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United States Nuclear Regulatory Commission
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NUREG-2267

NRCDose3 Code

Version 1.1.4

User Guide and Technical Manual

Office of Nuclear Regulatory Research

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Manuscript Completed: March 2024
Date Published: July 2024

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ABSTRACT

This report contains the user guide and technical basis (models and methods) for the NRCDose3 computer code. It provides the end user with instructions for using NRCDose3 and documents the bases for updates made to the previous version of the code, NRCDose 2.3.20. NRCDose3 is a software suite that integrates the functionality of three individual Fortran codes (LADTAP II, GASPAR II, and XOQDOQ) developed by the U.S. Nuclear Regulatory Commission (NRC) in the 1980s. The nuclear industry and the NRC staff have used these codes to assess liquid radioactive releases and offsite doses, gaseous radioactive effluents and offsite doses, and meteorological transport and dispersion, respectively. The codes are primarily used in support of reactor licensing, to evaluate the safety and environmental dose impacts of liquid and gaseous radioactive effluent releases. NRCDose3 uses the same basic calculation methods (algorithms) as the Fortran codes. However, the updated code includes a more user-friendly graphical interface for entering data. Also, significant changes have been made to the data management and operation to support expanded capabilities.

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ACKNOWLEDGMENTS

The improvements to the NRCDose3 code would not have been possible without the technical guidance, feedback, and help of the U.S. Nuclear Regulatory Commission (NRC) staff from the Office of Nuclear Reactor Regulation. Specifically, thanks go to NRC staff members Richard Clement, Michael Mazaika, Dr. Donald Palmrose, Eva Hickey, Zachary Gran, and Dr. Elijah Dickson. The authors also thank the staff of Information Systems Laboratories, Inc., and Dr. Keith Eckerman for their support and effort in updating NRCDose3. Finally, the authors would like to extend special thanks to Edward Harvey for his early project management of the draft document.

ABBREVIATIONS

ALARA	as low as is reasonably achievable
Bq	becquerel
cal/s	calories per second
CFR	*Code of Federal Regulations*
cfs	cubic feet per second (ft^3/s)
Ci	curie
CMMP	configuration management and maintenance plan
cm	centimeters
CNS	Chesapeake Nuclear Services, Inc.
DCF	dose conversion factor
DF	dilution factor
d	day
d/L	days per liter
DOE	U.S. Department of Energy
D/Q	atmospheric deposition factor
EPA	U.S. Environmental Protection Agency
EFH	Exposure Factors Handbook
F	Fahrenheit
f_1	fraction of an ingested element absorbed directly into body fluids
FGR	Federal Guidance Report
Fortran	Formula Translation (formerly FORTRAN)
FSAR	final safety analysis report
ft^3	cubic feet
ft/s	feet per second
g	gram
g/cm^3	grams per cubic centimeter
g/d or g/day	grams per day
g/m^3	grams per cubic meter
gal/d or gpd	gallons per day
GASPAR	dose analysis computer code for radioactive effluents to the atmosphere (update to the GASPAR II Fortran code)
GUI	graphical user interface
h or hr	hour
hr/yr	hours per year
ICRP	International Commission on Radiological Protection
JFD	joint frequency distribution
keV	kiloelectron volt
kg	kilogram
kg/d	kilograms per day
kg/m^2	kilograms per square meter
kg/yr	kilograms per year
L	liter
LAR	licensing action request
L/d	liters per day
$L/m^2/mon$	liters per square meter per month
L/yr	liters per year
LADTAP	dose analysis computer code for radioactive effluents to surface waters (update to the LADTAP II Fortran code)
m	meter

m^2	square meter
m^3	cubic meter
m/s	meters per second
m^3/yr	cubic meters per year
MeV	megaelectron volt
MeV/nt	megaelectron volts per nuclear transformation
mi	mile
mph	miles per hour
mrem	millirem
mrem/hr	millirem per hour
MS	Microsoft
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
NRCDose3	computer code integrating LADTAP II, GASPAR II, and XOQDOQ
NUREG	NRC technical report designation
person-hr/yr	person-hours per year
pCi/kg	picocuries per kilogram
R-factor	reconcentration factor
RadToolbox	Radiological Toolbox computer code
RAMP	Radiation Protection Computer Code Analysis and Maintenance Program
RG	regulatory guide
s or sec	second
s/m^3	seconds per cubic meter
XOQDOQ	computer code for atmospheric dispersion modeling for routine releases
X/Q	atmospheric dispersion factor
yr	year
μCi/s	microcuries per second

1.0 INTRODUCTION

NRCDose3 is the most recent version of the NRCDose code, a software suite that integrates under a unified graphical user interface (GUI) the functionality of three individual Fortran codes (LADTAP II, GASPAR II, and XOQDOQ) developed by and for the U.S. Nuclear Regulatory Commission (NRC) in the 1980s. NRCDose3 features an updated Windows GUI; an expanded radionuclide library including 203 radionuclides with dose conversion factors; fully user-modifiable parameters for LADTAP, GASPAR, and XOQDOQ; and compatibility with Windows 7 and above, as well as Internet Explorer 7 and above.

The original NRCDose code (version 2.3.20 and earlier) was developed by an NRC contractor, Chesapeake Nuclear Services, Inc. (CNS), for end users including the NRC staff, applicants, and licensees. It incorporated the LADTAP II, GASPAR II, and XOQDOQ Fortran codes, which the nuclear industry and the NRC staff use to assess and evaluate liquid radioactive releases and offsite doses, gaseous radioactive effluents and offsite doses, and meteorological transport and dispersion, respectively. The codes are primarily used in support of domestic and international reactor licensing, to assess the safety and environmental dose impacts of liquid and gaseous radioactive effluent releases associated with routine (normal) plant operations and anticipated operational occurrences.

The NRCDose3 code, together with the underlying LADTAP, GASPAR, and XOQDOQ Fortran codes, implements the calculation methodologies described in this manual and the following NRC regulatory guides (RGs):

- RG 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I,” Revision 1, issued October 1977 [Ref. 1]

- RG 1.111, “Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors,” Revision 1, issued July 1977 [Ref. 2]

- RG 1.113, “Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I,” Revision 1, issued April 1977 [Ref. 3]

The NRC staff applies these dose assessment methods in its safety and environmental reviews and evaluations as prescribed in the following:

- RG 4.2, “Preparation of Environmental Reports for Nuclear Power Stations,” Revision 3, issued September 2018 [Ref. 4]

- NUREG-1555, “Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan,” Revision 1, issued July 2007 [Ref. 5]

- NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Revision 6, issued March 2007 [Ref. 6]

1.1 LADTAP II Code

The LADTAP II Fortran code, described in NUREG/CR-4013, "LADTAP II—Technical Reference and User Guide," issued April 1986 [Ref. 7], implements the liquid pathway modeling described in RG 1.109 and RG 1.113. LADTAP II estimates the radiation dose to individuals, population groups, and biota from ingestion pathways (aquatic foods, water, and terrestrial irrigated foods) and external exposure pathways (swimming, boating, and shoreline recreational activities). The calculated doses provide information for National Environmental Policy Act (NEPA) evaluations and for determining compliance with the "as low as is reasonably achievable" (ALARA) philosophy of Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as Is Reasonable Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Effluents," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities" [Ref. 8].

1.2 GASPAR II Code

The GASPAR II Fortran code, described in NUREG/CR-4653, "GASPAR II—Technical Reference and User Guide," issued March 1987 [Ref. 9], implements the atmospheric pathway modeling described in RG 1.109 and RG 1.111. GASPAR II estimates the radiation doses to individuals and population groups from inhalation, ingestion (terrestrial foods), and external exposure (ground and plume) pathways. The calculated doses provide information for NEPA evaluations and for determining compliance with the ALARA philosophy of Appendix I to 10 CFR Part 50. GASPAR II does not estimate radiation doses to biota.

1.3 XOQDOQ Code

The XOQDOQ Fortran code, described in NUREG/CR-2919, "XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," issued September 1982 [Ref. 10], implements the atmospheric pathway modeling described in RG 1.111. XOQDOQ calculates the relative atmospheric dispersion (X/Q) and relative atmospheric deposition (D/Q) values at locations specified by the user and at various standard radial distances and distance segments for downwind sectors. The model is based on a straight-line Gaussian model, and the code can account for variation in the location of release points, additional plume dispersion due to building wakes, plume depletion through dry deposition and radioactive decay, and adjustments to consider nonstraight trajectories.

1.4 NRCDose3 Code Update

This update to the NRCDose code does not change the basic calculation methods (algorithms) of the LADTAP II, GASPAR II, and XOQDOQ Fortran codes. In general, this update improves the GUI to make it more user friendly for data input. It also includes significant changes to the data management and code operation to support expanded capabilities. The most significant changes and revisions to the code are summarized below and explained in greater detail in Section 4 of this manual:

- <u>Support for updated dose conversion factor (DCF)</u>. Previous versions of the NRCDose code containing LADTAP II and GASPAR II used only one set of DCF values, largely those appearing in RG 1.109 and based on the methodology in International Commission on Radiological Protection (ICRP) Publication 2, "Report of Committee II on Permissible Dose for Internal Radiation" (ICRP-2), issued 1960 [Ref. 11]. NRCDose3 allows the user to select the ICRP-2 (default) DCF values; those for exposure to workers from ICRP Publication 30, “Limits for Intakes of Radionuclides by Workers” (ICRP-30), issued 1979 [Ref. 12]; or those for public exposure from ICRP Publication 72, “Age-Dependent Doses to Members of the Public from Intake of Radionuclides—Part 5, Compilation of Ingestion and Inhalation Dose Coefficients” (ICRP-72), issued 1995 [Ref. 13].

- Updated age groups. ICRP-72 uses six age groups (infant, 1-year, 5-year, 10-year, 15-year, and adult). RG 1.109, the original basis for LADTAP II and GASPAR II, uses four age groups (infant, child, teen, and adult). NRCDose3 uses all six age groups when ICRP-72 DCF values are selected.

** **User Note** **—ICRP-30 provides DCF values only for the adult worker, not for other age groups. An applicant or licensee preparing an NRC licensing action request (LAR) should discuss use of ICRP-72 DCF values with the NRC staff before submitting the request.

- Updated default usage factors. When ICRP-72 DCF values are selected, NRCDose3 uses updated usage (consumption and exposure) factors based on data in the U.S. Environmental Protection Agency (EPA) publication EPA/600/R-090/052F, “Exposure Factors Handbook: 2011 Edition” (EFH), issued September 2011 [Ref. 14].

** **User Note** **—The EPA’s EFH usage factors are different from those in RG 1.109. An applicant or licensee preparing an NRC LAR should discuss use of EFH usage factors with the NRC staff before submitting the request.

- Updated LADTAP biota dose calculations. The LADTAP II Fortran code originally had limited provisions for estimating the radiation dose to biota from liquid radioactive effluent releases. In NRCDose3, the biota dose model has been revised, with updates to effective radius dose factors (as used for calculating internal doses to biota) and the ability to include user-defined biota. For every special location defined in LADTAP, biota doses may be calculated for the following species:

    - fish
    - muskrat
    - raccoon
    - duck
    - heron
    - user-defined species

  Section 6.3 and appendix D to this manual give the technical basis of the biota dose model used in NRCDose3 to estimate the radiation dose to biota from liquid radioactive effluent releases.

- Added GASPAR biota dose calculations. The GASPAR II Fortran code originally had no provision for estimating the radiation dose to biota from gaseous radioactive effluent releases. In NRCDose3, the code has been revised to include biota dose models. For every special location defined in GASPAR, biota doses may be calculated for the following representative and surrogate species, as applicable for gaseous effluents and exposure pathways, including direct exposure (plume and ground deposition), as well as dietary intake (plant and meat):

- muskrat
- raccoon
- duck
- heron
- cow
- fox
- user-defined species

Section 6.3 and appendix D to this manual give the technical basis of the biota dose model used in NRCDose3 to estimate the radiation dose to biota from gaseous radioactive effluent releases.

- Additionally, NRCDose3 features the following functional improvements:

  - updated Visual Basic .NET GUI.
  - expanded radionuclide library covering 203 radionuclides.
  - fully user-modifiable parameters for LADTAP, GASPAR, and XOQDOQ
  - compatibility with Windows 7 and above and Internet Explorer 7 and above.

1.5 Software Quality Assurance and Configuration Management Plans

More information about NRCDose3 is available in CNS-19001, "NRCDose3 Computer Code: Software Quality Assurance Plan," issued July 2019 [Ref. 15], and CNS-19003, "NRCDose3 Computer Code: Configuration Management and Maintenance Plan," issued July 2019 [Ref. 16]. NUREG/BR-0167, "Software Quality Assurance Program and Guidelines," issued February 1993 [Ref. 17], defines three levels of software:

(1) Level 1—technical application software used in a safety decision by the NRC.

(2) Level 2—technical or nontechnical application software not used in a safety decision by the NRC.

(3) Level 3—technical or nontechnical application software not used in a safety decision and having local or limited use by the NRC.

The NRCDose3 quality assurance documents conform to the Level 2 requirements. Development of NRCDose3 has proceeded under the software quality assurance plan and configuration management and maintenance plan (CMMP). CNS-19004, "NRCDose3 Computer Code: Validation and Validation Report," issued July 2019 [Ref. 18], describes the work done to verify proper implementation of the new coding.

