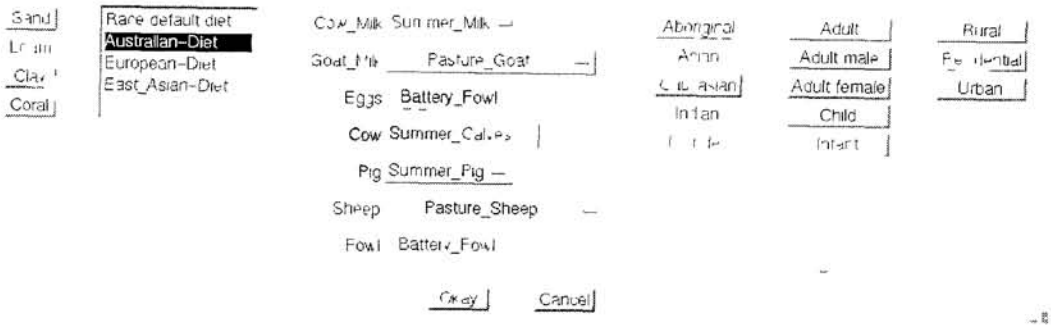
ANSTO M-128

RadCon: A Radiological Consequences Model



User Guide
Version 2.0

J. Crawford
R.U. Domel

Prepared within the Radiological Consequences Project
May 2000

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Australian Nuclear Science and Technology Organisation

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1 Introduction

RadCon is a flexible and user friendly Radiological Consequences model. It has been designed and implemented at ANSTO with focus on its use in the Australian and South East Asian region. Given that there is a large variability in the region, emphasis was given to the ability of the implementation to handle the variability of such factors as diets and lifestyle of the population and the various food crops being produced. Java was chosen as the language of implementation, as portability across computer platforms was required as well as the use of graphical user interfaces.

RadCon estimates the dose received by user selected groups in the population from an accidental release of radionuclides to the environment. The exposure pathways considered are external exposure from the cloud and ground and internal exposure from inhalation and ingestion of contaminated food. Atmospheric dispersion modelling is carried out externally to RadCon. RadCon accepts as input time varying air concentration and ground deposition and calculates exposure to humans, using the pathways as depicted in Figure 1.

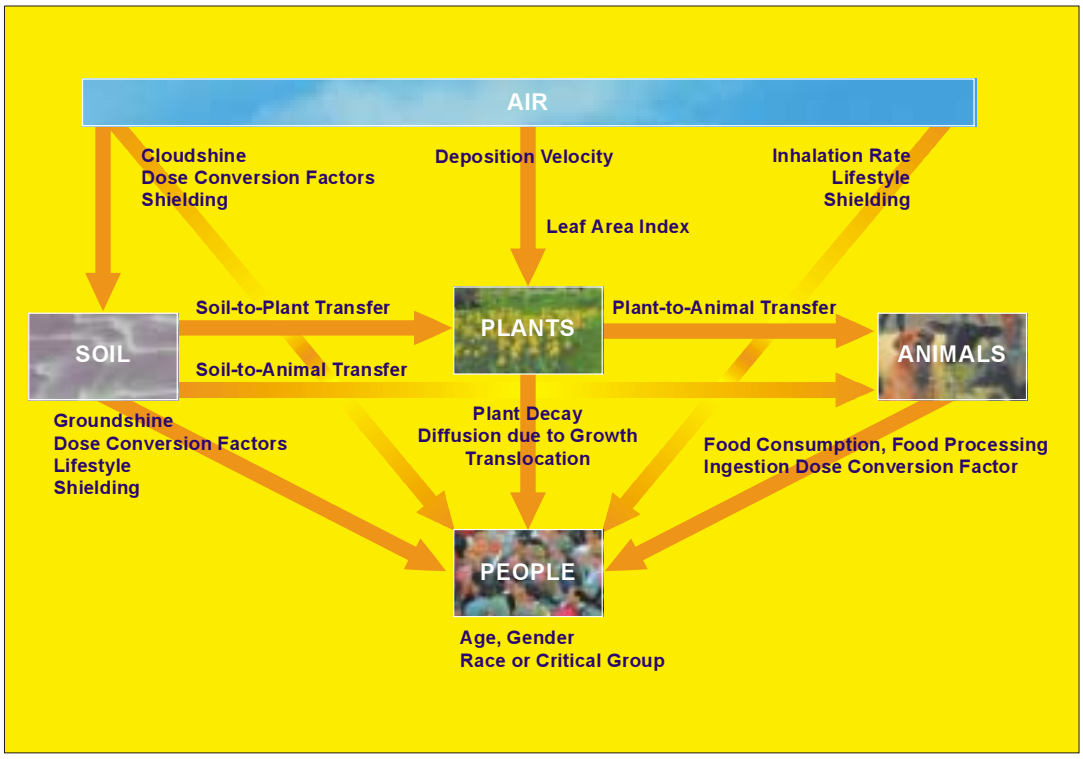


Figure 1: RadCon Exposure Pathways and some required data.

The air and ground concentrations may be generated by an atmospheric transport code (the HYSPLIT model developed by the Bureau of Meteorology, BoM, was used in Figure 2, as this was the atmospheric transport model used in the development stages of RadCon) or actual measured concentrations can be used. The mathematical models and assumptions used by RadCon are described in the technical guide [2].

Given a two dimensional time varying air and ground concentration of radioactive elements, RadCon allows the user to:

- view the air and ground concentration over the affected area,
- select optional parameters and calculate the dose to people,
- display the results to the user, and
- change the parameter values, [3, 4, 5].

The main components of RadCon are shown in Figure 2. RadCon offers two user interfaces:

- the standard graphical user interface which is started using
  - *java DoseApp* at the command line, or
  - by setting up a shortcut to this command (particularly when RadCon is installed on a PC)
- the text based interface used to generate information for the model inter-comparison exercise [1]. This is initiated using *java BIOMASS* at the command line, or an equivalent shortcut. The text based interface was developed for research purposes and is not generally available.

Appendices A, B and C provide a summary of instructions on setting up RadCon. This will generally be carried out by your computer support personnel.

To use the standard graphical user interface the following is required:

- The files containing the time varying air and ground concentration, which would typically be generated using a pre-processor to generate the appropriate format, see Appendix D for the information contained in these files.
- An image containing the background map (see Appendix E).
- The required parameters, [2, 4 and 5]. Appendix F provides a summary of the way the parameters are grouped into the data files that RadCon reads. Appendix G has a description of the format of these files and an example data file is given in Appendix H. For the text-based interface, only the parameter files are required. The text based interface was developed for research purposes and is not generally available.

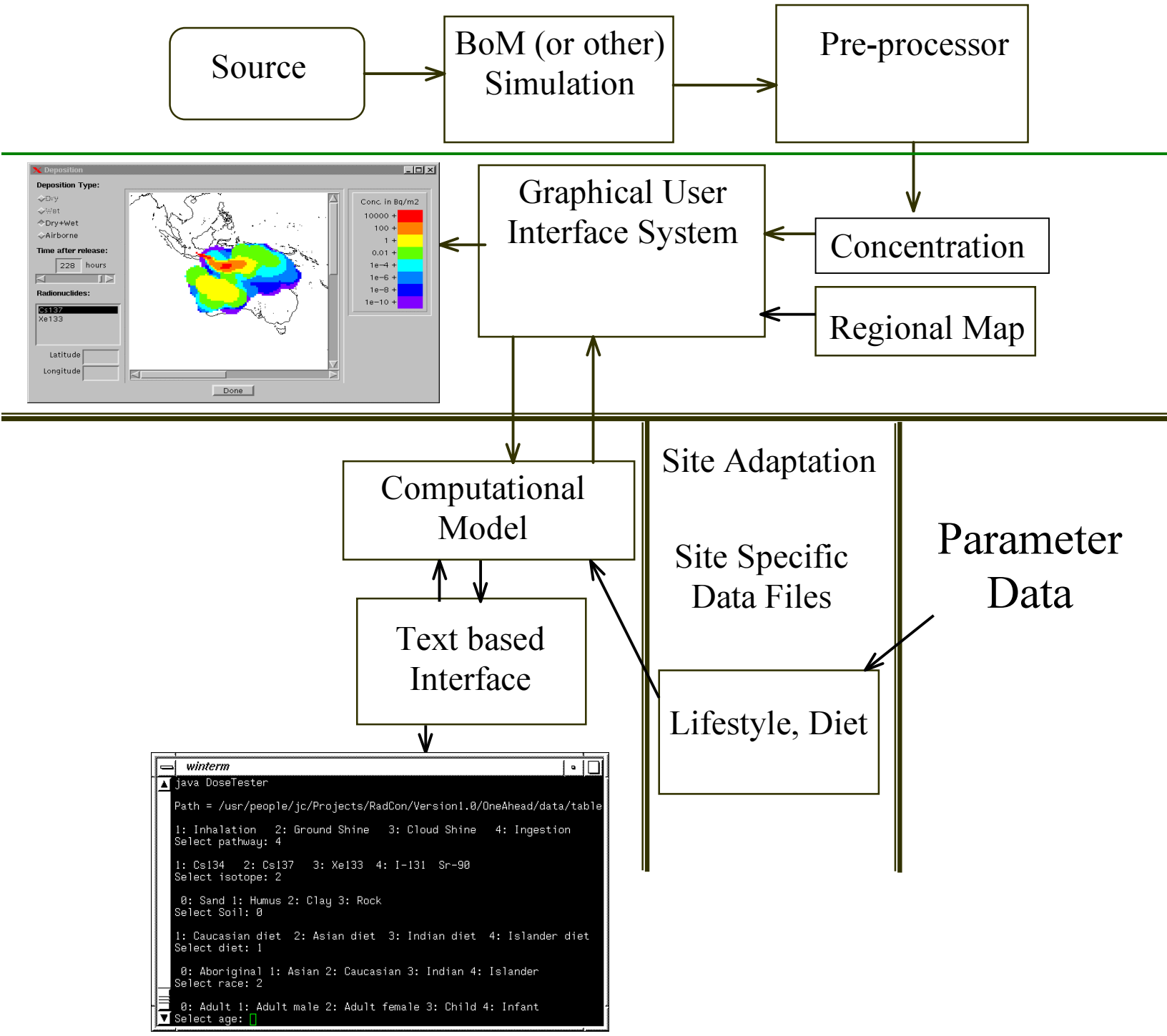


Figure 2: RadCon main components.

2 RadCon Data Needs - Summary

RadCon needs four main groups of input:

1. Two dimensional time varying ground deposition and air concentration for each of the radionuclides to be studied . A pre-processor has been written to extract the required information from the Bureau of Meteorology's HYSPLIT model. See Appendix D for a description of the content and format of the data files. In addition, the location and dimension of the region of the simulation may be extracted from the HYSPLIT model or alternatively may be added separately.
2. An image of the region, e.g. a map, is required for visualisation purposes. The dose is calculated for the affected region, which is then displayed superimposed on the map so that the user can easily identify affected regions. The map should be in *GIF* format, with the image size being an integer multiple of the dimension of the simulation region. See Appendix E for the spatial dimension of simulation.
3. A set of tables containing information on human diet, animal diet, transfer rates, dose conversion rates, *etc* [4, 5, 6]. A description of the data files can be found in Appendix F.
4. User defined scenarios. In order to compute dose effects to humans, the user needs to specify which pathways to consider and which data/parameters to use. Further, each pathway has a number of parameters with alternative options. The user needs to set the options before the calculation can proceed. A scenario is set up by selecting the pathways to be considered in a calculation and selected options for the parameters. A facility has been provided within RadCon to allow the user to set up scenarios over the two dimensional region of interest. Scenarios can be set up and saved to disk for subsequent use – see section 10, Edit Pathways. RadCon also uses a data editor to change the data/parameters and create new scenarios [3].

By default Version 2.0 of RadCon expects to find the data files to be used in the run in a subdirectory called *data*, located in the current working directory. Within *data*, a number of sub-directories are expected:

- *bom*, which contains the ground deposition and air concentration data. This directory itself has a number of subdirectories, each of which contains all the required information of a separate simulation carried out using an atmospheric dispersion model. The format of the files is given in Appendix D. When RadCon is started, these are the files that are presented as alternatives to the user, see Figure 3. You can select an alternative by pointing and clicking on the required option.
- *tables,* which contains the required parameter values, *e.g.* dose conversion, diet, transfer factors, *etc*. The data in these files is required for the calculation of dose to humans. The data included in these files is described in Appendix F and the format of the files is included in Appendix G, with sample data files included in Appendix H. The location of the data files can be changed to a location other than the default location, using RadCon '*Select data file directory*' option, see section 7.5.

- *user/scenarios,* where scenarios can be saved and loaded by the user from this directory. Although this is the default directory for scenario storage, user defined scenarios can be saved and loaded from any directory which can be accessed by the user, using a file dialogue as shown in Figure 5.
- *user/doses,* any calculation can be saved for future viewing, using the *ViewDoses* utility, see section 13.2.

3 Preparation

Before you can use RadCon you will need to set up:

- The data files using RadConEd, [3] or a system editor. If using a system editor you have to ensure that the format is adhered to, see Appendix G.
- The files containing the time varying ground and air concentrations. The format of these files is given in Appendix D.

4 Starting RadCon

RadCon can be started by:

1. Changing to the directory where the program is stored and typing, *java DoseApp,* or equivalently using a pre-set script *RadCon.* In either case the subdirectory *data* needs to reside in the working directory.
2. Initiate execution of RadCon by typing *RadCon* if a script has been set up. An example script for a Unix system could be:

```
#! /bin/sh
CLASSPATH=<location of class files>
export CLASSPATH
java –jit DoseApp
```

   See your computer support personnel for an appropriate script for your system.

3. On PC's a short cut could be set up to execute *java DoseApp* in the selected working directory. Double clicking on this shortcut will start-up RadCon.

5 Main Panel

When RadCon is started, the panel in Figure 3 is presented to the user. The user can then select the concentration files to be loaded and run.

First, select a deposit choice by clicking on the selection. This will activate the *Load Deposit* and the *Use Deposit* buttons.

Then, the *Load Deposit* button is clicked if the deposit is to be loaded, which is required for calculations to be carried out. The *Use Deposit* button is selected only if the dimensions need to be determined, for applications such as setting up and viewing scenarios.

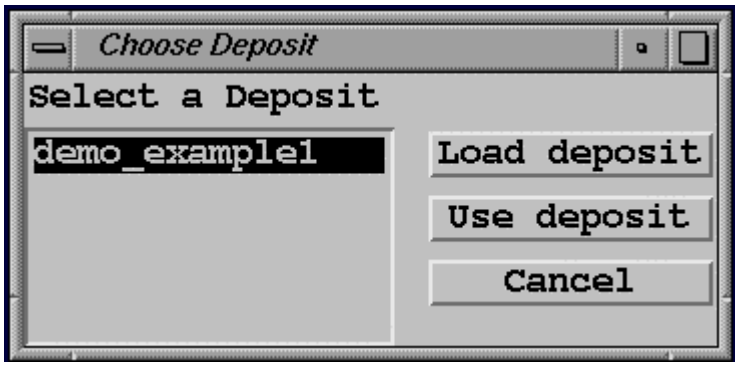


Figure 3: Selecting Files.

