DRAFT

MILDOS-AREA User's Guide

(Draft)

Environmental Assessment Division

Argonne National Laboratory

September 1998

Use of This Manual

MILDOS-AREA for Windows is built with many features to facilitate use and understanding of the software. This user's guide extends that design with further documentation. The manual is also found on the MILDOS-AREA web site with hypertext links set for easier navigation and searching. Sections for this support are:

1) Introduction: History and application of the code. Introduction to parameters and pathways used in the code.

2) Installation: Various installation procedures for distribution media.

3) Navigation: Moving around the interface to accomplish tasks. How to save input and output results.

4) Input Windows: A closer look at parameters on the input windows.

5) Output Windows: How to find results in the textual and graphical output.

Introduction

Nature of Problem Solved

The MILDOS Computer code calculates the dose commitments received by individuals and the general population within an 80 km radius of an operating uranium recovery facility. In addition air and ground concentrations are presented for individual locations, as well as for a generalized population grid. Extra-regional population doses resulting from transport of radon and export of agricultural produce are also estimated. The transport of radiological emissions from point and different area sources is predicted by using a sector-averaged Gaussian plume dispersion model. Mechanism such as radioactive decay, plume depletion by deposition, ingrowth of daughter products and resuspension of deposited radionuclides are included in the transport model. Alterations in operation throughout the facility's lifetime can be accounted for in the input stream. The pathways considered are: inhalation; external exposure from groundshine and cloud immersion; and ingestion of vegetables, meat and milk. Dose commitments are calculated primarily on the basis of the recommendations of the International Commission on Radiological Protection (ICRP). Only airborne releases of radioactive materials are considered: releases to surface water and to groundwater are not addressed in MILDOS. This code is multi-purposed and can be used to evaluate population doses for NEPA assessments, maximum individual doses for predictive 40 CFR 190 compliance evaluations, or maximum offsite air concentrations for predictive evaluations of 10 CFR 20 compliance.

The MILDOS/MILDOS-AREA Computer code was designed as a primary licensing and evaluation tool and is expected to provide basic input to critical licensing, regulatory and policy decisions. It is used by the staff of the Nuclear Regulatory Commission to perform routine radiological impact and compliance evaluations for various uranium recovery operations. This code is designed for uranium mill facilities, and should not be used for operations with different radionuclides or processes. Over the years MILDOS computer code has gone through many changes. The 1981 version of MILDOS was designed for mainframe computer. Latest 1998 version of MILDOS-AREA has graphic user interface uses the Windows 3.x (and Window 95) operating system and runs on personal computers.

Pathways

The pathways considered for individual and population impacts are:

- Inhalation
- External exposure from ground concentrations
- External exposure from cloud immersion
- Ingestion of vegetables
- Ingestion of meat
- Ingestion of milk

Dose Conversion Factors

Doses are calculated using dose conversion factors, which are ultimately based on recommendations of the International Commission on Radiological Protection (ICRP). These factors are fixed internally in the code, and are not part of the input options.

Site Description

The physical description of the mill site includes a grid of twelve concentric distance intervals (within 80 km) and sixteen angular intervals based on sixteen compass directions (N, NNE, NE, etc.). The mill center is assumed to be at the center of the grid. Source and receptor locations are defined relative to the mill center by specifying distances on a cartesian grid with east represented by the positive abscissa and north by the positive ordinate. The elevation with reference to the mill center is also defined.

Source Description

The user can define sources to represent each significant radionuclide release point for the mill under consideration. The locations of the radiation sources are defined relative to the mill center on the Cartesian grid system mentioned above. Typical sources include yellowcake stacks, crushers, grinders, conveyors, rod mills, fine ore blending, tailing areas, ore pads etc. Radionuclide releases are defined for each source for particulates and radon gas. The U-238 decay chain is assumed the only significant source of radiation for uranium milling operations. The contribution from the U-235 chins is less than 5% of that from the U-238 chain. Particulate releases are defined to include the radionuclides U-238, Th-230, Ra-226, and Pb-210. The gaseous releases are defined for Rn-222 with ingrowth of short-lived daughter products also considered. These Rn-222 daughters include Po-218, Pb-214, Bi-214, Pb-210, and Po-210. The dosimetry model accounts for releases and ingrowth of other radionuclides using assumption of secular equilibrium.

The time history of release for each source is defined for the life of the mill and post operational periods. Typically, a uranium mill will operate for a period of years during which there will be radon and particulate releases from the ore storage pile, the mill itself, and the tailings disposal area. During this operational period releases from tailings areas can be limited by wetting the piles to inhibit air suspension by wind action. Upon completion of the actual milling operation, the tailings pile is normally allowed to dry by natural evaporation until it is ready for stabilization. During this period, there are essentially no releases from the ore pad or the mill. However, as the tailings pile dries radon and particulate releases from this source may increase, reaching a maximum before stabilization. After stabilization and reclamation of the tailings area, there should be no further particulate releases. However, small quantities of radon may continue to be released to the atmosphere for long periods.

Atmospheric Transport and Diffusion

Emissions of radioactive materials from different sources are modeled using a sector-averaged Gaussian plume dispersion model, which utilizes user-provided wind frequency data. Mechanism such as deposition of particulates, resuspension, radioactive decay and ingrowth of daughter radionuclides are included in the transport model. Annual average air concentrations are computed, from which subsequent impacts to humans through various pathways are computed. Ground surface concentrations are estimated from deposition buildup and ingrowth of radioactive daughters. The surface concentrations are modified by radioactive decay, weathering and other environmental processes. The MILDOS

Computer code allows the user to vary the emission sources as a step function of time by adjusting the emission rates, which includes shutting them off completely. Thus the results of a computer run can be made to reflect changing processes throughout the facility's operational life.

Population Doses beyond 80 Km

Population doses to the North American continent from Rn-222 are calculated using estimates of population dose resulting from 1000 Ci releases from four specific locations in the western United States:

Casper, Wyoming
Falls City, Texas
Grants, New Mexico
Wellpinit, Washington

MILDOS has the precalculated population dose estimates for 1000 Ci releases from these four sites during the calendar year 1978. These dose factors are defined in subroutine POPDOS as the array parameter RADPOP. Table 1 has these dose factors.

TABLE 1 Population Doses Resulting From 1 KCi Release of Rn-222 During 1978, in organ-rem

Release Site	Bronchial Epithelium	Whole Body	Pulmonary Lung	Bone
Casper, WY	56	8.8	2.0	120
Falls City, TX	72	5.8	1.6	77
Grants, NM	52	8.2	1.8	110
Wellpinit, WA	43	9.0	1.7	120

The population dose to persons beyond 80 km radius is estimated from radon releases characterized by the nearest of these four sites. The array FRADON is used to select the radon release characteristics for one of the above sites or as a geographic average of the above sites.

Moreover, the population dose calculations beyond 80 km are based on total U.S. population growth relative to the year 1978. The array PAJUST gives relative population during each time step compared to the 1978 populations. A value for PAJUST must be given for each of the NSTEP (maximum allowed is 10) time steps in order. These values are used to obtain the proper continental population doses as a function of the time of exposure.

History

Over the years, the MILDOS computer code has gone through many changes. In 1981 MILDOS (NUREG/CR-2011) was developed from version IV of the Argonne National Laboratory (ANL) computer program UDAD (Uranium Dispersion And Dosimetry). Version IX of UDAD is documented as NUREG/CR-0553. The models and assumptions on which the MILDOS program was based are described in the U.S. Nuclear Regulatory Commission Draft Regulatory Guide RH 802-4 and portions of the UDAD document. Models were included in MILDOS to consider both point sources (stacks, vents) and area

sources (ore pads, tailing areas). Release of particulates are limited to U-238, Th-230, Ra-226, and Pb-210. Other radionuclides are implicitly accounted for under the secular equilibrium assumption. Gaseous releases were limited to consideration of Rn-222 plus ingrowth of daughters. The dose to exposed individuals is calculated for comparison with requirements of both 40 CFR 190 and 10 CFR Part 20. The version of MILDOS developed in 1981 allowed the user to define a maximum of twenty source terms, ten time steps, and forty-eight individual receptor locations. For the calculations, ingestion dose conversion factors were based on ingestion models in ICRP Publication 2 and 10A. Inhalation dose conversion factors were calculated by the UDAD computer code in accordance with the Task Group on Lung Dynamics (TGLM) lung model of ICRP (ICRP 1966 and 1972). The external dose conversion factors were directly taken from Hones and Soldat (1977)[1].

In 1989, Argonne National Laboratory developed the MILDOS-AREA code (ANL/ES-161) by modifying the MILDOS code developed in 1981. The changes were intended to provide enhanced capability to compute doses from large-area sources and to incorporate changes in methods for dosimetry calculations (ICRP 1979). The revised program was designed for use on IBM or IBM-compatible personal computers. This version of MILDOS-AREA allowed the user to define a maximum of 10 sources (point or area), 48 individual receptors, and 10 time steps. The number of sources were reduced from 20 allowed in MILDOS code because in the revised code a large-area source is considered as a single source rather than as two or more virtual-point sources[2]. MILDOS-AREA considers the same radionuclides as MILDOS. The MILDOS computer code could only be used on a mainframe computer, while MILDOS-AREA was designed for use on an IBM or IBM-compatible personal computer. MILDOS-AREA was easier to use; more flexible in handling the large amount of printer output. Although slower in execution, it usually exhibited a better net turnaround time than MILDOS. A validation study of MILDOS-AREA was conducted using measured Rn-222 concentration and flux data from the Monticello, Utah uranium mill tailings impoundment. The results of this study demonstrated that use of MILDOS-AREA can result in generally good agreement between model-generated and measured Rn-222 concentrations.

In 1997, the MILDOS-AREA computer code was further updated by ANL. The 1989 version of MILDOS-AREA computer code incorporated dose conversion factors derived by the ICRP recommendations of 1978. The annual average air concentrations were compared to the maximum permissible concentrations (MPCs) in the Nuclear Regulatory Commission's Standards for Protection Against Radiation (10 CFR Part 20). On January 1, 1994, a revision to 10 CFR Part 20 (revised Part 20) went into effect. The revised Part 20 updated its dosimetry to the ICRP 1978 recommendations. The dose limit to the general public also changed. The changes led to a revision of the calculated allowable concentrations for unrestricted areas. The changes led to a revision of the calculated allowable concentrations (ALC) for unrestricted areas, with MPC being replaced by the term "effluent concentrations." In addition, a new method of recovering uranium gained popularity in the late 1980s, and a majority of operating licensees started using the in-situ leach (ISL) method.

In 1997 MILDOS-AREA computer code was updated keeping two objectives in mind. The first objective was to update the code's data structures and terminology to meet the needs of the revised Part 20, and the second objective was to create an example problem for in-situ leach facilities. These two objectives resulted in the creation of a patch program that updated the 1989 version to the 1997 version of MILDOS-AREA computer code.

[1] Hoenes, G.R. and J.K. Soldat, 1977, "Age Specific Radiation Dose Conversion Factors for a One-Year Chronic Intake", NUREG-0172, U.S. Nuclear Regulatory Commission, Washington, D.C.

[2] In MILDOS a "virtual point source" method was used to describe dispersion from area sources and it was recommended that the area sources larger than 0.1 km2 should be broken down to smaller area source.

In 1998, ANL again updated the MILDOS-AREA computer code. The MILDOS-AREA computer code, as designed through 1997, lacked user-friendly features. To run the code, a user had first to separately develop an input file, which is an ASCII file containing all of the pertinent values that are required by the code. The code was then executed to produce the output file, which contains results of the calculations. This latest version of MILDOS-AREA code incorporates a user-friendly software interface into the 1997 version of MILDOS-AREA computer code. This graphical user interface (GUI) is simple and easy to use and allows MILDOS-AREA to run under the Windows operating system. The interface contains sufficient information so that the user clearly understands where to input each parameter needed for the calculations. The GUI follows standard Windows 3.x, 95 or NT structures. The GUI allows the creation, retrieval, and editing of MILDOS-AREA input files. In the various editing windows, the GUI provides information to clearly indicate where each parameter value should be input and what units should be used for each parameter. The GUI allows the results of the MILDOS-AREA calculations (the output file) to be viewed. This output file may then be saved, the information in the output file may be moved into other software applications, or the output files from previous runs may be retrieved.

The GUI is implemented with standard Windows usage of menus, windows, buttons, and other Windows functions. All user actions in the GUI are accessible through keystrokes and keystroke combinations as well as a pointing device (mouse). The GUI contains an online help system that uses Windows-standard protocols and include information from the user's manual and other basic operating information.

This 1998 GUI version of MILDOS-AREA computer code runs on a baseline PC, configured with a 486/66 MHz or higher CPU, with 8 MB RAM, that uses the Windows 3.x, 95 or NT operating system.

MILDOS/MILDOS-AREA Parameters

The MILDOS/MILDOS-AREA parameters can be classified into seven categories as follows:

Data Category	Parameter Names
Job Control	IFTODO, IRTYPE, JC
Source Terms	FRADON, IPACT, NSORCE, PACT, QAJUST, SORCE, IPSOL, PTSZ, PTSZFC, FAS, SRNS, HDP
Meteorology	DMM, DMA, FREQ
Food Pathway Parameters	FFORI, FFORP, FHAYI, FHAYP, FPR
Population Distribution	IPOP, PAJUST
Individual Receptors	IADD, XRECEP
Time History	NSTEP, TSTART, TSTEP

Job Control Parameters

The array IFTODO is used in conjunction with the time history data and controls calculation and printing of doses for each time step. The array IRTYPE requests output reports for each individual receptor location. The array JC controls selection of calculational options and report selections.

Source Term Parameters

Multiple release points may be defined as input to the MILDOS program. The number defined for a run is specified by the parameter NSORCE. The location, rate of release and characteristics of each release are defined in the array SORCE. Additional data is defined for area sources such as tailings piles where wind suspension is the main driving force for entry to the atmosphere. The sample area source isotopic composition mixes (specific activity in pCi/gm) are defined in array PACT. Three composition mixes may be defined to represent different ore mixes. The array IPACT then assigns these composition mixes to represent each area source as appropriate. For characterizing fixed particulate release rates for area sources (corresponding to the three isotopic composition mixes) array FAS is used. The code would generate the wind-erosion source term for particulate releases if FAS < 0.0. Similarly array SRNS defines the radon release rates.

