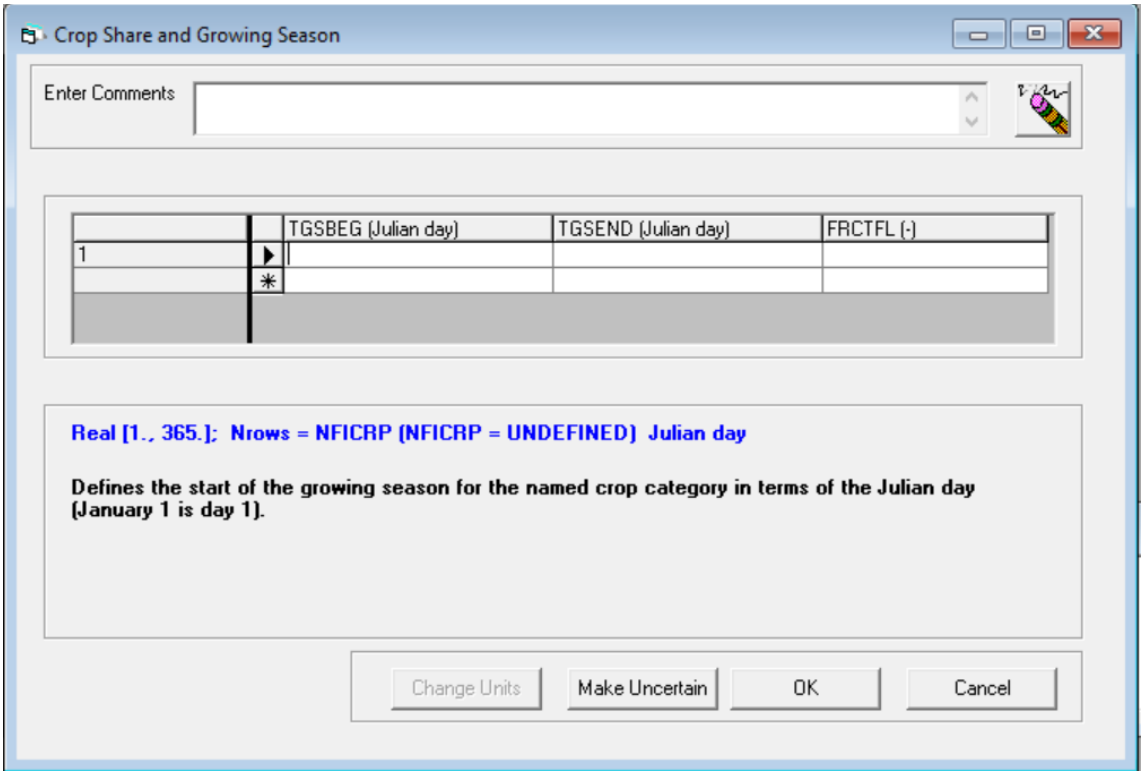


Figure 3-168 Crop Share and Growing Season Form

Table 3-166 Crop Share and Growing Season Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
TGSBEG	Yes	Real	NFICRP	1.0 to 365.0 Julian day
TGSEND	Yes	Real	NFICRP	1.0 to 365.0 Julian day
FRCTFL	Yes	Real	NFICRP	0.0 to 1.0

Protective Action Form

The *Protective Action* form is required when *MACCS Food Model* is selected on the *Food* tab.

For an accident that occurs during the growing season, there are two types of actions that can occur: disposal of milk and its products and disposal of crops other than milk (nonmilk crops). All agricultural production is divided between these two categories. The action levels used for determining when these two actions are necessary are the input parameters PSCMLK and PSCOTH, which are defined below.

When contamination levels are too high, agricultural production is restricted for one or more years after an accident. A single set of values for allowable ground concentration (parameter GCMAXR) is used to make this determination. During the long-term interdiction period, either all crops (both milk and nonmilk) can be produced or no crops can be produced.

For accidents that occur outside the growing season, MACCS, evaluates only the long-term action level (GCMAXR). The growing season action levels, PSCMLK and PSCOTH, are not evaluated since crop disposal can only occur during the growing season. For accidents that occur during the growing season, however, both types of criteria (growing season and long-term) may be

evaluated by the code. It is up to the user to determine whether these two types of evaluations are performed either independently of each other (uncoupled) or in such a way that the exceedance of one type of criteria automatically forces the exceedance of the other criteria (coupled). The choice of these two options is defined by the user-specified input parameter, COUPLD.

When the two types of criteria are chosen to be evaluated independently, there are no interactions between the growing season pathway and the long-term pathway. The resulting doses and economic costs from these two components of the food model are calculated in a completely independent manner.

When the user chooses the option of a coupled evaluation, the following rules define the interactions between two types of actions. Whenever the long-term criteria (GCMAXR) are exceeded, the disposal of any growing crops (both milk and nonmilk) is automatically triggered. Alternatively, whenever both milk and nonmilk crop disposal are called for because of exceeding both the PSCMLK and PSCOTH criteria, the code automatically imposes at least one year of long-term farmland interdiction.

COUPLD defines whether the growing season and the long-term action levels are evaluated in a coupled manner (True) or in a totally independent manner (False).

PSCMLK defines the growing season protective action level (i.e., maximum permissible surface concentration), for milk and milk products for the named radionuclide.

PSCOTH defines the growing season protective action level, maximum permissible surface concentration, for non-milk crops and their products for the named radionuclide.

The long-term uptake fractions for root uptake and soil ingestion by animals have been previously defined by parameter TCROOT. These uptake fractions are integrated over all time, that is, from t=0 to t=infinity. MACCS allows the user to define a model for the temporary interdiction of the long-term uptake pathway when certain ground contamination levels are exceeded at the time of the accident. When this model is activated, and temporary interdiction of long-term uptake is needed, the period of temporary interdiction is the shortest number of whole years that allows the long-term criteria to be met. The longest allowed period of long-term interdiction is 8 years. When 8 years of weathering and radioactive decay are insufficient, the farmland is condemned and permanently removed from production.

GXMAXR defines the protective action level (i.e., maximum permissible surface concentration) for long-term crop production for the named radionuclide. This is the criteria to be met for each ingestion radionuclide.

QROOT defines the rate constant for the decrease in availability over the temporary interdiction period. This value accounts for radioactive decay, irreversible chemical binding to the soil, percolation downward into the soil and uptake into plants or ingestion by animals.

The value assigned to QROOT is used to determine how effective temporary interdiction of the long-term agricultural pathway is for reducing ingestion doses. For example, when the depletion rate is 0.5 per year, a year of temporary interdiction causes the integrated dose to be Exp(–0.5) of what it would be if there were no interdiction.

The *MACCS food model* input parameters PSCMILK, PSCOTH, and GCMAXR are specified in terms of maximum allowable ground concentrations for each food radionuclide. The model sums the ratios of the actual to the maximum concentrations for the set of radionuclides. When this value is greater than 1.0, interdiction is imposed.

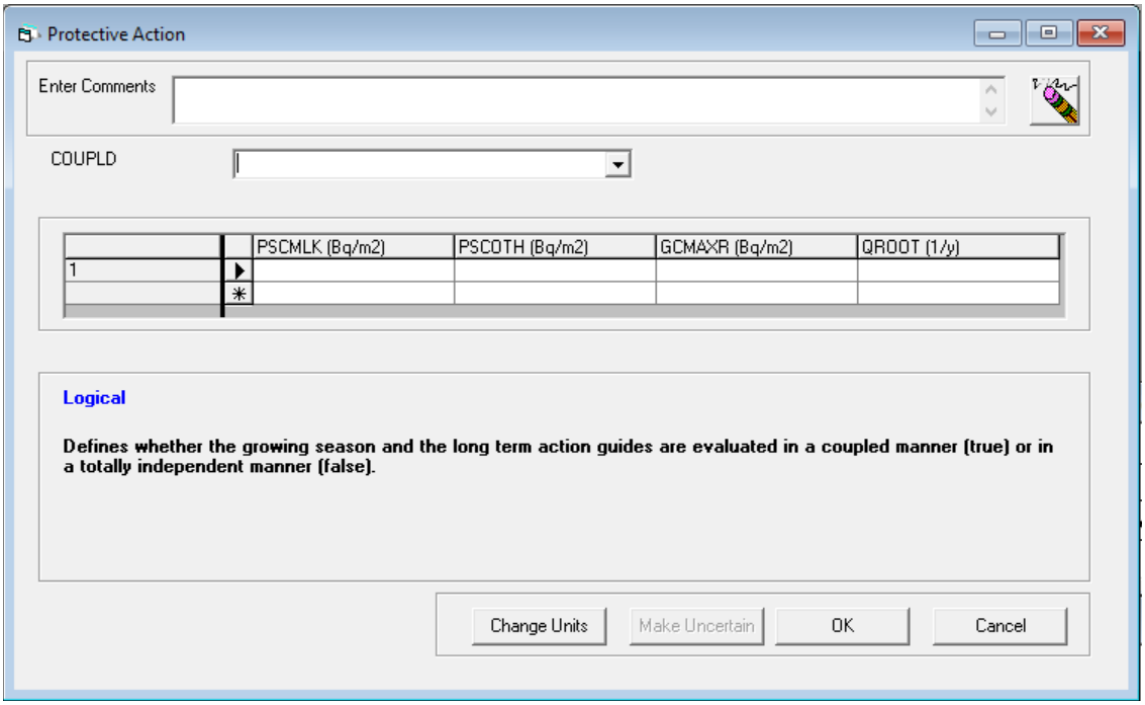


Figure 3-169 Protective Action Form

Table 3-167 Protective Action Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
COUPLD	Yes	Logical	None	True, False
PSCMLK	Yes	Real	NFIISO	10^{-6} to 10^{20} Bq/m^2
PSCOTH	Yes	Real	NFIISO	10^{-6} to 10^{20} Bq/m^2
GXMAXR	Yes	Real	NFIISO	10^{-6} to 10^{35} Bq/m^2
QROOT	Yes	Real	NFIISO	0.0 to 10^{35} yr^{-1}

Water Ingestion Radionuclides Form

The *Water Ingestion Radionuclides* form is required when either *MACCS Food Model* or *COMIDA2 Food Model* is selected on the *Food tab*.

When *Import* from *File* is selected on the *Site Data* tab, the entries on this form must agree with the water ingestion radionuclides specified in the site data file.

NUMWPI defines the number of water ingestion radionuclides. Its value is determined by the number of rows in the grid containing values of NAMWPI.

NAMWPI defines the name of a radionuclide used in the drinking water pathway. The user must supply these nuclides in the same order that they specified in the relevant food-chain model, either MACCS or COMIDA2. Nuclide choices are from parameter NAMIPI when the MACCS food-chain model is used. The choices must be consistent with radionuclides specified by parameter PARENTS when the COMIDA2 food-chain model is used.

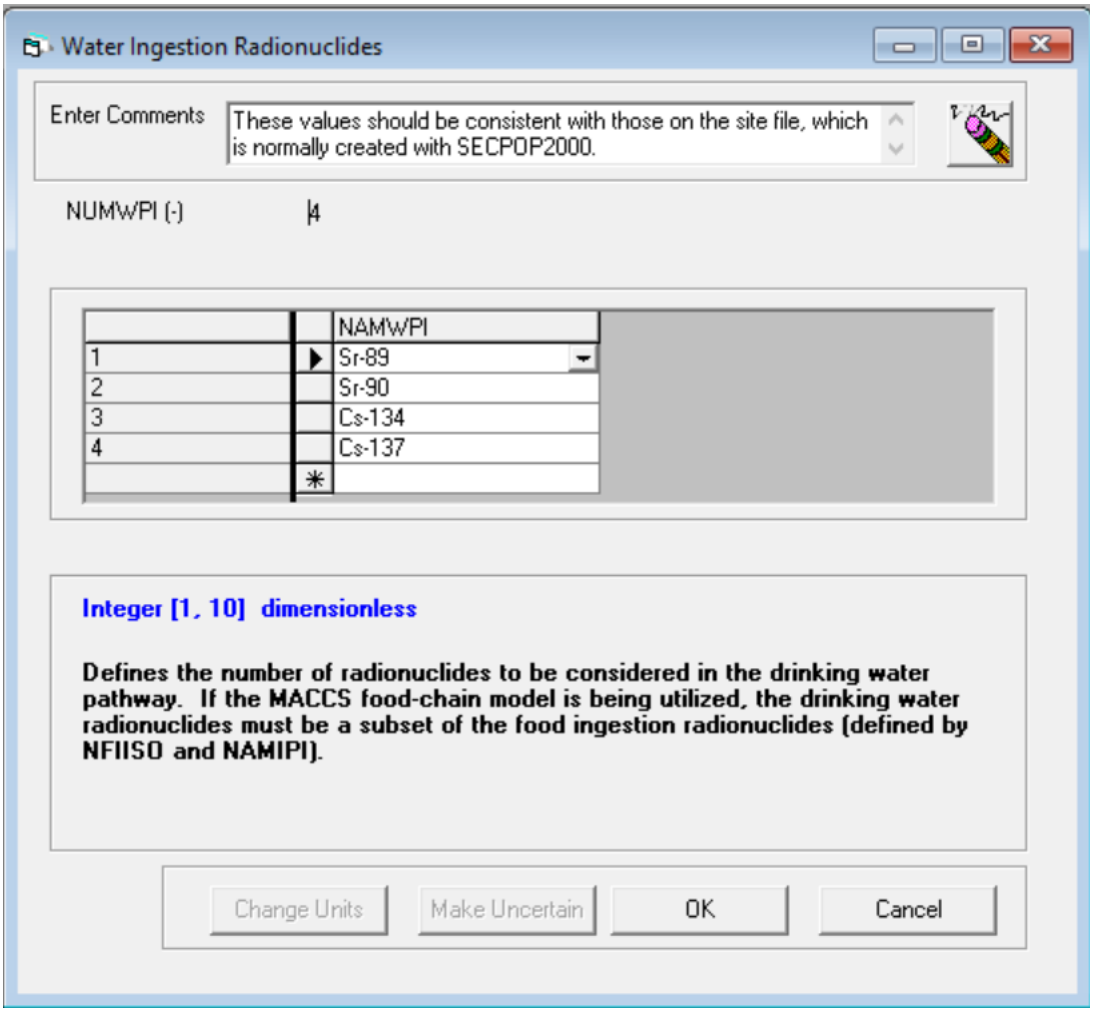


Figure 3-170 Water Ingestion Radionuclides Form

Table 3-168 Water Ingestion Radionuclides Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUMWPI	Linked	Integer	None	1 to 10
NAMWPI	Yes	Character	NUMWPI	Must select a radionuclide defined in NAMIPI

Water Washoff Fraction Form

The *Water Washoff Fraction* form is required when either the *MACCS Food Model* or *COMIDA2 Food Model* is selected on the *Food* tab.

The water-ingestion model does not account for the decay of parents or the buildup of decay products from radioactive decay that occurs between deposition and ingestion.

WSHFRI defines the initial wash-off fraction for the specified radionuclide. This is the fraction of material deposited on land that is easily washed off into the watershed drainage system shortly after the deposition of that radionuclide.

WSHRTA defines the annual wash-off rate for the specified radionuclide. This is the annual rate at which material deposited on land is washed off into the watershed drainage system following the initial deposition.

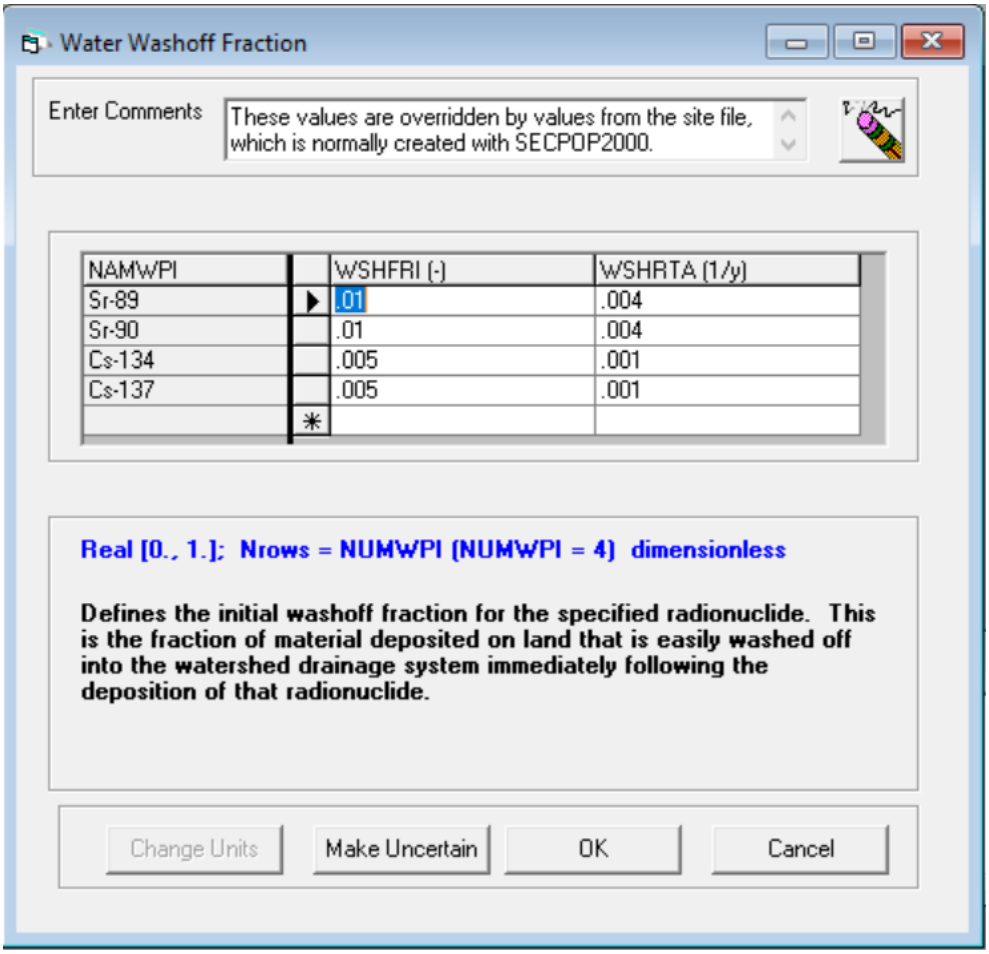


Figure 3-171 Water Washoff Fraction Form

Table 3-169 Water Washoff Fraction Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
WSHFRI	Yes	Real	NUMWPI	0.0 to 1.0
WSHRTA	Yes	Real	NUMWPI	0.0 to 1.0 yr^{-1}

Water Ingestion Factor Form

The *Water Ingestion Factor* form is required when the *MACCS Food Model* or *COMIDA2 Food Model* is selected on the *Food tab* and the *Site Data Specification* is set to *Uniform* on the *Site Data* tab.

WINGF defines the water ingestion factor for the radionuclide. This factor specifies the fraction of the radioactivity washed into the drainage system of the watershed that is ultimately consumed by humans. The values are taken from the site file when one is used.

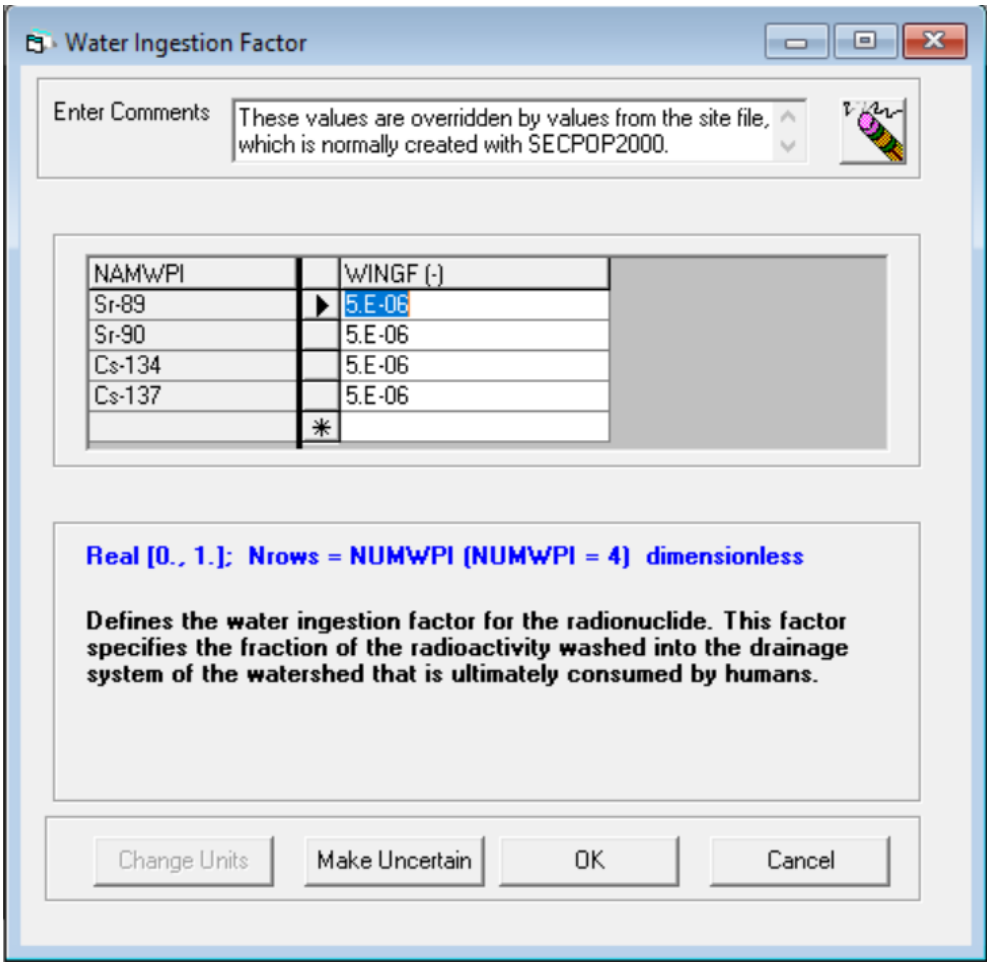


Figure 3-172 Water Ingestion Factor Form

Table 3-170 Water Ingestion Factor Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
WINGF	Yes	Real	NUMWPI	0.0 to 1.0

3.4.13 Output Control

3.4.13.1 Output Control Forms and Parameters

***Debug Flag* Form**

The *Debug Flag* form is required. This flag allows the user to print a detailed listing of values for intermediate parameters used in CHRONC calculations. The results for this option are written to the output file. Most of the parameters are CHRONC internal variables. Thus, this output may be more useful to MACCS developers than to a user.

KSWTCH is used to print intermediate results on the output listing. This parameter should be set to 0 for normal calculations. Because setting this parameter to 1 generates a large amount of output, it is usually preferable to use this option for single weather trial runs.

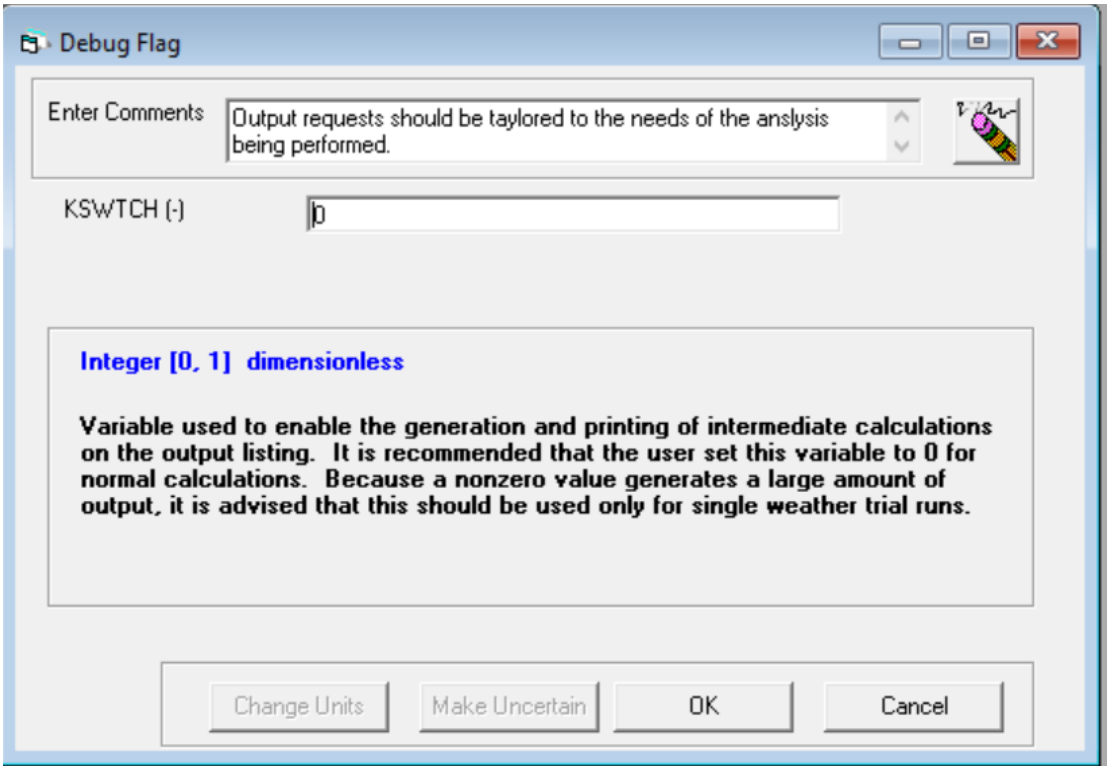


Figure 3-173 Debug Flag Form

Table 3-171 Debug Flag Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
KSWTCH	Yes	Integer	None	0 or 1

Population Dose Results Form

The *Population Dose Results* form is optional.

The CHRONC module calculates long-term population dose broken down by pathway for a list of organs defined in the EARLY input file. This result type has no counterpart in the EARLY module. The EARLY module does not allow for population dose to be broken down by exposure pathway.

No long-term population dose results for an organ are produced in the output listing unless the user requests it. Each request for the breakdown of long-term population dose to an organ produces a block of either 12 or 15 dose results (depending on which food-chain model is being used), as identified below. All the dose results are reported in person-Sv by default, although the units are listed simply as Sieverts (Sv) in the output file. The following dose results are reported:

- TOTAL LONG-TERM PATHWAYS DOSE—total long-term population dose from groundshine and resuspension, from the consumption of contaminated food, from the ingestion of contaminated surface water, and from decontamination work.

- LONG-TERM DIRECT EXPOSURE PATHWAYS—total long-term population dose to resident population from groundshine and inhalation of resuspended aerosols.

- TOTAL INGESTION PATHWAYS DOSE—total long-term population dose from the consumption of contaminated dairy products, contaminated nondairy products, and contaminated water.

- LONG-TERM GROUNDSHINE DOSE—total long-term population dose received by resident population from groundshine.

- LONG-TERM RESUSPENSION DOSE—total long-term population dose received by resident population from inhalation of resuspended aerosols.

- POP-DEPENDENT DECONTAMINATION DOSE—total long-term population dose received by groundshine to workers performing "population dependent" (nonfarm) decontamination (decontamination workers receive no inhalation dose).

- FARM-DEPENDENT DECONTAMINATION DOSE—total long-term population dose received from groundshine by workers performing farm-dependent (farmland) decontamination (decontamination workers receive no inhalation dose).

- WATER INGESTION DOSE—total long-term population dose from ingestion of contaminated surface water.

When the MACCS food-chain model is used, the following food pathway results are reported:

- MILK GROWING SEASON DOSE—total long-term population dose resulting from consumption of milk and dairy products contaminated because of deposition onto crops during the growing season.

- CROP GROWING SEASON DOSE—total long-term population dose resulting from consumption of nonmilk food products contaminated because of deposition onto crops during the growing season.

- MILK LONG-TERM DOSE—total long-term population dose resulting from consumption of milk and dairy products contaminated by long-term uptake during the entire period following the accident.

- CROP LONG-TERM DOSE—total long-term population dose resulting from consumption of nondairy crops and their products contaminated by long-term uptake during the entire period following the accident.

When the COMIDA2 food-chain model is used, the following food pathway results are reported:

- INGESTION OF GRAINS—total long-term population dose resulting from consumption of grains by humans.

- INGESTION OF LEAF VEG—total long-term population dose resulting from consumption of leafy vegetables by humans.

- INGESTION OF ROOT CROPS—total long-term population dose resulting from consumption of root crops by humans.

- INGESTION OF FRUITS—total long-term population dose resulting from consumption of fruits by humans.

- INGESTION OF LEGUMES—total long-term population dose resulting from consumption of legumes by humans.

- INGESTION OF BEEF—total long-term population dose resulting from consumption of beef by humans.

- INGESTION OF MILK—total long-term population dose resulting from consumption of milk by humans.

- INGESTION OF POULTRY—total long-term population dose resulting from consumption of poultry by humans.

- INGESTION OF OTHER MEAT CROPS—total long-term population dose resulting from consumption of other meat crops by humans.

The region of interest is used to determine the size of the potentially contaminated area being evaluated. In the context of this consequence measure, the population dose within a region is the population dose that occurs because of activity deposited within the region. For groundshine and resuspension inhalation, the dose is received by the resident population, but for ingestion and doses to decontamination workers, the dose could be received by individuals who reside elsewhere.

NXUM9 specifies the number of results. Its value is determined by the number of rows in the grid containing vectors ORGNAM, IX1DS9, IX2DS9, and Report Options.

ORGNAM defines the name of the organ for which the long-term dose breakdown is to be reported. The possible values depend on the DCF file chosen.

IX1DS9 defines the inner spatial interval of the region of interest. The location is the inner radius of the specified ring.

IX2DS9 defines the outer spatial interval of the region of interest. The location is the outer radius of the specified ring. MACCS requires that the value must be greater than or equal to IX1DS9.

Report Options determine whether CCDF data are written to the MACCS output file and whether the data are included in the summary report.

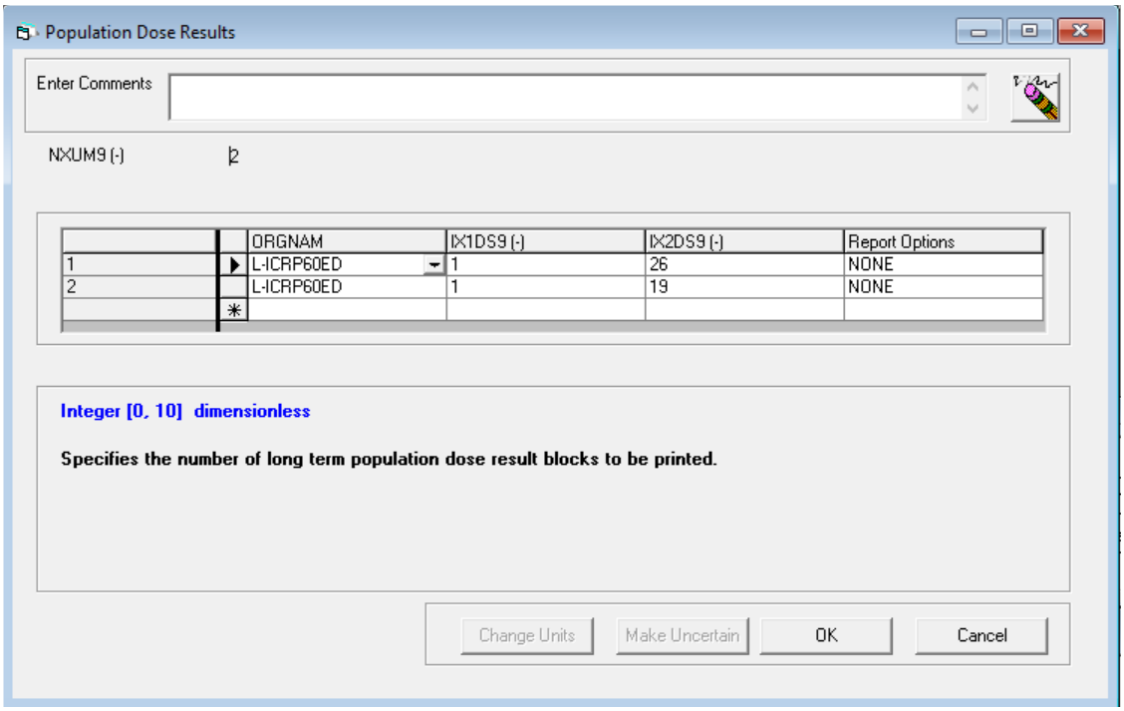


Figure 3-174 Population Dose Results Form

Table 3-172 Population Dose Results Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NXUM9	Linked	Integer	None	0 to 999
ORGNAM	Yes	Character	NXUM9	Long Term Organ name specified in EARLY
IX1DS9	Yes	Integer	NXUM9	1 to NUMRAD
IX2DS9	Yes	Integer	NXUM9	1 to NUMRAD
Report Options	Yes	Character	NXUM9	CCDF, NONE, REPORT, CCDF & REPORT

Economic Cost Results Form

The *Economic Cost Results* form is optional. The CHRONC module calculates the economic costs of all the long-term protective actions as well as the cost of the emergency response actions that were modeled by EARLY.

No economic costs are printed unless the user specifically requests them. When Flag10 is set to true, each request for economic results produces the block of 13 economic results described below. All the economic cost measures are reported in dollars.

- TOTAL ECONOMIC COSTS—the sum of population- and farm-dependent costs
- POP-DEPENDENT COSTS—the sum of population-dependent decontamination, interdiction, and condemnation costs
- FARM-DEPENDENT COSTS—the sum of farm-dependent decontamination, interdiction, and condemnation costs as well as milk and crop disposal costs

- POP-DEPENDENT DECONTAMINATION COST—decontamination cost of nonfarm property (*i.e.,* property associated with resident population)

- FARM-DEPENDENT DECONTAMINATION COST—decontamination cost of farm property

- POP-DEPENDENT INTERDICTION COST—depreciation and loss of use of nonfarm property during both decontamination and extended interdiction plus a one-time cost to relocate the population (see POPCST in Section 3.4)

- FARM-DEPENDENT INTERDICTION COST—depreciation and loss of use of farm property during both periods of decontamination and interdiction

- POP-DEPENDENT CONDEMNATION COST—compensation paid for permanent loss of nonfarm property plus a one-time cost to relocate the population

- FARM-DEPENDENT CONDEMNATION COST—compensation paid for permanent loss of farm property because it was not returned to production within 8 years of the accident

- EMERGENCY PHASE COSTS—per-diem costs to compensate people for being away from home due to evacuation and relocation during the emergency phase

- INTERMEDIATE PHASE COSTS—per-diem costs to compensate people for being away from home due to relocation for the duration of the intermediate phase when the projected dose exceeds DSCRTI.

- MILK DISPOSAL COSTS—compensation for lost milk sales during a quarter of a year when the first year's crops require disposal. This cost is incurred when the accident occurs during the growing season *and* any of the following conditions occur: the growing-season milk action guide is exceeded, or any decontamination actions are required, or (for MACCS food model only) when COUPLD=.TRUE. and any long-term interdiction is required.

- CROP DISPOSAL COSTS—compensation for lost nonmilk crop sales during a full year. This cost is incurred when the accident occurs during the growing season and any of the following conditions are found: the growing-season nonmilk action guide is exceeded, or any decontamination actions are required, or (for MACCS food model only) when COUPLD=.TRUE. *and* any long-term interdiction is required.

NXUM10 specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors I1DS10, I2DS10, and Report Options.

I1DS10 defines the inner spatial interval of the region of interest. The boundary is the inner radius of the specified ring.

I2DS10 defines the outer spatial interval of the region of interest. The boundary is the outer radius of the specified ring. MACCS requires that the value must be greater than or equal to I1DS10.

FLAG10 equal to true extends the output to include an expanded breakdown of costs.

Report Options determine whether CCDF results are written to the MACCS output file, and whether the results are to be included in the WinMACCS summary report.

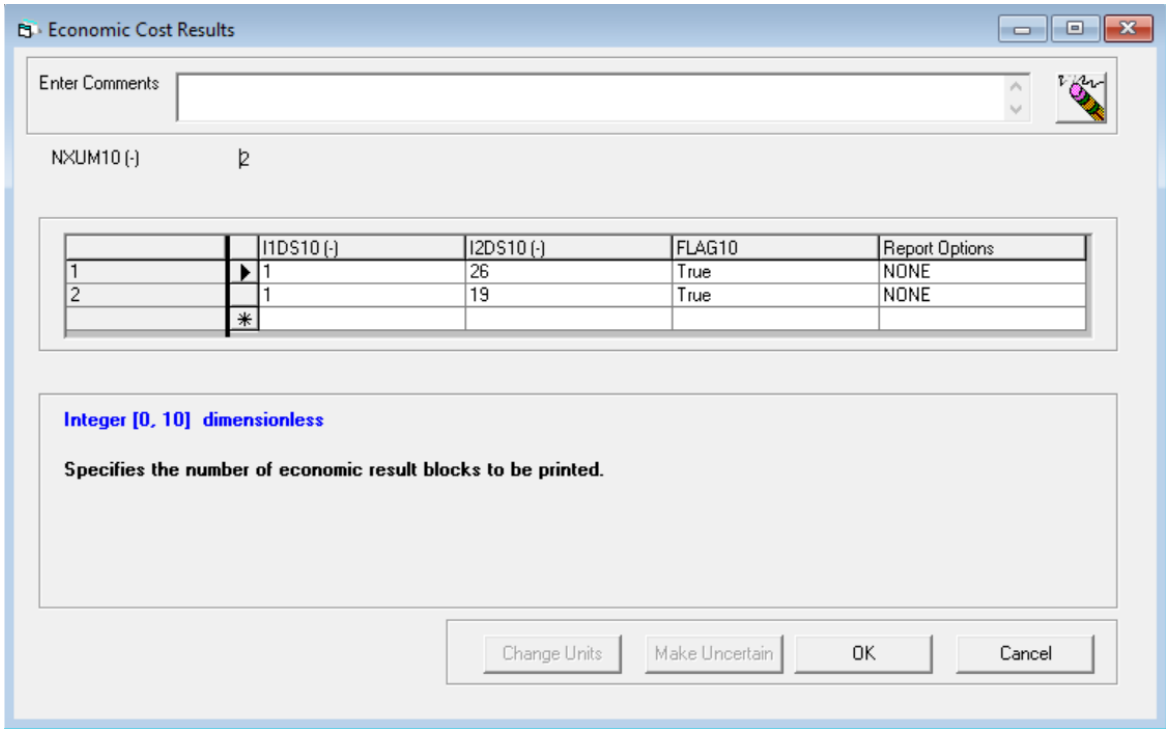


Figure 3-175 Economic Cost Results Form

Table 3-173 Economic Cost Results Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NXUM10	Linked	Integer	None	0 to 999
I1DS10	Yes	Integer	NXUM10	1 to NUMRAD
I2DS10	Yes	Integer	NXUM10	1 to NUMRAD
FLAG10	Yes	Logical	NXUM10	True, False
Report Options	Yes	Character	NXUM10	CCDF, NONE, REPORT, CCDF & REPORT

Action Distance Results Form

The *Action Distance Results* form is required when the *MACCS Food Model* or *COMIDA2 Food Model* is selected on the *Food* tab.

The long-term protective actions that result from the calculations of the CHRONC module depend on the data supplied by the user. Associated with the long-term actions of decontamination, interdiction, and crop disposal are the maximum distances to which these actions are implemented.

The option to print these long-term action distances is controlled by a flag specified by the user. When FLAG11 is set to true, MACCS produces the eight maximum action distance results that are described below. Each result is identified by the result name used on the output file along with a description of the result.

- FARM-DEPENDENT DECONTAMINATION DIST.—distance to which farmland decontamination is required.
- POP-DEPENDENT DECONTAMINATION DIST.—distance to which non-farmland decontamination is required.
- FARM-DEPENDENT INTERDICTION DIST.—distance to which farmland interdiction is required.
- POP-DEPENDENT INTERDICTION DIST.—distance to which non-farmland interdiction is required.
- FARM-DEPENDENT CONDEMNATION DIST.—distance to which farmland condemnation is required.
- POP-DEPENDENT CONDEMNATION DIST.—distance to which non-farmland condemnation is required.
- MILK DISPOSAL DIST.— distance to which milk disposal is required.
- CROP DISPOSAL DIST.— distance to which crop disposal is required.

FLAG11 set to true indicates that the output file includes maximum action distances.

The value chosen for Report Options determines whether CCDF values are written to the MACCS output file and whether they are included in the WinMACCS report generated after simulations are complete.

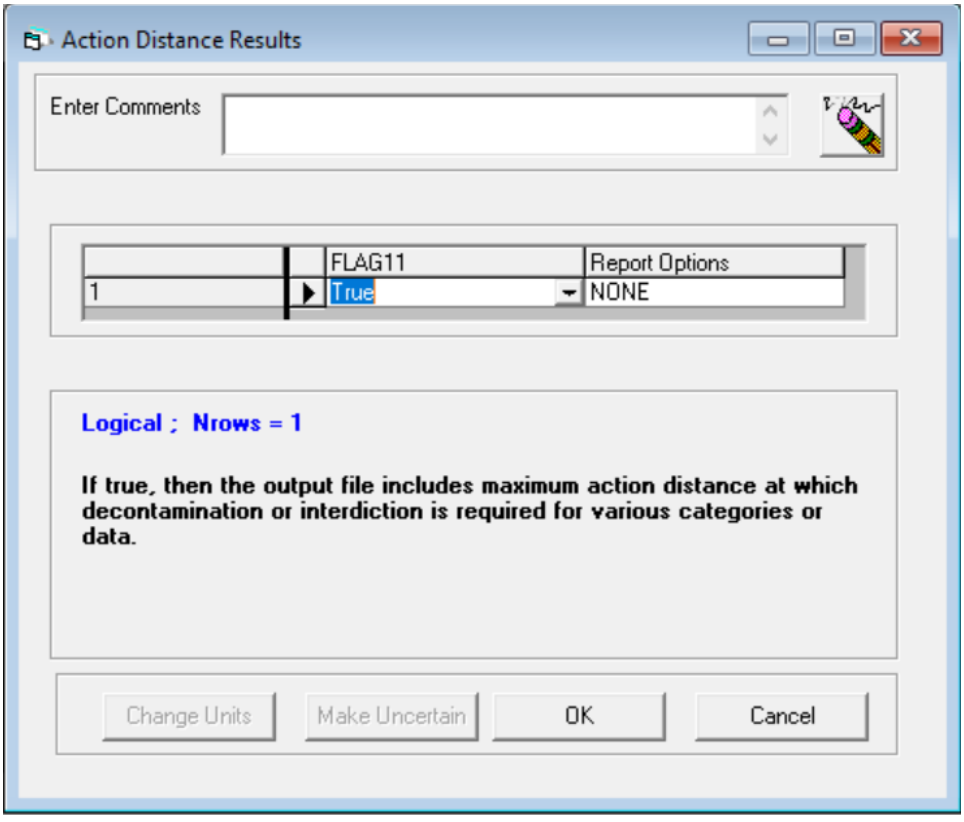


Figure 3-176 Action Distance Results Form

Table 3-174 Action Distance Results Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
FLAG11	Yes	Logical	1	True, False
Report Options	Yes	Character	1	CCDF, NONE, REPORT, CCDF & REPORT

Impacted Area/Population Results Form

The *Impacted Area/Population Results* form is optional when *MACCS Food Model* or *COMIDA2 Food Model* is selected on the *Food* tab. Associated with the long-term actions of decontamination, interdiction, condemnation, and crop disposal are the areas and populations that are affected by these actions. The option to print these impacted area/population results is controlled by the user.

Each request for impacted farm-area/population results produces the block of eight results described as follows:

- FARM DECONTAMINATION (ha)—farmland area that requires decontamination
- POP. DECONTAMINATION (INDIVIDUALS)—population of areas that require decontamination of nonfarm property
- POP. DECONTAMINATION AREA (ha)—land area of nonfarm property requiring decontamination
- FARM INTERDICTION (ha)—farmland area that requires interdiction
- POP. INTERDICTION (INDIVIDUALS)—population of areas that require interdiction
- POP. INTERDICTION AREA (ha)— area of nonfarm property requiring interdiction
- FARM CONDEMNATION (HECTARES)— farmland area that requires condemnation
- POP. CONDEMNATION (INDIVIDUALS)—population of areas that require condemnation
- POP. CONDEMNATION AREA (ha)—area requiring condemnation of nonfarm property
- MILK DISPOSAL AREA (ha)—area requiring milk disposal
- CROP DISPOSAL AREA (ha)—area requiring crop disposal

NUM12 specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors I1DS12, I2DS12, and Report Options.

I1DS12 defines the inner spatial interval of the region of interest. The location is the inner radius of the specified ring.

I2DS12 defines the outer spatial interval of the region of interest. The location is the outer radius of the specified ring. MACCS requires that the value must be greater than or equal to I1DS12.

Report Options determine whether CCDF values are written to the MACCS output file, and whether they are to be included in the summary report.

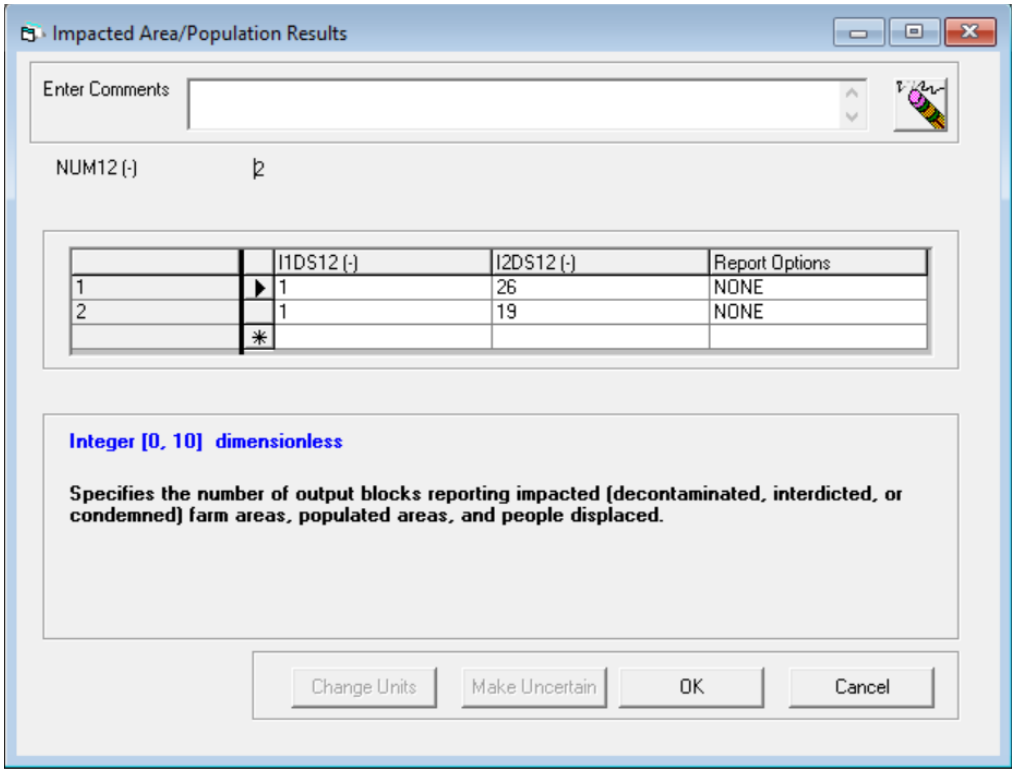


Figure 3-177 Impacted Area/Population Results Form

Table 3-175 Impacted Area/Population Results Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM12	Linked	Integer	None	0 to 999
I1DS12	Yes	Integer	NUM12	1 to NUMRAD
I2DS12	Yes	Integer	NUM12	1 to NUMRAD
Report Options	Yes	Character	NUM12	CCDF, NONE, REPORT, CCDF & REPORT

Individual Food Ingestion Dose Form

The *Individual Food Ingestion Dose* form is optional when the *COMIDA2 Food Model* is selected on the *Food* tab.

MACCS reports statistics on the maximum food ingestion dose calculated within a user-specified spatial interval for effective dose or thyroid dose. No other organs are available for this result.

The maximum dose is the dose calculated using the food consumption rates specified in the COMIDA2 input file for a representative individual. The projected doses in years 1 through 9 are examined in turn, and the maximum value found is used in generating this result.

NUM13 specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors I1DS12, I2DS12, and Report Options.

IRAD13 defines the spatial interval of the region of interest. The location is the outer radius of the specified ring. The inner radius is taken to be zero.

ORGN13 defines the organ to be used for each requested result.

Report Options determine whether CCDF values are written to the MACCS output file, and whether they are included in the summary report.

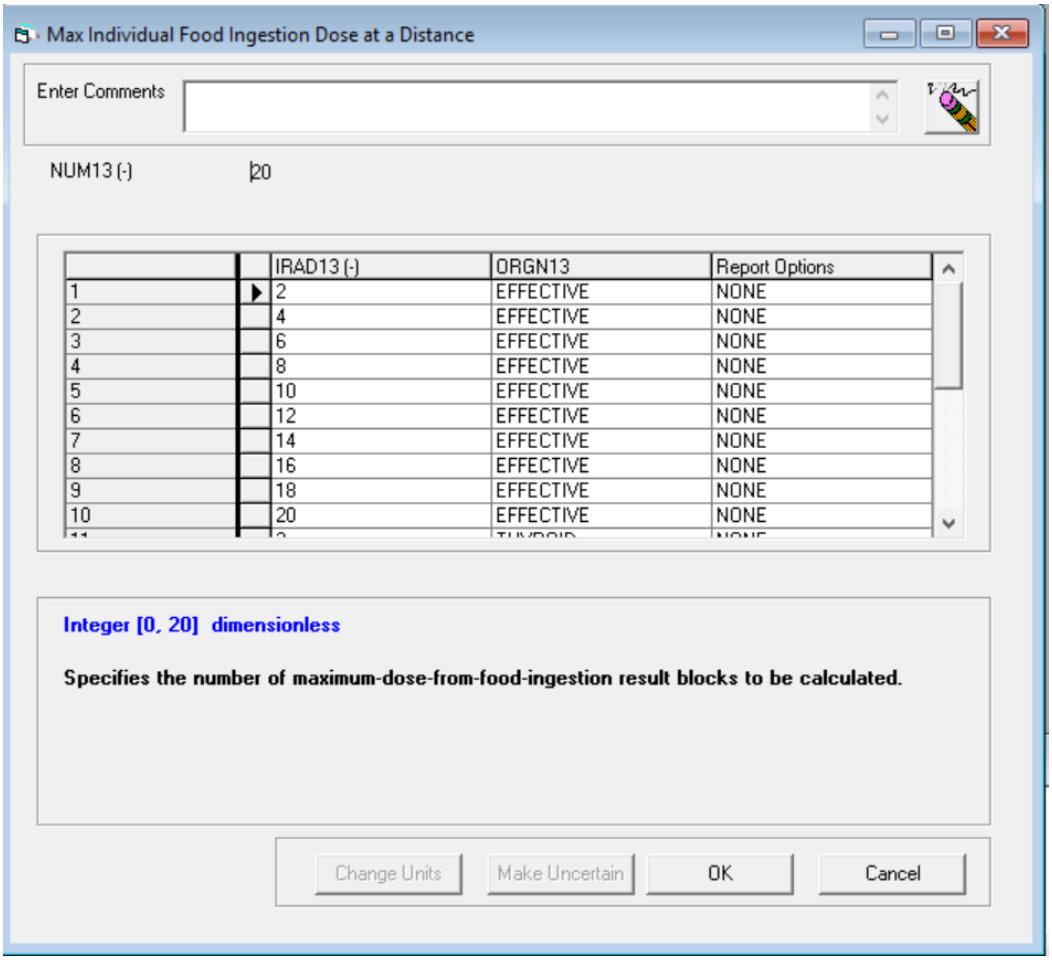


Figure 3-178 Individual Food Ingestion Dose Form

Table 3-176 Individual Food Ingestion Dose Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM13	Linked	Integer	None	0 to 999
IRAD13	Yes	Integer	NUM13	1 to NUMRAD
ORGN13	Yes	Character	NUM13	EFFECTIVE, THYROID
Report Options	Yes	Character	NUM13	CCDF, NONE, REPORT, CCDF & REPORT

Impacted Population Results Form

The *Impacted Population Results* form is optional.

The results from this output type convey information about evacuees, relocatees, and impacted individuals for each phase. The output includes the following results:

- EVACUEES NOT AFFECTED BY PLUME—the number of evacuees whose property is not contaminated and can return during or immediately after the emergency phase
- EVACUEES AFFECTED BY PLUME—the number of evacuees whose property is contaminated and may not be able to return immediately after the emergency phase
- NORMAL EMERGENCY PHASE RELOCATION—the number of relocatees who are affected by normal relocation during the emergency phase
- HOTSPOT EMERGENCY PHASE RELOCATION—the number of relocatees who are affected by hotspot relocation during the emergency phase
- INTERMEDIATE PHASE RELOCATION—the number of relocatees during the intermediate phase
- LEVEL 1 DECONTAMINATION RELOCATION—the number of people whose property requires the first level of decontamination during the long-term phase
- LEVEL 2 DECONTAMINATION RELOCATION—the number of people whose property requires the second level of decontamination during the long-term phase
- LEVEL 3 DECONTAMINATION RELOCATION—the number of people whose property requires the third level of decontamination during the long-term phase, but can return immediately after the decontamination is completed
- DECONTAMINATION+INTERDICTION RELOC—the number of people whose property requires the highest level of decontamination (depending on the number of levels specified in the input) plus additional interdiction following the decontamination
- CONDEMNATION RELOCATION—the number of people whose property is condemned

NUM14 specifies the number of results. Its value is determined by the number of rows in the grid containing values of vectors I1DS14, I2DS14, and Report Options.

I1DS14 defines the inner spatial interval of the region of interest. The location is the inner radius of the specified ring.

I2DS14 defines the outer spatial interval of the region of interest. The location is the outer radius of the specified ring. MACCS requires that the value must be greater than or equal to I1DS14.

Report Options determine whether CCDF values are written to the MACCS output file, and whether they are to be included in the summary report.

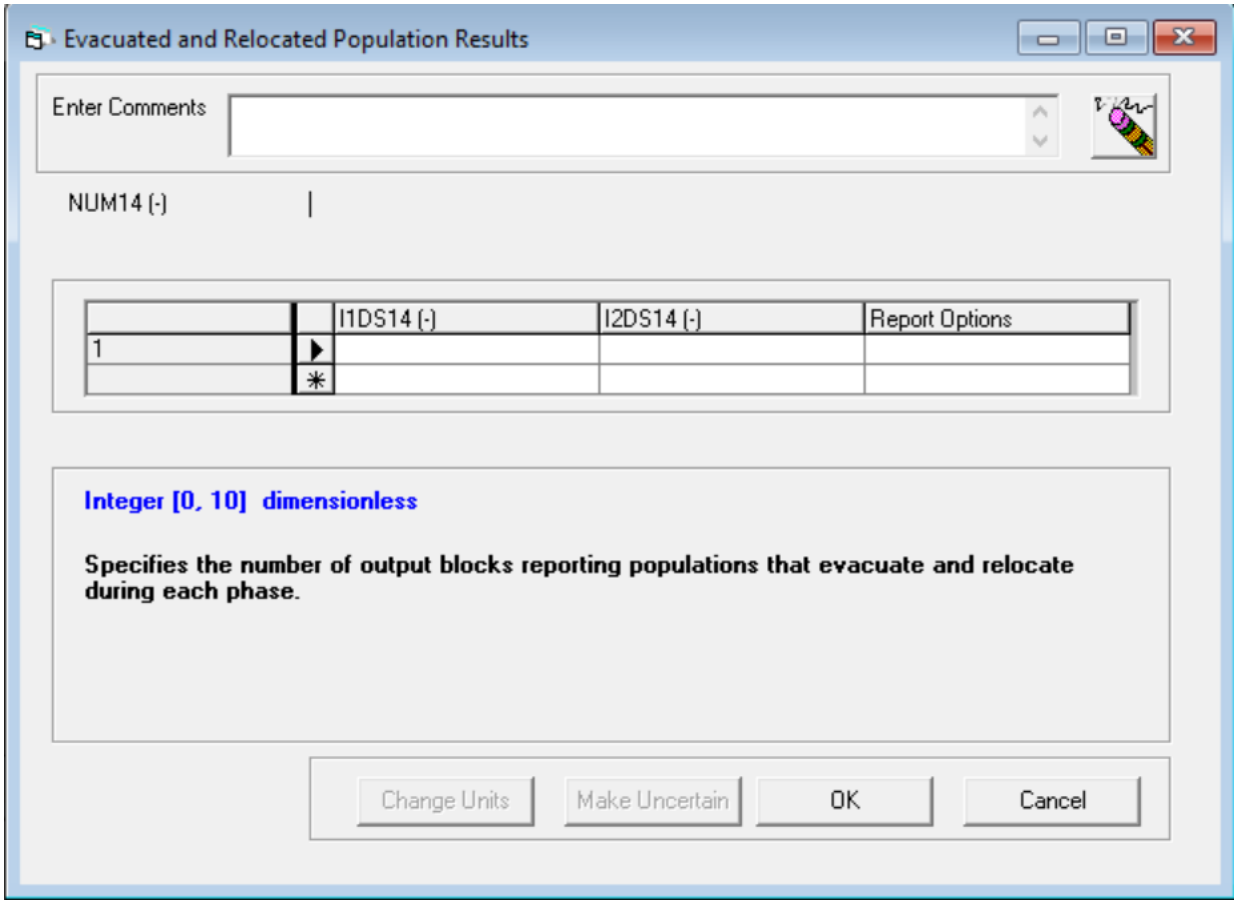


Figure 3-179 Impacted Population Results Form

Table 3-177 Impacted Population Results Form Inputs

Parameter Name	Definable	Type	Dimensions	Allowed Values
NUM14	Linked	Integer	None	0 to 999
I1DS14	Yes	Integer	NUM14	1 to NUMRAD
I2DS12	Yes	Integer	NUM14	1 to NUMRAD
Report Options	Yes	Character	NUM14	CCDF, NONE, REPORT, CCDF & REPORT

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4. WINMACCS REFERENCE GUIDE

4.1 Software Components

The MACCS suite is a set of interconnected software components. This section describes the main software components.

4.1.1 WinMACCS

The WinMACCS user interface was created using Microsoft Visual Basic Pro 6.0 (Service Pack 5) and Microsoft Access 2010. WinMACCS is the graphical user interface used to modify input parameters and model settings to support MACCS calculations. WinMACCS creates input files, initiates the MACCS model, and post-processes MACCS results. It can also run several preprocessors that support a variety of functions described below.

The following initialization files are used by WinMACCS:

- WinMACCS.ini contains initial settings. This file resides in the same folder as WinMACCS.exe. It is self-documenting and can be edited in an ASCII editor such as Notepad.

- Initialize2000.mdb is a Microsoft database used to create a new project file and when importing a project file in an older format, i.e., created by an older version of WinMACCS.

4.1.2 MACCS

The MACCS executable file is created using Intel Visual FORTRAN Version 11.1. MACCS is the modeling engine and can be initiated from WinMACCS or independently from a command prompt window.

The following input files may be required, depending on modeling choices. These files are either created by WinMACCS or supplied by the user when MACCS is initiated via a command prompt window:

- ATMOS input file containing parameters pertaining to atmospheric transport, dispersion, deposition, and source term,

- EARLY input file containing parameters pertaining to the emergency phase, which lasts up to forty days from the beginning of release, and

- CHRONC input file containing parameters used to model the intermediate and long-term phases.

Additional files used by MACCS are as follows:

- INDEXR.DAT is an ASCII file containing decay-chain information. This file is included as part of the installation.

- maccs2.ini. is an initialization file that contains two flags. When FileTempMem is set to true, temporary files are used instead of dynamic memory. The default value for FileTempMem is .FALSE. When BinFileFlag is set to true, all dose values for all grid

elements per cohort per weather trial is printed to a file for each source term in the ATMOS input file. The default value of BinFileFlag is .FALSE.

- MACCS.tmp is a text file containing the paths and names for the MACCS input files. The name of this file can be modified with a command line parameter.

- The meteorological file is an optional file that describes the weather conditions for one year.

- The site file is an optional file that defines population, land use, and economic parameters for each grid element.

- The DCF file is an optional file used to calculate doses to a set of organs from radionuclide exposures corresponding to a set of exposure pathways.

- The COMIDA2 binary file, created by COMIDA2.exe, is an optional file used to define food-chain DCFs.

- MACCS-HYSPLIT files generated by a pre-processor, HyGridConvert. This pre-processor can be run from WinMACCS. These files are relevant when using the HYSPLIT atmospheric transport model.

- Site specific economic data file generated by the pre-processor SecPOP defines county population and area fractions per grid element. This file is used when using the RDEIM GDP based economic model.

- CombineSource.out is generated using the pre-processor CombineSource and is used by MACCS. This can be created from WinMACCS. CombineSource uses data files generated by the pre-processor MelMACCS. This is used when running with the Multi Source model.