Select the required Deposit option by pointing and clicking on:

- ***`Load deposit' if you would like to view the deposit and perform dose calculations and set up scenarios.***
- ***`Use deposit' if you would like to setup scenarios only. This option bypasses the loading of the data files, thus improving the response time, if you only wish to set up scenarios for subsequent runs.***

If *Use Deposit* was chosen during the selection of the files, the *Calculate* and *View Deposits,* (see Figure 4) buttons will not be active, thus allowing the user to initiate *Edit Pathways* only. If *Load deposit* is chosen the deposit and air concentration information is loaded and is available for the user to view as well as calculating dose.

When the required concentration files are selected, the panel in Figure 4 is presented to the user. The user can then initiate other modules by selecting the appropriate option. This panel has been named the main panel and is a stand alone panel as well as being incorporated into subsequent panels, see Figure 13 and Figure 9.

Figure 4: Main Panel.

There are three main functions that can be initiated from this menu:

1. *Edit Pathways* allows the variation of some set scenarios. In order to carry out any dose calculations the user needs to define the pathways to be included in the calculation, as well as set optional parameters.
2. *Calculate*, where calculation of dose to humans is carried out.
3. *View Deposits* allows the user to view the time varying air and ground concentrations.

In addition, the *File* menu option is used to load and save scenarios and to allow the loading of new concentration files by re-displaying the panel shown in Figure 3.

6 The *File* menu option on the Main Panel

Three functions are available under the *File* menu option:

- Load Scenario
- Save Scenario
- Load Deposit

On selecting the *File* menu option with the left button, a drop down window appears with the above three options. Selecting *Load Deposit* causes the panel in Figure 3 to be displayed, allowing the user to select new deposit information.

Selecting *Save* or *Load Scenario* presents the file dialogue, shown in Figure 5, which can be used for storing or retrieving a scenario respectively. By default it assumes you will be loading or saving to the preferred directory *data/user/scenarios*. However using the file dialogue screen, you can navigate through your directory structure to choose the appropriate file location.

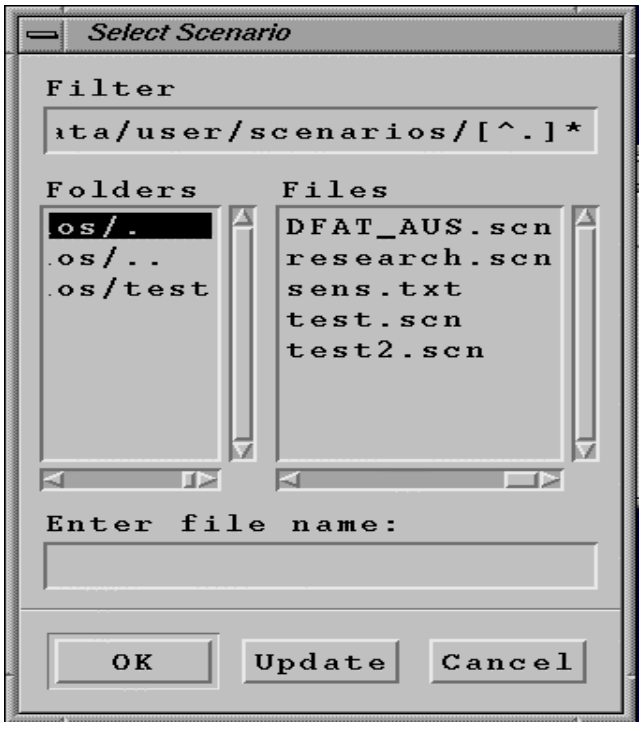


Figure 5: Loading and Saving Files.

7 The Set menu option (Figure 4)

Five functions are available under the *Set* menu option:

- Maximum Years
- Average Rainfall
- Legend
- Sensitivity Parameters
- Select Data Files Directory

On selecting the *Set* menu option with the left mouse button, the above five options appear in a drop down window. Each of these is described in the subsequent sections.

7.1 *Maximum Years - Setting Maximum Number of Years for Calculation*

For long term calculations *i.e.* ingestion and exposure from the ground, the number of years for which the calculations are to be carried out can be set using this option. On selection the option shown in Figure 6 will be displayed. The user can set the number of years for which they would like their calculation to be carried out by setting the value in the box, which is set to 5 in Figure 6. Selecting the *Use* button tells the system to use the new value, whereas selecting the *Cancel* button will result in the system reverting to the previously set value.

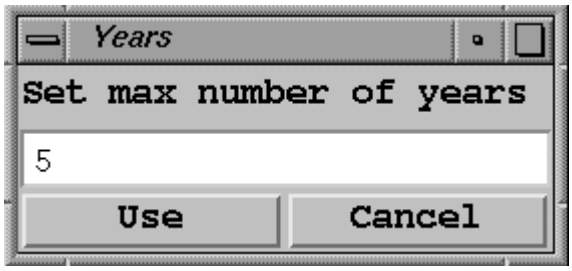


Figure 6: Setting the maximum number of years.

7.2 *Setting Average Rainfall*

The average rainfall is used in calculating the interception by plants. In Version 2.0 of RadCon this is a constant value over the region. This may be re-considered for later versions. On selecting the *Average Rainfall* option from the *Set* menu option, the screen shown in Figure 7 is presented to the user. The user can then set the rainfall by altering the value, which is 0.0 in Figure 7, followed by selecting the *Use* button. At any time the *Cancel* button can be selected to revert to the previously set value.

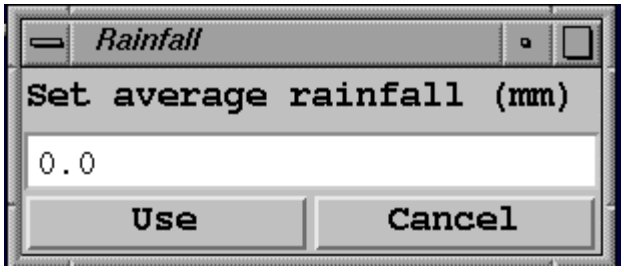


Figure 7: Setting Rainfall.

7.3 *Legend - Setting the Legend and Display Ranges*

RadCon has the ability to display outputs either in colour or grey scale. In addition the levels used for colour coding of concentrations and dose and the associated legend can be altered. This is achieved by using the *Legend* option under the *Set* menu option. On selecting this option the screen in Figure 8 is shown. The options to be set here are as follows:

- *Use colour for Concentration*: a radio button, which if selected will use colour for displaying of the radionuclide concentrations. By default this option is selected. To change to grey scale the user de-selects the button by pointing and clicking with the mouse.
- *Use colour for Sensitivity*: a radio button, which if selected will use colour for displaying of the sensitivity information. By default this option is selected. To change to grey scale the user de-selects the button by pointing and clicking with the mouse.
- *Use colour for Dose*: a radio button, which if selected will use colour for displaying of the calculated dose. By default this option is selected. To change to grey scale the user de-selects the button by pointing and clicking with the mouse.
- *Set Legend Size:* A value is entered in the text box indicating the number of levels to be used in displaying the output, for example in Figure 12, 8 levels are used to display the concentrations and in Figure 19, 7 levels are used to display the calculated dose.
- The buttons:
  - *Concentration*: on selecting this button the screen for setting the levels and associated labels for use in the displaying of the concentration is presented to the user.
  - *Dose*: on selecting this button the screen for setting the levels and associated labels for use in the displaying of the calculated dose is presented to the user.
  - *Sensitivity*: on selecting this button the screen for setting the levels and associated labels for use in the displaying of the calculated sensitivity values with each parameter is presented to the user.
- *Close*: the close button can be used at any time to exit the screen.

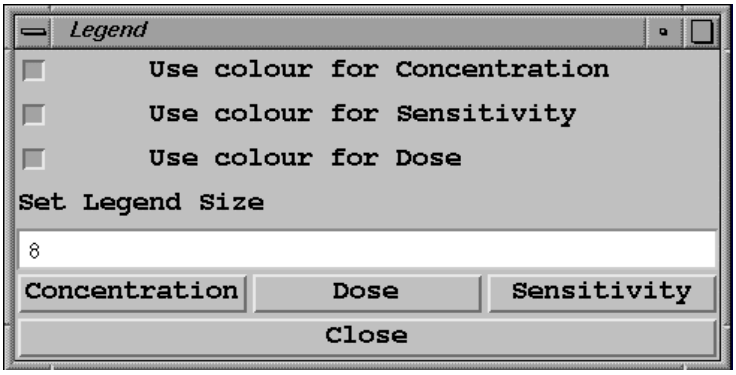


Figure 8: Legend Option.

To alter the legend itself the following steps need to be taken:

- set the number of levels to be used, for example in Figure 8 change the value 8 to the required value, followed by
- selecting which screen the levels are to be set for, *i.e. Concentration*, *Dose* or *Sensitivity*, by clicking on the button labelled appropriately.

On selecting the appropriate option, the screen in Figure 9 will appear. The levels to be used in displaying values and the corresponding labels can be altered here. **Note:** The values must be in descending order. The *Use* button tells the system to use the new information whereas cancel will revert to the previously set values and labels. **Note:** that in Figure 9, the title of the frame is set to *Set Legend for Concentration*. The word *Concentration* will be changed to *Dose* or *Sensitivity* depending on which button was selected in Figure 8.

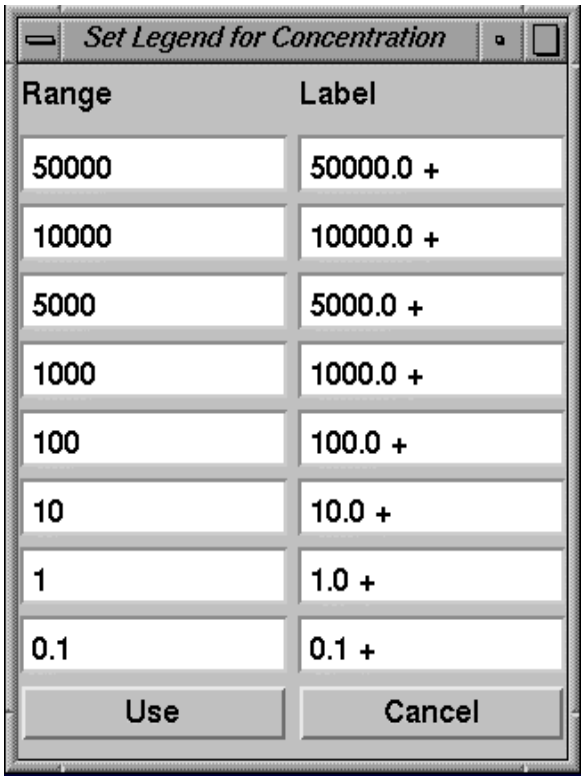


Figure 9: Setting the levels and labels.

7.4 *Setting Sensitivity Parameters*

RadCon implements two techniques for sensitivity analysis [2]. An alternative can be selected by using the *Sensitivity Parameters* option, under the *Set* menu option. On selecting the *Sensitivity Parameters* option, the screen shown in Figure 10 will be displayed. The options on this screen are as follows:

- *Unit Deposit*: use unit deposit over the entire region while calculating the sensitivity. By default this button is not set and as such the actual concentration over the region is used. If the button is set, by pointing and clicking on it, a unit value will be used in calculation the sensitivity in dose from perturbation to each of the model parameters.
- *Fraction of Mean*: if this option is set the technique which uses a fraction of the mean will be used.
- *Change Factor*: is the factor used in determining the perturbation amount of each parameter in the sensitivity analysis.
- *Use*: tells the system to accept the newly set factor.
- *Cancel*: tells the system to ignore the newly set factor.

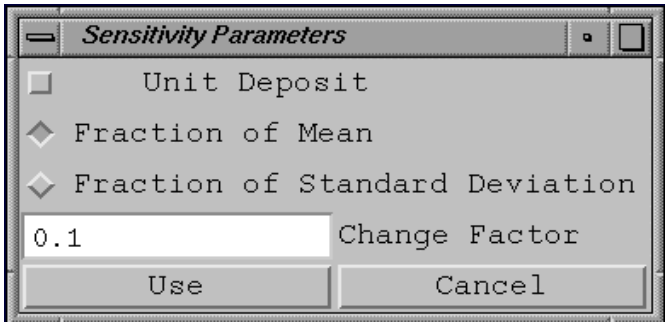


Figure 10: Setting sensitivity options.

7.5 *Selecting the Data files directory*

By default RadCon expects to find the values for the parameters in the directory *data/tables* from within the working directory. The location of these files can be altered by selecting the '*Select Data Files Directory'* option from the *Set* menu option. On selecting this option the screen in Figure 11 will be presented to the user. The user can then navigate their file system and select the appropriate directory from which RadCon is to read the parameter data files described in Appendix F.

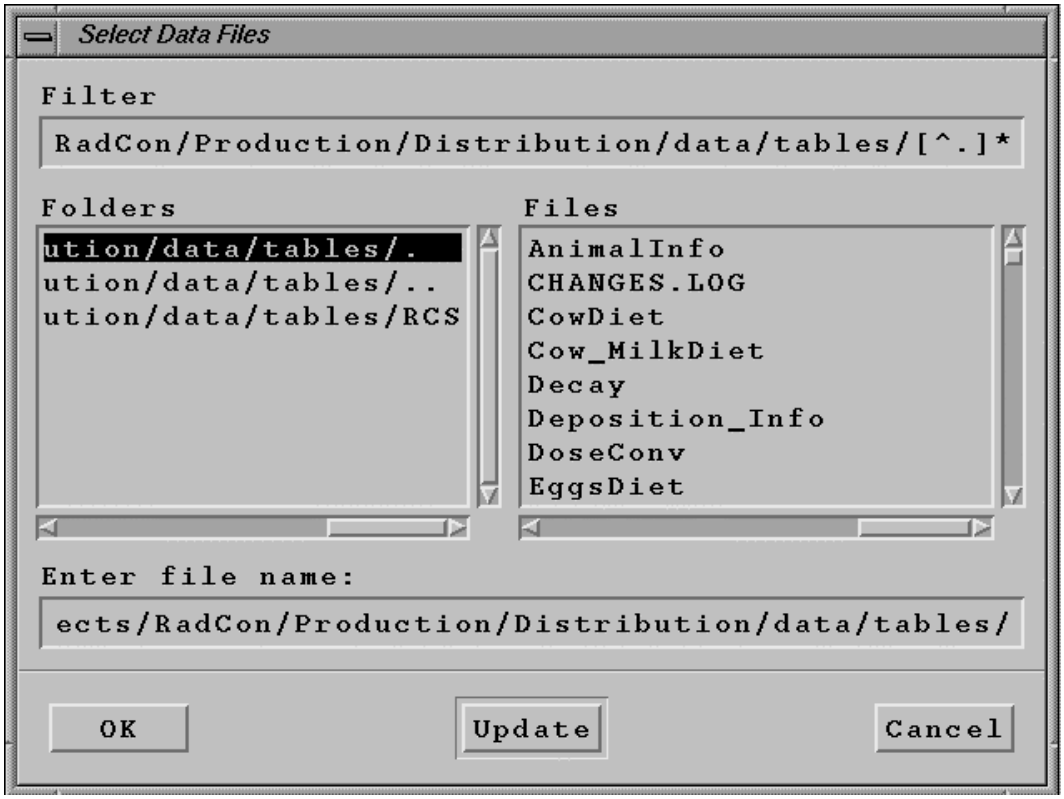


Figure 11: Setting the directory for the parameter files.