In addition, NRCDose3 was developed under CNS-19002, "NRCDose3 Computer Code: Software Design Document," issued July 2019 [Ref. 19]. The software design document presents detailed information on the code and database structure, integration of the modified Fortran codes, and definition of the supplemental databases used for program operation, data management, and generation of reports.

2.0 INSTALLATION

This section describes how to obtain and install NRCDose3 and specifies the computing requirements for doing so.

2.1 Distribution

The NRCDose3 code is available for download from the NRC's Radiation Protection Computer Code Analysis and Maintenance Program (RAMP) website (https://ramp.nrc-gateway.gov/), which also provides access to technical references, training and presentation materials, and code support (through forum boards).

2.2 Installation

The NRCDose3 code can be installed on a single computer running a Windows 7.0 or later operating system with administrative privileges and compatible with Internet Explorer 7.0 or later. The code is available through the RAMP website (https://ramp.nrc-gateway.gov/), where a user registration is required. Text reports are used for generating outputs such as the traditional, supplemental, and final safety analysis reports (FSARs) from the LADTAP, GASPAR, and XOQDOQ calculations.

The initial installation will create a user-specified directory (e.g., C:/NRCDose3 by default) for use by NRCDose3. For updates, the install routine will automatically delete the current version before installing the updated version. Only the updated program files are replaced. User-created case files (*.LNP, *.GNP, or *.XNP files) will not be deleted from the directory; however, it is recommended that all case files be saved to a different folder or storage device as a backup.

The NRCDose code (version 2.3.20 or earlier) is a separate program from NRCDose3. LADTAP and GASPAR files created in NRCDose (version 2.3.20 or earlier) are not compatible with NRCDose3. However, XOQDOQ files created in NRCDose (version 2.3.20 or earlier) are compatible with NRCDose3. Existing NRCDose code installations are not affected by the installation of NRCDose3, so both NRCDose and NRCDose3 may be installed and used on the same computer.

2.2.1 Installation Process

(1) Download and save the NRCDose3 installation file, NRCDose3_v114_Setup.exe, from the RAMP website (https://ramp.nrc-gateway.gov/). To begin installation, double-click (open) the NRCDose3_v114_Setup.exe file, which will start the installation process, and open the Welcome screen shown in Figure 2-1. Select the “Next” button to continue with installation.

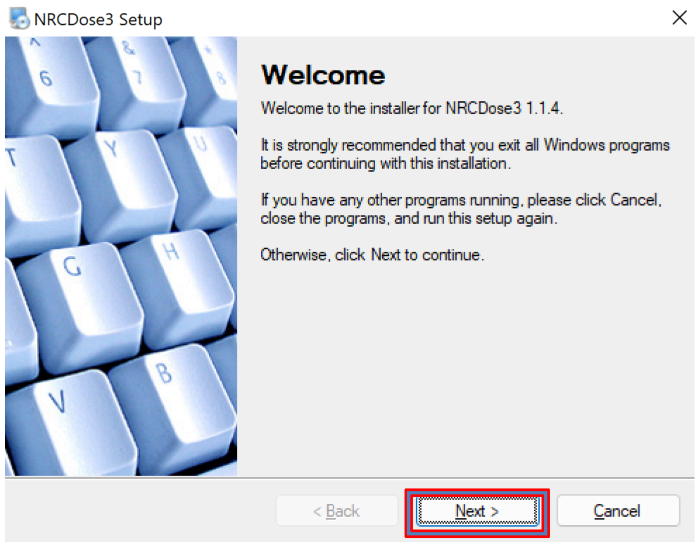


Figure 2-1 Installation Welcome Screen

(2) The installer will then allow the user to specify a destination folder for the installation of the NRCDose3 program, as shown in Figure 2-2. By default, the code will install on the root directory (i.e., C:/NRCDose3); however, a user-defined directory can be designated. The installer will create the installation directory if needed or will use the default directory. It will also display the computer hard drive space needed for NRCDose3 and the available space on the drive selected for installation (e.g., C:/). Select the "Next" button to continue with installation.

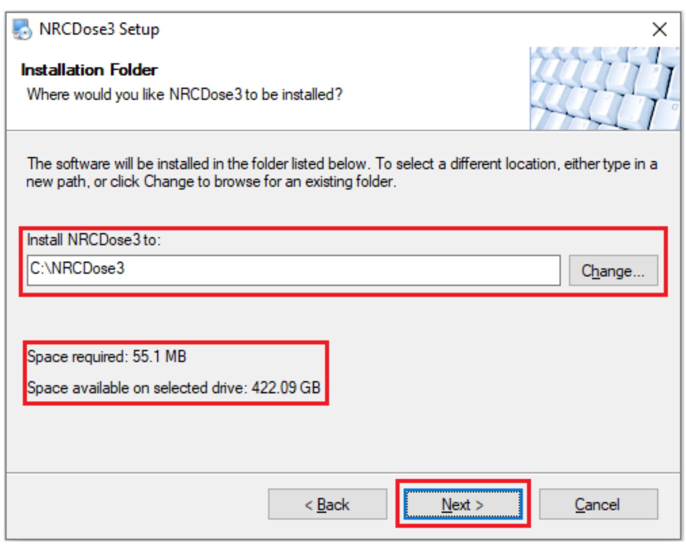


Figure 2-2 Installation Folder Screen

(3) The installer will then ask the user to select the location of the folder where the NRCDose3 shortcut icons will be created and installed, as shown in Figure 2-3. The installer defaults to the installation directory (i.e., C:/NRCDose3); the user may select a different directory using the drop-down menu arrow next to the file directory name. Additionally, the user can select whether to make the NRCDose3 icon available to either the current user or all users. The default option is to make the shortcut icon available to all users. Select the "Next" button to continue with installation.

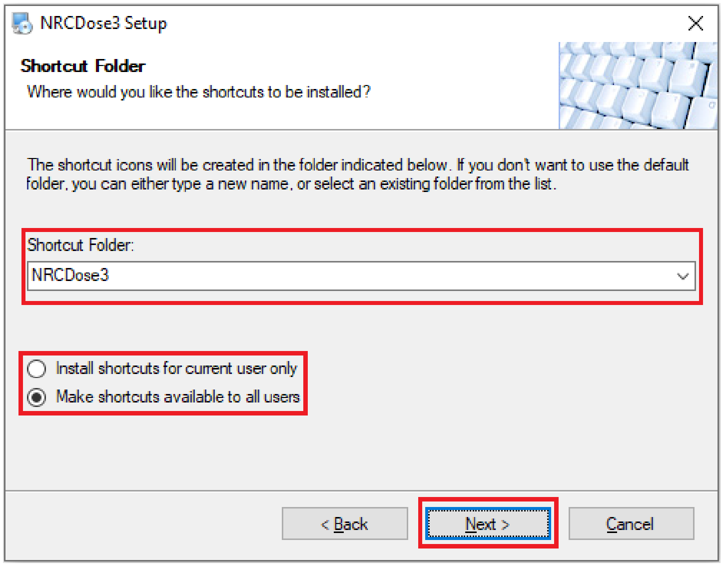


Figure 2-3 Shortcut Folder Screen

(4) The installer now has enough information to install the code and will display the settings used for installation as shown in Figure 2-4. Select the "Next" button to continue with installation. The user should see the installation progress screen shown in Figure 2-5. To terminate the installation of NRCDose3 at this point, select the "Cancel" button shown in Figure 2-5.

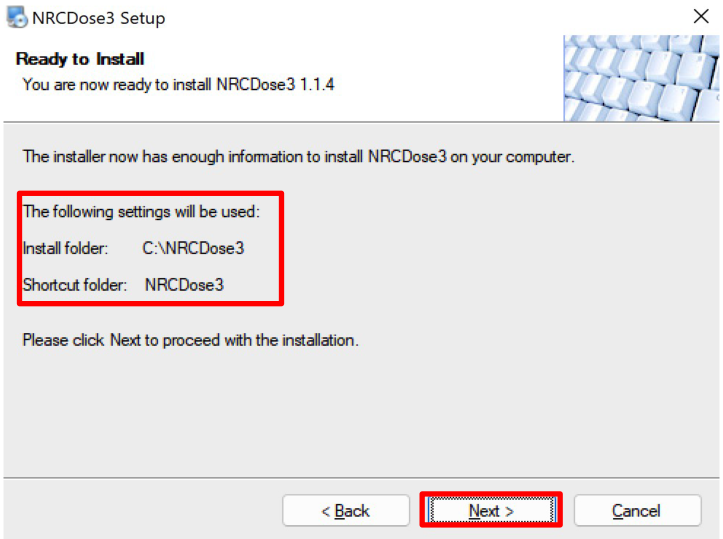


Figure 2-4 Installation Confirmation Screen

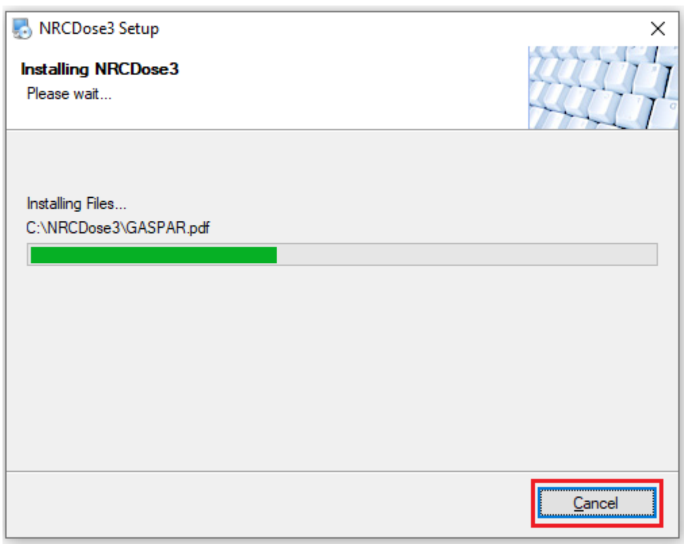


Figure 2-5 Installation Progress Screen

(5) When the installer has completed installing NRCDose3, the Installation Completion screen shown in Figure 2-6 will appear. Select the “Finish” button to exit the installer.

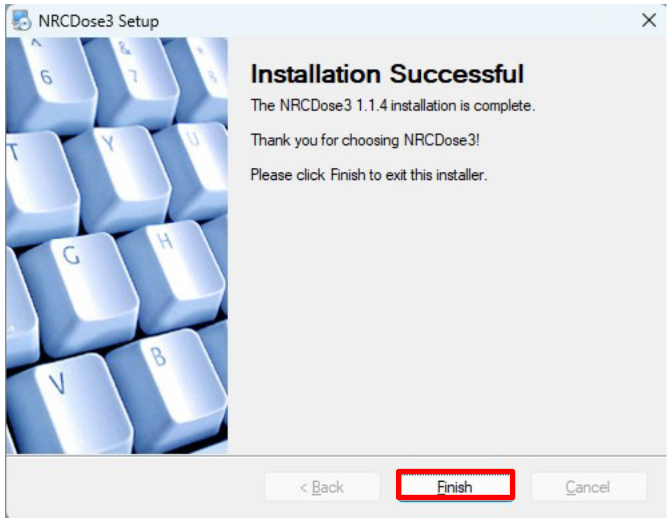


Figure 2-6 Installation Completion Screen

(6) The NRCDose3 shortcut icon will appear on the Windows operating system desktop as shown in Figure 2-7. Double-click on the NRCDose3 shortcut icon to open the program and display the NRCDose3 main selection screen shown in Figure 2-8.

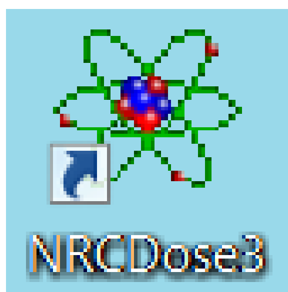


Figure 2-7 NRCDose3 Shortcut Icon

(7) As shown in Figure 2-8, the NRCDose3 main selection screen shows the LADTAP, GASPAR, and XOQDOQ modules. The toolbar at the top of the screen contains three tool/menu options:

- Quit—Select this tool to exit NRCDose3.
- About—Select this tool to open the About NRCDose3 screen as shown in Figure 2-9. This displays information about the version of NRCDose3. Select the "OK" button to return to the NRCDose3 main selection screen shown in Figure 2-8.
- Manuals—Select this tool to open a drop-down menu, shown in Figure 2-10, that lists the following technical references included with NRCDose3:
  - NRCDose3 Quick Start Guide

- NRCDose3 user’s manual: Draft NUREG-XXXX, “NRCDose3 Code Version 1.1.4: User Guide and Technical Manual”
- GASPAR II manual: NUREG/CR-4653
- LADTAP II manual: NUREG/CR-4013
- XOQDOQ manual: NUREG/CR-2919