Several output files are created by MACCS (e.g., model1.out, model2.out, etc.), where the number corresponds to the realization or calculation number. When the calculation is deterministic and the cyclical file option is not used, only model1.out is created.

- Model*n*.out is a text file containing output from MACCS.

- Model*n*.bin is a binary file containing output from MACCS. This file can be viewed as text using the File→Export Binary Results as Text option in the WinMACCS main menu or can be used to create plots from within the WinMACCS interface.

- FortErr.log is created when MACCS terminates abnormally.

- MaxStat.log contains the character string “OK” when MACCS terminates normally, “NO” when MACCS detects an error or when MACCS does not complete the simulation. This file contains an error message when termination is due to an error detected by MACCS.

4.1.3 Latin Hypercube Sampling (LHS)

The executable file, lhs.exe, generates values of uncertain parameters using LHS. This program is initiated from WinMACCS. The code, published by SNL, is used to perform sampling from user-defined probability distributions that represent uncertain input parameters. LHS allows the uncertain distributions to be correlated.

The following required input files are transparent to the user when running LHS from within WinMACCS:

- Lhs.inp is generated by WinMACCS. This file contains the probability distribution types and values and the number of samples to generate.
- sipra.inp contains software settings used by LHS.

The following output files are generated when using LHS:

- Lhs.out contains sampled values created by the LHS execution. This file is read by WinMACCS and it is used to create MACCS and COMIDA2 input files and uncertain DCFs using the sampled values.
- Lhs.err is created when an error is detected during LHS execution.
- Lhs.msg contains details of LHS execution.

4.1.4 COMIDA2

The executable file, Comida2.exe, is a semi-dynamic food chain model that estimates annual concentrations in various food sources given a set of radionuclides and transfer coefficients for each crop type considered.

The input files are generated by WinMACCS. Uncertainty is supported in this input. The following input files are required:

- Comida2.inp, a parameter input file
- Comida2.var, a parameter input file
- Comida2.par, a parameter input file.
- A DCF file

The following output files are generated by COMIDA2:

- Comida2.bin, a binary file that is used as input to MACCS
- Comida2.dmp, a text output file
- Comida2.lst, a text output file
- Comida2.cnc, a text output file

4.1.5 PopMod

PopMod was written to allow MACCS to support more than sixteen compass directions by interpolating an older site data file created by SecPop version 4.2.2 or older. This function is no longer needed when the user can create site files supporting the number of compass directions required for their simulation using current versions of SecPop.

PopMod reads a site file and creates a new population file containing more compass sectors. The work of PopMod is primarily interpolating and reformatting. No new information is added to the site file created by PopMod.

PopMod requires for input a site data file and the required number of angular sectors needed in the new file. The number of final sectors must be greater than the original site data file. PopMod generates a modified site data file.

Even though PopMod is still part of WinMACCS, it is not needed when SecPop 4.0 or later is used to create the site file. SecPop 4.0 uses Census 2010 data and supports up to 64 compass sectors.

4.1.6 CombineSource

The executable file CombineSource.exe is integrated into WinMACCS to support the multiple source model. The input files required are result files from MelMACCS, a separate software component used to extract source-term data from MELCOR (a reactor modeling product) results. Optionally, a user could create their own source files by replicating the format of a MelMACCS file.

4.1.7 Project Files

Data files managed by WinMACCS include a set of auxiliary files, such as the site file, the meteorological file, the COMIDA2 binary file(s), cyclical file(s), source term file(s), and DCF file(s).

Input files are created by WinMACCS using the model and input settings. This set can include Atmos*n*.inp, Early*n*.inp, Chronc*n*.inp, Comida*n*.inp, and Lhs.inp input files.

Output files are created by MACCS and its preprocessors (e.g., LHS and COMIDA2). One or more sets of MACCS output files, Model*n*.out and Model*n*.bin, are normally created. Other files may or may not be created, depending on settings.

A project database (e.g., project.mxd), is created from an Access 2010 database file, Initialize2000.mdb, by WinMACCS when a new project is created. The project database contains the following information:

- Input values specified by user,
- Default input values,
- Parameter descriptions and limits,
- Information to construct input forms,
- Information to construct input files,
- LHS results, and
- MACCS results read from binary files.

4.2 Main Menu Items

The main menu contains six drop-down menus that allow the user to control WinMACCS projects and perform several useful functions. These are described in the following subsections for each of the menu items.

4.2.1 File Menu

The *File* menu shown in Figure 4-1 allows the user to do the following:

- Manage MACCS projects via the New Project, Open Project, Save Project, SaveAs Project, and Close Project commands.

- Refresh the view of the project files using *Refresh File View.*
- Import a MACCS input file (ATMOS, EARLY, CHRONC, or a combination of these files) using *Import MACCS Input File*.
- Import custom report definitions from another WinMACCS project using *Import Custom Report Definitions.*
- View a MACCS binary output file in a text format using utility *Export Binary Results as Text.*

These commands are explained in more detail below.

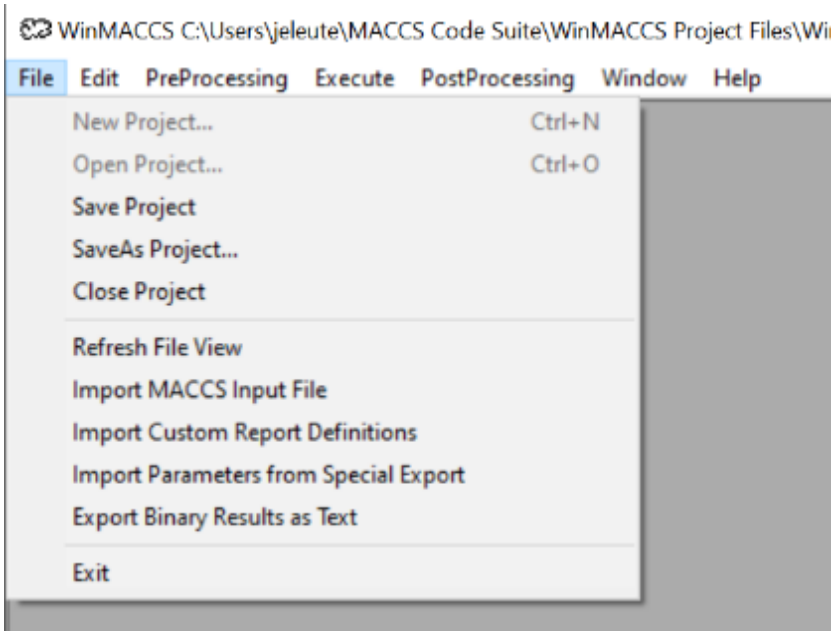


Figure 4-1 File menu

File→New Project

The command *File→New Project* is used to create a new WinMACCS project, as shown in Figure 4-2. The user is required to type a name for the project in the *Project Name* text box. This name is used as a folder name and as the prefix of the .mxd project file. The user is limited to enter only names that are legal names for windows folders and files. Optionally, the user can change the drive and parent folder for this new project.

By default, the project location is on the drive where MACCS is installed. If the program was installed on the C:\ drive, the default project folder is C:\WinMACCS Projects\.

The user should click *OK* to close this window and complete the operation of creating a new project or click *Cancel* to close this form without creating a new project.

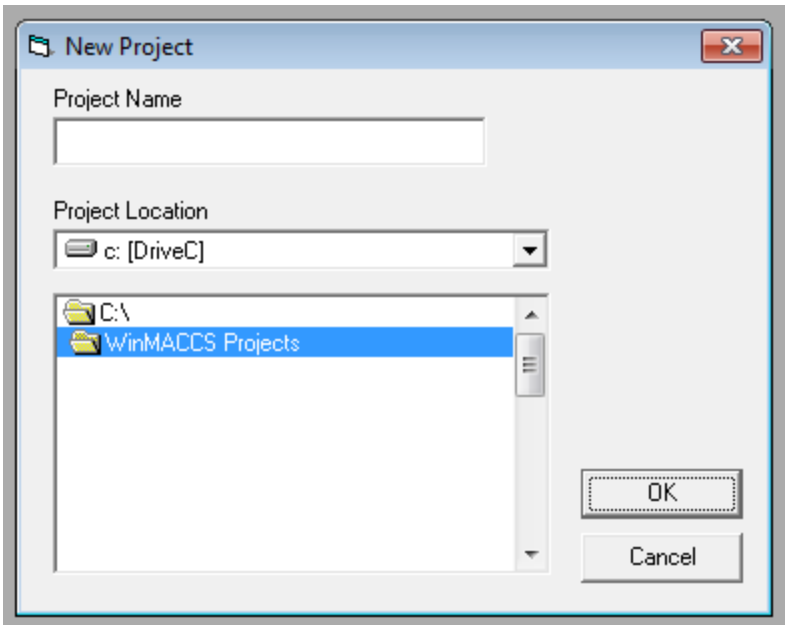


Figure 4-2 New project form

File→Open Project

The command *File→Open Project* opens an existing WinMACCS project. The user opens a project by selecting the .mxd file in the project root folder. When the project file was not created with the same WinMACCS version, a box like one shown in Figure 4-3 is displayed.

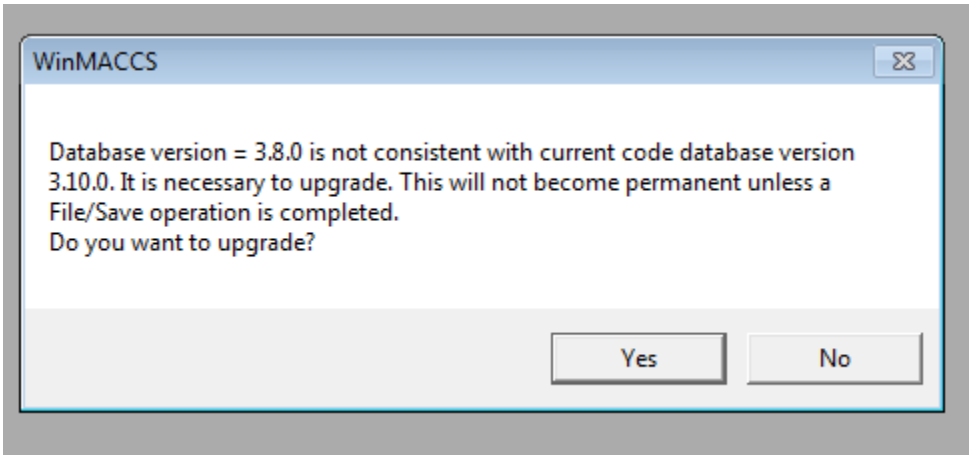


Figure 4-3 Example of database inconsistency

The database is upgraded to the current version of WinMACCS by clicking *Yes*. The original .mxd file is not modified unless the user selects *File→Save*. The user can also retain the old project version by selecting *File→SaveAs Project* to store the upgraded version under a different name.

File→Save Project

The command *File→Save Project* saves the changes made to the parameters and settings.

File→SaveAs Project

The command *File→SaveAs Project* creates a new WinMACCS project, as shown in Figure 4-2, based on the current project settings. The folder structure and all files are copied to the new project.

File→Close Project

The command *File→Close Project* closes the current project. The current project must be closed before opening another project because the interface supports only one project at a time. However, multiple instances of WinMACCS can be open at the same time provided each instance corresponds to a different project folder.

File→Refresh File View

The command *File→Refresh File View* refreshes the data displayed on the project *Files* tab. This causes WinMACCS to update the files shown in the *Input* and *Output* entries on the project *Files* tab to be consistent with the files saved on the computer in the project Input/ and Output/ folders. This is done automatically when simulations are run. However, when a file is copied or deleted manually from the computer, the file view may become out of date unless this command is used.

File→Import MACCS Input File

The command *File→Import MACCS Input File* prompts the user to select a MACCS input file such as an Atmos, Early, or Chronc input file (e.g., Atmos1.inp). The file contents are read and data values are imported into WinMACCS parameters in the current project. The file can also contain combinations of Atmos, Early, and Chronc parameters. When some of the WinMACCS parameters were previously defined, the values read from the file replace the old values.

The MACCS input file does not need to be complete. The MACCS input lines are read and the values overlaid onto the existing project. When a vector or array is present in the MACCS input file, all values associated with that vector or array are cleared before the new data are assigned to the project.

The model settings may also be modified while importing a MACCS input file. For example, the MACCS input file modifies the weather sampling method when a METCOD card is included in the file. When the model settings are modified, data relevant to those modified settings are imported. Data not relevant to the model settings are not imported.

File→Import Custom Report Definitions

The command *File→Import Custom Report Definitions* is used to import custom report definitions created in another WinMACCS projects into the current project. The WinMACCS project file is selected as shown in Figure 4-4. A new report definition is valid only when the results requested in the *Output Control* form that created that result is identical between the two projects.

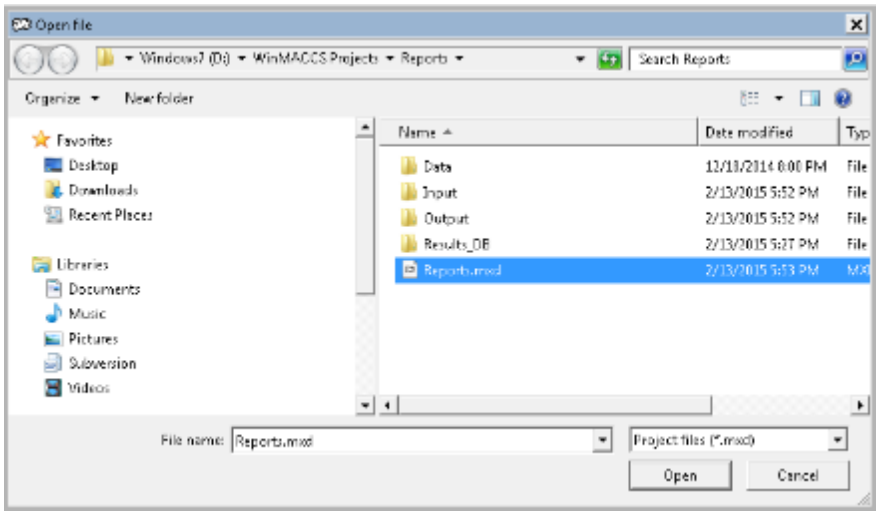


Figure 4-4 Import report definitions

File→Import Parameters from Special Export

The command File→ Import Parameters from Special Export is used to input parameters from a special report type.

File→Export Binary Results as Text

The command *File→Export Binary Results as Text* allows the user to open a MACCS binary output file in text format. These files are found in the Project\Output\ folder, one for each simulation, as shown in Figure 4-5. The binary output files are the same files that are used by the WinMACCS postprocessor to display MACCS results graphically.

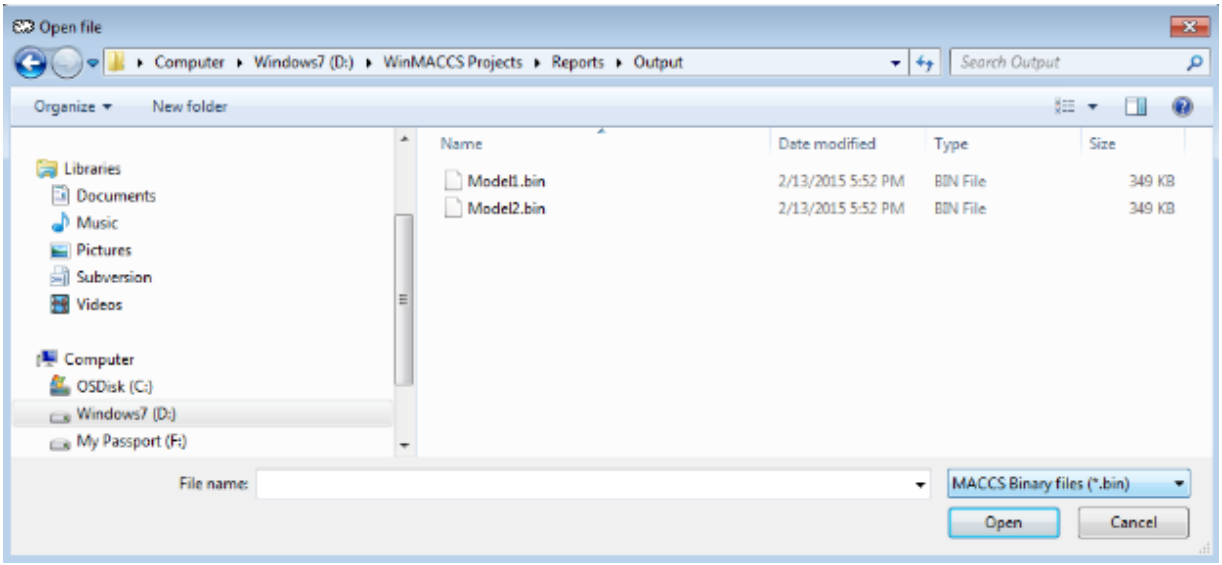


Figure 4-5 Export binary file as text

File→Exit

The command *File→Exit* closes the WinMACCS application. If the project has changed since the last time it was saved, a message box is displayed as shown in Figure 4-6.

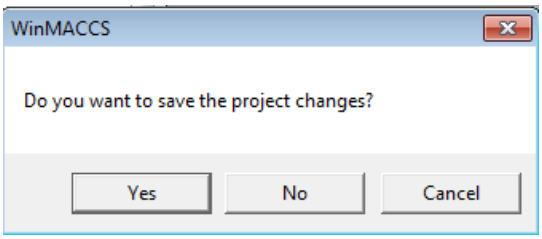


Figure 4-6 Message box to save project

4.2.2 Edit Menu

The *Edit* menu shown in Figure 4-7 allows the user to do the following:

- Show and hide the legend by checking or unchecking *Show Legend*. The legend defines the icons associated with forms in the Project window,
- Propagate parameters from one cohort to subsequent cohorts,
- Fill in missing cohort parameters when opening prior versions,
- Modify data grids on parameter modification forms using commands from the submenu *Grid,*
- Correlate uncertain parameters from the submenu *Correlate Uncertain Variables,*
- Modify form parameters by selecting the form name and selecting from the submenu *Modify Form Variables,*
- Open parameter modification forms by choosing the parameter name and export parameter values using the command *Find or Export Parameter…,* and
- Open the *Project Properties* window to modify basic modeling choices.

These commands are explained in more detail below.

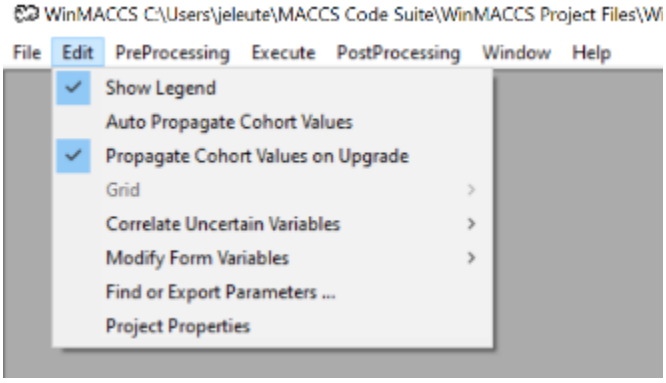


Figure 4-7 Edit menu

Edit→Show Legend

When the *Edit→Show Legend* command is checked, a window appears showing a legend, as shown in Figure 4-8. When the box is unchecked, the legend is hidden.

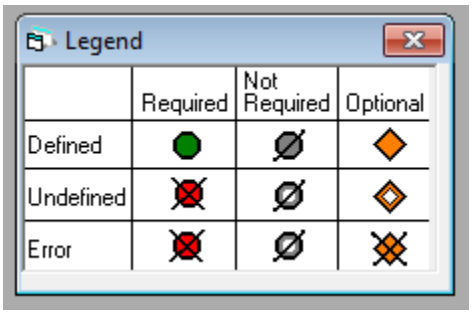


Figure 4-8 Legend

Edit→Auto Propagate Cohort Values

When the *Edit→Auto Propagate Cohort Values* command is checked, the values are propagated from one cohort form to other forms after the *OK* button is clicked on the parameter modification form. The propagation is applied to cohorts greater than the cohort saved that have not already been defined. This option is set to off by default.

When this option is enabled and the values are saved on a cohort form, the same values are saved on other undefined cohort forms for cohort numbers greater than the cohort number of the saved form. For example, when the parameter CRIORG is updated on the *Critical Organ* form for cohort 3 and there are a total of 6 cohorts, CRIORG for cohorts 4, 5 and 6 is assigned the same value provided this parameter is undefined for these cohorts. When a form is encountered that is defined, the propagation stops, and no more cohorts receive the new value.

As an example, when *Network Evacuation Speed* for cohort m is completed, propagation is performed for cohort m+1, m+2..., until a parameter is found to be defined on the *Network Evacuation Speed* form for cohort n, where n>m. At that point, the propagation ceases. No previously defined values are overwritten when using this option.

Edit→Propagate Cohort Values on Upgrade

The *Edit→Propagate Cohort Values on Upgrade* checked command was implemented to support backward compatibility with WinMACCS 3.6 and earlier. When this is checked, values are copied to undefined cohort forms when opening a project that was created earlier than the current WinMACCS version. This option is checked (enabled) by default. When this option is unchecked and the project saved, the unchecked state is also saved.

In earlier versions, the MACCS paradigm of change cards for cohort parameters was used within the user interface. Parameters for cohort one were required, but the corresponding value used for subsequent cohorts were assumed to be equal to the value used for the previous cohort unless explicitly changed.

All cohort forms are now required. This means that the values to define a cohort must be defined for each cohort. This option automatically fills in missing values when opening older projects with WinMACCS 4.0.

Edit→Grid

The submenu *Edit→Grid* provides commands to manipulate grids in parameter modification forms. Figure 4-9 shows a grid found on the *ATMOS/Release Description/Release Fractions* form. The options available in the *Edit→Grid* submenu are enabled when the current parameter modification form contains a grid.

There are two types of grids on parameter modification forms, vector and array grids. A grid showing an array represents a single parameter containing both rows and columns. For example, parameter RELFRC is an array displayed in a grid, as shown in Figure 4-9. A grid containing vectors may display multiple parameters on a single grid, one parameter for each column. When a grid displays multiple vectors, each vector on the grid must have the same number of rows, as shown in Figure 4-10.

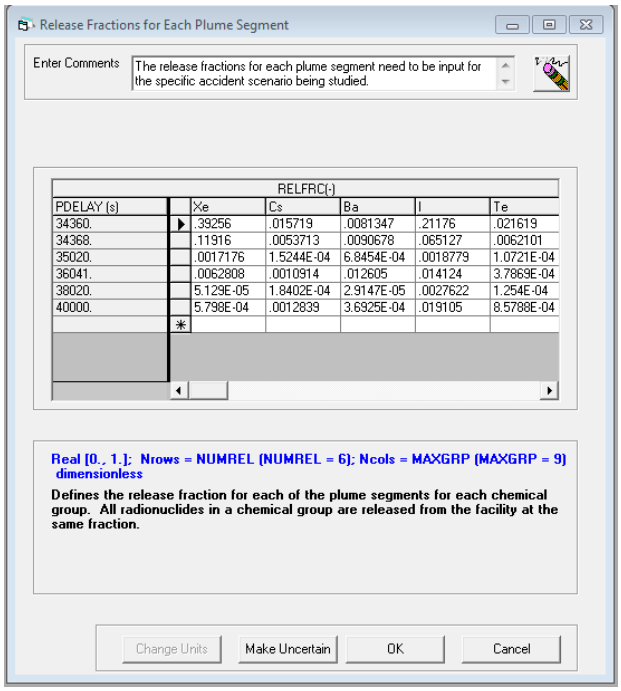


Figure 4-9 Grid showing an array of release fractions for each plume segment

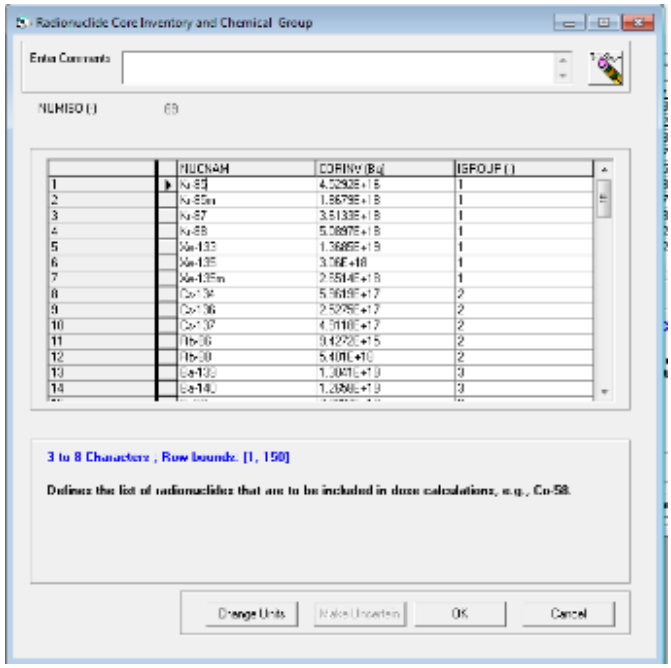


Figure 4-10 Grid showing multiple vectors: NUCNAM, CORINV, and IGROUP

The array operations, *Edit→Grid→Insert Columns* and *Edit→Grid→Delete Columns*, are enabled when the grid contains an array but are disabled when it contains one or more vectors.

When a parameter form contains either an array or vectors with a variable number of rows, the operations *Edit→Grid→Insert Rows* and *Edit→Grid→Delete Row Hint* are enabled. These functions are not enabled when the grid requires a fixed number of rows (e.g., vector parameters CYSIGA, CYSIGB, CZSIGA and CZSIGB all require exactly six rows).

Edit→Grid→Insert Rows

The *Edit→Grid→Insert Rows* command is used to insert rows in a grid. A row on the grid must be selected before this operation can be used. A row is selected by clicking on the small box between the row label and the data in the desired column. The row becomes highlighted, as shown below in Figure 4-11.

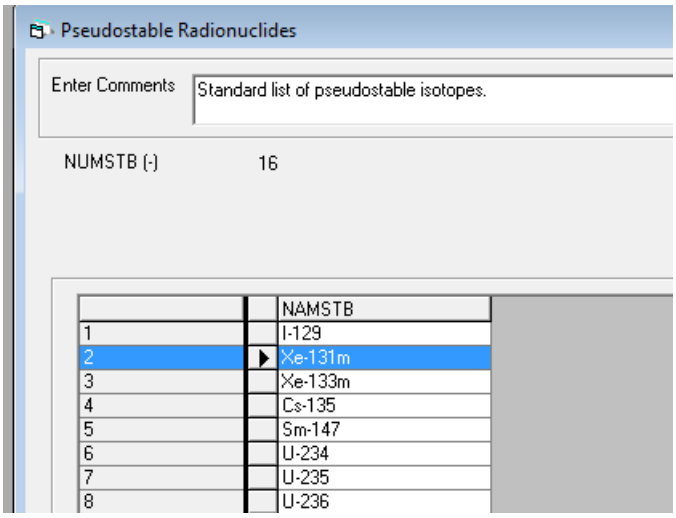


Figure 4-11 Grid showing a selected row

After the *Insert Rows* option is selected, the *Insert Row* form opens, as shown in Figure 4-12. By clicking on the radio button *Before,* the new rows are inserted before the current selected row. By clicking on the radio button *After,* the new rows are inserted after the current selected row. The number of rows to insert is entered. One or more rows are inserted by clicking *OK*.

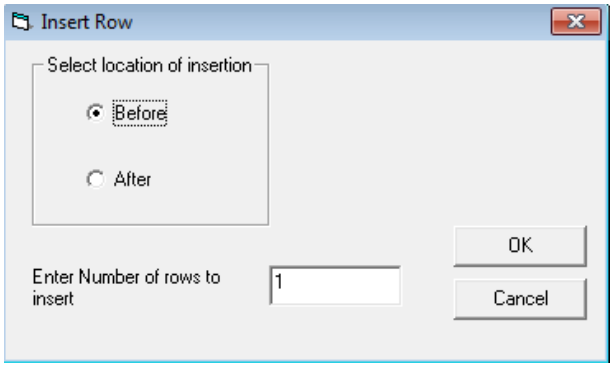


Figure 4-12 *Insert Row* form

The menu option to insert rows is not available when the number of rows on a form is fixed (e.g., the *ATMOS/Dispersion/Dispersion Function* form).

Edit→Grid→Delete Row Hint

The command *Edit→Grid→Delete Row Hint* opens a message box shown in Figure 4-13. This is a hint to give the novice user instructions on how to delete a row in the grid.

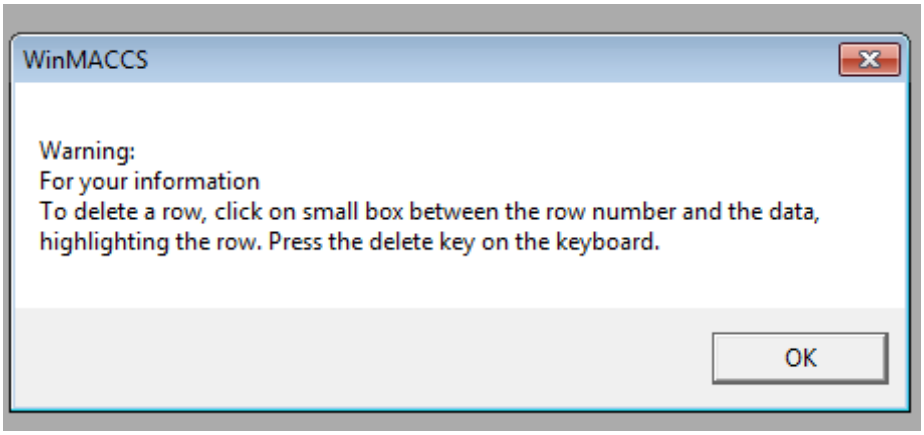
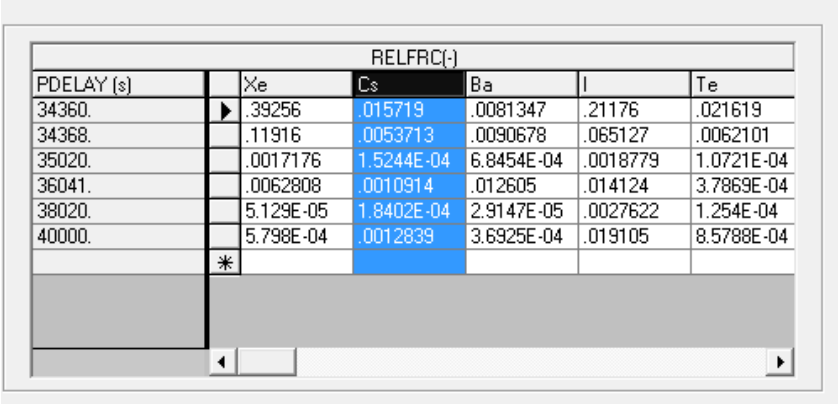


Figure 4-13 How to delete a grid row

Edit→Grid→Insert Columns

The command *Edit→Grid→Insert Columns* is used to insert columns in an array. A column of the array must first be selected by clicking the column header, as shown in Figure 4-14.



RELFRC(-)						
PDELAY (s)		Xe	Cs	Ba	I	Te
34360.	▶	.39256	.015719	.0081347	.21176	.021619
34368.		.11916	.0053713	.0090678	.065127	.0062101
35020.		.0017176	1.5244E-04	6.8454E-04	.0018779	1.0721E-04
36041.		.0062808	.0010914	.012605	.014124	3.7869E-04
38020.		5.129E-05	1.8402E-04	2.9147E-05	.0027622	1.254E-04
40000.		5.798E-04	.0012839	3.6925E-04	.019105	8.5788E-04
	*					

Figure 4-14 Grid showing a selected column

After the *Insert Column* option is selected, the *Insert Column* form opens, as shown in Figure 4-15. By clicking on the radio button *Before,* the new columns are inserted before the selected column. By clicking on the radio button *After,* the new columns are inserted after the selected column. The operation is completed by entering the number of columns to insert and clicking *OK*.

The menu option to insert columns is not available when the columns on a form represent vectors (e.g., the *ATMOS/Dispersion/Dispersion Table* form).

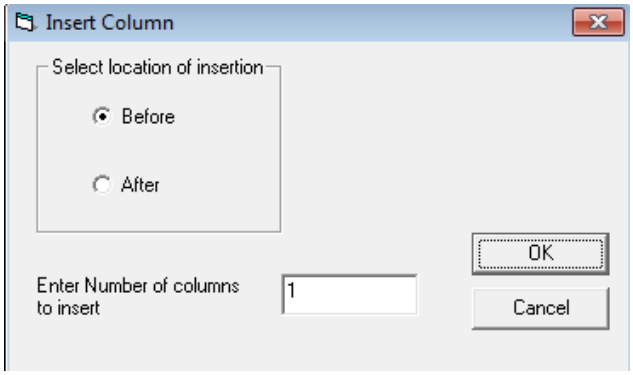


Figure 4-15 Insert Column form

Edit→Grid→Delete Columns

The command *Edit→Grid→Delete Column* is used to delete the currently selected array column.

Edit→Grid→Copy to Clipboard

The command *Edit→Grid→Copy to Clipboard* is used to copy a portion of the grid data to the Windows clipboard.

Data can be copied to the Windows clipboard as follows:

(1). A portion of a grid can be selected in WinMACCS by left clicking and holding button, dragging over the desired area, and then releasing the mouse button.

(2). The selected data can be copied to the clipboard by typing a keyboard short-cut for copying (Ctrl+F), selecting *Edit→Grid→Copy to Clipboard,* or right clicking and selecting *Copy* from the popup menu.

Other methods described in Section 4.4.1.1 are available for copying portions of the grid to the clipboard.

The data can be easily pasted into another application, such as Microsoft Excel, with the keyboard shortcut (Ctrl+V). Note that the shortcut for copying from the grid is different than the standard Windows shortcut because these are distinct operations.

Edit→Grid→Paste from Clipboard

The command *Edit→Grid→Paste from Clipboard* is used to transfer the grid data from the Windows clipboard into a grid in a parameter modification form.

Before this can be done, clicking on a cell in the grid defines the position where the data are pasted. Typing the keyboard short-cut for pasting (Ctrl+G), select *Edit→Grid→Paste from Clipboard*, or right clicking and selecting *Paste* completes the paste operation. Note that the shortcut for pasting onto the grid is different than the standard Windows shortcut because these are distinct operations.

These operations work well for transferring data from a Microsoft Excel spreadsheet into the grid. When data are not being transferred from Excel, it is helpful to know WinMACCS expects a TAB character to separate cells and a new line (i.e., the Enter key) to separate rows.

Edit→ Correlate Uncertain Variables

The submenu *Edit→ Correlate Uncertain Variables* offers commands to correlate uncertain parameters. Two options are offered, either to allow LHS to enforce rank correlations or to define a perfect rank order of parameter values after LHS has run. Section 4.4.3 can be referenced for more information.

Edit→ Correlate Uncertain Variables→ Linear Coefficients

The command *Edit→ Correlate Uncertain Variables→ Linear Coefficients* opens the *Correlate Uncertain Variables* form. This option, only relevant when LHS is being used to sample a set of uncertain parameters, allows the user to correlate pairs of uncertain parameters. The correlation coefficient specifies the degree to which two uncertain parameters are correlated. Section 4.4.3.1 contains more information.

Edit→ Correlate Uncertain Variables→ Enforce Rank Order

The command *Edit→ Correlate Uncertain Variables→ Enforce Rank Order* opens the *Enforce Rank Order of Uncertain Variables* form. After LHS has run and imposed correlations specified by the user, WinMACCS can reorder some of the parameters to be consistent with the rank order of other parameters. Section 4.4.3.2 can be referenced for more information.

Edit→Modify Form Variables

The submenu ***Edit→Modify Form Variables*** shown in Figure 4-16 contains commands that can be used to define parameters without opening the forms.

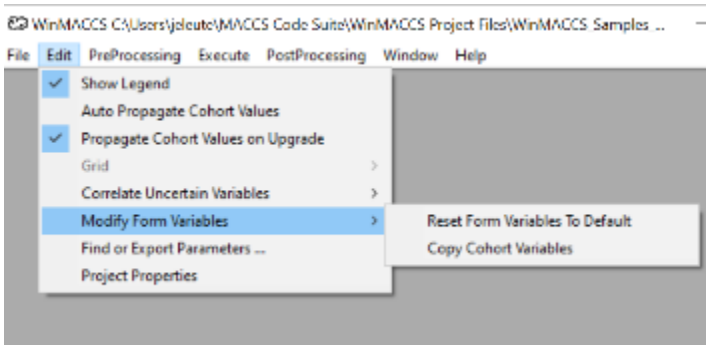


Figure 4-16 Submenu Modify Form Variables

Edit→Modify Form Variables→Reset Form Variables to Default

The command *Edit→Modify Form Variables→Reset Form Variables to Default* is used to conveniently replace all the data on a form with default values, as shown in Figure 4-17.

Most forms in WinMACCS are undefined by default; in a few cases, there are specific values that are standard for a model. Thus, in most cases, selecting this menu option has the same effect of clearing the form.

The following operations reset a form to its default values:

- When the form is open, click anywhere on the form. This identifies it as the form to be modified. Select the menu option, *Reset Form Variables to Default.* The values are set to the WinMACCS default values. This is a convenient way to clear the data from a form. In some cases, this resets parameters to default values rather than clearing the values on the form. This may produce a different outcome than that of the erase button found on the parameter modification form. The Erase button clears all values from the form but does not replace parameters with their default values when default values exist.

- When a form is not open, an equivalent method for resetting form parameters to their defaults is to click on the form name in the *Parameters* tab of the *Project* window, then select the menu option, *Reset Form Variables to Default*. Parameters defined on the selected form are reset to their default values.

- Another option to reset parameters to their defaults is to right click on the form name in the *Parameters* Tab and select *Reset to Default* from the popup menu.

Resetting parameters to default values does not affect read-only parameters on the form. Read-only parameters have gray backgrounds when viewed on parameter modification forms. They are defined on a different form.

Resetting form variables, as described above, is the only way to remove data from required forms. Opening a required form, deleting the data, and clicking the *OK* button is not allowed.

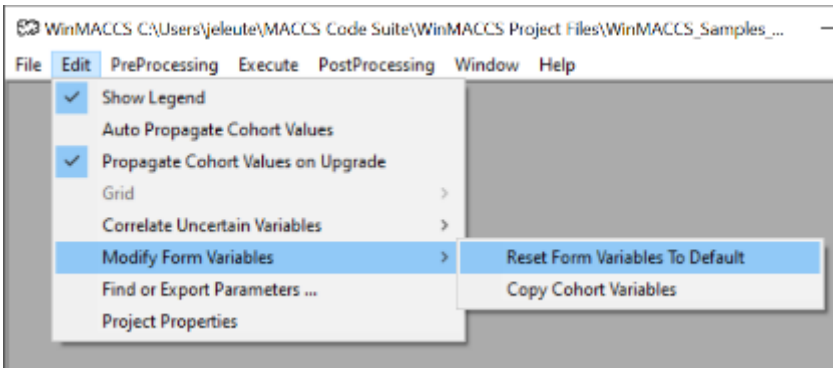


Figure 4-17 Reset form parameters to default

Edit→Modify Form Variables→Copy Cohort Variables

The command *Edit→Modify Form Variables→Copy Cohort Variables* is used to copy form data from one of the cohort forms to other cohort forms. To use this function, a form must first be selected from the Parameters tab. Section 4.4.4 can be referenced for more information.

Edit→Find or Export Parameters…

The command *Edit→Find or Export Parameters...* opens the *Open Parameter Form* as shown in Figure 4-18 to assist in locating input parameters within the user interface.

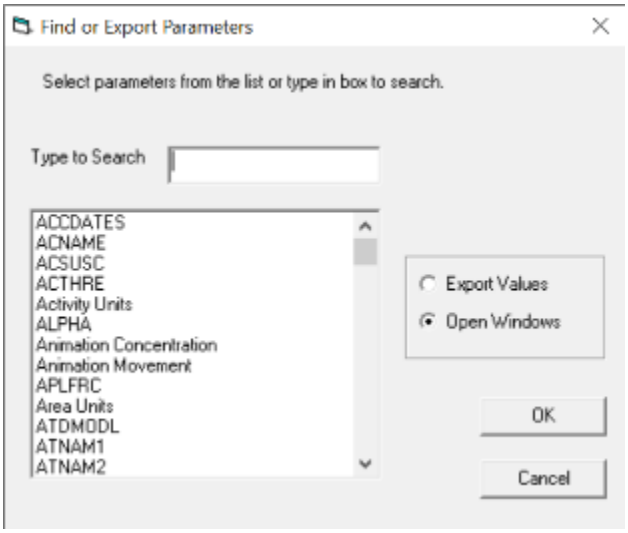


Figure 4-18 Find or Export parameters form

The list of parameters can be navigated by

- Pressing the up and down arrow keys on the keyboard
- Typing a letter to move to the first parameter starting with that letter. For example, typing the letter m positions the list at parameters starting with the letter M. Subsequent typing of that same letter moves to the next parameter starting with that letter.
- Moving the scroll bar on the form.

Multiple parameters can be selected in the list by:

- Clicking more than one of the parameter names on the list.
- By navigating through the list using the arrow keys, entries can be selected by pressing the space bar on the keyboard when the parameter name is highlighted. Focus is indicated by a dotted rectangle boxing the parameter name.

The windows associated with the selected parameters can be opened by

- Selecting OK
- Pressing the Enter key on the keyboard

In some cases, more than one form contains the same parameter name. Sometimes parameters have different meanings on different forms (e.g., ORGNAM has a different usage on the *Early Fatality Effects* form and *Off Centerline Dose* form). All the forms that contain the selected parameter are opened.

Edit→Project Properties

The command *Edit→Project Properties* opens the *Properties* form. This form is used to modify the basic model choices. By selecting models using the *Properties* form, other values may be required. Sections 3.1.1 and 4.3 contain more details.

4.2.3 Execute Menu

The *Execute* menu shown in Figure 4-19 allows the user to do the following:

- Control options on MACCS input files with respect to validation and creation before the MACCS simulations
- Switch from LHS to SRS for creating a set of Monte Carlo realizations to estimate the effects of parameter uncertainty. LHS is selected by default.
- Control whether binary result files are imported into WinMACCS and reports are created. *Auto Create Reports* is selected each time WinMACCS is started.
- Open the *Run Models* form to initiate a MACCS simulation.

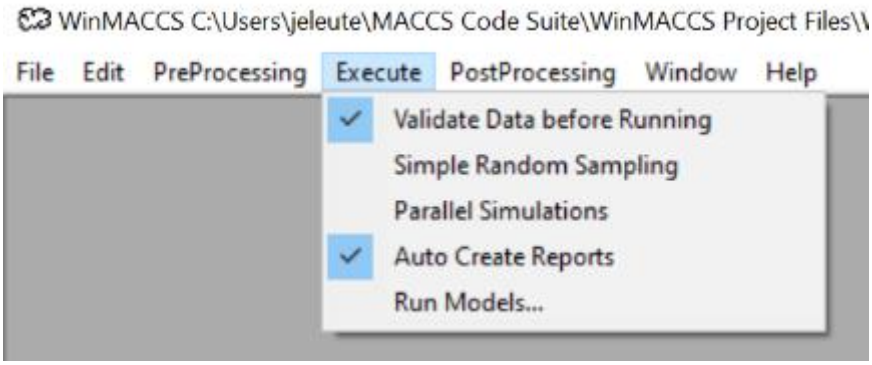


Figure 4-19 Execute menu

Execute→Validate Data before Running

The command *Execute→Validate Data before Running* has the following meaning:

- When checked, all input parameters are tested for consistency before a simulation
- When unchecked, consistency testing is skipped. This may be desired when a minor modification was made, and the user doesn't want to wait for the consistency checking to be performed before executing MACCS.

Execute→Simple Random Sampling

The command *Execute→Simple Random Sampling* has the following meaning:

- When checked, uncertain input parameter sampling uses SRS.
- When unchecked, a stratified sampling method known as LHS is used.

WinMACCS allows input parameter values to be made uncertain and enables sampling of the uncertain variables. Section 4.4.1.3 contains more information about uncertain variables. Note that LHS is the name of the underlying code that performs the sampling, but it supports both LHS and SRS.

Execute→Parallel Simulations

The command *Execute→Parallel Simulations* has the following meaning:

- When checked, WinMACCS takes advantage of the local system's processors to run multiple simulations concurrently.
- When unchecked, multiple simulations are not run concurrently.

Execute→Auto Create Reports

The command *Execute→Auto Create Reports* has the following meaning:

- When checked and reports have been requested, the binary files are imported into the project database and the requested report is created without additional action by the user following completion of an execution.
- When not checked, reports are not created after execution. The user has the option to create reports by selecting *PostProcessing→Create Custom Report* from the main menu. Probabilities used in reporting can be modified after execution on the *General→Reporting Options* form.

Execute→Run Models…

The command *Execute→Run Models*… opens the form used to initiate simulations. This can be used to perform a simulation after all model data have been defined. Section 4.5.1 contains more information.

4.2.4 PostProcessing Menu

The *PostProcessing* menu shown in Figure 4-20 and Figure 4-21 allow the user to do the following:

- Open various graphics windows using the Scalar Results, Statistical Summary Results, and Results over all Weather Trials options.
- Modify plot labels, save plots in various file formats, and select, unselect and delete series from plots.
- Create custom reports using the *Create Custom Report* command for user-defined probabilities.
- Create a summary report.

Post processing results are available after the simulations have completed. If the MACCS binary result files have not already been imported into WinMACCS, requesting a plot or report causes all binary files to be imported.

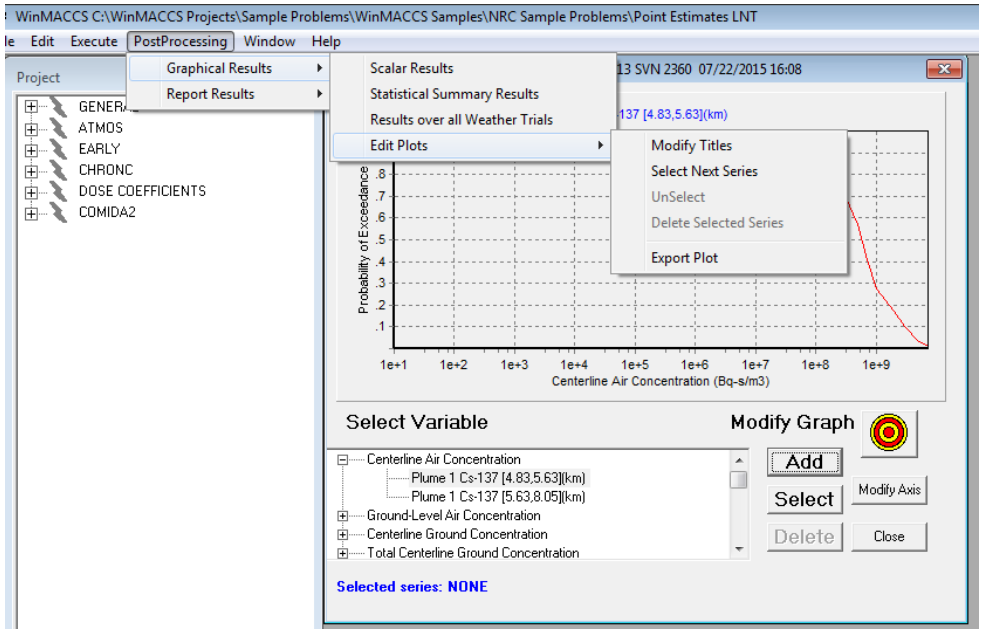


Figure 4-20 Postprocessing/Graphical Results menu

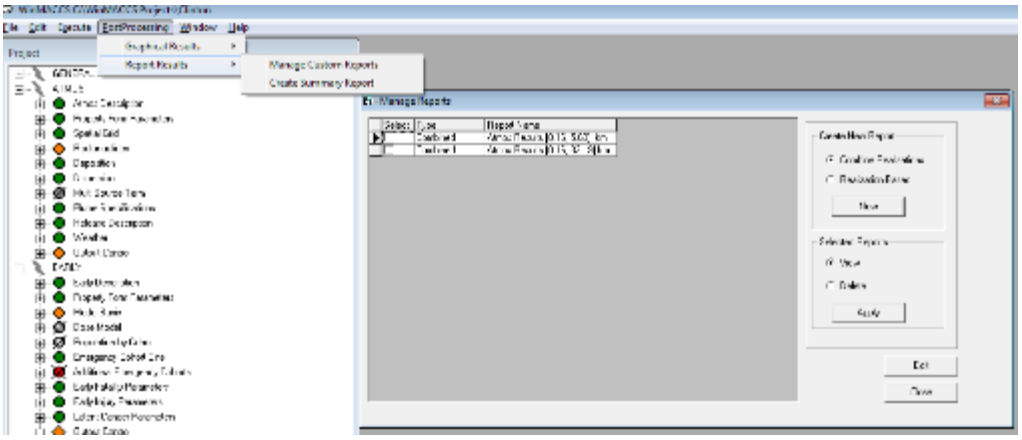


Figure 4-21 Postprocessing/Report Results menu

PostProcessing→Graphical Results→Scalar Results

The command *PostProcessing→Graphical Results→Scalar Results* is used to view released activity by radionuclide as a CCDF, as shown in Figure 4-22. Section 4.6.3.1 contains more information.

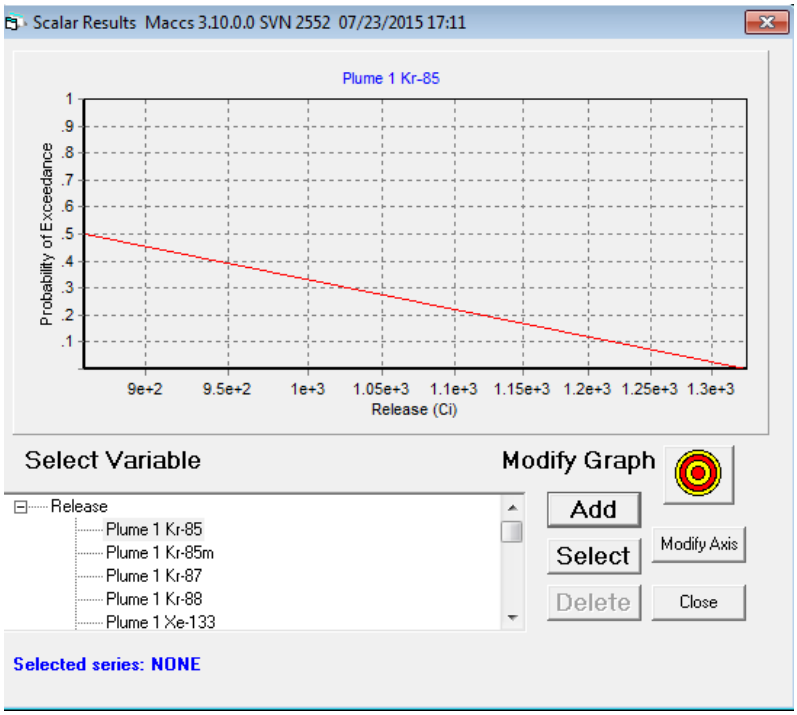


Figure 4-22 Plot of scalar results

PostProcessing→Graphical Results→Statistical Summary Results

The command *PostProcessing→Graphical Results→Statistical Summary Results* opens a graphics window to view statistical data for a set of realizations. The probability shown in the plot corresponds to a set of realizations, cyclical files, or a combination of both. The implicit assumption is that each of the results are equally probable. Section 4.6.3.2 contains more details.

PostProcessing→Graphical Results→Results over all Weather Trials

The command *PostProcessing→Graphical Results→Results over all Weather Trials* opens a graphical window to view the complementary cumulative distribution function reported on each individual simulation. Each series (the set of points representing a curve) shows probability of exceedance based on weather variability for an individual simulation. Section 4.6.3.2 provides more information.

PostProcessing→Graphical Results→Edit Plots→Modify Titles

The command *PostProcessing→Graphical Results→Edit Plots→Modify Titles* is used to change the plot title and the axis labels. A description of all functions available for graphics forms is provided in Section 4.6.3.4

PostProcessing→Graphical Results→Edit Plots →Select Next Series

The command *PostProcessing→Graphical Results→Edit Plots →Select Next Series* is used to select the next series drawn on the plot. This performs the same function as the *Select* button on the graphics screen. A description of all functions available for graphics forms is provided in Section 4.6.3.4.

PostProcessing→Graphical Results→Edit Plots →UnSelect

The command *PostProcessing→Graphical Results→Edit Plots →UnSelect* is used to remove the selection of a series drawn on the plot. It is possible to put the form in this same state by clicking the *Select* button repeatedly, though this is a tedious way to unselect when there are many series drawn on the plot. A description of all functions available for graphics forms is available in Section 4.6.3.4.

PostProcessing→Graphical Results→Edit Plots →Delete Selected Series

The command *PostProcessing→Graphical Results→Edit Plots →Delete Selected Series* is used to remove the selected series from the plot. This can also be accomplished by clicking the *Delete* button on the graphics form. A description of all functions available for graphics forms is available in Section 4.6.3.4.

PostProcessing→Graphical Results→Edit Plots → Export Plot

The command *PostProcessing→Graphical Results→Edit Plots → Export Plot* is used to save the plot that the user has specified. A variety of formats, such as Excel (*.xls), Windows bitmap (*.bmp), Text (*.txt), JPEG (*.jpg), XML (*.xml), and HTML (*.html) are available. Two of these capture an image of the plot (.bmp and .jpg); the others capture the data that are plotted.

PostProcessing→ Report Results→Manage Custom Reports

The command *PostProcessing→ Report Results→Manage Custom Reports* is used to open the *Manage Reports* form. Sections 4.6.2.3 contains more information.

PostProcessing→ Report Results→Create Summary Report

The command *PostProcessing→ Report Results→Create Summary Report* is used to create a summary report based on probabilities entered by the user on the *General→Output Options→Reporting Options* form for the selected output requests. Output requests are made on forms in the categories *Atmos→Output Control*, *Early→Output Control,* and *Chronc→Output*

Control. Outputs are available only for form entries where *Report Options* is set to *REPORT* or *CCDF & REPORT*. Section 4.6.2.2 can be referenced for more information.

4.2.5 The Window Menu

The *Window* menu shown in Figure 4-23 allows the user to do the following:

- Cascade the parameter modification forms and the plot form windows by selecting the *Cascade* function.
- Change the focus to another window by selecting that window from the numbered list.

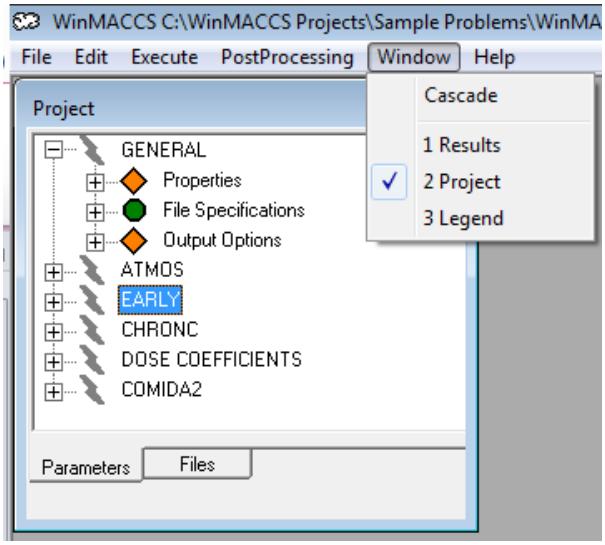


Figure 4-23 Window menu

4.2.6 The Help Menu

Selecting *About* on the *Help* menu, as shown in Figure 4-24 displays the version of WinMACCS.

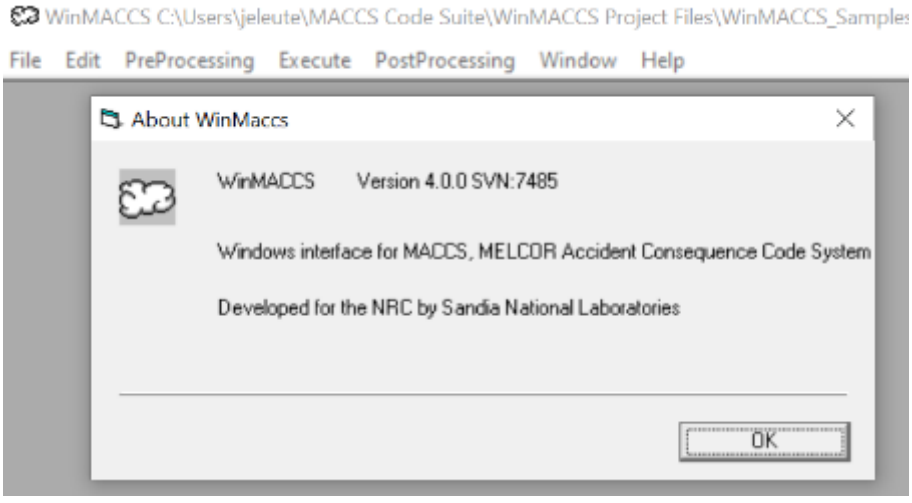


Figure 4-24 Help menu

4.3 Selecting Models on the *Properties Form*

The *Properties* form can be opened by selecting *Edit→Project Properties* from the main menu or by double-clicking on *General*/*Properties/Properties* from the *Parameters* tab in the *Project* window.

Basic model is chosen on the *Properties* form. The parameters affected by the *Properties* form can be viewed, but not modified, by opening the forms *ATMOS/Property Form Parameters, EARLY/Property Form Parameter* and *CHRONC/Property Form Parameters.*

The *Properties* form is automatically opened when a new project is created. Each tab of the *Properties* form has default selections. The user should ensure that the scope and specific model choices on the *Properties* form is aligned with the problem to be solved.

The decisions the user makes at this point determine which parameter forms are required. For example, when the *Late Consequences* module is not selected on the *Properties*/*Scope* tab, parameters in the *CHRONC* category are not required. Consequently, all *CHRONC* parameters in the *Project* window *Parameters* tab have gray icons associated with them. Additionally, all tabs related to the *Late Consequences* module in the *Properties* form also have gray icons associated with them.

Each tab on the *Properties* form has at least one basic model associated with it. There is an icon next to the tab name. The meanings of the icons are as follows:



A solid green octagon means that one or more choices on this tab are required but have already been made either by the user or by default. When any modifications are made on the *Properties* form, the user must click *OK* to save them.



A solid gray octagon with a diagonal line means that the user has completed this tab, but the information is not used in a MACCS calculation given the basic modeling options the user has chosen.



An X-ed red octagon indicates that the model settings on this tab have not been made or are not compatible with model settings on another tab.

Depending on the models selected, some of the radio buttons are disabled on the *Project Properties* form. For example, when *Constant Weather* is selected on the *Weather* tab, the group *File Sampling Method* is visible with the previous choices still showing on the form as shown in Figure 4-25. However, these controls are not available for editing because they are not relevant to the current model choices. This is indicated by light grey lettering and symbols.

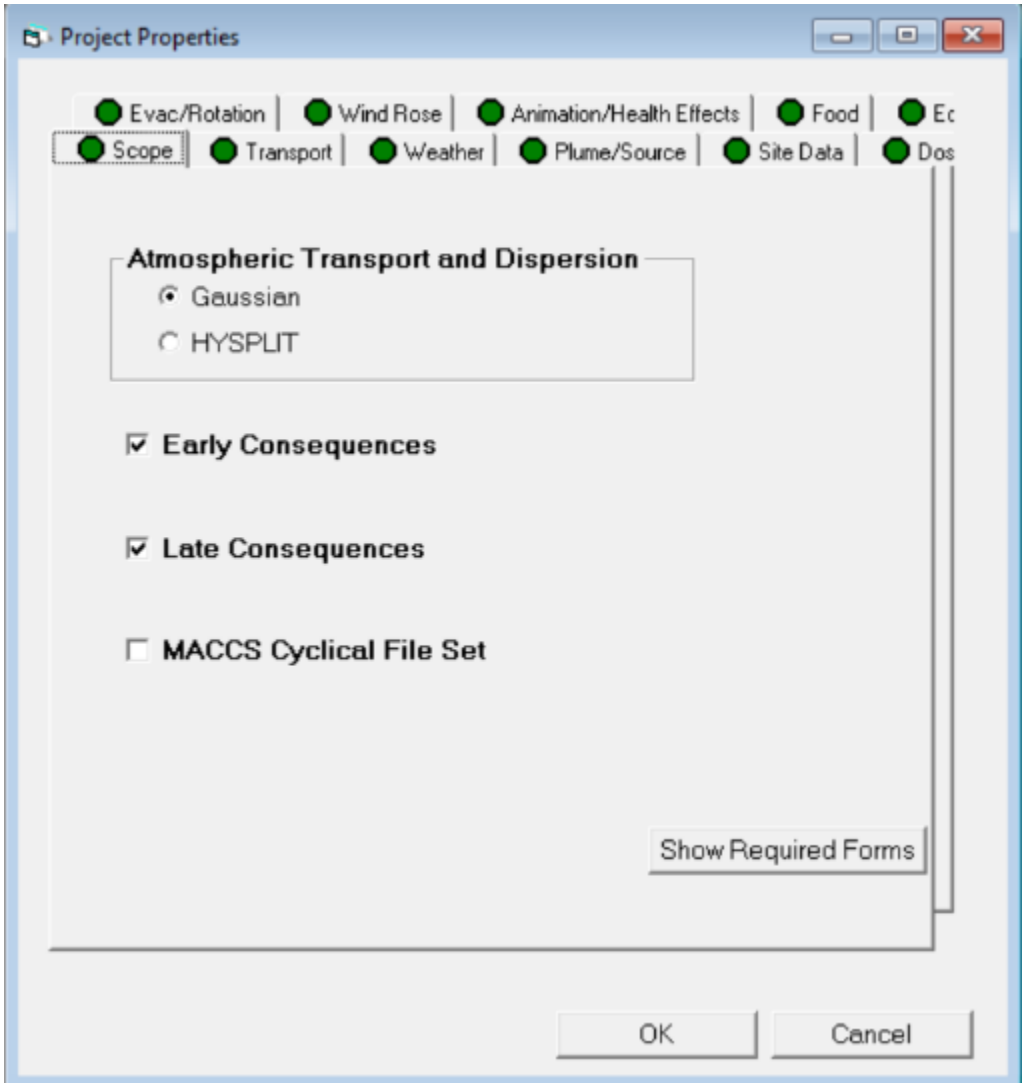


Figure 4-25 Disabled controls on Project *Properties form*

Clicking OK saves any changes that have been made.