8 Report Menu Option on the Main Panel (Figure 4)

On selecting the *Report* menu option, the *Dose Dump* drop down option appears. This option can be selected for saving a calculation that has just been performed. On selecting *Dose Dump* a file dialogue appears, similar to that in Figure 11. The file name in which the doses are to be stored should be set here. The default directory is set to *data/user/doses* from the working directory. To later view the doses see Section 13.2.

9 Viewing the Deposits

The *View Deposits* module enables the user to graphically view the ground deposition and airborne concentration of the various radionuclides over the region of interest. Figure 12 shows the panel presented to the user on the selection of the *View Deposits* option.

In order for the user to get a better perspective of regions impacted by a release, a map of the region is used as a background on which the deposition is superimposed for displaying to the user. For the current version of the implementation the map of the region is generated separately and is made available for the application.

The information that is available for viewing is spatial (latitude, longitude) and time dependent. Ground deposition is available as well as the airborne concentration for a number of radionuclides.

To allow for the selection of what is to be displayed on the screen, the following options are available:

- Selection of deposition (wet, dry, wet+dry) or airborne concentration by choosing the corresponding radio button.
- Selection of which radionuclide concentrations to view, by selecting from the list of elements.
- Selection of time step by using the scroll bar.

The selected concentration is then displayed and overlaid on the map of the region. A legend is provided on the right hand side and latitude and longitude positions of the curser as the user moves it across the display area are displayed in the boxes in the bottom left hand corner.

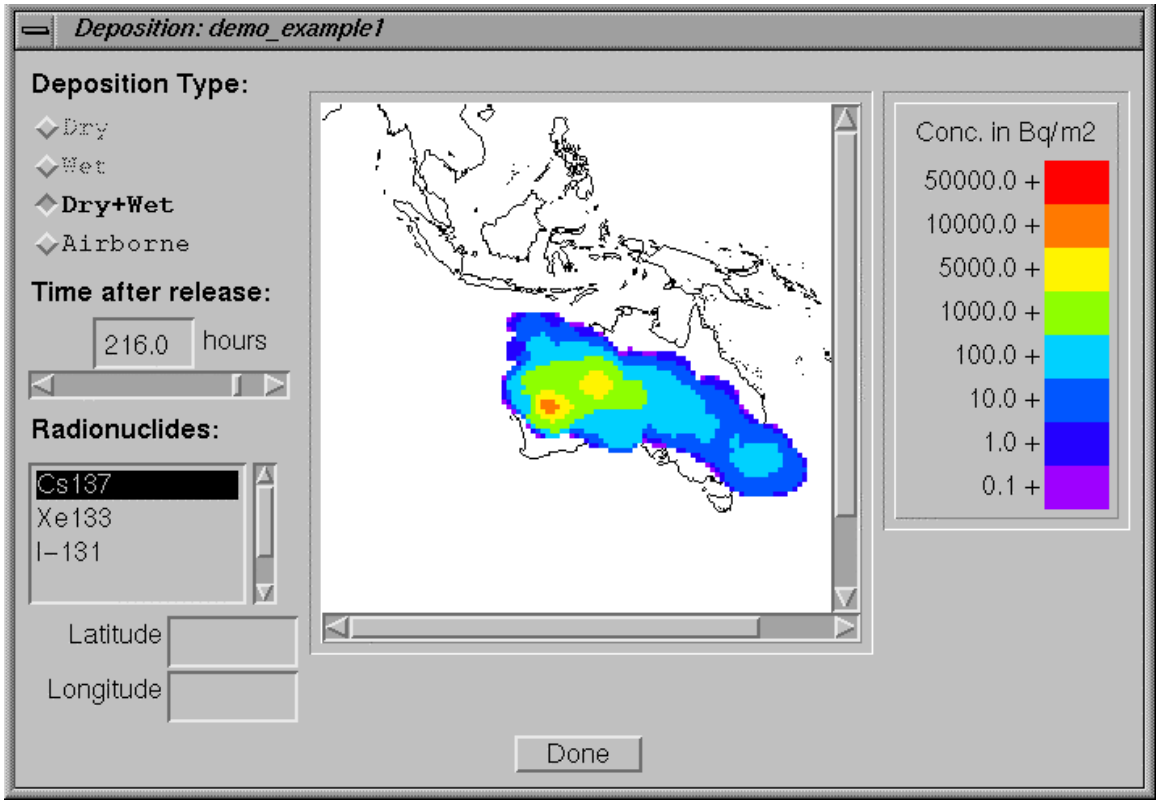


Figure 12: ViewDeposit Panel.

10 Edit Pathways

In order to estimate the dose to a critical or target group, the pathways to be considered and the parameters for these pathways need to be selected, forming a major scenario. The pathways for which the dose is to be calculated are selected as described in section 11. In order to carry out the calculation, the options over the selected region need to be set, ie if the dose from the inhalation pathway is to be calculated the parameters for the inhalation pathway need to be set as shown in section 10.2, for the ingestion pathway the parameters are set as in section 10.3. These major scenarios are established by the data

files and minor scenario variations or options may be selected in the *Edit Pathways Panel*, as shown in Figure 13. Here the user can select smaller sub regions within the major region of interest and set the pathways for each of the selected smaller sub regions. A single sub region can be selected by using the left mouse button, *i.e*. by positioning on the chosen area and expanding a rectangle. Multiple sub regions can be selected by following the same actions, but using the right mouse button.

The pathways are set by selecting from the list of pathways shown in the box labelled *Select a pathway*. When the required pathway has been selected a panel, for setting parameter variations within a scenario and specific to that pathway, is displayed. These are described in subsequent sections.

The setting of the parameters can be viewed by choosing from a box containing 12 parameters (labelled *Age* in Figure 13). On selecting this option a list of the parameters will appear (*e.g. race, age*, *lifestyle, soil, diet, cow, pig, sheep, fowl, cow_milk*, *goat_milk, eggs*), from which the user can select the parameter for which he/she would like the setting displayed on the map.

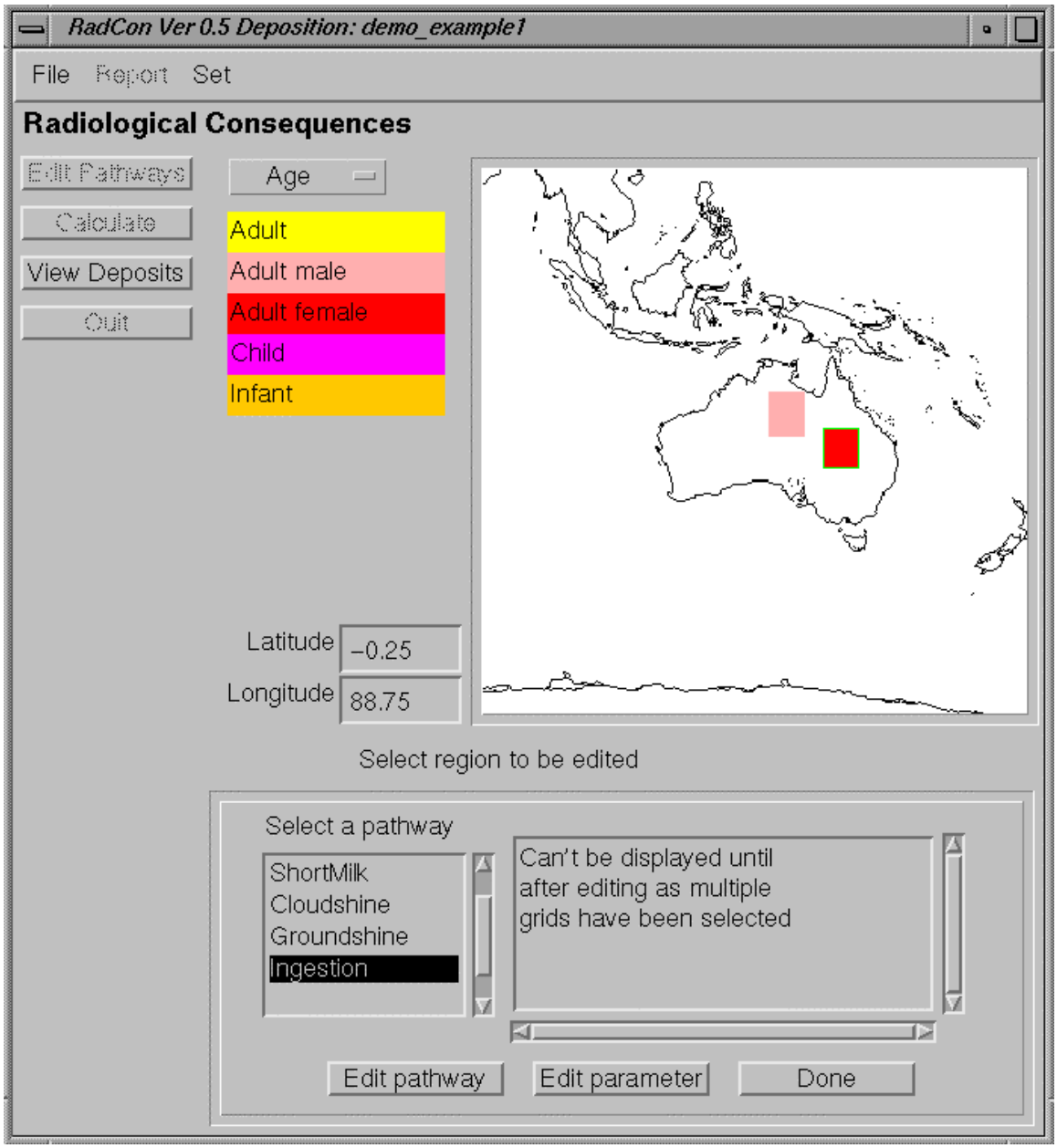


Figure 13: Setting up Scenarios.

When more than five alternatives are available, for example for animal diet, a list, as shown in Figure 14, appears. Two colours are used to display the set choices over the region. On selecting an option from the list one colour is used to represents the regions where the selected option is set and a second colour is used to represent the other selected region with options not in the immediately selected set.

Once the parameter variations within a scenario are set, it can be saved to a file for later use, as described in Section 6.

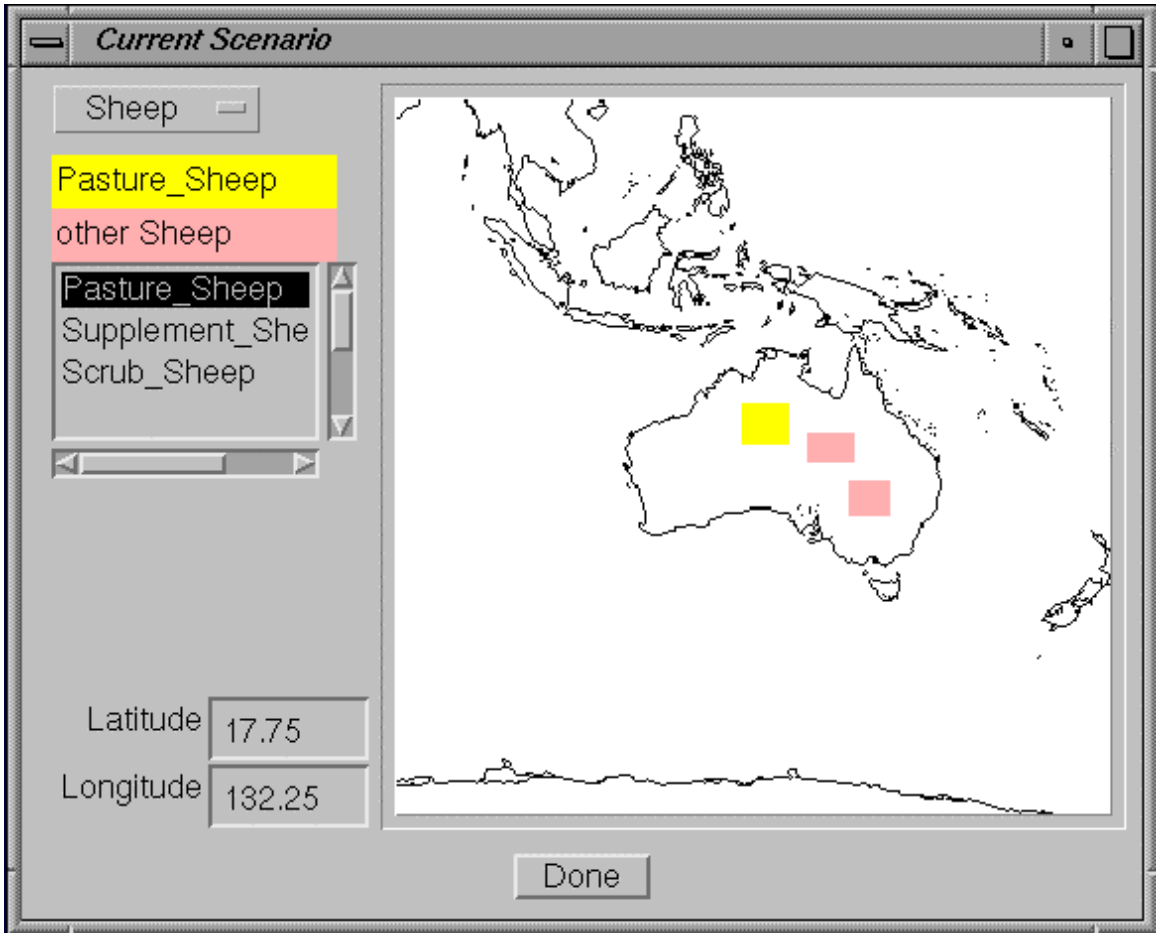


Figure 14: Viewing parameter setting.

An alternate method of setting the parameter variations within a scenario is to use the *Edit Parameter* option. On selecting this option a panel of the form shown in Figure 15 is displayed to the user. The user can then select the appropriate option.

Figure 15: Edit Parameter Panel.

10.1 *User Interface for Ground Shine*

To set the parameters for the ground shine module for a particular scenario, select Groundshine in the *Select a pathway* box (Figure 13) and click on it, then press the *Edit pathway* button and the following panel is presented to the user.

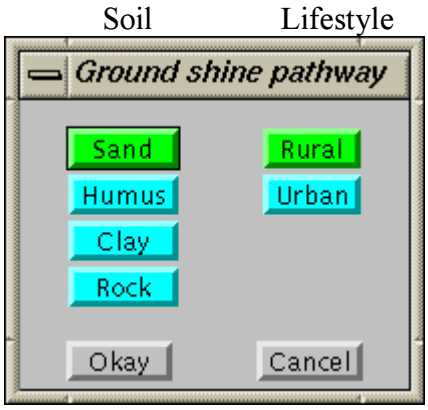


Figure 16: Ground Shine Panel.

The user then selects the required alternatives by using the mouse to point and click on the required button. If a parameter has already been set either via previous selection of this pathway or via one of the other pathways the user is asked if she/he wishes to override the setting. A pop-up panel will appear, to which the user can respond appropriately.

10.2 *User Interface for Inhalation*

As for section 10.1 and selecting the Inhalation pathway, the following panel, Figure 17, is presented to the user to select options for the Inhalation Module. Once again the options are selected by pointing and clicking. When the user is happy with the selected options, *Okay* can be selected, which accepts the options and clears the panel. *Cancel* can be used to ignore the selections and return to the pathway selection panel.