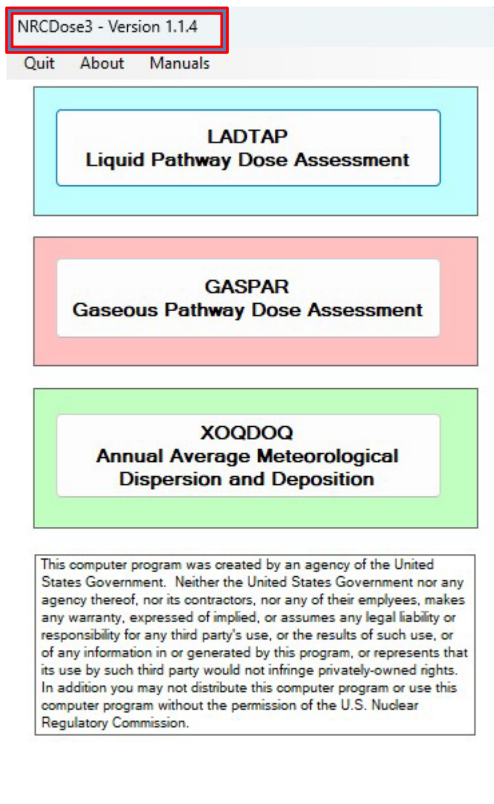


Figure 2-8 NRCDose3 Main Selection Screen

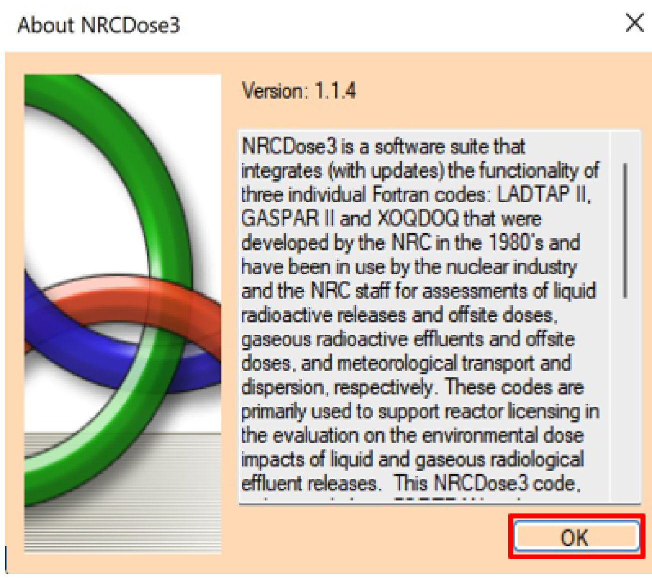


Figure 2-9 About NRCDose3 Screen

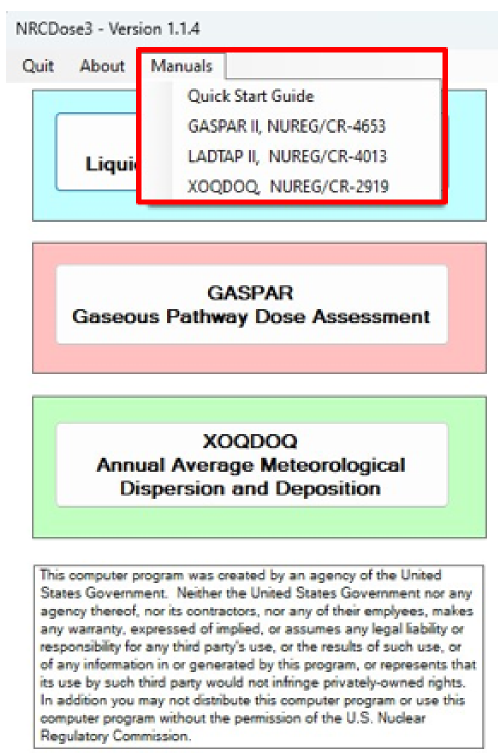


Figure 2-10 Manuals Tool Drop-down Menu

2.2.2 Code Support

Any questions, suggestions, corrections, or comments concerning the NRCDose3 code or its documentation should be submitted through the NRCDose3 support link on the RAMP website (https://ramp.nrc-gateway.gov/codes/nrcdose/request-support).

2.2.3 Code Error and Problem Reporting

While extensive testing has been performed and effort directed toward minimizing (noncomputational) errors in NRCDose3, unanticipated circumstances may lead to errors and problems (bugs). To report an error or bug in the program, first collect as much information as possible about it, including answers to the following questions:

- On what computer operating system is NRCDose3 being executed?
- Is the error or bug reproducible?
- What are the steps leading up to the problem?
- What are the exact symptoms (e.g., program crash, error message)?

To report a problem, send a ZIP file containing the case files and answers to the above questions through the NRCDose3 Forum webpage using the NRCDose3 support link on the NRC RAMP website (https://ramp.nrc-gateway.gov/codes/nrcdose/request-support).

3.0 LADTAP

The LADTAP module within NRCDose3 executes a modified version of the LADTAP II Fortran code. This update to the NRCDose code has not changed the basic calculation methods (algorithms) of LADTAP II, as described in NUREG/CR-4013, except as needed to accommodate the use of different DCFs with different age groups. However, significant changes have been made to the data management and operation to support the expanded capabilities of NRCDose3. LADTAP II performs environmental dose assessments for releases of liquid radioactive effluents from nuclear power plants in surface waters, implementing the dose assessment methods described in RG 1.109. LADTAP II calculates the radiation dose to individuals, population groups, and biota from ingestion of aquatic foods, water, and terrestrial irrigated foods. Additionally, LADTAP II calculates external exposures from boating, swimming, and shoreline recreational activities. The calculated doses provide information for NEPA evaluations and for determining compliance with the NRC public dose limits in 10 CFR Part 20, "Standards for Protection Against Radiation" [Ref. 20], the EPA public dose limits in 40 CFR Part 190, "Environmental Protection Standards for Nuclear Power Operations" [Ref. 21], and the NRC ALARA design objectives and numerical guides in 10 CFR Part 50, Appendix I.

The following sections discuss the steps for setting up and conducting LADTAP dose calculations using NRCDose3. The user is directed to NUREG/CR-4013 for the LADTAP II Fortran code user guide and for technical bases and detailed discussion of the assumptions, limitations, and methods of the LADTAP dose calculations.

To open the LADTAP module, select the "LADTAP Liquid Pathway Dose Assessment" button on the NRCDose3 main selection screen, shown in Figure 3-1. This will open the LADTAP module main screen, shown in Figure 3-2.

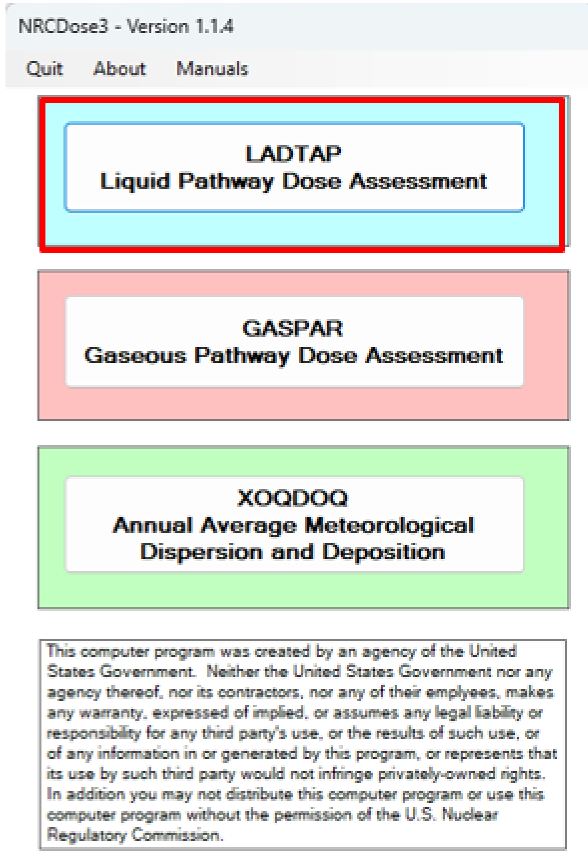


Figure 3-1 NRCDose3 Main Selection Screen (LADTAP Module)

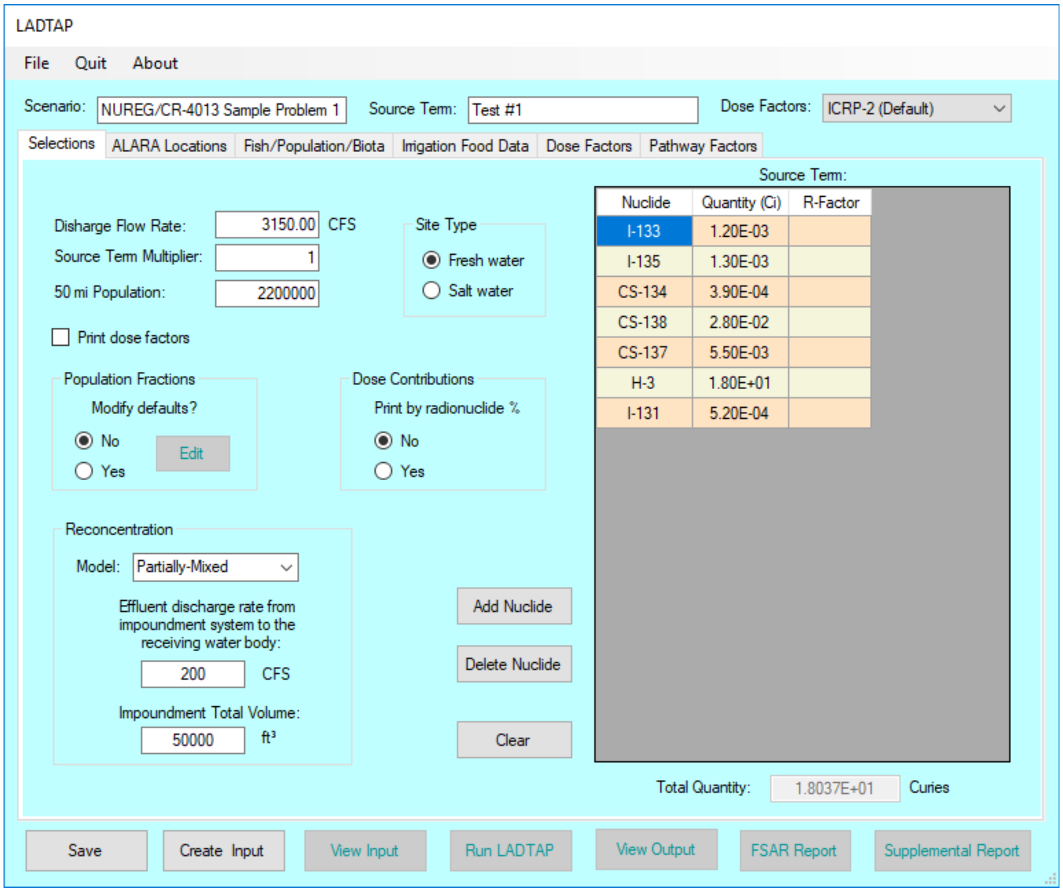


Figure 3-2 LADTAP Module Main Screen

The LADTAP module main screen opens with the case data last saved in the database. On initial install, the program loads with an example test case. There are three main functional areas for entering data and performing LADTAP dose calculations: (1) the toolbar and initial setup area, (2) the data input tabs, and (3) code execution and reports. The following sections discuss these areas and describe the options and capabilities in each.

3.1 Toolbar and Initial Setup

This portion of the LADTAP module main screen contains three tools and three initial setup input fields, as shown in Figure 3-2. The three tools are File, Quit, and About. The initial setup fields are Scenario, Source Term, and Dose Factors (drop-down menu).

3.1.1 File Tool

The File tool provides the functionality for managing the LADTAP files, as shown in Figure 3-3. The File drop-down menu offers the following options:

- New—Select this option to begin a new LADTAP case. This will clear any previously entered information from the database.

- Open LN3 File—Select this option to access and open a *.LN3 file previously created with NRCDose3.

- Save to Database—Select this option to save the current case to the database. When LADTAP starts, the data that were last saved (typically from the previous run) are loaded, populating all LADTAP screens and windows.

- Save to LN3 File—Select this option to save the completed case to a *.LN3 file, for later use or for sharing with others.

- Delete—Select this option to open an Explorer window that will allow the user to delete any previously saved *.LN3 files.

** **User Note** **—NRCDose3 uses the *.LN3 file type and format for LADTAP files. Files in other formats (for example, *.LNP files generated by LADTAP under NRCDose (version 2.3.20 or earlier)) are not compatible with NRCDose3.