Clicking *Cancel* or closing the window ignores changes that have been made.

The *Show Required Forms* button shows which forms in the *Project* window are required when the models selected in the *Properties* form were saved. This does not save any changes but is a visual tool to help the user understand what input are required with the currently selected options.

In Figure 4-26, *Radial* is selected and *Show Required Forms* is clicked. As a result, the *Radial Evacuation Speed* form link on the left changes from a gray octagon to an X-ed red octagon. This indicates that additional information is required for the *Radial Evacuation Speed* form and some form(s) in the *Additional Emergency Cohorts* category when *OK* is clicked, and this model option is saved.

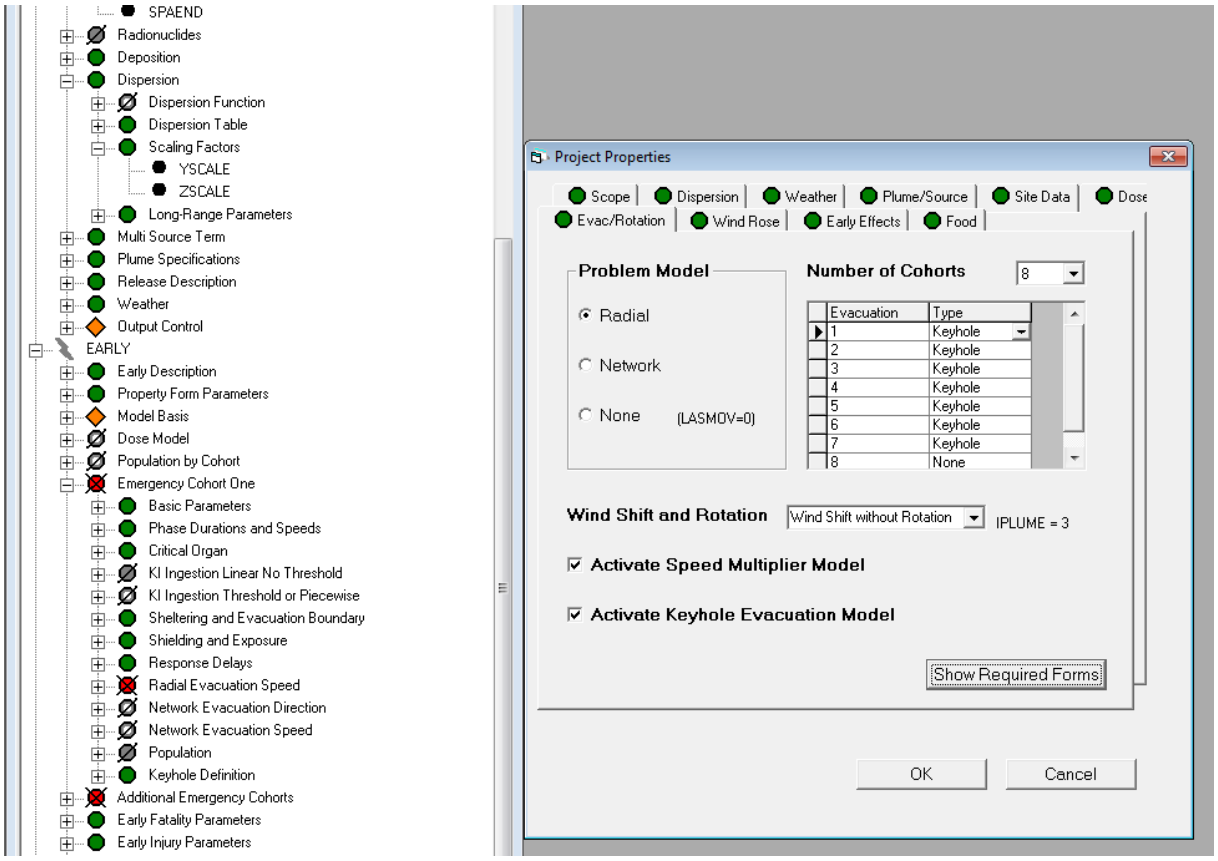


Figure 4-26 Relating model selection to forms

4.4 Modifying Parameters

A parameter modification form can be opened in one of two ways:

- By double-clicking on the parameter name or the form name containing the parameter found on the *Parameters* tab in the *Project* window.

- By selecting the parameter name in the *Find or Export Parameters Form* and clicking *OK*. The *Open Parameter Form* can be opened as shown in Figure 4-18 or by selecting *Edit→Find or Export Parameters…* from the main menu. See Section 4.2.2 for more information.

4.4.1 Generic Parameter Modification Forms

There are generic parameter modification forms and custom parameter modification forms, such as the forms to manage evacuation directions, evacuation speeds, and reports. This section describes the generic parameter modification forms.

The following are the main components of a parameter modification form as shown in Figure 4-27:

- Enter Comments: Optional comments can be entered in this field. A possible usage is to enter comments related to the justification or derivation of parameter values.

-  : Clicking clears all values on the form.

- Data entry area: The portion of the form where values are entered. These areas have a white background. Figure 4-27 shows examples for values of YSCALE and ZSCALE.

- Description area: Describes the data type, limits, and units of the parameter that has focus on the form. Below this is a brief description of the variable.

- *Change Units*: This button is used to change parameter units. See Section 4.4.2 for a further discussion.

- *Make Uncertain*: This button is used to associate a probability distribution with a variable. Most real-valued parameters can be specified as uncertain. To change the value of a parameter to uncertain, the user can either double-click on the text box or cell or click *Make Uncertain*. This function is also used to change a parameter from uncertain back to a constant.

- Clicking *OK* or *Cancel* closes the form. *OK* accepts any changes; *Cancel* ignores them.

All the data on the form must be entered before the user can save any of the values on the form. When a box is left blank, and *OK* is clicked, an error message pops up. This serves as a reminder to complete the form before clicking *OK* to save the values.

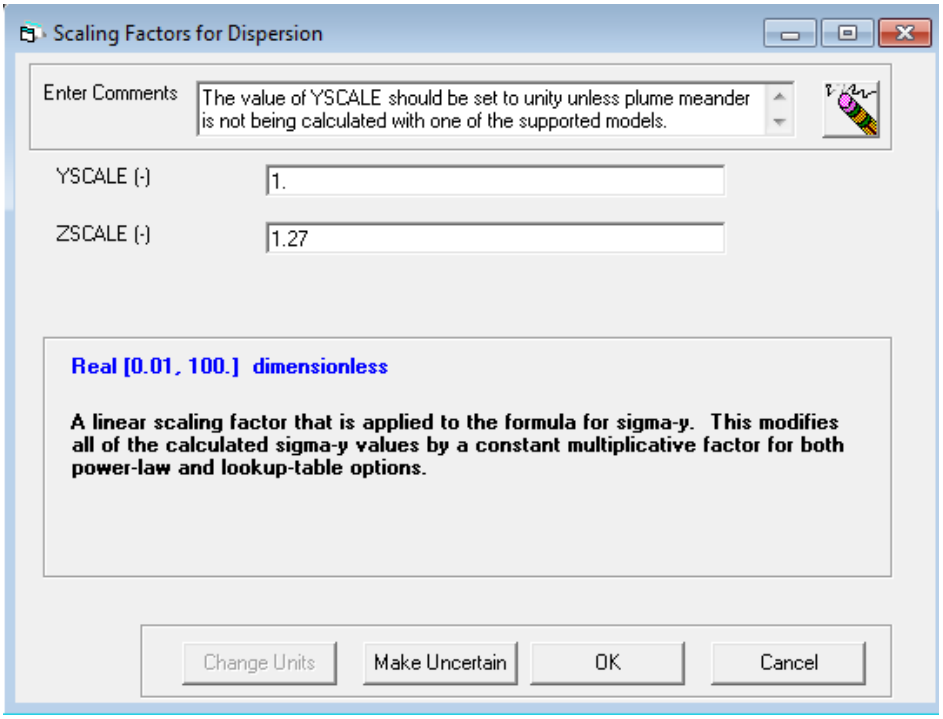


Figure 4-27 Parameter modification form

4.4.1.1 Modifying a Data Grid

Arrays and vectors are displayed in data grids. Data grids support the following operations:

- A row is selected by clicking on the small box between the row number and the values.

- A column is selected by clicking on the column heading.

- A row is deleted by pressing the Delete key on the keyboard after selecting the row.

- A change to a row can be undone by pressing the Esc key on the keyboard if the pencil icon is shown on the left margin of a row.

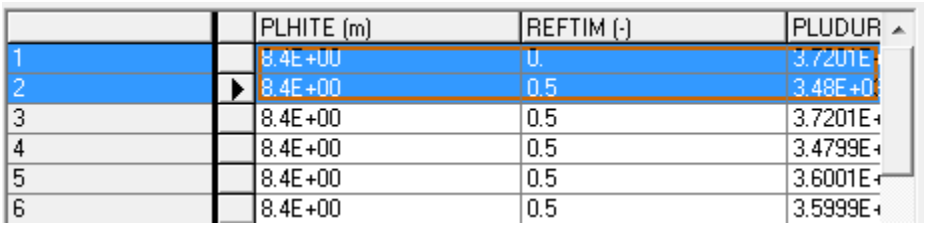
- Clipboard functionality is provided. To use the copy feature in the grid, select the desired data from the grid with a mouse down, drag, mouse up motion. Figure 4-28 illustrates a selected area in the grid. To copy the data in this selected area to the Windows clipboard, select the *Edit→Grid→Copy to Clipboard* function from the main menu. Similarly, the *Edit→Grid→Paste from Clipboard* function can be used to replace a selected area in the grid with data on the Windows clipboard. This function can be used to transfer data from an Excel spreadsheet into WinMACCS.

- Rows can be selected in a non-contiguous fashion by holding the control-key down while clicking on rows for selection. Non-contiguous rows can also be selected for pasting in the same way. In other words, not only can non-contiguous rows be selected for copying, but the affected rows for the past operation can also be selected.

- Columns can be selected; however, they must be contiguous. When pasting, the area defining the paste is required to be contiguous.

- A rectangular area can be selected for pasting by pressing the left mouse button down and dragging over the desired grid data.

- Copy and paste functions are supported with keyboard shortcuts Ctrl-F and Ctrl-G, respectively.



		PLHITE (m)	REFTIM (-)	PLUDUR
1		8.4E+00	0.	3.7201E
2	▶	8.4E+00	0.5	3.48E+0
3		8.4E+00	0.5	3.7201E
4		8.4E+00	0.5	3.4799E
5		8.4E+00	0.5	3.6001E
6		8.4E+00	0.5	3.5999E

Figure 4-28 Selecting grid data for copy and paste

When modifying a grid on a parameter form, it may be desirable to insert rows or columns. A row may be inserted by using the menu item *Edit→Grid→Insert Rows*. A column may be inserted by using the menu item *Edit→Grid→Insert Columns.*

4.4.1.2 Supported Data Types

The following data dimensions are supported:

- Scalar data: single values that are associated with variables. A scalar can have various types, as listed below.

- Vector data: singly subscripted variables. Multiple vectors are sometimes displayed on the same grid when each of the vectors has the same number of rows.

- Array data: multiply subscripted variables. Only one array is displayed on a grid.

The following types are supported:

- Integer: a number with no decimal point. An integer can be positive, negative, or zero.
- Real: a number that has a decimal point.
- Logical: value is either *True* or *False*. Choices are selected from a pull-down menu.
- Characters: a character string. Size requirements are shown in blue letters below the data entry area.
- Drop-Down Menu: possible values are displayed as a pull-down menu. Only a portion of the name needs to be typed. For example, on the ATMOS/Output Control/Spatial *Intervals for Output* form, typing a “c” for *CCDF* or an “n” for *NONE* and advancing to another field completes the data entry for the *CCDF* field.
- File: a file name is specified by clicking the browse button on the parameter modification form. The selected file is copied to the project\data\ folder.
- Linked Variables: the values of some parameters are vector or array sizes calculated by WinMACCS. For example, NUM_DIST is the length of the vectors DISTANCE, SIGMA_Y_A, etc. This parameter cannot be directly modified. When a linked parameter has focus, a description is displayed in the description area of the form. The value of the parameter is updated as the number of grid rows increases or decreases. Linked parameters are of type Integer but can only take on positive values. Parameter MAXGRP shown in Figure 4-29 is an example of a linked variable.

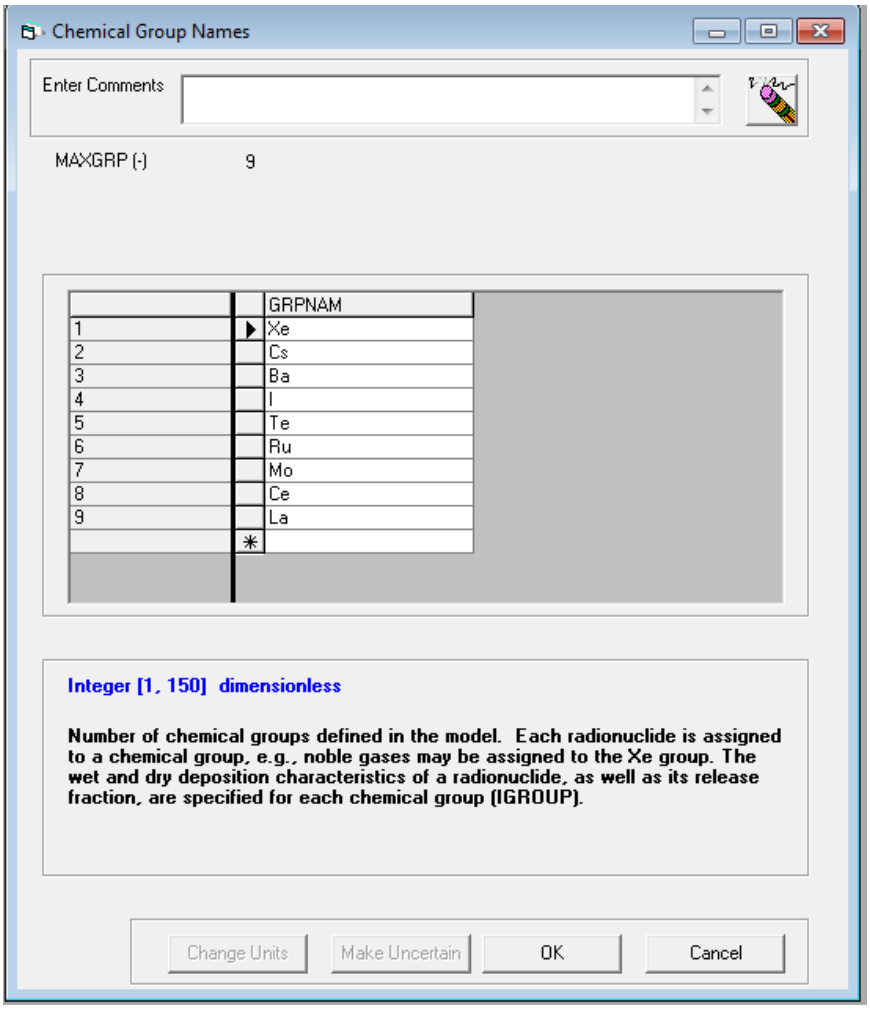


Figure 4-29 Example of a linked variable, MAXGRP

Note: A gray background in an input area indicates that the parameter is read-only and cannot be changed on that form.

Examples of the data type and bounds that could be found in the description area are as follows:

- Real [.01, 100.]: A number between 0.01 and 100, inclusive, must be entered in the text field. This is displayed in Figure 4-30.

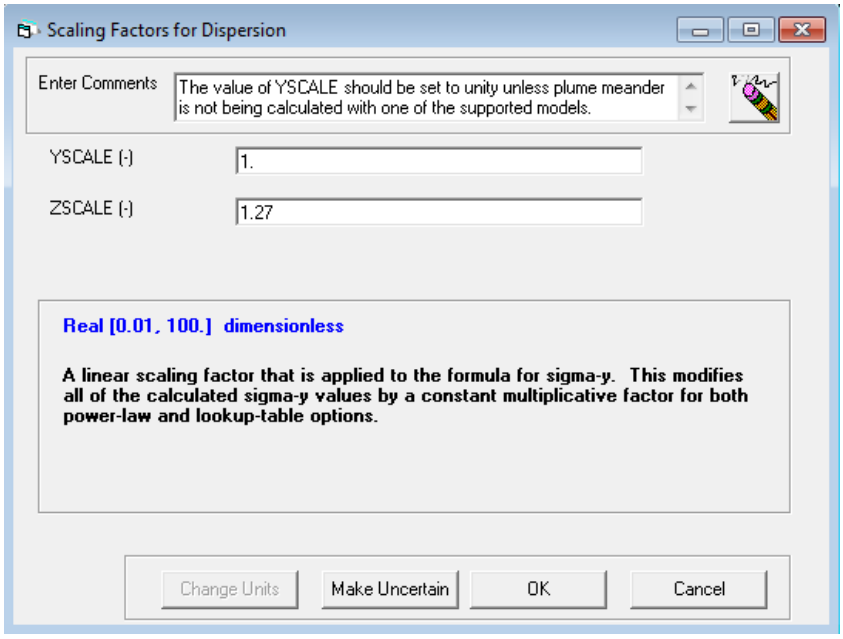


Figure 4-30 Real data type

- Integer [1, NUMREL], (NUMREL=10): An integer value from 1 to 10 must be entered in the text field. When the value of NUMREL, the number of plume segments, is modified and saved on another form, the bounds are changed to reflect the new value of NUMREL as shown in Figure 4-31.

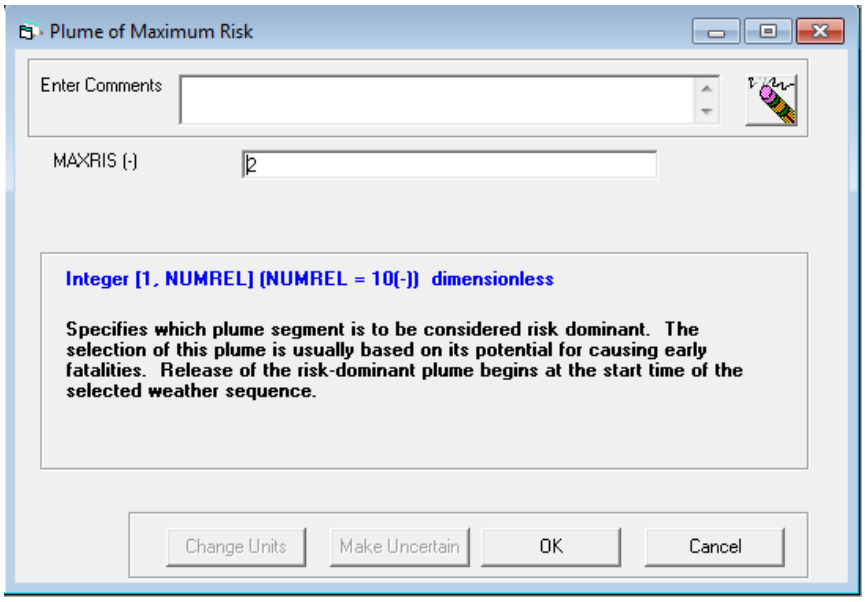


Figure 4-31 Parameter upper bound is a variable

- 1 to 16 Characters: A character string that is at least one character and not more than 16 characters must be entered in the field as shown in Figure 4-32.

- Row Bounds: [1, 10]: The grid must have at least one row and not more than 10 rows as shown in Figure 4-32.

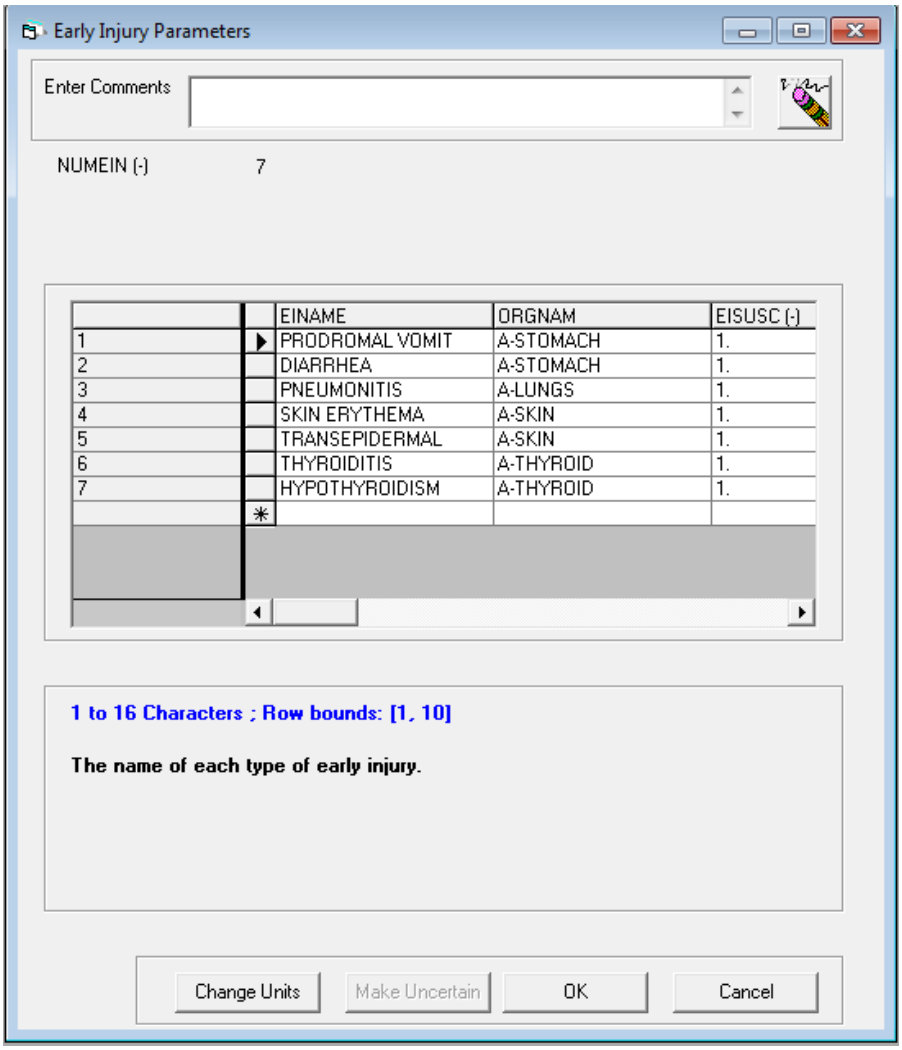


Figure 4-32 Character length limits

- Nrows = 6: The grid must have exactly 6 rows. This is shown in Figure 4-33.

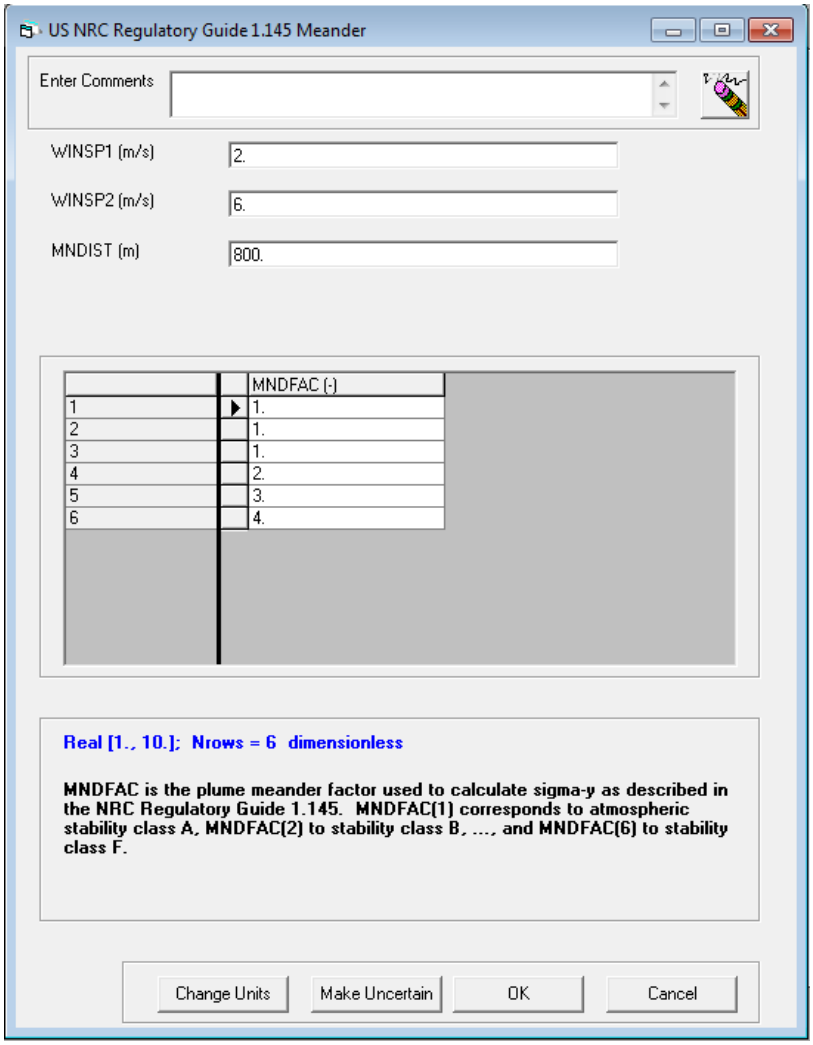


Figure 4-33 Grid with fixed number of rows

4.4.1.3 Making a Parameter Value Uncertain

WinMACCS allows input parameter values to be made uncertain and enables sampling of the uncertain variables. The sampling can be done using either SRS or a stratified method known as LHS. The sampling method can be changed from the default of LHS to SRS by selecting the main menu entry *Execute→Simple Random Sampling.*

The sampling allows the effect of an uncertain input value to be explored. Uncertain parameters must be assigned a distribution function from which samples are selected. The distribution function usually represents degree of belief over a range of values that are considered credible for that parameter.

A parameter value can be made to be uncertain by first opening the window associated with that parameter. This can be done by double-clicking on the parameter name in the *Parameters* tab in the *Project* window or by using *Edit→Find or Export Parameters...* to locate the form.

The user can double-click on the parameter value or click on the parameter value and then click on the *Make Uncertain* button. An example uncertain parameter form is shown in Figure 4-34. A form then opens with the parameter name in the form title (or caption). Use this form to:

- Change parameters from constants to uncertain values described by probability distributions.

- Change parameters from distributions to constants.

- Change the probability distribution associated with the variable.

Notice that the parameter name is shown in the form caption. When an array or vector element is associated with a distribution, the index is also part of the name shown in the title bar. In Figure 4-34, BUILDH(3) in the caption portion of the form indicates that the third value of vector BUILDH is being considered.

WinMACCS supports a wide range of distribution types, and each distribution type can accept a range of values for its parameters. It is possible to specify values for the distribution that lead to invalid parameter values, causing sampling to fail. The parameter values that define the distribution should chose so that they do not lead to values out of range for the input parameter being sampled (e.g., a negative value for a MACCS parameter that must be greater than zero).

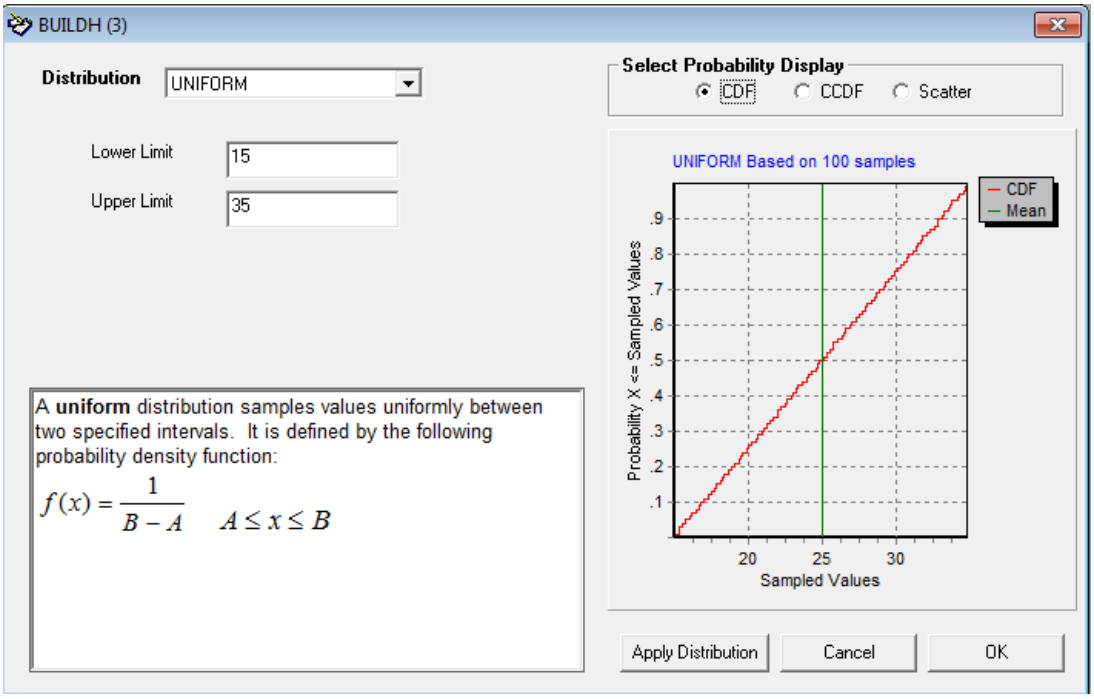


Figure 4-34 Assigning a probability distribution to a parameter

The value of an uncertain parameter can be modified as follows:

(1). The user first selects the distribution from the *Distribution* pull down list. The parameter can be changed from uncertain to constant (deterministic) by setting the distribution to CONSTANT.

(2). The user enters the values that define the distribution in the text boxes or tables. The type of distribution determines the amount and type of information needed to define the value. The values that define the distribution either consist of a list of (x, y) pairs (known as tabulated data), or a list of parameters (such as the mean and standard deviation of a normal distribution). An example is shown in Figure 4-35.

A representative sample of the current distribution can be viewed by clicking *Apply Distribution*, which causes LHS to run and create one hundred samples, and the samples to be displayed. The sampled values can be viewed as a CDF, CCDF, or a scatter plot. The mean of the distribution is shown in each view as a vertical green line. The sampled values used when running an uncertain calculation may differ from those shown on this graph because the number of samples and the value of the seed may not be the same.

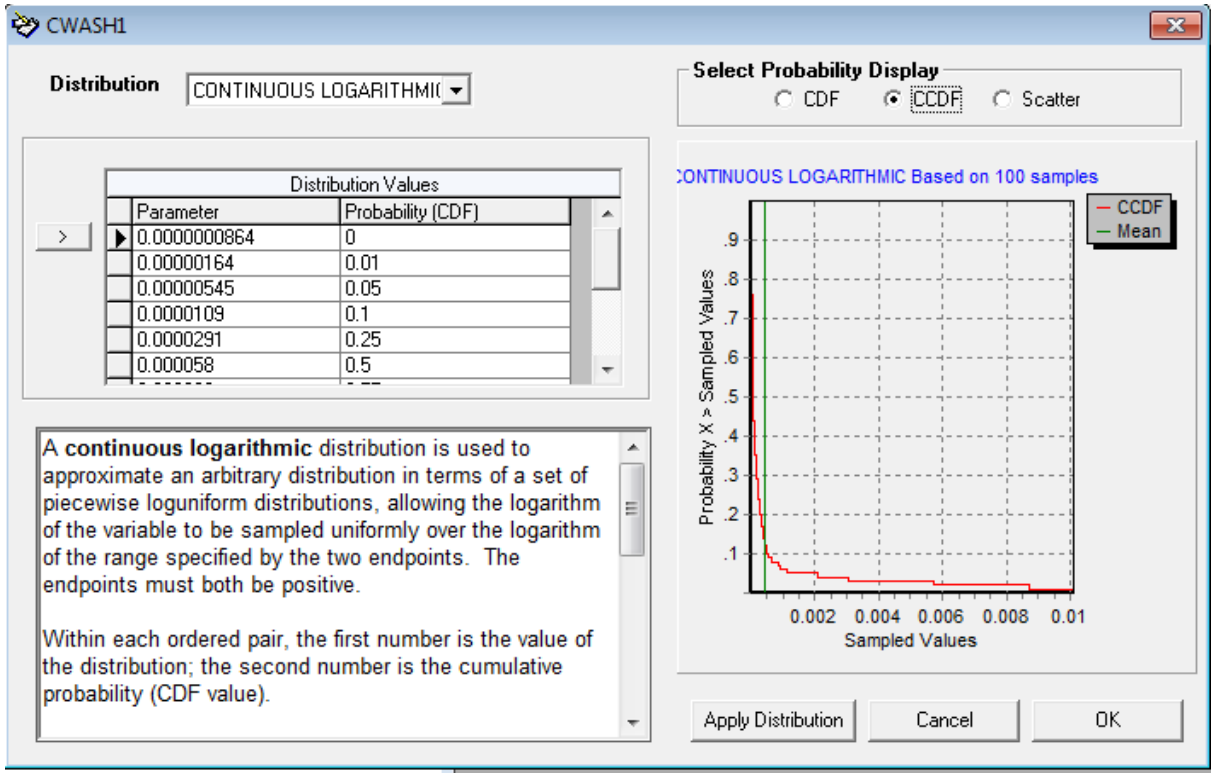


Figure 4-35 Tabulated uncertain parameters

(1). A row of tabulated data can be deleted by clicking on the left margin of the row to select it and by pressing the delete key on the keyboard.

(2). By pressing the ESC key on the keyboard, typing can be undone if the pencil icon is shown on the left margin of a row.

(3). A row of data can be inserted by selecting an existing row and clicking the row insert button ().

(4). By using the left or right arrow key on the keyboard, focus can be moved to an adjacent cell. The Enter key also advances the curser to the next cell.

(5). The *OK* button can be clicked shown in Figure 4-34 or Figure 4-35 can be clicked to save changes and close the window. The value of the parameter in the parameter modification form is set to the character string "Uncertain" and has a different colored background than constant values on the form, as shown in Figure 4-36.

(6). Changes can be discarded by selecting Cancel.

	PDELAY (s)	PLHITE (m)	REFTIM (-)
	34360.	39.64	0.E+00
▶	34368.	4.04	UNCERTAIN
	35020.	39.64	.5

Figure 4-36 Uncertain parameter on a parameter modification form

To view the set of parameters that were sampled after running MACCS, the user can open the LHS.inp file by clicking the *Files* tab, open the *Input* category, and double-click on the file name LHS.inp. The values used in the MACCS simulation can be viewed by examining the contents of the LHS.out file.

4.4.2 Changing Units

WinMACCS allows the user to change units. There are three different types of unit changes, namely input units on a parameter modification form, input units on forms defining cohort parameters, and output units used in MACCS reporting.

Unit changes are integrated into other WinMACCS functions as follows:

- The function that imports MACCS input files into the user interface (menu selection File/Import MACCS Input File) converts values to user specified units on each form.
- The reset to default function (right click on form name and select *Reset to Default*) respects units chosen by the user and converts default values to specified units.
- Uncertain parameter distributions must be changed by the user to be in the units specified on the form. In other words, when the units are changed on a form with an uncertain variable, the distribution is not automatically modified to be in the new units; the user is responsible to convert the distribution to the new units.
- Parameter bounds reflect the units selected on the parameter modification form.
- Map forms (*Network Evacuation Direction, Network Evacuation Speed,* and *Populations Assigned*) show values and units labels (km, mi, etc.) in specified units.

4.4.2.1 Modify the Input Units for Non-Cohort Variables

The user can change input units for many of the input forms by using the *Change Units* button on a parameter modification form, as shown in Figure 4-37. Each dimensioned parameter in WinMACCS is assigned to a unit family. The user can change input units and convert existing values to the new input units that belong to the family assigned. When there are no parameters on the form with units that can be changed, this button is grayed out. The *Change Units* button is always grayed out on the cohort specific forms since those units are changed on the *Cohort Units* form, as described below.

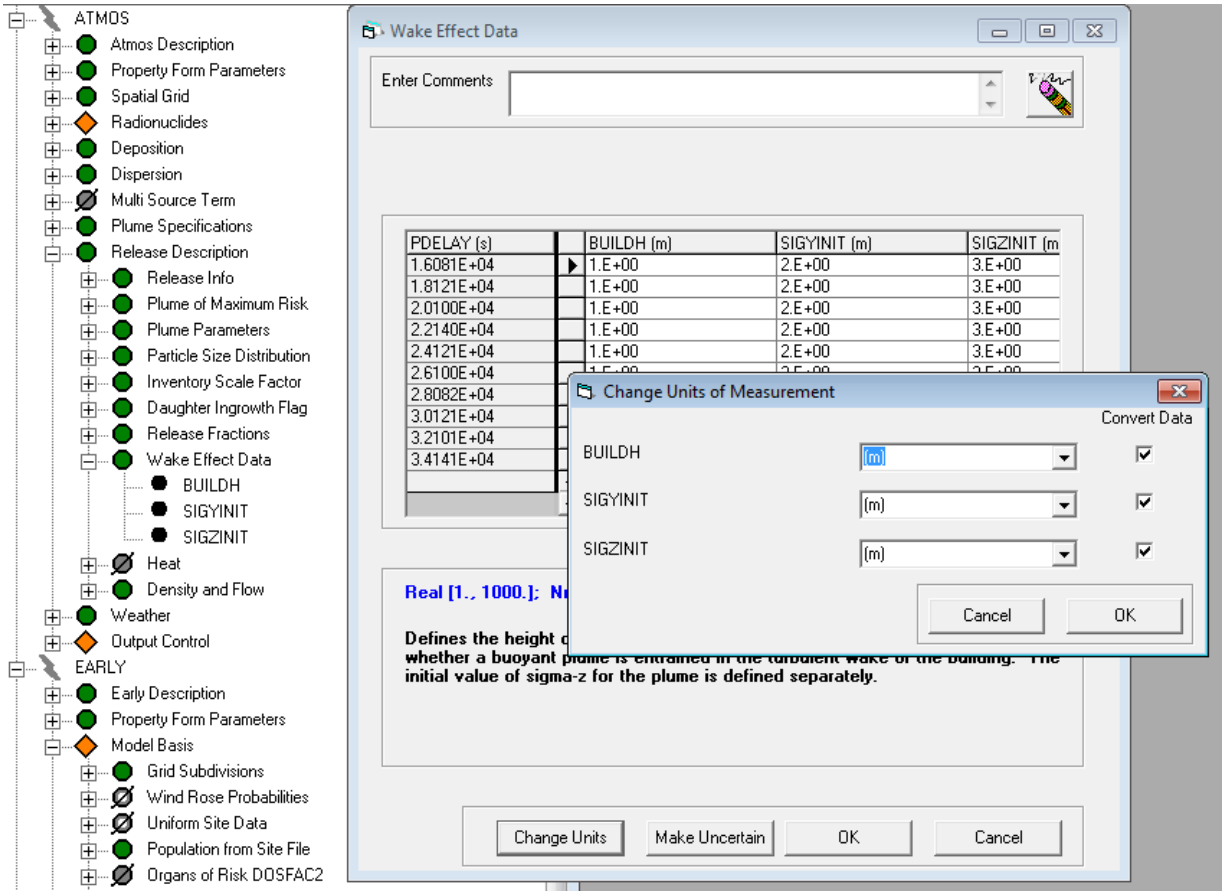


Figure 4-37 Changing units on a parameter form

When building MACCS input files, input parameter values are converted to standard MACCS input parameter units, which are the same as the default units shown in Table 4-1. Thus, MACCS input files retain their default units and input unit conversion is handled by WinMACCS.

Table 4-1 Default and optional units for MACCS reporting.

Unit Family	Default Unit	Optional Units
Activity	Bq	Ci
Distance	km	mi
Area	ha	km^2, mi^2
Dose	Sv	Rem

4.4.2.2 Modify the Input Units for Cohort Variables

To avoid confusion, units are not allowed to be different between the sets of cohorts. To enforce this requirement, there is one form used to specify units for all parameters associated with cohort definitions. This form is opened by clicking on the *EARLY/Model Basis/Cohort Units* entry as shown in Figure 4-38.

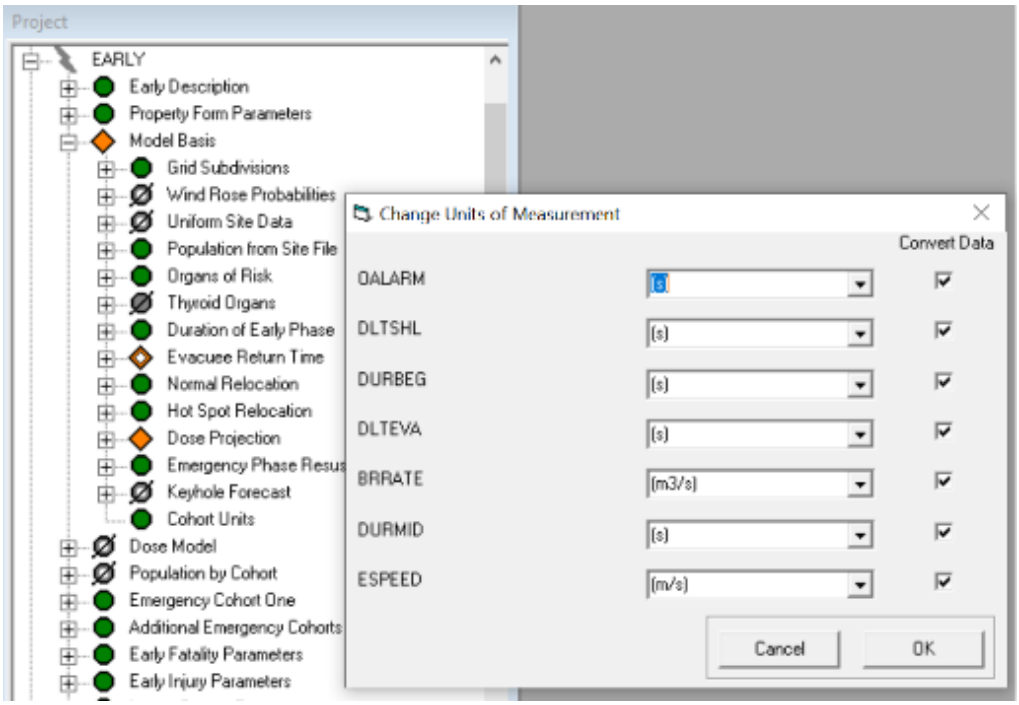


Figure 4-38 Assigning units for cohort parameters

4.4.2.3 Modify the Output Units for MACCS reporting

The form shown in Figure 4-39 allows the user to request results to be reported in the optional units. This applies to both text and binary output files created by MACCS.

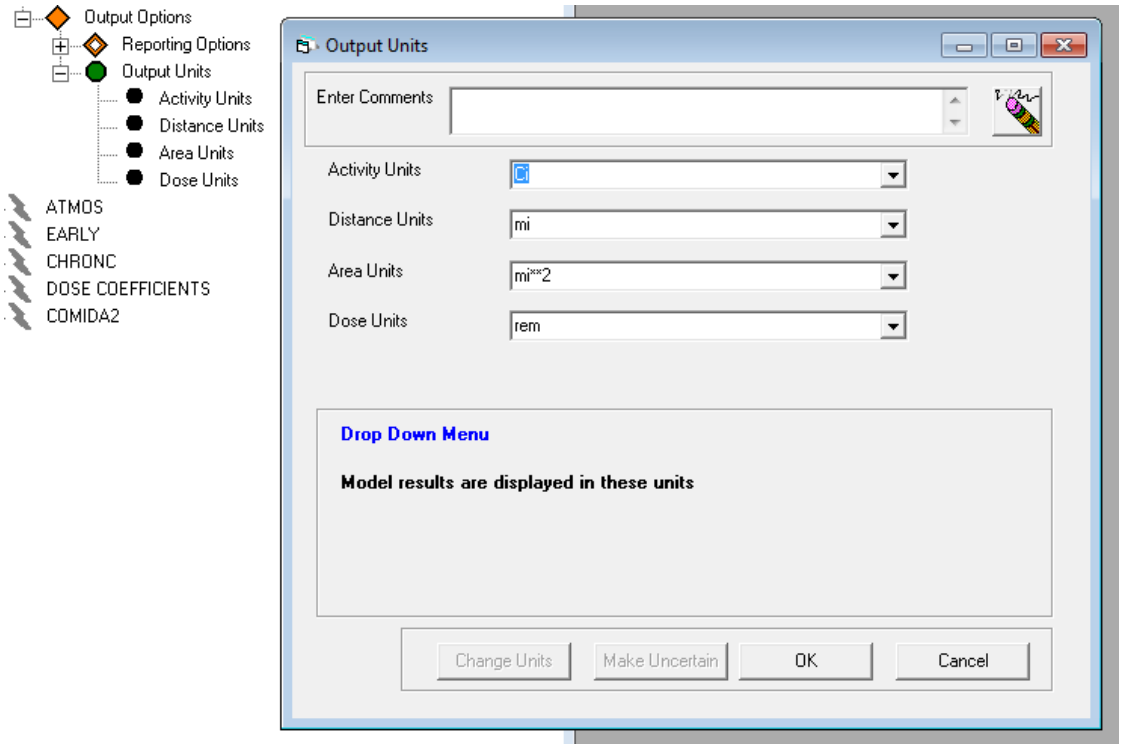


Figure 4-39 Specifying MACCS reporting units

4.4.3 Correlate Uncertain Parameters

In many cases, sets of uncertain input parameters are correlated.

WinMACCS allows two methods for correlating uncertain input variables. The first uses rank correlations; the second method performs a direct rank reordering of one parameter and is described in Section 4.4.3.2.

To correlate parameters that have been chosen to be uncertain, select *Edit→Correlate Uncertain Variables→Linear Coefficients* from the main menu. This opens the *Correlate Uncertain Variables* form, which lists each rank correlation coefficient that is currently defined and allows new correlations to be defined.

4.4.3.1 Correlation Using LHS

After LHS (the code, not necessarily the method) has run and imposed correlations specified by the user, WinMACCS can reorder some of the parameters to be consistent with the rank order of other variables. This is a desirable feature when it is desired to impose a perfect correlation (either in the same or inverse order) between two sets of variables. LHS does not support perfect correlation (i.e., values of -1 or +1 are not allowed).

The command Edit→Correlate Uncertain Variables→Linear Coefficients opens the *Correlate Uncertain Variables* form as shown in Figure 4-40.

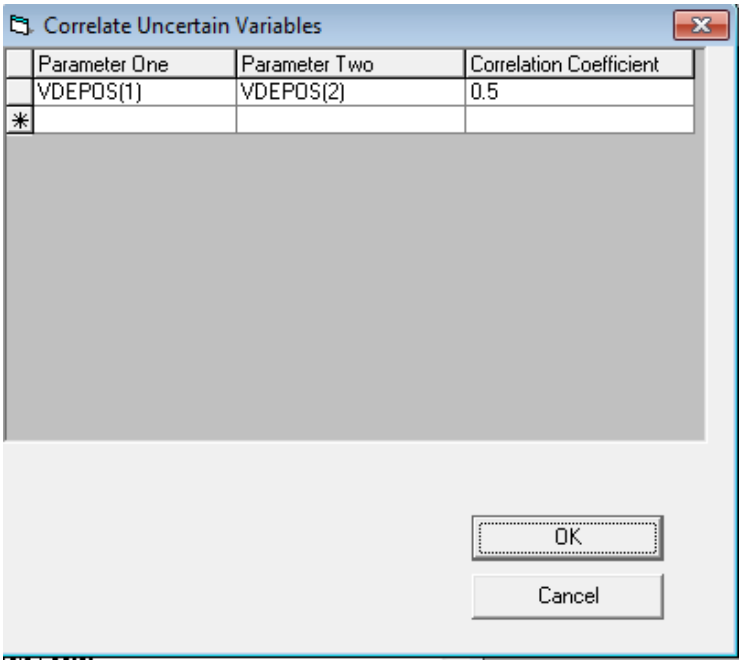


Figure 4-40 Correlate uncertain variables

Correlations can be added by doing the following:

(1). By clicking in the grid element in the *Parameter One* column, an uncertain parameter can be selected.

(2). By clicking in the grid element in the *Parameter Two* column, the uncertain parameter to correlate with *Parameter One* can be selected.

(3). The rank correlation coefficient for the two selected parameters is entered in the third column.

Parameters can be positively or negatively correlated by specifying a correlation coefficient within the range (-1.0, +1.0), where the values -1.0 and 1.0 are not allowed. The correlations apply to the ranks of the parameter values rather than to the values themselves.

When any two parameters are uncorrelated, they have an implied correlation coefficient of zero, which is the default. Implied correlation coefficients are not listed in the table. Correlations can be removed (i.e., set to zero) by selecting the grid row and pressing the delete key on the keyboard.

By using the arrow keys on the keyboard, focus moves from cell to cell in the grid.

Clicking *OK* preserves changes. Clicking *Cancel* discards changes.

WinMACCS creates a report titled SampleRank.out in the project Input/ folder that summarizes the correlations and the order and values of the uncertain parameters used in the MACCS simulations.

There are some restrictions on the correlations that WinMACCS allows. For example, it doesn't make sense to rank correlate two variables, say A and B, with a coefficient, and impose a rank order of B with respect to the order of A. WinMACCS does not allow the same pair of parameters to be rank correlated (as described in Section 4.4.3.2) and also to be reordered.

It is possible to specify combinations of rank correlations that are not mutually consistent. Such inconsistencies are generally in the form of circular correlations. For example, two parameters "A" and "B" can be assigned a correlation coefficient of 0.99, parameters "B" and "C" can also be given a correlation coefficient of 0.99, but parameters "A" and "C" can be assigned a correlation of -0.99. Each correlation is valid by itself, but the three are logically incompatible. Omitting any correlation between parameters "A" and "C" implies a correlation coefficient of zero, which is also incompatible with the other two correlations. The parameter sampling in LHS may fail when circular correlations are incompatibly defined.

This option does not accommodate perfect correlation of two parameters. The command *Edit→ Correlate Uncertain Variables→ Enforce Rank Order,* described in the following subsection, enforces a perfect correlation between two or more parameters.

4.4.3.2 Enforcing Rank Order

Selecting *Edit→Correlate Uncertain Variables→Enforce Rank Order* from the main menu allows ordering parameters that have been chosen to be uncertain. This opens the *Enforce Rank Order of Uncertain Variables* form shown in Figure 4-41, which lists each rank correlation that is currently defined and allows new correlations to be defined.

Rank orders are specified as follows:

(1). The *Enforce Rank Order of Uncertain Variables* form is opened by selecting *Edit→Correlate Uncertain Variables→Enforce Rank Order*.

(2). In the column labeled *Reorder Basis*, the user selects the first uncertain variable. The vector of values for this parameter is not reordered.

(3). In the column labeled *Reorder Parameter*, the user selects the uncertain parameter to be reordered.

(4). In the column labeled *Rank Order* the user selects either *Inverse Order* to order the parameter in the inverse order of the basis parameter or *Same Order* to order the parameter in the same order as the basis parameter.

(5). As many entries as needed may be added to the table.

(6). Clicking *OK* preserves changes. Clicking *Cancel* discards changes.

Rows can be deleted by selecting the grid row and pressing the delete key on the keyboard. The arrow keys can be used to move from cell to cell in the table.

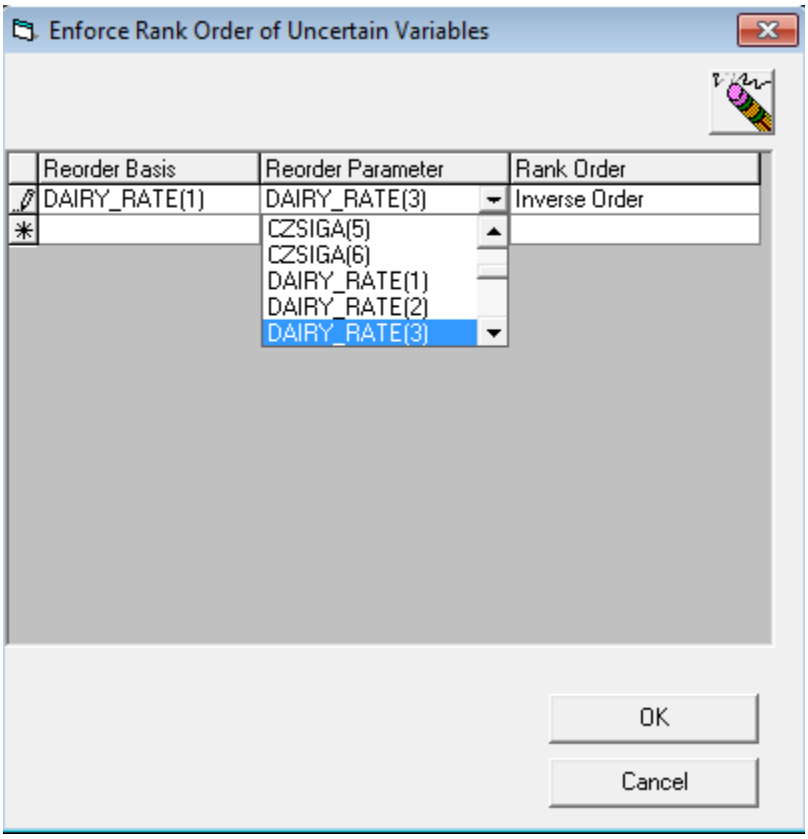


Figure 4-41 Enforce Rank Order form

In the example shown in Figure 4-42, a perfect positive correlation is imposed between ATMOS parameters BUILDH(1) and SIGZINIT(1), and a perfect negative correlation is imposed between COMIDA2 parameters DAIRY_RATE(1) and DAIRY_RATE(3). This causes the values of DAIRY_RATE(3) and SIGZINIT(1) to be reordered.

After execution, LHS.out can be opened by double clicking the entry LHS.out found on the *Files* Tab in the *Input* category. Sample values from LHS.out are shown in Table 4-2.

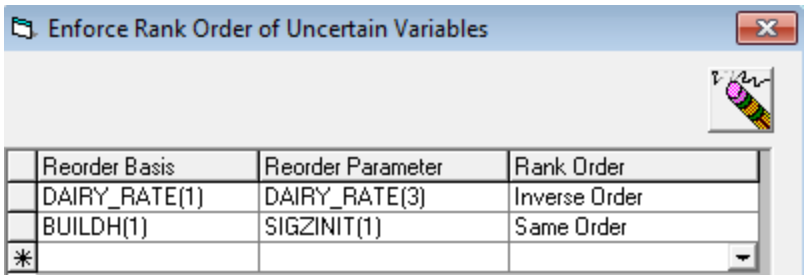


Figure 4-42 Enforce Rank Order example

Table 4-2 Sample values LHS output file.

Trial No.	BUILDH(1)	DAIRY_RATE(1)	SIGZINIT(1)	DAIRY_RATE(3)
1	249.675	5.81245	295.12	9.16814
2	123.061	10.1165	281.956	10.3411
3	180.287	15.7363	338.324	12.1482
4	214.842	21.8037	267.811	13.5931
5	188.622	19.2878	312.628	5.65193

The actual order used in the sequence of MACCS simulations is shown in SampleRank.out, which is found in the project Input folder. In this example, the rank order is shown in Table 4-3.

Table 4-3 Sample values after enforcement of rank order prescribed in Figure 4-42.

	Value	Rank	Value	Rank	Value	Rank	Value	Rank
Trial No.	BUILDH(1)		DAIRY_RATE(1)		SIGZINIT(1)		DAIRY_RATE(3)	
1	249.675	5	5.81245	1	338.324	5	13.5931	5
2	123.061	1	10.1165	2	267.811	1	12.1482	4
3	180.287	2	15.7363	3	281.956	2	10.3411	3
4	214.842	4	21.8037	5	312.628	4	5.65193	1
5	188.622	3	19.2878	4	295.12	3	9.16814	2

This table lists the values used in each MACCS simulation. For example, for trial number 3 (corresponding to the output file Model3.out), BUILDH(1) is set to 180.287 and SIGZINIT(1) is set to 281.956.

Notice that values of BUILDH(1) and DAIRY_RATE(1) are preserved from the order listed in the LHS output. However, values for SIGZINIT(1) and DAIRY_RATE(3) have been reordered so that the rank order for SIGZINIT(1) is the same as that of BUILDH(1), and the rank order of DAIRY_RATE(3) is the inverse of that for DAIRY_RATE(1).

WinMACCS creates a report titled SampleRank.out in the project Input/ folder that summarizes the correlations and provides the order and values of the uncertain parameters used in the MACCS simulations.

4.4.4 Copy Values between Cohorts

Cohort forms are forms that are in the *EARLY/Emergency Cohort One* and *EARLY/Additional Emergency Cohorts* categories. Copying form data from one cohort form to another cohort form can be accomplished by right clicking on the form name within a cohort category and selecting the popup menu item *Copy Cohort Variables* or by using the main menu function *Edit→Modify Form Variables→Copy Cohort Variables*. A dialog box opens as shown in Figure 4-43.

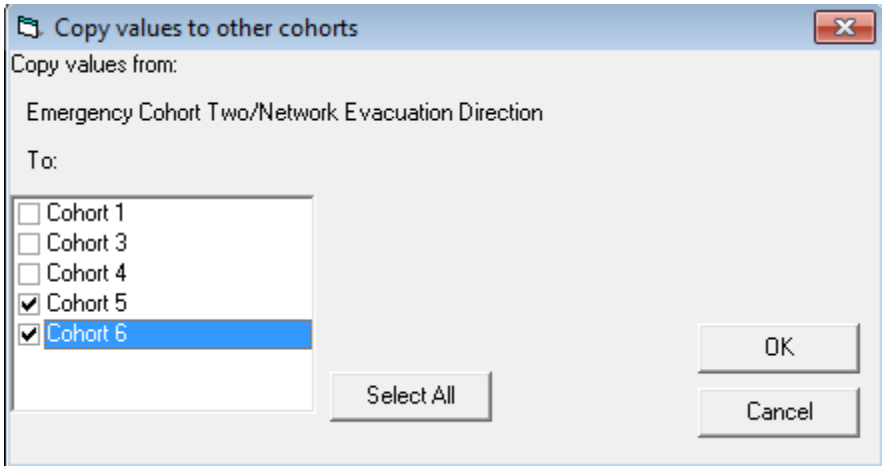


Figure 4-43 Copy values from one cohort form to other cohort forms

In the following example, the user wants to copy all the values in the *Network Evacuation Direction* from cohort two to cohort five and cohort six.

(1). The user first closes forms *Emergency Cohort Two/Network Evacuation Direction, Emergency Cohort Two/Network Evacuation Direction* and *Emergency Cohort Two/Network Evacuation Direction*.

(2). The user clicks on the form name *Network Evacuation Direction* under the category *Emergency Cohort Two*, highlighting the form name as shown in Figure 4-44.