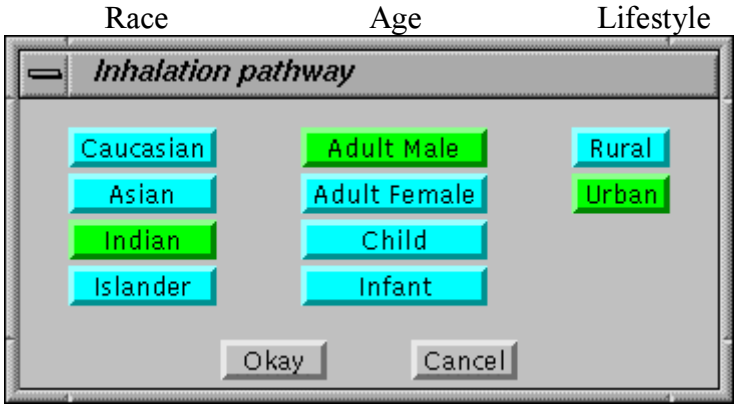


Figure 17: Inhalation User Interface.

10.3 *User Interface for Ingestion*

As for section 10.1 and selecting the Ingestion pathway, the following panel, Figure 18, is presented to the user to select options for the Ingestion Module. Once again the options are selected by pointing and clicking. The diet to be considered for the calculation is selected from the list provided. The diet can be race specific, *i.e.* default diets have been pre-defined for each of the races, or a user defined diet can be selected. The user specific diets are set-up by the user in the files in the *tables* directory (see section 3). For RadCon version 2 a number of `user' defined diets have been set-up, but you will not be able to define additional diet types using RadConEd version 1. Any system editor will allow this change to be made and reflected back in this panel – see Appendix I. The default diet for the selected race can be chosen by selecting the *Race default diet*. Variations for the following parameters may be set:

Soil Diet Animal Diet Race Age Lifestyle

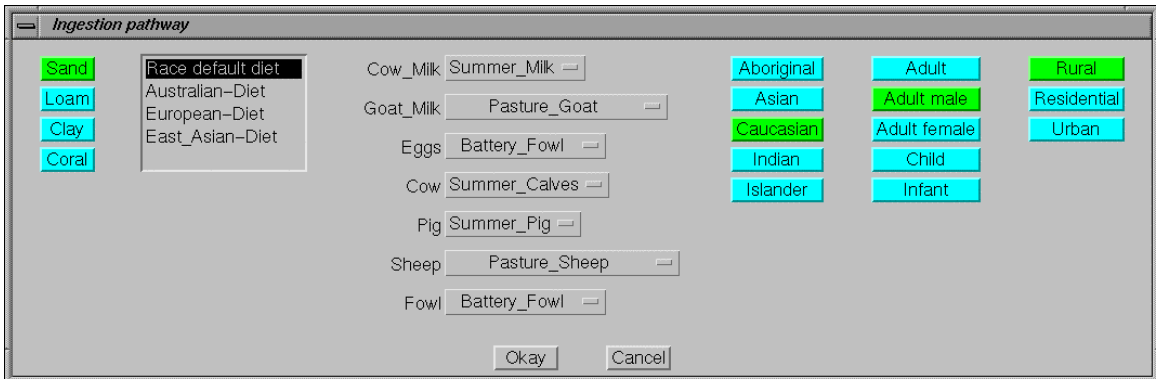


Figure 18: Ingestion User Interface.

Once all the parameter variations in the scenario have been selected, a click on the *Done* button (Figure 13) returns the user to the Main Panel (Figure 4).

11 Calculating and Viewing Dose

The Main Panel (Figure 4) enables the user to select the *Calculate* button, initiating the calculations of the pre-set scenario and allowing the user to view the resulting dose. Clicking on *Calculate* accesses a new window. This is shown in Figure 19. A pre-set scenario may be selected by using the *File* menu option, followed by *Load Scenario*, or the calculation can be initiated for the scenario established during the session. Once the scenario is selected the user can set the following options:

- Choice of pathways to consider, *i.e.* a subset or all of the pathways within the selected scenarios can be used in the calculation of the total dose.
- Choice of radionuclide, *i.e.* the contribution of all radionuclides or a subset can be calculated.
- Single period calculations can be carried out or cumulative calculations up to that point. This is selected by a choice between the radio buttons, *accumulate/single period.*

- Long term or short term effects can be calculated. Short term effects are those from the *inhalation,* and *external exposure,* as well as the consumption of milk. Short term effects are calculated for the period during the existence of airborne concentration. Long term effects result from the ground concentration and its effect on the food chain (for the Ingestion pathway) as well as dose from groundshine.
- Once all the options have been specified the *Calculate* button is used to signal to the system to carry out the calculations according to the selected options.
- The *Viewing Deposit* screen can be activated in order to cross-reference the dose calculated with the deposition data and to verify that a selected sub region (target group) has indeed received ground deposition.
- The *Show Scenario* screen can be activated in order to view the set-up of the scenario. Activating *Show Scenario* from this panel results in the panel shown in Figure 20. In this context the user can only view the scenario parameters, without being able to alter the settings.
- The *Do Sensitivity* button initiates sensitivity analysis for the chosen scenario. Note a dose calculation needs to be carried out before a sensitivity analysis can proceed.
- The *Previous Settings* button is used to revert to the previous setting of the options, as used in the last calculation.
- The total dose, together with the contributions from each of the pathways and each of the radionuclides will be presented to the user in a panel as shown in Figure 21 on the user pointing and clicking on a grid point.

Specific Operation:

1. Pathways: Press *Select all* or *Select from list* button. If selecting from list, one or more pathways may be selected.
2. Radionuclides: Press *All* or *Select from list* button. If selecting from list, one or more radionuclides may be selected.
3. Calculation method: Press *Accumulate* or *Single period* button
4. Calculation period: Press *Long term* or *Short term* button
5. Press *Calculate* button. On selecting the calculate button RadCon proceeds to calculate the doses. After the calculation is complete, the coloured sub region will appear on the map and the time scroll (*Viewing*) will appear on the right of the map
6. Click a point in the coloured sub region and the *Dose Values* box (Figure 21) will appear
7. Choose sensitivity option and click *Do Sensitivity* button. This may take time (5 to 30 minutes) depending on the size of the selected sub region. For full explanation go to section 12.

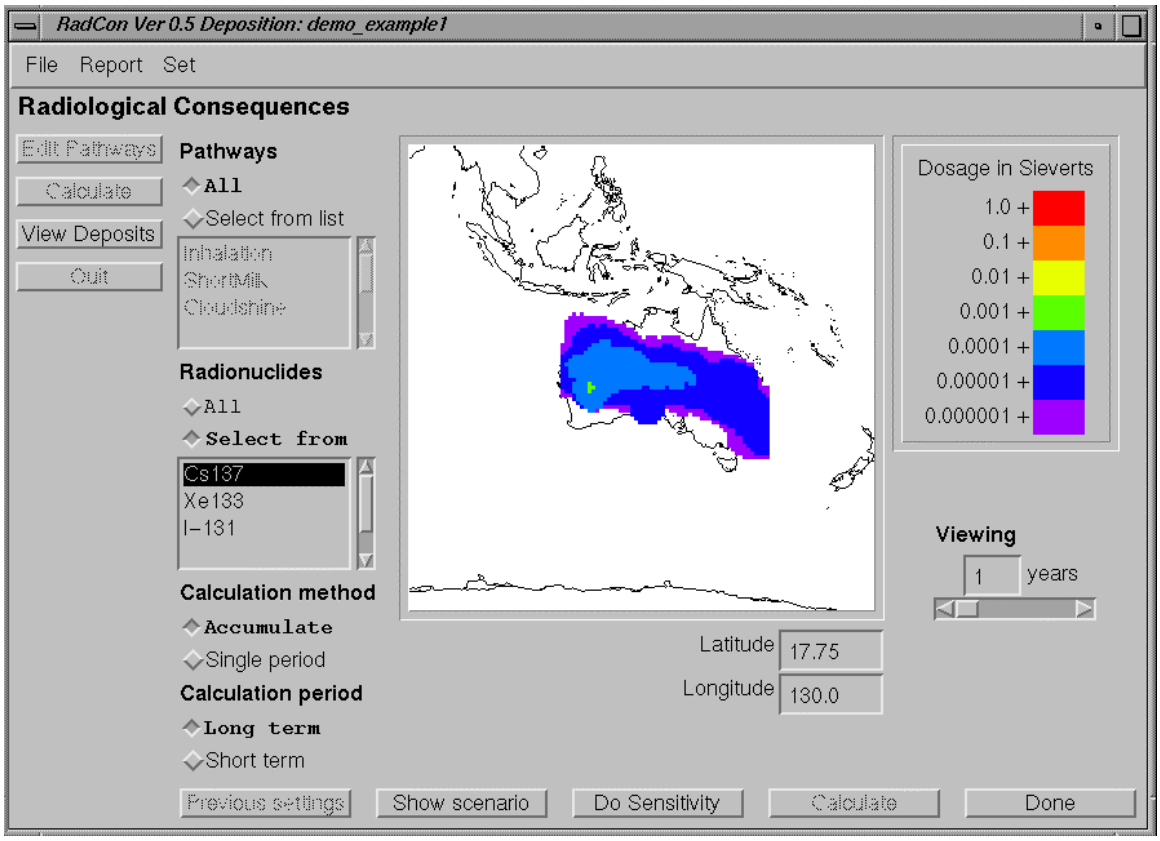


Figure 19: Calculating Dose.

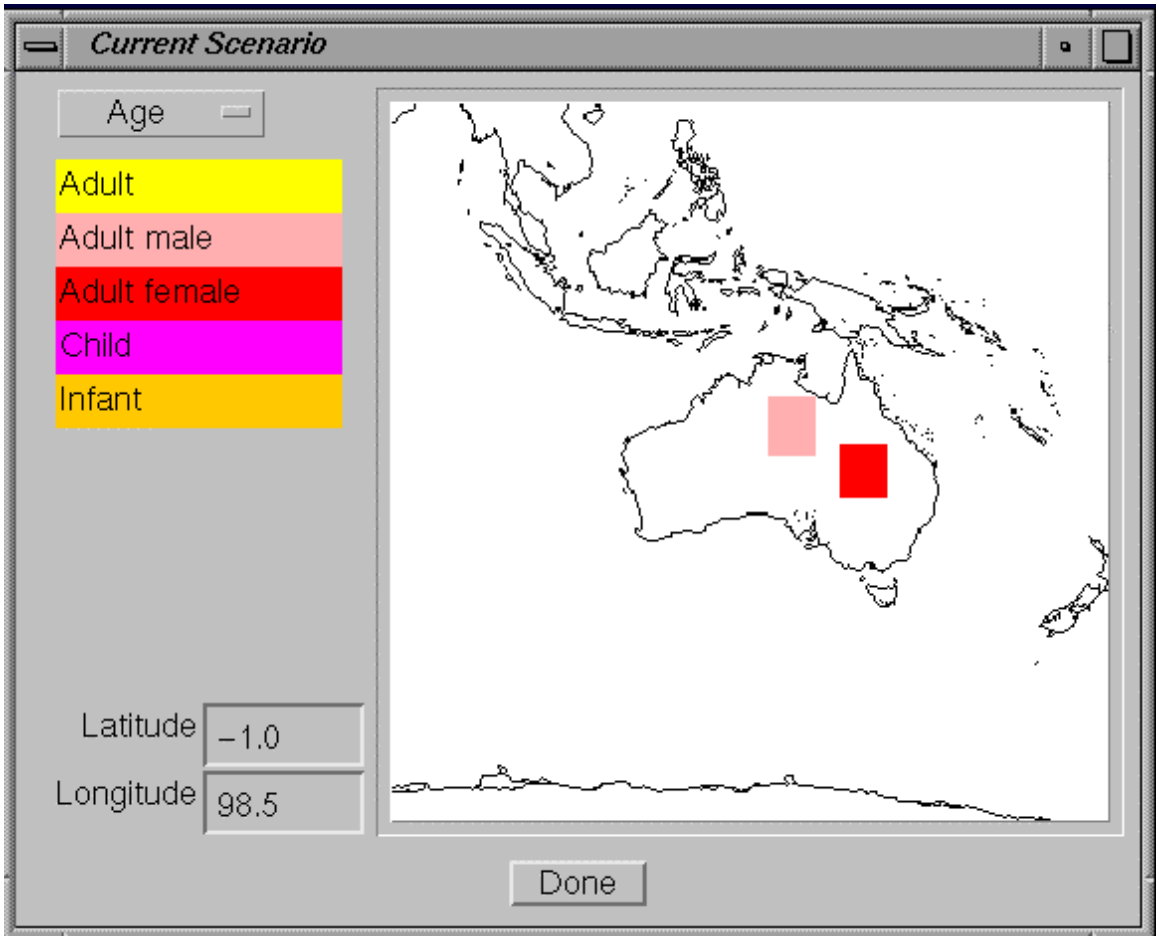


Figure 20: Viewing Scenario Parameters.

11.1 *Viewing the Dose values*

When the *Calculate Dose Panel* is active the user can select any location on the specified sub region (ie inside the coloured square or rectangle) of the map by pointing and clicking the left mouse button. The panel in Figure 21 appears, which displays the total dose for the selected grid location and time period. In addition a breakdown of dose contribution from each of the pathways in the scenario is given from each of the radionuclides. For the ingestion pathway a breakdown of the contribution from each food type is also given. The latitude and longitude values are the location of the selected grid point.

Data can be stored to a text file using the *Export* button. The intention being that this file be imported by a program such as a spread-sheet for further processing. On selecting the *Export* button a file dialog box will appear which will allow the user to navigate through their file system and choose the directory and file name where the results are to be stored. If no extension to the file is specified, RadCon will append the extension *.txt*.

The format of the file is as follows:

- Title – a character string
- "Lat", Latitude of the selected grid point, "Long", Longitude of the selected grid point.
- "Total", total dose for the grid point
- "Pathway","Isotope 1",……,"Isotope n"
- One line for each of the pathways in the calculation with the dose from that pathway from each radionuclide
- If ingestion is one of the pathways, the contribution from each of the food items in included

For example:

```
Dose Values
Lat,-26.5,Long,127.75
Total,2.365e-4
Pathway,Cs137
Groundshine,9.689e-8
Ingestion,2.364e-4

Rice,1.915e-5
Grain,5.889e-5
Leafy_Vegetables,4.891e-6
……
```

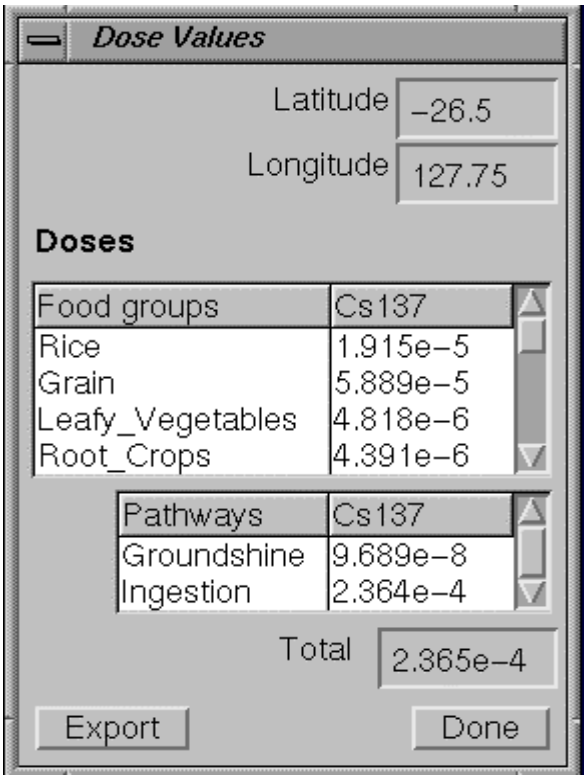


Figure 21: Viewing Values.