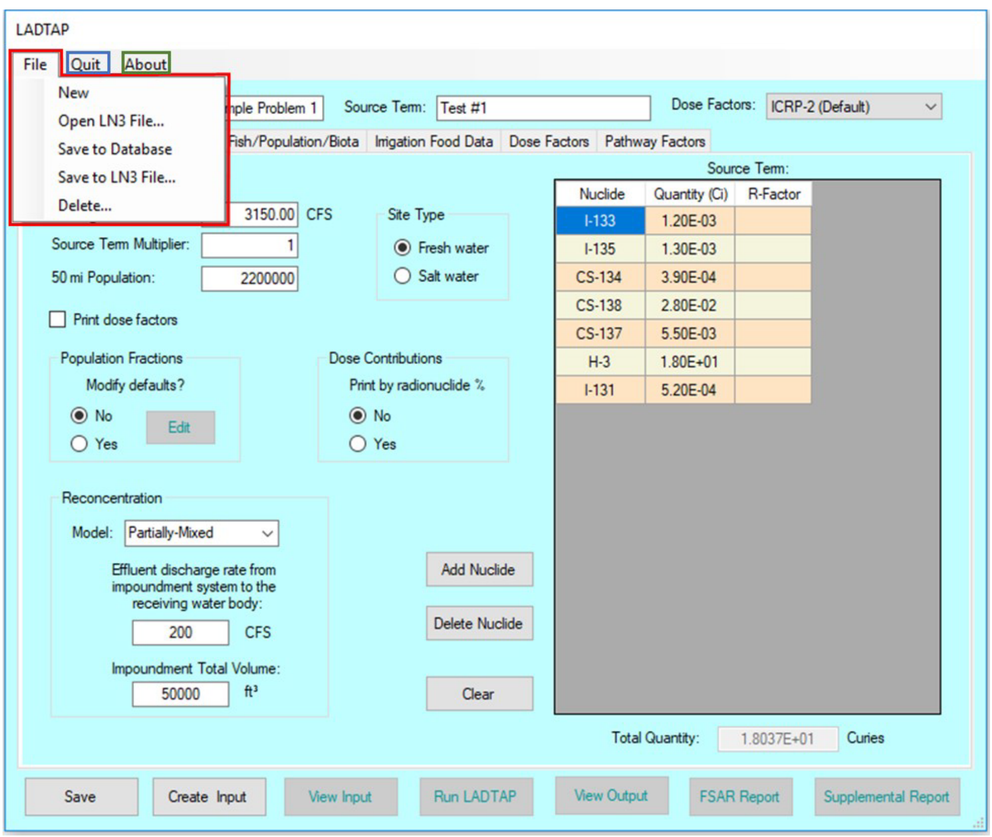


Figure 3-3 LADTAP Toolbar with File Drop-down Menu

3.1.2 Quit Tool

The Quit tool allows the user to terminate the operation of the LADTAP module. When the Quit tool is selected, the Question prompt screen (shown in Figure 3-4) will be displayed to verify that the user wants to exit the module. Select the "Yes" button to terminate the LADTAP module without saving any changes to the data not previously saved. To save changes (to the database and/or a *.LN3 file) before quitting, select the "No" button, then choose the appropriate entry from the File drop-down menu.

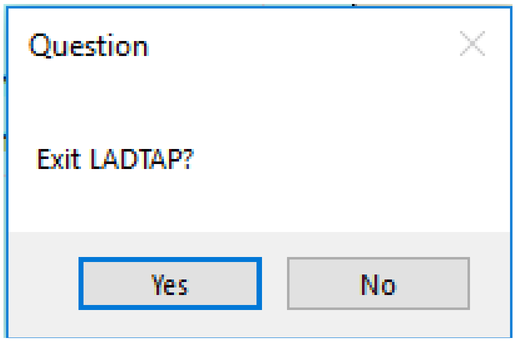


Figure 3-4 LADTAP Module Quit Tool Screen

3.1.3 About Tool

Selecting the About tool brings up the About LADTAP screen shown in Figure 3-5, which displays information about LADTAP II. Select the "OK" button to return to the LADTAP module main screen shown in Figure 3-2.

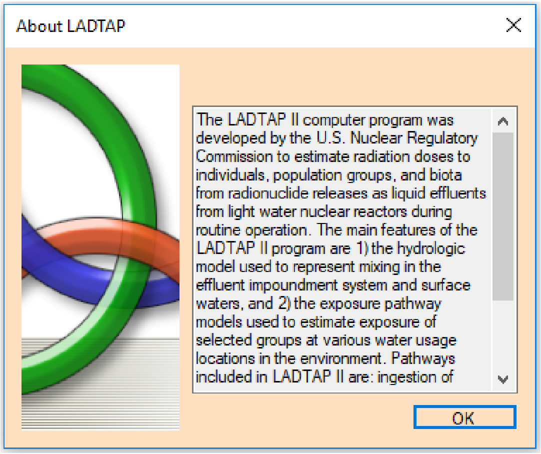


Figure 3-5 About LADTAP Screen

3.1.4 Scenario Field

In the Scenario field, enter a title for the LADTAP case. This is a descriptive text field only; the data in this field are not used for any LADTAP dose calculations. The title should help users identify the facility/site and release point (e.g., “Facility XYZ and Miscellaneous Waste Discharge”). As shown in Figure 3-2, the initial test case included in the NRCDose3 installation (which is loaded when the LADTAP module is first opened) is entitled “NUREG/CR-4013 Sample Problem 1—ICRP-2.” When opened subsequently, LADTAP will show the last saved case scenario.

3.1.5 Source Term Field

In the Source Term field, enter a name for the source term. This is a descriptive text field only; the data in this field are not used for any LADTAP dose calculations. As shown in Figure 3-2, the name of the source term in the initial test case, “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is “**Test #1**.”

3.1.6 Dose Factors Drop-Down Menu

The Dose Factors drop-down menu, shown in Figure 3-6, allows the user to select the DCF values to be used for the LADTAP dose calculations. The options available are “ICRP-2 (Default),” “ICRP-30,” and “ICRP-72.” Note that if the DCF values are changed, then the assumed source term (if any has been entered) will be cleared, and the assumed usage and consumption factors will be updated to the values associated with the selected ICRP methodology. The installation includes test cases using the ICRP-30 and ICRP-72 DCFs; apart from the DCFs, these test cases have the same data as the “NUREG/CR-4013 Sample Problem 1—ICRP-2” test case.

**** User Note ****—For the purposes of demonstrating compliance with 10 CFR Part 50, Appendix I, and 40 CFR Part 190, the ICRP-2 DCF values should be selected. For demonstrating compliance with 10 CFR Part 20, the ICRP-30 DCF values should be selected. An applicant or licensee preparing an NRC LAR should discuss the use of ICRP-72 DCF values with the NRC staff before submitting the request.

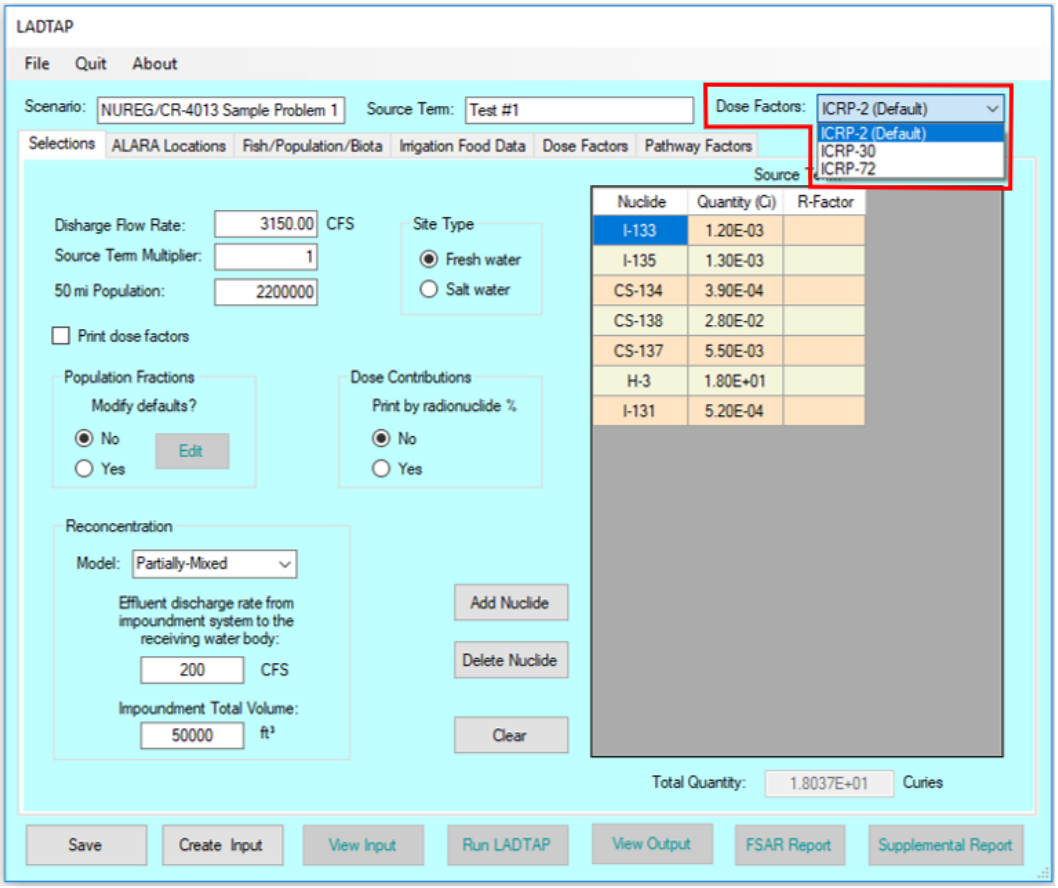


Figure 3-6 LADTAP Dose Factors Drop-down Menu

3.2 Data Input Tabs

The six LADTAP data input tabs, shown in Figure 3-2, are as follows:

(1) Selections
(2) ALARA Locations
(3) Fish/Population/Biota
(4) Irrigation Food Data
(5) Dose Factors
(6) Pathway Factors

It is recommended, though not required, that the user enter the necessary case parameters and data into the data input tabs in the order in which they are listed.

3.2.1 Selections Tab

The Selections tab is used to enter the basic parameters for the LADTAP dose calculations. The Selections tab includes several input fields, selection radio buttons, and three data-specific input sections, as shown in Figure 3-7. Refer to NUREG/CR-4013 for more information on the inputs in this tab.

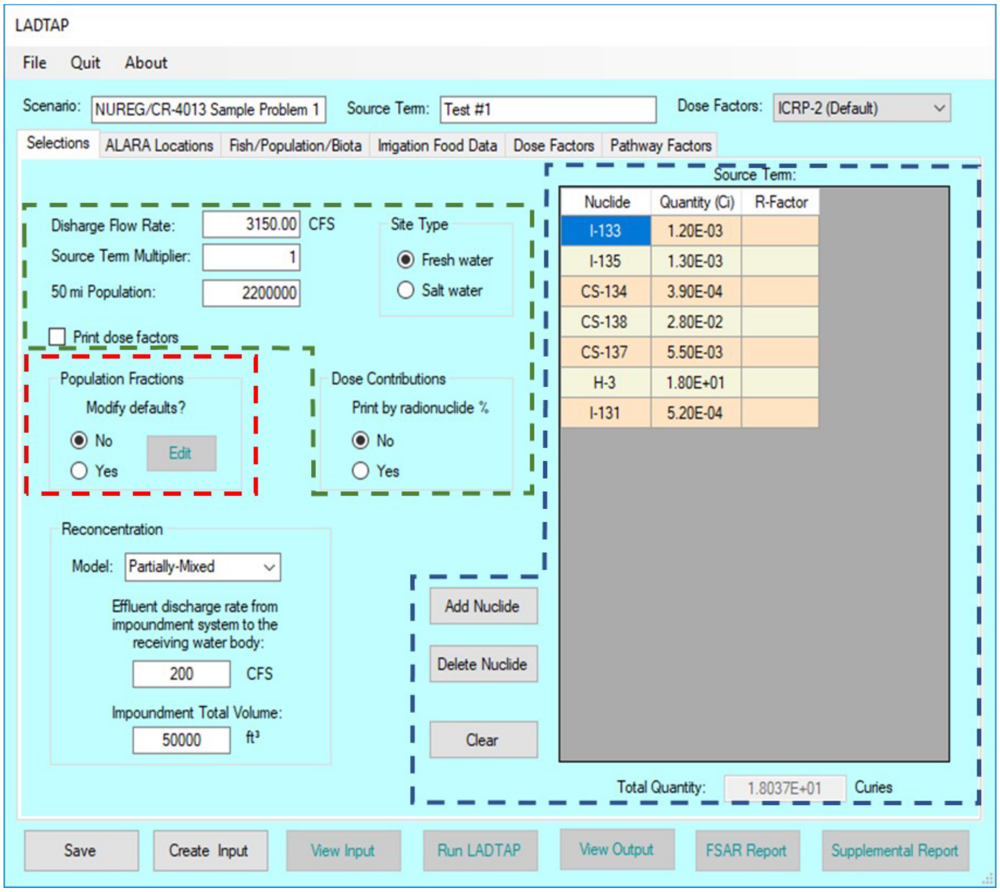


Figure 3-7 Selections Tab

3.2.1.1 Input Fields and Radio Buttons

3.2.1.1.1 Discharge Flow Rate

This field is used to enter the liquid effluent discharge flow rate, in cubic feet per second (cfs). The value from the initial test case, "NUREG/CR-4013 Sample Problem 1—ICRP-2," is **3150** cfs. The allowable range for values in this field is greater than 0 cfs.

3.2.1.1.2 Source Term Multiplier

This field is used to enter, if desired, a multiplier to the source term entered on the Selections tab. The allowable range for values in this field is 1 or greater, and the default value is **1**. Typically, the multiplier will remain at 1, but it can be adjusted to account for multiunit sites if the entered source term is on a per-unit basis.

3.2.1.1.3 50 mi Population

This field is used to enter the total human population within 50 miles of the site, as specified in 10 CFR Part 50, Appendix I. The value from the initial test case, "NUREG/CR-4013 Sample Problem 1—ICRP-2," is **2200000**. The allowable range for values in this field is greater than 0.

3.2.1.1.4 Print Dose Factors

The user should select this check box if DCF values are to be listed and printed in the LADTAP output file. The default value for this box is unchecked.

3.2.1.1.5 Site Type

Here the user should select either “Fresh water” or “Salt water” as appropriate for the site. This selection controls the bioaccumulation factors to be used, as different sets exist for freshwater and saltwater species, as well as certain consumption values (e.g., saltwater invertebrate). The value from the initial test case, “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is “**Fresh water**,” which is also the default selection in a new case/file.

3.2.1.1.6 Dose Contributions

This setting determines whether the dose contribution per radionuclide, in percent, is printed in the LADTAP output file. The value from the initial test case, “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is “**No**,” which is also the default selection in a new case/file.