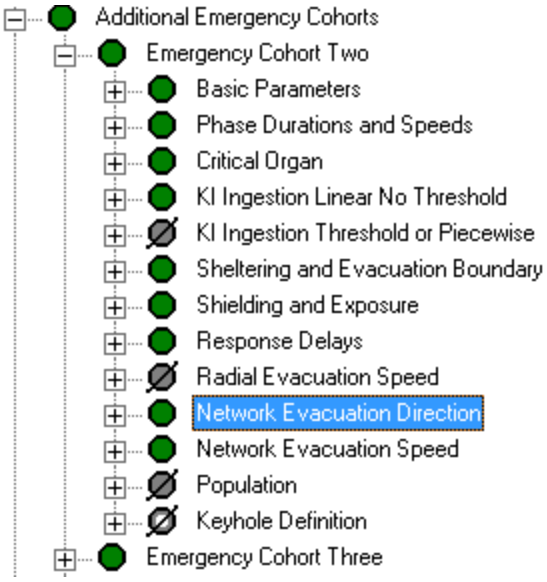


Figure 4-44 Select network evacuation direction form

The user right clicks on *Network Evacuation Direction* and selects the pop-up menu item *Copy Cohort Variables*. Alternatively, *Edit→Modify Form Variables→Copy Cohort Variables* can be selected from the main menu as shown in Figure 4-43. Checking the boxes labeled *Cohort 5* and *Cohort 6* and clicking *OK* replicates the data for this form into the cohort 5 and cohort 6 forms.

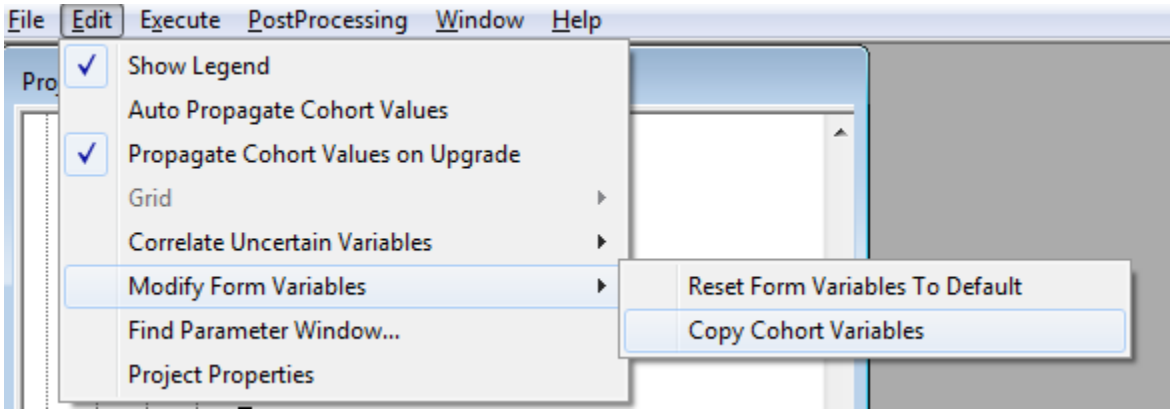


Figure 4-45 Copy form values between evacuation cohorts

(1). When an empty form is selected as the form to copy from (or base form), no data are replaced on the forms selected for application.

(2). When the base form is open and this option is used, the saved values of the parameters are used in the copy. In other words, when the base form is opened and values are changed, when selecting *Edit->Modify Form Variables->Copy Cohort Variables* the values that are copied are the values saved the last time the form's *OK* button was clicked, not the new values just entered.

Comments on forms are not copied or propagated.

4.4.5 Annual Dose Conversion Factor and Annual COMIDA2 Files

When the AT or Piecewise Linear dose-response models are chosen on the Dose tab of the *Project Properties* form, a set of fifty-one DCF files are needed by MACCS. Additionally, when either of these dose-response models is chosen and the *COMIDA2 Food Model* is chosen on the *Food* tab, a set of fifty-one COMIDA2 files are needed by MACCS, each COMIDA2 file having been created with its associated DOSFAC2 file.

WinMACCS is distributed with files sets to be used with the AT or PL dose-response models. The first set is based on DOE/EH-0070 (1988); the second is based on *EPA (2002) Federal Guidance Report No.13.*

The base DCF file is one that contains the conversion factors for a fifty-year commitment period. The base COMIDA2 file is created using the base DCF file.

The annual, differential DCF files contain the DCFs for each year of the 50-year commitment period. These file names are sequenced to enable the identification of the year number. For example, FGR13DCF03.inp corresponds to the DCFs used to calculate the dose in year three for an exposure that occurred in year one. The annual COMIDA2 files are created using the corresponding annual DCF files.

The following example shows how an annual differential DCF and COMIDA2 file set can be specified:

(1). Opening the *GENERAL/File Specifications/Annual Differential DCF Files* form allows the specification of the DCF files as shown in Figure 4-46.

(2). The *Browse* button may be used to select the Base File.

(3). Selecting the base DCF file results in the fields *Base DCF File* and *Expected Auxiliary Files* to be populated. In the example shown in Figure 4-46, the name of the base file is FGR13DCF.inp. The base file name is copied in the box labeled *Base File.* Other file names are generated given this base file following the algorithm of appending the year number to the file name. WinMACCS expects these additional files to be present in the current folder.

(4). *OK* can be clicked to save the changes. WinMACCS copies the base DCF file and the fifty auxiliary files to the project\Data folder. Click *Cancel* to close this form without saving any changes.

(5). Open the *GENERAL*/*File Specifications/Annual Differential COMIDA2 Files* form and repeat this process to define the COMIDA2 file set when needed

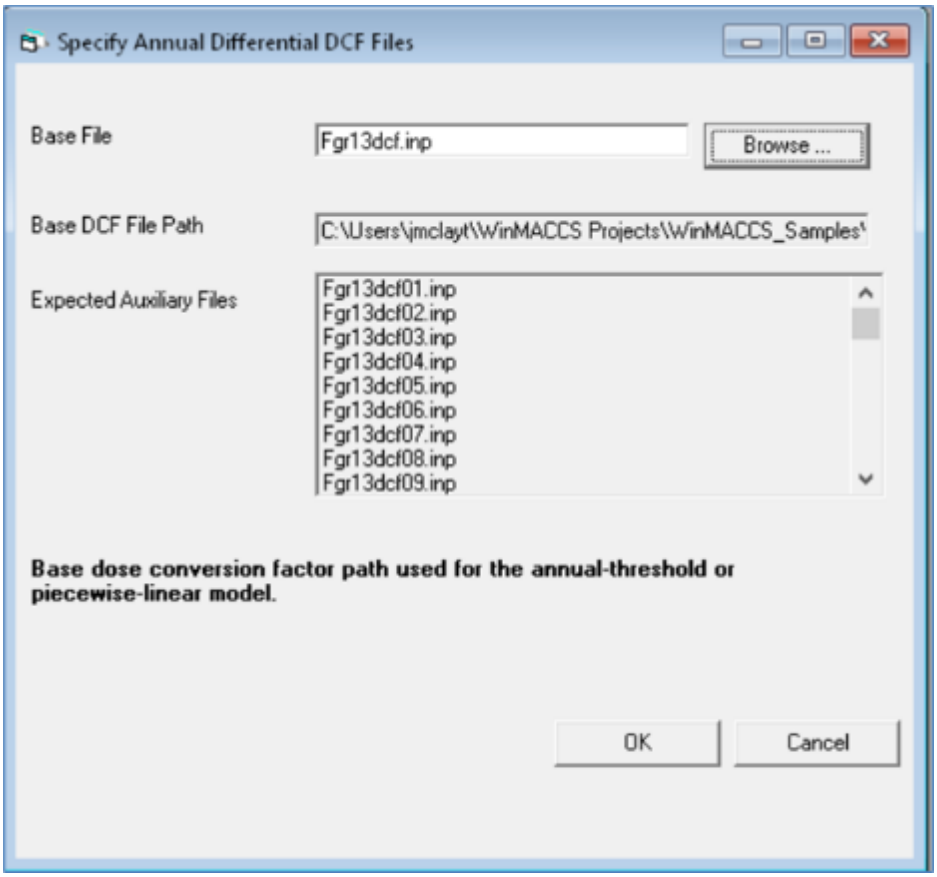


Figure 4-46 Threshold DCF files

4.4.6 Sequential MACCS Files

MACCS input can be changed using successive input files. A single MACCS simulation is run for each of the files specified.

The sequential, or cyclical, files must be formatted consistently as MACCS input files. However, the ATMOS, EARLY, CHRONC, and COMIDA2 input for a single simulation can be combined into a single file.

The parameter values specified in each of the cyclical files are used for a simulation. When a required parameter is not specified, the value of that parameter in the WinMACCS project is used.

Before executing a set of cyclical files, a complete problem description must be defined. Parameter values in the cyclical files override the parameters defined in WinMACCS. Thus, the cyclical files do not need to contain a complete problem description, but only the set of parameters to be modified.

An example of a cyclical file with a source term definition is a MelMACCS output file.

4.4.6.1 Specifying Cyclical MACCS Files

MACCS cyclical input files can be specified as follows:

- The *MACCS Cyclical File Set* model can be selected by opening the *Properties* form, checking the box *MACCS Cyclical File Set* on the *Scope* tab, and clicking *OK*.
- The *GENERAL/File Specifications/Cyclical File Set* form is opened, similar to the form shown in Figure 4-47.
- The location of the MACCS cyclical files should be located by selecting the correct drive and folder.
- Double-clicking on the MACCS cyclical file names adds them to the list on the right side of the window.
- Clicking *OK* saves the file selection. The files are copied to the project Data\ folder. Clicking *Cancel* closes the window without copying any files.

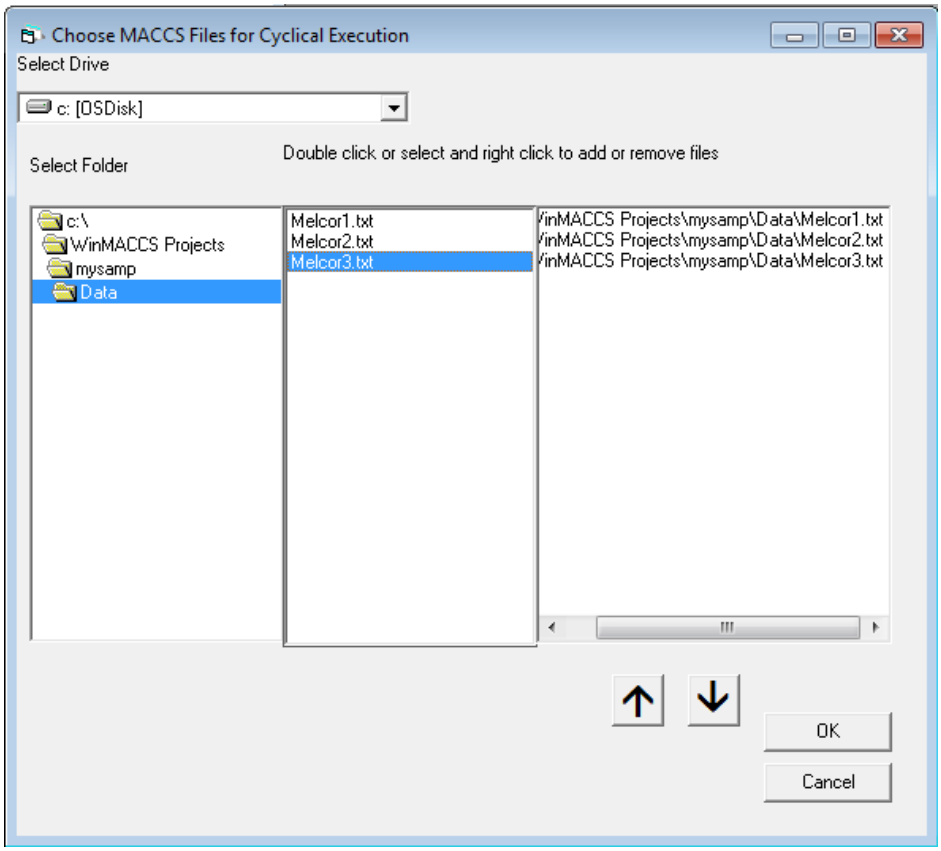


Figure 4-47 Choose input files for cyclical execution

A file can be removed from the cyclical set by selecting the file in the list on the right side of the form, as shown in Figure 4-47, and pressing the *Delete* key on the keyboard.

The order of processing the files by WinMACCS can be changed by selecting the file in the list of cyclical files and using the up and down arrow to change the order the selected file is listed. When MACCS executes, the files are used in the order they appear on this form.

An interface tool named MELMACCS can be used to create MACCS-formatted files that contain source term information extracted from a MELCOR plot file. These files can be specified as cyclical files. In this way, a set of source terms for a plant can be run sequentially.

4.4.6.2 Cyclical Execution with Uncertain Parameters

It is possible to perform calculations with a cyclical file set and to sample uncertain parameters using LHS simultaneously. When this is done, the number of simulations should be set to a multiple of the number of cyclical files. The values from the cyclical files are reused when the number of simulations is greater than the number of cyclical files.

For example, when six simulations are requested, but there are three cyclical files, simulation one and four use the values from the first file, two and five the values from the second file and three and six the values from the last file. LHS generates six sampled value sets and inserts these values into the MACCS input files as expected.

4.4.7 Spatial Grid Forms

Spatial grid forms are applicable in the following situations:

- Evacuation directions are required when network evacuation is enabled.
- When the speed multiplier option has been activated on the *Properties* form, speed multipliers per grid element (i.e., for each direction and spatial distance) can be specified for either the radial or network evacuation models, depending on which option is selected.
- When population by cohort is specified, populations per grid element can be specified. This option is activated on the *Properties* form on the *Site Data* tab.

All spatial grid forms contain the following functions

- A copy of a map with the directions and speed multipliers as is shown in the spatial grid form can be created by clicking on the *Save Map* button as shown in Figure 4-57.
- The map shown behind the polar grid can be hidden by checking the *Hide Map* check box.
- Comments can be entered at the top of the form.
- The inner ring and outer ring controls allow zooming in and out.
- Multiple radii and sectors can be selected using the Windows shift-select and control-select functions. The selected grid elements can be assigned a common value.

4.4.7.1 Evacuation and Speed Multiplier Model

Radial and network evacuation and speed multiplier model parameters are defined using spatial grid forms.

These models can be enabled as follows:

(1). By selecting *Edit→Project Properties* from the main menu, the *Project Properties* form can be opened.

(2). Clicking on the *Evac/Rotation* tab as shown in Figure 4-48 allows the user to select *Radial* or *Network* for the problem model.

(3). The evacuation type needs to be defined for each of the cohorts.

(4). When speeds vary within the evacuation grid elements for either the network or the radial evacuation models, check the box *Activate Speed Multiplier Model*.

(5). Clicking *OK* saves the settings, clicking *Cancel* cancels the settings.

When the *Network* evacuation is selected, the *Network Evacuation Direction* form is required for cohort one. When the *Activate Speed Multiplier Model* is checked, either the *Radial Evacuation Speed* or the *Network Evacuation Speed* form is required for cohort one.

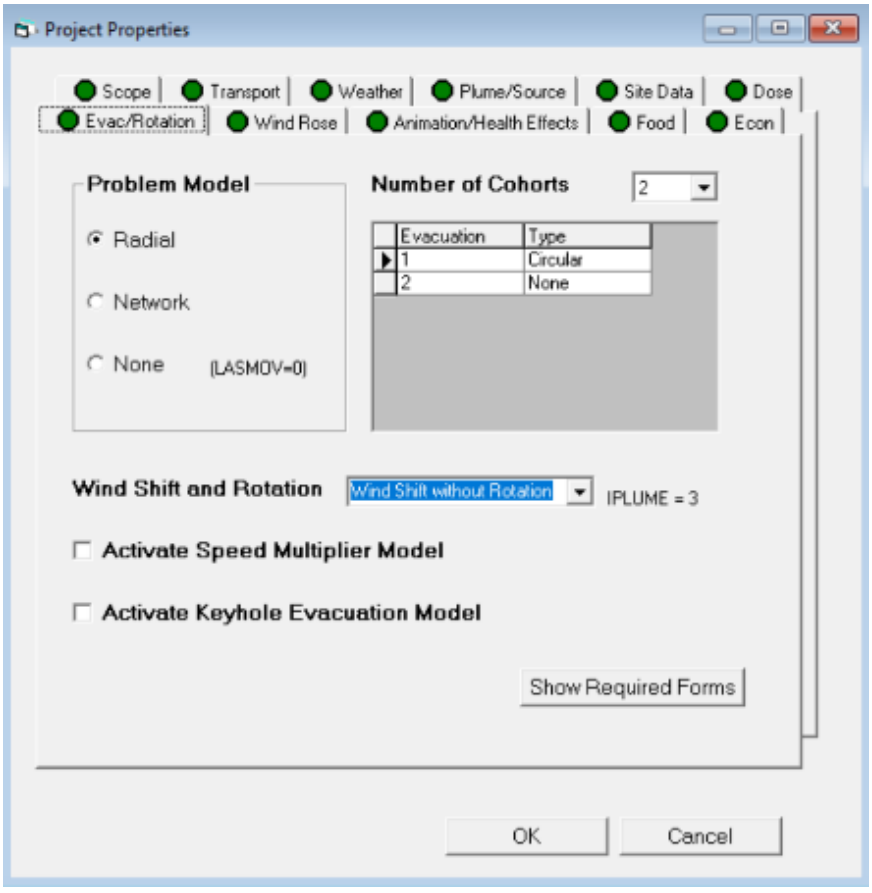


Figure 4-48 Activate speed multiplier model

The parameters SPAEND, as shown in Figure 4-49, and LASMOV, as shown in Figure 4-50, must be defined before the *Network Evacuation Direction* forms, *Radial Evacuation Speed* or the *Network Evacuation Speed* forms can be successfully opened. These two parameters are needed to define the evacuation grid. As a side effect, NUMEVA must also be defined because it is on the same form as LASMOV.

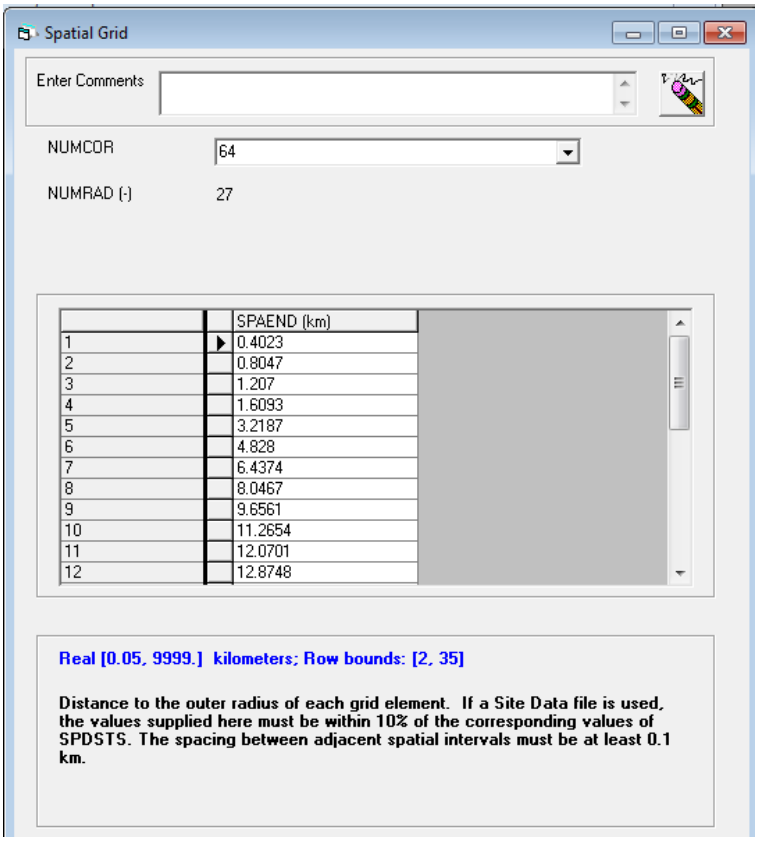


Figure 4-49 ATMOS radial grid, SPAEND

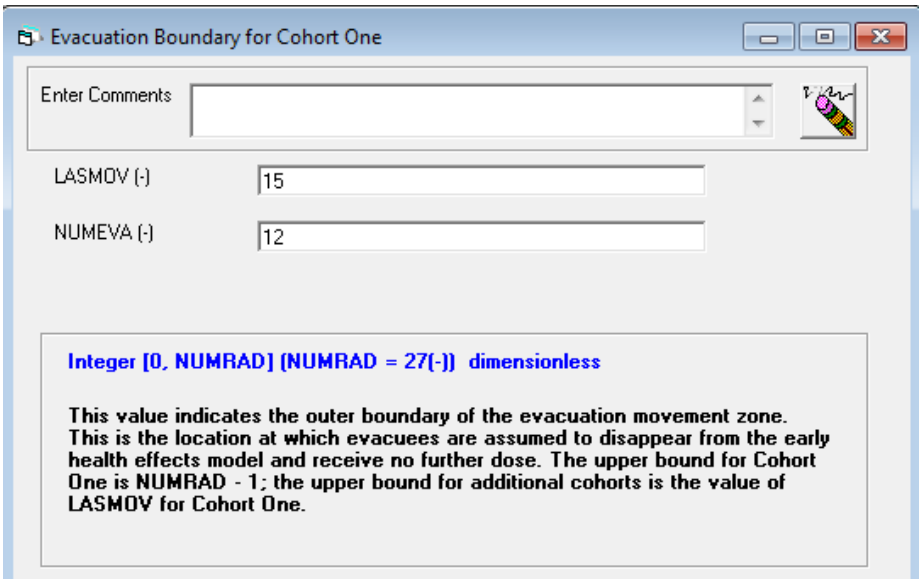


Figure 4-50 Evacuation boundary, LASMOV

The *Network Evacuation Direction* form and the *Evacuation Speed* form are similar. The navigation of the forms is the same; however, the navigation of the forms with respect to specifying the direction or speed parameters is different.

4.4.7.2 Population by Cohort

Populations are assigned to grid elements using a spatial grid form, *EARLY/Population by Cohort/Populations Assigned*.

To enable the specification of the population fraction by cohort, the *Results Weighting Factor* is set to SUMPOP in the *Project Properties* form as shown in Figure 4-51. This form is opened by selecting *Edit/Project Properties* from the main menu.

Site data files that are not used with the SUMPOP option contain one array of population data, specifying the population for each grid element. When using SUMPOP, there is an array of population data for each cohort. The populations used per cohort are defined in forms found in the *Project Parameters* tab category *EARLY/Population by Cohort*. The SecPop software is used to create the site data file, defining the populations to be consistent with Census data and the spatial grid.

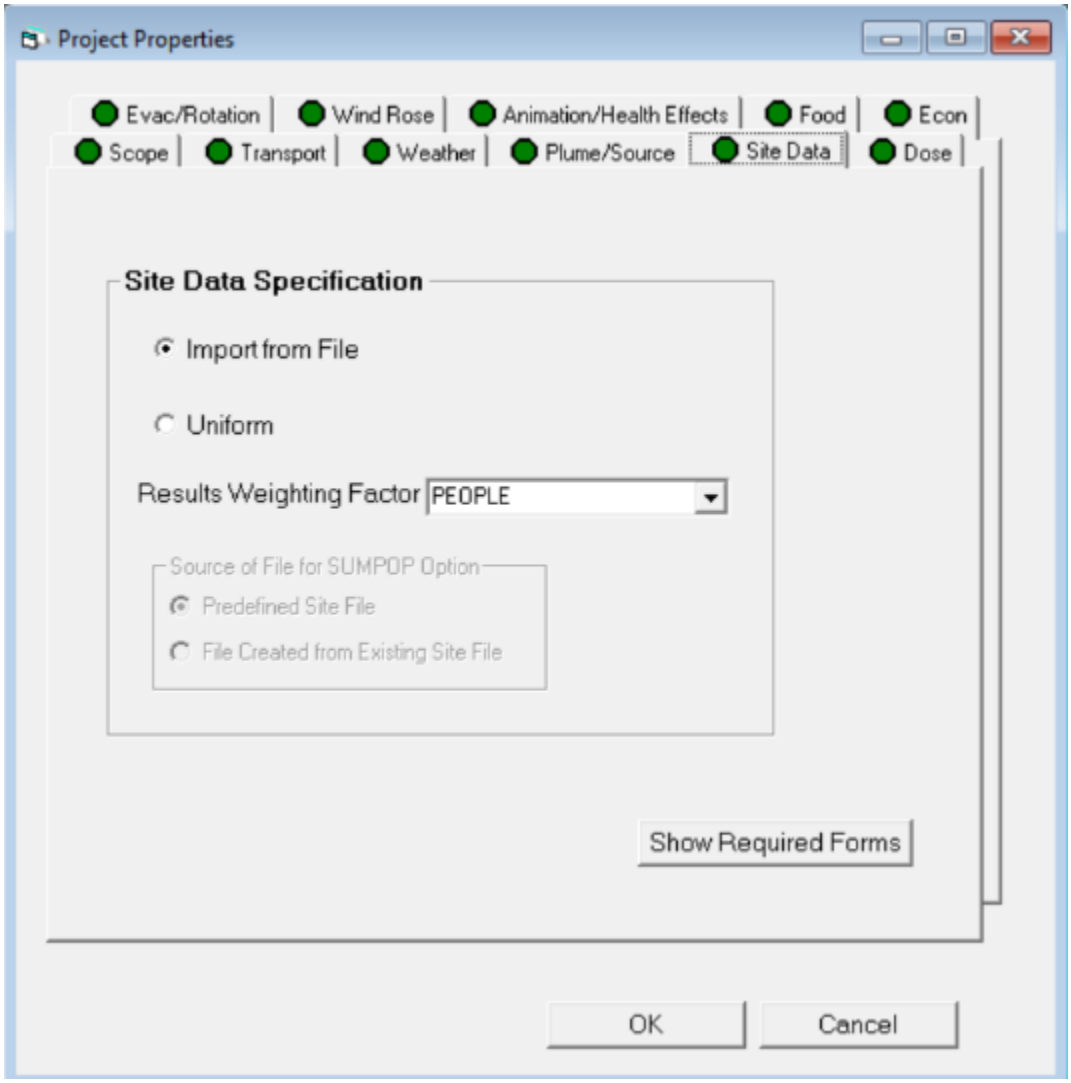


Figure 4-51 SUMPOP option on Project *Properties form*

An existing site file is specified to use as a basis for the new site file that supports the SUMPOP option. This site file can be one that has multiple cohorts defined (e.g., already supports SUMPOP), or it can be a site file with a single cohort defined.

A variable, *Population*, is defined when the site file is defined on the *General/File Specifications/Site File* form. This parameter contains the population array corresponding to the grid population in the existing site file. When the site file specified has multiple population arrays, *Population* is the array containing the sum of the population over all evacuation cohorts on the site file.

Though this parameter is defined on the *Site File* form, the *EARLY/Model Basis/Population from Site File* form must be opened to view this array as shown in Figure 4-52. It is not possible to change any values of the *Population* on this form. To change the *Population* values, a new site file must be specified on the *Site File* form. This parameter is defined whenever the site file is updated.

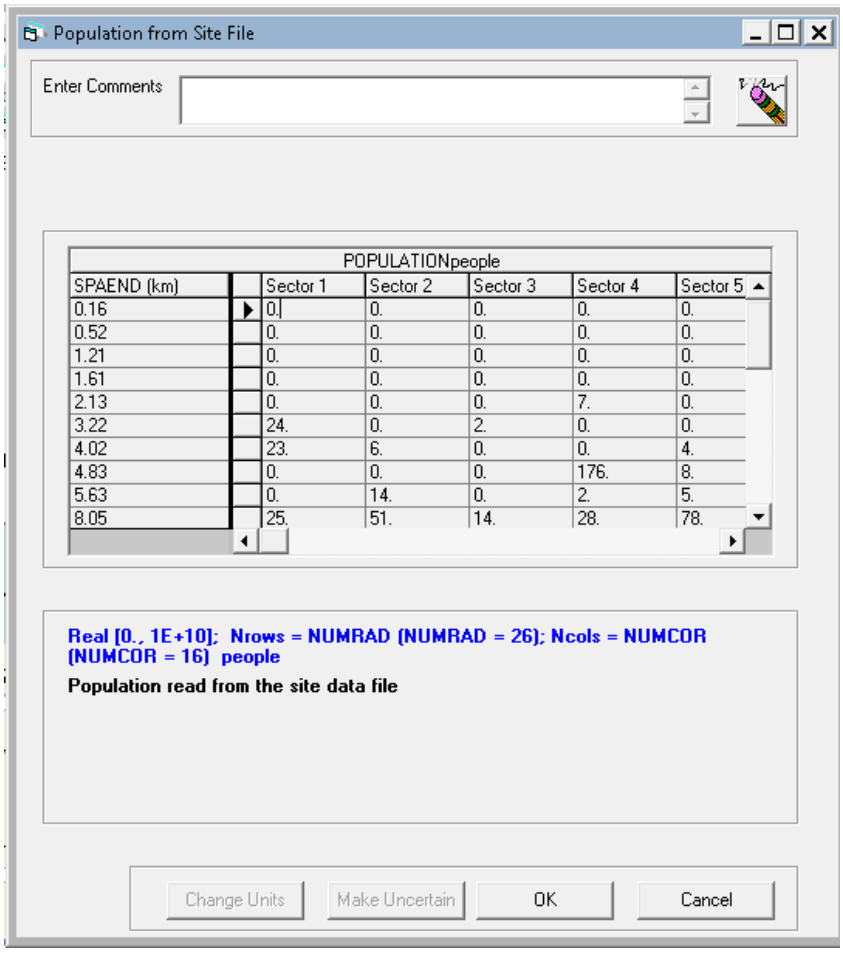


Figure 4-52 Population from Site File form

To support assigning portions of the population to different evacuation cohorts for a given spatial grid element, population distribution was introduced into the model. A population distribution is associated with a spatial grid element and defines the portion of each evacuation cohort that belongs to that grid element. For example, when there were two cohorts defined, a population distribution of (.6, .4) assigned to a spatial grid element would mean that 60% of the population exhibits cohort one evacuation behavior, and 40% belong to cohort two.

Opening the form *EARLY/Population by Cohort/Populations* allows the user to define the various population distributions. There can be up to ninety distributions defined. The example shown in Figure 4-53 shows four cohorts that are differentiated by the delay to evacuate. To aid in envisioning this problem, consider cohort one to be associated with the general population behavior, cohort two the behavior of special needs people, cohort three the behavior of children in schools, and cohort four does not evacuate.

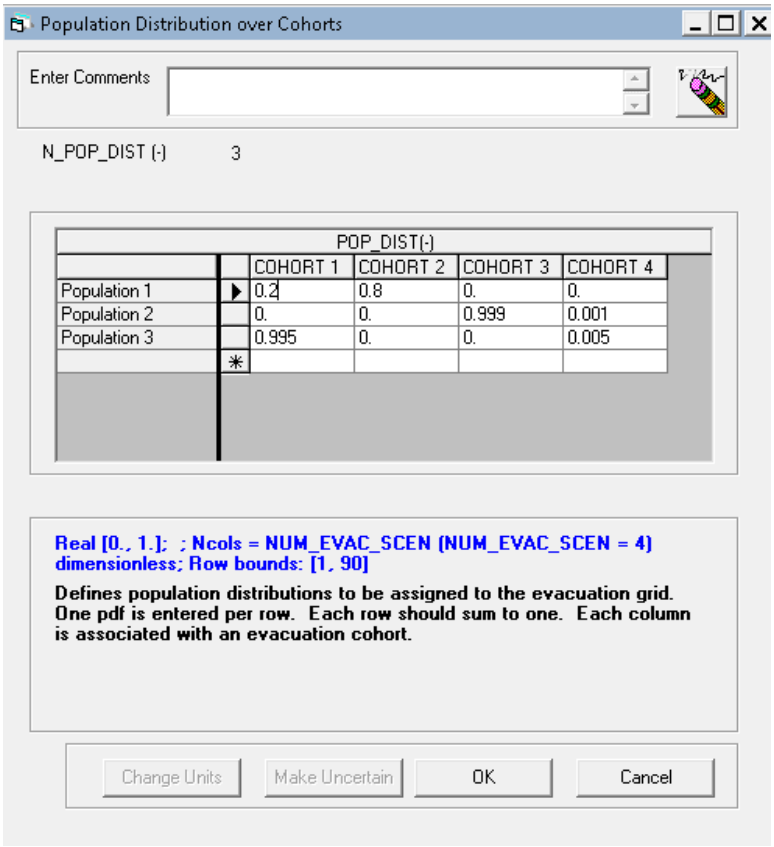


Figure 4-53 Population distributions over cohorts

To aid the user in assigning populations to spatial areas, the *EARLY/Population by Cohort /Population Labels* form, shown in Figure 4-54, allows a symbol and a label to be assigned to each of the population distributions. In this example, Population 2 is assigned to a spatial area that contains a school. The analyst has determined that 99.9% of the population in this area is in cohort 3, and .1% is in cohort 4. The fractional cohort for each of the populations must sum to one.

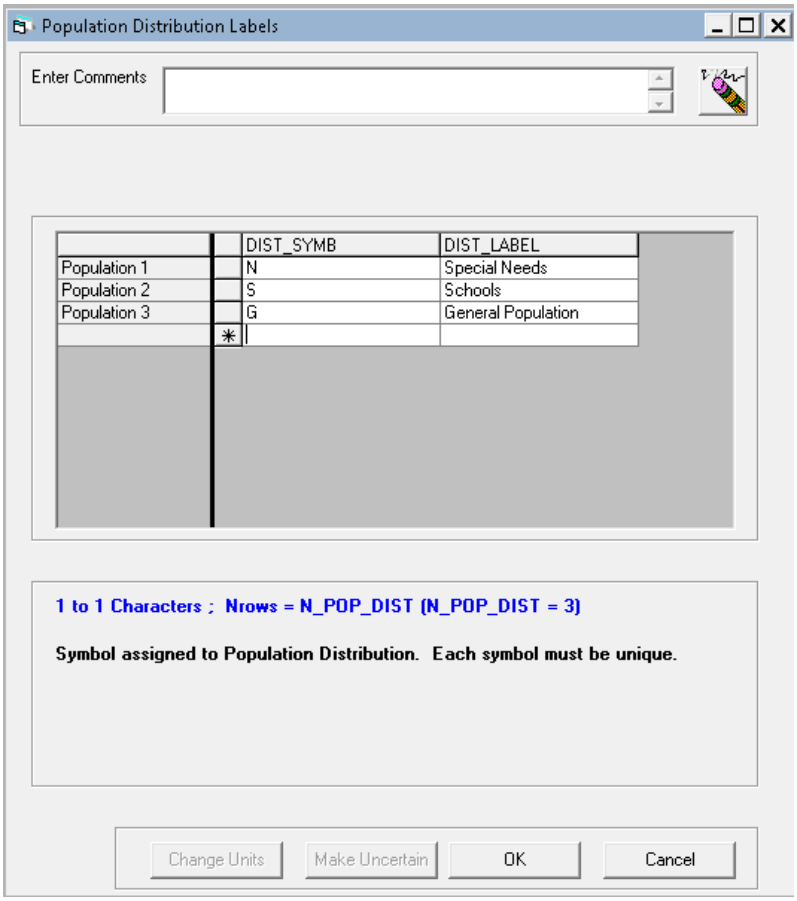


Figure 4-54 Population distribution labels

Lastly, a population distribution must be assigned to each spatial element. Open the form *EARLY/Population by Cohort/Populations Assigned* to assign distributions to grid elements.

4.4.7.3 Creating Road Maps

Radial distances vary from zero to the upper bound of SPAEND. Grid elements are numbered with 1 for north, 5 for east, etc., when the grid is divided into sixteen equal angles. Each value of SPAEND is represented as a concentric circle.

When a new project is created, the *Network Evacuation Direction* forms and the *Evacuation Speed* forms do not show a road map behind the polar grid. Evacuation directions are initially set to be radially outward, as shown in Figure 4-55, and the speed multiplier is set to one.

The number or letter drawn at the center of each of the grid elements indicates the associated speed multiplier rank. This is different than the value of the speed multiplier. If, for example, the speed multipliers are either .5 or 1.5, there are two possibilities for the multiplier rank, namely 1 corresponding to a speed multiplier of .5 and 2 corresponding to a speed multiplier of 1.5.

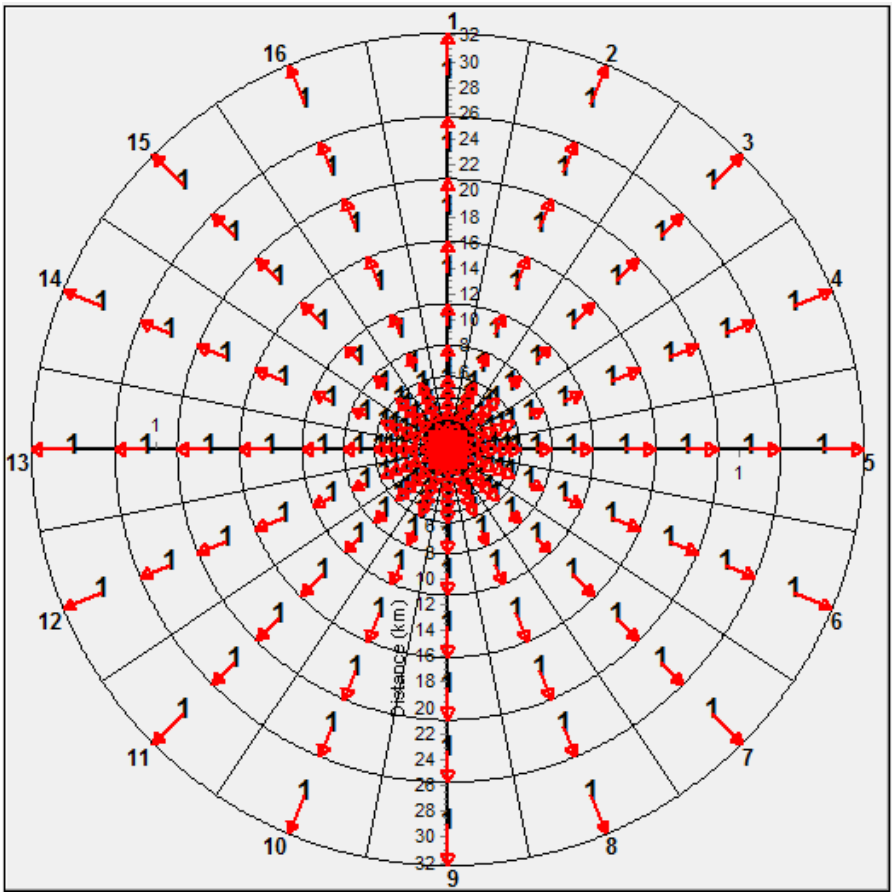


Figure 4-55 Initial state of evacuation grid

Road maps can be easily created to display behind the grid by using MapGen, a custom application that uses Microsoft MapPoint, by clicking the *Create Map File* button in any of the spatial grid forms in WinMACCS. When this is done, a file named *MapSummary.txt* is created and placed in the project *Input*\ folder.

The file, *MapSummary.txt* is subsequently read by MapGen to create the road maps. MapGen is implemented as a separate application because of licensing issues. No license outside of the NRC licensing requirements is required for MACCS. However, the map interface program, MapGen, requires that the Microsoft Map Point 2006 libraries be installed. Thus, to enable the use of maps in the MACCS, Microsoft Map Point 2006 must be purchased and installed.

***WARNING*: When the Spatial Grid is modified, a consistent set of road maps must be regenerated.**

Background map files can be created as follows:

(1). Opening the form *ATMOS/Weather/Site Location* by double-clicking on this entry in the *Parameters* tab of the *Project* window allows the user to enter the latitude and longitude of the site. This form is shown in Figure 4-56. This form may not be flagged as a required data entry form for the MACCS models selected (i.e., the icon may have a slash through it), but to generate a set of road maps, it is necessary to enter the latitude and longitude of the site.

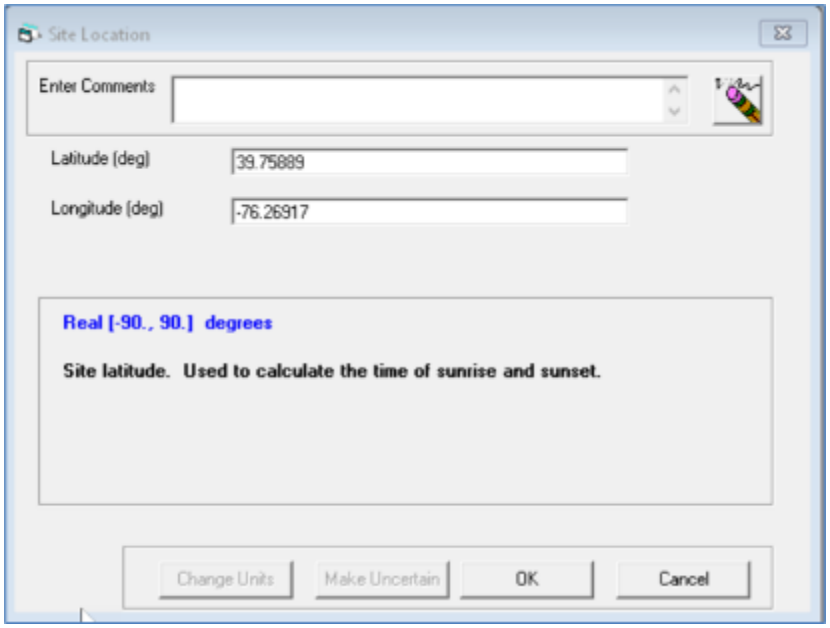


Figure 4-56 Enter latitude and longitude

(2). In any form that shows the polar evacuation grid, selecting *Create Map File* as shown Figure 4-57 causes a file titled MapSummary.txt to be created and placed into the WinMACCS project Input folder.



Figure 4-57 Create map file

Within the Files Tab in the Project window, this file can be optionally viewed by double-clicking on the entry *Input/MapSummary.txt*.

A sample map interface file is as follows:

```
* File created using WinMaccs Version 3.10.0 SVN:2560 7/15/2015 4:52:15 PM
* Latitude and Longitude as a decimal
/LAT      40.17194
/LON      -88.83417
* File Name to create, Distance in km from lat, long to edge of square map
/DAT      Map_0.16.gif      0.1704918
/DAT      Map_0.52.gif      0.5540984
/DAT      Map_1.21.gif      1.289344
/DAT      Map_1.61.gif      1.715574
/DAT      Map_2.13.gif      2.269672
/DAT      Map_3.22.gif      3.431148
/DAT      Map_4.02.gif      4.283607
/DAT      Map_4.83.gif      5.146721
```

```
/DAT    Map_5.63.gif    5.99918
/DAT    Map_8.05.gif    8.577869
/DAT    Map_11.27.gif   12.00902
/DAT    Map_16.09.gif   17.14508
/DAT    Map_20.92.gif   22.2918
/DAT    Map_25.75.gif   27.43852
/DAT    Map_32.19.gif   34.30082
```

Notice each line of the file that starts with the character string "/DAT". Each /DAT lines directs MapGen to create a gif file.

Example:

```
/DAT    Map_0.16.gif    0.1704918
```

Two parameters are shown per input line. The first is the name of the image file that is created by MapGen (e.g., Map_0.16.gif). The second parameter is the distance in km from the center of the map to the edge of the map as displayed in the WinMACCS interface. This input line corresponds to the spatial grid element 0.16 km.

WinMACCS creates a line in the file for each value of SPAEND, the spatial grid distance. The value of SPAEND is built into the name of the GIF file. This ensures that an incorrect map is not shown behind the evacuation grid when the spatial grid entries are modified (SPAEND is changed in WinMACCS).

The second number is a measure in km from the center of the map to the outer edge calculated in WinMACCS to allow the map to fit to the edge of the form.

This process assumes that all maps are square.

(1). MapGen can be started from the MapGen group found on the Windows Start Menu.

(2). From the main MapGen menu as shown in Figure 4-58, selecting *File→Generate Gif from File* allows the user to select the file *MapSummary.txt* file created in the previous step as shown in Figure 4-59. Clicking on *Open* completes this form.

(3). WinMACCS expects the map files to be located in the project Data folder. Choosing the Data folder for the gif file destination as shown in Figure 4-60 enables WinMACCS to find the map files. Clicking *OK* causes the maps to be generated.

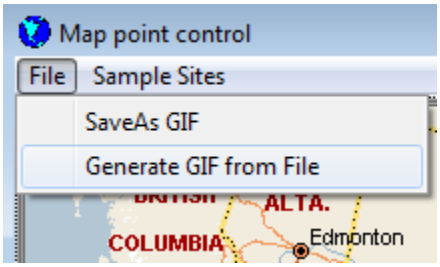


Figure 4-58 Generate road map files

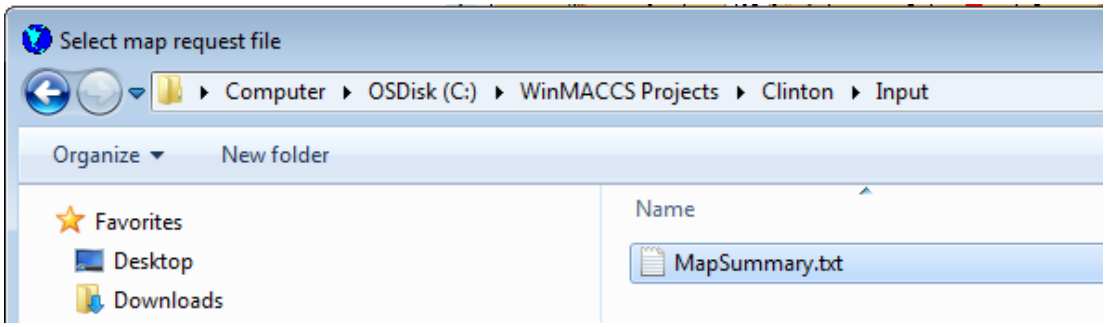


Figure 4-59 Open map summary.txt

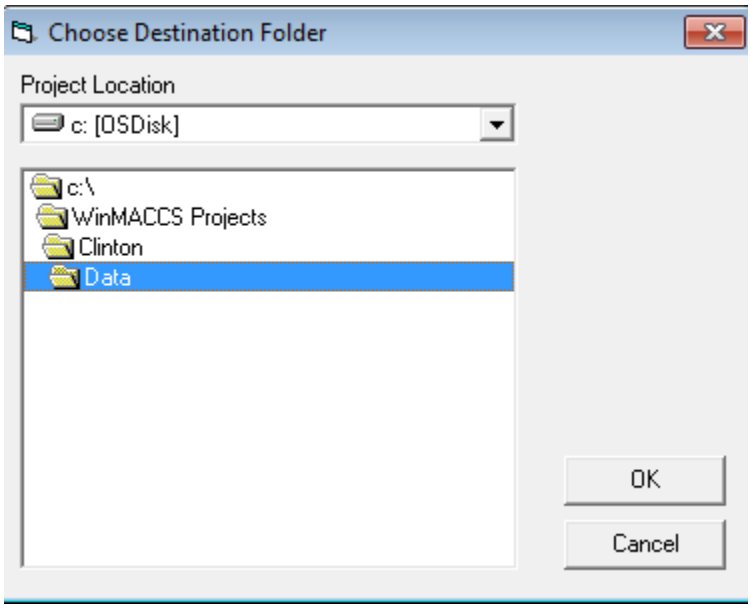


Figure 4-60 Complete creation of road maps

(4). Opening a form that shows the polar evacuation grid, for example, *Radial Evacuation Speed,* the user can observe the map updating when changing the *Outer Ring Shown* slider as shown in Figure 4-66. The maps are displayed behind the spatial grid. When the maps do not display, verifying that the *Hide Map* check box is unchecked, that the map .gif files are in the project Data folder, and that the spatial grid values are in agreement with the names assigned to the map .gif files should fix the problem. For example, Map_1609.34.gif corresponds to 1609.34 km. This is the map that is displayed when the outer ring in the polar grid is at 1609.34 km. This corresponds to an entry in array SPAEND.

The *Outer Ring Shown* slider must be clicked to refresh the background the first time the maps are created.

The roadmap can be displayed in MapGen by entering the latitude and longitude in decimal form and the distance from the center to the left edge as shown in Figure 4-61. These numbers can be read from the file MapSummary.txt as shown in the following example:

```
/LAT      40.17194
/LON      -88.83417
/DAT      Map_1.21.gif     1.289344
```

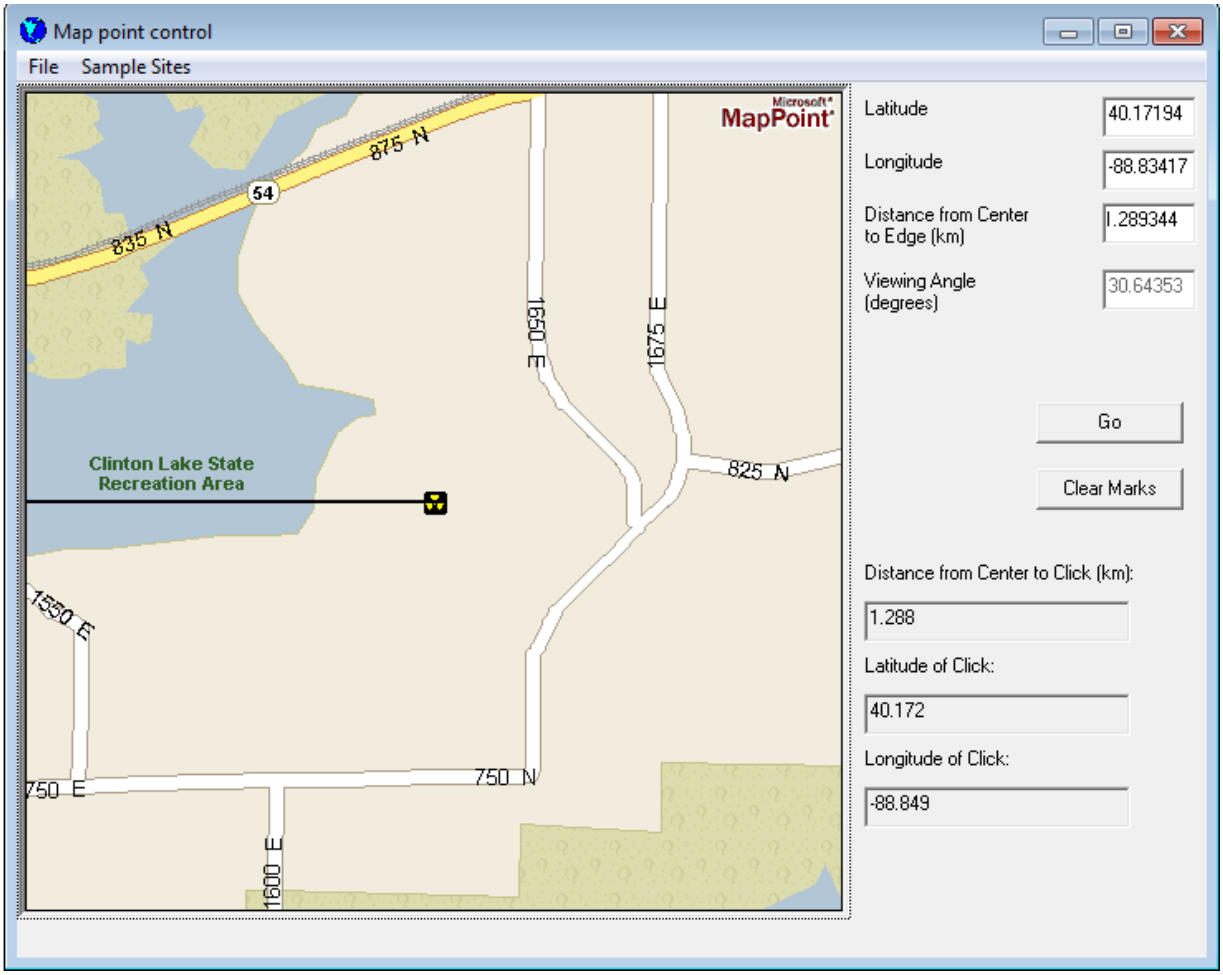


Figure 4-61 MapGen interface

The coordinates of each of the maps centers has a latitude of 40.17194 and a longitude of -88.83417. The line labeled /DAT instructs MapGen to create a map file named Map_1.21.gif, representing an outer radius of 1.21 km. This same line specifies that the distance from the center to the edge of the map is 1.289344 km.

Entering the latitude, longitude and the distance from the center to the edge in MapGen as shown in Figure 4-61 and clicking the button labeled *Go* generates the desired map manually. The actual distance from the center to the edge can be verified by clicking the edge of the map in MapGen. This is the shortest distance from the center to the edge as calculated by MapPoint, the underlying Microsoft map engine.

The MapPoint interface internally requires that a viewing altitude be specified. It was determined that the viewing angle of 30.64353 degrees creates consistent maps except for very high altitudes. However, this does not appear to be a problem at distances less than 2000 km.

MapGen is designed to be consistent with MapPoint 2006. Future versions of MapPoint could use a different algorithm or viewing altitude formula, and so could produce unexpected results when used with MapGen.

4.4.7.4 Assigning Values to Grid Elements

The *Network Evacuation Direction* form is used as an example, shown in Figure 4-66. The same techniques used to assign values to grid elements in the *Network Evacuation Direction* form is used for the *Populations Assigned* and the *Radial* and *Network Evacuation Speed* forms. The only difference between these forms is the possible values the grid elements can have. In the example of the *Network Evacuation Direction* form, the values can be set to *In, Out, Right* or *Left.* In the case of the *Populations Assigned* and the *Radial* and *Network Evacuation Speed* forms, the values are set to user defined populations or user defined speed multipliers respectively.

Understanding the Spatial Grid

Spatial grids are used to enter speed multiplier data for radial and network evacuations, and evacuation directions in the case of the network evacuation option. An example of this form is shown in Figure 4-66.

Arrows drawn on the grid elements indicate the evacuation direction as shown in Figure 4-62. There are four different directions supported by MACCS, outward, inward, counterclockwise, and clockwise. Each of these directions is shown in a different color.

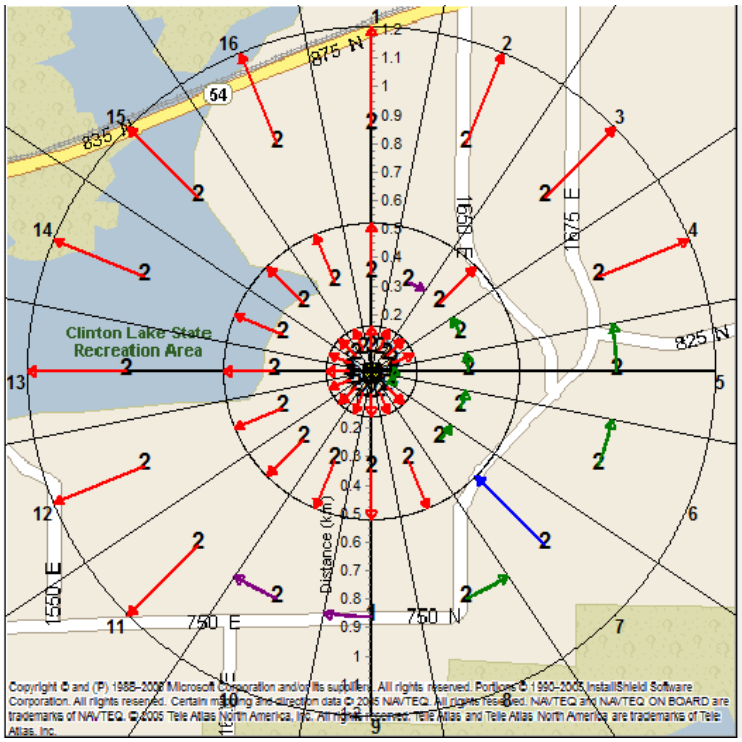


Figure 4-62 Evacuation grid

On the *Radial Evacuation Speed* form, all arrows are red and pointed outward as shown in Figure 4-55.

To the right of the map the inner and outer ring displayed on the polar grid are indicated as shown Figure 4-66. The integer value shown to the left of the sliders labeled *Inner Ring Shown* and *Outer Ring Shown* correspond to the first column labeled *Ring* as shown in Figure 4-63. In the example shown in Figure 4-64, the *Inner Ring Shown* is set to 2, corresponding to SPAEND(2) which is equal to 0.52. The *Outer Ring Shown* is set to 3, corresponding to SPAEND(3) which is equal to 1.21.

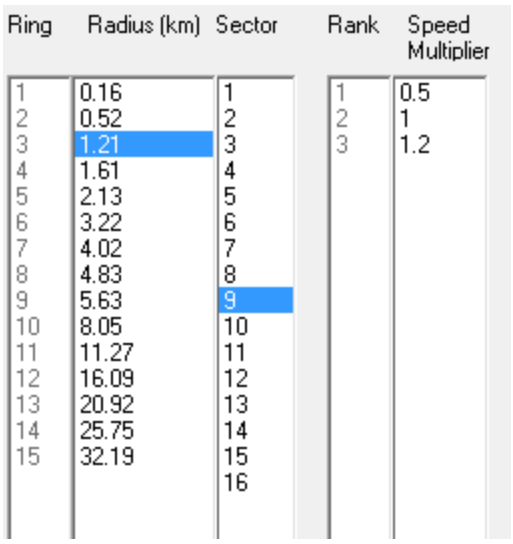


Figure 4-63 Radius, sector and multiplier

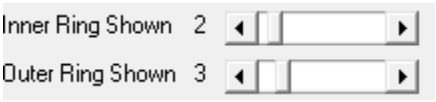


Figure 4-64 Inner ring and outer ring sliders

The symbols shown in column four labeled *Rank* as shown in Figure 4-63 indicate the speed multiplier rank. These values are different than the actual speed multiplier. In this example, the number 1 corresponds to a multiplier of 0.5, 2 to a multiplier of 1, and 3 to a multiplier of 1.2 as shown in column five, *Speed Multiplier*. By showing ranks, the speed multipliers can be adjusted without requiring the user to adjust the settings on the polar grid.

When the grid is clicked, the radial distance from the center of the grid to the click is shown on the bottom left portion of the form, as shown in Figure 4-65. This is useful for diagnostic reasons. Once a map is displayed behind the grid, the scale can be checked when there is a reason to believe that the polar scales and the map scales are inconsistent. The number shown in WinMACCS corresponds to the scale of the polar coordinate system. From the viewpoint of WinMACCS, the roadmap is simply a picture file.

Clicking *OK* preserves changes. Clicking *Cancel* discards changes.

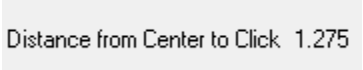


Figure 4-65 Radial click distance

Assigning Values to the Network Evacuation Direction Form

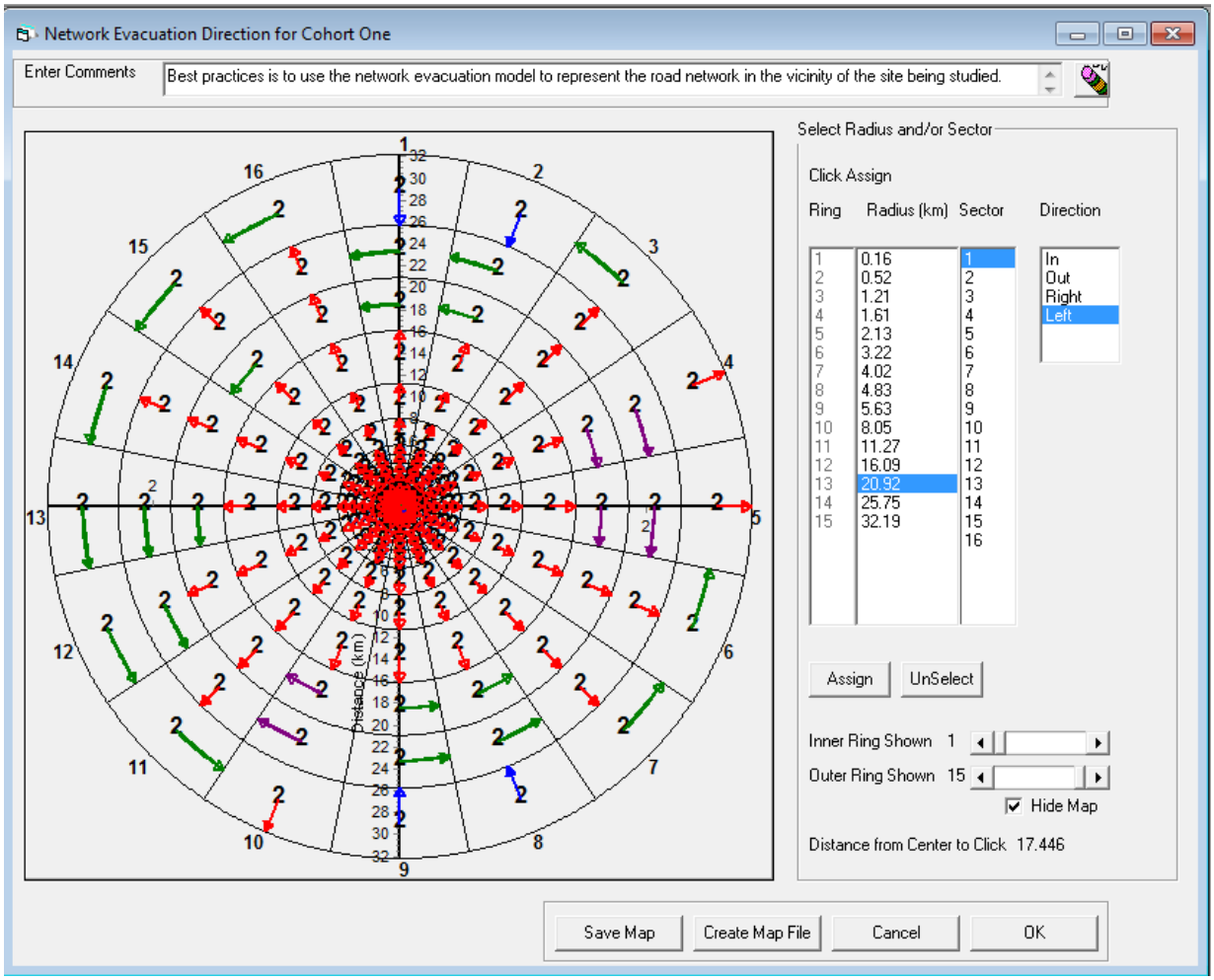


Figure 4-66 Network evacuation direction

The evacuation direction can be modified in two ways.