The population dose to persons beyond the 80 km radius is estimated from radon releases characterized by the nearest of the following four sites:

Casper, Wyoming
Falls City, Texas
Grants, New Mexico
Wellpinit, Washington

The array FRADON is used to select the radon release characteristics for one of above sites or as a geographic weighted average of the above sites. The release rate during each time period is defined by the array QAJUST and this array is used to adjust the release data in the SORCE array. This flexibility in source term specification is necessary over the lifetime of a uranium mill to account for transitions in operations.

Particle size distribution data is used in the atmospheric transport calculation by MILDOS. Three particle size distribution sets are available as internal data in MILDOS. The element SORCE(11,I) selects one of these sets to represent each source I.

Meteorological Parameters

Average meteorological data characteristics at the mill center is required as input to MILDOS. The data array FREQ is used to provide the annual average fractional frequency of occurrence of windspeed, wind direction and atmospheric stability. Data is supplied for sixteen wind directions in the order N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, NNW; six wind speed classifications in the order 0-3, 4-7, 8-12, 13-18, 19-24, >24 mph; in six Pasquill atmospheric stability categories in the order A - extremely unstable, B – moderately unstable, C – slightly unstable, D – neutral, E – moderately stable, F – very stable. The wind direction is the direction the wind is from. In addition to the joint frequency array, the annual average morning (DMM) and afternoon (DMA) mixing heights are provided.

Food Pathway Parameters

Several parameters used in the food pathway model are to be supplied by the user. Four parameters are required for the animal product pathway describing the feeding habits of livestock near the mill site. The parameter FFORI and FFORP give the fraction of total annual feed requirements that are provided as pasture grass for the individual doses and population doses respectively. The parameters FHAYI and FHAYP give the fraction of total annual feed requirements that are provided as locally grown stored hay for the individual doses and the population doses, respectively. These numbers are fractions that must be entered as non-negative real numbers between zero and one. A default value of 0.5 is used for any of the above parameters that are not supplied in the input set. Further restrictions on the parameters are

FFORI + FHAYI $\leq$ 1.0, and
FFORP + FHAYP $\leq$ 1.0

The array parameter FPR gives the food production rate for the region for three food types: vegetables, meat, and milk.

Population Distribution Parameters

The population distribution within 80 km of the mill center is provided by the integer array IPOP. This array gives the number of people living in each of twelve distance intervals in sixteen downwind directions. The distance intervals are (km): 1-2, 2-3, 3-4, 4-5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80. The direction representations are the same as for the meteorological parameter FREQ.

The population dose calculations beyond 80 km are based on total U.S. population growth relative to the year 1978. The array PAJUST gives the relative population during each time step compared to the 1978 population.

Receptor Location Parameters

The parameter IADD gives the number of individual receptor locations to be considered and the array XRECEP gives coordinates defining the locations.

Time History Parameters

This data set describes the time history of the mill operation. The year of initial release is given by parameter TSTART. The mill lifetime is divided into timesteps based on transition points in the mill life and tailings management plans, such as changing from a dry grinding to a semi-autogenous grinding. Up to 10 timesteps can be defined. The number of timesteps is specified by NSTEP and length of each timestep is given in array TSTEP.

Regulations

The Environmental Protection Agency (EPA) regulation, 40 CFR Part 190, addresses individual radiation doses from all pathways and all nuclear fuel cycle facilities combined, except exposure from radon and its daughters is excluded. The regulation 10 CFR Part 20 states that that all radiation exposure be kept “as low as reasonably achievable”

(ALARA). For ALARA evaluations all releases, including radon and its daughters, are considered for calculation of population doses as well as individual doses. Population doses are calculated for the region (within 80 km) of the mill center, and for the continental U.S. (from radon and its daughters only).

Installation

Requirements

- Windows 3.1, 3.11, Windows 95, or Windows NT Operating System
- 486 or higher processor
- 4 MB of RAM
- 15 MB of disk space

From Disks

- Insert Disk 1 into appropriate floppy drive
- Run SETUP.EXE program from disk drive (for example, A:SETUP)
  - With Windows95/NT, this can be done through the Start/Run sequence or though the Explorer
  - With Windows3.x, this can be done through the File Manager or Windows Program manager.
- Enter information requested by the standard installation program
- After installation, a new MILDOS-AREA icon will be placed in the MILDOS-AREA group. Double-clicking this icon will start MILDOS-AREA.

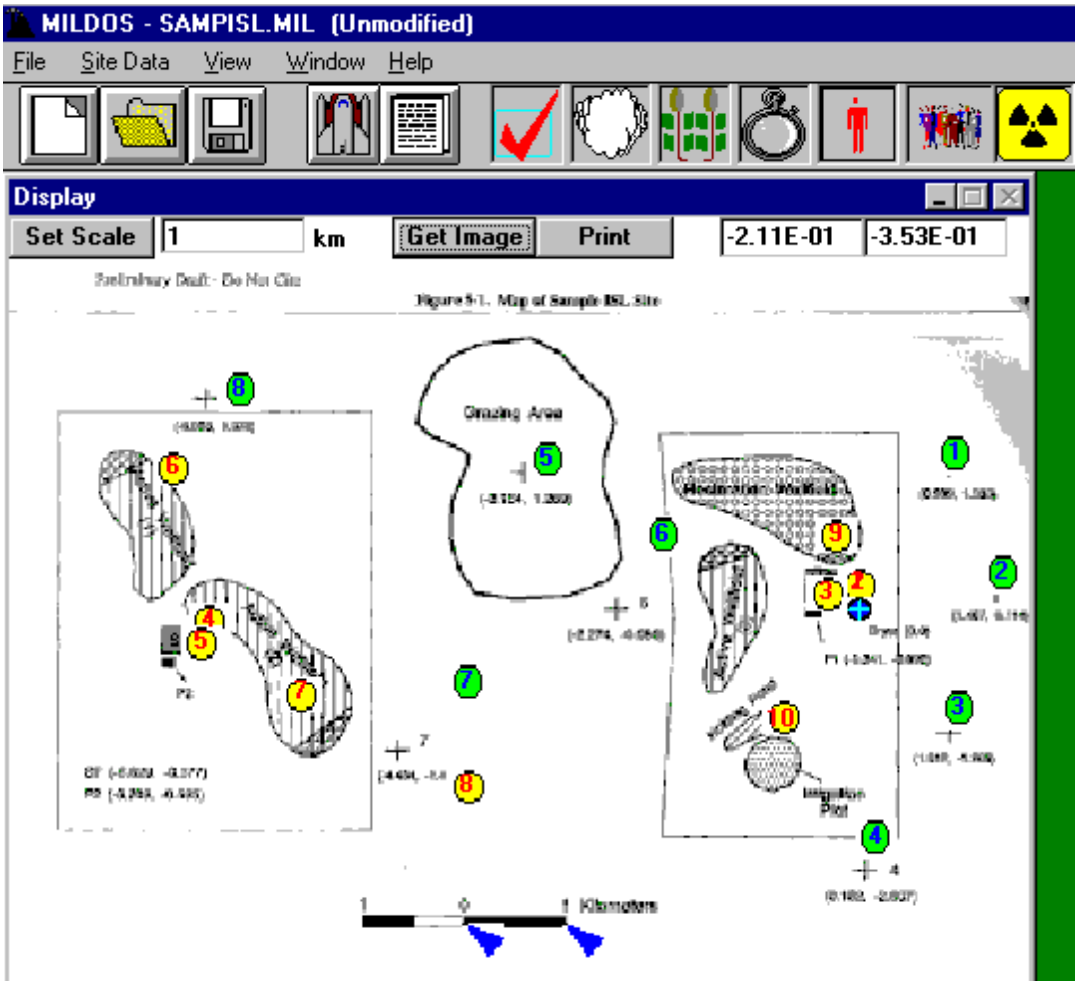
Uninstalling

- Click on Uninstall MILDOS-AREA icon
- Files will be removed from system

Troubleshooting

- Calculations don't finish: DOS mode should have at least the following in CONFIG.SYS: FILES=30; BUFFER=16; SHELL=C:\DOS\COMMAND /P/E:512
- Calculations with no feedback: In Windows3.x the Foreground Exclusive option should not be on. This can be found in the "386 Enhanced" property setting.
- Output report format: If MSLineDraw Font is not available as a font, install the font using the file Linedraw.ttf in your font directory.
- Viewing Output: MILDOS-AREA needs a printer driver installed. It is not necessary to attach a printer.
- Very slow computations compared with others: SMRTDRV.EXE in CONFIG.SYS for proper speed performance

Navigation



Navigation through the input for MILDOS-AREA can be accomplished either through the main menu, the toolbar or graphically with the above window. Users have the ability to draw or read in an image to display as a background reference. The image to be read in could be generated by a different application or by a scanning device. Use of the drawing tool could result in a schematic drawing like the one above. The drawing feature makes use of the Paint program that is included with the Windows operating system.

On top of this background, the user can specify the location of the sources and receptors. Once placed the objects can be moved and their detail properties accessed with the right mouse button. To use this method of placement the user must specify a scale through the placement of two anchor reference points.

Using the Graphic Display Screen

Creating a Graphic Image of the Site:

Menu: Select Help/Draw. This will load the Paint program packaged as an accessory to the Windows program. Using the Paint tools, draw a schematic diagram of the site, including site boundaries, locations of sources and receptors, and a scale bar in kilometers. Save the file as a bitmap (use 16 colors to create a smaller file if speed and/or memory constraints are a concern) in the MILDOS directory. Exit the Paint program and return to MILDOS.

Alternative Methods: Create a bitmap from a scanned image of the site or by using an alternative drawing or graphics program. Save the file to the MILDOS directory.

Viewing the Graphic Display Screen:

Menu: Select View/Graphic Display.

Display Screen: By default, the graphic display screen is minimized near the bottom left corner of the monitor. To display the graphic screen, click on the RESTORE button.

If working on a new problem (i.e., no source or receptor data have been entered yet) the display screen will contain the following items:

- Scale input window in the upper left corner of the screen.
- **Set Scale** button to establish the locations of sources and receptors relative to the origin.
- **Get Image** button to load a graphic image into the display screen.
- **Print** button to print a copy of the Graphic Display Screen.
- Two coordinate display windows to indicate the x and y coordinates of the selected arrow, receptor or source icon. These display windows update each time an icon is moved to a new location. The coordinates will depend on the current scale and location of the origin and anchor reference points.
- Two arrow icons used as anchor reference points to set the scale of the Graphic Image.
- A Source (yellow numbered disk), Receptor (green numbered disk), and Origin (blue disk with white plus sign) icon.

Loading a Graphic Image into the Graphic Display Screen:

- Click on the **Get Image** button.
- This brings up the **Open** dialog box with a list of all the files in the MILDOS directory.
- Select the Bitmap (extension *.bmp) file you want to load. If the file is not listed, check to see if was saved in a different directory. Alternatively, simply type the path (if needed) and file name directly in the **File name** input field. Click **OK** to load the file into the Graphic Display Screen.
- If necessary, drag on the bottom right corner of Graphic Display Screen with the mouse to view the entire Graphic Image.

Setting the Origin and the Scale of the Graphic Image:

- With the left mouse button, click on the origin icon and drag it to the location on the Graphic Image that you want to use as the origin. This will usually be the location of the main processing plant.

- Click on one of the arrow icons and drag it to the zero anchor point of the scale bar. Make sure the point of the arrow is as close as possible to the zero anchor point.
- Click on the second arrow icon and drag it to another anchor point on the scale bar. Again, make sure the point of the arrow is as close as possible to the desired anchor point. The farther apart the arrows are, the better the resolution will be.
- In the Scale input field, enter the distance in kilometers between the two anchor points. The default distance is 1 km.
- Click on the **Set Scale** button.

Moving Sources and Receptors

- Place the mouse cursor over the number in the Receptor or Source icon that you wish to move.
- Hold the left mouse button down and drag the icon to the desired location on the Graphic Image.
- Release the mouse button. The new x and y coordinates of the Receptor or Source will be displayed in the upper right corner of the Graphic Display Screen. If you wish to move the Receptor or Source to a different location, repeat the above steps.
- A Receptor or Source location may also be moved by directly editing the x and y coordinates in the input screen for that Receptor or Source.

Editing Sources and Receptors from the Graphic Display Screen

- Select a Receptor or Source by placing the mouse cursor on the desired Receptor or Source icon and pressing the RIGHT mouse button.
- Edit the desired fields in the Receptor or Source input screen.
- Click on **Save** or **Close** in the input screen to confirm your edits. If you changed the x or y coordinates, the icon for that Receptor or Source will move accordingly.
- Receptors or Sources may be added by pressing the Receptor or Source button on the tool bar and pressing the **New** or **Copy** buttons. After adding Receptors or Sources, you may then move them to the desired location as indicated above or by using the mouse.
- Receptors or Sources may be deleted by pressing the Receptor or Source button on the tool bar, selecting the desired Receptor or Source in the name list, and pressing the **Delete** button.

Printing

- Setting up the Printer: MILDOS uses the standard windows printer. The setup for the printer can be accessed through the File/Printer/Setup menu option. Options include printer selection, paper size selection, and orientation selection.
- Printing: Press the print button in the Graphic Display Screen (NOT the printer icon in the tool bar). This will print a copy of the Graphic Display Screen on the selected printer.

Using the Toolbar

The toolbar allows the user to quickly access input screens for the following parameters:

Source Term specification. Up to 10 sources can be specified. There are the 4 standard MILDOS-AREA source types supplemented by 5 In-Situ Leaching source types.

Population Distribution specification.