3.2.1.2 Population Fractions

As shown in Figure 3-7, this section gives the option of modifying the population age group fractions, with the default value setting of “**No**.” Table 3-1 shows the default population fractions. These values are from Section 2.1.1 of NUREG/CR-4013 and represent U.S. averages at the time of development of RG 1.109.

Table 3-1 LADTAP Age Group Population Fractions

Population Age Group	Age Range (years)	Default Age Group Fractions (percent)	ICRP-30 Age Group Fractions (percent)
Children	0–11	18	0
Teens	11–17	11	0
Adults	17 and older	71	100

To change or adjust these default values, select the “Yes” button, then the “Edit” button when it becomes active (not grayed out). This will open the Population Fractions screen shown in Figure 3-8, where the age group fraction of the total population can be adjusted. Provide a justification when any default NRCDose3 parameter is modified. As noted in Table 3-1, if the LADTAP dose calculation to be performed is using the ICRP-30 DCF values, the age group fractions are automatically set to 1.00 for adults and 0 for teens and children. This is because ICRP-30 contains DCF values only for the adult age range; therefore, only adult doses are calculated.

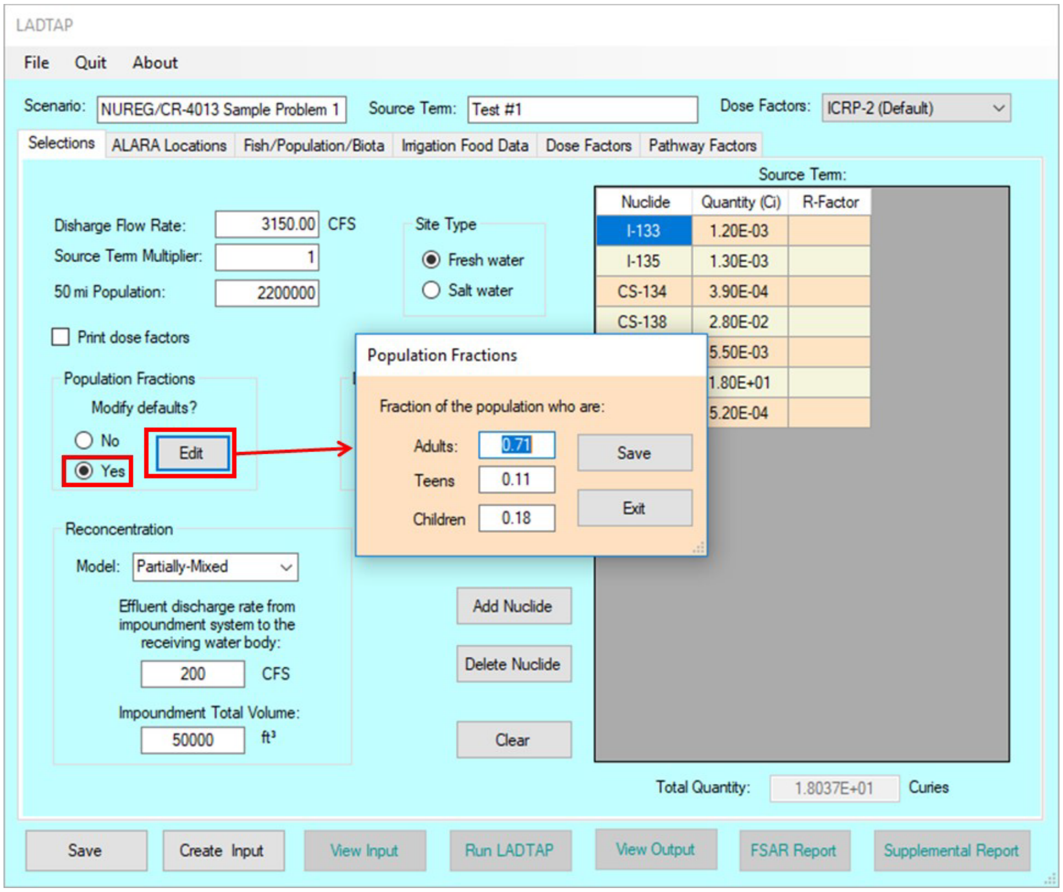


Figure 3-8 Population Fractions Screen

3.2.1.3 Reconcentration

This section of the Selections tab provides information on the reconcentration factor (R-factor) in the LADTAP dose calculation, as shown in Figure 3-7. The R-factor is used to account for any recirculation that may occur in the receiving water body, which could increase the environmental concentrations above that calculated directly from the effluent activity and the discharge flow rate. As shown in Figure 3-9, one of four impoundments or reconcentration models can be selected:

(1) None—This model assumes no additional decay or dilution of the liquid effluents before they reach the main receiving water body. The discharge point radioactivity concentration is determined simply by the activity release rate and the discharge flow rate.

(2) Completely Mixed—This model estimates the effluent reconcentration at the midpoint of the plant life and assumes complete mixing within a closed impoundment volume. This model assumes negligible radioactivity loss due to leakage or evaporation.

(3) Plug Flow—This model assumes that radioactive effluents are released to an impoundment system (pond), where they are naturally diluted and delayed (and

therefore decay) before they are released to the main receiving water body. The degree of dilution and decay is proportional to the relative size of the impoundment system. This model assumes no radioactivity loss due to leakage or evaporation. When this model is selected, the blowdown rate and the reactor effluent discharge rate (entered at the top of the Selections tab) are compared. If the blowdown rate is less than 99 percent of the effluent discharge rate, an error message is printed. However, the run is not stopped, and the values given are used.

(4) Partially-Mixed—This model is derived from a mass balance for steady-state conditions described in RG 1.113. It assumes no radioactivity loss due to leakage or evaporation.

Impoundment systems delay release to the main receiving water body, allowing additional dilution or time for radiological decay. The option selected in “NUREG/CR-4013 Sample Problem 1—ICRP-2” for this setting is “**Partially-Mixed**.” The calculated R-factor is site and radionuclide specific. Section 3.3.3 of NUREG/CR-4013 describes each of these models in detail.

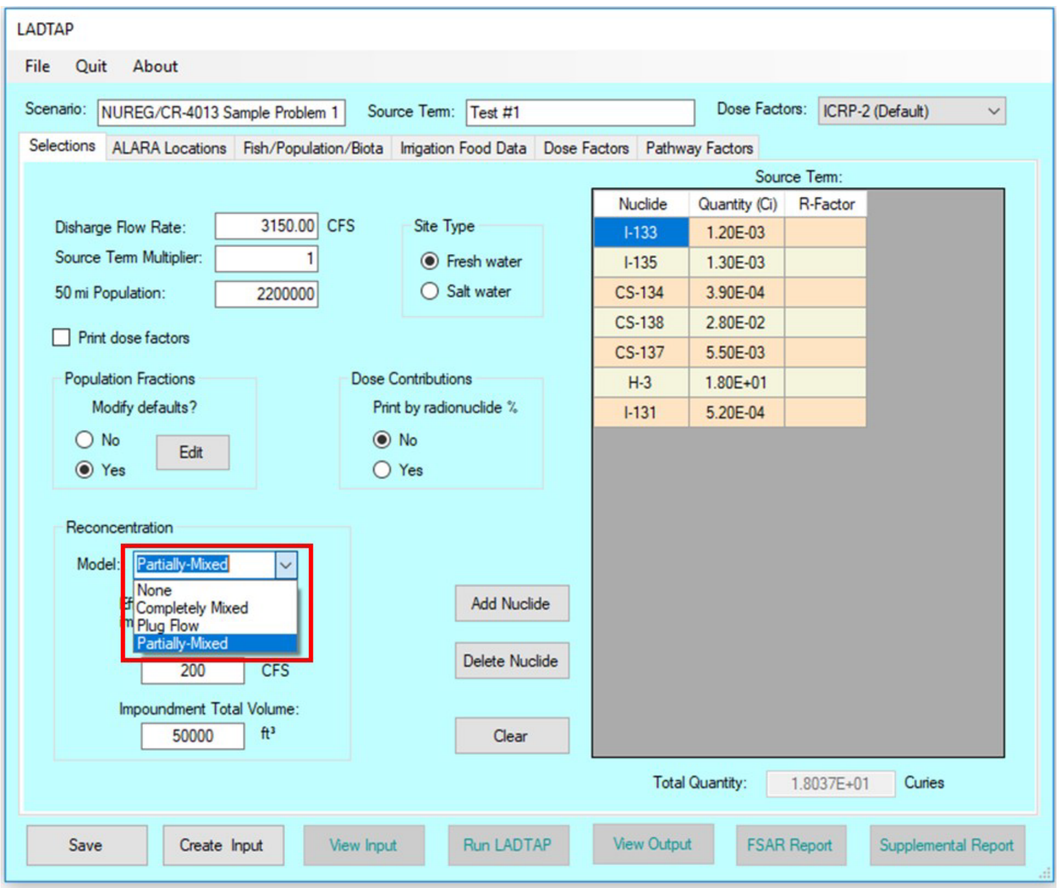


Figure 3-9 R-Factor Model Options

All the impoundment or reconcentration models except for the “None” option require the user to input two additional parameters, as shown in Figure 3-7:

- Effluent discharge rate from impoundment system to the receiving water body, in cfs. The value from the initial test case, “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is **200** cfs, and the allowable range for values in this field is greater than 0 cfs.

- Impoundment total volume, in cubic feet (ft^3). The value from the initial test case, “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is **50000** ft^3, and the allowable range for values in this field is greater than 0 ft^3.

3.2.1.4 Source Term

As shown in Figure 3-7, the final section on the Selections tab is the Source Term section, where the user can enter the annual released activity in curies (Ci) and the R-factor (if desired) for each radionuclide. The R-factor, as entered here, would be a value derived using a site-specific model, which can be manually entered for each radionuclide. Enter the R-factors only if the reconcentration model option of “**None**” has been selected in the Reconcentration section (see Section 3.2.1.3). Selecting any other reconcentration model (“**Completely Mixed**,” “**Plug Flow**,” or “**Partially-Mixed**”) will override any manually entered R-factors.

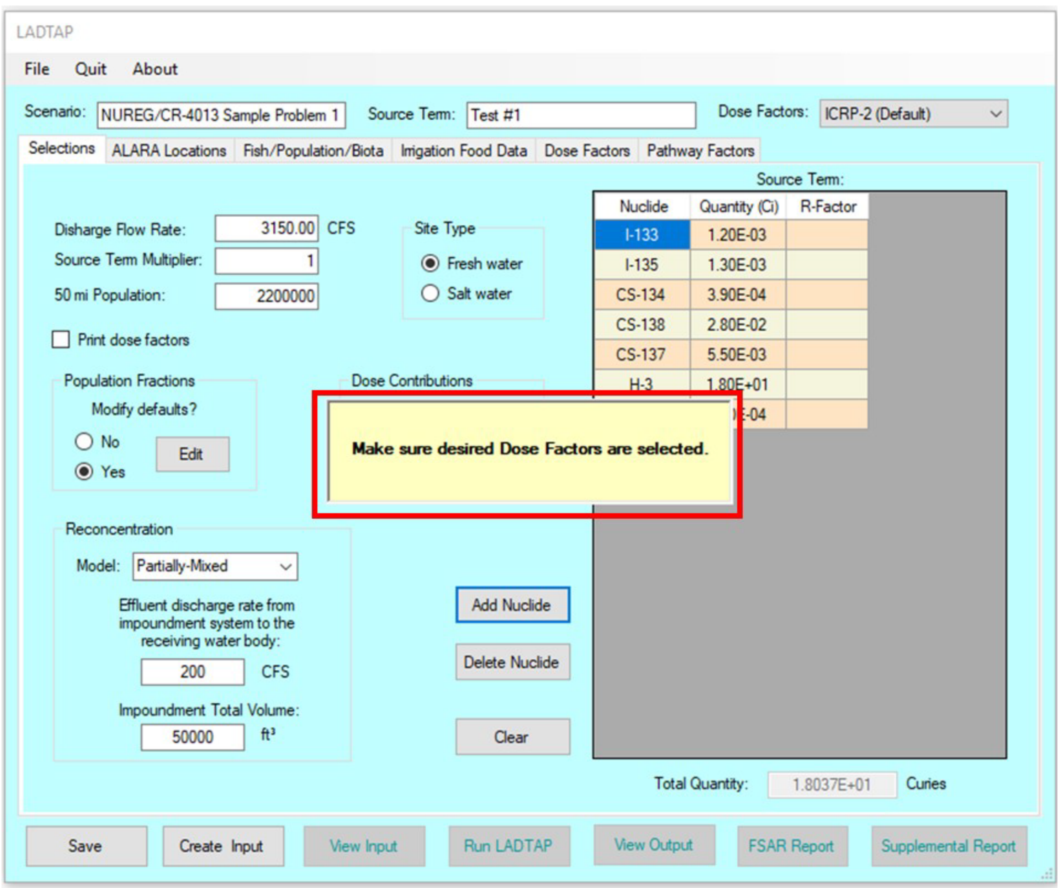


Figure 3-10 DCF Warning Message

More radionuclides can be added to the bottom of the list by selecting the “Add Nuclide” button, which will flash the DCF warning message shown in Figure 3-10, and then open the Select

Nuclide screen, shown in Figure 3-11. Select the radionuclide to be added, and then click the “Add” button as shown in Figure 3-11 to add the radionuclide to the source term. By holding down the “Ctrl” key during radionuclide selection, the user can select multiple radionuclides.