12 Carrying out parameter sensitivity an alysis

In order to improve model prediction we need to identify which parameters have a large impact on model results and therefore should have very reliable underlying basic data. Parameter sensitivity analysis has been implemented in RadCon to allow the user to rank the importance of parameters for a given scenario. In order to compute parameter sensitivity analysis the user needs to first compute a calculation (as described in the previous section). Following this, a particular position in the coloured sub region and a specific time can be selected on the calculating window and sensitivity can be initiated by selecting the *Do Sensitivity* button on the screen shown in Figure 19. The system proceeds to calculate the sensitivity, and when completed the screen in Figure 22 will appear. The following options can be selected using this screen:

- *Pathways*: The pathway for which the sensitivity is to be examined.
- *Radionuclides*: The radionuclide for which the sensitivity is to be examined.
- *Parameters*: The specific parameter.

The parameter sensitivity analysis is carried out for each of the selected pathways and each of the selected radionuclides. In order to see the effect of a selected parameter on the dose from the selected pathway and selected radionuclide one needs to select each of these and **then click on the *Display* button in order to re-fresh the screen with the values**. The selection of the *Done* button will exit the screen.

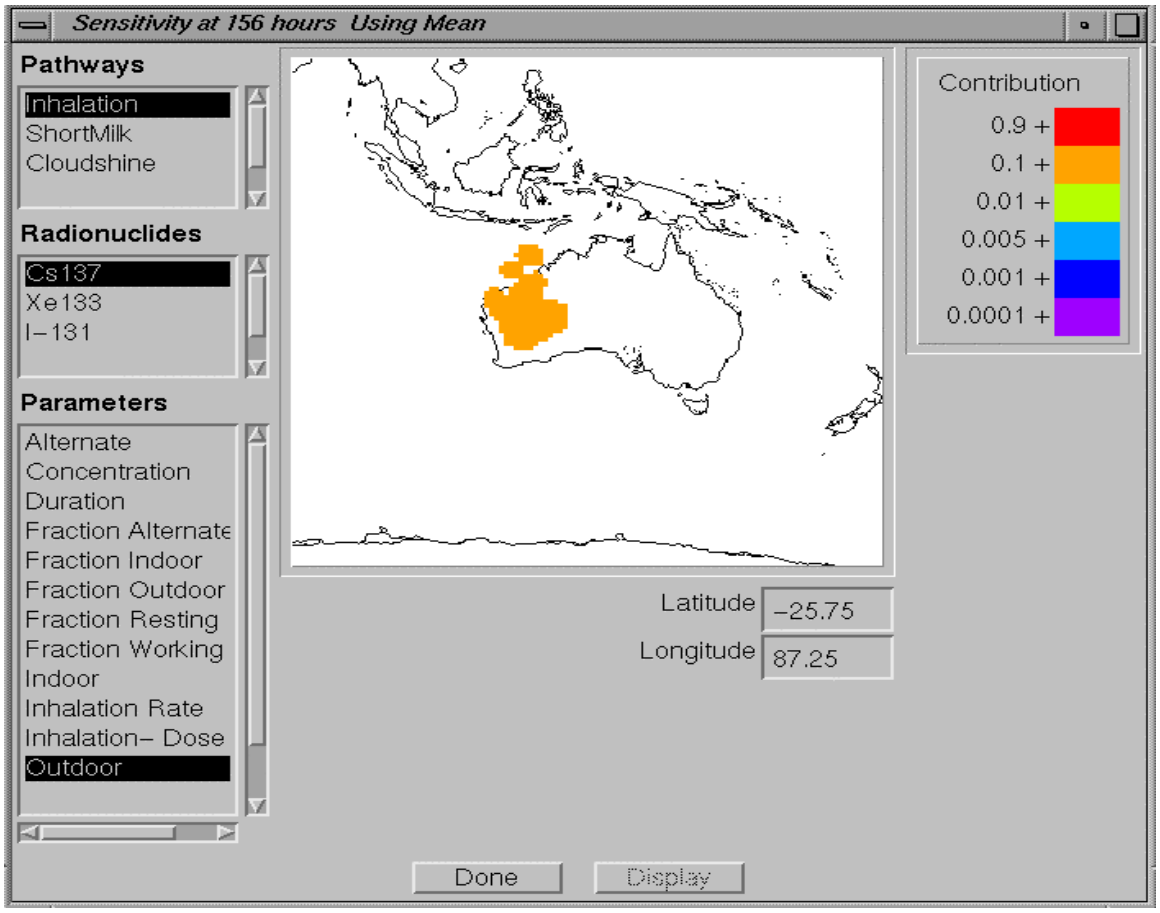


Figure 22: Parameter Sensitivity Display Screen.

Limitations of RadCon Version 2.0:

- For short term calculations parameter sensitivity analysis can only be carried out if the calculation method is *single period*.
- Parameter sensitivity analysis for ingestion could take considerable time in Version 2.0 of RadCon. Optimisation could be considered for future versions of RadCon.

12.1 *Viewing parameter sensitivity values*

In order to view the sensitivity values at a particular point, the user can select the point by clicking on the image and the screen as shown in Figure 23 will appear. This screen shows the sensitivity values for the parameters in the selected pathway and radionuclides.

The results can be sorted either by the parameter names or by the values for each of the radionuclides. This is achieved by the use of a list selection, which is activated by clicking on the button labelled *Cs137* in Figure 23. The label of this button will be that of the currently active sort field, *i.e.* parameter name or one of the radionuclides.

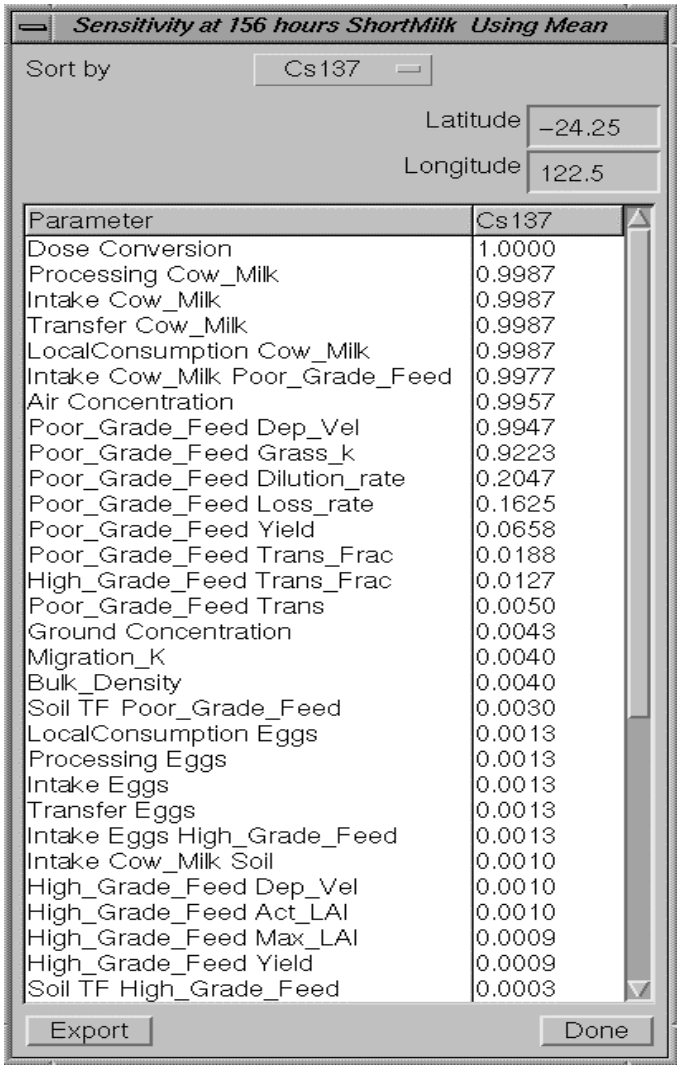


Figure 23: Sensitivity Values Screen.

To close the screen, select the *Done* button.

Data can be stored to a text file using the *Export* button. The intention being that this file be imported by a program such as a spread sheet for further processing.

On selecting the *Export* button a file dialog box will appear which will allow the user to navigate through their file system and choose the directory and file name where the results are to be stored. If no extension to the file is specified, RadCon will append the extension *.txt*.

The format of the file is as follows

- Title – a character string
- "Lat", Latitude of the selected grid point, "Long", Longitude of the selected grid point.
- "Parameter","Isotope 1",……,"Isotope n"
- One line for each of the parameters in the pathway, giving the name of the parameter and the associated rank for each radionuclide

The following is an example of a file generated by the *Export* function, during sensitivity analysis:

```
Sensitivity at 198 hours Inhalation  Using Mean
Lat,-23.5,Long,133.0
Parameter,Cs137,I-131
Alternate,0.00    ,0.00
Concentration,1.0000,1.0000
Duration,1.0000,1.0000
Fraction Alternate,0.00    ,0.00
Fraction Indoor,0.4118,0.7000
Fraction Outdoor,0.5882,0.3000
Fraction Resting,0.00    ,0.00
Fraction Working,1.0000,1.0000
Indoor,0.4118,0.7000
Inhalation Rate,1.0000,1.0000
Inhalation- Dose Conv,1.0000,1.0000
Outdoor,0.5882,0.3000
Resting,0.00    ,0.00
Working,1.0000,1.0000
```

When the above data is imported into a different application eg a spreadsheet, then the application can be set to recognise that the data is comma delimited and if that option is chosen the data will appear in columns in the spreadsheet – very handy for further analyses.

13 Additional Utilities

Two additional utilities have been provided, which are described in the subsequent sections.

13.1 *Deposition Values Viewer*

The user can view the actual concentration at a particular location using the frame shown in Figure 24. The application is started by using '*java DepositionViewer'* or an equivalent short cut. On starting the application, the frame in Figure 3 will be presented to the user to select the concentration scenario. Once the scenario has been selected Figure 24 is started and the user can navigate through the data to see the actual concentration at the point of interest.

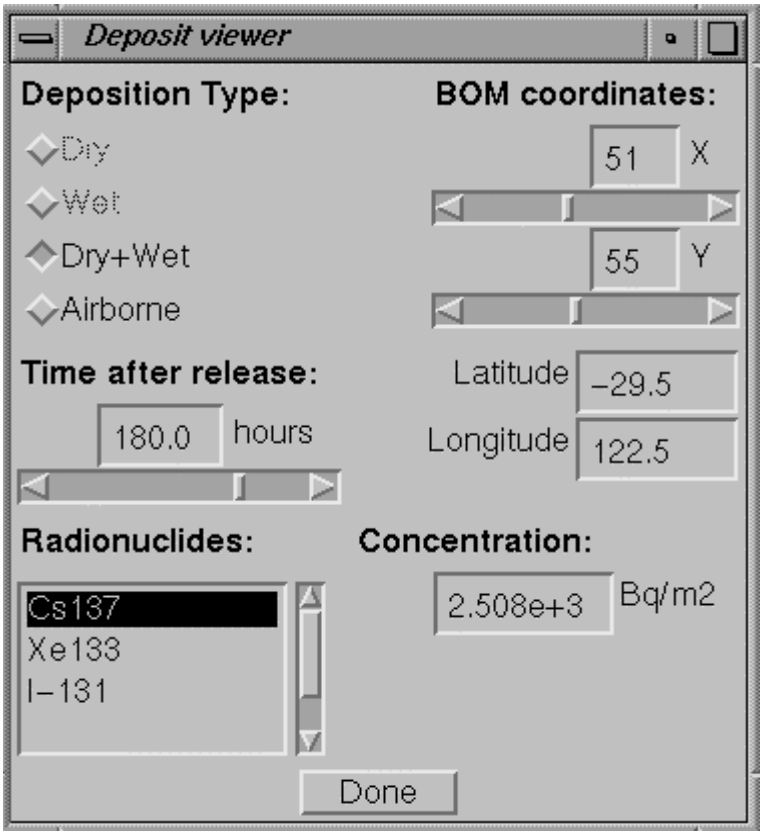


Figure 24: Deposit Viewer Frame.

13.2 *Saving and Viewing Dose Calculations*

After carrying out a calculation the dose over the region can be saved to a data file using the *Report* menu option, followed by the '*Dose Dump'* option and save the results to a selected location. These results can later be viewed using the application '*java DoseViewer scenario-name'*. **Note:** For Version 2.0 of RadCon, the dose viewer expects to find the saved data in the directory *data/user/doses,* thus at this stage ensure that you

store the files in this directory when using the *Report/Dose Dump* option in the calculate screen, i.e. when the file dialogue screen is displayed as shown in Figure 25, ensure that you set the directory appropriately by double clicking on the first entry and it appears in the '*Eneter file name'* box before you type in the actual name for storing the data, as shown in Figure 25.

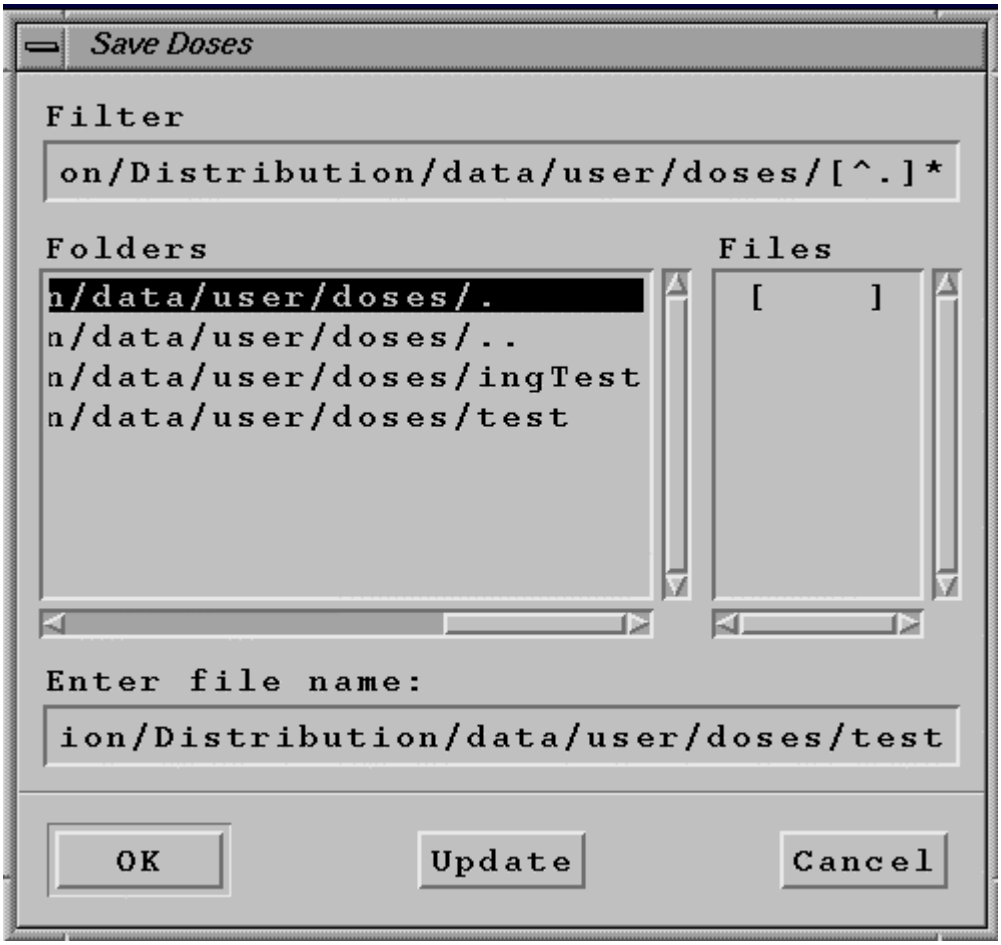


Figure 25: File Dialogue for storing calculated doses.