The first method is to click the grid element on the map. The direction changes for that grid element each time the area is clicked. The direction rotates ninety degrees clockwise each time the grid element is clicked.

When a grid element is clicked, the clicked element is selected in the Radius/Sector list. In the example shown in Figure 4-67, the grid element between 3.22 km and 4.02 km in the fourth sector is selected. Sector 4 corresponds to ENE in a grid that has been divided into 16 sectors.

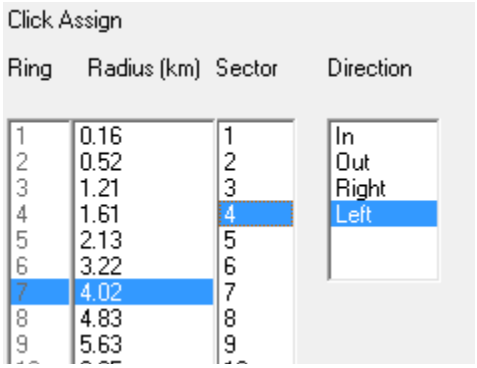


Figure 4-67 Radius and sector selected

The second method is to use the *Assign* button.

Clicking the *UnSelect* button clears the selection of the radius and sector.

Selecting a radius and a direction from the list and clicking the *Assign* button changes the direction for all grid elements at the selected radius.

Similarly, selecting a sector and a direction but no radius as shown in Figure 4-68 and clicking the *Assign* button changes the direction for all grid elements in the selected sector.

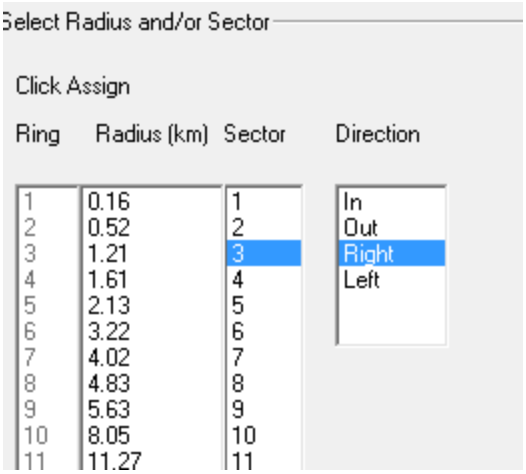


Figure 4-68 Select sector only

Assigning Values to the Radial or Network Speed Multiplier Form

The speed multiplier ranks can be modified in two ways.

The first method is to click the grid element on the map. The rank is incremented by one each time that grid element is clicked. For example, clicking a grid element with an initial rank of four results in a rank of five assigned when five or more ranks are defined, otherwise, the rank cycles from four back to one.

When a grid element is clicked, the clicked element is selected in the radius and sector lists.

The second method is to use *Assign* button. This method is the preferred way to change all the speed multipliers for a given radius or a given sector. This can be done as follows:

(1). Clicking the *UnSelect* button clears the selection of the radius and sector.

(2). Selecting a radius and a direction from the list and clicking the *Assign* button changes the speed multiplier for all grid elements at the selected radius.

(3). Selecting a sector and a direction but no radius and clicking the *Assign* button changes the speed multiplier for all grid elements in the selected sector.

(4). Selecting a radius, a sector, and a speed multiplier rank and clicking *Assign* only changes the rank of the selected grid element.

In the example shown in Figure 4-69, the speed multiplier rank for the grid elements between 0.52 and 1.21 in sector two is changed to 2 when *Assign* is clicked.



Figure 4-69 Select speed multiplier

Assigning Values to the Populations Assigned Form

A graphical window similar to the *Network Evacuation Direction* and *Network Evacuation Speed* windows used to assign populations to grid elements is shown in Figure 4-70. However, instead of assigning evacuation directions or evacuation speeds to the grid sectors, population distributions are assigned.

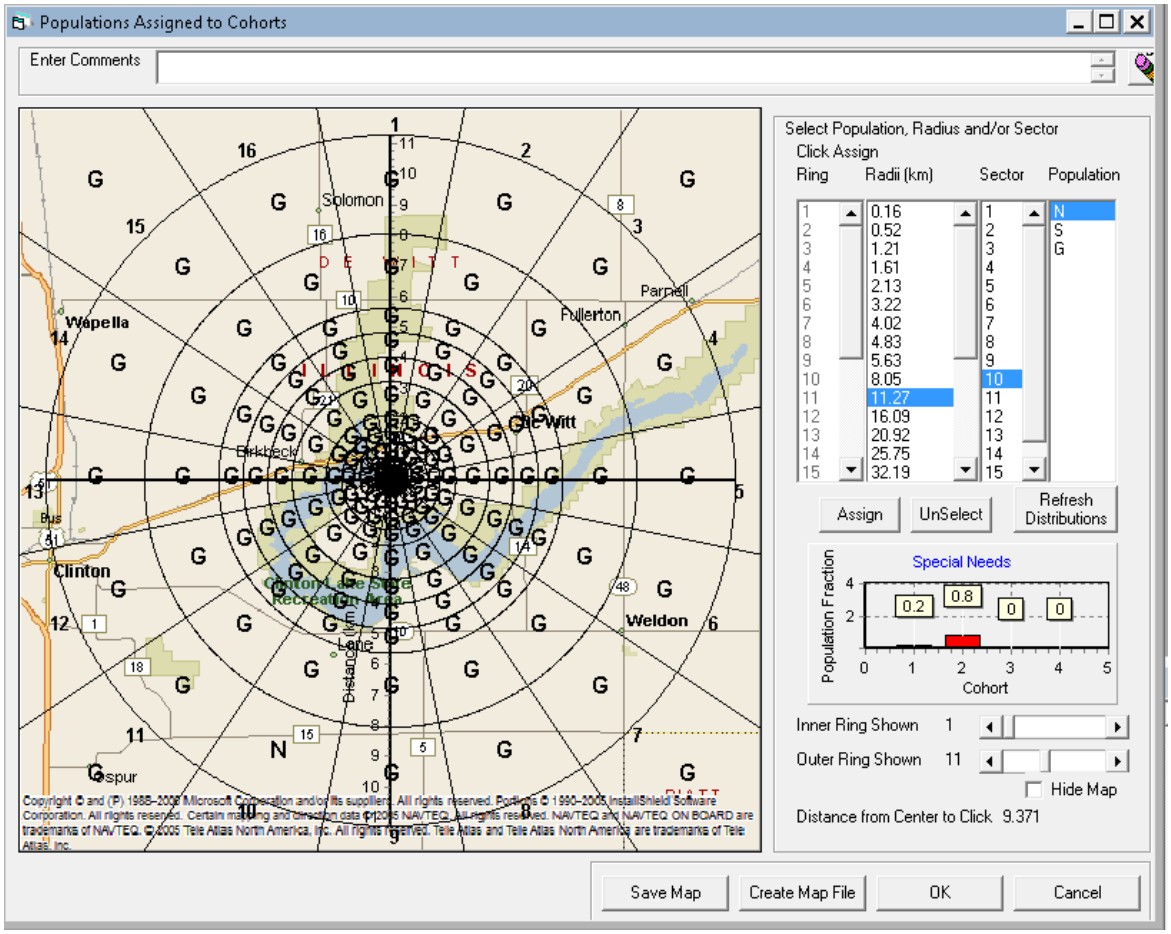


Figure 4-70 Selecting populations assigned to cohorts

On the right side of this window there is a list titled *Population.* In the example shown in

Figure 4-70, three symbols are listed, namely N, S and G. These symbols correspond to the distributions and distribution labels assigned on the forms *EARLY/Population by Cohort/Populations* and *EARLY/Population by Cohort /Population Labels.* A bar chart of the population distribution selected is shown below the radii, sector and population lists.

A population distribution can be assigned to a sector by clicking the distribution symbol and clicking the sector on the map. For example, the sector (11.27, 10) is assigned the distribution N. This was accomplished by clicking on the N in the population list and clicking on the grid element on the map.

A population can be assigned to all of the grid elements in a radius by clicking the *UnSelect* button to remove the highlighted list elements, clicking the radius of interest in the list labeled *Radius*, clicking the population in the list labeled *Population*, and clicking the *Assign* button. Similarly, a population can be assigned to all grid elements in each sector by following this same procedure, but instead of clicking on a radius, the user should click on the sector of interest in the list labeled *Sector*.

It can be convenient to predefine all grid elements to a population by clicking the *UnSelect* button, clicking a distribution in the *Population* list, and clicking the *Assign* button. This can be followed by manually setting less-common populations by one of the other methods described. Clicking *OK* when completed saves the changes.

When the MACCS simulation has finished, the site file used in the simulation, Sumpop_site.inp, can be viewed. This file is found in the project Input folder. This site file, created by WinMACCS and used by MACCS, contains a population array for each of the evacuation cohorts.

The population for a grid element for a single evacuation cohort is calculated by considering the population fraction for that grid element. For the cohort of interest, the population fraction associated with the evacuation cohort is multiplied by the total population for that grid element. Recall the total population for each of the sectors can be viewed on the *EARLY/Model Basis/Population from Site File* form.

The population values per cohort can be viewed on the *EARLY/Emergency Cohort One/Population, EARLY/Additional Emergency Cohorts/Emergency Cohort Two (etc.)/Population, …* forms. Fractional populations are supported.

4.4.7.5 Editing the Speed Multiplier List

The same basic form used to assign speed multipliers to grid elements is also used to specify evacuation directions and population assignments as shown in Figure 4-66. The *Modify Multipliers* button is not available on the *Network Evacuation Direction* forms but is available on the *Radial Evacuation Speed* and *Network Evacuation Speed* forms.

A speed multiplier for each grid element is used to adjust the speeds assigned for ESPEED found on the *Evacuee Travel Speed* form for each emergency cohort. A value of one for the multiplier indicates that the speed in that grid element is the same as ESPEED.

The default value for the speed rank and the speed multiplier is one. Additional speed multipliers can be added by clicking the *Modify Multipliers* button in the *Radial Evacuation Speed* or the *Network Evacuation Speed* form as shown in Figure 4-71.

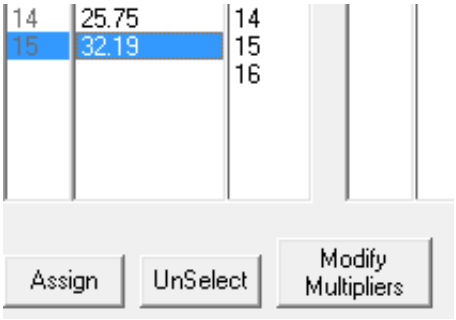


Figure 4-71 Modify multipliers

A dialog box like the one in Figure 4-72 opens.

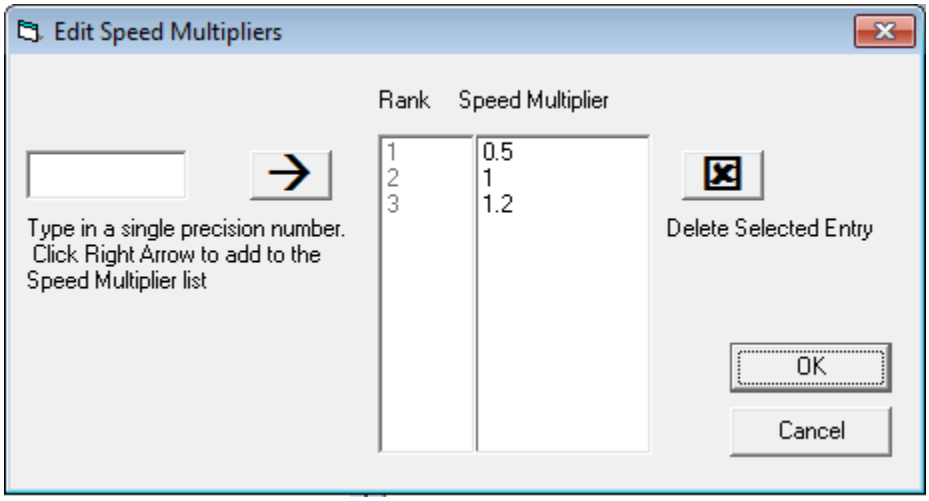


Figure 4-72 Edit speed multipliers

Speed multipliers can be added to the list by entering a number in the text box followed by pressing Enter on the keyboard or clicking the arrow button on the form.

Multipliers can be deleted by selecting a multiplier from the *Speed Multiplier* list and clicking the delete button as shown in Figure 4-73.

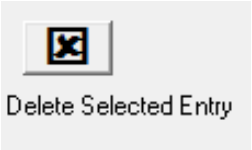


Figure 4-73 Delete speed multiplier button

Multipliers are automatically sorted in ascending order. Multiple entries of the same number are not allowed.

Clicking *OK* preserves changes. Clicking *Cancel* discards changes.

Ranks shown on the spatial grid may be modified by WinMACCS when the multipliers are modified. For example, the default speed multiplier value is a single rank of one corresponded to a speed multiplier set to one. In this example, a multiplier of 0.5 is added using the *Edit Speed Multipliers* dialog box resulting in two multipliers, namely 0.5 and 1.0 with respective ranks one and two. After this dialog box is closed, the rank of one now corresponds to a speed multiplier of 0.5. The polar grid is updated to show the rank of two to correspond to a speed multiplier of one as shown in Figure 4-74.

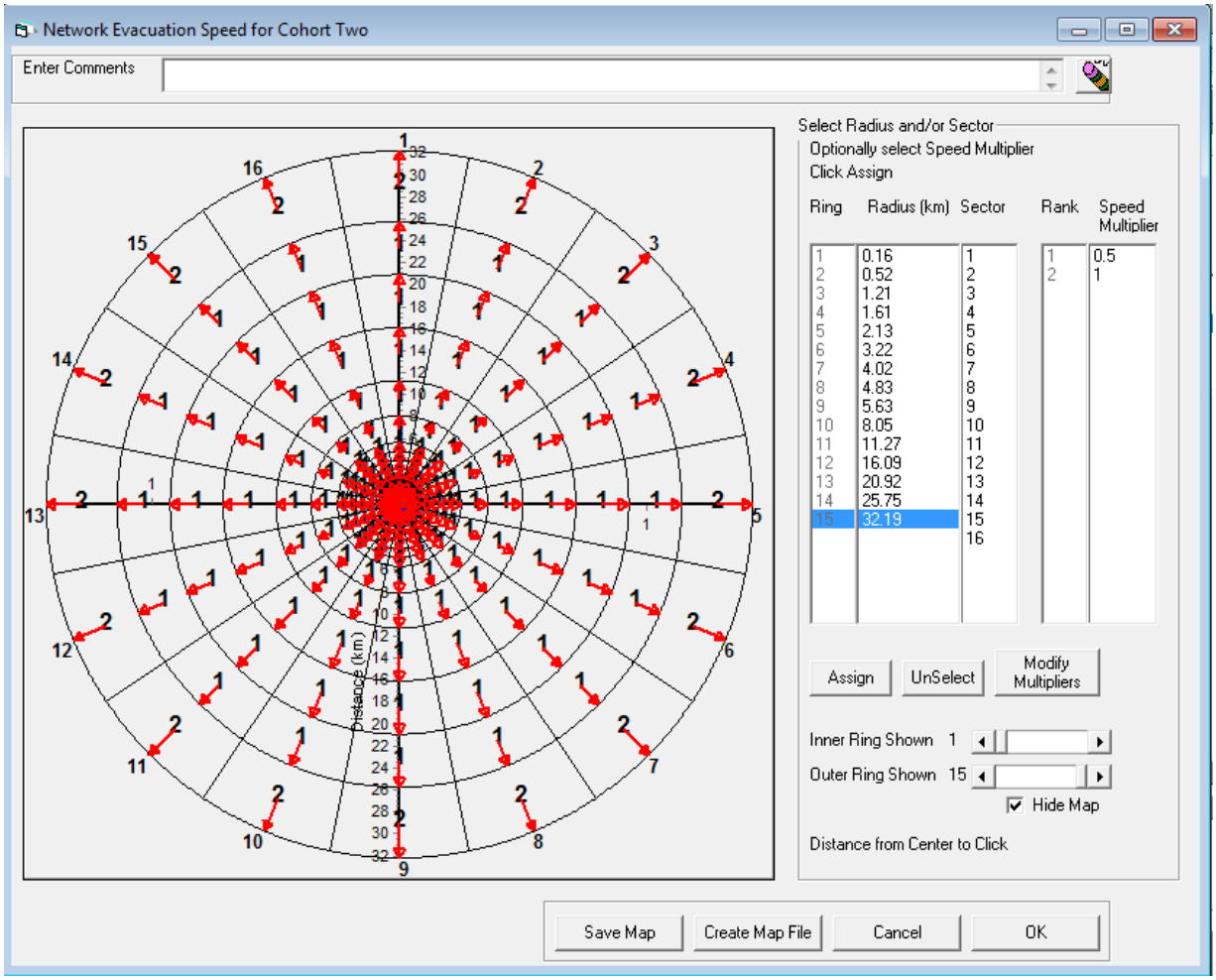


Figure 4-74 Speed multiplier ranks

Uncertain speed multipliers are not supported in WinMACCS.



Figure 4-75 Selecting a speed multiplier

4.4.8 Specifying a Site File

Files are generally specified in a general parameter modification form. However, the site file is specified in a custom form.

The site file is usually created using an external software source, such as SecPop. When SecPop 4.0 or later is used, it is possible to choose 16, 32, 48 or 64 compass directions (or sectors). Older versions of SecPop such as SECPOP2000 support only 16 compass directions. For compatibility with MACCS models that require more compass directions, WinMACCS can create a site file that supports 32, 48 or 64 sectors from a site file that supports 16 sectors.

Double clicking on the *GENERAL/File Specifications/Site File* opens a form like the form shown in Figure 4-76.

A label titled *Angular Directions* shows the actual number of angular directions written to the site file shown in the text box labeled *Site File.*

Click *Browse* to choose a site file. After choosing a site file, the field *Angular Directions* is updated to reflect the number of sectors defined on the file.

NUMCOR, the number of sectors in the spatial grid, is shown as a pull-down menu. It can't be modified in this form but can be modified in the *ATMOS/Spatial Grid* form.

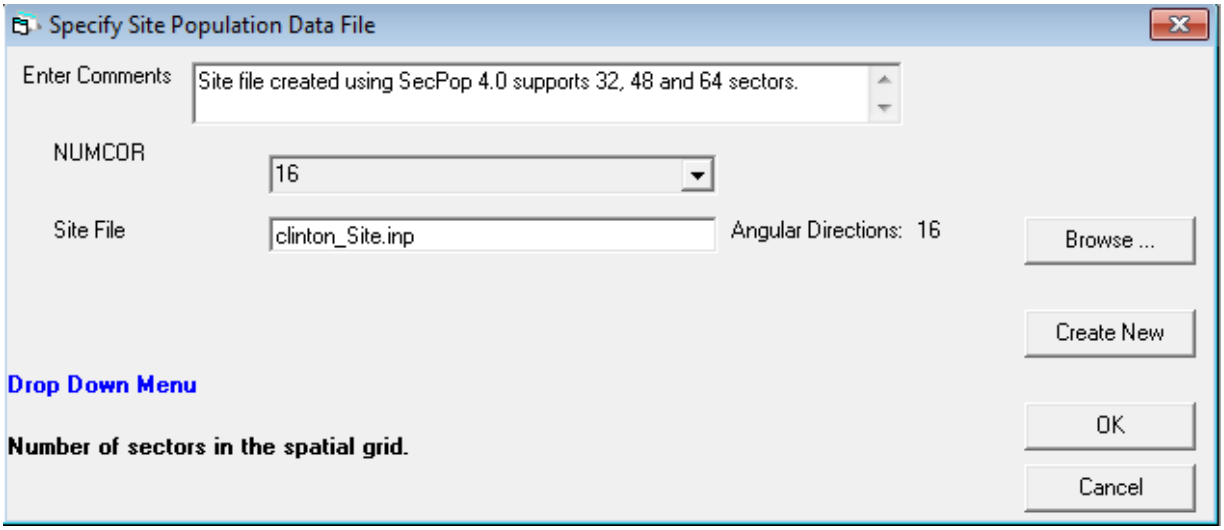


Figure 4-76 Specify site population file

Click *Create New* to create a new site file with more angular resolution. A dialog as shown in Figure 4-77 opens.

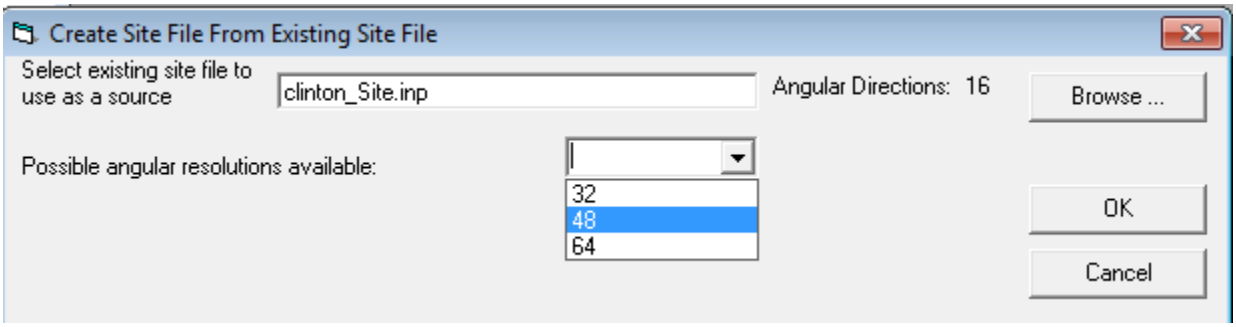


Figure 4-77 Create site file from existing site file

A new site file with more angular directions can be created from an existing site file as follows:

(1). Clicking *Browse…*, as shown in Figure 4-77, the user can choose a site file that has a smaller angular resolution than the file needed.

(2). The angular resolution can be selected from the pull-down menu labeled *Possible angular resolutions available*.

(3). Clicking OK preserves changes and causes a new site file to be created. An external software program, PopMod, has been integrated into WinMACCS to create the new file. Clicking Cancel discards changes and the new file is not created.

(4). The new file created is assigned a file name that contains the number of new angles appended to the file name. In our example, the source file is Clinton_Site.inp. The new file created with 48 sectors is Clinton_Site_48.inp. No new population data was added to the file. The existing population data was spread out into the new sectors.

(5). Clicking OK preserves changes as shown in Figure 4-76. Clicking *Cancel* closes this form and discards changes.

4.4.9 User Specified Dose Conversion Factors in WinMACCS

Normally, a single DCF file is used to specify the dose coefficients. These files have been created in the past using a process independent from WinMACCS, such as running the program DOSFAC2 to create this file or using a DCF file supplied with the WinMACCS installation such as one based on FGR-13.

Default values for the DCFs are determined by a predefined DCF file chosen within the WinMACCS user interface. After this file is specified, it is possible to replace DCF values by constants or probability distributions. This capability has been integrated into WinMACCS. This allows these values to be correlated against any other parameters that have been assigned uncertain values, including other dose uncertain DCFs.

The COMIDA2 Food Model is not currently integrated into the user specified DCF option.

4.4.9.1 Project Properties Settings

The *Project Properties* form can be opened by selecting *Edit/Project Properties* from the main menu.

The user specified DCF model can be defined on the *Properties* form as follows:

(1). By selecting *Early Consequences* or *Late Consequences* on the *Scope* tab the user specified DCF model is available.

(2). Selecting *File created from Existing DCF File* on the Dose tab chooses this model, as shown in Figure 4-78.

(3). When Late Consequences is selected on the Scope tab, the user must select the Food model on the Food tab as shown in Figure 4-79. Either the *No Food* or the *MACCS Food Model* must be selected. The *COMIDA2 Food Model* is available for selection but does not properly function with the *File created from Existing DCF File* selection.

(4). Clicking *OK* preserves changes.

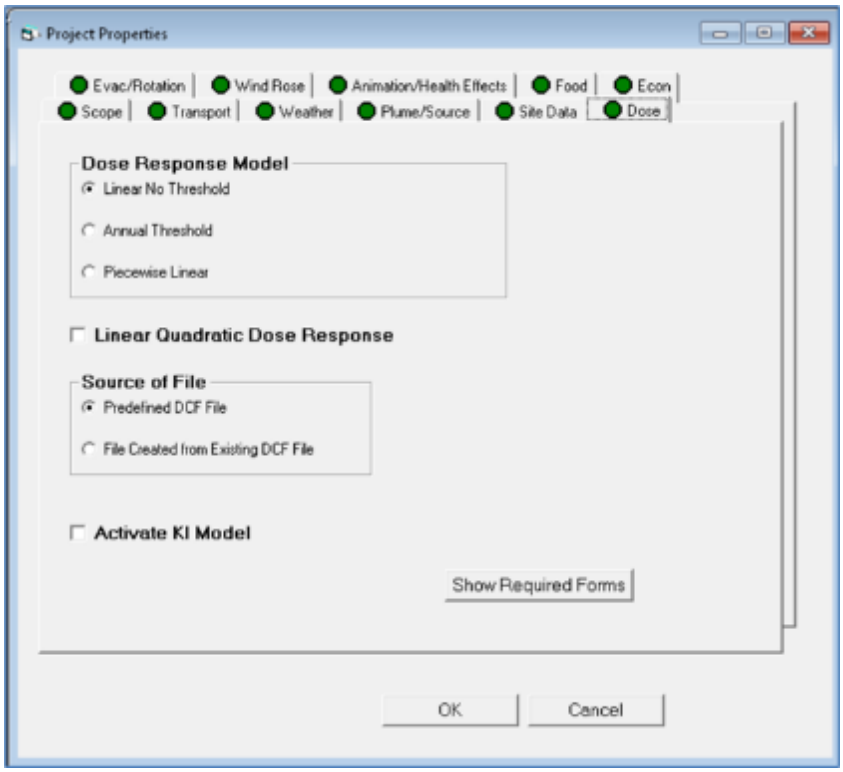


Figure 4-78 Project Properties Dose tab



Figure 4-79 Project Properties *Food tab*

4.4.9.2 Specify a Basis Dose Conversion Factor File

WinMACCS requires a preexisting DCF file to use for default values. This is specified on the same form used for specifying a predefined DCF file when not using the user specified option.

The DCF file can be specified by opening the form named *DCF File* found on the *Parameters* tab of the main *Project* window in the *GENERAL/File Specifications* category as shown in Figure 4-80. Browse for the DCF file by clicking the *Browse* button. In the example shown, a DCF file that is distributed with WinMACCS based on Federal Guidance Report 13 has been selected.

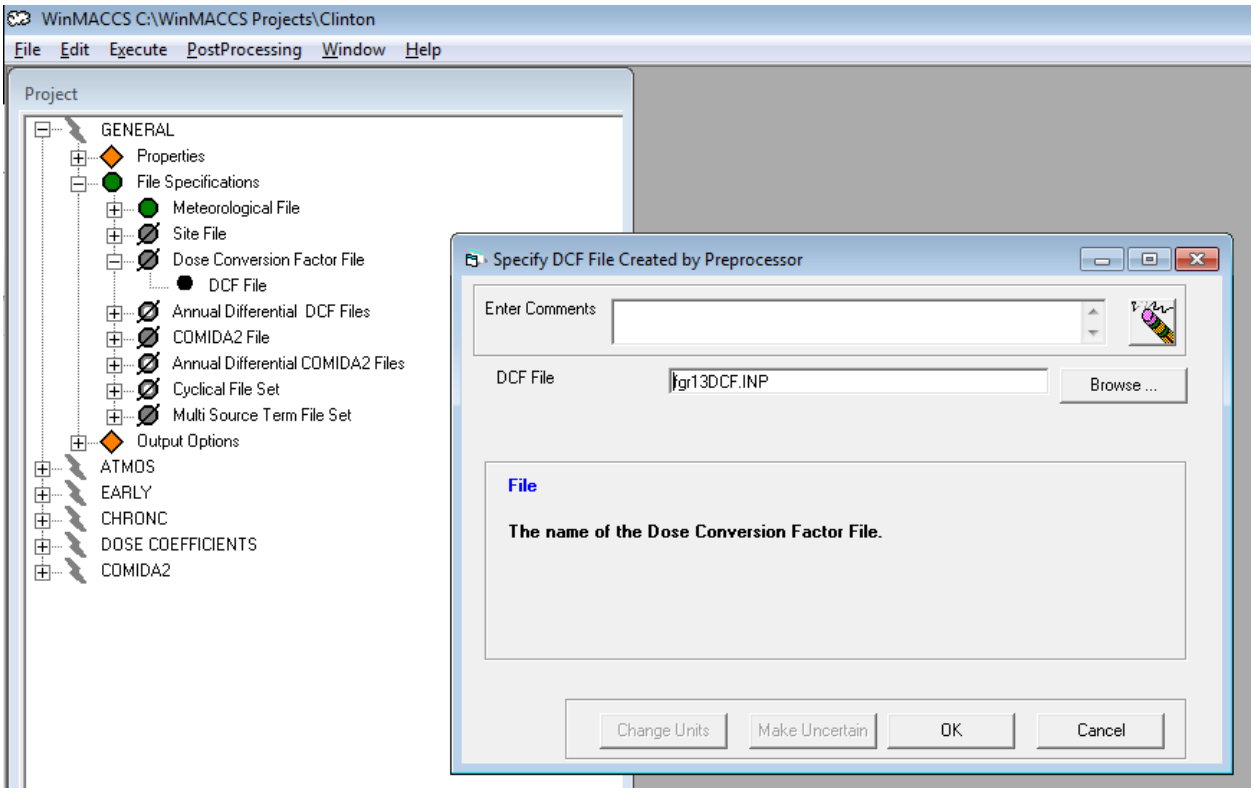


Figure 4-80 Identify location of the DCF file

4.4.9.3 ATMOS/Reveal Nuclides to modify DCF Values

The list of radionuclides to be considered in the MACCS simulation are specified on the *Radionuclides* form found on the *Parameters* tab in the *ATMOS/Radionuclides* category as shown in Figure 4-81. Modifying the DCF values of any of these radionuclides impacts subsequent actions by MACCS.

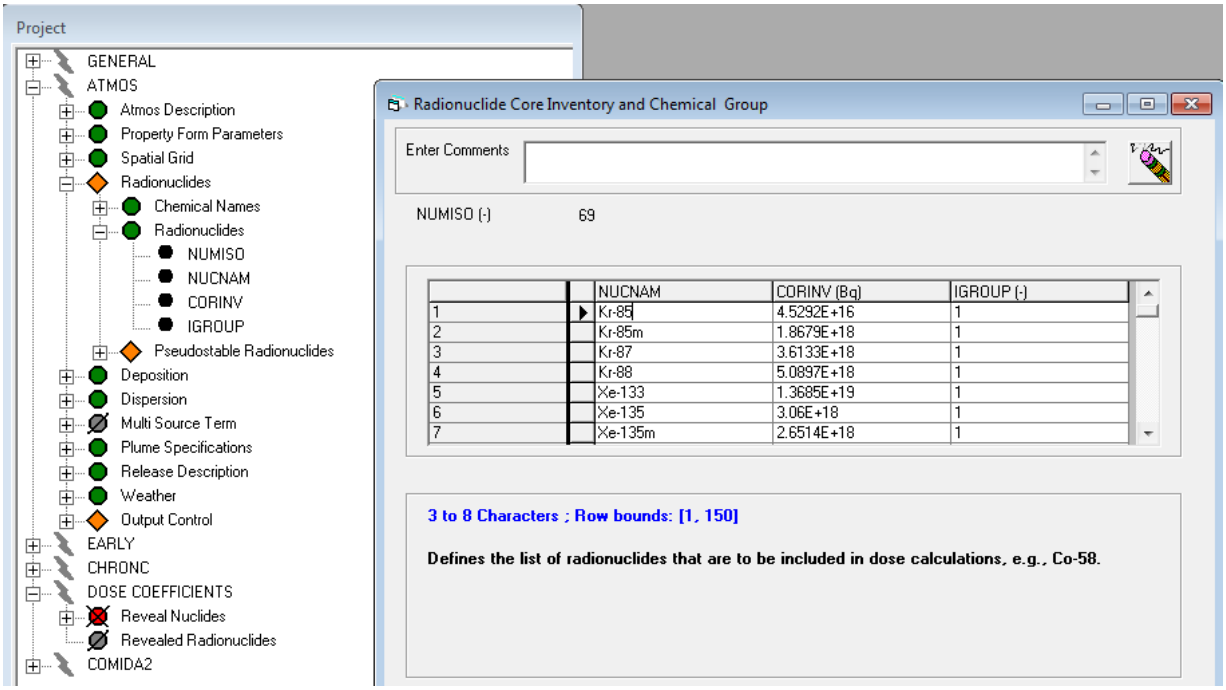


Figure 4-81 Radionuclides Used by MACCS

4.4.9.4 Specify Dose Coefficients to Change

Dose coefficients can be modified by opening the form *DOSE COEFFICIENTS/Reveal Nuclides* as shown in Figure 4-82. Notice that the DCF file previously specified, referred to as the base DCF file, is read and a list of nuclides is shown in the left-hand portion of this form. These are the radionuclides in the DCF file. This DCF file name previously specified is saved in a parameter named DCF_REVEALED.

Indicate the nuclides of interest by selecting the nuclides and clicking the arrow pointing to the right to move the selected nuclides from the *Hidden Nuclides* list to the *Revealed Nuclides* list. Double clicking on the radionuclide moves it from one list to the other list.

Nuclides can be moved back from the revealed list to the hidden list by selecting the nuclide on the revealed list and clicking the arrow pointing to the left.

Only nuclides whose DCF values need to be modified should be put on the list *Revealed Nuclides*. The original values in the DCF are used for the nuclides that are not revealed.

Shift click and Control click can be used to select multiple nuclides.

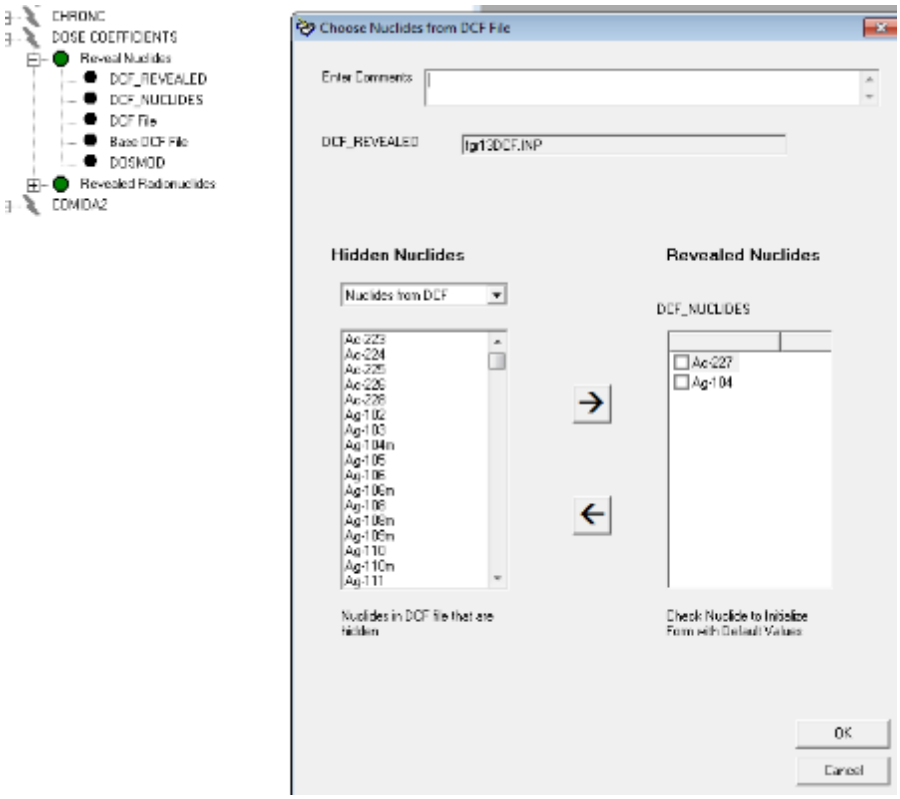


Figure 4-82 Choosing nuclides from DCF file

The check mark next to the nuclide name on the *Revealed Nuclides* list means that the forms for those nuclides are populated with default values read from the basis DCF file.

By revealing nuclides, MACCS creates forms to allow modification of the DCFs for those nuclides.

When these forms already exist, checking the nuclide name causes the current DCF values on these forms to be replaced with the default DCF values. When the user had replaced DCF values on some of these forms with their own distributions or with constant values, that information is overwritten with the default values.

Clicking *OK* preserves changes. This can take a long time the first time a radionuclide is exposed. Clicking *Cancel* discards changes.

4.4.9.5 Modifying the DCF Values

The first word in the base DCF file identifies the source of the data. MACCS expects this first word to be one of the following:

- FGR13DF
- FGRDCF
- DOSFAC2

The type of the base DCF file determines the forms to be built exposing the DCF values. This also determines the list of organs and pathways that are available.

In the following example the base file is of type FGR-13. In this case and in the case of a DOSFAC2 file, two forms are created for each exposed radionuclide as shown in

Figure 4-83. The Acute Inhalation pathway is relevant for a subset of organs; hence the related DCF values are placed on a separate form.

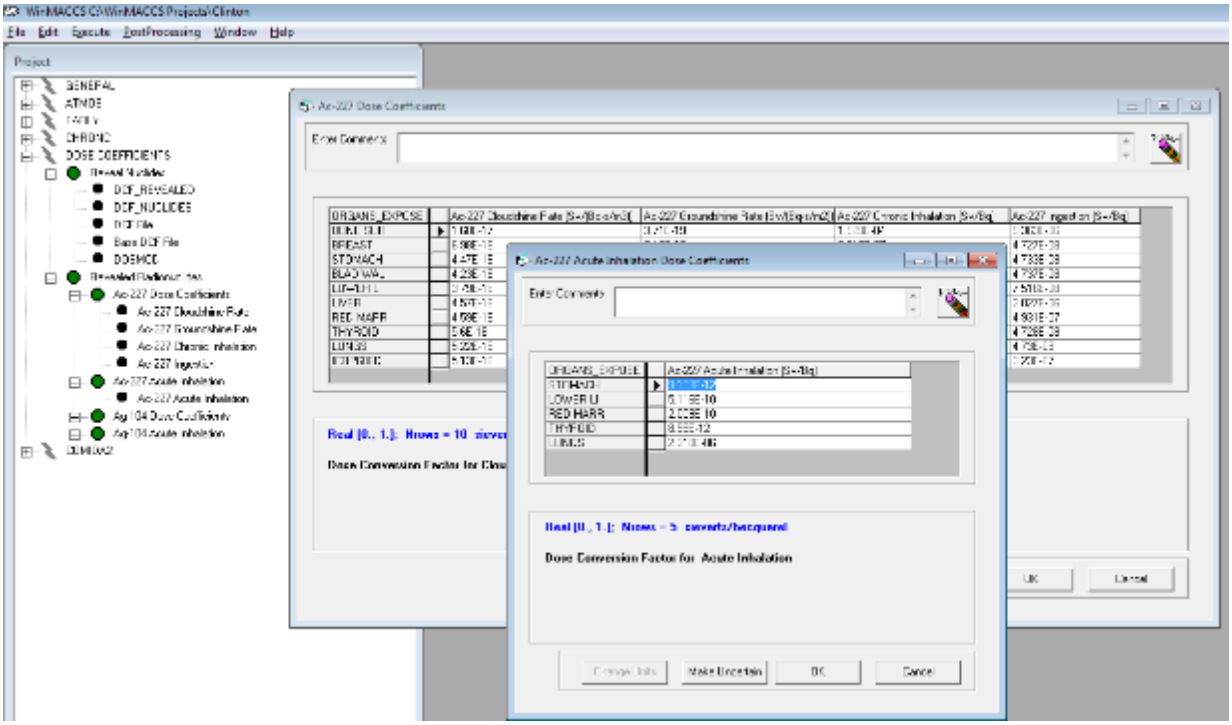


Figure 4-83 Dose Coefficient forms for FGR-13 file

In the example shown in Figure 4-84, the base file is of type DOSFAC2. Notice that the organ list is different than the organ list shown for the FGR-13 base file.

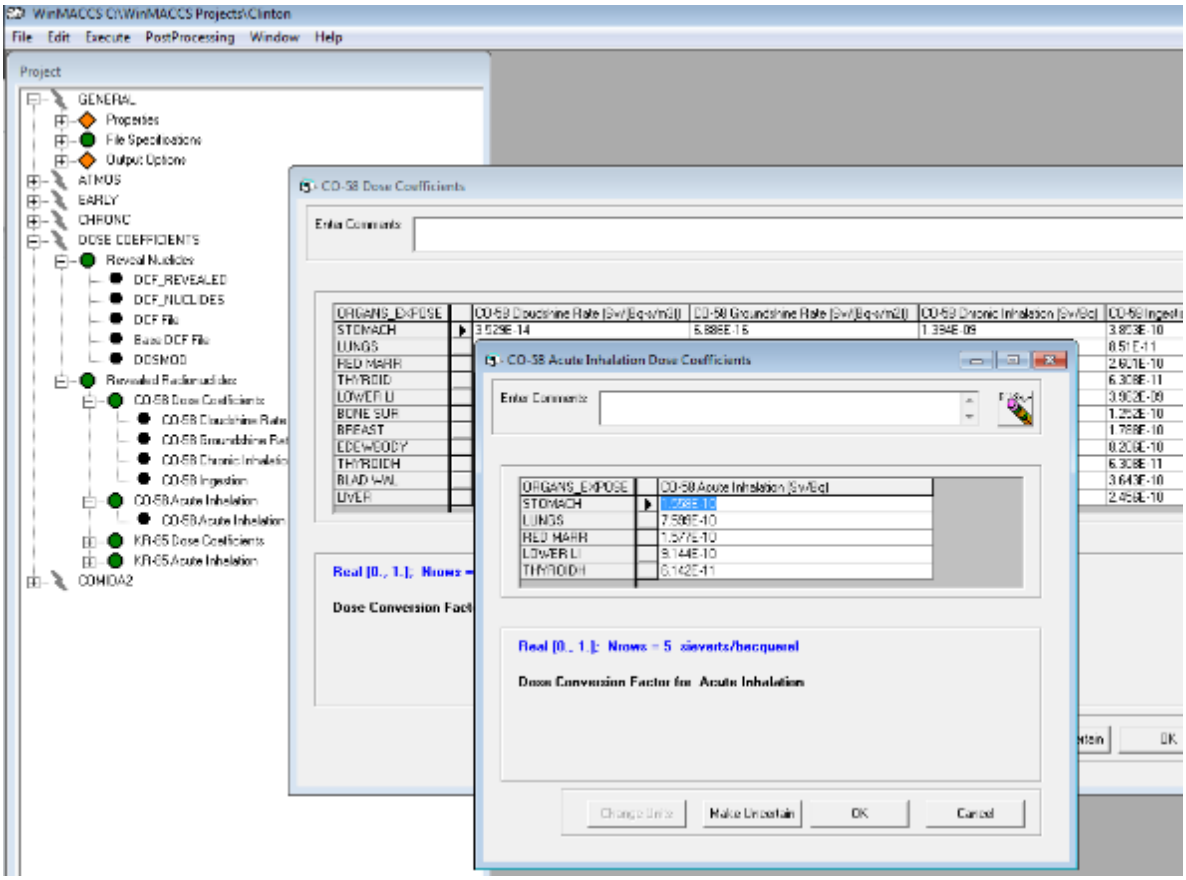


Figure 4-84 Dose Coefficient forms for DOSFAC2 DCF file

In the case of FGRDCF, there is one form per nuclide because acute health effects are not calculated when this DCF file is used as shown in Figure 4-85. The acute inhalation pathway is not relevant in this case.

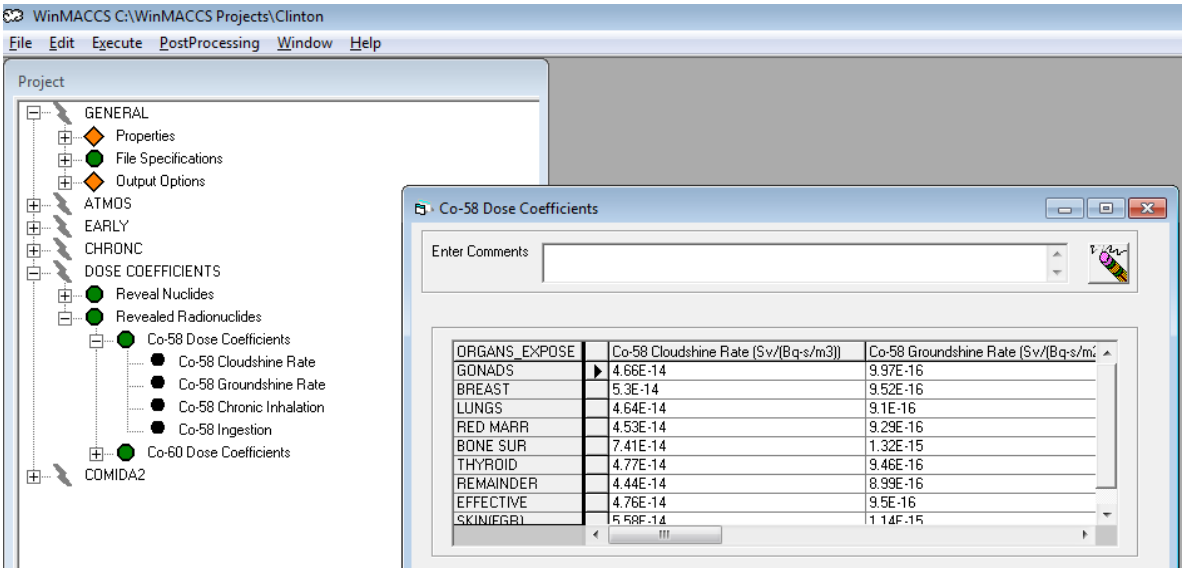


Figure 4-85 Dose Coefficient form for FGR 11-12 DCF file

DCF values can be modified by clicking on the grid cell and typing the new value. It is also possible to set any values to be uncertain by double clicking on the cell or by clicking in the cell and clicking the *Make Uncertain* button on the form. Clicking OK preserves changes. Clicking Cancel discards changes.

4.4.9.6 Running a Simulation

Select *Execute/Run Models* from the main menu to open the *Run Models* form. Notice that the *File created from Existing DCF File* check box is checked.

When a simulation is run in this mode, a DCF file is created for each LHS realization. The values are generated by LHS in the same LHS instance that generates all MACCS uncertain values.

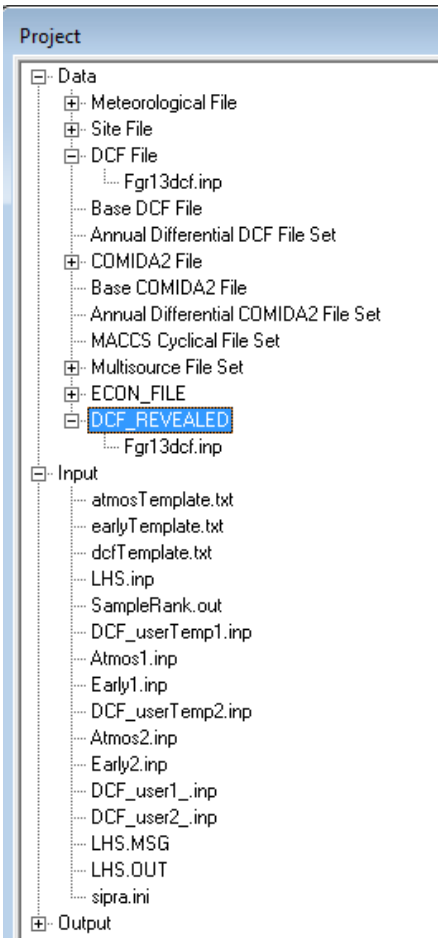


Figure 4-86 Files tab when creating DCF files

The *Files* tab in the WinMACCS *Project* window shown in Figure 4-86 shows a new entry in the Data category called *DCF_REVEALED*. This is the file that is used to define the *DOSE COEFFICIENTS* forms, the default values on those forms and the list of unexposed radionuclides. In this example, a file created by Fgr-13 was used, Fgr13dcf.inp.

The Input category lists files that are created by WinMACCS when running model simulations. The following files were created in an example with two simulations:

- Template file dcfTemplate.txt containing deterministic DCF values and place holders for LHS realizations were first created.

- Files DCF_userTemp1.inp and DCF_userTemp2.inp were created per realization. Uncertain values generated by LHS were inserted into these files. These files are in a MACCS standard input format, not in a DCF format.

- Files DCF_user1.inp and DCF_user2.inp are files in a standard DCF format. These files are used by MACCS and contain the user specified DCFs. There is one file per realization. These files were created from the files DCF_userTemp1.inp and DCF_userTemp2.inp.

4.4.9.7 Food Model available in WinMACCS with User Specified DCF

When the CHRONC module of WinMACCS is selected, there is an option allowing the use of a COMIDA2 food-chain file. It is required that the dose conversion file used in the EARLY module of MACCS be identical to the dose conversion file used to create the COMIDA2 food chain file.

The capabilities that create DCF files have not been integrated into the COMIDA2 Food Model. Either the food-chain model must be off, or the older MACCS food-chain model used.

It is possible to create the DCF files and manually run each one through COMIDA2 by selecting the *Predefined DCF File Option*.

4.4.9.8 User Specified DCF file when using Annual DCF Files

When specifying the AT or piecewise-linear dose-response model options, it is necessary to have the *Late Consequences* module on. Additionally, it is required that the *No Food Model* is also selected. Though the interface indicates that it is possible to use the *COMIDA2 Food Model*, this option is not functional.

It is also necessary, as in all threshold type calculations, to specify the basis AT files as shown in Figure 4-46. These files are used to create the annual user specified threshold files.

In the following example, in the input folder, there are additional files created by WinMACCS.

When there are two realizations, there are two files created, DCF_TH_MULT1.inp and DCF_TH_MULT2.inp. These files are in a MACCS recognized DCF format. These files do not contain DCF values, but contain multipliers used to transform a predefined DCF file into a user based DCF file. These multipliers are applied to each of the predefined DCF threshold files to derive the user defined DCF threshold files. Values that are -1 indicate that the data are not used.

For example, the following is an excerpt from one of the multiplier files. For all DCF values used (values not equal to -1) the multiplier used is one. This means that the data are used with no changes. Columns correspond to pathways. Some values are set to -1 because MACCS does not consider these pathways.

```
Am-241
BONE SUR          1        -1        -1        1        -1        1         1
BREAST            1        -1        -1        1        -1        1         1
STOMACH           1        -1        -1        1         1        1         1
BLAD WAL          1        -1        -1        1        -1        1         1
LOWER LI          1        -1        -1        1         1        1         1
LIVER             1        -1        -1        1        -1        1         1
RED MARR          1        -1        -1        1         1        1         1
THYROID           1        -1        -1        1         1        1         1
LUNGS             1        -1        -1        1         1        1         1
ICRP60ED          1        -1        -1        1        -1        1         1
```

There is a multiplier file for every LHS realization.

In the following example, fgr13dcf.inp and its associated AT files, fgr13dcfYY.inp, are shown, where YY is the year number (01, 02…50). Realization number 5 is shown in the following illustration.

- DCF_user5.inp is the DCF file associated with realization number five. LHS results for realization five have been inserted into this file.

- DCF_TH_MULT5.inp contains the multipliers calculated by calculating the ratio of the user defined value in the file DCF_user5.inp to the original value in FGR13dcf.inp. After this step has been completed, the 50 files used by the threshold model can be calculated by using this multiplier as a scale factor.

- DCF_user5_01.inp through DCF_user5_50.inp are the threshold files used for realization 5, derived by multiplying the DCF values in the predefined threshold DCF file, fgr13dcfYY.inp where YY is the year (01 through 50), with the multipliers for realization 5 in DCF_TH_MULT5.inp.

For example, to derive the file for realization number 5 for year 9, the multiplier file, DCF_TH_MULT5.inp is used with the data in the file Fgr13dcf09.inp to create a user defined input file DCF_user5_09.inp.

4.4.10 Multi Source

A group of MelMACCS files, possibly created from a combination of different MELCOR plot files and single files with multiple rings, can be run using the *Multi Source Term* option. This is done by opening a project in WinMACCS and merging the source term files using the following steps:

(1). The multi-source option is activated by clicking on the box labeled *Multi Source* on the *Plume/Source* tab, as shown in Figure 4-87. This setting needs to be saved by clicking *OK* in the *Project Properties* form.

Source term files are selected from the GENERAL/File Specifications/Multi Source Files form. From this form, the user can navigate to the folder containing the multi-source files created by MelMaccs. Files can be selected by double clicking on the file names or by selecting or shift selecting, right clicking, and selecting Add Files from the pop-up menu. The order that the files are processed can by changed by selecting the file in the left most window pane, and clicking the up or down arrow below that pane to change the order, as shown in Figure 4-88. The order of the files affects some of the subsequent steps.

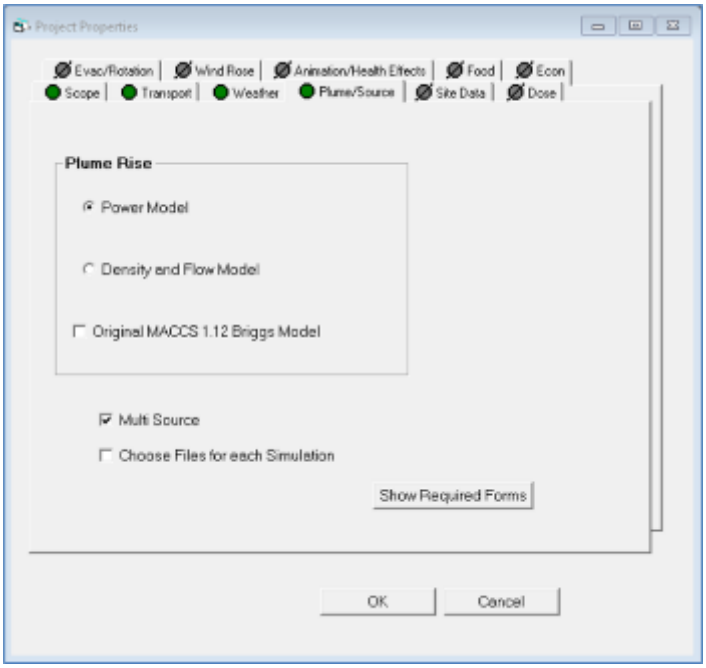


Figure 4-87 Selecting Multi Source option

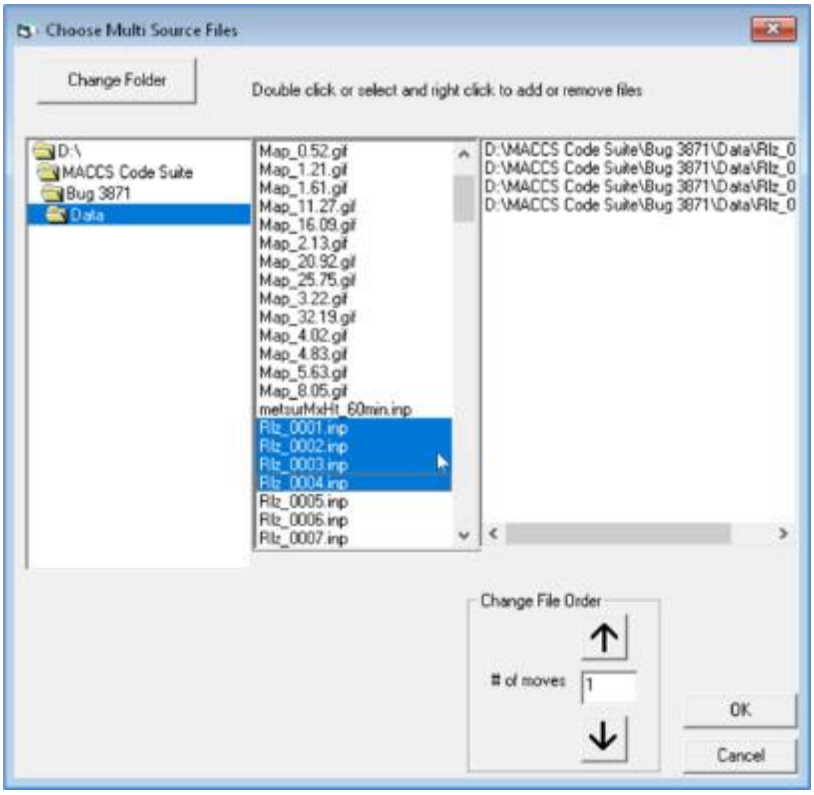


Figure 4-88 Specifying *Multi Source* input files

(2). Forms under the category, Multi Source, are required. Two of the forms are the same or similar to the ones required for a single-unit source term, the *Chemical Names* and *Radionuclides* forms. The *Time Offsets* form allows the user to specify time offsets for each source term file, as illustrated in Figure 4-89. The *Plume*

Segments form shows the plume segments arranged chronologically and identifies which multi source term file each plume segment is from. The plume delay values on this form account for the time offset values specified on the *Time Offsets* form. In the example shown, there are fifteen plume segments defined, ten from the file Ring1.inp and five from the file Ring2.inp. The files used by WinMACCS are copies of the original and are in the Input folder of the project.

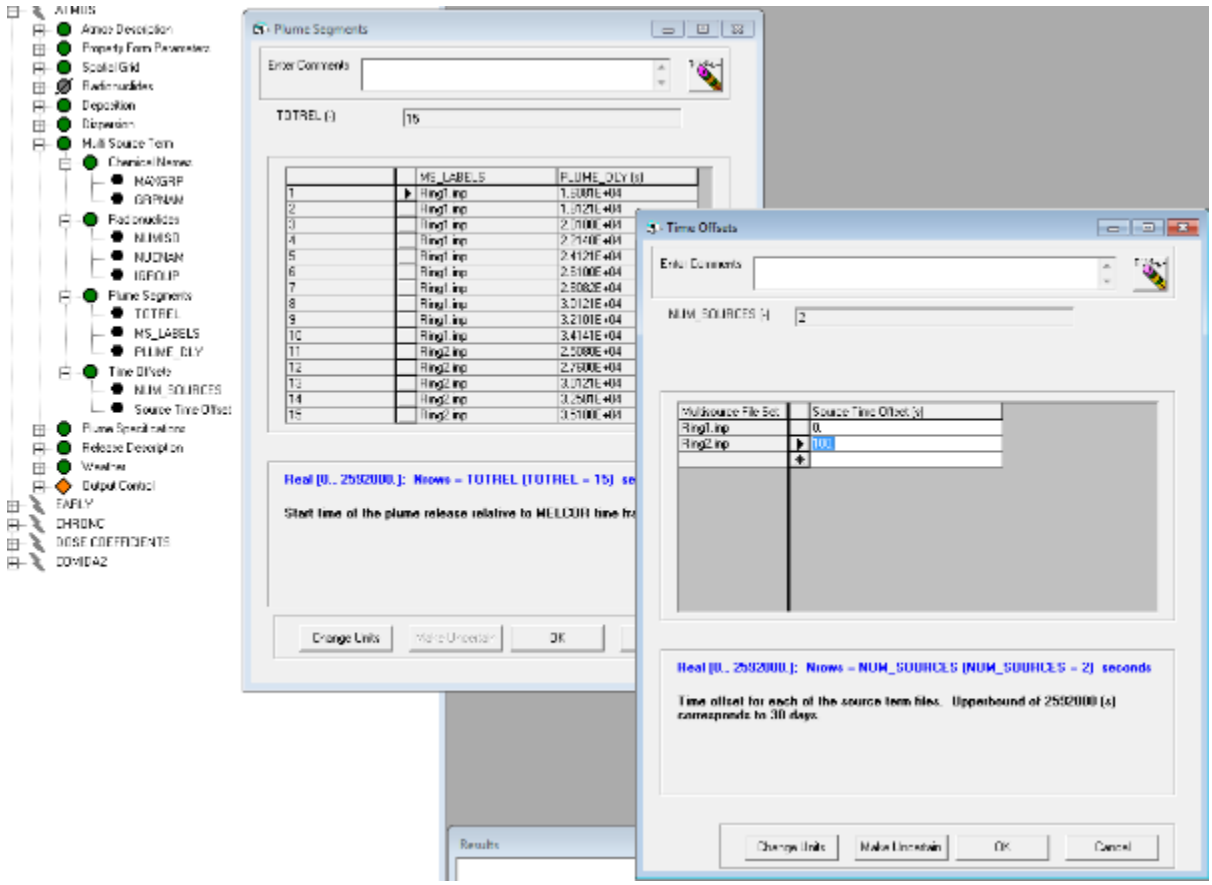


Figure 4-89 Forms for specifying multi-unit source

(3). A special form named *Spatial Intervals* can be found under the ATMOS/Output Control category. This form has the same name as another form, as shown in Figure 4-90. However, the upper bound for the parameter INDREL, indicating the plume segment number, is the number of plumes segments in all of the multi-source files. The row number on the *Plume Segments* form shown in Figure 4-89 identifies value of INDREL for a specific plume segment.