** **User Note** **—Before adding any radionuclides, the user should verify that the proper ICRP methodology is chosen so that the code selects the correct forms of the radionuclides.

The user can remove radionuclides from the Source Term section by selecting (highlighting) the radionuclide to be removed and then clicking the “Delete Nuclide” button. Selecting the “Clear” button clears all source term data (nuclide, quantity, and R-factor) for all radionuclides in the Source Term section of the Selections tab.

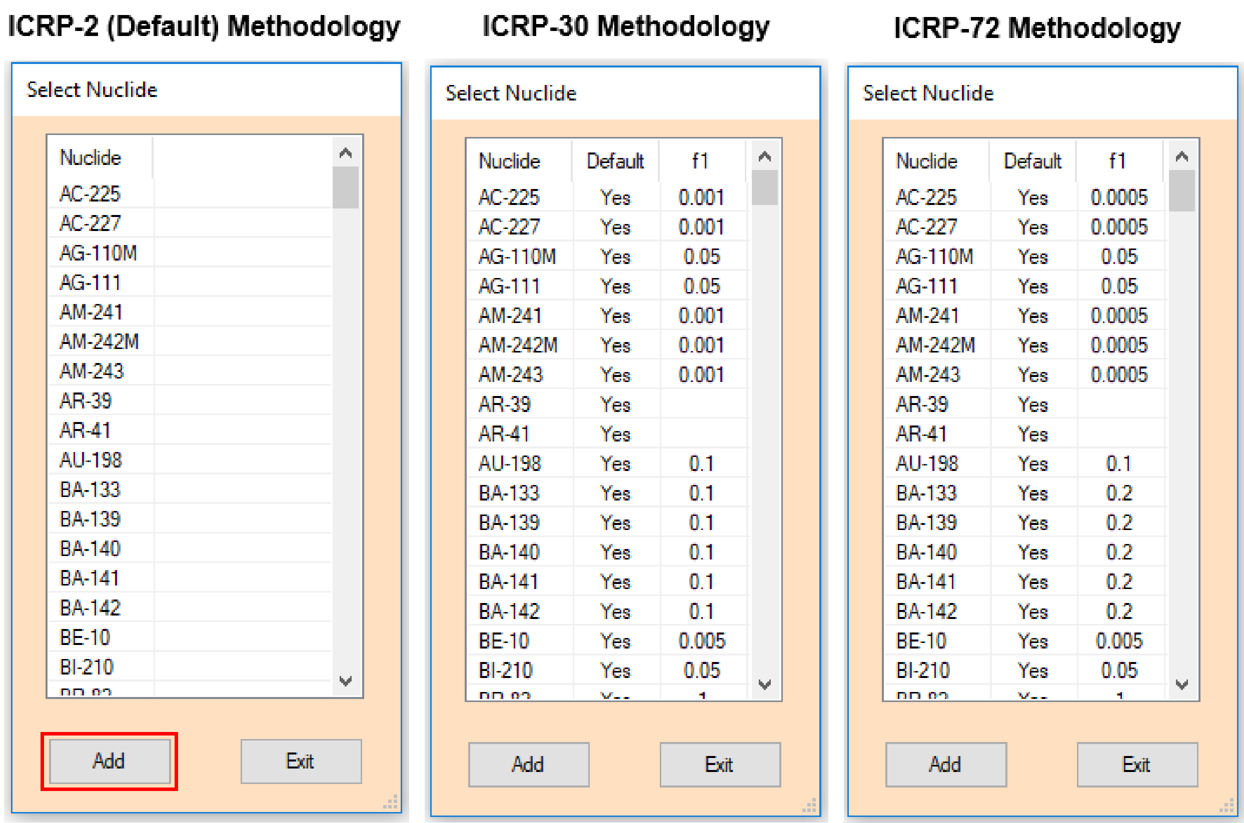


Figure 3-11 Select Nuclide Screens

** **User Note** **—The input data should be periodically saved using the “Save” button at the bottom of the LADTAP module main screen (Figure 3-2). This will save the data to the database, under the file name designated by the user. Saved values (and the saved file) will then be available should the program be inadvertently terminated or otherwise quit. Remember that upon initial opening of the LADTAP module (or the GASPAR or XOQDOQ module), the data loaded are those last saved to the database. In this situation, the loaded data are not linked to any file name; they should be saved to an existing or new file as appropriate. To ensure that the data are those desired, the user should open the file corresponding to the case desired, edit the data for an existing case and save them under a different file name, or create a new file name.

3.2.2 ALARA Locations Tab

The ALARA Locations tab is used to enter the parameters for the maximum exposed individual in the LADTAP dose calculation. As shown in Figure 3-12, the ALARA Locations tab contains two sections: (1) the ALARA—Max. Individual section and (2) the Additional Usage Locations section. The ALARA—Additional Location section is used to enter the exposure assumptions for any additional usage locations.

3.2.2.1 ALARA—Max. Individual

The ALARA—Max. Individual section is divided into four data input sections: (1) "Shore-width factor," (2) "Dilution Factor," (3) "Transit Time," and (4) "Change default usage and consumption data."

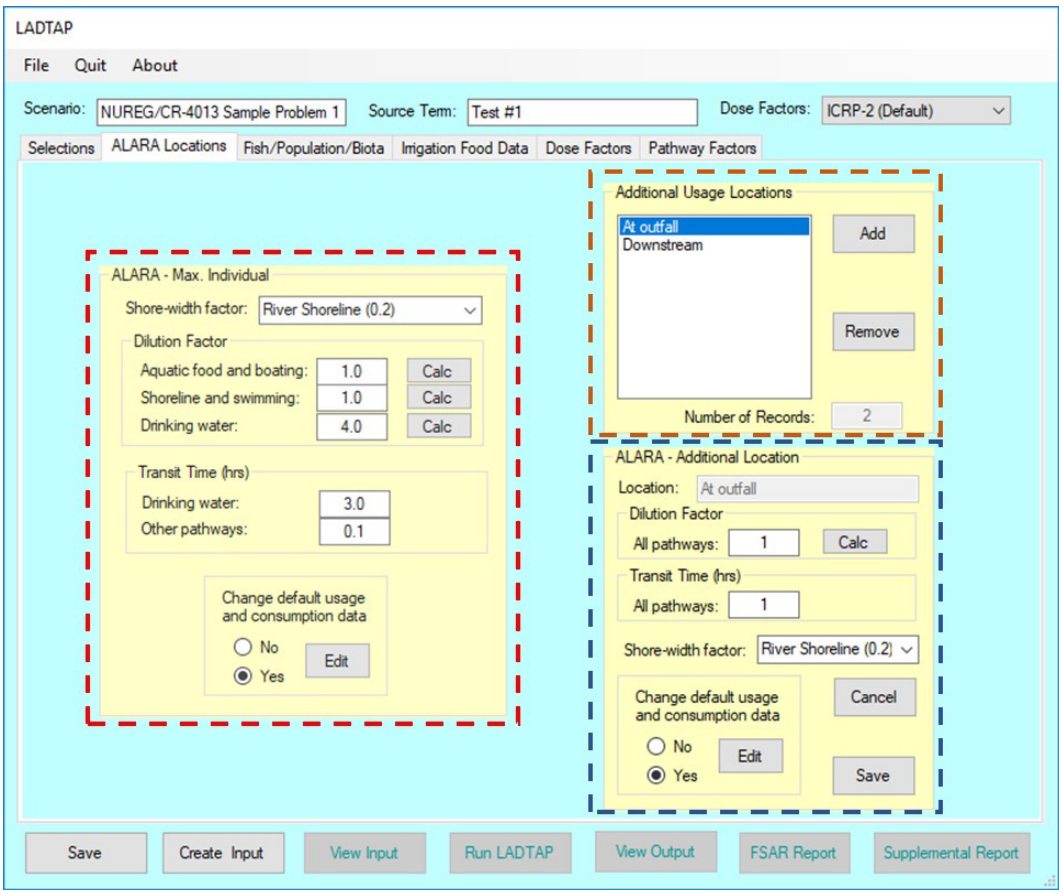


Figure 3-12 ALARA Locations Tab

3.2.2.1.1 Shore-Width Factor

The shore-width factor represents a fraction of the dose from an infinite plane source that would be received from the shoreline geometry at the location of interest. Here the user should select the location that will be used to determine the shore-width factor. Table 3-2 shows the exposure situations and the assumed shore-width factors from RG 1.109.

Table 3-2 Shore-Width Factors

Exposure Situation	Shore-Width Factor
Discharge Canal Bank	0.1
River Shoreline	0.2
Lake Shore	0.3
Nominal Ocean Site	0.5
Tidal Basin	1.0

3.2.2.1.2 Dilution Factor

The dilution factor represents the amount of dilution expected from the discharge point to the receiving water body and the usage location for the pathway. In practice, the concentration at the point of exposure is determined by dividing the radionuclide concentration (as calculated from the source term (activity released), the discharge flow rate, and any R-factor) by the dilution factor. There are three dilution factor pathway types: (1) aquatic food and boating, (2) shoreline and swimming, and (3) drinking water. A known value may be entered manually, or a value may be calculated using the characteristics of the receiving water body. For each pathway type, select the “Calc” button to open the Dilution Factor Calculation screen shown in Figure 3-13. Section 3.1 of NUREG/CR-4013 provides more information on calculating dilution factors based on applicable parameters and a hydrological surface water model.

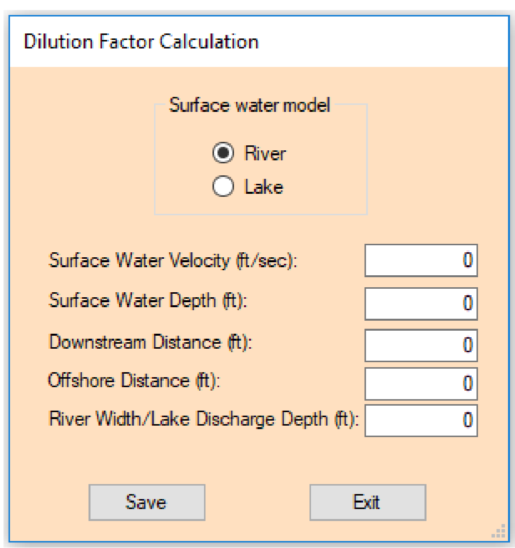


Figure 3-13 Dilution Factor Calculation Screen

To calculate a dilution factor using the screen shown in Figure 3-13, the user must input the following parameters:

- Surface Water Model—Select the appropriate hydrological model by clicking on either "River" or "Lake."
- Surface Water Velocity—Enter the surface water velocity in feet per second (ft/s). The allowable range for values in this field is greater than 0 ft/s.
- Surface Water Depth—Enter the surface water depth in feet. The allowable range for values in this field is greater than 0 feet.
- Downstream Distance—Enter the downstream distance in feet. The allowable range for values in this field is greater than 0 feet.
- Offshore Distance—Enter the offshore distance in feet. The allowable range for values in this field is greater than 0 feet.
- River Width / Lake Discharge Depth—Enter either the river width or the lake discharge depth (depending on the model selected) in feet. The allowable range for values in this field is greater than 0 feet.

The dilution factor is calculated from the values entered for the receiving water body characteristics (flow, depth, and downstream distance) in the selected hydrological model.

** **User Note** **—If the discharge flow rate is large compared to the parameter values entered for the receiving water body characteristics, LADTAP could return a dilution factor less than 1, which indicates that the defined parameters are not compatible with the selected model. If this occurs, dose calculations will not be correct. The LADTAP output will issue the following error message, at which point the program will terminate:

> **WARNING: PARAMETER VALUES INPUTTED FOR THE DILUTION CALCULATION ARE INCOMPATIBLE WITH THE MODEL. TERMINATING PROGRAM**

3.2.2.1.3 Transit Time

This section is used to enter the transit time, in hours (hr), from the discharge point of the receiving water body to the usage location. As shown in Figure 3-12, a separate transit time can be entered for the drinking water pathway, while all other pathways have the same transit time. The value from the initial test case, "NUREG/CR-4013 Sample Problem 1—ICRP-2," is **3.0** for the drinking water pathway and **0.1** for the other pathways. The allowable range for values in this field is greater than 0 hours.

3.2.2.1.4 Change Default Usage and Consumption Data

This section allows the user to change the default usage and consumption data for the maximum exposed individual. The default data are taken from RG 1.109, Revision 1, for the ICRP-2 (default) and ICRP-30 DCF values, and from the EPA's EFH for the ICRP-72 DCF values. To change the usage and consumption data, select the "Yes" radio button and the "Edit" button shown in Figure 3-12 to open the Max Individual Consumption screen shown in Figure 3-14.