The screen in Figure 26 can be used to navigate through calculated doses and saved in previous runs of RadCon. In addition, export can be used to save the dose values at the selected point to a text file as described in section 11.1.

The *Done* button on the right of the screen can be used to exit the application.

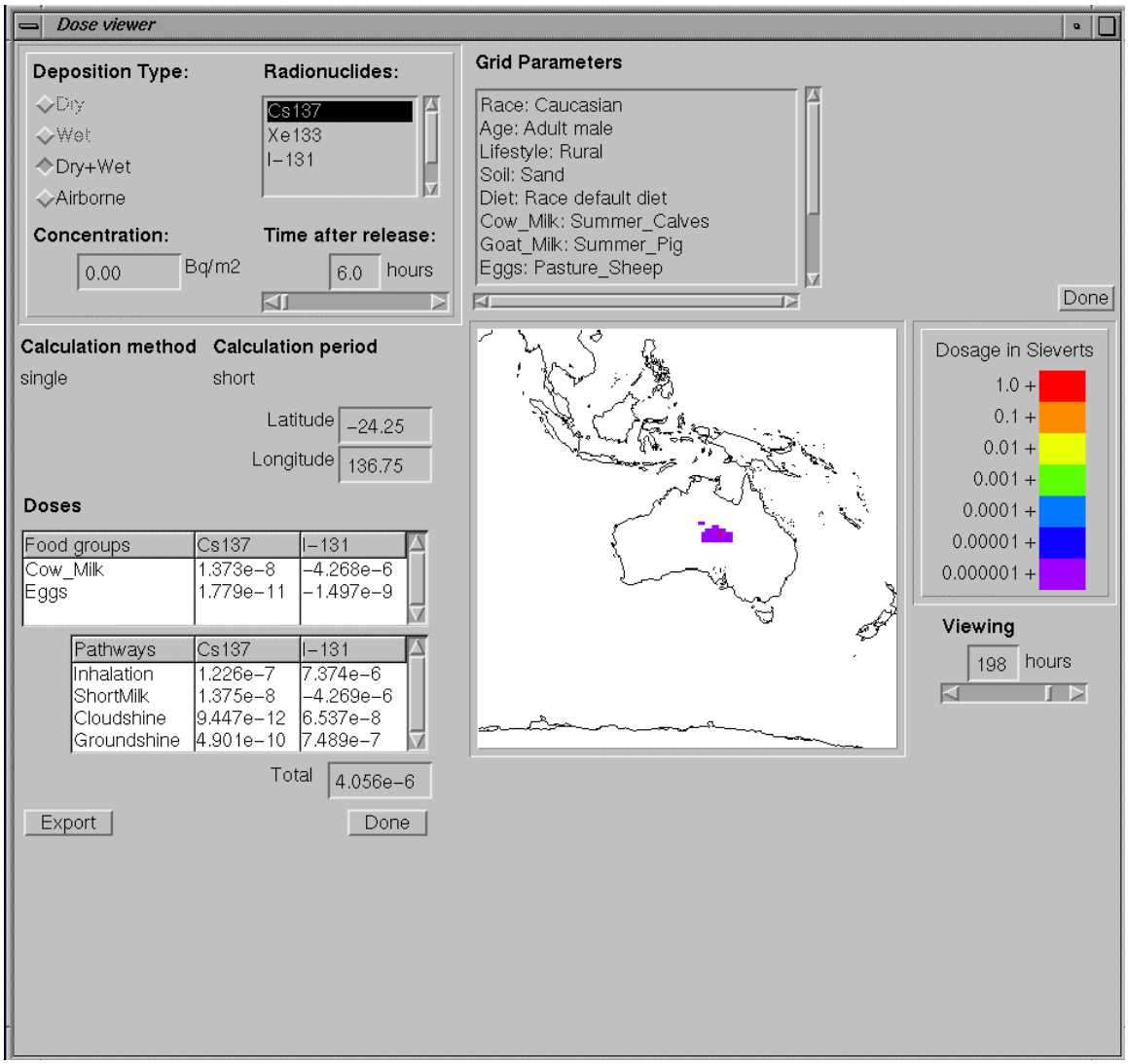


Figure 26: Dose Viewer Frame.

14 Acknowledgements

The authors would like to thank the other team members, Frank Harris and John Twining for their contribution to this work. In addition the first author would like to thank Frank Crawford for his continuous support and substantial contribution to the implementation of RadCon.

15 References

[1] BIOMASS Programme on BIOsphere Modelling and ASSessment, Theme 2: Environmental Releases, Dose Reconstruction Working Group – IAEA TecDoc in preparation.

[2] Crawford J., Domel R.U., Harris F.F. and Twining R.T. RadCon: A Radiological Consequences Model, Technical Guide, Version 2.0, ANSTO E-744, ISBN 0-642-59982-3, May 2000.

[3] Crawford J. and Domel R.U., RadConEd: A Graphical data Editor for the Radiological Consequences Model, RadCon, ANSTO M-129, ISBM 0-642-59984-X, May 2000.

[4] Domel R.U., Crawford J., Harris F.F., Twining J.R, March 2000: Parameter Report (Focusing on Tropical and Subtropical Environments in Australia). ANSTO Internal Report.

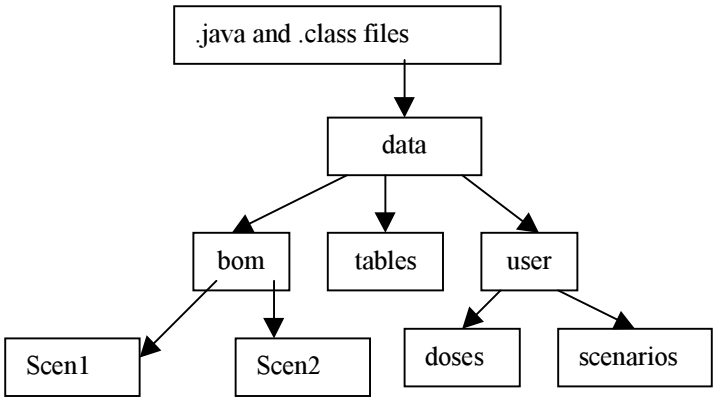
[5] Domel R.U., Crawford J., Harris F.F., Twining J.R, March 2000: Data, Assumption, Justifications and References used by the RadCon Model to Estimate Predictions for the Iput Test Scenario. ANSTO Internal Report.

Appendices

A. Installing RadCon

Before RadCon can be used on any system, the Java Virtual Machine needs to be implemented.

RadCon and the required directory structure are supplied in a zip file *radcon.zip*. To install RadCon choose your directory location where RadCon will be stored and unzip the file. This will produce the following directory structure:



The information in these files is as follows:

- The *.java* and *.class* files contain the code of RadCon.
- The subdirectory *data* contains data that is required to run RadCon.
- Subdirectories:
  - *bom* – contains a sample output from an atmospheric transport simulation, *Scen1*, *Scen2* being the separate directories containing the data for each simulation, see Appendix D, and a map of the simulation region, *map.gif,* see Appendix E.
  - *tabales* – parameter data for an Australian scenario, see Appendix F.
  - *user* – user created scenarios are stored here, see Section 4.
  - *Doses* – calculated doses can be stored in this directory.

B. Using RadCon at ANSTO

While RadCon can be installed on a PC, at the time of writing this report, RadCon was installed on a Silicon Graphics workstation, known as *iris*, which is connected to the ANSTO network. To access the code one needs:

- an X terminal or an X emulator running on a PC
- an account on *iris*, and
- data files.

If you don't have an X terminal or an X emulator, the Division of Information Management will make an X terminal emulator called *X-Win*, available, on request, which you will be able to install on your PC. An *ANSTO request for support* form needs to be forwarded to Information Management with a cost code, as a small cost is

associated. If you do not currently have an account on *iris*, an account can be arranged by following ANSTO's request for computer account procedures.

➢ *What you need*

You need the following:

1. X terminal or a PC running *X-Win.*
2. Account on *iris.*
3. A shell script which enables execution of RadCon, *RadCon*
4. The RadCon data files editor, *RadConEd*, and
5. Default data files.

➢ *Connecting to* iris

If you are using a PC:

1. Start *X-Win* by double clicking on its icon. It should be installed in the Applications group of programs.
2. Start a session by selecting the *Session*s menu option and select *iris* from the list of options. If an *iris* session has not been set up, set one up, as follows:
   - Select *Edit Sessions* followed by *New Session*, then set the following:
     - *Session Name*: iris
     - Choose the *rexec* radio button
     - *Host Name*: iris.ohs.ansto.gov.au
     - *Login*: your login id
     - *Command*: /usr/bin/X11/xterm -ls -n iris -display $MYIP:0 &
   - Select *Accept*
3. Type in your *iris* password and choose the OK button.

If you are using an X terminal, start a new session and log onto *iris*, either using *telnet* or *rlogin.*

C. Customising RadCon

There are only two changes that need to be made to the source code in RadCon Version 2.0:

- If one wishes to change the names of the soil types and animals, one will need to change the values in Pathwayconstants.java. For the soil names the following line was in the code at the time of writing this report:

```
public final static String kSOILS[] = {“Sand”, “Loam”, “Clay”,”Coral”);
```

A new soil can be added by adding a new entry, or a particular name can be changed. To add a new animal or change the name of an animal the following needs to be changed:

```
public final static String kANIMALS[] = {“Cow”, “Pig”, “Sheep”,
“Fowl”};
public final static String kANIMAL_PRODUCTS[] = {“Cow_Milk”,
                                        “Goat_Milk”, “Eggs”};
public final static String kALL_ANILAMS[] = {“Cow”, “Pig”, “Sheep”,
                      “Fowl”, “Cow_Milk”, “Goat_Milk”, “Eggs”};
public final static String kDISPLAYABLES[] = {“Race”, “Age”,
                     “LifeStyle”,   “Soil”,   “Diet”,   “Cow”,   “Pig”,
“Sheep”,
                      “Fowl”, “Cow_Milk”, “Goat_Milk”, “Eggs”};
```

Where names appear in more than one location, the relative order must be the same. After making the appropriate change re-compile the entire system using *javac *.java.*

- The translocation discrete functions are stored in a class *Translocations.java*. This should be changed if other than those supplied by the distribution. To alter these follow the instructions at the beginning of *Translocations.java.* After making the appropriate change re-compile *Translocations.java.*

Both of these could be read from data files in future versions of RadCon.

D. Deposition Files Data Format

RadCon expects the ground deposition and air concentration to be stored in sub-directories under the directory, *bom*, which itself is stored in directory *data.* Each scenario is stored in a separate subdirectory, for example the data for *example1* will be stored in sub-directory *example1*. In sub-directory *example1* RadCon looks for a number of files:

- A file with the same name as the directory and *.hdr* as an extension.
- The image of the background map to be used, in file *map.gif*, using the *gif* format.
- Two files for each of the radionuclides being modelled, one containing the air concentration, with an extension *.air*, and the other containing the ground concentration with an extension, *.dep*. The base name of these files is made up from the character symbol used for the radionuclide.

For example, if the name of the simulation is *example1*, then the information about the simulation will be stored in a file with name *example1.hdr*. This file contains the following information:

- Line 1
  - Model name – a character string without any embedded blanks
  - Year – an integer representing the year of simulation
  - Month – an integer representing the month of simulation
  - Day – an integer representing the day of the simulation
  - Hour – an integer representing the hour of the simulation
  - Two additional integers not used directly in RadCon
- A number of lines, one for each release, with the following information:
  - "REL" – the string "REL" for release information
  - Year – an integer representing the year of release
  - Month – an integer representing the month of release
  - Day – an integer representing the day of the release
  - Hour – an integer representing the hour of the release
  - Latitude – real number giving the latitude of the release
  - Longitude – real number giving the longitude of the release
  - Height - height of the release
- A line giving the dimension of the simulation region
  - Number of grids in the x direction - integer
  - Number of grids in the y direction - integer

  - Size of grids in horizontal direction – delta latitude – real number
  - Size of grids in the vertical direction – delta longitude – real number
  - Latitude reference point – bottom left hand corner – real number
  - Longitude reference point – bottom left hand corner – real number
- A line giving
  - The total number of radionuclides - integer
  - Number of time steps performed and for which the data is available - integer
  - Value, below which concentrations have not been reported– real number
  - Overall maximum concentration recorded – real number
- A line for each of the radionuclides, with the following information
  - Isotope name – a string without spaces
  - Maximum reading for ground concentration – real number
  - Maximum reading for air concentration – real number
- A single real number representing the averaging time in hours.

An example of a *.hdr* file is as follows:

```
TAPS      95       1       1       0      12       2
REL       95       1      28       0     -6.43    110.78   5000.00
REL       95       1      28       0     -6.43    110.78   5250.00
     120     120      0.75      0.75    -70.00     85.00
             4          40  1.0000000E-10   196060.3
 Cs137       12615.89       292.4314
 Xe133      0.0000000E+00   8686.327
 I-131       196060.3       2299.222
 Sr-90       1216.068       20.51381
             6
```

For this example the actual concentrations are stored in files:

- Cs137.air, Cs137.dep
- Xe133.air, Xe133.dep
- I-131.air, I-131.dep
- Sr-90.air, Sr-90.dep

These files are stored in binary format and contain the following information:

- Dummy integer – as original output was generated using Fortran
- Dummy integer - as original output was generated using Fortran
- Number of non-zero entries – an integer value
- Minimum column value for which non-zero values are available – an integer value
- Maximum column value for which non-zero values are available – an integer value
- Minimum row value for which non-zero values are available – an integer value
- Maximum row value for which non-zero values are available – an integer value
- Maximum concentration in this file – a real number

- Dummy integer – as original output was generated using Fortran

The rest of the file contains the following, one for each non-zero grid reading.

- Dummy integer – as original output was generated using Fortran
- X co-ordinate – an integer value
- Y co-ordinate – an integer value
- The actual concentration – a real number
- Dummy integer – as original output was generated using Fortran

E. Map of the Region

The image of the map of the region is stored in file *map.gif* in sub-directory, *data/bom/scenario/map.gif*, where scenario is the name of the dispersion scenario, *i.e example1* in Appendix D. **Note:** The size of the image must be an integer multiple of the dimension of the simulation region in both dimensions, see Appendix D. This is because RadCon needs to work out the number of pixels representing a grid, i.e. the horizontal image size in pixels has to be a multiple of the number of sub-divisions in the x direction of the region and similarly for the vertical.