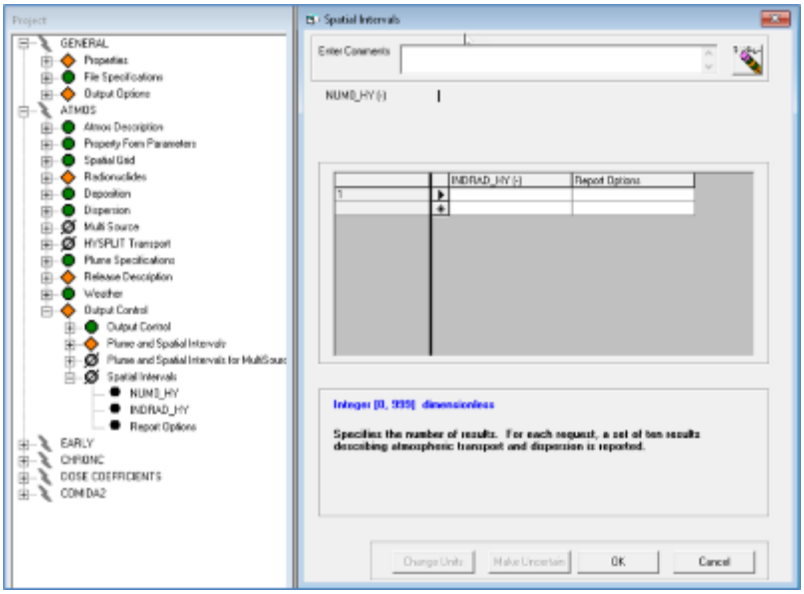


Figure 4-90 Specifying ATMOS output with the multi-unit source model

(4). Running a multi-unit source calculation is performed from the Run Models form by selecting Execute/Run Models from the main menu, as shown in Figure 4-91. Notice that Create Multi Source Term File is checked. This means that Combine Source is to be run to recreate a file called CombineSource.out. This file is used by MACCS, and the file name is specified on an input card in the ATMOS input file.

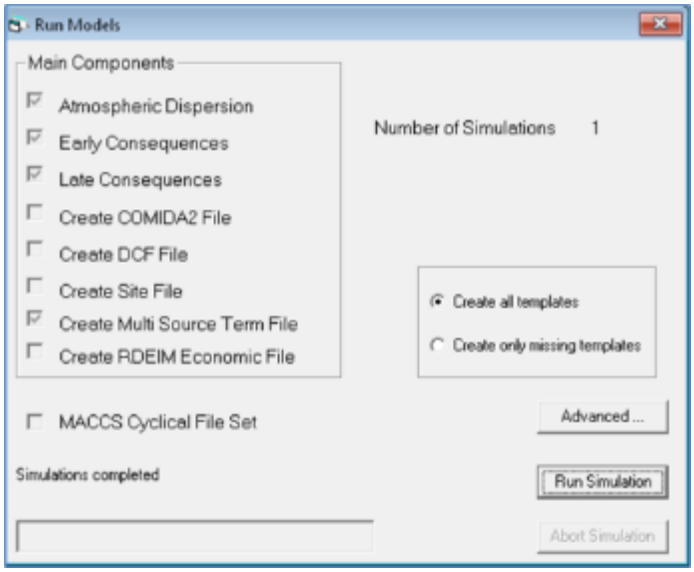


Figure 4-91 Running multi source term calculation with MACCS

4.5 Running Simulations

Model execution can be initiated by opening the *Run Models* form by selecting *Execute→Run Models…* from the main menu and clicking on *Run Simulation.*

This section describes the options available when running simulations.

4.5.1 Run Models Form

The following are the main components of the *Run Models* form as shown in Figure 4-92. The model settings are modified from the *Project Properties* form. The MACCS modules to be used, namely *Atmospheric Dispersion, Early Consequences, and Late Consequences*, are selected from the *Scope* tab of the *Project Properties* form. The *MACCS Cyclical File Set* is also selected from the *Scope* tab. The *File Created from User Input* setting can be modified from the *Food* tab, *File created from Existing DCF File* from the *Dose* tab, *Create Site File* from the *Site/Data* tab, and the *Create Multi Source Term File* from the *Plume/Source* tab.

None of these settings can be modified directly from the *Run Models* form.

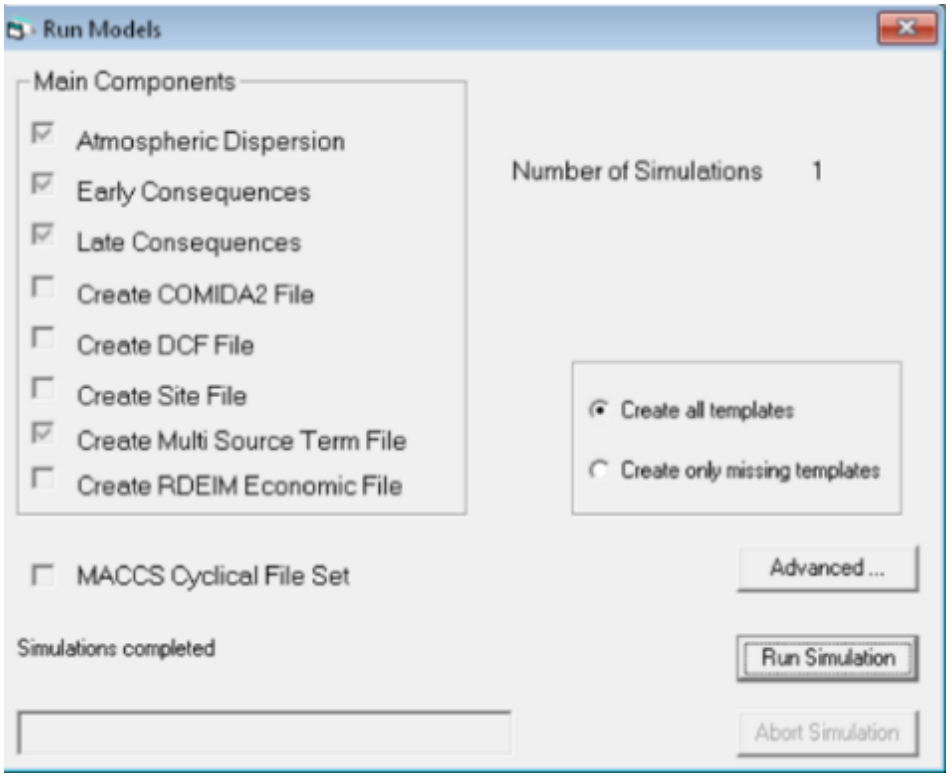


Figure 4-92 Run a simulation

The *Number of Simulations* is the number of cyclical and/or LHS samples to be run. However, MACCS attempts to prevent redundant simulations. For example, when no cyclical files or uncertain parameters are specified within MACCS, only a single simulation is performed. Likewise, when a set of cyclical files are specified but there are no uncertain parameters, MACCS performs the same number of simulations as cyclical files.

The *Number of Simulations* can be changed by selecting *Advanced* to open the *Advanced Execution Parameters* form. The seed used by the LHS random number generator can also be modified on this form.

Clicking *Run Simulation* initiates simulations. Progress is reported in the *Results* window.

The current simulation number (e.g., the MACCS run number) is displayed in the status bar found at the bottom of the *Run Models* form.

Selecting *Abort Simulation* aborts a MACCS run in progress.

4.5.2 Advanced Execution Parameters Form

Opening the *Run Models* window by selecting *Execute→Run Models* from the main menu allows the user to set advanced execution options. Clicking the button *Advanced* opens the *Advanced Execution Parameters* dialog as shown in Figure 4-93.

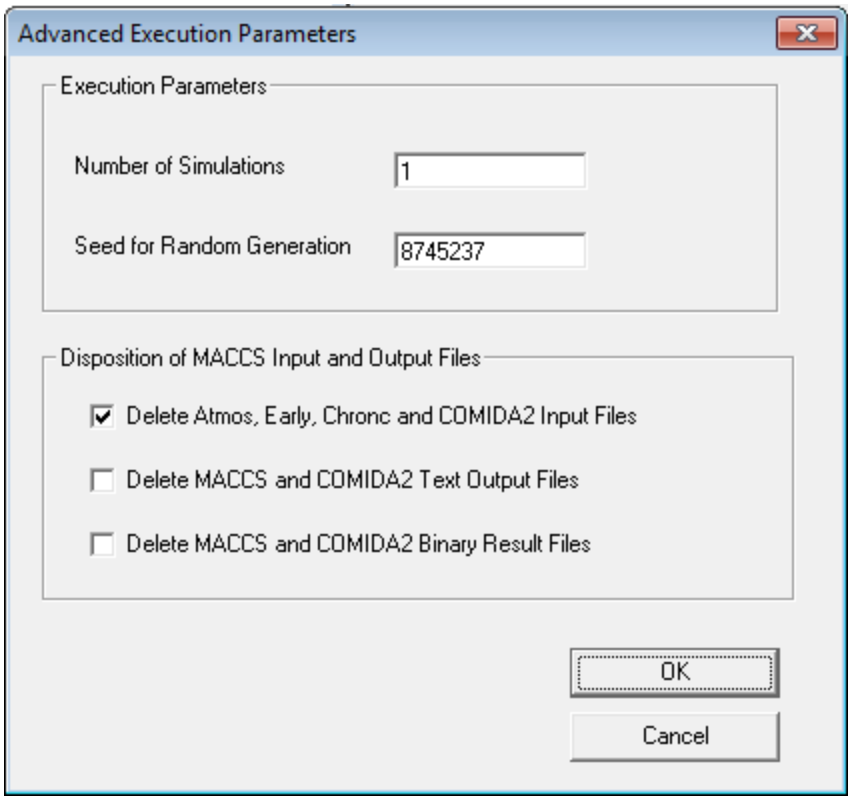


Figure 4-93 Advanced execution parameters form

The *Number of Simulations* text box is the number of times MACCS runs.

When there are uncertain parameters, set number of simulations to the number of LHS simulations that are to be used in the analysis. Changing this number changes the sampled values of the uncertain parameters used in the simulations.

When MACCS cyclical files are used with or without LHS, enter the number of times you want MACCS to run. When LHS is not used, the Number of Simulations should be the same as the number of cyclical files; when LHS is used, the Number of Simulations must be an integer multiple of the number of cyclical files. When the value entered by the user is not a multiple of the number of cyclical files, WinMACCS resets this value to be the next larger integer that is a multiple of the number of cyclical files. Statistical results for the aggregated output assume that the conditions represented by the cyclical files are equally likely.

The value in the *Seed for Random Generation* text box is the random number seed used by LHS to create distribution samples of the parameters the user has chosen to be represented by probability distributions. Changing this number changes the sampled values of the uncertain parameters used in the simulations. The LHS users guide recommends choosing values of about 1000 or greater because “certain smaller values can generate random sequences that compromise statistical randomness properties” (Wyss and Jorgensen, 1998). The value of the seed must be between 1 and 2,147,483,647.

The section labeled *Disposition of MACCS Input and Output Files* gives the user the option of deleting various files that do not need to be referenced. These are useful options when there are many simulations. The files deleted are removed after MACCS has executed a single sample except for the MACCS binary results files. The template files are always retained in the project Input folder.

When the *Delete Atmos, Early, Chronc and COMIDA2 Input Files* check box is checked, the MACCS input files are deleted after they have been used in a simulation. The template files (e.g., AtmosTemplate.txt) are not deleted. These files are in the project /Input folder.

When the *Delete MACCS and COMIDA2 Text Output Files* check box is checked, the MACCS text output files and the COMIDA2 text output files are deleted after the simulations have all completed. These files are in the project /Output folder.

When the *Delete MACCS and COMIDA2 Binary Result Files* check box is checked, the MACCS binary files are deleted after the reports are created. When no reports are requested and the *Execute→Auto Create Summary Report* checked command is off the MACCS binary results files are removed after each MACCS run and data is not available for post processing. In each other case, the binary data is imported into the project database and is available for post processing. Data for plots and additional reports are available through the database, even after the binary files are removed.

Clicking *OK* preserves changes. Clicking *Cancel* discards changes.

4.5.3 Template files

Template files are created by MACCS to facilitate the task of creating input files. These are named atmosTemplate.txt, earlyTemplate.txt, chroncTemplate.txt and comidaTemplate.txt. The positions where the values of uncertain parameters are inserted are tagged within these files. The tags can be used to identify the uncertain variables. For example, notice the special characters around the number 309 in the following input line taken from a sample atmosTemplate.txt file.

- WDCWASH1001 §309§

This line indicates that CWASH1 is uncertain. A sampled value from LHS is inserted into the space §309§ when the input file is created from the template file. The number 309 is an internal key used by MACCS to identify which parameter to insert.

The Atmos1.inp, Early1.inp, Chronc1.inp and the three COMIDA2 input files are recreated from the template files when the user selects *Run Simulation*.

When the user desires to manually modify one or more input parameters within the MACCS template files, the user must first uncheck the main menu option *Execute→Refresh Template Input Files before Running*. Otherwise, the modified file is overwritten before MACCS executes and the modification is lost.

4.6 Model Results

Results are output from MACCS in text format (e.g. Model1.out), and in binary format (e.g., Model1.bin).

The binary results are available from WinMACCS as custom reports, custom plots or a text view of the binary file.

4.6.1 Text Results from MACCS

Text results from MACCS can be viewed in a text editor such as Notepad. These files can be opened directly by double clicking on the file name (e.g. Model1.out) found in the *Project/Files* tab.

Most MACCS results from a single simulation are probability distributions representing uncertain weather. For example, in Figure 4-94, the MACCS results for Center Air Concentration for Cs-137 for plume number one at 4.8 to 5.6 km is a probability distribution. MACCS reports statistics such as *Prob Non-Zero, Mean,* etc., calculated from this distribution. These statistics are listed as column headings in Figure 4-94.

	PROB		QUANTILES					PEAK	PEAK	PEAK
	NON-ZERO	MEAN	50TH	90TH	95TH	99TH	99.5TH	CONS	PROB	TRIAL
Source Term 1: Plume 1, at 4.8-5.6 km										
Cs-137 Center Air Conc. (Ci-s/m3)	0.9994	9.79E-03	6.41E-03	2.50E-02	3.17E-02	4.26E-02	4.83E-02	5.53E-02	2.08E-03	152
Cs-137 Ground Air Conc. (Ci-s/m3)	0.9994	1.07E-02	6.74E-03	2.81E-02	3.75E-02	5.33E-02	5.62E-02	5.99E-02	2.08E-03	152
Cs-137 Center Ground Conc. (Ci/m2)	0.9994	8.72E-05	6.16E-05	2.27E-04	2.92E-04	3.53E-04	3.80E-04	4.17E-04	2.08E-03	152
Total Center Ground Conc. (Ci/m2)	0.9997	2.91E-02	2.04E-02	7.75E-02	1.01E-01	1.26E-01	****	1.35E-01	6.09E-03	127
Ground-Level Dilution, X/Q (s/m3)	0.9997	5.99E-06	3.13E-06	1.55E-05	2.32E-05	3.30E-05	3.50E-05	3.77E-05	2.08E-03	242
Cs-137 Adjusted Source, Q (Ci)	0.9994	2.05E+03	2.03E+03	2.19E+03	2.26E+03	2.43E+03	2.52E+03	2.62E+03	2.17E-03	58
Plume Sigma-y (m)	0.9997	4.38E+02	3.49E+02	7.23E+02	7.46E+02	8.03E+02	8.29E+02	8.35E+02	4.25E-03	76
Plume Sigma-z (m)	0.9997	5.47E+03	1.05E+02	2.14E+04	2.29E+04	****	****	2.63E+04	1.31E-02	36
Plume Height (m)	0.9997	3.27E+01	3.28E+01	4.05E+01	4.44E+01	5.82E+01	****	6.61E+01	5.62E-03	230
Plume Arrival Time (s)	0.9997	1.90E+04	1.35E+04	2.15E+04	2.31E+04	****	****	2.65E+04	1.34E-02	63

Figure 4-94 MACCS statistical summary results

The *Statistical Summary Results* form described in Section 4.6.3.3 allows the user to display a graphical view of the CCDF for each of the entries in Figure 4-94(e.g., the mean value of Center Air Concentration for Cs-137 for plume number one at 4.8 to 5.6 km) over all realizations. In other words, a plot created with this option displays a probability distribution (CCDF) of one of the statistics above calculated over the set of LHS samples.

A binned CCDF of output requests is created by MACCS when the Report Option is set to CCDF or CCDF & REPORT on the forms in the ATMOS/Output Control, EARLY/Output Control and CHRONC/Output Control categories.

Parameters set under the EARLY and CHRONC *Output Control* categories of the interface determine the consequences calculated by MACCS. MACCS can calculate a variety of different consequence measures to portray the impact of a facility accident on the surrounding region. The user has control over the results that are produced. By choosing appropriate values in *Output Control*, the user can ensure that the code produces only desired results. This affords a great deal of flexibility, but it also requires that the user anticipate the results that are needed. When any are omitted, the user needs to correct the parameter choices and rerun the calculation.

In this regard, a result can only be produced when the model needed for its calculation has been previously defined in the appropriate section. When any results pertaining to health effects are requested, risk factors for that model must have been supplied on forms *Early Fatality Parameters, Early Injury Parameters,* and *Latent Cancer Parameters.*

EARLY can produce many different types of results. Some of these types of results are also calculated by CHRONC, but some are not. For instance, both EARLY and CHRONC calculate cancer cases and population dose, but only EARLY calculates early fatalities, and only CHRONC calculates economic costs. When the user requests EARLY to produce a result that is also produced by CHRONC, the code automatically calculates results for both EARLY and CHRONC.

Summary statistics with respect to each requested result are reported independently of the value of the WinMACCS variable, *Report Options*. There are ten columns of numeric data which provide a statistical summary, as follows:

- PROB NON-ZERO is the conditional probability of having a nonzero consequence estimate, conditional on the occurrence of the release under consideration.

- MEAN is the average (expected) consequence over all weather trials. This is calculated by taking the sum of all the products [(consequence value) $\times$ (conditional probability of that value)] for each weather trial. The probabilities of the weather trials are not necessarily the same, so the conditional probabilities can be different for each weather trial.

- 50TH QUANTILE is the median of the estimated CCDF.

- 90TH QUANTILE is based on the estimated CCDF. It is the value for which there is a 10% chance this consequence magnitude is exceeded.

- 95TH QUANTILE is based on the estimated CCDF. It is the value for which there is a 5% chance this consequence magnitude is exceeded.

- 99TH QUANTILE is based on the estimated CCDF. It is the value for which there is a 1% chance this consequence magnitude is exceeded.

- 99.5TH QUANTILE is based on the estimated CCDF. It is the value for which there is a 0.5% chance this consequence magnitude is exceeded.

- PEAK CONS is the largest consequence magnitude obtained from the set of weather trials that were examined.

- PEAK PROB is the conditional probability associated with the largest consequence magnitude.

- PEAK TRIAL refers to the weather trial for which the largest consequence occurred. By referring to the ATMOS portion of the output file, the user can determine the start time (day and time period) of this weather sequence.

A CCDF is an estimate of the distribution of consequence magnitudes. The variability of consequence values in a single MACCS simulation is due solely to the uncertainty of the weather conditions existing at the time of the accident. A MACCS output file is created for each simulation when any input parameters are chosen to be uncertain. In this case, the user chooses the number of realizations to capture the uncertainty in the input variables. MACCS produces one CCDF per realization. WinMACCS can quantify the overall uncertainty in results by assembling the set of CCDFs into a single CCDF that accounts for both weather and input uncertainty.

CCDFs can be viewed as spider plots (one CCDF curve per simulation) from within the WinMACCS interface using *Post Processing/Graphical Results/Results over all Weather Trials* under the main menu selection. Additionally, statistical results (such as the mean result over all weather trials) can be viewed using *Post Processing/Report Results/Create Summary Report* under the main menu.

Report Options appears on most of the output request forms. When set to *CCDF* or *CCDF & REPORT*, CCDF data are reported in the MACCS output file. When set to *REPORT* or *CCDF & REPORT*, WinMACCS automatically generates a report over all realizations based on quantiles specified on the *Reporting Options* form.

When the user did not select *Report Options* to be *CCDF* or *CCDF & REPORT* when requesting the calculation in the WinMACCS input forms, it is still possible to retrieve those data from WinMACCS. Though the CCDF data are not written to the output file, when the user requests a report based on the desired data using the custom report form, *Post Processing/Create Custom Report*, CCDF data are read into WinMACCS from the binary output file and are available in the *Post Processing/Graphical Results* forms. The user should be aware that the method used to estimate quantile levels in WinMACCS differs from the one used in MACCS, so quantile values for a single realization produced by WinMACCS may differ slightly from those produced by MACCS.

When a consequence measure was calculated by both EARLY and CHRONC, the output lists results separately for EARLY and CHRONC. The weighted sum or average of all consequence results is presented at the beginning of the output file in a section labeled OVERALL RESULTS. Following the overall results, those from each of the cohorts are presented. The total number of cohorts listed is one greater than the number of emergency response cohorts created in EARLY. The final cohort in the output represents CHRONC.

4.6.2 Custom Reporting Options

Reports created from the MACCS binary result files are created using different methods as follows:

- Reports that combine the results over the MACCS simulations can be requested on the forms in the *ATMOS/Output Control*, *EARLY/Output Control* and *CHRONC/Output Control* categories. These requests result in a *Summary Report.*

- Reports that combine the results over the MACCS simulations can also be created using the custom report features. Data is available from every calculation request made from ATMOS/Output Control, EARLY/Output Control and CHRONC/Output Control categories, even when report requests were not made on those forms. These can be created using the *Combine Realizations* option on the *Manage Reports* form as described in Section 4.6.2.3.

- Reports that display results without combining data over the MACCS simulations are created using the *Realization Based* option on the *Manage Reports* form as described in Section 4.6.2.5.

Reports are created automatically after the simulations are completed, provided the main menu item *Execute→Auto Create Reports* is checked. The reports created include the *Summary Report* and all the custom reports defined. These reports are placed in the project \Output folder, and are also available within WinMACCS on the *Project/Files* tab.

When the menu item *Execute→Auto Create Reports* was not checked before the simulations began, the reports can still be requested from the *Manage Reports* form described in Section 4.6.2.3 and Section 4.6.2.5. The summary report can be created by selecting *PostProcessing→Report Results→Create Summary Report.* These post processing features only function when the MACCS binary files have not been deleted.

Custom reports are defined using the menu item *PostProcessing→Report Results→Manage Custom Reports.* New custom reports must be defined after the MACCS simulations have completed because the list of results to place in the reports is not available before the run has been finished. After the custom reports have been set up, it is possible to recreate them for each subsequent run.

When the output requests to MACCS (see the forms in *Output Control*) are modified to exclude some output requests that were used to define the custom reports, those custom reports are not created. The user should be careful not to confuse reports from previous runs with current runs because previously created reports are not deleted unless the new file has the same name as the existing file.

It is possible to import custom report definitions from other projects using the menu item *File→Import Custom Report Definitions* as described in Section 4.2.1.

4.6.2.1 Combining Results over Realizations

Reports that combine realizations contain the grand mean (i.e., the mean of the means for each realization) and the interpolated values based on the binned CCDF results for a user entered set of probabilities, or quantiles. The first step in defining these reports is to define the quantiles to use. When the probabilities are not defined, only the grand mean is reported.

Opening the form *GENERAL/Output Options/Reporting Options* allows quantiles to be entered. This is shown in Figure 4-95. When the MACCS simulations have already completed, a *Summary Report* cannot be created, but custom reports can be requested that combine the realizations.

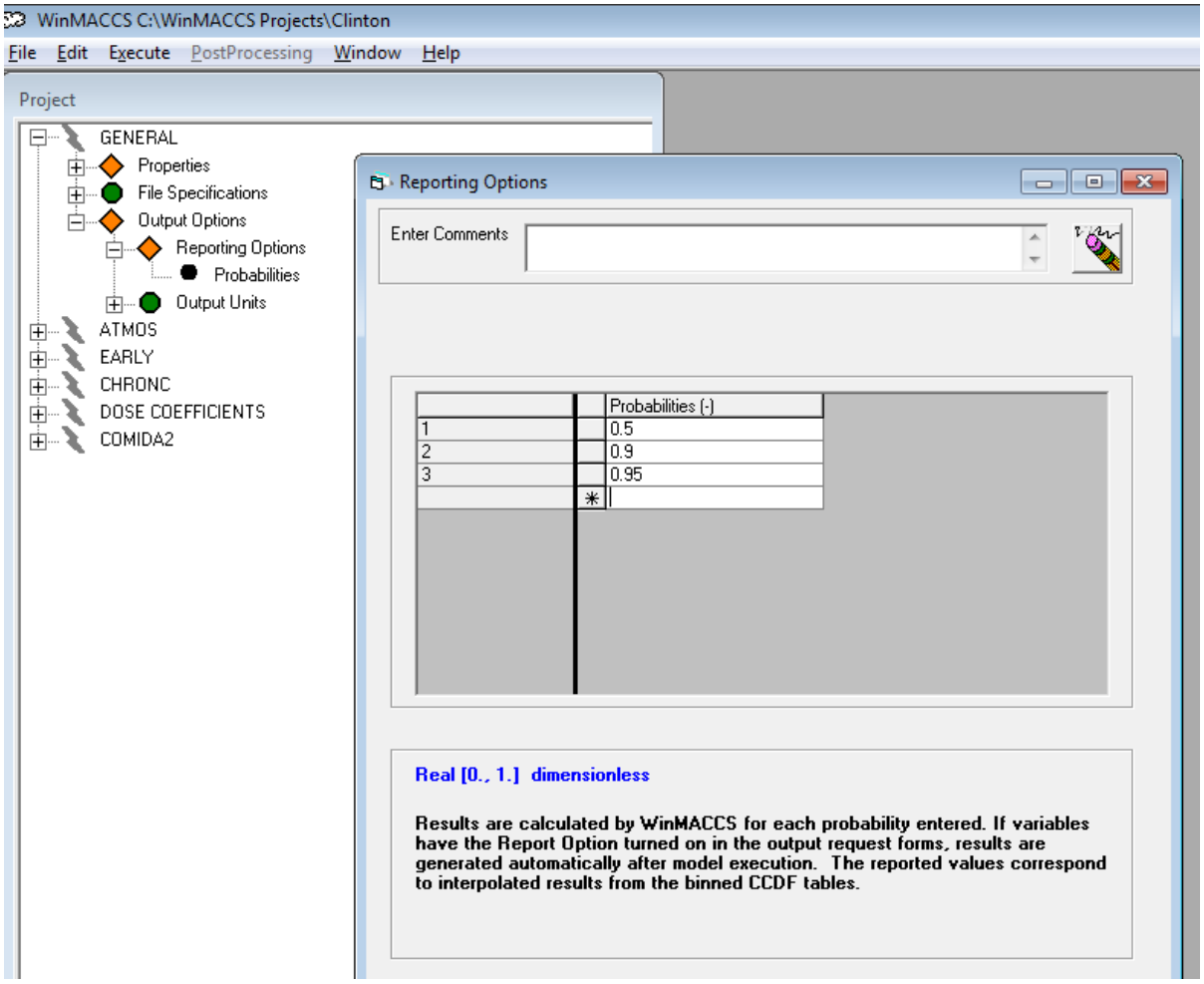


Figure 4-95 Specifying quantiles

4.6.2.2 Creating a Summary Report

A summary report based on MACCS outputs is created after MACCS simulations have completed. To include a result in the summary report, the *Report Options* flag should be set to *REPORT* or to *CCDF & REPORT* as shown in Figure 4-96.

The summary report is created after MACCS simulations have completed, provided the *Execute→Auto Create Summary Report* menu item is checked. This report can also be created by selecting *PostProcessing→Report Results→Create Summary Report.*

The categories *ATMOS/Output Control*, *EARLY/Output Control* and *CHRONC/Output Control* contain calculation requests. Most of the forms in these categories contain the *Report Options* flag.

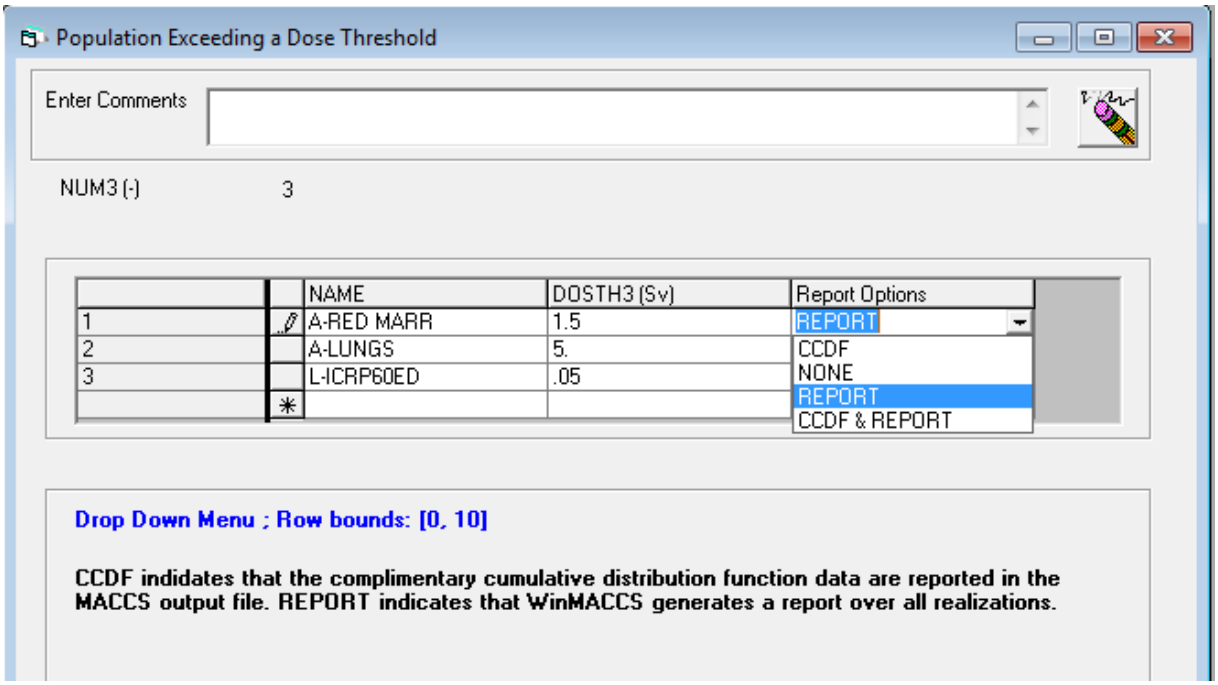


Figure 4-96 Summary report request

Summary reports can be requested as follows:

(1). Quantiles are defined as shown in Figure 4-95.

(2). The outputs of interest are selected by first opening an output request form. This is a form that is in one of the *Output Control* categories.

(3). In the *Report Options* column, by choosing either *REPORT* or *CCDF & REPORT* causes WinMACCS to include this result in the report after all MACCS simulations are completed. When the CCDF & REPORT is chosen, the additional binned data for each cohort is printed in each of the MACCS output files associated with the simulation.

(4). This process can be repeated for all results to be included in the summary report. Clicking *OK* preserves the summary report requests.

(5). After running the MACCS simulations, the binary result files, Model1.bin and Model2.bin, are imported into the database. The report, summary.txt, is automatically created based on the user input, and placed in the project output folder. Double clicking on Output/Summary.txt found on the *Files* tab of the *Project* window opens the report.

4.6.2.3 Creating a Report that Combines Realizations

This section describes how to create new combined-realization reports after MACCS simulations have completed.

After MACCS has run, the *PostProcessing* menu is available. The custom report generator can be opened by selecting *PostProcessing→Report Results→Manage Custom Reports* as shown in Figure 4-97 .

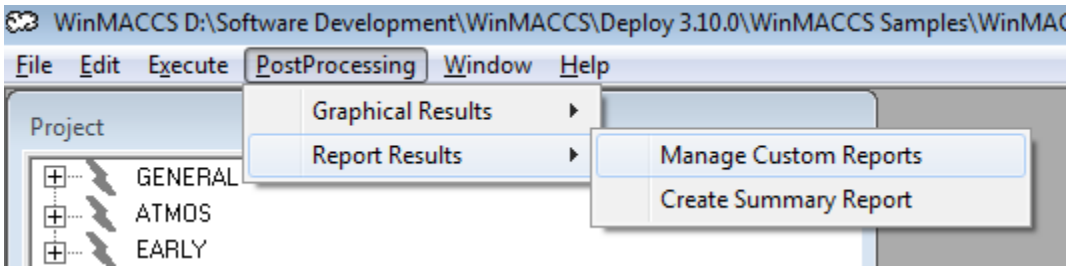


Figure 4-97 Opening the Manage Reports form

This form lists the custom reports currently defined as shown in the example shown in

Figure 4-98. In this example there are two reports defined. The column labeled *Type* identify the report format as *Combined.* This means that these are reports based on combining realizations. When the menu item *Execute→Auto Create Reports* is checked, all reports listed in the *Manage Reports* form are automatically created after the MACCS simulations have completed.

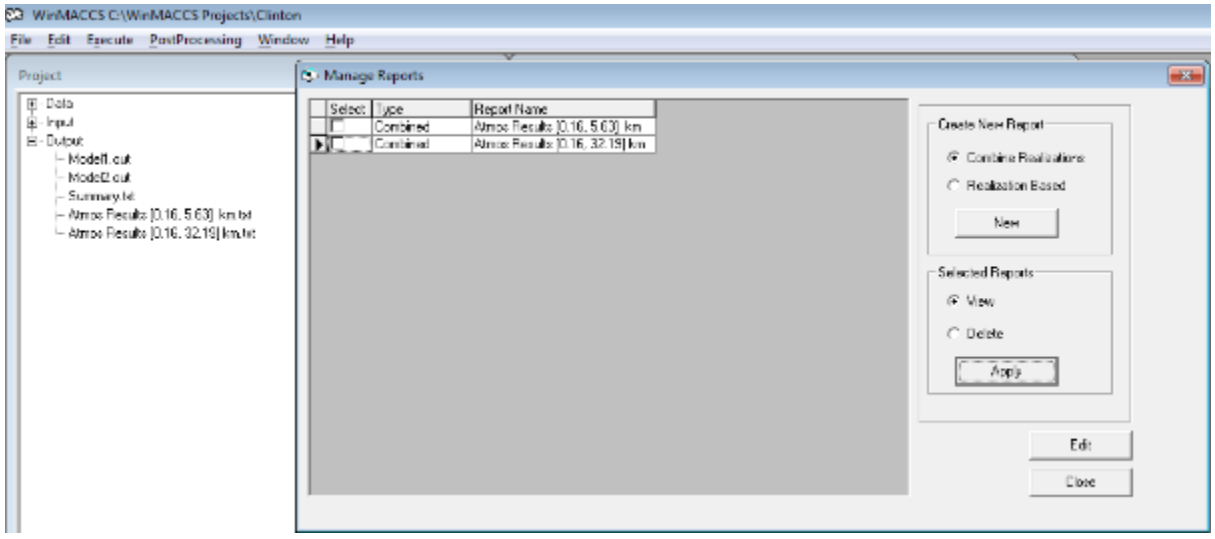


Figure 4-98 Reports based on combining realizations

The *Custom Combined Report* form as shown in Figure 4-99 lists each of the MACCS output requests. This form is opened when a new *Combine Realizations* report is created, or when an existing *Combine Realizations* report is edited.

The column labeled *Report Description* identifies the form description as found in the *Project/Parameters* tab. For example, in Figure 4-99 the entries defining the report *Population Dose* were requested from the WinMACCS form *EARLY/Output Control/Population Dose.* The column labeled MACCS Input Card is a copy of the line written to the MACCS input file EARLY1.inp.

The *Combine Realizations* report contains results like the Summary.txt report. WinMACCS combines the CCDF data over all the MACCS binary result files and displays the grand mean and the interpolated quantile values.

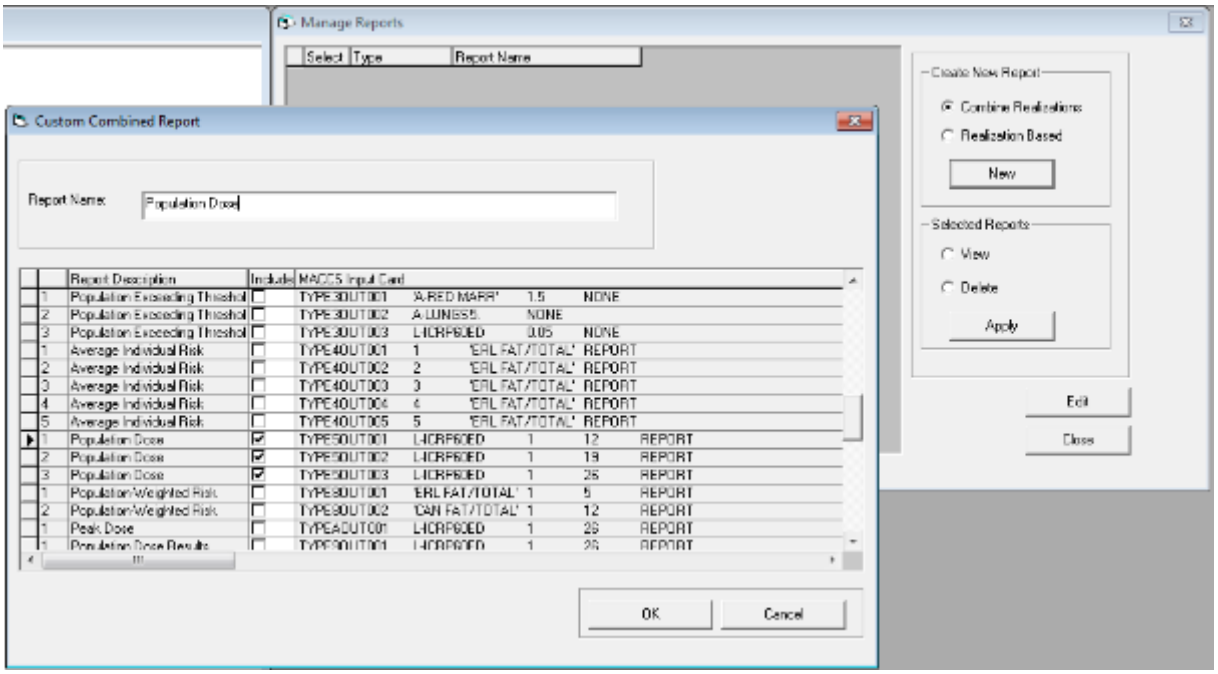


Figure 4-99 Defining a Combine Realizations report

New combine realization reports can be defined as follows:

1. Quantiles are defined as shown in Figure 4-95.
2. The Manage Reports form is opened by selecting *PostProcessing→Report Results→Manage Custom Reports* as shown in Figure 4-99.
3. A new definition can be defined by first selecting the radio button *Combine Realizations* and clicking on the button *New*.
4. The user can enter report name in the field labeled *Report Name*.
5. The MACCS output requests are selected by clicking check boxes in the *Include* column.
6. Clicking *OK* to saves the new report definition.

If the report has already been defined, the report can be opened by checking the box in the column labeled *Select.* Selecting the radio button labeled *View* in the group *Selected Reports and* clicking the *Apply* button creates and opens the report.

A defined report can be edited by checking the box in the column labeled *Select* and clicking the *Edit* button.

A defined report can be deleted by checking the box in the column labeled *Select*, selecting the radio button labeled *Delete* in the group *Selected Reports* and clicking the *Apply* button.

4.6.2.4 Interpretation of Combining Realization Reports

The report format used for summary reports is the same format that is used when creating a custom report when the combine realization is option is used as shown in Figure 4-99.

These reports consist of the grand mean and an estimate for the probability of exceedance for the probabilities requested on the *General/Reporting Options* form based on the binned cumulative probability distributions calculated by MACCS.

If all of the CCDF values are identical, there is no variance in the parameter values. In this case it is not possible to calculate a meaningful value for the probability of exceedance and the report contains the text “Unable to transform CCDF No differences in probability values in CCDF”.

In the following example, the report request was made on the form *Early/Output Control/Health-Effect Cases.* The statistics from each of the LHS trials are combined.

```
**************************************************************************
Request 1 Health-Effect Cases
MACCS Image:  TYPE1OUT009      'CAN FAT/TOTAL'     1        26       REPORT
**************************************************************************

Evacuation CHRONC CAN FAT/TOTAL [0.,1609.34](km)
                                Probability of Exceedance
                                Grand Mean      0.5         0.9          0.95
Health-Effect Cases (none)  2.732E+03     9.231E+02     1.006E+02     5.008E+01

Evacuation Evac #1 CAN FAT/TOTAL [0.,1609.34](km)
                                Probability of Exceedance
                                Grand Mean      0.5         0.9          0.95
Health-Effect Cases (none)  4.094E+02     1.017E+02     5.141E+00     1.856E+00

Evacuation Evac #2 CAN FAT/TOTAL [0.,1609.34](km)
                                Probability of Exceedance
                                Grand Mean      0.5         0.9          0.95
Health-Effect Cases (none)  3.637E+00     1.83E+00      3.321E-01     2.049E-01

Evacuation Overall CAN FAT/TOTAL [0.,1609.34](km)
                                Probability of Exceedance
                                Grand Mean      0.5         0.9          0.95
Health-Effect Cases (none)  3.145E+03     1.273E+03     1.35E+02      7.178E+01
```

The first entry, CHRONC, reports the cancer fatalities due late consequences. The next two entries, Evac # 1 and Evac # 2 report the cancer fatalities due to early consequences for cohort 1

and cohort 2 respectively. The early and late consequences are combined in the entry labeled Evacuation Overall.

Interpreting the results for the overall health effects, we are 90 percent certain that the number of total fatalities exceeds 135. The mean number of fatalities over all LHS realizations is 3145. This is precisely the sum of the mean cancer fatalities due to the late and early consequences.

Cohort results are combined using the weighting factors stored in *WTFRAC* when the overall results are calculated for some of the results that are independent of the population such as Average Individual Risk, Peak Dose and Population Weighted Risk calculations.

4.6.2.5 Creating a Report Based on Individual Realizations

This section describes how to create reports that show results for individual realizations after MACCS simulations have completed.

After MACCS has run, the *PostProcessing* menu is available. The custom report generator is opened by selecting *PostProcessing→Report Results→Manage Custom Reports*.

This form lists the custom reports currently defined. In the example shown in Figure 4-100 the column labeled *Type* indicates the report format. For reports based on individual realizations, the *Type* is either *byVariable* or *byTrial* depending on whether the *By Variable* or the *By Realization* radio button was selected on the *Custom Realization Based Report* form as shown in Figure 4-101. See Section 4.6.2.3 for creating reports where the *Type* is *Combined.*

All reports listed are automatically created after the MACCS simulations have completed provided the menu item *Execute→Auto Create Reports* is checked.

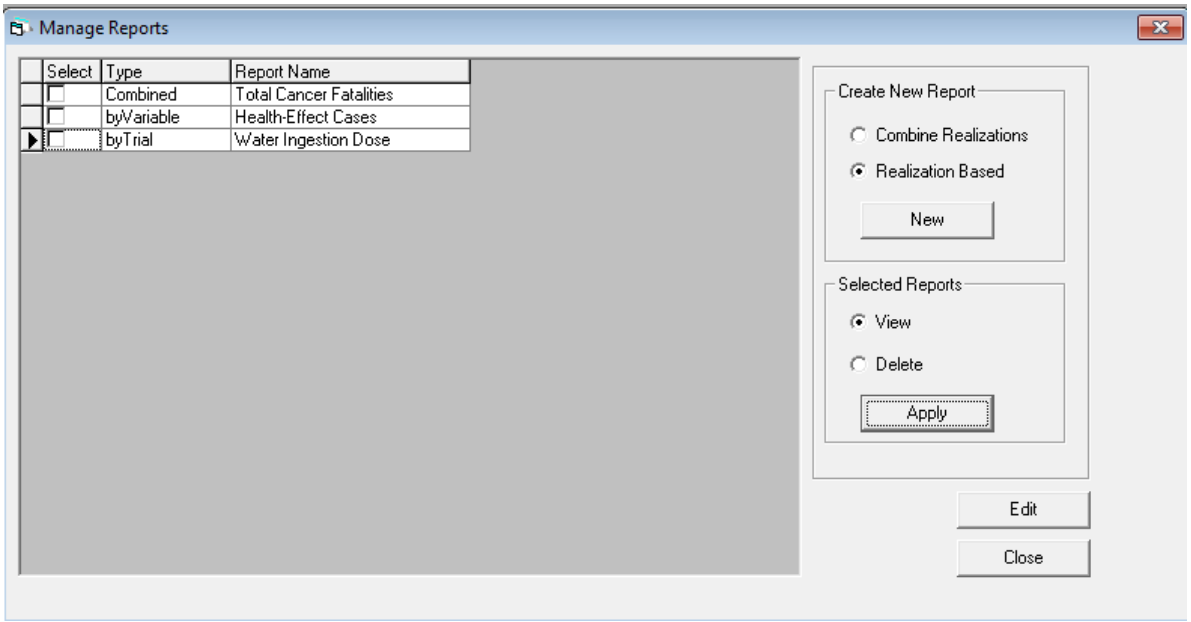


Figure 4-100 Reports based on each realization

The *Custom Realization Based Report* form as shown in Figure 4-101 is organized as a list of available results read from the MACCS binary results file. Each available result for reporting is listed. A list is opened by clicking the plus sign where more specific results can be selected. In the example, there are two results available for Total Centerline Ground Concentration. Items in

the list, called qualifiers, can be individually selected or selected as a group by clicking on the box preceding the result name.

This form is opened when a new *Realization Based* report is created, or when an existed *Realization Based* report is edited.

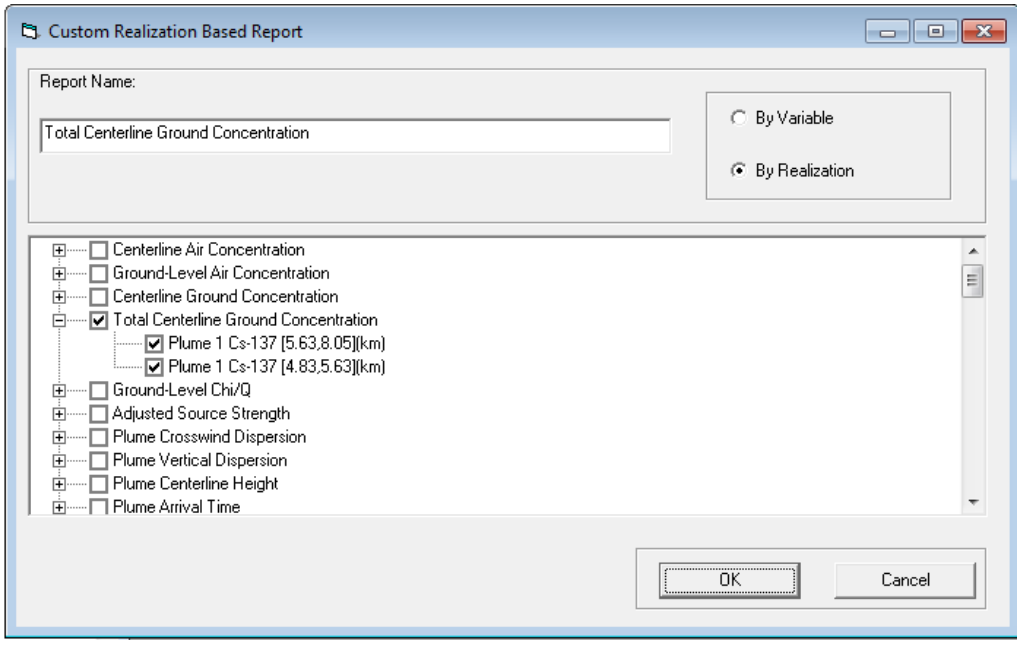


Figure 4-101 Defining a Realization Based report

New realization-based reports can be defined as follows:

(1). The Manage Reports form can be opened by selecting PostProcessing→Report Results→Manage Custom Reports from the main menu.

(2). Selecting the radio button *Realization Based* and clicking the button *New* opens the *Custom Realization Based Report* form as shown in Figure 4-101.

(3). A report name must be entered in the field labeled *Report Name*.

(4). Results can be selected by clicking on the empty boxes in front of the result names. Individual items can be selected from the qualifier lists by clicking the + in front of the result name and clicking the empty boxes in front of the qualifiers.

(5). Selecting either the radio button *By Variable* or *By Realization* completes the report definition. When *By Variable* is selected, the results are listed for a given trial when the report is created. When *By Realization* is selected the results for each trial are listed for a given result as shown in Figure 4-102.

(6). Clicking *OK* saves the report definition.

When the report has already been defined the report can be opened by checking the box in the column labeled *Select.* Select the radio button labeled *View* in the group *Selected Reports.* Click the *Apply* button. The report is created and opened.

A defined report can be edited by checking the box in the column labeled *Select* and clicking the *Edit* button.

A defined report can be deleted by checking the box in the column labeled *Select,* selecting the radio button labeled *Delete* in the group *Selected Reports* and clicking the *Apply* button.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Report based on Project D:\Software Development\WinMACCS\Deploy 3.10.0\WinMACCS Samples\WinMACCS Samples\NRC Sample Problems\Sampled Values LNT\Sampled Values LNT.mxd												
2	WinMACCS Version 3.10.0 SVN:2560												
3	Report based on MACCS Version 3.10.0.0 SVN 2560												
4	First binary file date/time stamp 03/27/2015 16:40												
5	7/15/2015 18:28												
6													
7	Health-Effect Cases (none) Evacuation Evac # 2 ERL FAT/TOTAL [0.,1609.34](km)												
8		Probability Non-zero	Mean	5th Quantile	10th Quantile	50th Quantile	90th Quantile	95th Quantile	99th Quantile	99.5th Quantile	Peak Concentration	Peak Probability	Peak Trial
9	Realization 1	2.09E-01	2.01E-04	0.00E+00	0.00E+00	0.00E+00	4.16E-04	1.14E-03	3.16E-03	3.63E-03	9.99E-02	1.81E-04	2.26E+02
10	Realization 2	1.12E-01	3.01E-02	0.00E+00	0.00E+00	0.00E+00	5.28E-03	1.92E-01	7.43E-01	8.41E-01	1.56E+00	3.90E-04	2.64E+02
11	Realization 3	2.08E-01	1.30E-02	0.00E+00	0.00E+00	0.00E+00	8.27E-03	6.52E-02	3.56E-01	4.85E-01	5.61E-01	2.28E-03	4.19E+02
12	Realization 4	3.01E-02	1.83E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-03	5.65E-03	1.80E-01	1.81E-04	1.30E+02
13	Realization 5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	Realization 6	1.81E-04	2.31E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E-03	1.81E-04	2.26E+02
15	Realization 7	5.05E-01	6.47E-03	0.00E+00	0.00E+00	1.47E-07	7.74E-03	5.07E-02	1.15E-01	1.36E-01	5.77E-01	1.62E-04	5.95E+02
16	Realization 8	1.47E-01	1.86E-03	0.00E+00	0.00E+00	0.00E+00	1.63E-06	2.92E-05	4.24E-02	1.10E-01	1.31E+00	1.81E-04	2.26E+02

Figure 4-102 Report of type *By Realization* opened in Excel

4.6.3 Custom Plotting Options

Graphical output can be displayed after completing a MACCS run by selecting an entry from the main menu *Post Processing→Graphical Results.* The following results are available:

- Scalar results are displayed by selecting *PostProcessing→Graphical Results→Scalar Results* from the main menu.
- Statistical summary results are displayed by selecting *PostProcessing→Graphical Results→Statistical Summary Results* from the main menu.
- Probability distribution results representing weather uncertainty are displayed by selecting *Post Processing→Graphical Results→Results over all Weather Trials* from the main menu.

When a plot request is made after a simulation (e.g., one of the menu entries such as *PostProcessing→Graphics→ Results over all Weather Trials*) is selected, the MACCS binary result files (e.g., Model1.bin and Model2.bin*)* are imported into the project database (unless they were already imported to create reports). This progress can be observed in the *Results* window as shown in Figure 4-103.

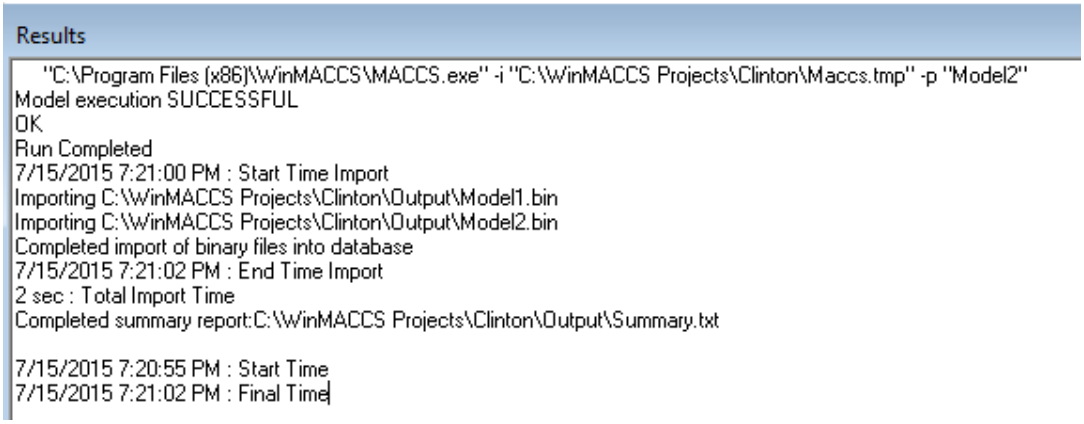


Figure 4-103 Results window after processing binary files

After the binary result files have been processed into the project database, the result information is available for quick access without repeating the import process.

4.6.3.1 Scalar Results

Graphical results are displayed after completing a MACCS run by selecting an entry from the main menu item *PostProcessing→Graphical Results→Scalar Results* as shown in Figure 4-104. This graph was made by selecting the entry under release, *Plume 1 Kr-85*, clicking *Add* and clicking *Select* to show the data points. In this example, the release duration was made uncertain.

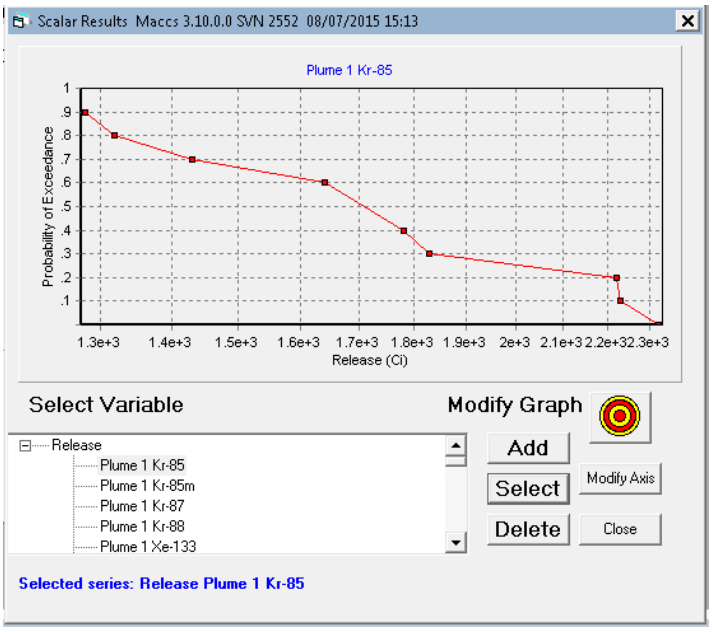


Figure 4-104 *Scalar Results* plot

4.6.3.2 Results Displayed as a Complementary Cumulative Distribution Function (CCDF)

Graphical results are displayed after completing a MACCS run by selecting an entry from the main menu *PostProcessing→Graphical Results→Results over all Weather Trials* from the main menu as shown in Figure 4-105. This graph was made by selecting the entry under *Ground Level Air Concentration*, *Plume 1 Cs-137(25.75, 32.19] km*, and clicking *Add.* In this example, uniform bin sampling from the weather file was used.

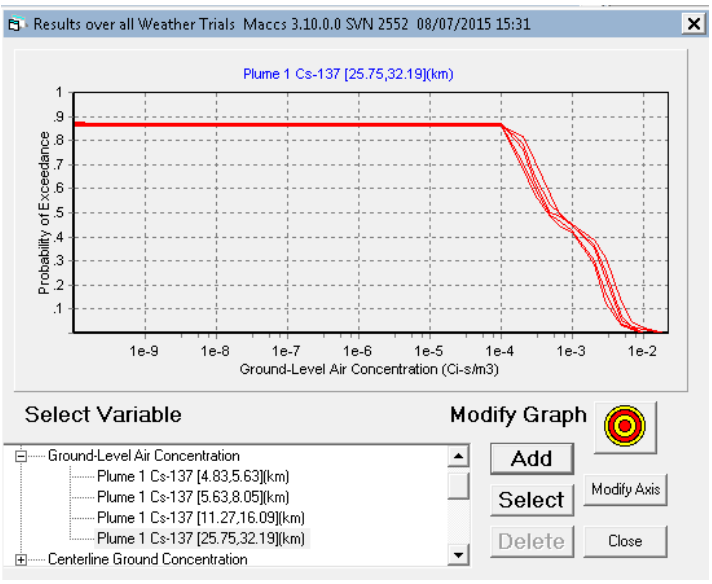


Figure 4-105 *Results over all Weather Trials* plot

Early and Chronc MACCS results from a single execution are often CCDF's or statistics representing uncertainty of the weather during a hypothetical accident. This window displays the CCDF distributions for each MACCS calculation. For example, when five MACCS simulations were run using LHS, there would be five CCDF curves for each result.

Even when not requested by the user, all CCDF results are written to the binary results files *(e.g.,* Model1.bin). In the example shown in Figure 4-106, even though CCDF results for plume one (INDREL) at grid element ten (INDRAD) are not reported in the Model1.txt results files, they are saved in the binary-result files and are available in the plots and reports.

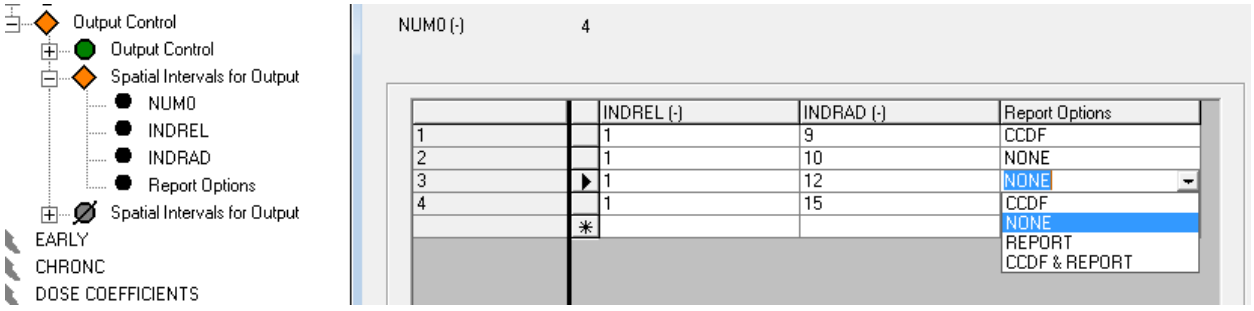


Figure 4-106 Requesting CCDF results in WinMACCS

4.6.3.3 Statistical Summary Results

Graphical results can be displayed after completing a MACCS run by selecting an entry from the main menu *PostProcessing→Graphical Results→Statistical Summary Results* from the main menu as shown in Figure 4-110. This graph was made by selecting the entry under *Ground-Level Air Concentration*, *Plume 1 Cs-137[4.83, 5.63] km*, and clicking *Add.* The mean of the means (over all realizations) is shown on the plot as a vertical green line. The plot is the distribution of the means.