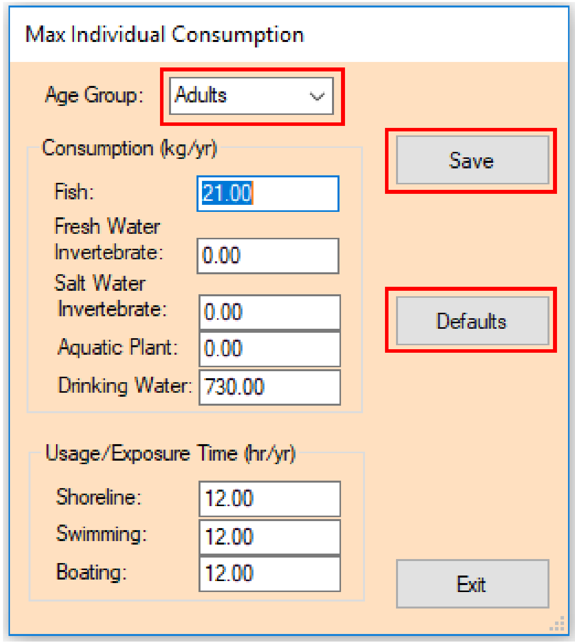


Figure 3-14 Max Individual Consumption Screen

Using the drop-down menu, select the appropriate age group from RG 1.109, and enter the applicable rates of consumption of fish, invertebrates, aquatic plants, and drinking water, in kilograms per year (kg/yr), for the assumed maximum individual. Also, enter the assumed usage/exposure time (hr/yr) for shoreline, swimming, and boating recreational activities. When edits are complete, select the "Save" button to save the revised usage and consumption data. While progressing through the different age groups, save the data for each age group separately. Select "Defaults" to restore the default usage and consumption data from RG 1.109.

3.2.2.2 Additional Usage Locations

The Additional Usage Locations section allows the user to enter additional locations for the LADTAP dose calculation. The initial test case, "NUREG/CR-4013 Sample Problem 1—ICRP-2," includes information for two additional usage locations ("At outfall" and "Downstream"). To add a usage location, select the "Add" button to activate the ALARA—Additional Location section, as shown in Figure 3-15. To remove a usage location, select (highlight) the location to be removed, and click the "Remove" button.

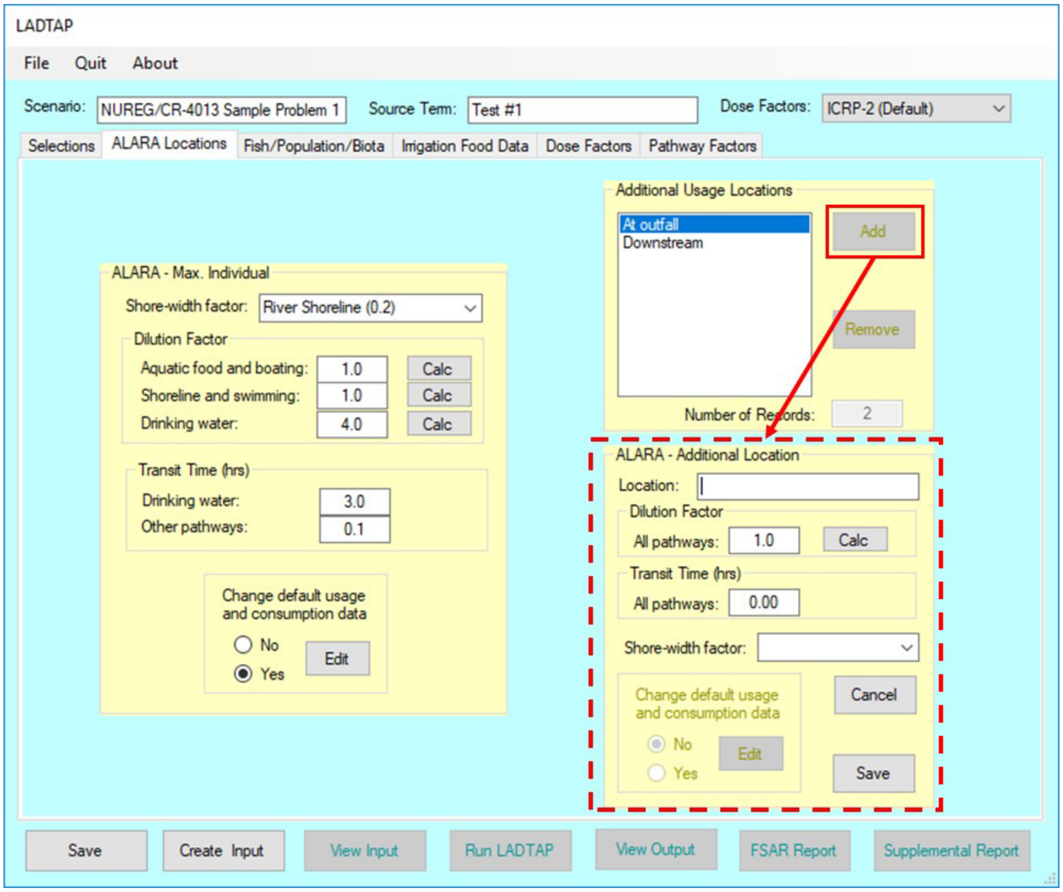


Figure 3-15 ALARA—Additional Location Section, Activated

3.2.2.3 ALARA—Additional Location

After activating the ALARA—Additional Location section (see Section 3.2.2.2), the user can enter the information required for each additional usage location: namely, the location, the pathway dilution factor, the transit time, and the shore-width factor (as discussed in Section 3.2.2.1). For each additional usage location, only a single dilution factor and transit time can be entered. Location-specific usage and consumption data can be entered by selecting the "Yes" radio button and then the "Edit" button shown in Figure 3-15 to open the Max Individual Consumption screen shown in Figure 3-14.

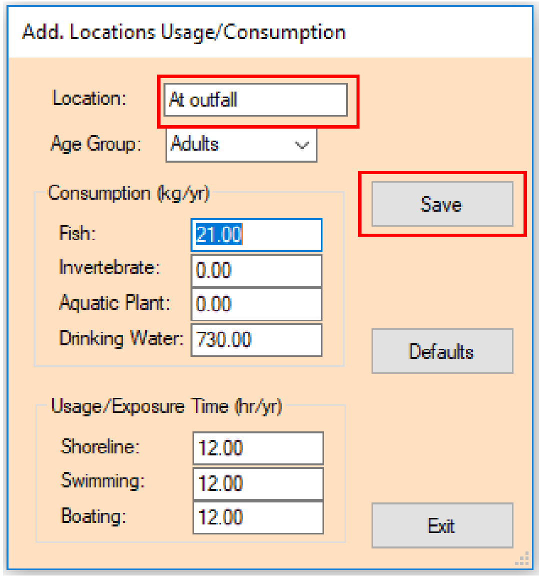


Figure 3-16 Add. Locations Usage/Consumption Screen

Enter the required usage and consumption data following the instructions in Section 3.2.2.1.4 and select the "Save" button when edits are complete to save the revised data. Save the data for each age group separately.

3.2.3 Fish/Population/Biota Tab

The Fish/Population/Biota tab is used to enter the parameters for the annual aquatic animal harvest and consumption, as well as the total population drinking water consumption and recreation time. As shown in Figure 3-17, the Fish/Population/Biota tab contains three sections: (1) the Fish Usage section, (2) the Population Usage section, and (3) the Biota Locations section. Figure 3-17 also displays the four drop-down menu options for the Fish Usage section (sport or commercial fishing and sport or commercial invertebrate harvest) and the four drop-down menu options for the Population Usage section (drinking water, shoreline, swimming, and boating).

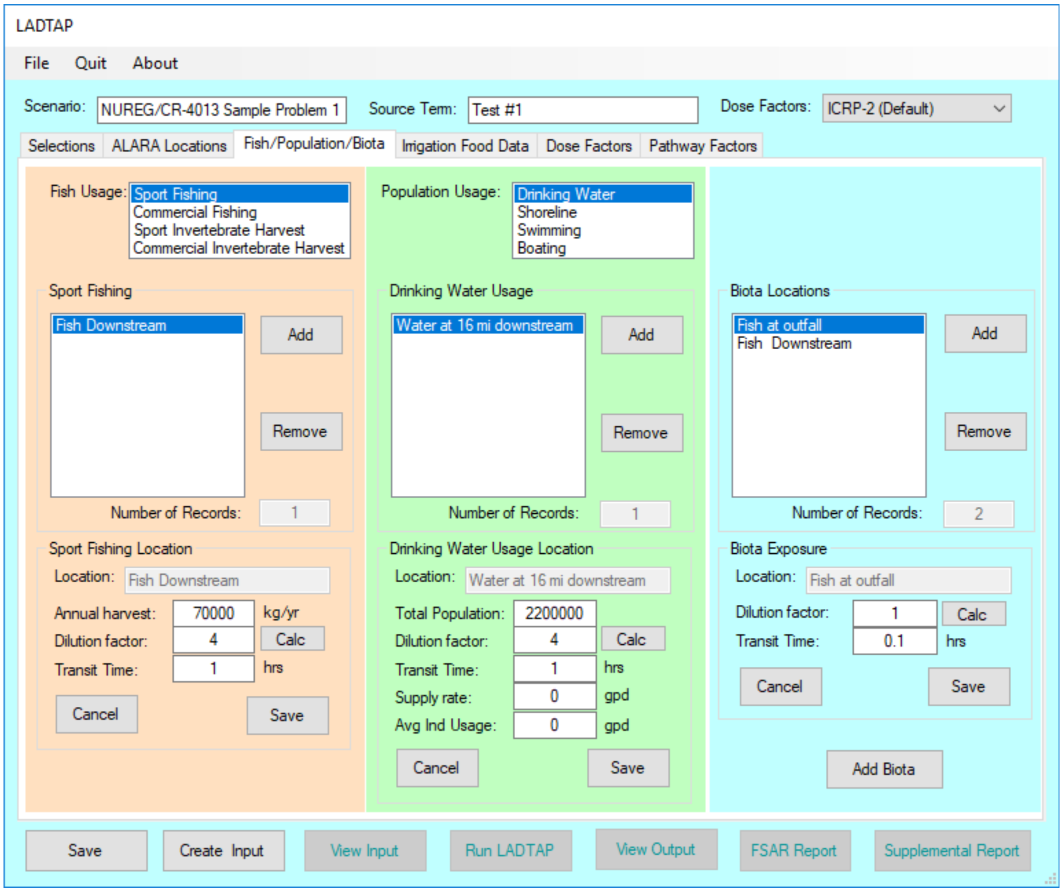


Figure 3-17 Fish/Population/Biota Tab

3.2.3.1 Fish Usage

This section is for data on the total fish and invertebrate harvests at user-designated locations. Select the usage type from the four options shown in Figure 3-17:

- Sport Fishing
- Commercial Fishing
- Sport Invertebrate Harvest
- Commercial Invertebrate Harvest

After selecting an option, the user can add or edit locations, then enter the annual harvest (catch), dilution, and transit time for each location, as shown in Figure 3-18. To define a new location for fishing or invertebrate harvesting, select the "Add" button, which will activate the location area at the bottom of the Fish Usage section. For each location, enter the name of the location, the amount of the annual harvest (in kg/yr), a dilution factor (unitless), and the transit time (in hours). (The values used in "NUREG/CR-4013 Sample Problem 1—ICRP-2" are "**Fish Downstream**," **70000** kg/yr, **4**, and **1** hr, respectively.) If necessary, select the "Calc" button to open the Dilution Factor Calculation screen shown in Figure 3-13, and enter the parameters required for the code to calculate a dilution factor, as discussed in Section 3.2.2.1.2 above.

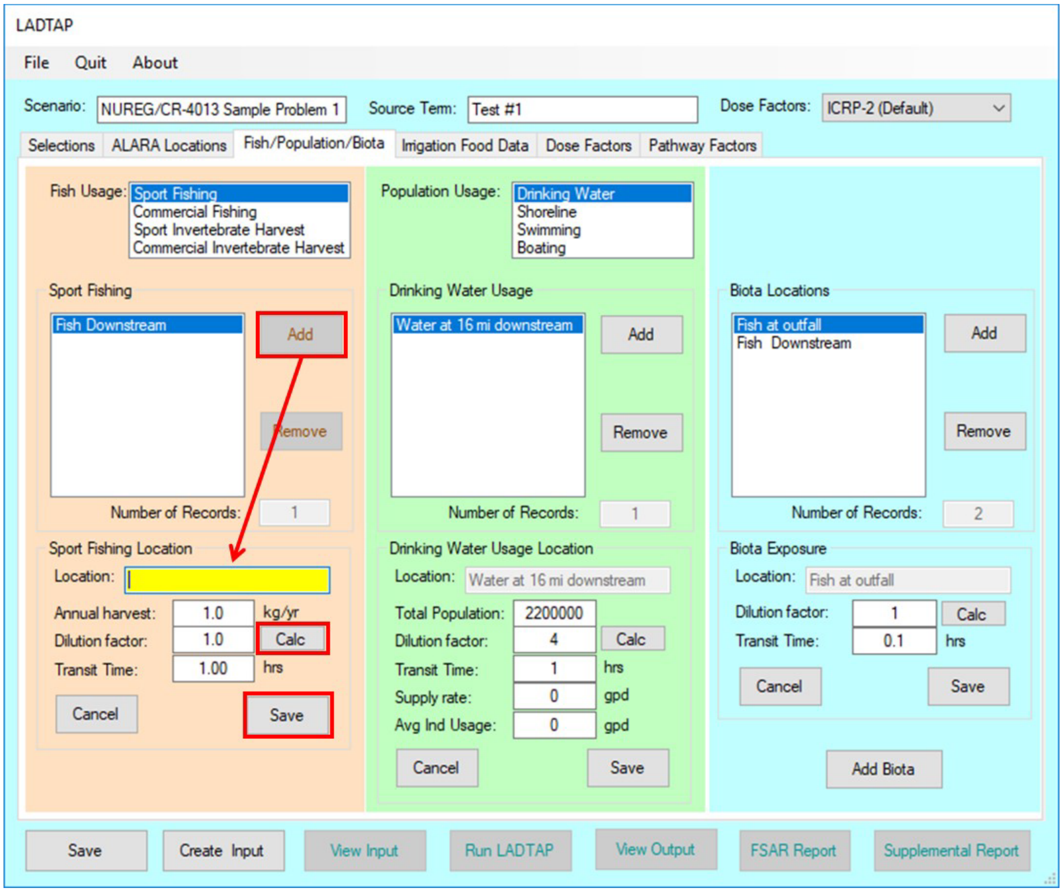


Figure 3-18 Fish Usage Section of the Fish/Population/Biota Tab

After entering the required input parameters for the location, select the "Save" button to add the location to the LADTAP dose calculation input file. To remove a location, select (highlight) the location from the "records" (upper) portion of the Fish Usage section, and select the "Remove" button.