Individual Receptor location

Time parameters for source and population dynamics

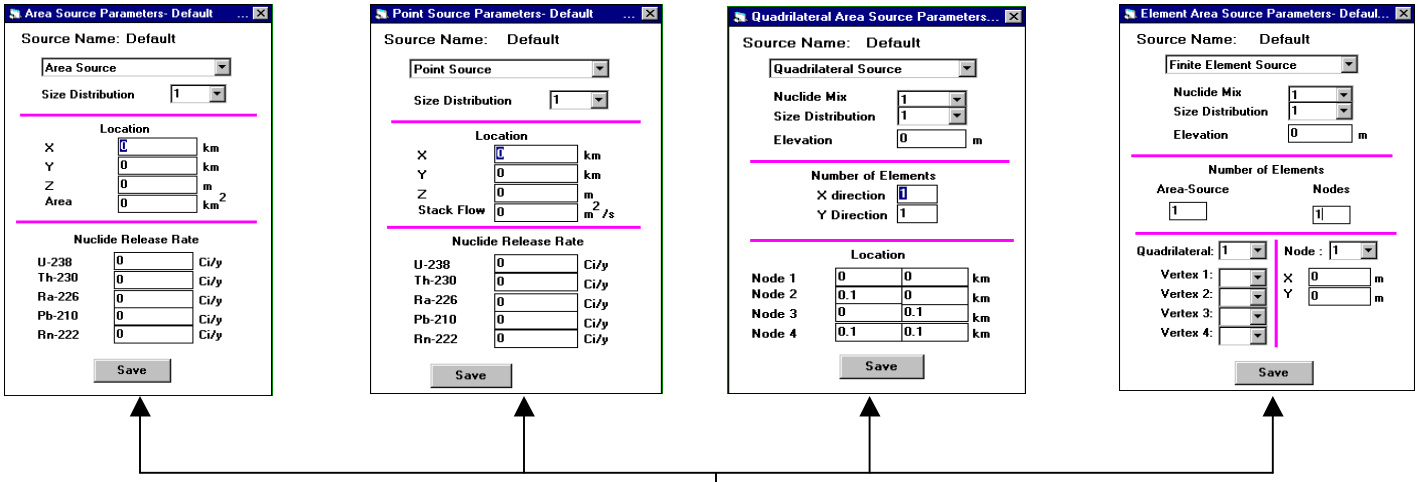
Food pathway parameters

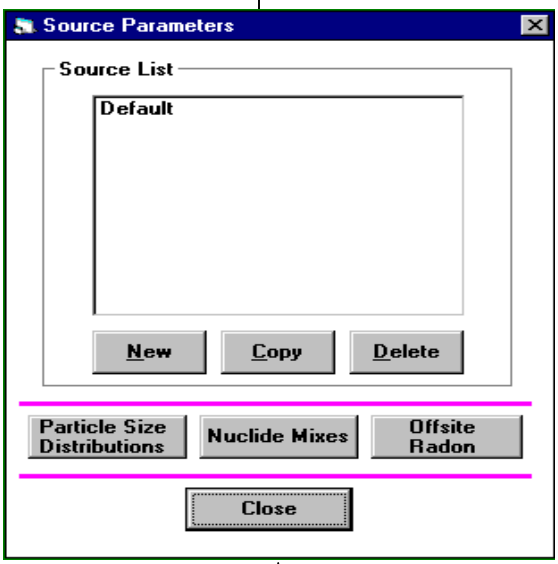
Meteorological parameters

Calculation options

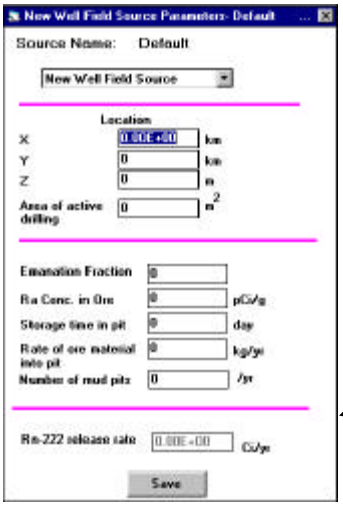
Navigation

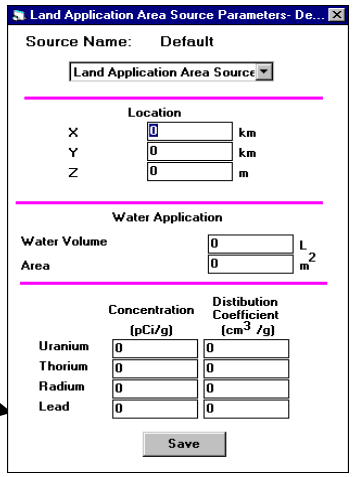
Source Types

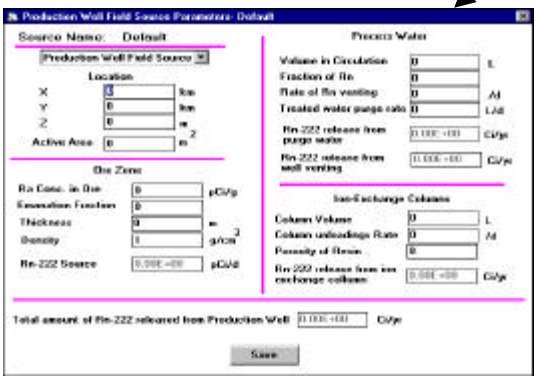


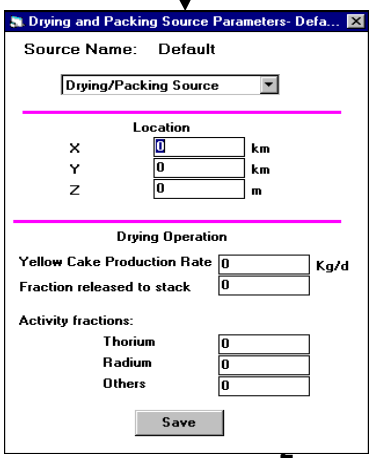


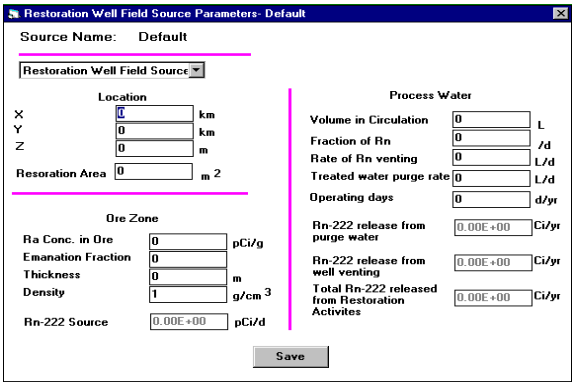
ISL Sources











Input Windows

There are 13 input windows to enter the parameters concerning site data, assumptions, problem identification, and calculation specifications. The following pages describe each screen in detail. Most input is through numerical entry into boxes, although some selections are through standard windows list boxes, check boxes, and option boxes. Some common features for all input windows:

Saving Information to Memory: There are two levels of saving information in MILDOS-AREA. In the first level, the information is temporarily saved to memory. This is done with any of the following commands.

- Function Keys: Press F10 key to save, ESC key to cancel
- On Window: Press Save Button to save, Cancel Button to cancel
- Menu: Select Form Options/Form Save from main menu to save, Form Options/Form Cancel to cancel
- ToolBar: Press the Folder Button to save; the Canceled Folder Button to cancel

Saving Information to File: The second level is to save the settings to a disk file. This is done with any of the following commands.

- Menu: Select File/Save or Save As
- ToolBar: Press the Disk Button to save to a file
- Run: the file must be saved to disk before a run. Follow prompts to save in desired place.

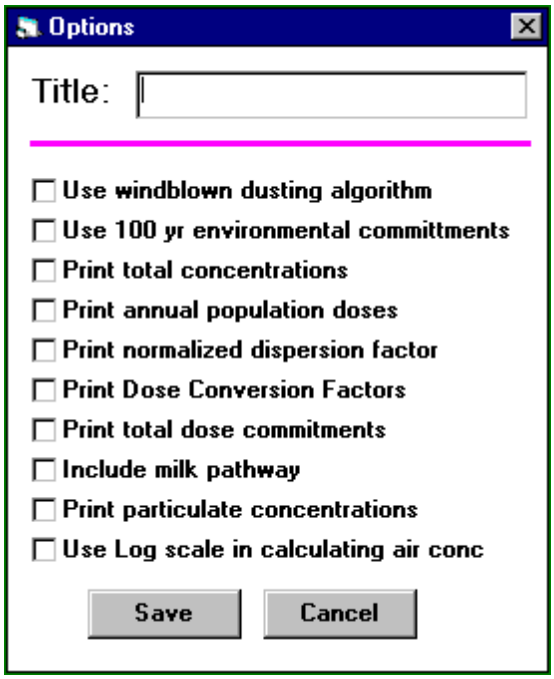
Numerical Entries: (Some entry boxes may be grayed out because they are not applicable to the current case)

Defaults: To set the selected parameter back to its default either select Form Options/Default from the main menu or press the F6 function key.

Bounds: To set the selected parameter to its upper (or lower) bound either select the Form Options/Upper Bound(Lower Bound) from the main menu or press the F7 (F5) function key.

Help: Context specific help will be shown anytime the F2 function key is pressed. For further sources of help, please refer to the Extensions & Help section of this chapter.

Options



Title: text to describe the problem being modeled. This text will appear at the top of each report page.

Options: clicking in the box next to each option box will select or deselect that option. If selected,

- **Use windblown dusting algorithm:** uses the internal windblown dusting-rate algorithm in calculating all sources. If deselected, the default dusting values are used.
- **Use 100-year environmental commitments:** computes the 100-year environmental dose commitments. If deselected, the annual population dose commitments are computed.
- **Print total concentration:** prints total air concentrations (pCi/m3), ground concentrations (pCi/m3), and total deposition rates (pCi/m2 s) for each spatial interval. If deselected, no total concentrations are printed.
- **Print annual population dose:** prints annual population dose for each spatial interval. Reports are printed for each pathway and organ. If deselected, then only a summary table is printed for the population within 80 km and the extraregional population.
- **Print normalized dispersion factor:** prints the normalized dispersion-factor (X/Q) arrays. The output include the air concentration normalized by the release rate of U-238 for each source, receptor, and particle size and for Rn-222 and six daughters for each source and receptor. The units are: [pCi/m3 (air concentration)/pCi/s (release rate)]. This option will generate lengthy output when several sources and receptor locations are specified. If deselected, no normalized dispersion factors are printed.
- **Print dose conversion factors:** prints a table of dose conversion factors for various pathways, organs, and isotopes. Other information printed includes particle sizes, density, age groups, environmental concentration factors, and time-step dependent variables. If deselected, no dose conversion factors are printed.

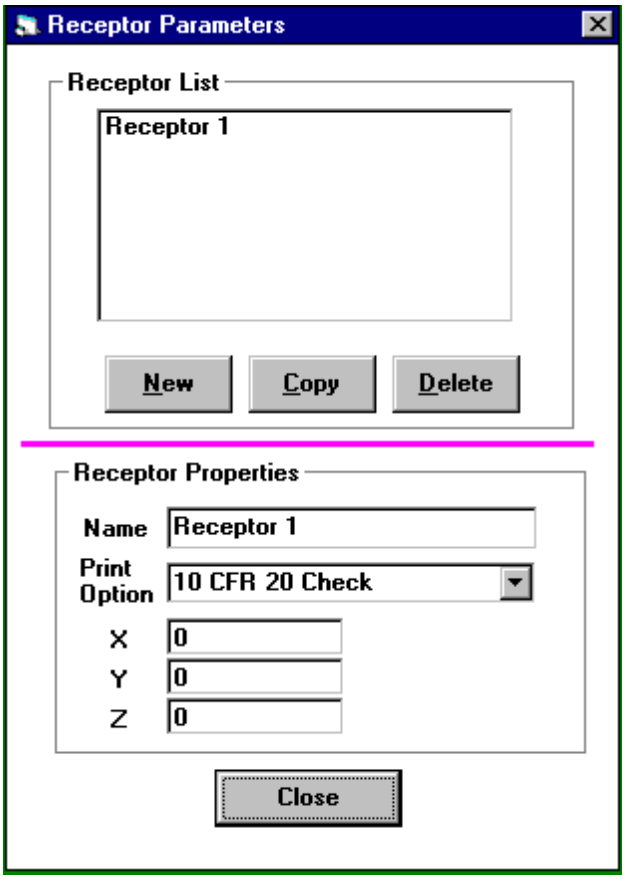
- **Print total dose commitments:** prints total dose commitments (mrem/yr) and 40 CFR 190 dose commitments by age group, pathway, and organ for each receptor location and time step. If deselected, the pathway data are not printed, and only total dose commitments are printed for each location. This parameter overrides report requests made through the **Receptor Parameters** input screen. If a full dose printout for any receptor location is desired, this option must be selected.

- **Include milk pathway:** includes the milk pathway in the calculation of doses at receptor locations. If deselected, the milk pathway is not included or printed.

- **Print particulate concentration:** prints particulate concentrations for air (pCi/m3) and ground (pCi//m2) at each receptor location. In addition, particle size data for particulates (U-238, Th-230, Ra-226, and Pb-210) concentrations of radon and daughters (Rn-222, Po-218, Pb-214, Bi-214, Pb-210, Bi-210, and Po-210), and ground concentrations from radon daughters (Po-218, Pb-214, Bi-214, and Po-210) are printed. If deselected, no normalized dispersion factors are printed.

- **Use log scale in calculating air concentration:** computes the radial dependence of air concentrations in logarithmic increments. If deselected, linear increments are used.

Receptor Parameters



Receptor List: click on the name of a receptor to select it and enter or modify the parameters for that receptor. Up to 48 receptors and their properties may be defined. You may click on the buttons to obtain the following results:

- **New:** adds a new receptor with the default name, print options and location.
- **Copy:** makes a copy of the selected receptor's properties. These may then be modified.
- **Delete:** removes the selected receptor from the Receptor List.

Receptor Properties: enter the name and coordinates of the selected receptor location. Select one of four print options.

- **Name:** enter text that will identify the receptor.
- **Print Option:** use the pull-down menu to select one of the following options:
  - **Suppress:** suppresses printing of doses.
  - **10 CFR 20 Check:** performs a compliance check with 10CFR 20 on radionuclide allowable concentrations (pCi/m3) and prints a report. The allowable concentrations (ALC) are solubility class dependent. The most conservative ALC values listed in the revised 10 CFR Part 20 are included in the MILDOS computer code as the defaults. The MILDOS computer code calculates the fractions of the allowable concentrations for all output radionuclides. For radon gas emissions, a value of 1/900 working level (WL) is used as the effluent concentrations for the short-lived radon daughters.
  - **Totaled Doses:** prints total doses over all pathways.