4.6.3.4 Navigation of the Plot window

Multiple plot windows can be opened after simulations have completed as shown in Figure 4-107.

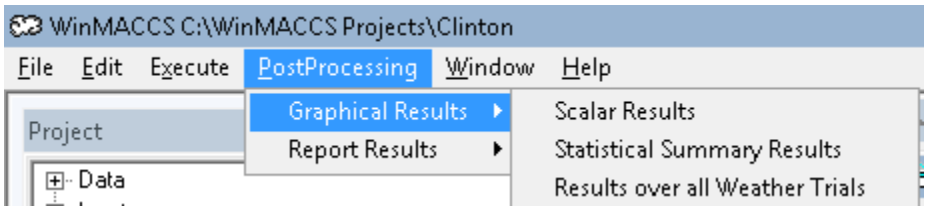


Figure 4-107 Plot windows available

The caption of each plot window contains the MACCS version used in the simulation. The date and time correspond to a date/time stamp written on the first binary output files (e.g., model1.bin) as shown in Figure 4-108.

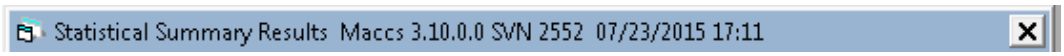


Figure 4-108 Plot window caption

A series can be added to a *Statistical Summary Reports* window by selecting the result to plot from the *Select Variable* list as shown in Figure 4-109, selecting the desired statistic in the *Statistic* list and clicking *Add* to add it to the existing graph.

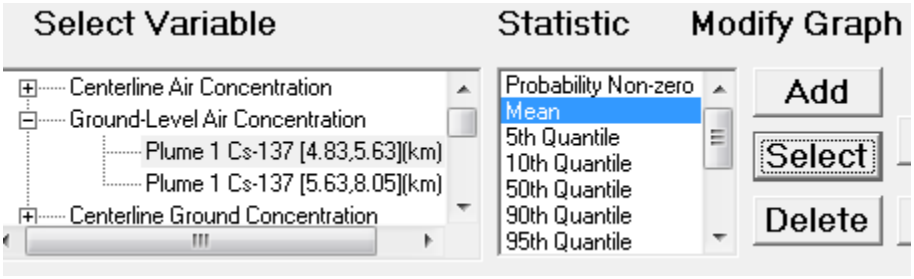


Figure 4-109 Add a Series to a Statistical Summary Reports Window

When the *Mean* is added, notice that the grand mean (average of all means over all simulations) is calculated and displayed on the graph as a vertical line.

A series can be selected by doing any of the following operations:

- Clicking the *Select* button.
- Selecting Select Next Series from the PostProcessing→Graphical Results→Edit Plots menu.
- Clicking on the series on the plot.
- Pressing the Enter key on the keyboard.

After a series is selected the following is true:

- The individual points are marked.
- The details, including the qualifier, indicating the series selected are shown in blue at the bottom of the window.
- The Select Variable list and the Statistic list are selected to entries consistent with the selected series.
- The series is also selected in the legend.
- When the bulls-eye button is pushed in, the data values of the selected series are shown on the plot.

Series are selected in the order they were added. Only one series can be selected at a time.

When the last series added is the selected series and the *Select* is clicked, no series is selected. This feature allows the user to cycle through all the series, unselect all plots, and start the selection again with successive mouse clicks on the *Select* button.

In Figure 4-110, the *Ground-Level Air Concentration for Plume 1, Cs-137* at a spatial distance of 4.83 to 5.63 km for the mean statistic is chosen. Notice that this information is displayed in blue at the bottom of the window. Also notice that the *Grand Mean* is displayed on the plot as a vertical line.

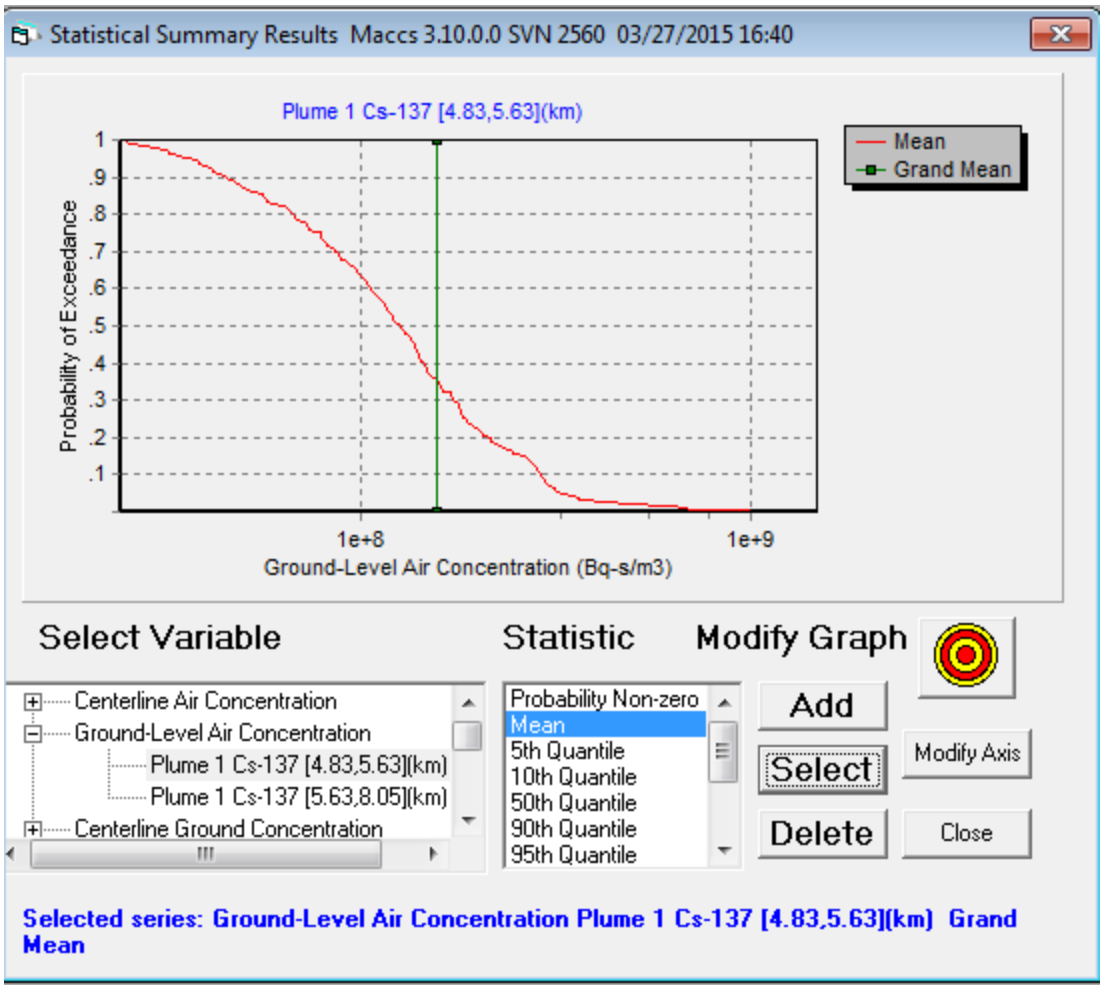


Figure 4-110 *Statistical Summary Results* plot

A series can be deleted by selecting the plot by clicking *Select* until the desired plot is selected, clicking *Delete*. After the series has been selected, it can also be deleted by selecting *Delete Selected Series* from the *PostProcessing→Graphical Results→Edit Plots* menu.

The axis labels or title of a graph can be modified by selecting the *Modify Titles* entry from the *PostProcessing→Graphical Results→Edit Plots* menu. The *Modify Titles* form opens as shown in Figure 4-111. This allows the user to modify the plot and axis titles. Notice that by default the main plot title and the X axis title corresponds to the first plot placed on the graph. Clicking *OK* saves the settings. Clicking *Cancel* discards the changes.

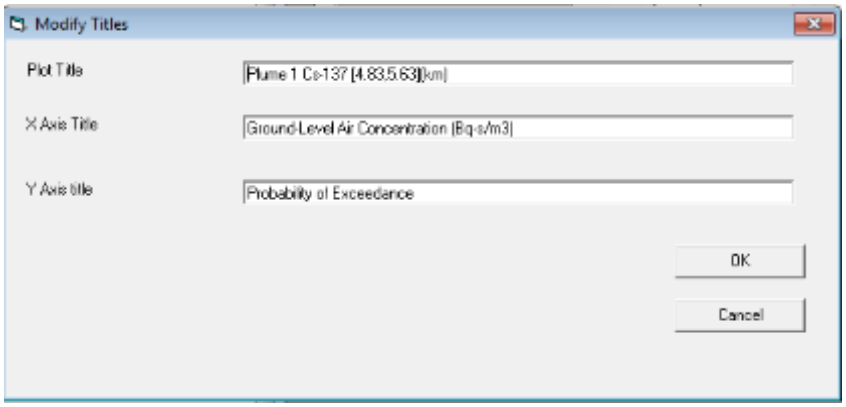


Figure 4-111 Modify plot titles

To zoom in the graphics window, hold the left mouse down in the top right corner of the desired area. Drag a rectangle by moving the mouse down and to the right. Release the mouse.

To un-zoom or restore the graphics window to its original scale, hold the left mouse down anywhere in the plot. Drag a rectangle by moving up and to the left. Release the mouse.

To show the values in the series select the bulls-eye toggle. When this toggle is pushed in, as shown in Figure 4-112, the associated data points in the selected series are overlayed as coordinate pairs. To view some of the values, it may be necessary to use the zoom feature.

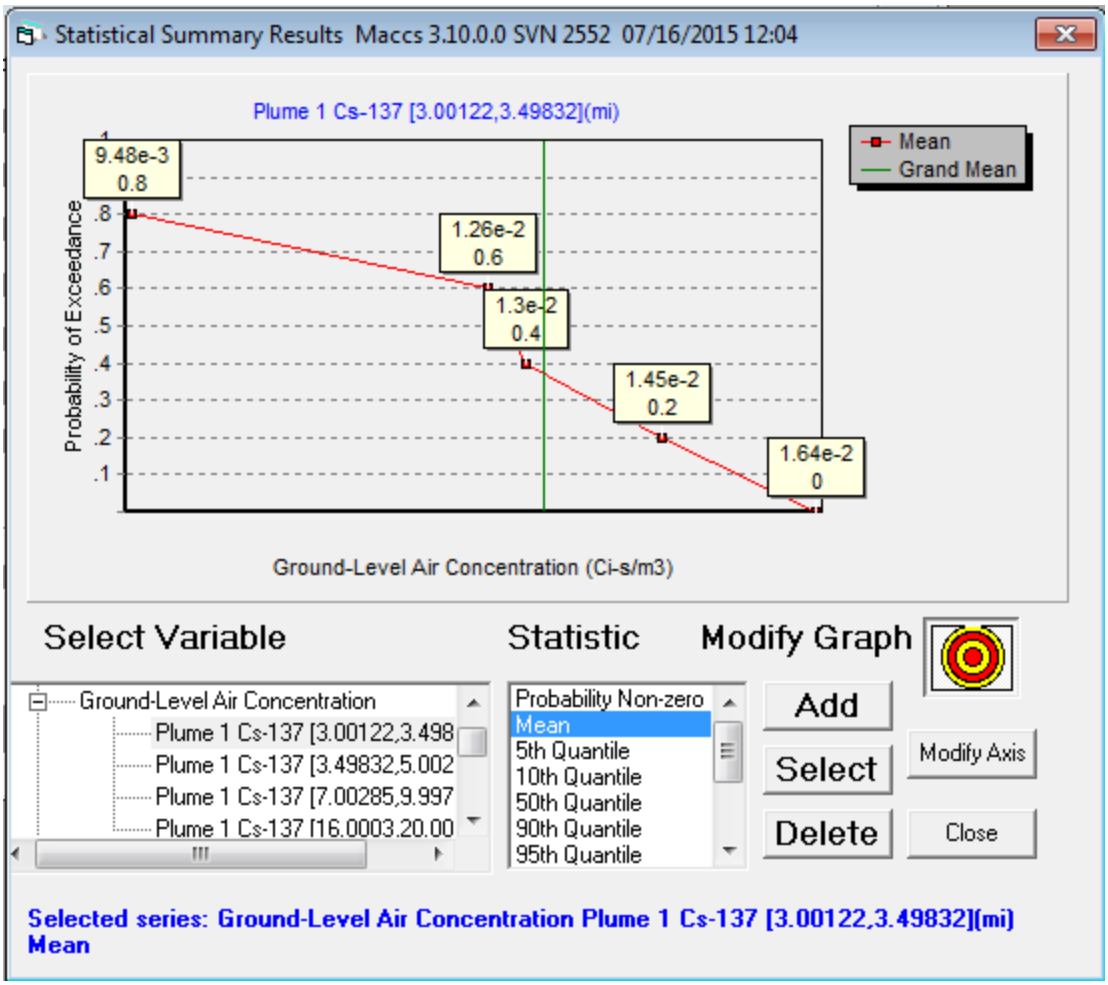


Figure 4-112 Data values as text displayed in a plot window

To modify the plot axis click *Modify Axis* to open the *Modify Axis Bounds* form as shown in Figure 4-113. This allows the user to change the axis limits or switch to a log scale.

The *X* or *Y* axis can be rescaled by:

- Selecting the X or Y toggles. By default, the X axis is selected.
- Selecting the scale of the toggled axis by selecting either *Linear* or *Log*.
- Setting the bounds of the toggled axis to *Automatic* or *Manual*.
- Deciding whether the axis limits are to be determined by WinMACCS by selecting *Automatic* or entered by the user by selecting *Manual*.
- Manually entering the axis limits if the selection was *Manual* in the text boxes labeled *Minimum* and *Maximum*.
- Clicking OK preserves changes. Clicking Cancel discards changes.

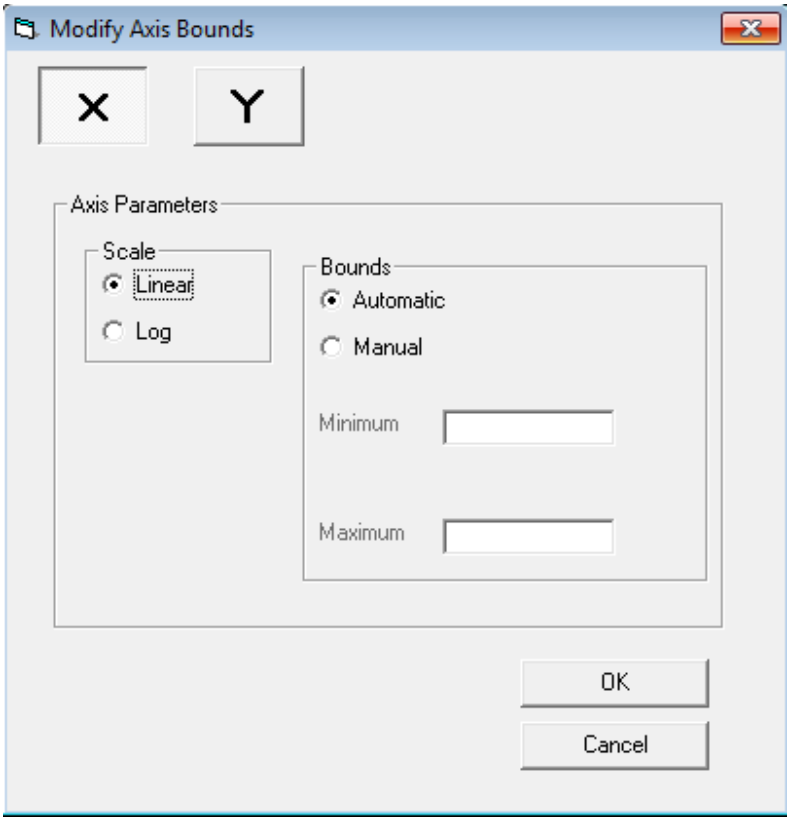


Figure 4-113 Modify axis bounds

The plots can be exported by selecting *Export Plot* from the *PostProcessing→Graphical Results→Edit Plots* menu. A *SaveAs* dialog is opened as shown in Figure 4-114. The following file types are supported:

- Windows bit map (.bmp): A graphical format that integrates into other Microsoft documents such as Microsoft Word, Excel, or WordPad. Files can be edited in Microsoft Paint.
- Jpeg (.jpg): Viewable as a graphic in a web browser or photo editing software. Requires less memory than a .bmp file.
- Text files (.txt): ASCII text that is viewable in a text editor such as Notepad, WordPad, or Microsoft Word.
- XML and HTML: Viewable in a web browser such as Internet Explorer. This file can also be edited in Microsoft Word.
- Excel file (.xls): A document that can be opened with Microsoft Excel. Allows the user to do further data analysis in the graphical and functionally rich environment of Excel.

The result file is saved in the Project\Output folder unless the path is modified in the *Save As* form. Saved files are shown in the *Files* tab of the *Project* window as shown in Figure 4-115. Double-clicking on the exported file in the *Project* window causes the associated application to open that file for viewing.

The file names shown in the *Files* tab of the Project window are updated by selecting *File→Refresh File View* from the main window.

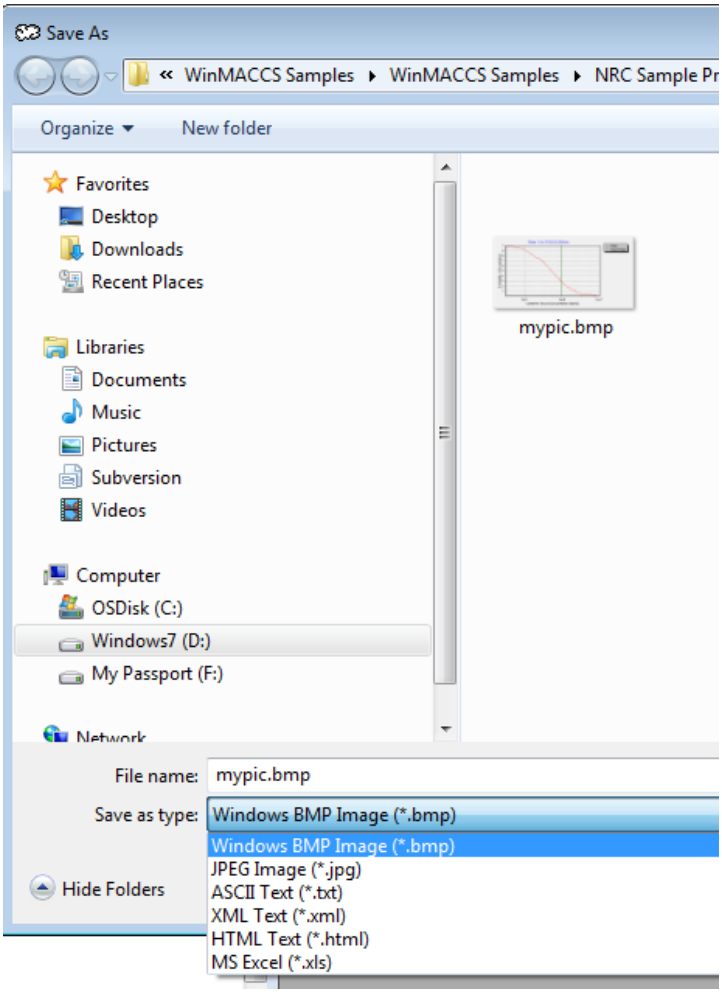


Figure 4-114 Exporting plots

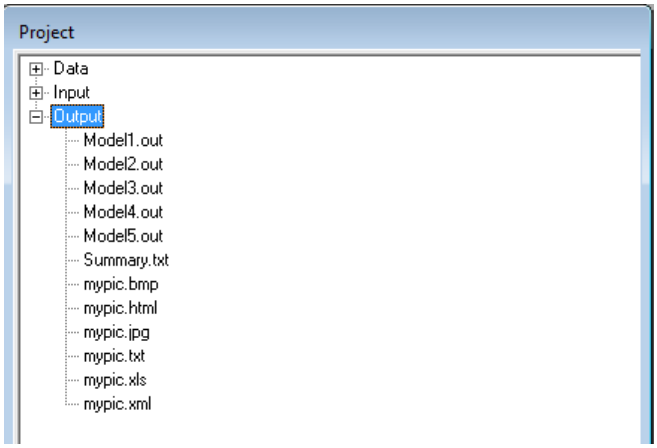


Figure 4-115 Exported plots in *Files* tab of project window

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5. TUTORIALS

Sections 5.1 and 5.2 are tutorials demonstrating how to modify an existing WinMACCS project and how to convert a legacy MACCS project into a WinMACCS project. Section 5.3 contains some guidelines for constructing a new project from scratch (i.e., without the benefit of an existing project).

Tutorial One should be tried by all new users. Tutorial Two is useful when it is necessary to convert MACCS input files into a WinMACCS project file.

Tutorial One demonstrates how to:

- open the existing sample project, Point Estimates LNT,
- save this as a project, Sample 1,
- modify models,
- run a simulation,
- modify a deterministic parameter and compare results,
- change the number of evacuation scenarios,
- create uncertain parameters,
- run an uncertainty calculation, and
- view and export results.

Tutorial Two demonstrates how to:

- import MACCS input files to create a sample WinMACCS project.,
- connect the meteorological file, site data file, DCF file and COMIDA2 file with the imported project,
- understand how the import process is reported in the WinMACCS Results window, and
- understand that some modifications to the input are required to run MACCS.

5.1 Tutorial One

What follows is a description of running six samples using sample problem “Point Estimates LNT” as a basis.

Table 5-1 Open WinMACCS project.

User Action	WinMACCS response
Double-click on the WinMACCS icon on the desktop or select *WinMACCS* from the WinMACCS group within the Windows *Start* Menu.	WinMACCS starts and displays menus on the top of the screen. *File* and *Help* are accessible.
Choose *File→Open Project*. Change directory to C:*WinMACCS Samples\NRC Sample Problems*	WinMACCS shows available sample project folders.
Double-click on the *Point Estimates LNT* folder.	Folder opens and shows the project file Point Estimates LNT.mxd.
Double-click on *Point Estimates LNT.mxd*.	WinMACCS loads the project. All projects will have four directories, \Input, \Data, \Results_DB and \Output. WinMACCS will display a message and will create the missing folder(s) if any of these folders are missing. WinMACCS displays two tabs on the bottom of the *Project* window: *Parameters* and *Files*. Above the tab, WinMACCS displays a list containing the following headings: *GENERAL, ATMOS, EARLY, CHRONC, DOSE COEFFICIENTS* and *COMIDA2*.
Select *File→Save As Project* from the main menu. Change to the directory in the root drive called *WinMACCS Projects*. Type *Sample 1* in the *Project Name* field. Click *OK*.	A new copy of the sample project, Sample 1, is created in the default WinMACCS project directory, WinMACCS Projects. The path shown in the caption of the main WinMACCS window is as follows: *C:\WinMACCS Projects\Sample 1*
Click on the *Files* tab in the *Project* window.	Above the tab, WinMACCS displays a list containing the following headings: *Data, Input,* and *Output*.

Table 5-2 Viewing parameters.

User Action	WinMACCS response
Click on the *Parameters* tab in the *Project* window.	Each + button, when clicked, displays sub-lists until the lowest level is reached. At the lowest levels, black bullets appear next to the names of variables. For example, *METCOD* is one of the variables under *ATMOS/Property Form Parameters*.
Open the *ATMOS* or *EARLY* heading by clicking on the + button. Peruse the different lists by clicking on the + buttons.	 A solid green octagon next to a form entry means that all the variables under that entry are required and have been properly defined.
	 A solid orange diamond next to a form entry means that all the optional variables under that entry have been properly defined.
	 An empty orange diamond next to a form entry means that all the optional variables have not been defined.
	 A cross over a red octagon means that there are variables that must be defined or corrected before proceeding with a MACCS simulation.
	 A cross over an orange diamond next to a form entry means that there is an error on this optional form.
	 A solid gray octagon containing a diagonal line means that the variables are not used in a MACCS simulation because they are not needed under the current choices. This symbol also indicates that all the variables have been defined.
	 An empty gray octagon containing a diagonal line means that the variables are not used in a MACCS simulation because they are not needed under the current choices. This symbol also indicates that not all the variables have been defined.
Choose *ATMOS/Property Form Parameters* by clicking on the + button. Double-click on the word *METCOD*.	The *Property Form Parameters* form opens. At the bottom of the form, the variable type "Integer" and range of values "[1,5]" is shown, as well as a description of the METCOD variable. Values on this form cannot be modified as indicated by the grey background; the values indicate choices made on *GENERAL/Properties/Properties* form.

User Action	WinMACCS response
Click inside the other variable boxes in the *Property Form Parameters* window.	Notice that the variable type, range, and description change for each variable.
Close the property form by clicking *OK* or *Cancel*.	*Property Form Parameters* form closes.
Open the *ATMOS/Deposition* category by clicking on the + button.	Notice that this entry on the *Parameters* tab contains a list of several forms, namely *Wet/Dry Depos Flags*, *Wet Deposition*, *Particle Size Groups*, and *Dry Deposition*. The category, *Deposition,* contains many forms. The icon next to a category name summarizes the state of those forms.  A solid green octagon means the information under that category is required and has been properly specified. This also means that there are no optional variables in this category. No more user attention is required.
Click on the *ATMOS/Radionuclides* category	Notice that the Pseudostable Radionuclides form is optional.  An orange diamond, empty or solid, indicates that there is at least one optional form in this category.
	 A crossed red octagon means that there are forms in this category containing variables that must be defined or corrected before proceeding with a MACCS simulation.
	 A crossed orange diamond means that there are optional forms in this category that need to be corrected before proceeding with a MACCS simulation.
Click on the *COMIDA2/Model Basis* category	Notice that none of these forms are used in this simulation. This is consistent with the current model settings on the *GENERAL/Properties/Properties* form.  All forms in this category have a grey symbol; hence the category symbol is grey. No user attention is required.

Table 5-3 Changing the main model to early only.

User Action	WinMACCS response
Click on the + sign next to *General.* Click the + sign next to *Properties*. Double-click on the solid green octagon next to *Properties*.	The *Project Properties* window opens with tabs showing different model options. The model definition state is displayed in color at each of the tab headings. A solid green octagon indicates that the data have been defined; if there were an empty red octagon on this form, it would indicate that the data were not defined, or the data were inconsistent with other choices.
Click on the check box next to the heading *Early Consequences*.	Both check boxes *Early Consequences* (EARLY) and *Late Consequences* (CHRONC) are unchecked. If *Early Consequences* is unchecked, then it is not possible to run the *Late Consequences* model. The choice means that only *Atmospheric Dispersion* (ATMOS) will be considered in the simulation.
Click on the tab labeled *Transport*	Notice that the *Properties* form is the location where modeling choices are made. When the *Transport* tab is clicked the symbols next to the heading prefixes are updated to reflect that Atmospheric Dispersion will be the only main module considered. Only tabs relevant to the ATMOS module, namely *Scope, Transport, Weather, and Plume/Source,* have a solid green octagon next to them in this example. The rest of the headings are prefixed with a solid gray octagon containing a diagonal line, indicating the model selections are valid but are not needed.
Click on the *Scope* tab.	Notice that all of the labels within the *Parameters* tab in the *Project* window under the *EARLY* heading continue to have green and orange icons associated with them, except *Dose Model* and *Population by Cohort* which are grey, even though the *Early Consequences* check box is unchecked.
Click the *Show Required Forms* button.	The EARLY module is temporarily deactivated. Notice that the symbols within the *Parameters* tab in the *Project* window in the *EARLY* category now have grey octagons associated with them.
Click on the check box next to the heading *Early Consequences*. Click the *OK* button to save the model settings.	By clicking *OK*, the simulation will have ATMOS and EARLY results. The *Project Properties* window closes.

Table 5-4 Run a simulation.

User Action	WinMACCS response
Choose *Execute→Run Models…* on the top menu.	The *Run Models* window opens.
Click the button labeled *Advanced…*	The *Advanced Execution Parameters* window opens.
Uncheck the check box labeled *Delete Atmos, Early, Chronc and COMIDA2 input files*. Click *OK*	All check boxes should be unchecked. This will insure that all intermediate files will not be deleted.
Click *Run Simulation*. A minimized command window will be created. Bring the command window to the foreground to see the progress of the MACCS simulation.	WinMACCS executes the run and shows the steps in the process in the *Results* window at the bottom of the screen (e.g., *"Verifying data are defined*"). Trials listed in the command window refer to calculating results for each weather trial. After the simulation has completed, notice one of the messages written in the Results window is "*Model execution SUCCESSFUL*," indicating that the simulation was successful. If an error had occurred, an error condition would have been reported in the *Results* window.
A message box will be displayed as follows: "Do you want to save the project changes?" Click "Yes" or type the Enter key to save the project changes.	After running a simulation, the user is prompted to save the changes made to modeling parameters.
Close *Run Models* box by clicking on the 	

Table 5-5 Viewing simulation results.

User Action	WinMACCS response
Click on the *Files* tab on the bottom of the *Project* window.	Above the tab, WinMACCS shows a list containing the following headings: *Data, Input,* and *Output*.
Click the + next to *Input.*	Notice that four files have been created as follows: atmosTemplate.txt, earlyTemplate.txt, Atmos1.inp, Early1.inp Atmos1.inp and Early1.inp contain model input parameters to MACCS. The file atmosTemplate.txt is identical to Atmos1.inp because there are no uncertain parameters specified in this project. Similarly, earlyTemplate.txt and Early1.inp are identical. The template files contain placeholders for uncertain values if these are specified.
Double-click on the Atmos1.inp file in the *Input* category.	Atmos1.inp will open up in Notepad. Notice that the creation date of the input file and version of WinMACCS is reported on the first line.
Close Atmos1.inp by clicking on the 	The text editor closes.
Click on the + next to the *Output* category.	Notice that files that are in the project Output folder are shown in the interface with exceptions as noted. When the model is run, MACCS results are written to Model1.out. WinMACCS also creates a log file, Run.log, recording each step of the run. Other files saved in this folder with a .out extension are also shown. MACCS also creates a binary results file, model1.bin, when run. This is not shown in the WinMACCS interface but is read by WinMACCS. The information read is saved in the /Results_DB folder and will be used to create custom reports and plots upon request.
Double-click on Model1.out.	Notepad starts and Model1.out opens. Notice that the creation date of the output file and version of MACCS is reported on the first line for quality assurance considerations
Search for the second occurrence of *AVERAGE INDIVIDUAL RISK.* Select the row titled *ERL FAT/TOTAL 0.2-0.5 km*. (The early fatality risk considering all radionuclides to the average individual at a spatial range of .2 to .5 km.)	The second number in the row (mean risk) should be 4.91E-06, reflecting a weighted combination of evacuating and non-evacuating cohorts. Values can also be located reflecting evacuation risk for COHORT 1 (0.0) and non-evacuation risk for COHORT 2 (9.83E-04).
Close Model1.out by clicking on the  .	The text editor closes.

Table 5-6 Sample effect of changing a single input parameter.

User Action	WinMACCS response
Click on the *Parameters* tab in the *Project* window. Find *ATMOS/Release Description/Inventory Scale Factor*. Double-click on *CORSCA*.	*Radionuclide Inventory Scaling Factor* window opens.
Modify the value of *CORSCA* from 1. to 2. Click *OK*.	*Radionuclide Inventory Scaling Factor* window closes.
Choose *Execute→Run Models* on the top menu. Click *Run Simulation*. Wait until the simulation has completed.	WinMACCS executes run with the changed input. A message box may open stating "A MACCS output file (ex. Model1.out) was found in the /Output directory. Output flies will be deleted if you continue. You can cancel this execution and rename the files if you wish to save them. Do you want to continue?" Click *Yes*. In the Results window the text "*Model execution SUCCESSFUL*," is displayed indicating that the simulations were successful. A message box opens stating: "Do you want to save the project changes? Warning: Not saving the project can lead to inconsistencies between MACCS output files and project settings." *Save* changes.
Open the file Model1out found in the Output category. Search for the second occurrence of *AVERAGE INDIVIDUAL RISK*. Select the row titled *ERL FAT/TOTAL 0.2-0.5 km.*	The mean of *AVERAGE INDIVIDUAL RISK ERL FAT/TOTAL 0.2-0.5* km from all causes should be larger than before (i.e., 7.79E-05 as compared with 4.91E-06).
Close Model1.out.	The text editor closes.

Table 5-7 Changing parameters from deterministic to uncertain.

User Action	WinMACCS response
Click on the *Parameters* tab. Open the category *EARLY/Additional Emergency Cohorts* by clicking on the +. Select *Edit→Project Properties* from the main window. Click the *Evac/Rotation* tab Change the *Number of Cohorts* from 2 to 1. Click *OK*	*EARLY/Additional Emergency Cohorts* graphic is now grey. This means that there is only one evacuation scenario to be considered.
Open the parameter modification form that contains the variable WTFRAC by selecting *Edit→Find or Export Parameters Window…* From the main menu. Scroll down to *WTFRAC* using the scroll bar. Select *WTFRAC*. Alternatively, type *WT* in the text box labeled *Type to Search*. Ensure *Open Windows* radio button is selected. Click *OK* Change the value of variable WTFRAC from .995 to 1. Click *OK*.	Variable WTNAM has the value PEOPLE. This means that the population fraction, WTFRAC, is considered for each cohort (defined on the *Edit→Project Properties, Site Data* tab). The previous run had two evacuation cohorts. The value of WTFRAC associated with cohort 1, .995, meant that 99.5% of the people would evacuate according to the parameters specific to cohort one. The value of WTFRAC associated with cohort 2, no evacuation, was set to .005 (defined on the *EARLY/Additional Emergency Cohorts/Emergency Cohort Two/Basic Parameters* form*)*. Because all values of WTFRAC must sum to one, WTFRAC needed to be set to 1.
Using the *Edit→Find or Export Parameters* open the form associated with variable ESPEED.	Variable ESPEED is displayed in a grid. There are three rows shown corresponding to the Initial, Middle and Late evacuation phases for cohort one. Notice that the tree displayed on the *Parameters* tab is expanded and the variables on the form, *Phase Durations and Evacuee Travel Speeds for Cohort One*, are listed in the Project window in the category *EARLY/Emergency Cohort One/Phase Durations and Speeds*

User Action	WinMACCS response
Click the ESPEED text box associated with the initial travel phase. This is the value in the first row of the grid. Click the *Make Uncertain* button.	A dialog will open when the *Make Uncertain* button was clicked with a caption as follows: *ESPEED(1)* . A pull-down menu of distribution types next to the label *Distribution* is shown with *Constant* indicated. Note: to change a distribution from uncertain to deterministic, open the distribution window either by double clicking on the variable value or by changing focus to the variable text box and clicking the *Make* Uncertain button. Change the distribution to *Constant.* It is not possible to type in a constant in a variable value on a parameter modification form that has been set to be uncertain.
Click on the down arrow and select *Uniform.* Enter 0.9 in the text box labeled *Lower Limit*. Enter 3.6 in the text box labeled *Upper Limit*. Click *OK*	The dialog box closes. The uncertain value has been associated with variable ESPEED(1). The background of the text box associated with ESPEED(1) is shaded and contains the text *UNCERTAIN.*
Set ESPEED(2) and ESPEED(3), associated with the middle and late travel phases, to a Uniform distribution using the same parameters used for ESPEED(1). Click *OK* in the *Phase Durations and Evacuee Travel Speeds for Cohort One* window.	Only when *OK* is clicked in the main parameter modification form (e.g., *Evacuee Travel Speed for Scenario One)* will the uncertain values be saved.
Find and double click the box associated with SCLADP. Set variable SCLADP to a UNIFORM distribution where the Lower Limit is 0.5 and the Upper Limit is 1.5.	The background of the text for variable SCLADP on the form *Plume Rise Data* is shaded and contains the text *Uncertain*.
Choose *File→SaveAs Project*. Change directory to WinMACCS Projects Specify "*sample 1 uncertain"* for the Project name.	WinMACCS creates a new project, *sample 1 uncertain.*
Choose *Execute→Run Models* Click on the button *Advanced…* Type 3 in the box labeled *Number of Simulations* Click the *OK* button	Number of samples (or number of MACCS simulations) is now three.

User Action	WinMACCS response
Click the *Run Simulation* button Click *Yes* when prompted to save the project	MACCS will run three times, creating three results files, model1.out, model2.out and model3.out.
Click on the *Files* tab on the bottom of the *Project* window.	Above the tab, WinMACCS shows a list containing the following headings: *Data, Input,* and *Output*.
Click the + next to *Input*.	WinMACCS created MACCS input files *Atmos1.inp, Early1.inp, Atmos2.inp, Early2.inp, Atmos3.inp, Early3.inp,* one set of files for each realization from LHS using the data in LHS.out. WinMACCS also created files to manage the multiple uncertain executions of MACCS. The files *atmosTemplate.txt*, *earlyTemplate.txt* are used to create the MACCS input files. These files have place holders for the uncertain values. Latin Hypercube sampling software LHS, creates the uncertain values. The files *LHS.inp*, *SampleRank.out*, *LHS.MSG*, *LHS.OUT*, *sipra.ini* are related to this process. See the MACCS User's guide for more details.
Double-click on the input file for Latin Hypercube Sampling, LHS.inp.	LHS.inp, a file created by WinMACCS, contains a summary of uncertain variables and their distributions. The Latin Hypercube Sampling program, LHS, is run with input as reported in this file: ESPEED(1) UNIFORM 0.9 3.6 ESPEED(2) UNIFORM 0.9 3.6 ESPEED(3) UNIFORM 0.9 3.6 SCLADP UNIFORM 0.5 1.5
Open the file in the Input folder created by Latin Hypercube Sampling, LHS.out.	A list of mean values for each variable and the sampled values are shown.
Close LHS.inp and LHS.out	The text editors close.
Click on the + next to *Output*.	Model1.out, Model2.out and Model3.out and Run.log are displayed.

User Action	WinMACCS response
Choose *PostProcessing→Report Results→Manage Custom Reports* Click on the radio button labeled *Combine Realizations*. Click on the button *New*. Click on the column labeled *Include* for the first two entries labeled *Spatial Intervals for Output*. Click on the column labeled *Include* for all of the entries where the *Report Description* column is labeled *Population Dose*. There are three entries. Enter report name Atmos Summary and Population Dose. Click *OK* to close the *Custom Combined Report* form.	Define a new custom report. A copy of the MACCS output requests created by WinMACCS are shown in the grid. The type of the report is Combined indicating that the results summarized in this report combine data from all of the realizations. Data is read from the MACCS binary output files.
Click the box to choose the report Atmos Summary and Population Dose. Select the button labeled *View*.	Report defined in the previous step is created and opened in the Notepad text editor. This file is created with tabs separating fields and is easier to read when opened in Excel.
In the report, scroll down to *Request 3 Population Dose*	Notice that the columns labeled *Probability of Exceedence* are based on quantiles specified on the form *GENERAL/Output Options/Reporting Options* found on the *Parameters* tab. The reported data is based on binned CCDF tables. Variation of values for any given LHS simulation is due to weather sampling. These CCDF tables can be viewed in the MACCS output if the Report Option variable is set to CCDF or CCDF & REPORT for the Output Control form of interest (e.g., *EARLY/Output Control/Population Dose*). Notice the following message is displayed for request 3: Evacuation Cohort 1 L-ICRP60ED [0.,16.09](km) Grand Mean Population Dose (Sv) 7.704E-00 This is because the population dose was zero from 0 to 16.09 km and did not change for the set of weather trials.

User Action	WinMACCS response
In the report, scroll down to the entry labeled *Request 4 Population Dose.*	The Population Dose corresponding to combining the LHS realizations is shown as follows: Evacuation Cohort 1 L-ICRP60ED [0.,80.47](km) Grand Mean Population Dose (Sv) 2.907E+03 Note: The custom reports can be used to report overall statistics when multiple realizations are being calculated with sampled variables. However, it can also be used to conveniently calculate additional quantile information using the binned CCDF results from MACCS.
Close report.	The text editor closes. The report, Atmos Summary and Population Dose.txt, can also be opened by double clicking on this named entry *Output* category found on the Files tab. Note: It is possible to summarize the output without combining the data from the realizations. When creating a new report, select the radio button labeled *Realization Based* on the *Manage Reports* form instead of the *Combine Realizations* button.
On the Parameters tab,double-click on *General/Output Options/Reporting Options* to open the *Reporting Options* form.	A form labeled *Reporting Options* opens.
Clear all old entries by clicking the erasor icon. Enter the following quantiles: 0.01, 0.25, 0.50, 0.75, 0.99 Click OK.	Note: Rows can be deleted in a grid by selecting the row and pressing the Delete key on the keyboard. New rows can be added to the grid by clicking on the text in a row and selecting *Edit →Grid →Insert Rows* A new row can be added to the bottom of the grid by typing in the text area of the last row.
Create a new summary report by selecting *PostProcessing→Report Results→Manage Custom Reports.* Click on the Report titled “Atmos Summary and Population Dose” under “Report Name” in the table box to choose the report; the text should then highlight black or blue. Select the button labeled *View.* Click X to close Notepad.	Under Request 1, see the user chosen Grand Mean values of 0.01, 0.25, 0.5, 0.75 and 0.99. Data corresponding to these user chosen quantiles are calculated by interpolating values from the binned CCDF’s that MACCS calculates.

Table 5-8 Viewing results as plots.

User Action	WinMACCS response
Choose *PostProcessing→Graphical Results→Results over all Weather Trials*.	A *Results Over All Weather Trials* window opens with the version of MACCS used in the simulation displayed in the Window caption.
Click the + next to *Centerline Ground Concentration* Click on *Plume 1 CS-137[5.63, 8.05] (km)* Click on *Add*.	Result is placed on chart. There is a single plot corresponding to each of the three simulations.
Click *Modify Axis*.	The *Modify Axis Bounds* window opens with options for *X*- and *Y*-axis and their bounds. In addition, the user may choose a linear or a logarithmic scale for *X* and *Y*. The minimum and maximum values must be specified for the logarithmic scale; the linear scale can either be automatically set or manually set by the user.
Click *Cancel* in the *Modify Axis Bounds* window.	The *Modify Axis Bounds* window closes.
Select *PostProcessing→Graphical Results→Edit Plots→Modify Titles*. Close the *Modify Titles* window by clicking the *Cancel* button.	The plot title and axis labels can be modified.
Click the *Select* button on the plot window three times.	The data points representing the complimentary cumulative distribution function (CCDF) are shown. Notice that the sample numbers, LHS1, LHS2 and finally LHS3 are shown. The bottom of the plot window displays details describing the selected plot series in blue lettering.
Click the *Select* button again.	The plot is now in an unselected state. Notice that the bottom of the plot window displays the words "Selected Series: NONE."
Click the *Bulls-eye* button. 	The plotted values are now displayed as text. Click and drag to select an area from upper left corner to lower right to zoom in on the plot. Click and drag from lower right to upper left to un-zoom.
Click the *Bulls-eye* toggle button again.	The text values are no longer displayed.
Select *PostProcessing→Graphical Results→Edit Plots→Export Plot*.	A *Save As* window appears. Notice the different file formats available, including JPEG image, MS Excel, and ASCII text.

User Action	WinMACCS response
Enter "MyData" in the text box labeled *File Name*. Select *Windows BMP Image (*.bmp)* in the *Save as Type* pull-down menu. Do not type an extension.	WinMACCS saves the data as a .bmp file called *MyData.bmp* into the \WinMACCS Projects\sample 1 uncertain\Output directory. This file can be opened in MS Paint.
Double-click on file MyData.bmp in the *Output* directory found under the *Files* tab in WinMACCS.	The .bmp file opens in the associated application, usually MS Paint.

5.2 Tutorial Two

What follows is a description of how to import a MACCS input set into WinMACCS. This is necessary when there are MACCS input files that have been used outside of the WinMACCS environment.

Table 5-9 Create a new project based on a MACCS input set.

User Action	WinMACCS response
Double-click on the WinMACCS icon on the desktop or select *WinMACCS* from the WinMACCS group from the Windows *Start* Menu.	WinMACCS starts and displays pull-down menus on the top of the screen. *File* and *Help* are accessible.
Choose *File→Open Project* Open file Point Estimates LNT.mxd found in directory C:\WinMACCS Samples\NRC Sample Problems\Point Estimates LNT	Sample project *Point Estimates LNT* is opened. Path is displayed in caption of main window *C:\WinMACCS Samples\NRC Sample Problems\Point Estimates LNT*
Choose *Execute→Run Models* From the main menu	The run models window is open
Click the button labeled *Advanced…*	The *Advanced Execution Parameters* window opens.
Uncheck the check box labeled *Delete Atmos, Early, Chronc and COMIDA2 input files*. Click *OK*	All check boxes should be unchecked. This will ensure that all intermediate files will not be deleted. The MACCS input files were created in the previous exercise, but were deleted because the box labeled *Delete Atmos, Early, Chronc and COMIDA2 input files* was checked.
Click *Run Simulation*. Click *No* when asked if you want to save the project changes	WinMACCS creates input files every time the *Run Simulation* button is checked. A simulation is run.

User Action	WinMACCS response
Choose *File→Close Project* When prompted *Do you want to save the project changes?* click *No*	Sample problem will be closed. MACCS input files will be used in this exercise. The following MACCS input files have been created. These files are in the project directory. Maccs.tmp \Input\Atmos1.inp \Input\Early1.inp \Input\Chronc1.inp
Open an ASCII text editor such as Windows Notepad. Open the file *C:\WinMACCS Samples\NRC Sample Problems\Point Estimates LNT\Maccs.tmp* in your default editor by double clicking on Maccs.tmp or by opening Maccs.tmp using the Notepad application. Open the file *Early1.inp* the same way.	Some of the files used by the MACCS simulation are listed. This file is read by MACCS. The full path is referenced, but only the file names are indicated below. These are as follows: Line 1: ATMOS input file Atmos1.inp Line2: EARLY input file Early1.inp Line 3: CHRONC input file Chronc1.inp Line 4: Meteorological data file, metsurMxHt_60min.inp Line 5: Site data file FicticiousSite.inp Line 5: Output data file, specified name of results file written by MACCS Model1.out The file Early1.inp contains the name of the DCF file on the line labeled DCF_FILE001 as follows: Data\FGR13GyEquiv_RevA.inp Chronc1.inp contains the name of the COMIDA2 binary file on line labeled BIN_FILE001 Data\ comida2_2.0.0.2_FGR13GyEquiv_RevA.bin
Close the ASCII text editor.	The text editor closes.
Choose *File→New Project*. Navigate to the folder *WinMACCS Projects*. Enter the name *Sample 2* in the *Project Name* field. Click *OK*.	A new project is created. The *Project Properties* form is opened. This form is used to select the appropriate models for the simulation. Notice that only the ATMOS model is checked. This is the default setting for new projects.
Click the *Cancel* button in the form titled *Project Properties.*	It is not necessary to select models when importing MACCS input files such as Atmos1.inp. WinMACCS will define the radio buttons and check boxes in the Project Properties form dependent on the values in the imported files

Table 5-10 Import Atmos1.inp, Early1.inp and Chronc1.inp.

User Action	WinMACCS response
On the *Parameters* tab of the *Project* window, click the plus sign, +, to the left of the headings GENERAL, ATMOS, EARLY and CHRONC.	Notice the crossed red octagons next to categories of data in the GENERAL and ATMOS categories indicating that data are required but are not yet defined. Notice the filled in green octagon next to the heading *Property Form Parameters*. These are variables that are defined and can be changed only by using the *Project Properties* form. These are set to default model settings. Notice the slashed grey octagons in the EARLY and CHRONC categories. These data are not required because *Early Consequences* and *Late Consequences* have not been checked on the *Project Properties* form.
Select *File→Import MACCS Input File* from the main menu. Select the ATMOS input file titled Atmos1.inp in the directory *C:\WinMACCS Samples\NRC Sample Problems\Point Estimates LNT\Input* Click *Open*.	The file Atmos1.inp is read by WinMACCS. The data in this file is loaded into the interface. The progress of processing this file can be seen in the WinMACCS *Results* window. The ATMOS crossed red octagons have turned into solid green octagons, indicating that the data on these forms are now defined. The EARLY model is now on. This is because a variable, ENDAT1, in the file Atmos1.inp, was set to .FALSE. indicating that the EARLY model should be executed.
Observe stage one of the import process. Expand the *Results* window by moving the mouse to the Title bar on that window. When the mouse pointer turns to a double sided arrow, hold the left mouse button down while dragging towards the main window caption. Release the mouse button to resize the window. Models are normally turned on or off in WinMACCS using the *Project Properties* form. This is done automatically when reading in a MACCS file.	The first line shown in the Results window indicates the name of the file that is being imported is as follows: *Importing MACCS input file C:\WinMACCS Samples\NRC Sample Problems\Point Estimates LNT\Input\Atmos1.inp* The next line shows that the file is being read to determine which models are turned on in WinMACCS. *Processing input lines that define models* The next set of lines report which lines of Atmos1.inp are used to determine the model settings.

User Action	WinMACCS response
The models that are set in WinMACCS can be viewed or changed on the Properties form that can be opened by selecting *Edit→Project Properties* from the main menu. Open the form *Project Properties* Click on the *Transport* tab	This tutorial will not go through all the logic used to define WinMACCS model settings from the MACCS input files. However, dispersion is offered as a single example to increase understanding of this process. Some project property settings defined on the *Project Properties* form are translated into variable values. These variable values can be observed by opening the forms *ATMOS/Property Form Parameters* *EARLY/Property Form Parameters* *CHRONC/Property Form Parameters* Notice that the dispersion model is set to *Lookup Tables* in the Project Properties form. If the MACCS variable NUM_DIST was equal to zero in the imported file, then the dispersion model would have been set to *Power Law Functions (NUM_DIST=0)* Often, there is a direct correspondence between a model setting and the value of a MACCS imported variable (e.g., NUM_DIST). In these cases, the value of the MACCS input variable will be part of the model label shown on the *Project Properties* form.
Open the file Atmos1.inp in an ASCII text editor such as Notepad. Search for the character string NUM_DIST001 Notice that the value is set to 50	Recall, the MACCS input file Atmos1.inp can be found in the following folder: *C:\WinMACCS Samples\NRC Sample Problems\Point Estimates LNT\Input* The input lines that are used to define the models are shown in the *Results* window, e.g., *Saving MACCS Data for input line: NUM_DIST* Setting this value to a nonzero quantity indicates that the source of the dispersion data is the form *ATMOS/Dispersion/Dispersion Table.*
Observe stage two of the import process. The variables relevant to the updated model settings are extracted from the file. Lines are processed until a period in column one is encountered. This is considered the end of the data to be imported in stage two.	In the second stage, only the data relevant to the current model settings are extracted. The file is read for the second time. Example output in the *Results* window from the second pass is: *Processing input lines for file section 1* *Saving MACCS Data for input line: RIATNAM1*

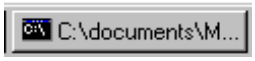
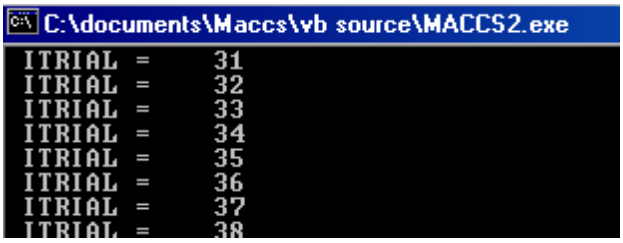
User Action	WinMACCS response
Observe stage three of the import process. In the last step in the import process, WinMACCS looks for multiple cohort data. If other cohorts (I.e., change card sets) are present, they will be separated by a period in column one. EARLY model input sets created by WinMACCS may contain up to twenty cohorts to support multiple evacuation scenarios.	There was no additional scenario data present. Example output from stage three is as follows: *Processing input lines for file section 2* *No data to import for file section 2* *WARNING - Check the Properties form for model settings.* *When importing older MACCS input files, some models are not specified.* This concludes the import of the ATMOS input file.
Close the Project Properties form. Repeat the import process and import the file Early1.inp and Chronc1.inp.	Notice that two evacuation cohorts were defined in the Early1.inp file. WinMACCS properly processes this and sets the variables accordingly. You have completed importing the data from Early1.inp and Chronc1.inp into the WinMACCS project.

Table 5-11 Define additional forms.

User Action	WinMACCS response
Click on the *Parameters* tab of the *Project* Window. Click on the plus sign, +, next to the label GENERAL	Notice that the File Specification category has an associated icon as follows:  This indicates that attention is needed.
Click the plus sign, +, to the left of the heading *GENERAL\Properties*. Double click on the form name *Problem Description*. Enter the following: Project based on Point Estimates LNT Click *OK.*	Notice that the form *Problem Description* is an optional form, as indicated by the diamond shaped icon:  After the file is defined, the diamond becomes filled. The text entered will become comments in the MACCS input files.
Click the plus sign, +, to the left of the heading *GENERAL\File Specifications*. Double click on the form name *Meteorological File*.	Notice that all file specifications for the project are listed in the category *File Specifications.* The form titled *Specify Meteorological File* is opened.
Click on the button labeled *Browse*. Locate file titled metsurMxHt_60min.inp and click on the file name Click *Open.* A copy of this file is in *C:\WinMACCS Samples\NRC Sample Problems\Point Estimates LNT\Data* Click *OK.*	A copy of this file will be made and placed in the current projects \Data directory. Recall that the name of this file was referenced in the file Maccs.tmp An information message box is displayed indicating that a copy of the file metsurMxHt_60min.inp will be copied to your project /Data folder. This is not an error. Click OK.
Define the site file by double clicking on the form name *GENERAL/File Specifications/Site File*. Click on the *Browse* button to find the file FicticiousSite.inp in the directory *C:\WinMACCS Samples\NRC Sample Problems\Point Estimates LNT\Data* Click *OK*. Answer *Yes* to the following questions shown in the message box: *Do you want to update the spatial grid to be consistent with the site file?*	Notice that after the file FicticiousSite.inp is linked to the project using the *Browse* button, the number of angular directions shown in 16. WinMACCS opens and reads FicticiousSite.inp to determine this. If the user needs to change the number of angular directions on the evacuation grid on an existing site file, the *Create New* button can be used to create a new site file based on the older site file. It is preferable to create a new site file using the program SecPOP. A copy of this file will be made and placed in the current projects /Data directory. When the *OK* button is clicked, this form updates the values of variable SPAEND to ensure that SPAEND and the site file are consistent. NUMCOR will be updated to be consistent with the number of angular directions specified on the site file independent of the answer given in the message box. Recall that the name of this file was referenced in the file Maccs.tmp

User Action	WinMACCS response
Open the form *Dose Conversion Factor File*. Specify the file FGR13GyEquiv_RevA.inp in the directory C:\WinMACCS *Samples\NRC Sample Problems\Point Estimates LNT\Data* Click *OK*.	A copy of this file will be made and placed in the current projects /Data directory. The name of this file can be found in the file Early1.inp on the line containing the keyword DCF_FILE001. The data files can be opened by clicking on the *Files* tab of the *Project* window, clicking on the + next to the word *Data,* clicking on the variable of interest (e.g., Site File), and then double clicking on the file name.
Open the form EARLY/Model Basis/Organs of Risk. Click OK.	This form is marked as needing attention. By opening the form and clicking OK, the values from the DCF file, Fgr13dcf.inp, are saved in the project database. Other forms that are dependent on the organs of risk will now be marked as completed with solid orange diamonds or green icons.
Open the form *COMIDA2 File*. Specify the file comida2_2.0.0.2_FGR13GyEquiv_RevA.bin in the directory *C:\WinMACCS Samples\NRC Sample Problems\Point Estimates LNT\Data* Click *OK*.	A copy of this file will be made and placed in the current projects /Data directory. The name of this file can be found in the file Chronc1.inp on the line containing the keyword: `BIN_FILE001` MACCS requires that this binary file was created using the specified DCF file (in this example Fgr13dcf.inp) using the COMIDA2 preprocessor.
Click the plus sign, +, to the left of the heading CHRONC.	Notice there are no errors. Interface should appear as follows: 

Table 5-12 Execute new project.

User Action	WinMACCS response
Select *Execute→Run Models* from the main menu. Click on the *Run Simulation* button on the *Run Models* form. Click on the entry on the task bar: 	The progress is displayed in the command prompt window.  Successful execution can be verified by observing that the *Results* window contains the following: *Running model as follows:* *"C:\Program Files\WinMaccs\MACCS.exe" -i "C:\WinMACCS Projects\Sample 2\Maccs.tmp" -p "Model1"* *Model execution SUCCESSFUL* *OK* *Run Completed*

5.3 Guidelines for Creating and Importing Projects

The following are a few guidelines for creating a new project from scratch:

- When a new project is created by selecting *File→New Project* from the main menu, the WinMACCS *Properties* form is opened. The settings on this form should be reviewed and changed as needed. After this has been reviewed, click *OK* to save the settings. These settings determine which subsequent forms are required, not required, or optional.

- Starting at the top of the *Parameters* tab, fill in the required forms in order. There are six main models listed, namely GENERAL, ATMOS, EARLY, CHRONC, DOSE COEFFICIENTS, and COMIDA2. Each contains many forms, however only the data in the required forms are used. A form is not required when the icon to the left of the form name is a grey octagon with diagonal line. Forms with orange diamond shaped icons are optional. The *Project Properties* form can be modified as desired. It is not required that the forms be filled out in order, but it may be helpful because information on some forms is required before other forms can be completed. Filling out the forms in order avoids any conflicts.

- When the X-ed red octagons have been converted to solid green octagons, select *Execute→Run Models* from the main menu. Click on *Run Simulation* to run. Look in the *Results* window to verify that the execution was successful. The output files from the execution can be opened by double clicking on the file names on the *Files* tab.

- It may be easier to debug the input when only the ATMOS model is enabled the first time MACCS is executed. After ATMOS is running successfully, change the main model to include EARLY on the *Properties* form. When needed, continue with CHRONC and COMIDA2 as each set of model input is debugged.

The following are a few guidelines for importing a project from MACCS input files:

- When importing MACCS input files, the improved Briggs model is always used unless *Original MACCS 1.12 Briggs Model* is manually checked on the *Plume Rise* tab of the *Project Properties* form. To recreate results consistent with MACCS 1.12, it is helpful for the plume rise model to be consistent.

- ATMOS input for MACCS 1.12 supported multiple source terms using change card sets. This is not supported with WinMACCS for ATMOS. Any additional change card sets in an imported card set is considered to be related to additional evacuation cohorts only. However, multiple source terms can be modeled by using the MACCS Cyclical File Set feature found on the *Scope* tab of the *Project Properties* form. Multiple Source terms can also be modeled by selecting the *Multi Source Term* check box on the *Plume/Source* tab. This process requires input files in a format compatible with MelMACCS version 1.7.3 (or greater) output files. However, this function causes the multiple source terms to be modeled in a single consequence analysis; the Cyclical File Set option performs a consequence analysis for each source term, one at a time.

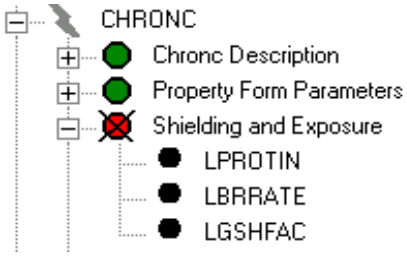
- When importing an ATMOS input deck created using MACCS 1.12, it is necessary to manually define the chemical group names, GRPNAM.

- Before importing an EARLY input file, when the DCF file used is not based on Federal Guidance Report FGR-13, it is necessary to manually specify this on the *Dose* tab of the *Project Properties* form. For example, when the DCF file was created by the preprocessor DOSFAC2, the form EARLY/Model Basis/Organs of Risk DOSFAC2 is required. Similarly, the form EARLY/Model Basis/Organs of Risk FGR-13 is required when the DCF file was created from FGR-13 data. Neither form is required when the DCF file is of type FGRDCF (based on FGR-11 and FGR-12).

- When importing an EARLY input file, the number of evacuation cohorts are not decreased from the number specified on the Project Properties tab. However, the number may be increased when more cohorts are specified than is defined on the Project Properties tab. This can be manually changed by using the *Evac/Rotation* tab of the *Project Properties* form. This is by design because of considerations with respect to the MACCS Cyclical File Set option that uses the same import algorithms.

- When importing a CHRONC input deck created using MACCS 1.12, the CHRONC/*Shielding and Exposure* form is not defined. To be consistent with older version of MACCS, the value used for the *Shielding and Exposure* parameters defined for Normal Activity in Early should be used, as shown in Table 5-13.