F. Parameter Data Files

The values for the parameters used by the RadCon program are grouped into 14 main files with the following names and content. The reader is referred to the RadCon Technical Guide [2] for further descriptions of the parameters and to references 4, 5 and 6 for specific parameter and data files.

- `AnimalInfo` - parameters required for the calculation of radionuclide biological excretion rates from contamination in animals. The parameters are:

Name in RadConEd	*Parameter*	*Description*	*Units*
Age	T	Age of animal at slaughter	years
Removal_Rate_1	$\lambda_{m1}(m,r)$	removal rate constant (fast) of radionuclide concentration in an animal due to physiological processes	d^{-1}
Removal_Rate_2	$\lambda_{m2}(m,r)$	removal rate constant (slow) of radionuclide concentration in an animal due to physiological processes	d^{-1}
Fraction_1	$\alpha_{m1}(m,r)$	fast removal component fraction	dimensionless

These are further described in [2] table 9 and equation 10.

- `Decay` - radionuclide decay constants in days, calculated as ln(2)/half-life
- `Deposition_Info` – parameters required for the calculating the concentration in plants due to direct deposition and interception. These are described in tables 5,6 and 7 and are used in equations 5,6 and 7 in [2]. In addition the three parameters
  - ACT_LAI, Max_LAI and Yield depend on plant type only and not on the radionuclide, but for this version of RadCon they are reproduced for each radionuclide. If the variable Grass_k is non zero, RadCon will model that particular plant following grass, i.e. equation 6 in [2].

Name in RadConEd	Parameter	Description	Units
Dep_Vel	$V_{max}(r,p)$	maximum deposition velocity for plant p, i.e. for a fully developed plant	$m\ s^{-1}$
Act_LAI	LAI(p)	leaf area index of plant p at the time of deposition	$m^2\ m^{-2}$
Max_LAI	$LAI_{max}(p)$	maximum leaf area index of plant p at the time of fully developed foliage	$m^2\ m^{-2}$
Retention	S(p)	retention coefficient of plant p	mm
Yield	Y(p)	yield of plant p at time of harvest	$kg\ m^{-2}$
Yield	$Y_1(g)$	yield of grass at time of deposition	$kg\ m^{-2}$
Loss_rate	$\lambda_w(r,p)$	loss rate due to weathering of plant p or grass g	d^{-1}
Dilution_Rate	$\lambda_b(r,g)$	dilution rate by increase of biomass in grass	d^{-1}
Trans_Frac	$\alpha(r,g)$	fraction of activity translocated to the root zone in grass	dimensionless
Trans	$\lambda_t(r,g)$	rate of activity decrease due to translocation to the root zone in grass	d^{-1}
Grass_k	k	normalisation factor	m^2kg^{-1}

Note: Grass_k must be 1 for grass or 0 otherwise. Other values will give incorrect answers.

- `DoseCov` – contains the dose conversion factor for Inhalation, Ground_Shine, Cloud_Shine and Ingestion. The dose conversion factors for Inhalation and Ingestion (their units being Sv/Bq and depend on age and race of the individual) and those for Ground_Shine and Cloud_Shine (their units being (Sv m^2/(Bq s)).
- `HumanDiet` – contains the quantity (kg/day) of each food item consumed by infants, children, adult males, adult females and adults. Note that valid data is required only for those age/sex groups that an assessment is to be carried out. In addition a vale for the processing field needs to be entered. This gives the fraction of radioactivity remaining in the food after food processing i.e. before the food is consumed. See table 11 and equation 13 in [2].

The following three files are used in calculating dose from inhalation. For further information see the section on inhalation in [2].

- `InhalationRate` – contains the inhalation rate (for each of the age/sex groups (infant, child, adult male, adult female and adult). Further, different inhalation rates can be entered for the different races. Note that the inhalation rate can be entered using this table or a combination of the next two tables, see equation 3 and table 3 in [2]. If this option is selected the data in the following two tables has to be chosen such that

  I(race,age/sex_group) = Fraction of Time Resting x Resting Inhalation Rate +
  Fraction of Time Working x Working Inhalation Rate +
  Fraction of Time Alternate Activity x Alternate Activity Inhalation Rate = 1

  If the second alternative is chosen then the inhalation rate in this table must be set to 1 and the values in the next two tables must be chosen appropriately.
- `InhalationModifier` – the inhalation rate (m^3/hour) for each of the physical activities (working, resting and alternate) is entered here. In version 2.0 of RadCon these are race independent. This should be reconsidered for future releases of RadCon.
- `PhysicalActivity` – contains the fraction of time that each age/sex group undertakes each of the physical activities (working, resting and alternate).

Note: The data in the above two files is used to calculate the inhalation rate, I(race,age), using the above equation.

- `LocalConsumption` – contains the fraction of each food item consumed by humans that was produced locally. Any imported food is assumed to be un-contaminated. See table 11 and equation 13 in [2].
- `Occupancy` – contains the fraction of time that individuals spend indoors and outdoors. For version 2.0 of RadCon this is age and race independent. Considerations should be given to this in later versions of RadCon. These factors are used in dose calculations from inhalation and exposure from the cloud and ground. See the respective sections in [2] for further details.
- `SoilCharacteristics` – contains information on soil, see table 4 and equation 4 in [2].

Name in RadConEd	Parameter	Description	Units
Bulk_Density	P(s)	initial soil bulk density	kg m^{-2}
Migration_K	K(s)	soil reduction factor	dimensionless
Ground_Shine	Not used		

- `SoilRemoval-` contains soil information controlling the radionuclide availability for root uptake and contribution to external exposure. See tables 1 and 4 and equations 1 and 4 in [2].

Name in RadConEd	Parameter	Description	Units
The following relate to ingestion, table 4 and equation 4 in [2].			
Mobile_Fraction	$\alpha(r,s)$	mobile component fraction	dimensionless
Fixed_Component	$\lambda_1(r,s)$	rate of migration below root zone of mobile component of radionuclide	d^{-1}
Mobile_Component	$\lambda_2(r,s)$	rate of migration below root zone of fixed component of radionuclide	d^{-1}
Fixation	$\lambda_f(r,s)$	Rate of fixation	d^{-1}
The following relate to exposure from the ground, table 1 and equation 1 in [2].			
Gr_A	$\alpha(r,s)$	fixed component factor	dimensionless
Gr_Lambda1	$\lambda_1(r,s)$	migration rate, fixed component	d^{-1}
Gr_Lambda2	$\lambda_2(r,s)$	migration rate, mobile component	d^{-1}

- `Transfer` – contains a table with the soil to plant transfer rates (see equation 4 and table 4 in [2]). The file also contains a second table with transfer rates from food consumed by animals to the animal products (see table 9 and equation 10 in [2]).
- `TransmissionFactors` – contains four tables with the shielding factors for indoors in case of cloushune and groundshine and the filtering factors for inhalation. For further information on these see [2] tables 1,2 and 3 and equations 1, 2 and 3.

In addition for each animal product in the diet a file is required, animalDiet, which contains the daily consumption rates (kg/day) for each food in the animal's diet.

G. Format of Parameter Data Files

The data files have the following layout.

```
#comment1
#comment2
TITLE: tabletitle1
COLUMN_IDENTIFIERS:     columntitle1    columntitle2
UNITS:                  "column1 units"             "column2 units"
GROUPIDENTIFIER: Groupname1 (as defined in the GROUPS.DAT file)
VARIABLE IDENTIFER: Variablename1   column1value column2value
VARIABLE IDENTIFER: Variablename2   column1value column2value
VARIABLE IDENTIFER: Variablename3   column1value column2value
GROUPIDENTIFIER: Groupname2
VARIABLE IDENTIFER: Variablename1   column1value column2value
VARIABLE IDENTIFER: Variablename2   column1value column2value
VARIABLE IDENTIFER: Variablename3   column1value column2value

#comment1
#comment2
TITLE: tabletitle2
COLUMN_IDENTIFIERS:     columntitle1    columntitle2
```

The group identifiers and variable identifiers must be consistent within a single set of files (a set being the basefile and the accompanying data files, i.e. the files containing the minimum, maximum, distribution type and standard deviation, whose names are formed by using the dasefile name prefixed with *min*, *max*, *dist* and *sd*). The units are required to be in quotation marks. None of the identifiers or group/variable names should contain white space. Ensure that a blank line is available between each table in the files.

H. Sample Parameter Data Files

The following shows the contents of `Transfer`. A value of –99.0 implies that the data for that field has not been set.

```
# SOIL to Crop transfer rates
# Depend on crop type and radionuclide
# There should be an entry in this table for every crop consumed by people and
TITLE: Transfer_Crop
ELEMENT:                            Cs137       Sr-90       Xe133       I-131
UNITS:   "(Bq/kg)/(Bq/kg)"  "(Bq/kg)/(Bq/kg)" "(Bq/kg)/(Bq/kg)" "(Bq/kg)/(Bq/kg)"
SOIL: Sand
FOOD_GROUP: Rice                    0.128       -99.0       -99.0       -99.0
FOOD_GROUP: Grain                   0.004       -99.0       -99.0       -99.0
FOOD_GROUP: Leafy_Vegetables        0.400       -99.0       -99.0       -99.0
FOOD_GROUP: Ground_Fruit            0.203       -99.0       -99.0       -99.0
FOOD_GROUP: Legumes_Pulses          0.045       -99.0       -99.0       -99.0
FOOD_GROUP: Root_Crops              0.096       -99.0        -99.0      -99.0
FOOD_GROUP: Tubers                  0.21        -99.0       -99.0       -99.0
FOOD_GROUP: Tree_Fruit              0.041       -99.0       -99.0       -99.0
FOOD_GROUP: Poor_Grade_Feed         0.032       -99.0       -99.0       -99.0
FOOD_GROUP: High_Grade_Feed         0.21        -99.0       -99.0       -99.0
```

```
SOIL: Clay
FOOD_GROUP: Rice                0.027   -99.0   -99.0   -99.0
FOOD_GROUP: Grain               0.014   -99.0   -99.0   -99.0
FOOD_GROUP: Leafy_Vegetables    1.099   -99.0   -99.0   -99.0
FOOD_GROUP: Ground_Fruit        0.807   -99.0   -99.0   -99.0
FOOD_GROUP: Legumes_Pulses      0.2     -99.0   -99.0   -99.0
FOOD_GROUP: Root_Crops          0.384   -99.0   -99.0   -99.0
FOOD_GROUP: Tubers              0.71    -99.0   -99.0   -99.0
FOOD_GROUP: Tree_Fruit          0.014   -99.0   -99.0   -99.0
FOOD_GROUP: Poor_Grade_Feed     0.022   -99.0   -99.0   -99.0
FOOD_GROUP: High_Grade_Feed     0.027   -99.0   -99.0   -99.0
SOIL: Loam
FOOD_GROUP: Rice                0.015   -99.0   -99.0   -99.0
FOOD_GROUP: Grain               0.0042  -99.0   -99.0   -99.0
FOOD_GROUP: Leafy_Vegetables    0.217   -99.0   -99.0   -99.0
FOOD_GROUP: Ground_Fruit        0.015   -99.0    -99.0  -99.0
FOOD_GROUP: Legumes_Pulses      0.173   -99.0   -99.0   -99.0
FOOD_GROUP: Root_Crops          0.501   -99.0   -99.0   -99.0
FOOD_GROUP: Tubers              0.009   -99.0   -99.0   -99.0
FOOD_GROUP: Tree_Fruit          0.263   -99.0   -99.0   -99.0
FOOD_GROUP: Poor_Grade_Feed     0.0136  -99.0   -99.0   -99.0
FOOD_GROUP: High_Grade_Feed     0.028   -99.0   -99.0   -99.0
SOIL: Coral
FOOD_GROUP: Rice                -99.0   -99.0   -99.0   -99.0
FOOD_GROUP: Grain               4.439   -99.0   -99.0   -99.0
FOOD_GROUP: Leafy_Vegetables    40.9    -99.0   -99.0   -99.0
FOOD_GROUP: Ground_Fruit        3.89    -99.0   -99.0   -99.0
FOOD_GROUP: Legumes_Pulses      3.90    -99.0   -99.0   -99.0
FOOD_GROUP: Root_Crops          -99.0   -99.0   -99.0   -99.0
FOOD_GROUP: Tubers              3       -99.0   -99.0   -99.0
FOOD_GROUP: Tree_Fruit          8.37    -99.0   -99.0   -99.0
FOOD_GROUP: Poor_Grade_Feed     7.41    -99.0   -99.0   -99.0
FOOD_GROUP: High_Grade_Feed     8.23    -99.0   -99.0   -99.0

#
# Plant to Animal transfer rates
# Depend on Animal type and radionuclide
# There should be an entry in this table for all meat types consumed by
# people
TITLE: Transfer_Animal
ELEMENT:                        Cs137   Sr-90   Xe133   I-131
UNITS:  "(Bq/kg)/(Bq/kg)"  "(Bq/kg)/(Bq/kg)" "(Bq/kg)/(Bq/kg)" "(Bq/kg)/(Bq/kg)"
SOIL: Animal
FOOD_GROUP: Cow_Milk            0.0079  0.0028  0       0.01
FOOD_GROUP: Cow                 0.05    0.008   0       0.04
FOOD_GROUP: Pig                 0.24    0.04    0       0.0033
FOOD_GROUP: Eggs                0.4     0.0028  0       0.01
FOOD_GROUP: Fowl                3.0     0.08    0       0.01
FOOD_GROUP: Sheep               0.49    0.33    0       0.03
```

The data in the *minTransfer, maxTransfer, sdTransfer* and *distTransfer* files will be given in the same order and will have the same format. Although the TABLE names will have a prefix of *min, max, sd* and *dist* respectively. e.g. *distTransferCrop, distTransfer_Animal.*

I. Adding additional diet types

Version 1.0 of the data file editor, RadConEd [3], does not provide a facility to add new tables to data files. In the case of diets for both animals and humans additional tables might need to be added and existing ones might need to be removed. To achieve this a system editor can be used. Make sure that the files are opened and saved as text. In addition, some editors append a file extension, e.g. *txt* could be added by Microsoft Word – ensure that the extension is not added as RadCon will not be able to find the file.