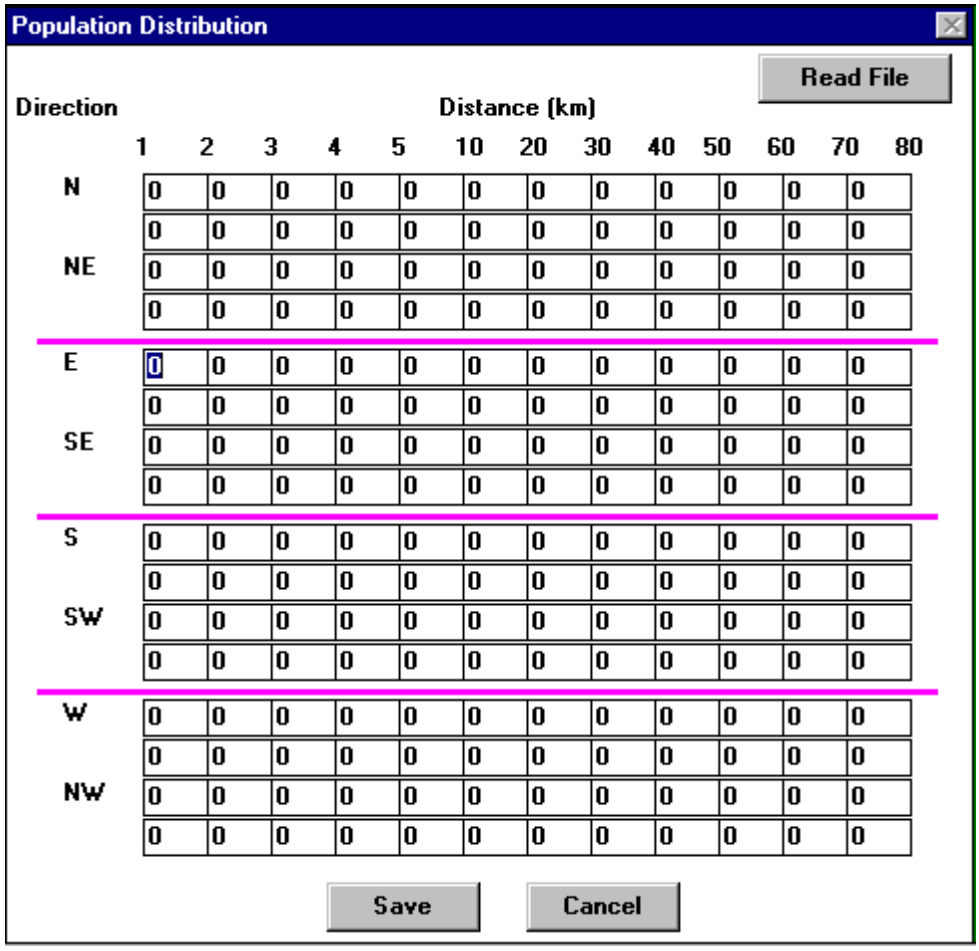
- **Pathway Doses:** prints doses by exposure pathway and total doses and this option also should include the calculation of doses by exposure pathways, i.e., **Print total dose commitments** should be selected in the **Options** menu.

If either **Totaled Doses** or **Pathway Doses** is selected, reports are printed for total dose commitments and for 10 CFR 190 dose commitments.

For each receptor location, enter the coordinates as:

- **X:** distance (km) of the receptor to the east (positive value) or west (negative value) of the origin.
- **Y:** distance (km) of the receptor to the north (positive value) or south (negative value) of the origin.
- **Z:** elevation (m) of the receptor above (positive) or below (negative) the elevation of the origin.

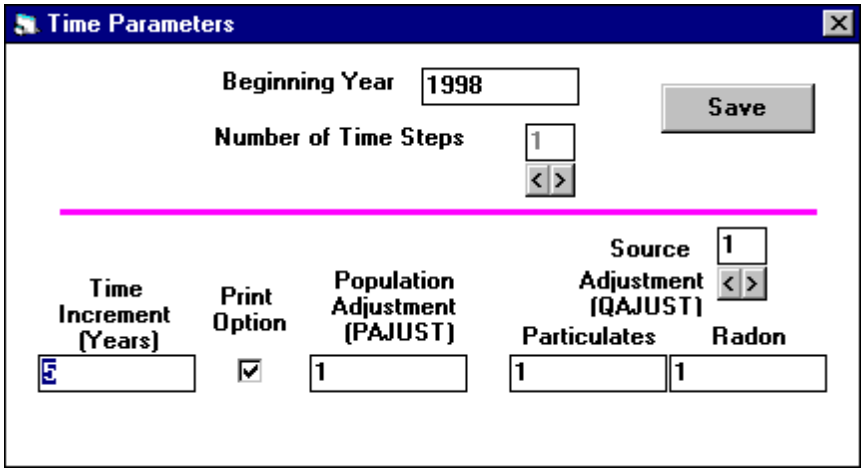
Population Distribution



Population data may be entered directly in this screen or retrieved from an existing population array file. Clicking the **Read File** button will bring up an **Open** file selection dialog box listing available population files with extension *.POP in the current directory. An appropriate population file must be available on this or another directory. Otherwise, population data may be entered in the following format:

Input fields are arranged in an array of 12 annuli (distance bins) from 1 km to 80 km and 16 directions (sectors) starting north of the origin and going clockwise around the compass. In each input field enter the population of the spatial interval defined by the distance interval (column heading) and the direction (row heading).

Time Parameters



Beginning year
Number of time steps, max is 10
Source, max allowed 99?
Time increment, yrs
Print option?
Population adjustment (PAJUST)
Source adjustment (QAJUST) for particulates and Radon

Beginning Year: year effluent releases begin, e.g., 1998. Fractional values (non-integer) are used to account for startup during a year, e.g., 1998.5 would indicate startup at the beginning of July 1998.

Number of Time Steps: number of time steps for which the calculations are required. This is done by pressing the forward or backward arrow buttons until the required number (between 1 and 10) appears in the box. This parameter specifies the number of **Time Increments** (defined below) that will be entered. Together, these parameters are used to define the facility lifetime.

Time Increment: interval in years for each time step. As an example, assume the **Beginning Year** is set to 1998, the **Number of Time Steps** is set to 2, and the first and second **Time Increment** are set to 5 and 10 years, respectively. Calculations will be performed for the year 1998, 2003, and 2013.

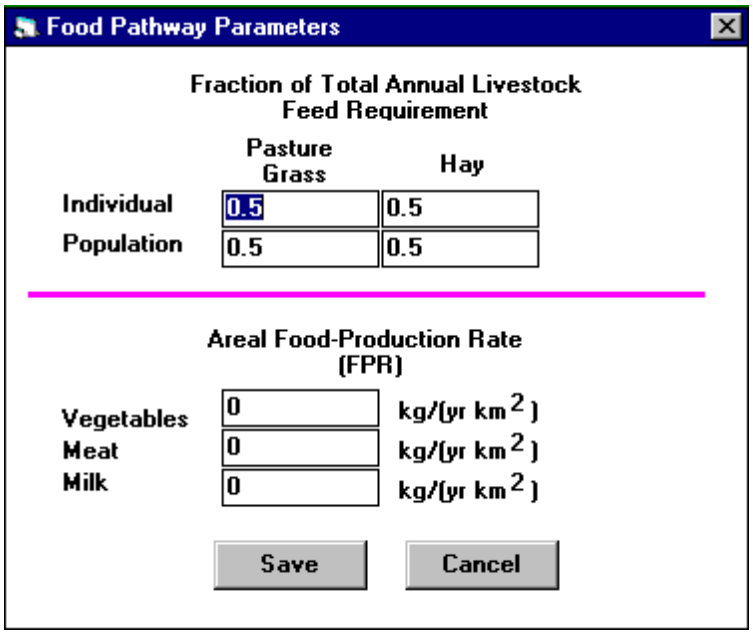
Print Option: clicking the box to the right of a **Time Increment** selects or deselects the calculation and printing of doses for that time step. The doses are always calculated and printed for the **Beginning Year**.

Population Adjustment (PAJUST): ratio of the U.S. population during a particular **Time Step** to that during the year 1980. A positive value must be given for each time step in order to obtain the proper continental population doses as a function of the time exposure. The default value of 1 does not adjust for population changes. A value greater than one or less than one indicates an increase or decrease of the population, respectively.

Source Adjustment (QAJUST): factor for multiplying the input source strength of a particular source to get the desired source strength of that source for duration of a given

time step for particulates and for radon. This must be specified for each source by typing, or selecting with the arrow buttons, the source number for which the adjustments will apply. Then, for each **Time Increment**, specify a zero or positive value for the release of particulates and radon from that source. A value of zero indicates no releases from that source. A value between zero and one indicates a reduction in the annual release. A value of one indicates no change in the annual release. A value greater than one indicates an increase in the annual release.

Food Pathway Parameters



Agricultural production parameters are entered in this screen as follows:

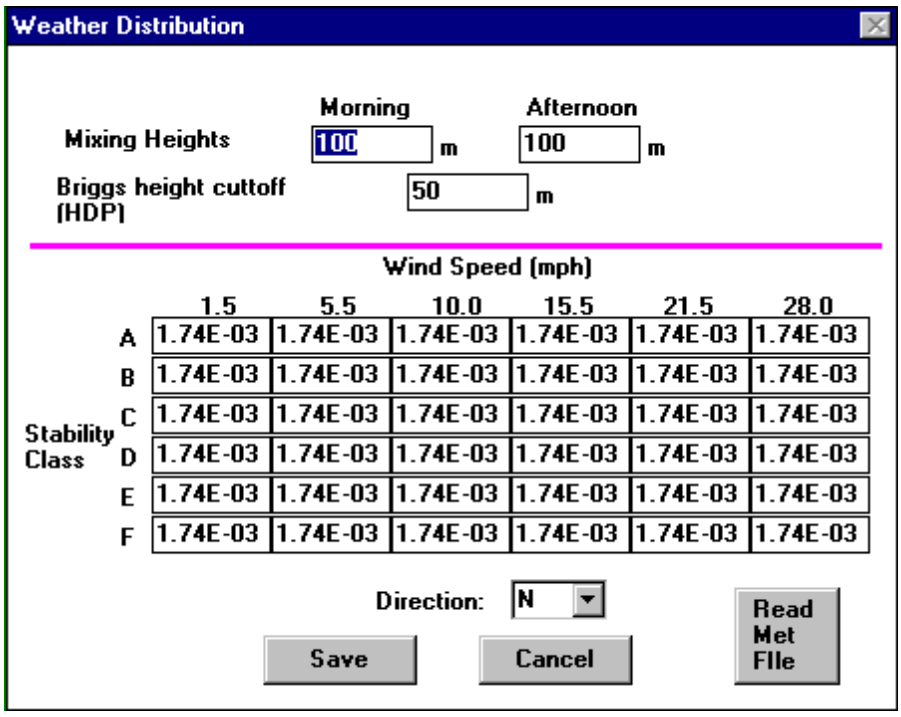
Fraction Of Total Annual Livestock Feed Requirement

- **Pasture Grass/Individual:** fraction of total annual livestock feed requirements assumed to be satisfied by pasture grass, for use in calculating individual doses. Default value is 0.5.
- **Pasture Grass/Population:** fraction of total annual livestock feed requirements assumed to be satisfied by pasture grass, for use in calculating population doses. Default value is 0.5.
- **Hay/Individual:** fraction of annual livestock feed requirements assumed to be satisfied by locally grown stored feed, for use in calculating individual doses. Default value is 0.5.
- **Hay/Population:** fraction of annual livestock feed requirements assumed to be satisfied by locally grown stored feed, for use in calculating population doses. Default value is 0.5.

Areal food-production rate (FPR): food production rates per unit area in the region around the facility. All defaults values are zero.

- **Vegetables:** areal food production rate for vegetables (kg/yr km2).
- **Meat:** areal food production rate for meat (kg/yr km2).
- **Milk:** areal food production rate for milk (L/yr km2).

Meteorological Parameters



The meteorological parameters consist of defining the annual average mixing heights and the wind speed and atmospheric stability distribution.

Mixing Heights: annual average **Morning** and **Afternoon** atmospheric mixing height in meters. The default value is 100 m for both.

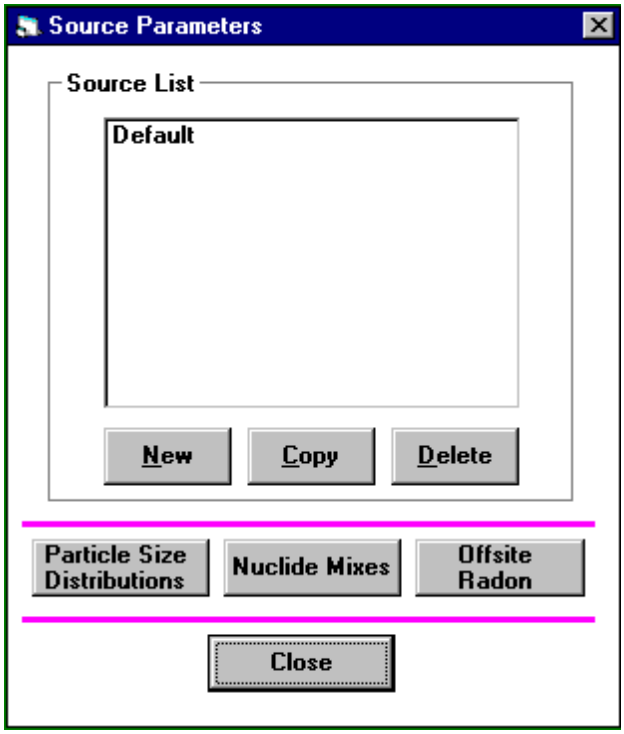
Briggs height cutoff (HDP): source height in meters below which the Martin-Tickvart (rather than Briggs) vertical dispersion coefficients are used. The default is 50 meters.

The fractional joint frequency of occurrence of wind from one of 16 directions, in one of six wind speed classes, and in one of six atmospheric stability classes, may be entered directly or by reading a Stability Array (STR) file. Values should be derived from data taken at a height of 10 m or less. Clicking the **Read Met File** button will bring up an **Open** file selection dialog box listing available joint frequency distribution files with extension *.STR in the current directory. An appropriate file must be available on this or another directory. Otherwise, meteorological data may be entered in the following format:

- Select the direction the wind is blowing from by clicking on the pull-down menu. Use the scroll bar if the direction required is not visible.
- For each direction, enter the fraction of a year that the wind is blowing at one of six average **Wind Speeds** (columns, 1.5-28.0 miles per hour) and under one of six **Stability Classes** (rows A-F).

Each entry must be a number greater than or equal to zero. The sum of all entries in the 6x6x16 array must sum one.