Table 5-13 Defining CHRONC shielding and exposure.

User Action	WinMACCS response
Click on the + next to the headings GENERAL, EARLY and CHRONC if these headings are not already open. Double click on the form name *Shielding and Exposure* in CHRONC. 	Notice that the CHRONC variables LPROTIN, LBRRATE and LGSHFAC are not defined. These are new variables that do not have images in the imported file.
Open the form *EARLY/Emergency Cohort One/ Shielding and Exposure* Enter the related data in the row labeled *Normal* into the *CHRONC/Shielding and Exposure* form.	Adding these CHRONC variables ensures that consistent values are independent of the EARLY evacuation scenarios. Before this modification, MACCS used the values used during the last EARLY evacuation scenario for the CHRONC calculation. It was not clear to the user which values were used, so these variables were added to CHRONC.

6. SITE FILE FORMAT

6.1 Format Overview

A site file contains the population distribution and land use information for the region surrounding the site subject to user inputs. It contains the radial and azimuthal intervals used to define the grid, the population within each grid element, the fraction of the area that is land, watershed data for the liquid pathways model, information on agricultural land use and growing seasons, and regional economic information. An example of a site file is provided in NUREG/CR-4691, Volume 1, Appendix D.2.

Site files for sites within the continental US are usually created by SecPop. Users should consult NUREG/CR-6525, Rev. 2 (Weber et al., 2019), for details on using SecPop. The latest version, SecPop 4.3.1, produces four types of result files as follows:

- A file ending with _REAcct.econ that is required when using the RDEIM economic model
- A file ending with _REAcct_Extended.tsv that is in tab-separated format, contains information like the previous file, and is convenient for examining in a spreadsheet. This file is not currently used by MACCS.
- A file ending with _Site.inp that is the standard site file required by MACCS
- A file ending with _Site_Extended.tsv that is in tab-separated format, contains information like the previous file but treats each grid element as its own economic region, and is convenient for examining in a spreadsheet. This file is not currently used by MACCS.

On the *Site Data* tab of *Properties* form, the user specifies whether a site data file is to be used. When it is not used, the population density applied in the EARLY and CHRONC modules are specified on the *EARLY/Model Basis/Population Data* form. Beyond a user-specified radius representing the exclusion area boundary, this density is applied uniformly over the grid.

The site file used in MACCS is a fixed-format file. The data must appear exactly as described below and in the same order.

The file is fixed format, which requires care to align the values into their proper fields. Any numeric items specified in exponential format (*e.g.,* 1.E-6) must be right-justified in the field because trailing blanks are processed as zeros. To prevent errors due to right justification, it is recommended that a decimal point be used, and the exponential portion of the field is indicated using the letter E as in 1.E-6. When this recommendation is followed, the number to the right of the FORTRAN format descriptor (e.g., the 2 in F8.2 or E8.2) is ignored and only the field length is considered (e.g., the 8 in F8.2).

The FORTRAN fixed field input rules for an edit descriptor Fw.d or Ew.d are as follows. The input field consists of an optional sign, followed by a string of digits optionally containing a decimal point. When the decimal point is omitted, the rightmost d digits of the string are interpreted as the fractional part of the value represented. The basic form may be followed by an exponent of one of the following forms:

(1). Signed integer constant (e.g., 1.-6 means 1.E-6)

(2). E followed by zero or more blanks followed by an optionally signed integer exponent.

Users are cautioned that site files use a fixed format. Site files are formatted correctly by SecPop, but there are some reasons for the user to manually edit the site file (e.g., to add a transient population or to modify the watershed information). Sites outside the continental US must be constructed manually or with other software. Failure to conform to the formatting requirements for a site file may lead to incorrect results in a MACCS calculation.

When using SecPop to create a site file, quality assurance information is written to the first two lines that includes the version identification of SecPop and parameter settings used to create the site data file. For example, the first two lines in the sample site file distributed with WinMACCS are as follows:

- SECPOP Version: 4.3.0 SVN:2242 FileType: MACCS_Site Project: "Fictitious" Census: "C:\Program Files (x86)\SecPop\Census\Census2010.bin" County: "C:\Program Files (x86)\SecPop\Census\County2012.dat"

- Lat: 36d11'35" Long: 115d58'55" Latitude: 36.193058 Longitude: 115.98194 Population_multiplier: 1.0 Economic_multiplier: 1.0 Run_Time: 2016/02/04_12:28:56

Following the descriptive text fields, there are six records that specify the amount of data that are contained in the file. The values defined on these data records must be consistent with values defined in WinMACCS. The data are input as integers in FORTRAN (I4) format. The integers must be right justified in the four-character input field.

Some of the parameters defined in the site file must agree with parameters defined in WinMACCS. However, when the parameter is not required by WinMACCS, agreement is not required. For example, when the CHRONC model is not selected, parameters such as NFICRP, NUMWPI are not required to be defined in WinMACCS. When the *MACCS Food Model* is not selected, the CROP parameters are not used by WinMACCS. The parameters listed in Table 6-1 are required to be defined in the site file even though they may not be used by MACCS to perform calculations.

Table 6-1 Basic site file parameters.

Line in site file	Columns	FORTRAN Format	MACCS Parameter Name	*Allowed Values*	*Description*	Example line from FicticiousSite.inp
3	1 to 4	I4	NUMRAD	2 to 35 Must agree with WinMACCS variable NUMRAD	Number of radial intervals.	26 SPATIAL INTERVALS
4	1 to 4	I4	NUMCOR	16, 32, 48 or 64 Must agree with WinMACCS parameter NUMCOR.	Number of sectors in the spatial grid.	16 WIND DIRECTIONS
5	1 to 4	I4	NFICRP	1 to 10 Must agree with WinMACCS parameter NFICRP	Number of crop categories that are to be used by the food pathway model	7 CROP CATEGORIES
6	1 to 4	I4	NUMWPI	1 to 10 Must agree with WinMACCS parameter NUMWPI	Number of radionuclides in drinking water pathway	4 WATER ISOTOPES
7	1 to 4	I4	NUMWPA	1 to 4	Number of watersheds	1 WATERSHED
8	1 to 4	I4	NECRGN	1 to 99	Number of economic regions	97 ECONOMIC REGIONS

SECPOP2000 only supports NUMCOR equal to 16. SecPop 4.0 and later allow the values of NUMCOR to be 16, 32, 48 or 64. WinMACCS can create a new site file that supports NUMCOR equal to 32, 48 or 64 based on an existing site file. This feature can be accessed on the WinMACCS form GENERAL/File Specifications/Site File. This is useful when WinMACCS uses a finer grid resolution than the original site file. When not using a site data file, WinMACCS assumes one watershed. Water ingestion data for each radionuclide considered in the water pathway are defined in the WinMACCS parameter WINGF for one watershed only. Only by using the site data file can more water pathways be specified. In this case, MACCS uses the ingestion factor read from the site file. The format for input of the ingestion data is described below. SecPop enters constants for these values with the intention that they can be edited by the user if needed.

Eight blocks of site data follow the introductory block described in Table 6-2. Each of these data blocks are summarized in Table 6-2 and are introduced by a separator line that identifies the block of the data to follow. Data block separators start in column 2 and are right justified.

Table 6-2 Site file data blocks.

Data block in site file	Columns	FORTRAN format	First line of data block	Description of data block
1	2 to 23	A22	SPATIAL DISTANCES	Defines the distance to the outer radii of each grid element
2	2 to 23	A22	POPULATION	Defines the population of each grid sector
3	2 to 23	A22	LAND FRACTION	Defines the fraction of land of each grid sector
4	2 to 23	A22	REGION INDEX	Defines the economic region for each grid sector.
5	2 to 23	A22	WATERSHED INDEX	Defines the appropriate watershed to use for each grid sector
6	2 to 23	A22	CROP SEASON AND SHARE	Defines parameters associated with crops
7	2 to 23	A22	WATERSHED DEFINITION	Defines water ingestion data for each watershed
8	2 to 23	A22	REGIONAL ECONOMIC DATA	Economic data for each economic region defined

6.2 Spatial Distances Data Block

The spatial distances data define the spatial grid for which the population and some other data are specified. The data define the distances in kilometers to the endpoints of the spatial intervals. The areas between the spatial interval endpoints within each of the 16, 32, 48 or 64 direction sectors are referred to as grid elements. This grid definition must agree with the grid defined by the ATMOS input parameter SPAEND. MACCS reads the spatial intervals distances in the site file and compares the values with SPAEND. MACCS allows a relative error of 10%, but only the ATMOS values for SPAEND are used in calculations. For larger discrepancies in the geometry data, an error flag is set and execution terminates upon completion of the site data file input processing. WinMACCS sets the values of SPAEND to be identical with the values in the site data file, so it is not possible to have any difference between the spatial distances data block in the site file and SPAEND.

The first line of the spatial distance data block contains the 22-character separator beginning with SPATIAL DISTANCES in column 2. Next, the endpoint distances in kilometers are specified, up to eight values per line, using the format described below, using as many lines as needed. The minimum spacing between adjacent spatial intervals is 0.1 km.

The first interval endpoint is in columns 1–10, the second interval endpoint is in columns 11–20, etc. The values must be right justified within the ten columns allotted. The values are input as real numbers.

Table 6-3 Spatial Distances Data

Parameter Name	Dimensions	FORTRAN Format	Allowed Values	Description
SPAEND	NUMRAD	8E10.2	0.05 to 9999.0 km	Radial spatial intervals

6.3 Population Data Block

The population data for each element in the spatial grid is defined here. The first line of the data block contains the 22-character separator beginning with POPULATION in column 2. Next, the number of people in each element is given for the first sector, which is centered on north. The sector number increases in the clockwise direction.

The population data are input as real numbers; fractional values are supported. The population data for up to eight grid elements may be defined per line and the data are input in ten column intervals; *i.e.*, the population of the first element is in columns 1–10, the population in the second element is in columns 11–20, etc. The data must be right justified in the ten columns allotted to that value.

Table 6-4 Population Data

Parameter Name	Dimensions	FORTRAN Format	Allowed Values	Description
POPDAT	NUMRAD by NUMCOR	8E10.0	0.0 to 10^9	Number of people living in grid element

MACCS combines evacuation scenarios using one of three different algorithms specified by a parameter WTNAM. This parameter can be set to PEOPLE, TIME or SUMPOP. This parameter is defined on the *Site Data* tab in WinMACCS.

When WTNAM is set to PEOPLE, the EARLY variable, WTFRAC, specified per cohort, represents the fraction of the population that belongs to the cohort. When WTNAM is set to TIME, the EARLY parameter WTFRAC represents the fraction of time (i.e., probability) that this evacuation scenario is applicable. With this option, the entire population follows an evacuation scenario a fraction of the time. When the parameter WTNAM is set to SUMPOP, population data for each evacuation scenario are defined in the site data file as described below.

When WTNAM is set to TIME or PEOPLE the population data block is delimited with the header record POPULATION beginning at column 2, followed by the population data.

When the SUMPOP option is selected, the header lines for each population data block are POPULATION1, POPULATION2, and POPULATION3, corresponding to the corresponding emergency-phase cohorts, all beginning in column 2. MACCS reports an error when the number of population data blocks does not equal the number of emergency-phase cohorts defined in the EARLY input file.

6.4 Land Fraction Data Block

The fraction of each spatial element that is land (as opposed to lakes, oceans, *etc.*) is defined for each grid element. The first line of the data block contains a 22-character separator beginning in column 2, the character string LAND FRACTION. Next, the fraction of area that is land in each radial spatial interval of the first sector is given. All values must be between 0 and 1. A value of 0 means the grid element has no land, a value of 1 means the element is all land. The land fraction data are specified, 16 values per line, using the format described below. As many lines as needed to define all the spatial intervals in the sector are used. The land fraction data for the second and subsequent sectors follow in clockwise order. The values for each sector begin on a new line.

The land fraction data are read as real numbers and land fractions values each occupy five columns. The values must be right justified in the five columns allotted.

Table 6-5 Land Fraction Data

Variable Name	Dimensions	FORTRAN Format	Allowed Values	Description
FRCLND	NUMRAD by NUMCOR	16F5.2	0.0 to 1.0	Fraction of sector that is land

6.5 Region Index Data Block

In this data block the user assigns a user-defined economic region to each of the spatial intervals. The values defining each of the economic regions are in the regional economic data block. The data for each sector begins on a new line.

The first line in the Region Index data block contains a 22-character separator beginning in column 2 and containing the character string REGION INDEX. The next line contains two-digit integers associating a region index with each of the spatial elements in the first sector, which limits the number of regions to 99. For example, a region index of 09 means that economic data for region number nine is used to define the grid element. Though the FORTRAN format, 40I2, supports up to forty values per line, the number of values considered on each line is NUMRAD. Each sector starts a new line and they are ordered in the clockwise direction. For example, when the spatial grid is divided into 16 sectors, there are a total of 16 lines of data starting with north and ordered clockwise around the compass.

Each value must be right justified in the two columns allotted. The values are integers.

Table 6-6 Region Index Data

Parameter Name	Dimensions	FORTRAN Format	Allowed Values	Description
INDREG	NUMRAD by NUMCOR	40I2	1 to NECRGN	Economic region associated with sector

6.6 Watershed Index Data Block

Each of the spatial intervals in the grid must be associated with one of the watershed indices. The watershed identification data block begins with a 22-character separator beginning in column 2 containing the character string WATERSHED INDEX. The next line contains two-digit integers associating a watershed type for each of the grid elements in the first sector. Data for all sectors must be provided. The data for each sector begins on a new line.

A watershed index of 1 means that the water ingestion factor for watershed type 1 is used for all deposition in that grid element. A watershed index of 2 means that the water ingestion factor for watershed type 2 is used for all deposition in that spatial element. Though the FORTRAN format, 40I2, supports up to forty values per line, the number of values on each line should be NUMRAD. The number of lines in this data block is the number of compass sectors, a new line for each sector ordered in a clockwise fashion starting from north.

Table 6-7 Watershed Index Data

Parameter Name	Dimensions	FORTRAN Format	Allowed Values	Description
INDWTR	NUMRAD by NUMCOR	40I2	1 to NUMWPA	Watershed index associated with sector

6.7 Crop and Season Share Data Block

The length of the growing season and the average fraction of the farmland area at the site devoted to each crop type must be specified. These fractions need not sum exactly to 1, but their sum should not exceed a value of 1. When these values sum to a value less than 1, that sum indicates the fraction of farmland in production in an average year (some fraction of farmland may be fallow). Values must be specified for each of crop type.

This information is used only when *MACCS Food Model* is specified on the *Food* tab in WinMACCS; it is not used when the *MACCS Food Model* is not used, but the values are required, nonetheless.

When *MACCS Food Model* is specified on the *Food* tab in WinMACCS, the crop names must agree with the parameter NAMCRP. The data block begins with the separator CROP SEASON AND SHARE in column 2. This is followed by NFICRP lines of data.

Table 6-8 Crop and Season Share Data

Parameter Name	Columns	FORTRAN Format	Allowed Values	Description
I	1 to 4	I4	1 to NFICRP	Crop Index, line number starting at 1
CROP	6 to 25	A20	When the *MACCS Food Model* is selected, must match with a value in vector NAMCRP	Name of crop group.
GBEG	26 to 30	F5.0	1 to GEND	Day of the year the growing season begins
GEND	31 to 35	F5.0	GBEG to 365	Day of the year the growing season ends
FRCLCP	36 to 45	F10.0	0.0 to 1.0	Fraction of the site-averaged farmland devoted to this Crop

6.8 Watershed Definition Data Block

The data block begins with a 22-character separator beginning in column 2 containing the character string WATERSHED DEFINITION. For each of the radionuclides considered in the liquid pathways model, a single line is supplied. Exactly NUMWPA ingestion factors are supplied on each line. Values supplied override values of WinMACCS parameter WINGF when defined. MACCS supports up to 10 radionuclides in the liquid pathway model.

Table 6-9 Watershed Definition Data

Parameter Name	Columns	FORTRAN Format	Allowed Values	Description
I	1 to 4	I4	1 to NWPISO	Radionuclide Index, line number starting at 1
NMISO	6 to 13	A8	Should match WinMACCS parameter NAMIPI when defined. Otherwise, should match a value in vector NUCNAM.	Radionuclide name
WTRINF(1)	36 to 45	E10.1	to 1.0	Ingestion Factor for Watershed Class 1
WTRINF(2)	46 to 55	E10.1	0.0 to 1.0	Ingestion Factor for Watershed Class 2
WTRINF(3)	56 to 65	E10.1	to 1.0	Ingestion Factor for Watershed Class 3
WTRINF(4)	66 to 75	E10.1	to 1.0	Ingestion Factor for Watershed Class 4

6.9 Regional Economic Data Block

Economic data must be specified for each of the economic regions. The data block begins with the separator REGIONAL ECONOMIC DATA in column 2. An economic region is typically identified with the name of a county, state, or country to provide an indication of the source of the data or the type of geographical area it is intended to represent. The economic regions defined in this section are identified with spatial elements in the Region Index data block. There is a line for each one of the economic regions.

Table 6-10 Regional Economic Data

Parameter Name	Columns	FORTRAN Format	Allowed Values	Description
I	1 to 4	I4	1 to NECRGN	Region index, starting with 1
NMRGN	6 to 15	A10		Name of region
FRMFRC	21 to 25	F5.3	0.0 to 1.0	Fraction of land devoted to farming
DPF	26 to 30	F5.3	0.0 to 1.0	Fraction of farm sales from dairy
ASFP	31 to 40	F10.1	0.0 to 10^9 $/hectare	Total annual farm sales
VFRM	41 to 50	F10.1	0.0 to 10^9 $/hectare	Farmland property value
VNFRM	51 to 60	F10.1	0.0 to 10^9 $/person	Non-farmland property value

6.10 Sample Site Data File

This is an example site file for a fictitious site located in Pahrump, Nevada, USA. It includes 16 compass sectors, 26 spatial intervals, uses one watershed, and has 98 economic regions. It uses the 2010 Census for population and 2012 economic data. Multipliers for population and economic values are both set to unity. Crop season and watershed definition are defaults from SecPop and must be edited manually if they need to be modified.

```
SECPOP Version: 4.3.0 SVN:2242 FileType: MACCS_Site Project: "Fictitious" Census:
"C:\Program Files (x86)\SecPop\Census\Census2010.bin" County: "C:\Program Files
(x86)\SecPop\Census\County2012.dat"
Lat:  36d11'35''  Long:  115d58'55''  Latitude:  36.193058  Longitude:  115.98194
Population_multiplier: 1.0 Economic_multiplier: 1.0 Run_Time: 2016/02/04_12:28:56
  26 SPATIAL INTERVALS
  16 WIND DIRECTIONS
   7 CROP CATEGORIES
   4 WATER PATHWAY ISOTOPES
   1 WATERSHEDS
  98 ECONOMIC REGIONS
 SPATIAL DISTANCES     KILOMETERS
    0.1600    0.5200    1.2100    1.6100    2.1300    3.2200    4.0200    4.8300
    5.6300    8.0500   11.2700   16.0900   20.9200   25.7500   32.1900   40.2300
   48.2800   64.3700   80.4700  112.6500  160.9300  241.1400  321.8700  563.2700
  804.6700 1609.3400
 POPULATION
       0.        0.       44.        3.        9.      198.        0.       12.
      29.       43.       96.      536.       25.        0.        0.        1.
       0.        0.        0.        0.        0.       94.      203.    48711.
  153798.  2143468.
       0.       13.      235.       61.        0.        8.       35.        5.
       0.        5.        0.        0.        0.        0.        5.        0.
       2.      746.        0.        0.     1193.      136.      678.    18438.
  949973.   929596.
       0.        0.        4.        0.       17.       16.        0.        0.
       0.        0.        0.        0.        0.        0.       10.       82.
       0.     5237.        0.        0.        3.     3741.     9992.   129062.
 1669744.   676429.
       0.        0.        0.       15.        5.       42.        0.        0.
     148.        0.        0.        0.        0.        0.      212.      220.
     292.    18068.     8387.        0.     8549.   109552.    93470.    18927.
  284016.  5256346.
       0.        7.        0.       57.       73.      327.        0.        0.
       0.        0.        0.        0.        0.        0.        3.        0.
     152.   254610.   848885.   365223.      255.     1224.      500.    68862.
  358505.  2331523.
       0.        0.      159.       42.       31.      198.      171.      167.
       0.       97.        5.       11.        0.        0.        0.        0.
     107.    22919.   211576.   177910.      465.    58248.     2876.   355158.
  147099.  2542701.
       0.        0.       50.       15.       72.      298.      288.      303.
      16.     1266.     1273.       10.        0.        0.        0.        0.
     609.     1677.      169.      354.      935.    97790.    54566.  4173727.
 1169129.    20674.
       0.       29.       46.       79.       66.      283.      148.      130.
     154.      605.     1963.      316.        2.       10.       45.        0.
       0.       48.        5.       42.       46.       65.    29179.   203628.
     106.        0.
       0.        0.        7.       33.      333.      266.      329.      627.
     340.     1449.      218.      311.        0.       16.        4.        0.
       0.        0.        0.      743.       25.    63475.   412494.   199515.
       0.        0.
       0.        0.        0.       24.        5.      215.      284.       66.
      25.      144.        0.        0.        0.        0.        6.        0.
     137.        0.        0.        0.    10691.   287689.  3724726.  4275018.
       0.        0.
       0.       36.        0.        0.       81.      305.      283.      196.
      46.        0.        0.        0.        0.        5.        0.       31.
      13.        0.        0.        0.       11.   147077.  6849804.  5136399.
       0.        0.
       0.        0.       83.      175.      123.      425.      193.      304.
     323.      494.       79.        0.        0.        0.        0.        0.
       0.        0.        0.        0.     2024.    65914.   648666.   647997.
       0.        0.
       0.        0.      155.      131.       42.      352.      392.      307.
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     214.      343.     1846.       74.        0.        0.        0.        3.
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     652.        0.
       0.        0.        0.       71.      114.      436.      616.      240.
     461.     1494.     1536.       42.        9.        0.        0.        0.
      89.        0.      344.      101.        3.     4595.    31218.  6807141.
 4594572.     2463.
       0.        0.       38.       98.      471.       92.      345.      362.
     320.     1130.     1871.      957.      126.        0.       13.        0.
      30.     1058.      270.     1002.       28.      330.     1578.   863619.
  660171.   795687.
       0.        0.        5.       60.       80.       18.       67.       33.
      37.      500.     1571.     1242.       14.        0.        0.      100.
       7.        0.        0.        0.        4.     2720.     1712.    37428.
   15288.  9114675.
LAND FRACTION
0.00 0.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.99
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0.00 0.00 1.00 1.00 0.99 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
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0.00 0.00 1.00 1.00 1.00 0.99 1.00 1.00 1.00 1.00 1.00 1.00 0.00 0.00 1.00 0.99
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0.00 0.00 1.00 1.00 0.99 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
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1.00 1.00 1.00 1.00 1.00 1.00 1.00 0.99 0.98 0.95
REGION INDEX
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1 4 4 4 4 4 4 4 4 4 3 3 3 311121313141516171883839 8
1 3 4 4 4 4 4 4 4 3 4 4191313131313131320212223848498
1 4 4 4 4 4 4 3 3 4 4241313 313131313131325266278585 98
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1 4 4 4 4 4 4 4 4 4 35750 35050505058474747596092 3 3
1 3 4 4 4 4 4 4 4 4 4 46162 3 350505050506364656693 3 3
1 3 4 4 4 4 4 4 4 4 4 4 467 3 3505050505050506869949 4 3
1 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4707172505050737495959 8
1 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 47576777879969698
1 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 48081979798
WATERSHED INDEX
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1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
CROP SEASON AND SHARE
  1 PASTURE                90. 270.  0.4100
  2 STORED FORAGE         150. 240.  0.1300
  3 GRAINS                150. 240.  0.2100
  4 GRN LEAFY VEGETABLES  150. 240.  0.0020
  5 OTHER FOOD CROPS      150. 240.  0.0040
  6 LEGUMES AND SEEDS     150. 240.  0.1500
  7 ROOTS AND TUBERS      150. 240.  0.0030
WATERSHED DEFINITION  -- INITIAL AND ANNUAL WASHOFF AND INGESTION FACTORS
  1 Sr-89                           5.00E-06       0.0
  2 Sr-90                           5.00E-06       0.0
  3 Cs-134                          5.00E-06       0.0
  4 Cs-137                          5.00E-06       0.0
REGIONAL ECONOMIC DATA
  1 EXCLUSION       .000 .000        .0        .0        .0
  2 EMPTY02         .000 .000        .0        .0        .0
  3 EMPTY03         .000 .000        .0        .0        .0
  4 Nye04           .006 .000    2675.0    5531.0  325945.0
  5 MIX_CNTY05      .006 .000    2635.1    5745.5        .0
  6 MIX_CNTY06      .005 .000    2589.3    5791.5        .0
  7 MIX_CNTY07      .004 .000    2075.2    4290.7        .0
  8 MIX_CNTY08      .003 .000    1497.8    3096.9        .0
  9 MIX_CNTY09      .004 .000    2099.9    4341.8  278872.3
 10 MIX_CNTY10      .005 .000    2511.3    5331.2  325945.0
 11 MIX_CNTY11      .003 .000    1080.0   14111.0  359500.0
 12 MIX_CNTY12      .005 .000    2150.7    8351.3        .0
 13 Clark13         .003 .000    1080.0   14111.0  359500.0
 14 MIX_CNTY14      .003 .000    1079.9   14110.3        .0
 15 MIX_CNTY15      .000 .000       2.7      35.0        .0
 16 Lincoln16       .000 .000        .0        .0  261817.0
 17 MIX_CNTY17      .001 .000     617.0    1275.7  261817.0
 18 MIX_CNTY18      .002 .001     486.8    1620.2  368899.1
 19 MIX_CNTY19      .004 .000    1681.0   10878.0        .0
 20 MIX_CNTY20      .003 .000    1017.4   13293.0        .0
 21 MIX_CNTY21      .000 .000      34.2     447.5  261817.0
 22 MIX_CNTY22      .014 .005      32.5    1235.3  262068.2
 23 MIX_CNTY23      .172 .133    1195.1    4544.1  254878.7
 24 MIX_CNTY24      .003 .000    1080.0   14111.0        .0
 25 MIX_CNTY25      .002 .000     831.6   10865.9  359500.0
 26 MIX_CNTY26      .094 .006     217.8   40749.5  291911.2
 27 MIX_CNTY27      .131 .037     192.5   37899.7  270410.3
 28 MIX_CNTY28      .059 .000     679.8   39357.5  330392.3
 29 MIX_CNTY29      .128 .000     190.1   70249.3  261836.0
 30 MIX_CNTY30      .376 .000      27.0  309321.1  334469.2
 31 MIX_CNTY31      .104 .000     356.6   59747.0  272337.5
 32 Mohave32        .146 .000      60.0   78456.0  261836.0
 33 MIX_CNTY33      .241 .000      79.6  155479.9  287032.1
 34 MIX_CNTY34      .004 .000    1448.4   12129.4        .0
 35 MIX_CNTY35      .004 .051    2397.4   15520.1  359002.3
 36 MIX_CNTY36      .004 .108    3908.4   17345.3  359500.0
```

37	MIX_CNTY37	.004	.179	5776.0	19480.8	354342.9
38	MIX_CNTY38	.014	.249	7537.0	26199.0	358495.8
39	MIX_CNTY39	.095	.214	6035.3	61683.1	271843.2
40	MIX_CNTY40	.093	.054	1542.5	51014.8	269887.5
41	MIX_CNTY41	.007	.000	2615.5	5468.3	325945.0
42	MIX_CNTY42	.025	.000	1504.1	4919.9	374168.5
43	MIX_CNTY43	.038	.000	445.0	5605.8	418105.5
44	MIX_CNTY44	.048	.000	201.4	3532.4	.0
45	MIX_CNTY45	.039	.180	5128.1	11304.4	.0
46	MIX_CNTY46	.007	.659	18361.4	33720.8	307340.0
47	San_Bern47	.006	.669	18636.0	34186.0	307340.0
48	MIX_CNTY48	.054	.174	7152.4	21712.8	310148.9
49	MIX_CNTY49	.023	.000	1673.8	4475.6	325945.0
50	Inyo50	.051	.000	146.0	2865.0	422392.0
51	MIX_CNTY51	.046	.075	2224.9	6386.5	.0
52	MIX_CNTY52	.006	.666	18571.0	34139.4	307340.3
53	MIX_CNTY53	.085	.133	7674.7	27115.0	311830.5
54	MIX_CNTY54	.042	.135	3873.5	9179.2	422392.0
55	MIX_CNTY55	.036	.222	6286.0	13265.8	.0
56	MIX_CNTY56	.061	.274	10340.4	31195.3	342463.5
57	MIX_CNTY57	.018	.000	2004.4	4824.1	.0
58	MIX_CNTY58	.048	.036	1148.5	4563.2	.0
59	MIX_CNTY59	.121	.468	13731.4	28287.7	310216.5
60	MIX_CNTY60	.057	.045	6120.4	31832.6	443771.9
61	MIX_CNTY61	.006	.000	2647.9	5502.4	325945.0
62	MIX_CNTY62	.050	.000	199.0	2920.9	.0
63	MIX_CNTY63	.035	.240	6793.3	14125.2	.0
64	MIX_CNTY64	.029	.453	12671.0	24123.4	312914.7
65	MIX_CNTY65	.413	.157	5060.7	13126.1	336839.9
66	MIX_CNTY66	.424	.115	4527.7	13533.2	337157.7
67	MIX_CNTY67	.024	.000	1637.8	4437.6	365045.1
68	MIX_CNTY68	.269	.277	5042.5	13256.6	376652.8
69	MIX_CNTY69	.417	.392	7587.6	18887.0	311376.9
70	MIX_CNTY70	.009	.000	2478.8	5324.2	.0
71	MIX_CNTY71	.049	.000	229.4	2952.9	327028.7
72	MIX_CNTY72	.049	.000	228.0	2951.4	.0
73	MIX_CNTY73	.094	.044	1067.0	4921.6	422392.0
74	MIX_CNTY74	.343	.070	5391.2	17111.6	394223.3
75	MIX_CNTY75	.006	.000	2674.4	5530.4	325945.0
76	MIX_CNTY76	.007	.000	2602.8	5454.9	325945.0
77	MIX_CNTY77	.018	.000	1903.3	4775.2	332834.1
78	MIX_CNTY78	.024	.000	802.5	4269.0	447628.5
79	MIX_CNTY79	.015	.000	584.1	4300.2	408604.4
80	MIX_CNTY80	.007	.000	2469.8	5429.5	339779.0
81	MIX_CNTY81	.006	.000	2338.6	5144.8	325945.0
82	MIX_CNTY82	.183	.126	916.5	3266.3	358653.5
83	MIX_CNTY83	.240	.114	794.5	4224.6	333545.4
84	MIX_CNTY84	.207	.091	571.4	4251.9	358974.7
85	MIX_CNTY85	.162	.008	260.7	13629.7	341927.2
86	MIX_CNTY86	.500	.010	34.1	183740.1	303938.2
87	MIX_CNTY87	.334	.012	167.6	145198.8	299802.0
88	MIX_CNTY88	.152	.149	1830.4	35440.3	364356.0
89	MIX_CNTY89	.070	.006	7822.9	10749.2	259639.5
90	MIX_CNTY90	.140	.019	8597.2	31095.0	330385.6
91	MIX_CNTY91	.086	.038	7810.2	45764.2	494904.5
92	MIX_CNTY92	.159	.000	8860.2	35902.6	453981.2
93	MIX_CNTY93	.458	.022	4370.8	18134.3	456231.0
94	MIX_CNTY94	.576	.076	5302.3	15582.4	400578.5
95	MIX_CNTY95	.472	.094	3086.1	18982.9	528965.4
96	MIX_CNTY96	.175	.023	676.9	8584.3	405306.7
97	MIX_CNTY97	.125	.046	533.9	3165.3	400316.2
98	MIX_CNTY98	.601	.039	626.9	4428.2	412895.8

7. METEOROLOGICAL FILE FORMAT

7.1 Format Overview

When running WinMACCS, a weather model is selected using the *Weather* tab when it is needed. When one of the file sampling methods is chosen, a meteorological file is required. It is also required when modeling a weather sequence starting with a day and time period from the weather file.

Data must be provided for a 365-day year. The file consists of either fifteen-minute, thirty-minute, or hourly averages. Each line of the file contains the Julian day of the year, the time period of the day, wind direction, wind speed, atmospheric stability class, and precipitation rate. Most commonly, the data are taken from a weather station at the site or from a nearby weather station.

The meteorological data file is a formatted text file. The first two lines of contain identification information. Up to 80 characters may be used on each line. This header information is printed on the output listing.

Table 7-1 Meteorological Data Identification Information

Line in Met file	FORTRAN Format	Allowed Values	Description
1 and 2	A80	N/A	File identifying information. Should contain quality assurance information.

The default recording interval for the weather data is an hour. When 30-minute or 15-minute averaging times are used, the next line is required. When this line is omitted in the meteorological file, a period of 60 minutes is assumed.

Table 7-2 Meteorological Data Interval Information

Columns	FORTRAN Format	Allowed Values	Description
1 to 7	A7	/PERIOD	Keyword that identifies parameter
9-10	I2	60, 30 or 15	Time-averaging period for values in the file

The possible values for the parameter WINDIR depend on the WinMACCS parameter NUMCOR. WinMACCS and MACCS allow NUMCOR to be 16, 32, 48, or 64. The value should be consistent with NUMCOR in WinMACCS and in the site data file when a site data file is used. It is up to the user to select or create a meteorological file that is consistent with the value of NUMCOR used in MACCS. If the meteorological file is based on fewer sectors than NUMCOR, no error message is created, but the results reported by MACCS are not calculated correctly. If the meteorological file contains values for WINDIR that exceed the value of NUMCOR, MACCS stops with a fatal error.

NUMCOR can be optionally defined using a line following the /PERIOD line, or following the last comment line if the /PERIOD line is missing.

Table 7-3 NUMCOR Allowable Values

Columns	FORTRAN Format	Allowed Values	Description
1 to 7	A7	/NUMCOR	Keyword that identifies parameter
9-10	I2	16, 32, 48 or 64	Number of compass directions. The parameter WINDIR must be a positive number less than or equal to this value.

This is followed by a line for each recorded period. There are 8760 lines when the period is 1 hr; there are 17520 lines when the time period is 30 min; there are 35040 lines when the period is 15 min.

Table 7-4 Weather Period Data

Columns	FORTRAN Format	Variable	Allowed Values	Description
2 to 4	I3	ISTRDY	1 to 365	Julian day of the year
6 to 7	I2	ISTRHR	1 to 96	Interval of the day. Should not exceed 24 when period is 60 min; 48 when period is 30 min; 96 when period is 15 min.
9 to 10	I2	WINDIR	1 to NUMCOR	Direction of wind. 1 is north and the number increases in the clockwise direction.
11 to 13	I3	WINDSPD	1 to 300*	Units are 0.1 m/s.
14	I1	ISTAB	1 to 7**	Stability category. Value corresponds to Pasquill stability class A through G.
15 to 17	I3	RNMM	-1 to 999***	Rain rate in units of 0.01 in/hr.

* Values less than 5 are automatically changed to 5 (0.5 m/s). Values greater than 300 result in an error.

** A value of 7 is automatically changed to 6 by the code.

*** Some meteorological data files use –1 to indicate a trace of precipitation during the hour. MACCS interprets these values to be 0.

Following these lines of input is a line with eight values of mixing layer height. The units for these values are 100 m. Two values of mixing height are supplied for each of the four seasons of the year. The first four of these values correspond to morning (average daily minimum) mixing heights and the final four values correspond to afternoon (average daily maximum) mixing heights.

The FORTRAN format for these values is F10.0. This means that the input field is ten characters long and should be right justified when no decimal point is included (i.e., any blanks to the right of the number within the field of 10 characters are interpreted as zeros). To reduce the possibility of an error, it is recommended that a decimal point be used. Engineering format can also be used (e.g., 1.4E1). A real number within the allowed range of 1 to 100 (100 m to 10,000 m) is allowed.

Table 7-5 Mixing Height Data

Columns	FORTRAN Format	Variable	Allowed Values	Description
1 to 10	F10.0	HEIGHT(1,1)	1 to 100	Morning winter mixing height. Units are 100 m.
11 to 20	F10.0	HEIGHT(2,1)	1 to 100	Morning spring mixing height. Units are 100 m.
21 to 30	F10.0	HEIGHT(3,1)	1 to 100	Morning summer mixing height. Units are 100 m.
31 to 40	F10.0	HEIGHT(4,1)	1 to 100	Morning autumn mixing height. Units are 100 m.
41 to 50	F10.0	HEIGHT(1,2)	1 to 100	Afternoon winter mixing height. Units are 100 m.
51 to 60	F10.0	HEIGHT(2,2)	1 to 100	Afternoon spring mixing height. Units are 100 m.
61 to 70	F10.0	HEIGHT(3,2)	1 to 100	Afternoon summer mixing height. Units are 100 m.
71 to 80	F10.0	HEIGHT(4,2)	1 to 100	Afternoon autumn mixing height. Units are 100 m.

7.2 Sample Meteorological Data File

A sample set of records from the meteorological data file is provided, which shows the first and last ten records of the file. NUMCOR is assumed to be 16. The weather conditions for day one, hour one (record number three) are: wind direction—blowing toward the SE, wind speed of 2.6 m/s, stability category 4 (D), and precipitation rate of 0.07 in/hr (1.8 mm/hr) during the hour. The winter, spring, summer, and autumn mixing heights for neutral and unstable conditions (record 8763) are all 1200 m.

```
U.S. NATIONAL WEATHER SERVICE METEOROLOGICAL DATA FILE
Sample Input for the MACCS Documentation
 1     1   70264   7
 1     2   60624   7
 1     3   80414   2
 1     4   80364  -1
 1     5   90314   0
 1     6  110464   0
 1     7  110264  -1
 1     8  110414  -1
 .
 .
 .
365  16  120154   4
365  17  110154   4
365  18  130214   4
365  19  130154   3
365  20  130104   2
365  21  130154   2
365  22  140104   2
365  23  130104   2
365  24  140104   2
      12.       12.       12.     1.2E1        12        12        12        12
```

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8. DOSE CONVERSION FACTOR FILE

8.1 Introduction

WinMACCS is supplied with a set of 51 “adult” dose coefficient files which are based on the CD supplement to Federal Guidance Report 13 (EPA 2002). Data for 825 isotopes are provided. This dose factor file set supports WinMACCS calculations using the LNT, AT, and PL dose-response models for latent cancer health effects and the acute health effects model.

These dose factors use ICRP publication 60 (ICRP 1991) tissue weighting and the respiratory tract model defined in ICRP-publication 66 (ICRP 1994). Federal Guidance Report 13 dose coefficients are generally similar to those published in ICRP publication 72 (1996), but they incorporate modifications to ICRP publication 72 assumptions that were agreed to by the EPA and the Oak Ridge National Laboratory Center for Biokinetic and Dosimetric Research. Minor differences between Federal Guidance Report 13 and ICRP publication 72 dose coefficients are largely attributable to differences in:

1. Assumptions of shared kinetics in some decay chains
2. Systemic biokinetic models for some elements, and
3. Gastrointestinal tract absorption-to-blood fractions, f1.

8.2 Lung Clearance Behavior

With few exceptions, the absorption types are consistent with those in ICRP 72. The dose coefficient files do not indicate an absorption type for certain isotopes when either there was no choice of clearance type in Federal Guidance Report 13, or the choice was superfluous because the inhalation dose coefficients were zero.

8.3 Gastrointestinal Tract Uptake Fraction, f1

Federal Guidance Report 13 assigned *f1* values for uptake of elements from the digestive tract via the ingestion pathway based on the chemical form expected to be encountered in the environment, and these values were not necessarily consistent with the *f1* values used in the computation of inhalation dose coefficients in FGR 13. There were choices of *f1* to be made for only four elements: hydrogen, sulfur, mercury, and polonium. The ingestion dose coefficient for tritium was based on tritiated water (HTO). Sulfur, mercury, and polonium isotopes were assigned ingestion dose coefficients based on the form and f1 that gave the highest dose.

8.4 Particle Size Distribution

Inhalation dose coefficients for micron sized particles depend on the activity median aerodynamic diameter (AMAD). The Federal Guidance Report 13 inhalation dose factors are based on an activity mean aerodynamic diameter (AMAD) of 1 μm.

8.5 Organs Included in Data Set

The following organs and tissues are included in the Federal Guidance Report 13 dose coefficient files.

Table 8-1 Organs and Tissues Included in Data Set

Organs with annual and 50-year equivalent dose commitment coefficients	Organs with acute dose commitment coefficients
Adrenals	
Urinary Bladder Wall	
Bone Surface	
Brain	
Breasts	
Stomach Wall	Stomach Wall
Small Intestine Wall	Small Intestine Wall
Upper Large Intestine Wall (ULI)	
Lower Large Intestine Wall (LLI)	Lower Large Intestine Wall
Kidneys	
Liver	
Esophagus	
Muscle	
Ovaries	
Pancreas	
Red Marrow	Red Marrow
Skin	
Spleen	
Testes	
Thymus	
Thyroid	Thyroid
Uterus	
Lungs	Lungs
Colon	
Gonads	
Remainder	
Effective	

8.6 Annual and 50-year Equivalent Dose Commitment Factors

The annual and 50-year dose commitment factors are intended for stochastic health effect (cancer and heritable effect) estimation, so they include a radiation weighting factor of 20 for the high linear energy transfer contributions to these dose coefficients. The annual files contain the contribution to dose in a specific year from an exposure during the first year.

8.7 Calculating Annual and 50-Year Dose Commitment Factors for "Composite Organs"

Dose factors for composite organs were calculated from dose factors for the underlying tissues or organs as follows:

(1). The **esophagus** was assigned the corresponding inhalation dose coefficients and ingestion dose coefficients of the **thymus**.

(2). Inhalation and ingestion dose coefficients for the **colon** were calculated as a weighted sum of the dose coefficients for upper large intestine (57%) and lower large intestine (43%)

(3). The inhalation and ingestion dose coefficients for the **lung** (thoracic portion of respiratory tract) and $\mathbf{ET_{Reg}}$ (the extra-thoracic region of the respiratory tract) were calculated using equations on page 35 of ICRP publication 66. The lung coefficient is the weighted sum of the coefficients for the several respiratory tract tissues.

(4). The dose coefficients for **remainder** were calculated using equations in ICRP publication 71 (ICRP 1995) page 27.

(5). The dose coefficients for **gonads** were the larger of the dose coefficients for testes and ovaries.

(6). The dose coefficients for **effective** were computed from the individual organ dose coefficients using the ICRP 60 tissue weighting method.

8.8 Acute Inhalation Dose Factors

Reliable data on relative biological effectiveness, **RBE**, of high linear energy transfer radiation at causing acute health effects were not located; so, the acute inhalation dose factors were based on an RBE of 10 for consistency with DOSFAC2 DCF files.

Next, the resulting acute dose coefficients **DCF [i, at, org, cp**] were weighted by acute dose protraction factors, **WTFRAC [cp,org],** and summed to obtain adjusted acute dose coefficients, **DCF [i, at, org]**. Here, **i** represents an isotope, **at** represents absorption type (equivalent to lung clearance class), **org** represents an organ, and **cp** represents a commitment period. The values of **WTFRAC [cp, org]** that were used are given in the DOSFAC2 Users Manual (Young and Chanin, 1997).

8.9 Designating Pseudo-Stable Isotopes When Using Federal Guidance Report 13 Dose Coefficient Files

In contrast to DOSFAC2 and FGRDCF dose coefficients, Federal Guidance Report 13 dose coefficients do not implicitly account for doses from a decay product in the dose coefficients of the parent. Consequently, one must be mindful about specifying both parent and the corresponding progeny that are released or form as decay products in the environment via the WinMACCS "Radionuclide Core Inventory and Chemical Group" window. For long decay chains, such as uranium-238, the sixth member of the chain (thorium-230 for example) must be identified as pseudo-stable. When the pseudo-stable isotope conventions commonly observed for DOSFAC2 or FGRDCF dose factor files are used with Federal Guidance Report 13 dose factor files, doses and health effects may be significantly underestimated. For example, Ba-137m must

be listed as a pseudostable isotope when using a DOSFAC2 dose factor file because its dose is included implicitly with Cs-137. With the FGR-13 dose factor file, including Ba-137m as a pseudostable isotope could lead to a significant under-prediction of overall dose.

8.10 Known Issues

The FGR-13 dose coefficient files have inherited the following issues from the CD Supplement to FGR-13:

(1). The ingestion and inhalation dose coefficients for four alpha-emitting rare-earth isotopes (Sm-146, Sm-147, Gd-148, and Gd-152) are incorrect.

(2). The ingestion and inhalation dose coefficients for four isotopes having significant spontaneous fission decay modes (Cm-248, Cm-250, Cf-252, and Cf-254) are listed as zero.

9. CYCLICAL FILE FORMAT

It is possible to run successive MACCS simulations without using LHS. Model values can be varied using successive MACCS input files. This feature is enabled in WinMACCS through the Project Properties form setting on the Scope tab. The files are selected and copied into the WinMACCS project after the user completes the form *GENERAL/File Specifications/Cyclical File Set*.

When the user clicks the Run button to begin a simulation, WinMACCS reads a cyclical file, and imports the values temporarily into the project using the algorithm identical to the *File→Import MACCS Input File* option on the main menu. WinMACCS creates the MACCS template input files. The template input files are identical to the MACCS input files when sampling is not used for the simulation.

The format required for the cyclical input files is identical to the input format required for MACCS with the following exceptions:

(1). ATMOS, EARLY, CHRONC and COMIDA2 model input can be grouped together in a single cyclical input file. When MACCS is run directly, input for these models must be in separate files.

(2). A period in column one is used solely to separate EARLY evacuation scenarios. The first evacuation scenario occurs before the first period in column one. MACCS also supports using a period in column one to separate different source terms in the ATMOS input, but this is not supported in WinMACCS. Instead, WinMACCS uses the cyclical file capability to support multiple source terms.

(3). MACCS has evolved since 1.13.1, and though cyclical file input is backward compatible, new model options and hence new input values have been added. Thus, older files may not be entirely compatible with newer versions of WinMACCS and MACCS.

The MACCS file format is not documented in detail here. However, note the following rules:

(1). An asterisk (*) in column one signifies a comment.

(2). Multiple values on an input line can be separated by any amount of white space, including TAB characters.

(3). An input line begins with a prefix. Depending on the input line, this is followed by a two- or three-digit sequence number or by no sequence number. The value(s) of the variable(s) follow separated by white space. For example, the following line is a valid MACCS input file line with a three-digit sequence number and the prefix “RDPDELAY”

- RDPDELAY001 3700.

Cyclical input files can be created in a number of ways as follows:

(1). Modify a MACCS file to reflect the changes desired. As a starting point, use a file created by WinMACCS such as Atmos1.inp, Early1.inp, etc.

(2). Include only relevant changes between the simulations in a cyclical input file. As a starting point, edit a file created by WinMACCS, removing data that are not changed between cyclical runs.

(3). Use a file created by MelMACCS when the basis of the cyclical input file is a varying source term created by the MELCOR modeling code.

The easiest way to determine the proper format of a cyclical input card is to run a simulation with the *MACCS Cyclical File Set* option in the *Project Properties* form, *Scope* tab, set to OFF. Open the MACCS input file (Atmos1.inp, Early1.inp, Chronc1.inp or Comida1.inp) in the project Input folder, and copy the relevant lines into the cyclical input file.

For example, to find the parameter PDELAY in the MACCS input file, as referenced in the WinMACCS interface, search for the string PDELAY in the Atmos1.txt file. This is first found in a comment immediately preceding the MACCS input lines responsible for setting the value of PDELAY, as shown in the following excerpt from atmosTemplate.txt:

```
* PDELAY, time of release for each plume from xxxx (sec)
RDPDELAY001        3700.
RDPDELAY002        10000.
```

These lines can be copied into a new cyclical input file created in Notepad or other basic text processor.

(1). The order of the lines is not important.

(2). Include all lines relevant to a variable. In the above example, when the second line is omitted, PDELAY is set to be a vector of length one.

(3). Blank lines are allowed.

(4). Cohort definitions are separated by a line containing a period in column one.

The following is a sample cyclical file. Notice that there are ATMOS, EARLY and CHRONC parameters in the first section. The second section, separated from the first section with a period in column one, contains values to define the second EARLY emergency cohort.

```
* CWASH1, Washout Coefficient Number One, Linear Factor
WDCWASH1001  9.7x10-5

* WTFRAC - weighting fraction applied to EARLY emergency response cohort one
EZWTFRAC001    .90

* EXPTIM - long term exposure period, CHRONC variable
CHEXPTIM001    9.7x108

* WTFRAC - weighting fraction applied to EARLY emergency response cohort two
EZWTFRAC001    .1
```

10. MACCS BINARY FILE FORMAT

10.1 Binary File Overview

With the development of WinMACCS, it became desirable to create a file to facilitate communication of results from the MACCS modeling engine to WinMACCS. The standard text output file created by MACCS is not an ideal basis for this communication. As a result, a structured, binary output file was created. Results in this file contain the full numerical precision of the MACCS calculations. When additional parameters are added to the file, WinMACCS does not have to be modified to display the new data.

The binary file supports multidimensional data. For example, Centerline Ground Concentration is associated with the plume number, a radionuclide, and a position on the spatial grid.

10.2 Multidimensional Data

Many of the MACCS data are multidimensional. Each result written to the binary file is associated with a set of qualifiers. Qualifier can have one of three data types, character, 4-byte integer, and 4-byte real. The qualifier "MACCS2_Input" is not an additional dimension to the variable but is used internally by WinMACCS to identify the input line associated with the result. The qualifier units for many of the results are specified in the MACCS input.

New qualifiers can be defined without modifications to WinMACCS. A list of the current qualifiers and the optional units are shown in Table 10-1.

Table 10-1 Qualifiers associated with variables.

Qualifier	Units	Data type	Example value
Nuclide	none	character	Co-60
Ldistance	km, mi	real	5.3
Rdistance	km, mi	real	6.5
Distance	km, mi	real	6.6
Plume	none	integer	3
Evacuation	none	integer	1
Health Effect	none	character	ERL INJ/PRODROMAL VOMIT
Exceeds Risk	none	real	5.6
Organ	none	character	A-LUNGS
Exceeds Dose	Sv, rem	real	5.2
Source Term	none	integer	1
Angle	none	character	ENE
Pathway	none	character	GRD
Elevation Dose	Sv, rem	real	10.
Elevation Concentrat	Bq/m^2, Ci/m^2	real	4.2
MACCS2_Input	none	not applicable	TYPE1OUT001 'ERL FAT/TOTAL' 1 26 NONE
Time	S	real	60
Industry Type	none	character	3 : Agriculture, forestry,

Qualifier	Units	Data type	Example value
GDP loss for Year #	none	Integer	1

10.3 Data in the Binary File

The results in the binary file are defined by input to MACCS. Output requests to MACCS are organized by an output type and details regarding the output request. For example, the following EARLY input card results in a type1 output request of the total early fatalities between spatial intervals 1 to 26.

```
TYPE1OUT001        'ERL FAT/TOTAL'    1        26       NONE
```

The number of results associated with this request is one, namely the number of total early fatality health effects.

The following describes the format of the binary file. Some results are available in units that depend on the ATMOS input.

The data for each of the results are the statistics shown in Table 10-2 and the CCDF of the data stored in a binned form, the same as in the MACCS output file.

Table 10-2 Statistics written to the binary file.

StatID	StatLab
1	Probability Non-zero
2	Mean
3	50th Quantile
4	90th Quantile
5	95th Quantile
6	99th Quantile
7	99.5th Quantile
8	Peak Concentration
9	Peak Probability
10	Peak Trial

The types of results are shown in Table 10-3.

Table 10-3 Binary file results records.

VarLab	Comments	Qualifiers	Units
Release	This output is always included. There are entries for each isotope (1 to NUMISO), for each plume release, and for each ATMOS change set (or source term)	Source Term Plume Nuclide	Bq, Ci

VarLab	Comments	Qualifiers	Units
Centerline Air Concentration	Type 0 output	Source Term Plume Nuclide Ldistance Rdistance MACCS_Input	Bq-s/m^3, Ci-s/m^3
Ground-Level Air Concentration	Type 0 output	Source Term Plume Nuclide Ldistance Rdistance MACCS_Input	Bq-s/m^3, Ci-s/m^3
Centerline Ground Concentration	Type 0 output	Source Term Plume Nuclide Ldistance Rdistance MACCS_Input	Bq/m^2, Ci/m^2
Total Centerline Ground Concentration	Type 0 output	Source Term Plume Nuclide Ldistance Rdistance MACCS_Input	Bq/m^2, Ci/m^2
Ground-Level Chi/Q	Type 0 output	Source Term Plume Nuclide Ldistance Rdistance MACCS_Input	s/m^3
Adjusted Source Strength	Type 0 output	Source Term Plume Nuclide Ldistance Rdistance MACCS_Input	Bq, Ci
Plume Crosswind Dispersion	Type 0 output	Source Term Plume Nuclide Ldistance Rdistance MACCS_Input	m
Plume Vertical Dispersion	Type 0 output	Source Term Plume Nuclide Ldistance Rdistance MACCS_Input	m

VarLab	Comments	Qualifiers	Units
Plume Centerline Height	Type 0 output	Source Term Plume Nuclide Ldistance Rdistance MACCS_Input	m
Plume Arrival Time	Type 0 output	Source Term Plume Nuclide Ldistance Rdistance MACCS_Input	s
Health-Effect Cases	Type 1 output	Source Term Evacuation Health Effect Ldistance Rdistance MACCS_Input	none
Health Effects LNT Adjusted Population Dose	Type 1 output Note: This output is only printed when the Threshold or Piecewise model is used	Source Term Evacuation Health Effect Ldistance Rdistance Organ MACCS_Input	Sv, rem
Health Effects Used Adjusted Population Dose	Type1 output Note: This output is only printed when the Threshold or Piecewise model is used	Source Term Evacuation Health Effect Ldistance Rdistance Organ MACCS_Input	Sv, rem
Early Fatality Radius	Type 2 output	Source Term Evacuation Exceeds Risk MACCS_Input	km, mi
Population Exceeding Threshold	Type 3 output	Source Term Evacuation Organ Exceeds Dose MACCS_Input	none
Average Individual Risk	Type 4 output	Source Term Evacuation Health Effect Ldistance Rdistance MACCS_Input	none

VarLab	Comments	Qualifiers	Units
Population Dose	Type 5 output	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	Sv, rem
Centerline Dose	Type 6 output	Source Term Evacuation Organ Pathway Ldistance Rdistance MACCS_Input	Sv, rem
Centerline Risk	Type 7 output	Source Term Evacuation Health Effect Ldistance Rdistance MACCS_Input	none
Population-Weighted Risk	Type 8 output	Source Term Evacuation Health Effect Ldistance Rdistance MACCS_Input	none
Peak dose	Type A output	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	Sv, rem
Peak dose Polar	Type B results	Source Term Evacuation Organ Ldistance Rdistance Angle MACCS_Input	Sv, rem
Dose by Grid Element	Type C results	Source Term Evacuation Organ Angle Ldistance Rdistance MACCS_Input	Sv, rem

VarLab	Comments	Qualifiers	Units
Area that Exceeds Dose Threshold	Type C results	Source Term Evacuation Elevation Dose Organ Ldistance Rdistance MACCS_Input	Ha, km^2, mi^2
Ground Concentration by Grid Element	Type D output	Source Term Evacuation Nuclide Angle Ldistance Rdistance MACCS_Input	Bq/m^2
Area That Exceeds Concentration Threshold	Type D output	Source Term Evacuation Elevation Concentration Nuclide Ldistance Rdistance MACCS_Input	Ha
Air Concentration by Grid Element	Type D output	Source Term Evacuation Nuclide Angle Ldistance Rdistance MACCS_Input	$Bq\text{-}s/m^3$
Population Movement	Type E output	Source Term Evacuation Distance Time MACCS2_Input	Fraction of Cohort
Tot Long-Term Pathways Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Tot Long-Term Direct Exposure Pathways	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv

VarLab	Comments	Qualifiers	Units
Tot Ingestion Pathways Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Long-Term Groundshine Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Long-Term Resuspension Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Population Dependent Decontamination Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Farm Dependent Decontamination Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Water Ingestion Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Milk Growing Season Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Crop Growing Season Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv

VarLab	Comments	Qualifiers	Units
Milk Long-Term Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Crop Long-Term Dose	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Ingestion of Grains	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Ingestion of Leafy Vegetables	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Ingestion of Root Crops	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Ingestion of Fruits	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Ingestion of Legumes	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Ingestion of Beef	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv

VarLab	Comments	Qualifiers	Units
Ingestion of Milk	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Ingestion of Poultry	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Ingestion of Other Meat Crops	Type 9 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	person-Sv
Total Economic Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Pop Dependent Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Farm Dependent Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Pop Dependent Decontamination Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Farm Dependent Decontamination Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Pop Dependent Interdiction Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$

VarLab	Comments	Qualifiers	Units
Farm Dependent Interdiction Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Pop Dependent Condemnation Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Farm Dependent Condemnation Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Emergency Phase Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Intermediate Phase Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Milk Disposal Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Crop Disposal Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
National GDP Losses for Year	Type 10 results	Source Term Evacuation Ldistance Rdistance GDP loss for Year # MACCS_Input	$
Direct GDP Losses for Year	Type 10 results	Source Term Evacuation Ldistance Rdistance GDP loss for Year # MACCS_Input	$

VarLab	Comments	Qualifiers	Units
TOTAL LOSSES	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
TOTAL NATIONAL GDP LOSSES	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
ALL DIRECT INDUSTRIES GDP LOSSES	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Direct Industry GDP Losses	Type 10 results	Source Term Evacuation Ldistance Rdistance Industry Type MACCS_Input	$
ALL INDIRECT INDUSTRIES GDP LOSSES	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Indirect Industry GDP Losses	Type 10 results	Source Term Evacuation Ldistance Rdistance Industry Type MACCS_Input	$
ALL INDUCED INDUSTRIES GDP LOSSES	Type 10 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	$
Induced Industry GDP Losses	Type 10 results	Source Term Evacuation Ldistance Rdistance Industry Type MACCS_Input	$

VarLab	Comments	Qualifiers	Units
Farm Dependent Loss Of Use Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance Industry Type MACCS_Input	$
Pop Dependent Depreciation Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance Industry Type MACCS_Input	$
Farm Dependent Depreciation Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance Industry Type MACCS_Input	$
Long-Term Phase Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance Industry Type MACCS_Input	$
Pop Dependent Loss Of Use Costs	Type 10 results	Source Term Evacuation Ldistance Rdistance Industry Type MACCS_Input	$
Farm Dependent Decontamination Distance	Type 11 results	Source Term Evacuation MACCS_Input	km
Pop Dependent Decontamination Distance	Type 11 results	Source Term Evacuation MACCS_Input	km
Farm Dependent Interdiction Distance	Type 11 results	Source Term Evacuation MACCS_Input	km
Pop Dependent Interdiction Distance	Type 11 results	Source Term Evacuation MACCS_Input	km
Farm Dependent Condemnation Distance	Type 11 results	Source Term Evacuation MACCS_Input	km

VarLab	Comments	Qualifiers	Units
Pop Dependent Condemnation Distance	Type 11 results	Source Term Evacuation MACCS_Input	km
Milk Disposal Distance	Type 11 results	Source Term Evacuation MACCS_Input	km
Crop Disposal Distance	Type 11 results	Source Term Evacuation MACCS_Input	km
Farm Decontamination	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	ha
Pop Decontamination	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	individuals
Pop Decontamination Area	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	ha
Farm Interdiction	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	ha
Pop Interdiction	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	individuals
Pop Interdiction Area	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	ha
Farm Condemnation	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	ha

VarLab	Comments	Qualifiers	Units
Pop Condemnation	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	individuals
Pop Condemnation Area	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	ha
Milk Disposal Area	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	ha
Crop Disposal Area	Type 12 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	ha
Maximum Annual Food Dose	Type 13 results	Source Term Evacuation Organ Ldistance Rdistance MACCS_Input	Sv
Emergency Phase Reloc No Plume Affect	Type 14 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	none
Emergency Phase Reloc Plume Affected	Type 14 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	None
Normal Emergency Phase Relocation	Type 14 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	None
Hotspot Emergency Phase Relocation	Type 14 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	None

VarLab	Comments	Qualifiers	Units
Intermediate Phase Relocation	Type 14 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	None
Level 1 Decontamination Relocation	Type 14 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	None
Level 2 Decontamination Relocation	Type 14 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	None
Level 3 Decontamination Relocation	Type 14 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	None
Decontamination +Interdiction Relocation	Type 14 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	None
Condemnation Relocation	Type 14 results	Source Term Evacuation Ldistance Rdistance MACCS_Input	None

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