In the following an example of a human data file, *HumanDiet*, is given. Each table is defined by a table name, which will appear on panel Figure 18. The first 5 tables correspond to the race specific diet, which must appear first. To remove a diet (aside from the race specific diet which must always be available) delete the title and all the associated data to the next blank line. A new diet can be added by copying and pasting an existing table and making the appropriate changes. **Note:** A blank line must exist between table entries. If a new food item is added, one for which a soil to plant transfer factor does not exist in file *Transfer* or the local consumption fraction in file *LocalConsumption*, these should be added using RadConEd.

```
# The diet for humans is defined in the following tables using food groups.  The
# processing factor is a scaling factor defining the amount of radioactivity remaining
# after processing.
# The first 5 tables are the race specific tables.
# User defined diets should be added at the end of the file.
# For the current implementation relative position of the tables is important.
# When adding new food types, ensure that additional data is supplied, for example,
# when adding crops, make sure that a transfer rate from soil to crop is given in
# file Transfer.
# The Diet is specified in kg per day
# Note three Cow diets, first for meat, second for milk, third for milk product

TITLE: Caucasian-Diet
AGE:                    Processing Infant   Child    Adult_Male Adult_Female Adult
UNITS:  "None"  "kg / day"     "kg / day"     "kg / day"     "kg / day"     "kg / day"
FOOD_TYPE: Crop
FOOD_GROUP: Rice                1     -99.0   -99.0     0.0465    0.0345   0.0404
FOOD_GROUP: Grain               0.55  -99.0   -99.0     0.3578    0.2468   0.1748
FOOD_GROUP: Leafy_Vegetables    0.8   -99.0   -99.0     0.0166    0.0129   0.0168
FOOD_GROUP: Root_Crops          0.6   -99.0   -99.0     0.0235    0.0200   0.0218
FOOD_GROUP: Tree_Fruit          0.7   -99.0   -99.0     0.1413    0.1457   0.1435
FOOD_GROUP: Ground_Fruit        0.65  -99.0   -99.0     0.0933    0.1088   0.1123
FOOD_GROUP: Tubers              0.6   -99.0   -99.0     0.1062    0.0728   0.0893
FOOD_GROUP: Legumes_Pulses      0.6   -99.0   -99.0     0.0334    0.0238   0.0285
FOOD_TYPE: Meat
FOOD_GROUP: Cow                 0.7    -99.0   -99.0    0.08455     0.00467  0.0655
FOOD_GROUP: Pig                 0.6    -99.0   -99.0    0.03705     0.0185   0.0278
FOOD_GROUP: Sheep               0.7    -99.0   -99.0    0.0266      0.0147   0.0205
FOOD_GROUP: Fowl                0.5    -99.0   -99.0    0.0515      0.0354   0.0434
FOOD_TYPE: MeatProduct
FOOD_GROUP: Cow_Milk            0.6    -99.0   -99.0    0.3219     0.2577     0.2893
FOOD_GROUP: Eggs                0.9    -99.0   -99.0    0.0162     0.0112     0.0137

TITLE: Aboriginal-Diet
AGE:                    Processing Infant   Child    Adult_Male Adult_Female Adult
UNITS:  "None"  "kg / day"     "kg / day"     "kg / day"     "kg / day"     "kg / day"
FOOD_TYPE: Crop
FOOD_GROUP: Grain          0.55       0.041    0.173    0.231      0.179        0.179
FOOD_GROUP: Leafy_Vegetables 0.8        0.02     0.039    0.035      0.045        0.045
FOOD_GROUP: Root_Vegetables 0.6        0.02     0.026    0.05       0.05         0.05
FOOD_GROUP: Tree_Fruit     0.7        0.03     0.25     0.225      0.275        0.275
FOOD_GROUP: Ground_Fruit   0.65       0.0      0.03     0.05       0.058        0.058
FOOD_GROUP: Tubers         0.6        0.012    0.115    0.21       0.15         0.15
FOOD_TYPE: Meat
FOOD_GROUP: Cow_Milk       0.6        0.0      0.05     0.5        0.57         0.57
FOOD_GROUP: Cow            0.7        0.01     0.05     0.064      0.049        0.049
FOOD_GROUP: Sheep          0.7        0.0      0.019    0.027      0.027        0.027
FOOD_GROUP: Pig            0.6        0.0030   0.065    0.088      0.054        0.054
FOOD_GROUP: Fowl           0.5        0.0010   0.03     0.05       0.04         0.04

#
TITLE: Asian-Diet
AGE:                    Processing Infant   Child    Adult_Male Adult_Female Adult
UNITS:  "None"  "kg / day"     "kg / day"     "kg / day"     "kg / day"     "kg / day"
FOOD_TYPE: Crop
FOOD_GROUP: Rice           0.9        0.212    0.213    0.214      0.215        0.215
```

```
FOOD_GROUP: Grain          0.9        0.222    0.223    0.224      0.225        0.225
FOOD_GROUP: Leafy_Vegetables 0.9        0.232    0.233    0.234      0.235        0.235
FOOD_GROUP: Root_Vegetables 0.9        0.242    0.243    0.244      0.245        0.245
FOOD_GROUP: Tree_Fruit     0.9        0.252    0.253    0.254      0.255        0.255
FOOD_GROUP: Ground_Fruit   0.9        0.262    0.263    0.264      0.265        0.265
FOOD_GROUP: Tubers         0.9        0.272    0.273    0.274      0.275        0.275
FOOD_TYPE: Meat
FOOD_GROUP: Cow            0.9        0.282    0.283    0.284      0.285        0.285
FOOD_GROUP: Sheep          0.9        0.292    0.293    0.294      0.295        0.295
FOOD_GROUP: Pig            0.9        0.202    0.203    0.204      0.205        0.205
FOOD_GROUP: Fowl           0.9        0.212    0.213    0.214      0.215        0.215

#
TITLE: Indian-Diet
AGE:                       Processing Infant   Child    Adult_Male Adult_Female Adult
UNITS:  "None"  "kg / day"     "kg / day"     "kg / day"     "kg / day"     "kg / day"
FOOD_TYPE: Crop
FOOD_GROUP: Rice           0.9        0.312    0.313    0.314      0.315        0.315
FOOD_GROUP: Grain          0.9        0.322    0.323    0.324      0.325        0.325
FOOD_GROUP: Leafy_Vegetables 0.9        0.332    0.333    0.334      0.335        0.335
FOOD_GROUP: Root_Vegetables 0.9        0.342    0.343    0.344      0.345        0.345
FOOD_GROUP: Tree_Fruit     0.9        0.352    0.353    0.354      0.355        0.355
FOOD_GROUP: Ground_Fruit   0.9        0.362    0.363    0.364      0.365        0.365
FOOD_GROUP: Tubers         0.9        0.372    0.373    0.374      0.375        0.375
FOOD_TYPE: Meat
FOOD_GROUP: Cow            0.9        0.382    0.383    0.384      0.385        0.385
FOOD_GROUP: Sheep          0.9        0.392    0.393    0.394      0.395        0.395
FOOD_GROUP: Pig            0.9        0.302    0.303    0.304      0.305        0.305
FOOD_GROUP: Fowl           0.9        0.312    0.313    0.314      0.315        0.315

#
TITLE: Islander-Diet
AGE:                       Processing Infant   Child    Adult_Male Adult_Female Adult
UNITS:  "None"  "kg / day"     "kg / day"     "kg / day"     "kg / day"     "kg / day"
FOOD_TYPE: Crop
FOOD_GROUP: Rice           0.9        0.412    0.413    0.414      0.415        0.415
FOOD_GROUP: Grain          0.9        0.422    0.423    0.424      0.425        0.425
FOOD_GROUP: Leafy_Vegetables 0.9        0.432    0.433    0.434      0.435        0.435
FOOD_GROUP: Root_Vegetables 0.9        0.442    0.443    0.444      0.445        0.445
FOOD_GROUP: Tree_Fruit     0.9        0.452    0.453    0.454      0.455        0.455
FOOD_GROUP: Ground_Fruit   0.9        0.462    0.463    0.464      0.465        0.465
FOOD_GROUP: Tubers         0.9        0.472    0.473    0.474      0.475        0.475
FOOD_TYPE: Meat
FOOD_GROUP: Cow            0.9        0.482    0.483    0.484      0.485        0.485
FOOD_GROUP: Sheep          0.9        0.492    0.493    0.494      0.495        0.495
FOOD_GROUP: Pig            0.9        0.402    0.403    0.404      0.405        0.405
FOOD_GROUP: Fowl           0.9        0.412    0.413    0.414      0.415        0.415

TITLE: Australian-Diet
AGE:                       Processing Infant   Child    Adult_Male Adult_Female Adult
UNITS:  "None"  "kg / day"      "kg / day"      "kg / day"      "kg / day"      "kg /
day"
FOOD_TYPE: Crop
FOOD_GROUP: Rice                1     -99.0   -99.0     0.0465    0.0345   0.0230
FOOD_GROUP: Grain               0.55  -99.0   -99.0     0.3578    0.2468   0.1735
FOOD_GROUP: Leafy_Vegetables    0.8   -99.0   -99.0     0.0166    0.0129   0.0158
FOOD_GROUP: Root_Crops          0.6   -99.0   -99.0     0.0235    0.0200   0.0221
FOOD_GROUP: Tree_Fruit          0.7   -99.0   -99.0     0.1413    0.1457   0.1381
FOOD_GROUP: Ground_Fruit        0.65  -99.0   -99.0     0.0933    0.1088   0.1108
FOOD_GROUP: Tubers              0.6   -99.0   -99.0     0.1062    0.0728   0.0916
FOOD_GROUP: Legumes_Pulses      0.6   -99.0   -99.0     0.0334    0.0238   0.0287
FOOD_TYPE: Meat
FOOD_GROUP: Cow                 0.7   -99.0   -99.0     0.08455   0.00467  0.06365
FOOD_GROUP: Pig                 0.6   -99.0   -99.0     0.03705   0.0185   0.0284
FOOD_GROUP: Sheep               0.7   -99.0   -99.0     0.0266    0.0147   0.02075
FOOD_GROUP: Fowl                0.5   -99.0   -99.0     0.0515    0.0354   0.00435
FOOD_TYPE: MeatProduct
FOOD_GROUP: Cow_Milk            0.6   -99.0   -99.0     0.3219    0.2577   0.2953
FOOD_GROUP: Eggs                0.9   -99.0   -99.0     0.0162    0.0112   0.014
```

```
TITLE: European-Diet
AGE:                        Processing Infant   Child    Adult_Male Adult_Female Adult
UNITS:  "None"  "kg / day"      "kg / day"      "kg / day"      "kg / day"      "kg /
day"
FOOD_TYPE: Crop
FOOD_GROUP: Rice                1     -99.0   -99.0     0.0465    0.0345   0.0342
FOOD_GROUP: Grain               0.55  -99.0   -99.0     0.3578    0.2468   0.1874
FOOD_GROUP: Leafy_Vegetables    0.8   -99.0   -99.0     0.0166    0.0129   0.025
FOOD_GROUP: Root_Crops          0.6   -99.0   -99.0     0.0235    0.0200   0.0172
FOOD_GROUP: Tree_Fruit          0.7   -99.0   -99.0     0.1413    0.1457   0.2176
FOOD_GROUP: Ground_Fruit        0.65  -99.0   -99.0     0.0933    0.1088   0.1117
FOOD_GROUP: Tubers              0.6   -99.0   -99.0     0.1062    0.0728   0.0768
FOOD_GROUP: Legumes_Pulses      0.6   -99.0   -99.0     0.0334    0.0238   0.025
FOOD_TYPE: Meat
FOOD_GROUP: Cow                 0.7    -99.0   -99.0    0.08455   0.00467  0.0692
FOOD_GROUP: Pig                 0.6    -99.0   -99.0    0.03705   0.0185   0.0272
FOOD_GROUP: Sheep               0.7    -99.0   -99.0    0.0266    0.0147   0.0207
FOOD_GROUP: Fowl                0.5    -99.0   -99.0    0.0515    0.0354   0.383
FOOD_TYPE: MeatProduct
FOOD_GROUP: Cow_Milk            0.6    -99.0   -99.0    0.3219    0.2577   0.2513
FOOD_GROUP: Eggs                0.9    -99.0   -99.0    0.0162    0.0112   0.0094


TITLE: East_Asian-Diet
AGE:                        Processing Infant   Child    Adult_Male Adult_Female Adult
UNITS:  "None"  "kg / day"      "kg / day"      "kg / day"      "kg / day"      "kg /
day"
FOOD_TYPE: Crop
FOOD_GROUP: Rice                1     -99.0   -99.0     0.0465    0.0345   0.3671
FOOD_GROUP: Grain               0.55  -99.0   -99.0     0.3578    0.2468   0.1628
FOOD_GROUP: Leafy_Vegetables    0.8   -99.0   -99.0     0.0166    0.0129   0.0254
FOOD_GROUP: Root_Crops          0.6   -99.0   -99.0     0.0235    0.0200   0.0119
FOOD_GROUP: Tree_Fruit          0.7   -99.0   -99.0     0.1413    0.1457   0.1516
FOOD_GROUP: Ground_Fruit        0.65  -99.0   -99.0     0.0933    0.1088   0.1079
FOOD_GROUP: Tubers              0.6   -99.0   -99.0     0.1062    0.0728   0.0357
FOOD_GROUP: Legumes_Pulses      0.6   -99.0   -99.0     0.0334    0.0238   0.0312
FOOD_TYPE: Meat
FOOD_GROUP: Cow                 0.7   -99.0   -99.0    0.08455   0.00467  0.0741
FOOD_GROUP: Pig                 0.6   -99.0   -99.0    0.03705   0.0185   0.0251
FOOD_GROUP: Sheep               0.7   -99.0   -99.0    0.0266    0.0147   0.0223
FOOD_GROUP: Fowl                0.5   -99.0   -99.0    0.0515    0.0354   0.0607
FOOD_TYPE: MeatProduct
FOOD_GROUP: Cow_Milk            0.6   -99.0   -99.0    0.3219    0.2577   0.2271
FOOD_GROUP: Eggs                0.9   -99.0   -99.0    0.0162    0.0112   0.0179
```

J. Generating Screen Dumps

Version 2.0 of RadCon has no print or save to file options. In order to produce a hard copy of the screens one can use:

- A public domain program called *display* can be used on Unix system, or
- On PCs the *print screen* key or *alt print screen* can be used to capture images of the screen generated by RadCon.

This is an area that should be considered for future versions of RadCon.

K. BIOMASS module

For the participation in the model inter-comparison exercise [2] an additional module was implemented in RadCon. This provides a text based user interface to the RadCon Computational Model, see Figure 2. In addition it was customised to producing the intermediate results that were required for the model inter-comparison exercise and allows calculation of doses for periods other than multiples of a year, which is a necessary restriction for a graphical interface. This interface accepts a single value for the ground and air concentration and calculates the dose from the selected pathway.

Parameter uncertainty propagation is also implemented in this interface, using a mixture of normal and log-normal distributions for the parameters. Monte Carlo sampling is used to propagate the uncertainty to the calculated dose.

One can start this interface by using:

java BIOMASS at the command prompt or the equivalent shortcut

The following text based interface will appear:

```
Path = usr/people/jc/Projects/RadCon/Production/Distribution/data/tables

1: Inhalation 2: Ground Shine 3: Cloud Shine 4: Ingestion
Select pathway: 4

1: Cs134   2: Cs137   3: Xe133  4: I-131  Sr-90
Select isotope: 2

 0: Sand 1: Loam 2: Clay 3: Coral
Select Soil: 0
 0: Aboriginal-Diet 1: Asian-Diet 2: Caucasian-Diet 3: Indian-Diet 4: Islander-Diet 5:
Australian-Diet 6: European-Diet 7: East_Asian-Diet
Select diet:
```

The options presented to the user reflect the graphical user interfaces describe in Section 10. On completion of the options the doses are calculated and printed on the screen. As this interface was designed for a specific application, full details will not be included here.

L. Possible Procedure for Using RadCon

Following is one possible sequence of steps to be undertaken in an assessment.

- Prepare the air and ground concentrations as indicated in Appendix D.
- Prepare the map of the region, Appendix E.
- Prepare the parameter files as indicated in Appendix F.
- Start the RadCon system.
- Set up a scenario by selecting the *Edit Pathways* screen.
- Carry out a calculation by selecting the *Calculate Screen*.

To carry out a parameter sensitivity analysis:

- Select the year for which the parameter sensitivity will be carried out and select the *Do Sensitivity* button. **Note:** that for short term calculations, parameter sensitivity can only be carried out in single period mode.