Source Parameters



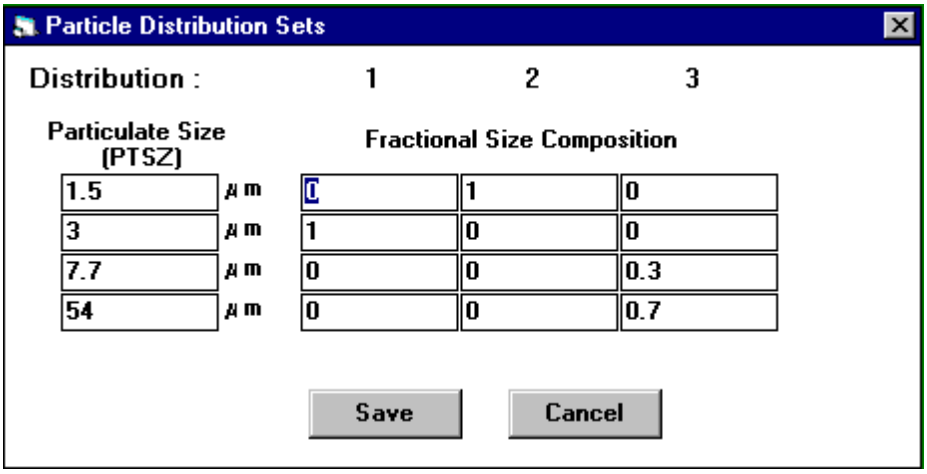
Source List: Click on the name of a source to select it or double-click on the name to modify or view the source properties. If specifying a new source, type a name for this source and then double-click on the name to enter the source specification and parameters. Up to 10 sources and their properties may be defined. You may click on the buttons below the **Source List** to obtain the following results:

- **New:** adds a new source with the default name and location.
- **Copy:** makes a copy of the selected source's properties. These may then be modified.
- **Delete:** removes the selected source from the **Source List**.

Within a source window, specify the **Source Type**. The MILDOS-AREA computer code supports nine different sources, which can be specified by selecting one of the following source types from the pull-down menu. These are point source, area source, quadrilateral source, fine-element source, land application area source, new well field source, production well field source, drying and packaging source, and restoration well field source. Refer to the appropriate page in this user's guide for help on entering data specific to one of the nine source types.

The following pages describe how to specify **Particle Size Distributions**, **Nuclide Mixes**, and **Offsite Radon**.

Particle Size Distributions



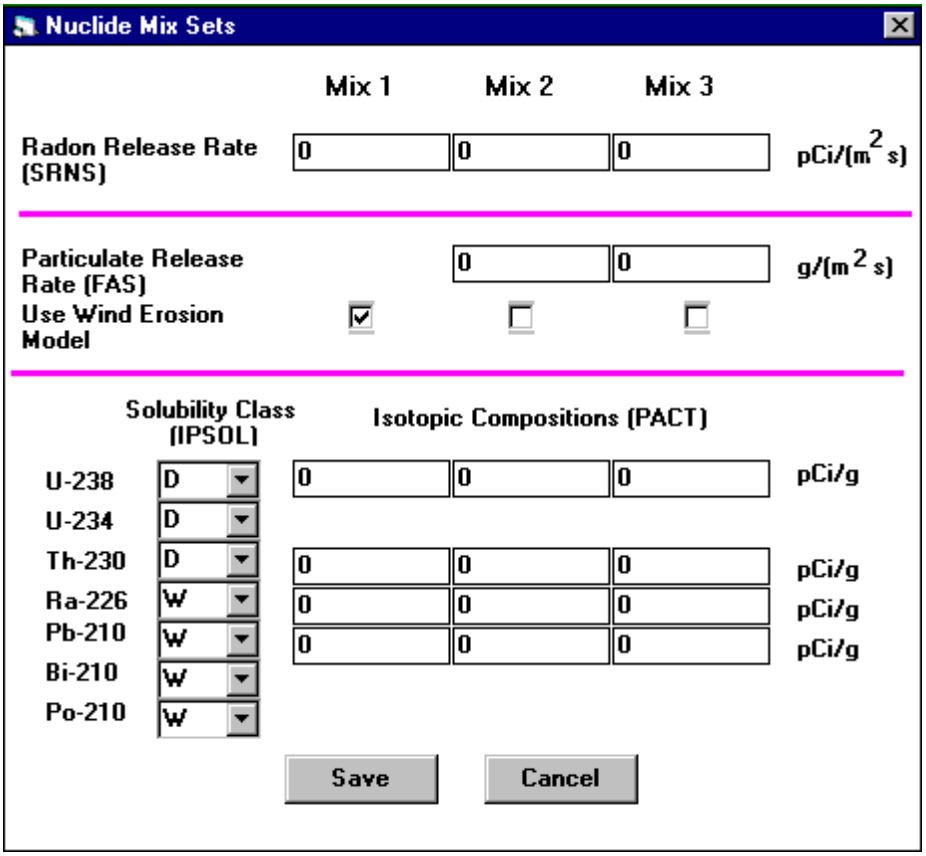
Clicking on the **Particle Size Distributions** button in the **Source Parameters** window opens a window where the particle distribution sets that will be used for a source may be specified. Up to three particle-size distribution sets are available. Set number one is assigned to the yellowcake dryer packaging or equivalent source type. Set number 2 is assigned for the crushers, grinders, rod mills, conveyers, fine-ore blending, and other mill-process source types. Set number 3 is assigned to tailings and ore-storage piles source types. Both the default **Particle Size** and the **Fractional Size Distribution** may be modified if a source releases particles with different sizes or distributions. These parameters do not apply to ISL source types.

Particle Size (PTSZ): defines up to four AMADs (um) per distribution set. Default particle size values are 1.5, 3.0, 7.7, and 54 um. A fifth particle size set is reserved for radon-daughter-attached aerosols with an AMAD of 0.3 um, and cannot be accessed or modified.

Fractional Size Distribution: assigns distributions for the four AMADs and three distribution sets. The total fraction within each set must equal one. Defaults for the three distribution sets are:

- **Set 1**: 0, 1.0, 0, 0
- **Set 2**: 1.0, 0, 0, 0
- **Set 3**: 0, 0, 0.3, 0.7

Nuclide Mix Sets



Clicking on the **Nuclide Mixes** button in the **Source Parameters** window opens a window where the nuclide mix sets that will be used for a source may be specified. Up to three nuclide sets are available. These parameters are only used for quadrilateral or finite element area sources. They are not used for point, area or ISL source types.

Radon Release Rate (SRNS): defines up to three radon release rates (corresponding to the three **Isotopic Compositions**) for characterizing radon releases in pCi/m^2 s.

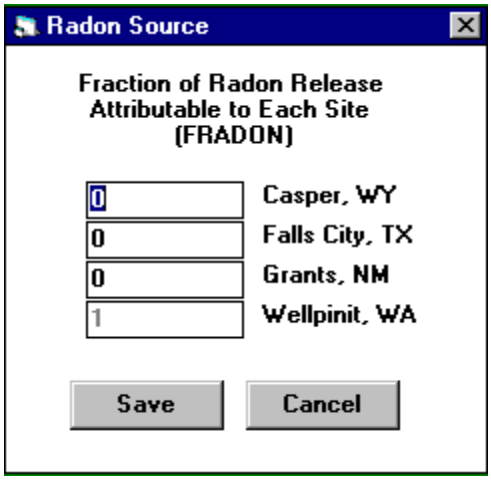
Particulate Release Rate (FAS): defines up to three particulates release rates (corresponding to the three **Isotopic Compositions**) for characterizing particulate releases in g/m^2 s.

Use Wind Erosion Model: If one or more box is selected (checked), the code overrides the value entered in the **Particulate Release Rate** for that mix set. A code-generated wind-erosion source term will then be used for particulate releases in that mix set. Deselecting the box will re-enable input of the **Particulate Release Rate**.

Isotopic Compositions (PACT): defines up to three isotopic composition mixes for characterizing area-source particulate releases. Enter the activity (pCi/g) for each radionuclide in a nuclide mix.

Solubility Class (IPSOL): defines the solubility classes for each radionuclide. The solubility classes used to specify the inhalation dose factors are D, W, and Y. The default solubility class may be changed by clicking on the arrow next to the radionuclide and selecting the appropriate value.

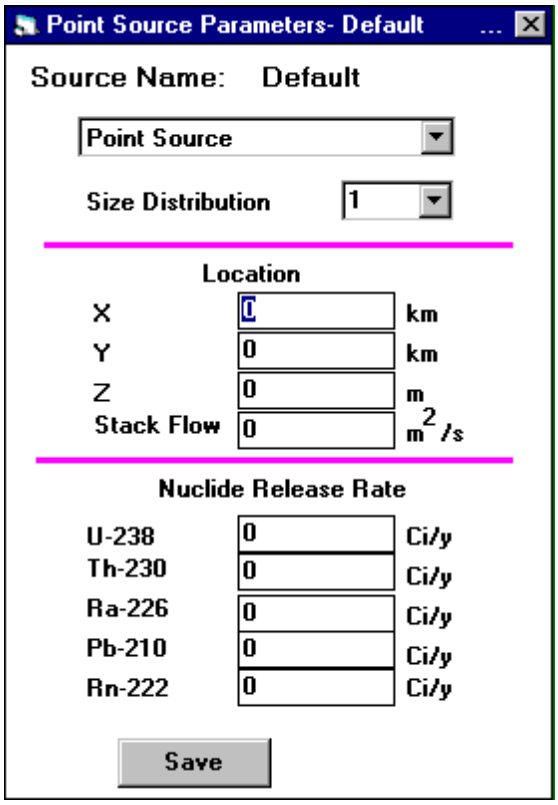
Off-Site Radon Source



Clicking on the **Offsite Radon** button in the **Source Parameters** window opens a window where the fraction of radon from offsite sources may be entered.

Fraction of Radon Release Attributable to Each Site (FRADON): fraction of radon releases for which doses beyond 80 km are calculated using dose/kCi coefficient for each of four release points. Four values for **FRADON** are allowed in MILDOS computer code. The sum of these fractions must equal one.

Point Source Parameters



Size Distribution: use the pull-down menu to select one of three **Particle Distributions Sets**.

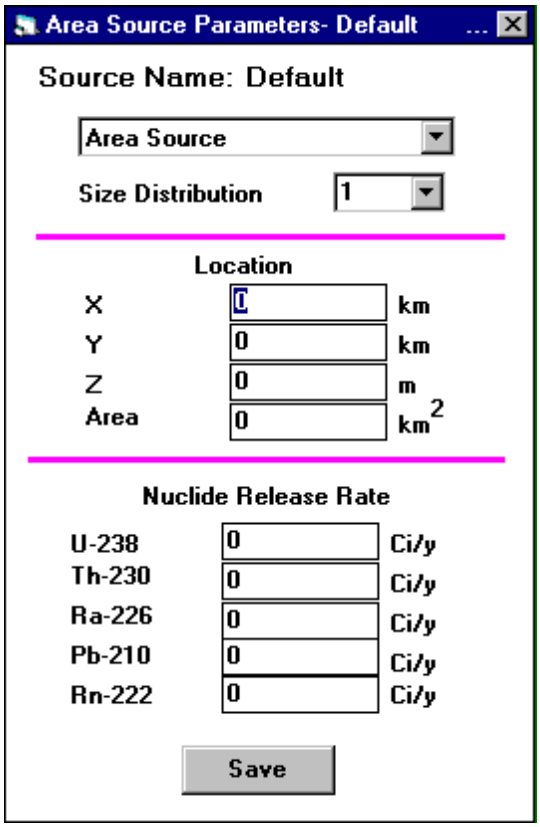
Location: enter the coordinates as:

- **X:** distance (km) of the source to the east (positive value) or west (negative value) of the origin.
- **Y:** distance (km) of the source to the north (positive value) or south (negative value) of the origin.
- **Z:** elevation (m) of the source above (positive) or below (negative) the elevation of the origin.

Stack Flow: product of stack input diameter (m) and effluent exit velocity (m/s) for the source, in m^2/s.

Nuclide Release Rate: annual average release rate (Ci/yr) from the source of U-238, Th-230, Ra-226, Pb-210, and Rn-222.

Area Source Parameters



Size Distribution: use the pull-down menu to select one of three **Particle Distributions Sets**.

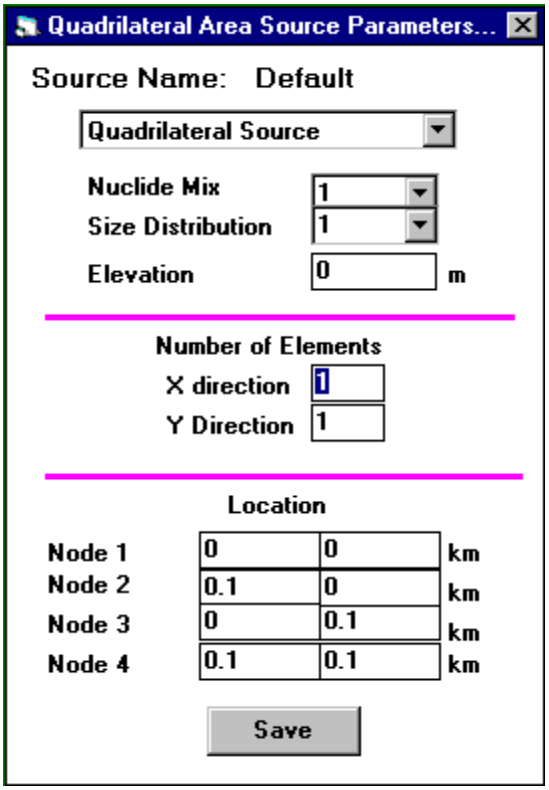
Location: enter the coordinates as:

- **X:** distance (km) of the source to the east (positive value) or west (negative value) of the origin.
- **Y:** distance (km) of the source to the north (positive value) or south (negative value) of the origin.
- **Z:** elevation (m) of the source above (positive) or below (negative) the elevation of the origin.

Area: areal dimensions of the source (km^2).

Nuclide Release Rate: annual average release rate (Ci/yr) from the source of U-238, Th-230, Ra-226, Pb-210, and Rn-222.

Quadrilateral Area Source Parameters



Nuclide Mix: use the pull-down menu to select one of three **Nuclide Mix Sets**.

Size Distribution: use the pull-down menu to select one of three **Particle Distributions Sets**.

Elevation: enter the elevation (m) of the source above (positive) or below (negative) the elevation of the origin.

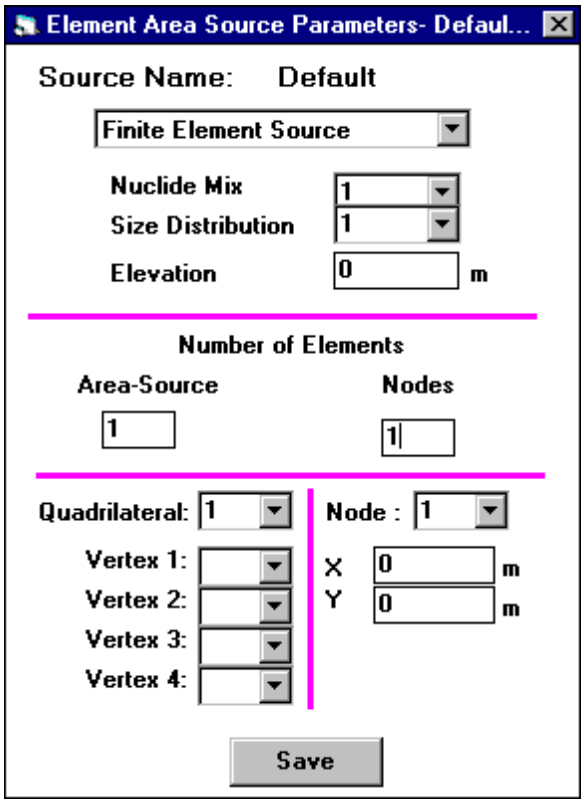
Number of Elements: used in an automeshing algorithm for the quadrilateral source:

- **X direction**: number of elements in X (E-W) or approximate X
- **Y direction**: number of elements in y (N-S) or approximately y direction.

Location: for each of **Node 1-4** provide the vertex coordinates of the quadrilateral source in km.

- First column: x coordinate of the vertex for that node.
- Second column: y coordinate of the vertex for that node.

Element Area Source Parameters



Nuclide Mix: use the pull-down menu to select one of three **Nuclide Mix Sets**.

Size Distribution: use the pull-down menu to select one of three **Particle Distributions Sets**.

Elevation: enter the elevation (m) of the source above (positive) or below (negative) the elevation of the origin.

Number of Elements: enter the number of **Area-Source** (Quadrilateral) elements and the number of **Nodes**. Up to a maximum of 300 nodes may be entered.

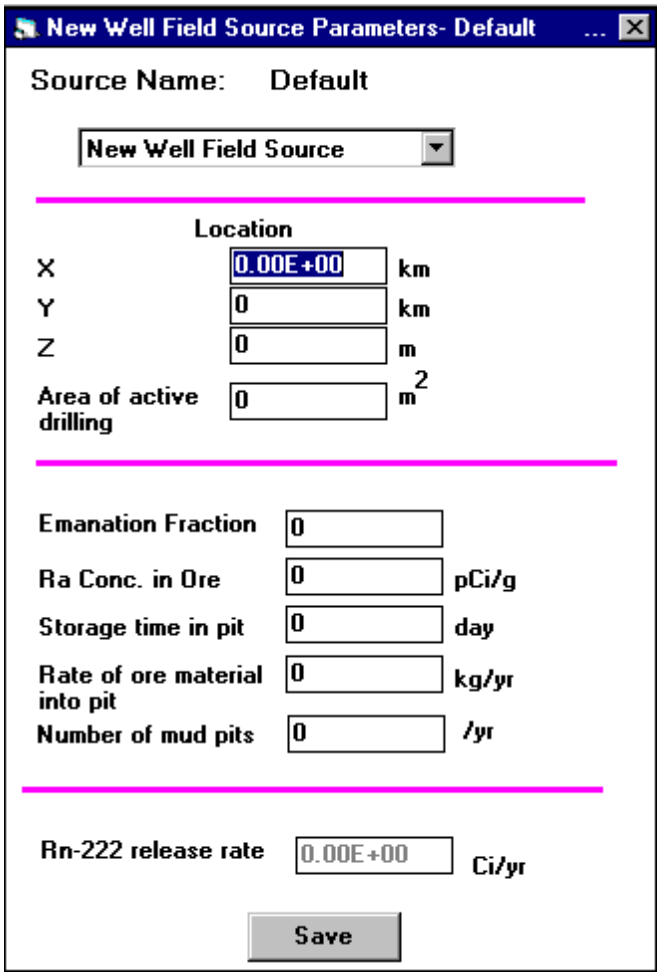
Quadrilateral:: use the pull-down menu to select one of the area sources (1-*i*, where *i* is the number of **Area-Source** elements entered).

Vertex: for each of 4 vertexes 1, 2, 3, and 4, use the pull-down menu to select the node number (1-*n*, where *n* is the number of **Nodes** entered)

Node: for each of node 1-*n* provide the vertex coordinates in m.

- **X**: x coordinate for that node.
- **Y**: y coordinate for that node.

New Well Field Source Parameters



Conventional rotary rigs are commonly employed for all drilling activities at an ISL facility. Because all exploration drill holes are drilled by using and are sealed with high-viscosity bentonitic mud to maintain aquifer isolation, no particulates are expected to be released during drilling operations. The only source of radioactive release is the Rn-222 from radium-containing ore cuttings temporarily stored in the mud pit. During the period when the ore cuttings are awaiting disposal while stored in a mud-pit, radioactive decay of Ra-226 is producing radon continuously.

Location: enter the coordinates as:

- **X:** distance (km) of the source to the east (positive value) or west (negative value) of the origin.
- **Y:** distance (km) of the source to the north (positive value) or south (negative value) of the origin.
- **Z:** elevation (m) of the source above (positive) or below (negative) the elevation of the origin.

Area of Active Drilling: area in m^2 of the ore zone that is being developed.

Emanation Fraction: fraction of the total radon generated by radium decay that escapes from the soil particles. Observed values range from about 0.01 to 1.0. The emanating power is dependent upon on many factors, such as mineralogy, porosity, particle size distribution, and moisture content. For soils with low moisture content a typical value is around 0.25.

Radium Concentration in Ore: concentration in pCi/g of the Ra-226 in the ore that is used to estimate the amount of Rn-222 generated by radioactive decay.

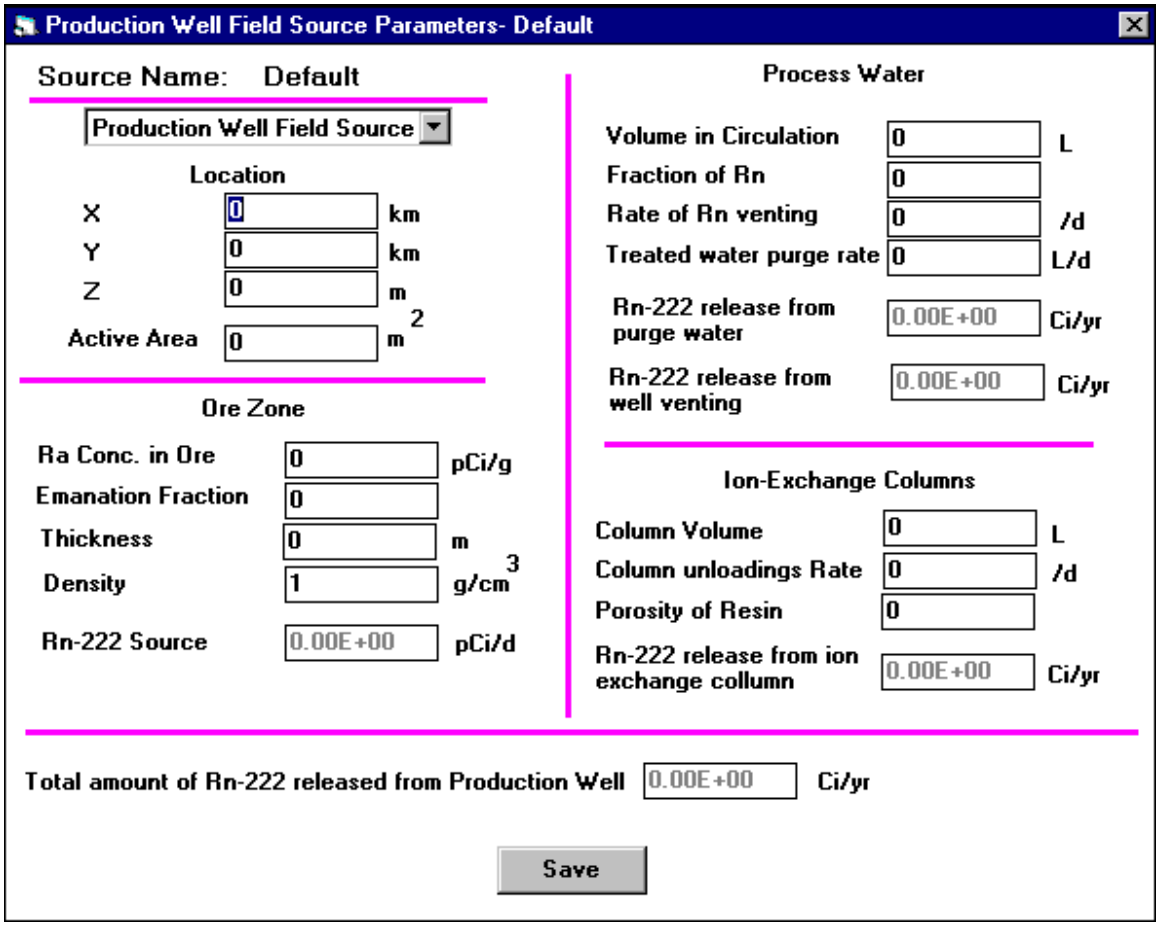
Storage Time in Pit: average number of days between the time the well cuttings are placed in the mud pit and the time at which these cuttings are disposed.

Rate of Ore Material into Pit: rate in kg/year at which ore material is placed in a mud pit.

Number Of Mud Pits: number of mud pits generated in a year.

Rn-222 Release Rate: calculated release rate of radon-222 in Ci/yr from the mud pits.

Production Well Field Source Parameters



No particulate materials are expected to be released from the production well field because its process streams, from production and injection wells to ion-exchange (IX) columns in the satellite facility, are all in a closed-loop circuit. The primary radioactive emission from the process streams of the production well field is Rn-222 gas. In an ISL production well field, the radon released from the ore body is readily removed by the process water moving through the well field by injection and production wells.

Location: enter the coordinates as:

- **X:** distance (km) of the source to the east (positive value) or west (negative value) of the origin.
- **Y:** distance (km) of the source to the north (positive value) or south (negative value) of the origin.
- **Z:** elevation (m) of the source above (positive) or below (negative) the elevation of the origin.

Active Area: area in m^2 of the ore zone that is being mined.

Radium Concentration in Ore: concentration in pCi/g of the Ra-226 in the ore that is used to estimate the amount of Rn-222 generated by radioactive decay.

Emanation Fraction: fraction of the total radon generated by radium decay that escapes from the soil particles. Observed values range from about 0.01 to 1.0. The emanating power is dependent upon on many factors, such as mineralogy, porosity, particle size distribution, and moisture content. For soils with low moisture content a typical value is around 0.25.

Thickness: average thickness in meters of the ore zone that is being mined.

Density: dry bulk density of the ore material in g/cm^3.

Volume in Circulation: total volume in liters of process water that is actively circulating between injection wells, extraction wells, and ion exchange columns.

Fraction of Radon: fraction of the radon that is carried by circulating water. The balance of the fraction of radon in the mined area that is not swept in the injection-extraction well loop and remains trapped in the ore zone.

Rate of Radon Venting: fractional daily rate of radon release due to occasional venting from wellheads, valves and leaking transport piping during circulation.

Treated Water Purge Rate: rate in liters/day at which treated water is purged from the system. The purge in the production well field is necessary to maintain a hydraulic cone of depression around each well field to prevent leakage of mining solutions outside the production zone.

Water Discharge Rate: rate in liters/day at which water is discharged from unloading the resin in the ion exchange columns. Note: this is a calculated quantity derived from the product of the following three parameters. If the user enters a value for this parameter it should override the next three input fields.

Column Volume: volume in liters of the space in the ion exchange columns occupied by resin.

Column Unloading Rate: average daily number of times the ion exchange columns are unloaded.

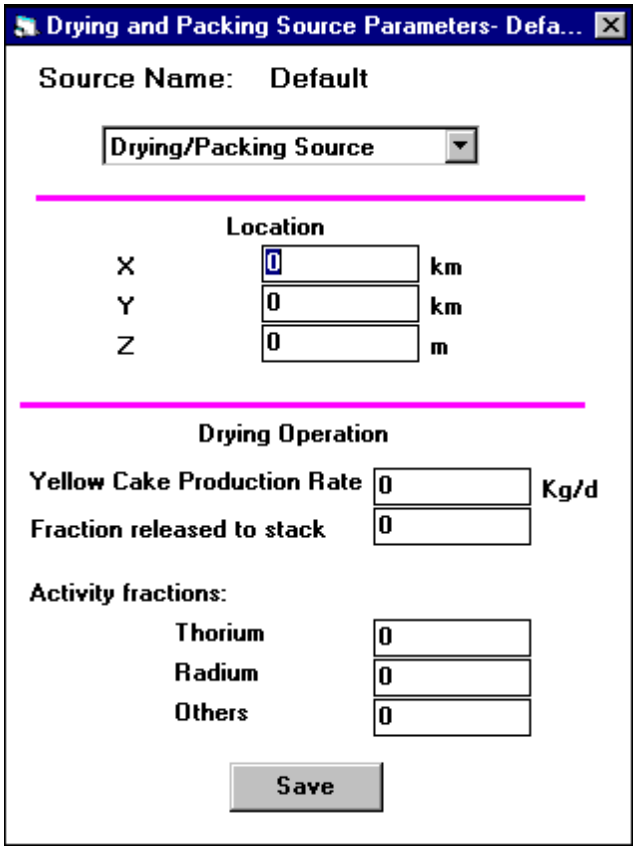
Porosity of Resin: porosity of the ion exchange resin material. This is the fraction of the ion exchange resin volume that is occupied by process water.

Radon-222 Source: calculated release rate of radon-222 to the circulating water in pCi/d.

Radon-222 Release from Purge Water, Well Venting, Ion Exchange Column: calculated release rate of radon-222 in Ci/yr from these sources.

Total Amount of Radon-222 Released from Production Well Field: sum of the release rate of radon-222 from purge water, well venting, and ion exchange columns in Ci/yr.

Drying and Packaging Source Parameters



For facilities using rotary vacuum dryers for processing yellow cake, no particulate emissions are expected under normal operating conditions. For facilities using thermal drying, stack release may be estimated on the basis of information provided by a number of operating ISL uranium recovery facilities. Although more data are needed, the stack release of yellow cake has been estimated to be about 0.05% of the amount produced. However, because the day-to-day variations of particulate release rates can vary by several times, the assumption is that 0.1% of the uranium produced escapes as particulates into the atmosphere, as suggested in the Final Generic Environmental Impact Statement on Uranium Milling.

The particulate release of nuclides other than uranium isotopes is estimated by grab samples reported by ISL facilities. On the basis of the field measurements, the conservative assumption is that the activities of thorium (0.15-0.4 % of measured values), radium (0.2-0.3%), lead, polonium, and its decay progeny are 0.5% of the U-238 activity in the yellow cake. Furthermore, it may be assumed that the fraction of this activity that is released is the same as the fraction of uranium (0.1%) that is released.

Location: enter the coordinates as:

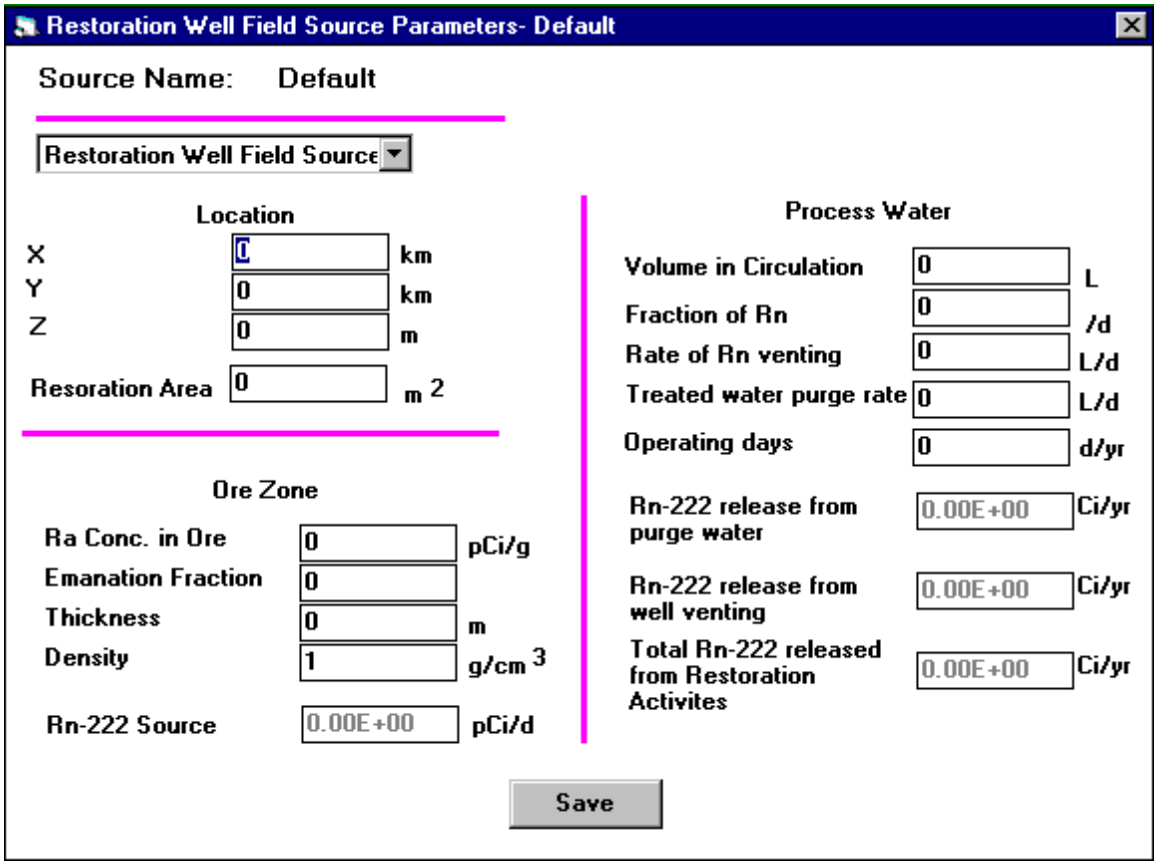
- **X:** distance (km) of the source to the east (positive value) or west (negative value) of the origin.
- **Y:** distance (km) of the source to the north (positive value) or south (negative value) of the origin.
- **Z**: elevation (m) of the source above (positive) or below (negative) the elevation of the origin.

Yellow Cake Production Rate: average amount of yellow cake (U_3O_8) in kg that is produced daily at the facility.

Fraction Released to Stack: fraction of yellow cake produced that is released from the stack. A typical value may range from 0.0005 to 0.001. This fraction is applied to the Yellow Cake Production Rate to estimate the activity of U-238 released from the stack.

Activity Fractions (Thorium, Radium and Other Radionuclides): fraction representing the activity present in the yellow cake from thorium, radium and other radionuclides divided by the activity of U-238 in the yellow cake. Typical values range from 0.0015 to 0.005. The **Fraction Released to Stack** is applied to the **Activity Fraction** to obtain the activity of each radionuclide that is released from the stack.

Restoration Well Field Source Parameters



The basic operating processes of the restoration well field are similar to those of the production well field. Groundwater affected by leaching processes in the production well fields is restored to its pre-mining levels (1) by the "pump and treat" (groundwater sweep) method and by flushing with fresh water injection, and (2) by using the permeative stream from reverse-osmosis treatment units. Like the production well field, no particulate materials are expected to be released from the restoration well field operations. The primary source of radioactive release is the Rn-222 gas in the process water circulating within and discharged from the restoration operations. The annual Rn-222 releases from a restoration well field therefore can be calculated using the same methodology applied to a production well field.

Location: enter the coordinates as:

- **X:** distance (km) of the source to the east (positive value) or west (negative value) of the origin.
- **Y:** distance (km) of the source to the north (positive value) or south (negative value) of the origin.
- **Z:** elevation (m) of the source above (positive) or below (negative) the elevation of the origin.

Restoration Area: area in m^2 of the ore zone that is being restored.

Radium Concentration in Ore: concentration in pCi/g of the Ra-226 in the ore that is used to estimate the amount of Rn-222 generated by radioactive decay.

Emanation Fraction: fraction of the total radon generated by radium decay that escapes from the soil particles. Observed values range from about 0.01 to 1.0. The emanating power is dependent upon on

many factors, such as mineralogy, porosity, particle size distribution, and moisture content. For soils with low moisture content a typical value is around 0.25.

Thickness: average thickness in meters of the ore zone that is being mined.

Density: dry bulk density of the ore material in g/cm^3.

Volume in Circulation: total volume in liters of process water that is actively circulating between injection wells, extraction wells, and ion exchange columns.

Fraction of Radon: fraction of the radon that is carried by circulating water. The balance of the fraction of radon in the mined area that is not swept in the injection-extraction well loop and remains trapped in the ore zone.

Rate of Radon Venting: fractional daily rate of radon release due to occasional venting from wellheads, valves and leaking transport piping during circulation.

Treated Water Purge Rate: rate in liters/day at which treated water is purged from the system. The purge in the production well field is necessary to maintain a hydraulic cone of depression around each well field to prevent leakage of mining solutions outside the production zone.

Water Discharge Rate: rate in liters/day at which water is discharged from unloading the resin in the ion exchange columns. Note: this is a calculated quantity derived from the product of the following three parameters. If the user enters a value for this parameter it should override the next three input fields.

Column Volume: volume in liters of the space in the ion exchange columns occupied by resin.

Column Unloading Rate: average daily number of times the ion exchange columns are unloaded.

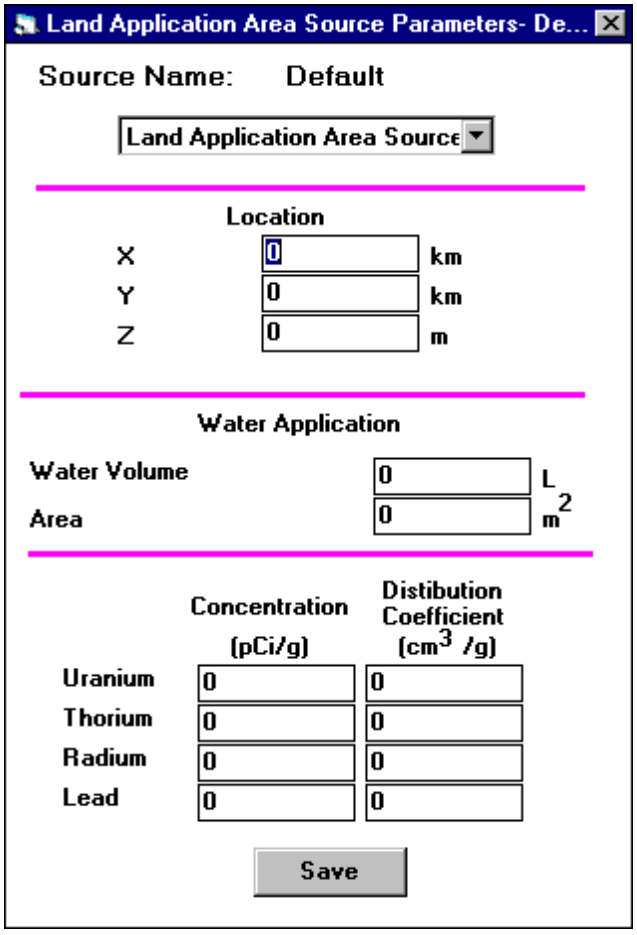
Porosity of Resin: porosity of the ion exchange resin material. This is the fraction of the ion exchange resin volume that is occupied by process water.

Radon-222 Source: calculated release rate of radon-222 to the circulating water in pCi/d.

Radon-222 Release from Purge Water, Well Venting, Ion Exchange Column: calculated release rate of radon-222 in Ci/yr from these sources.

Total Amount of Radon-222 Released from Restoration Well Field: sum of the release rate of radon-222 from purge water, well venting, and ion exchange columns in Ci/yr.

Land Application Area Source Parameters



Radionuclide-containing water both from purge water from production well fields or from restoration wastewater from restoration well fields is treated to unrestricted release levels and disposed of by irrigation. Release onto the soil surface will contaminate the soil at the land application areas. The radionuclides adsorbed by the soil will become a source term for radioactive release through wind erosion processes.

Location: enter the coordinates as:

- **X:** distance (km) of the source to the east (positive value) or west (negative value) of the origin.
- **Y:** distance (km) of the source to the north (positive value) or south (negative value) of the origin.
- **Z:** elevation (m) of the source above (positive) or below (negative) the elevation of the origin.

Water Volume: amount of treated water (in liters) released onto the irrigated area over the duration of the land application.

Area: area of land application in m^2.

Concentration: concentrations (in pCi/L) of radionuclides in the treated water released onto the land application area.

Distribution Coefficient:: ratio of the radionuclide activity adsorbed or precipitated on the soil per unit of dry mass of the soil to the radionuclide concentration in the water (in cm^3/g). The distribution coefficient represents the partition of the radionuclides in the soil matrix and soil water, assuming that equilibrium conditions exist between the soil and solution phases.

Soil Water Content: fraction of the total porosity of the soil material occupied by water. A value of 0 represents dry soil, while a value of 1 represents a saturated soil.

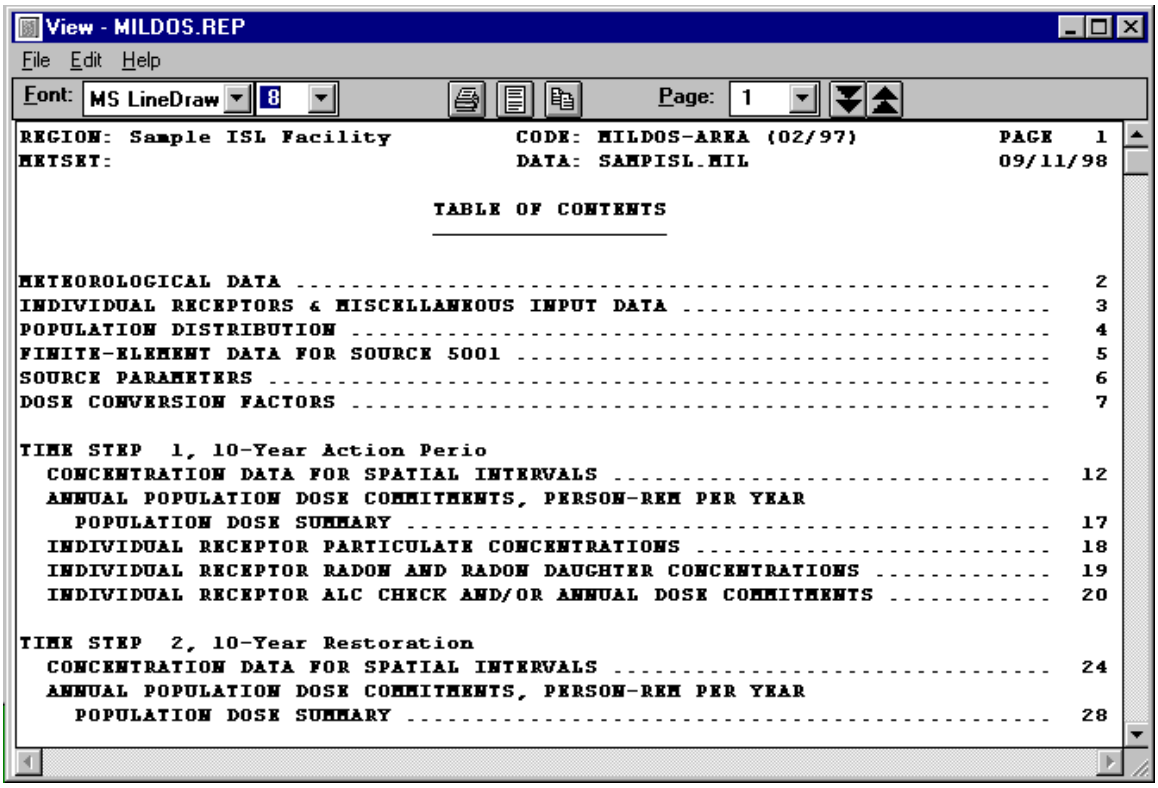
Density: dry bulk density of the surface soil in g/cm^3.

Depth: thickness (in meters) of the soil over which the contaminants are distributed. A typical value may be 0.15 m.

Results

MILDOS-AREA produces a textual report for standard problems. The report's first page is a table of contents.

Report Viewer



The Report Viewer is launched automatically at the end of each run, displaying the Summary Report (MILDOS.REP). However, the Report Viewer may be accessed at any time from the Menu or Toolbar.

Getting to the Report Viewer from:

Menu: Select View/Text output/Summary Report.

Toolbar: press the report page icon

Moving Around:

Pages: to go to another page choose one of the following methods:

- Enter page number in page text box and hit return
- Pull down the page list and click on desired page
- Advance a page by pressing the "Page Down" key, click on the double down arrows.

- Go back a page by pressing the “Page Up” key or by clicking the double up arrows.

Within a Page: Use scroll bars to position text.

Saving Files:

- **Note:** Every time a calculation is run, the previous report is overwritten. The results can be saved under different names allowing their retrieval later.
- Saving All Files: Select File/Save All under the Viewer menu. This will save the report to a file with extension *.rep. If the input filename is xxxx.* the reports will be saved as xxxx.rep.
- Saving the open report: Select File/Save under the Viewer menu. This will prompt for a name chosen by the user to save the currently displayed report.

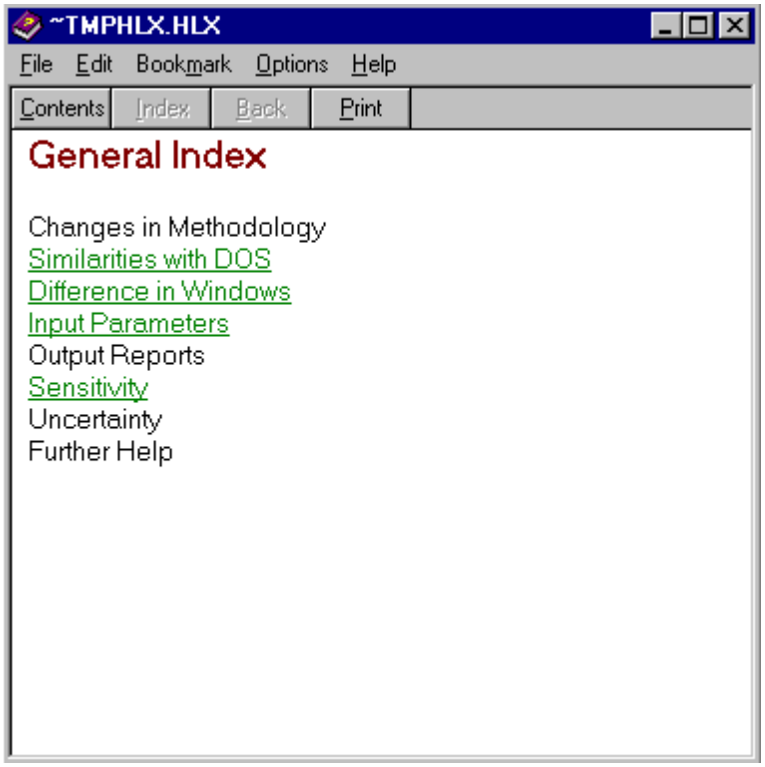
Copying Selections:

- Copy highligted section: Select Edit/Copy under the Viewer menu. The selected text will be placed on the windows clipboard and can be placed into any document such as a spreadsheet or word processor.
- Copy the current page: Select Edit/Select All followed by Edit/Copy. Or press the icon that looks like two pages.
- Copy to Excel**:** If MS Excel is on the computer, a table can be highlighted and automatically placed into an Excel spreadsheet. This feature does not currently work with MS Excel 97.

Printing

- Setting up the Printer: MILDOS-AREA uses the standard windows printer. The setup for the printer can be accessed through the File/Printer/Setup menu option. Options include printer selection, paper size selection, and orientation selection.
- Setting up the report for printing: Press the single page icon button to automatically select the best font size to fit the report to a single page width.
- Printing: Select the File/Print menu option or press the printer icon button. A dialogue box will appear allowing printing of the whole report, sets of pages, or the current highlighted text.

General Help



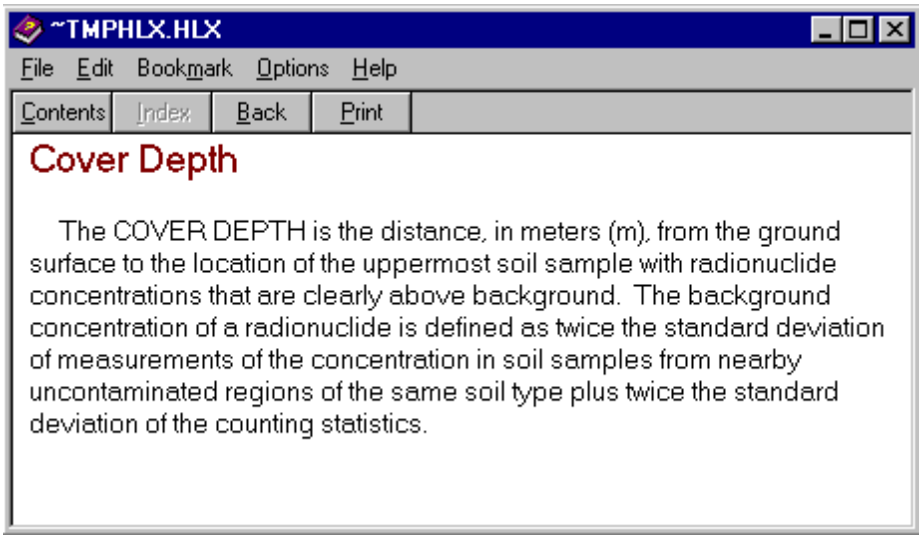
Getting To:

- Press the F1 key
- If the Help window is open click contents to get to the first page.
- Choose Help/Contents from the Main menu.

Contents:

- Differences with other versions
- Interface operational features
- Output help
- Contacts for further help

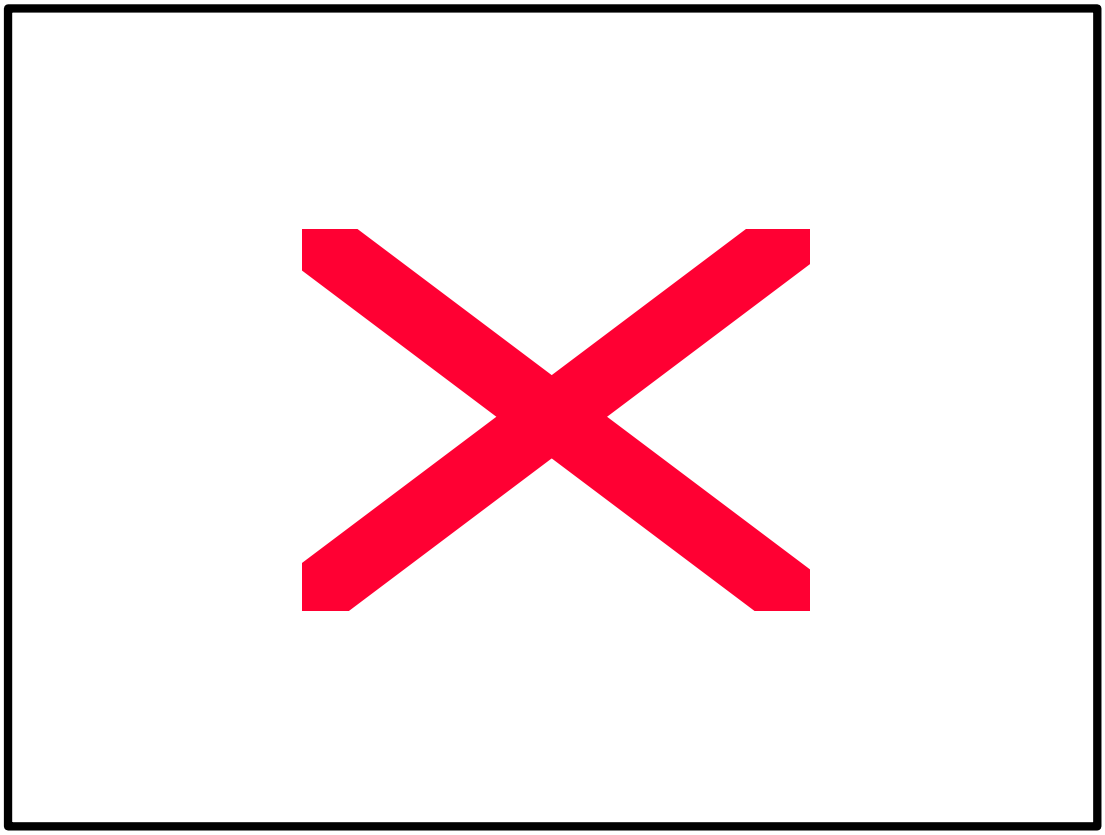
Parameter Description



Getting To:

- Choose the input box of the input parameter of interest, then press the F2 key
- Click the parameter description in the Textual Help list found on the Navigator's Help tab window.
- If the Help window is open click contents and follow table of contents to find the parameter of interest.

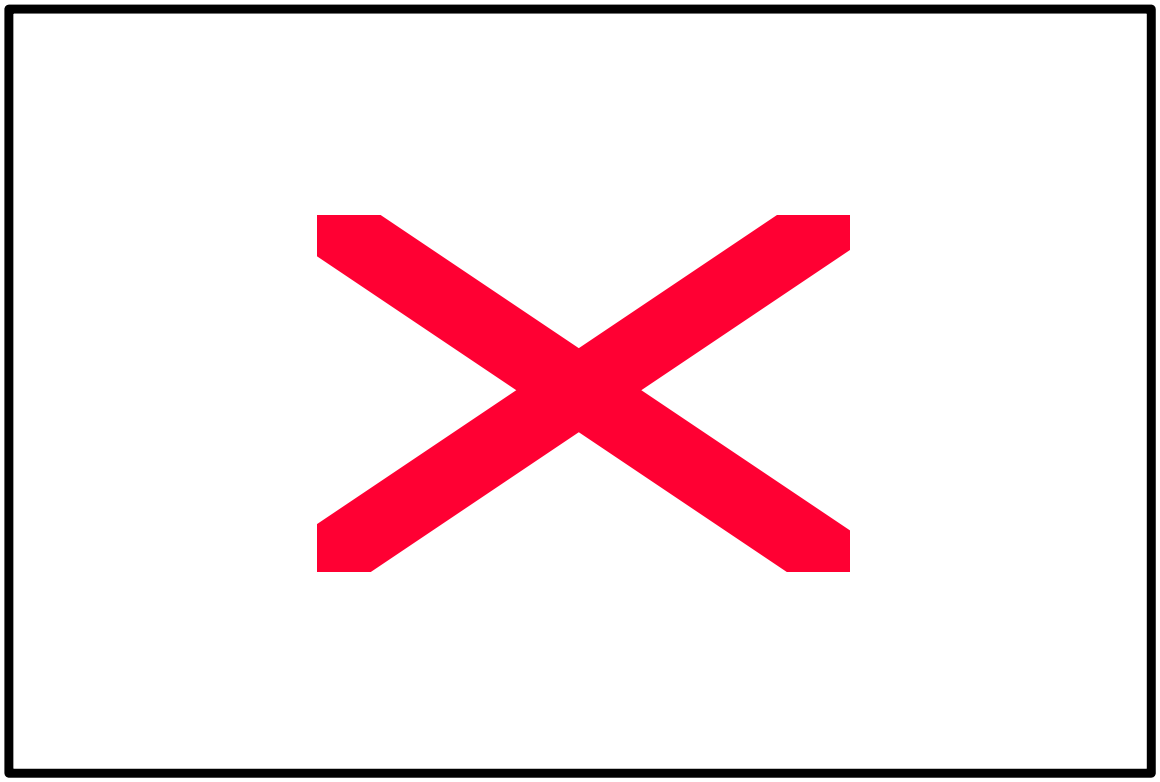
Graphical Help



Getting To: Click the Graphical Help topic of interest in the Navigator's Help Tab Window. To close click the standard close window control.

Contents: Various slides from the MILDOS-AREA Workshop

Web Site

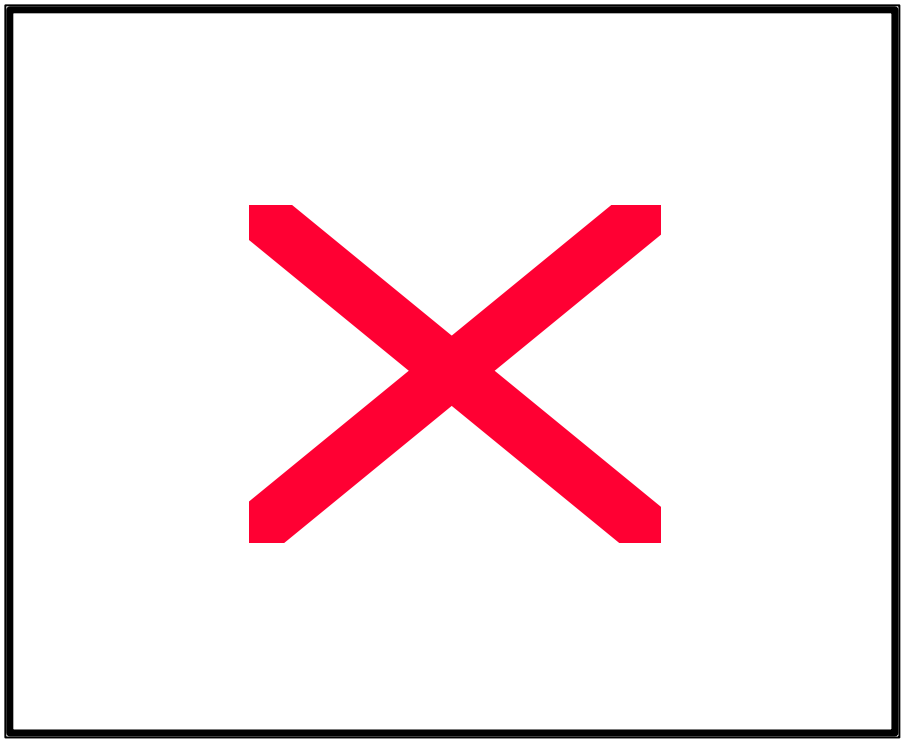


Getting To: The MILDOS-AREA web site is at www.ead.anl.gov/resrad.html This site can be reached through your normal browser.

Contents:

- Descriptions of the MILDOS-AREA Code
- Table of current versions and release status
- Upcoming training workshops and pictures from previous workshops
- Listing of version releases and dates along with a short description of the included modifications
- Email contact

Message Log



Getting To: From the main menu, choose View/Message Log.

Interpretation: This file contains calculation execution information which normally can be disregarded. If there were some problems with the calculation, this file should show some type of diagnostic which can be reported. The execution time is also displayed at the end of this file.

Reporting Problems: The email address for communicating problems and questions is MILDOS-AREA@anl.gov.