3.2.3.2 Population Usage

In this section, the user can enter data on the total drinking water usage and recreation (shoreline, swimming, and boating) times at user-designated locations. Select the desired population usage pathway from the four options shown in Figure 3-17:

- Drinking Water
- Shoreline
- Swimming

- Boating

Then enter the input parameters for the selected pathway, as shown in Figure 3-19. To define a new population usage location, select the “Add” button to activate the location area at the bottom of the Population Usage section.

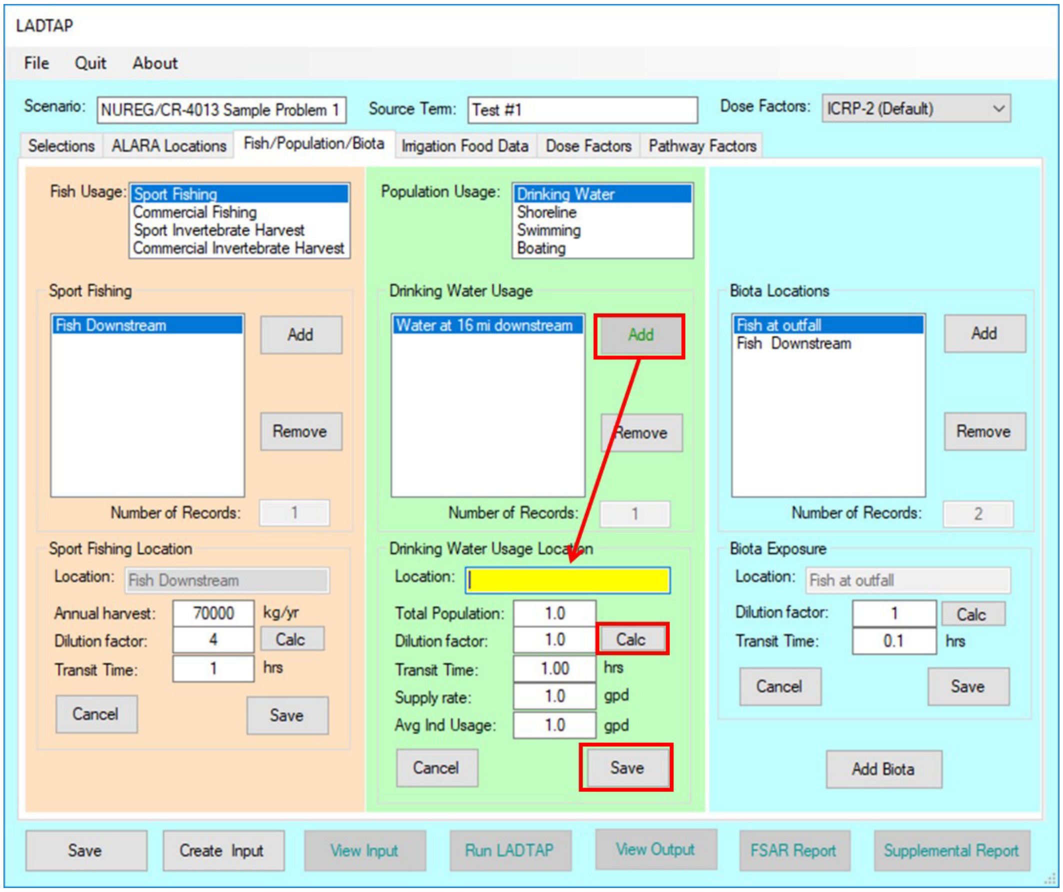


Figure 3-19 Population Usage Section of the Fish/Population/Biota Tab

The input required for each location depends on the usage option chosen from the drop-down menu:

- When the “Drinking Water” option is selected, enter the name of the drinking water location, the total population, the dilution factor (unitless), and the transit time (in hours). (The values from “NUREG/CR-4013 Sample Problem 1—ICRP-2” are “**Water at 16 mi downstream**,” **2200000**, **4**, and **1** hr, respectively.) The default average individual consumption rates and population age-group distribution will be used for the dose calculation. Alternatively, enter the supply rate and average individual usage rate in gallons per day. The code will then calculate the exposed population. If necessary, select the “Calc” button to open the Dilution Factor Calculation screen shown in Figure 3-13, and enter the parameters required for the code to calculate a dilution factor, as discussed in Section 3.2.2.1.2 above.

- When the “Shoreline” option is selected, enter the name of the shoreline location, the annual usage in person-hours per year (person-hr/yr), the dilution factor (unitless), the transit time (in hours), and the shore-width factor. (The values from “NUREG/CR-4013 Sample Problem 1—ICRP-2” are “**Downstream Shore**,” **83000** person-hr/yr, **4**, and **1** hr, respectively.) Table 3-2 lists the shore-width factor drop-down menu options, which are described in Section 3.2.2.1.1. If necessary, select the “Calc” button to open the Dilution Factor Calculation screen shown in Figure 3-13, and enter the parameters required for the code to calculate a dilution factor, as discussed in Section 3.2.2.1.2 above.

- When the “Swimming” option is selected, enter the name of the swimming location, the annual usage (in person-hr/yr), the dilution factor (unitless), and the transit time (in hours). (The values from “NUREG/CR-4013 Sample Problem 1—ICRP-2” are “**Water at 16 mi downstream**,” **120000** person-hr/yr, **4**, and **1** hr, respectively.) If necessary, select the “Calc” button to open the Dilution Factor Calculation screen shown in Figure 3-13, and enter the parameters required for the code to calculate a dilution factor, as discussed in Section 3.2.2.1.2 above.

- When the “Boating” option is selected, enter the name of the boating location, the annual usage (in person-hr/yr), the dilution factor (unitless), and the transit time (in hours). (The values from “NUREG/CR-4013 Sample Problem 1—ICRP-2” are “**Downstream boating**,” **520000** person-hr/yr, **4**, and **1** hr, respectively.) If necessary, select the “Calc” button to open the Dilution Factor Calculation screen shown in Figure 3-13, and enter the parameters required for the code to calculate a dilution factor, as discussed in Section 3.2.2.1.2 above.

After entering the required input parameters for the location, select the “Save” button to add the location to the LADTAP dose calculation input file. To remove a location, select (highlight) the location from the “records” (upper) portion of the Population Usage section, and select the “Remove” button.

3.2.3.3 Biota Locations

In this section, the user can identify and define biota exposure locations. To define a location, select the “Add” button to activate the “Location” area at the bottom of the section, as shown in Figure 3-20. For each location, enter the name of the location, the dilution factor (unitless), and the transit time (in hours). (The values from “NUREG/CR-4013 Sample Problem 1—ICRP-2” are “**Fish at outfall**,” **1**, and **1** hr, respectively.) If necessary, select the “Calc” button to open the Dilution Factor Calculation screen shown in Figure 3-13, and enter the parameters required for the code to calculate a dilution factor, as discussed in Section 3.2.2.1.2 above. Section 3.2.5 of NUREG/CR-4013 provides additional information and explains the biota dose function in the LADTAP II Fortran code.

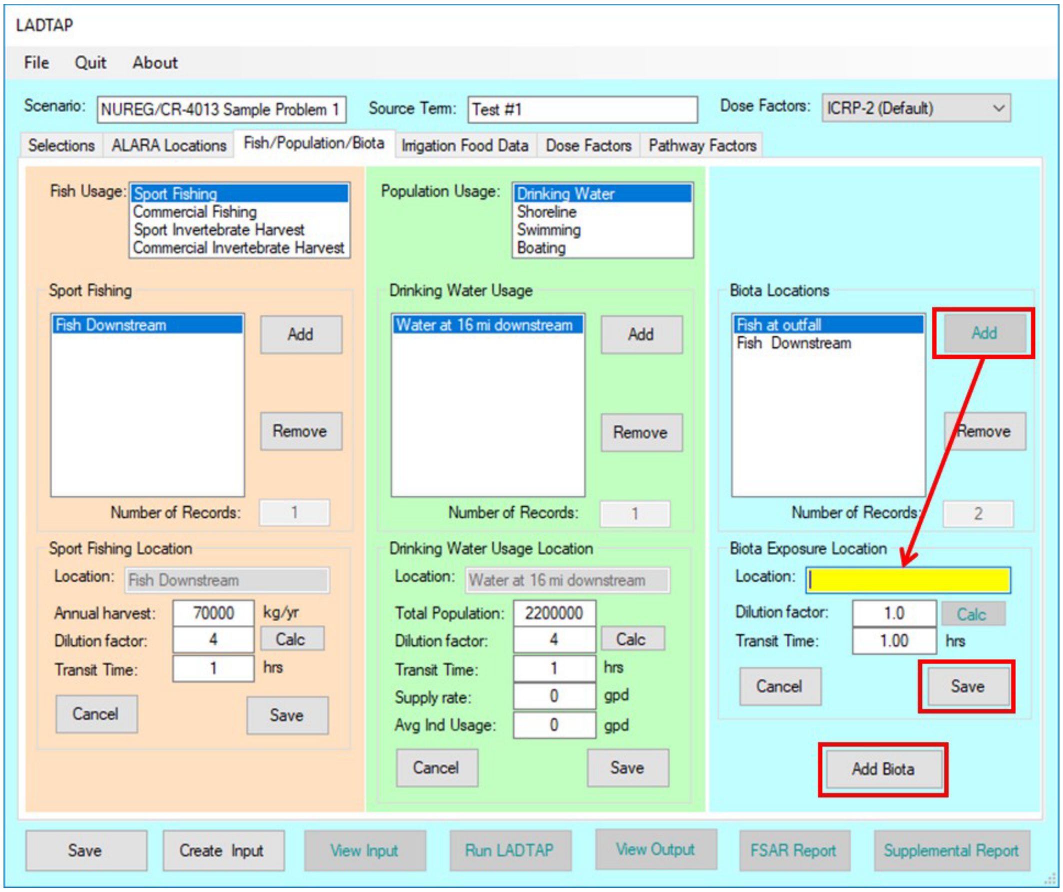


Figure 3-20 Biota Locations Section of the Fish/Population/Biota Tab

The LADTAP code includes three primary aquatic species (fish, invertebrate, and algae) and four secondary terrestrial species (muskrat, raccoon, heron, and duck). As described below, more species can be added with user-defined exposure assumptions. NUREG/CR-4013, Section 3.2.5, provides details on the modeling and exposure assumptions for the three primary and four secondary species. The internal dose component to primary species is calculated considering the bioaccumulation factors for each radionuclide concentration, at the defined location and dilution, which determine an assimilated concentration in the biota mass. The dose to an individual organism is determined by multiplying this biota mass concentration by the nuclide-specific effective energy deposited in the individual, based on a defined effective radius. Tables 3-3 and 3-4 below summarize the modeling and exposure assumptions.

The effective radius is used to model organisms as spheres, so that different dose absorption values can be applied for organisms of different sizes or masses. The effective radius is the radius of a sphere (considered muscle) that has the same mass as the organism in question, assuming the mass is uniformly distributed. Appendix D describes the modeling and calculations for the nuclide-specific deposited energy (dose) values based on effective radius.

Table 3-3 Default Values for Terrestrial Biota Exposure Parameters

Terrestrial Biota	Effective Body Radius (cm)	Body Mass (g)	Consumption of Food (g/d)	Food Organism
Muskrat	6	1,000	100	Aquatic plants
Raccoon	14	1,200	200	Invertebrate
Heron	11	4,600	600	Fish
Duck	5	1,000	100	Aquatic plants

Table 3-4 Biota Exposure Assumptions

Biota	Shoreline (Sediment) Exposure Time (h/yr)	Swimming Exposure Time (h/yr)
Fish	4,380	8,760
Invertebrate	8,760	8,760
Algae	0	8,760
Muskrat	2,922	2,922
Raccoon	2,191	0
Heron	2,922	2,920
Duck	4,383	4,383

If a new biota type will be used, select the “Add Biota” button shown in Figure 3-20 to open the Additional Biota Types screen shown in Figure 3-21. Then select the “Add Biota Type” button, as shown in Figure 3-21, to activate the input parameter fields for the new biota. Enter the following input parameters:

- Name—Enter the name of the biota to be added.
- Food Type—Choose the food type for the new biota from the three options in the drop-down menu (“Algae,” “Fish,” and “Invertebrate”).
- Mass—Enter the mass of the biota, in grams (g). The allowable range for values in this field is greater than 0 g.
- Effective Radius—Enter the effective radius in centimeters (cm). The allowable range for values in this field is greater than 0 cm.

- Consumption Rate—Enter the consumption rate of the biota in grams per day (g/day). The allowable range for values in this field is greater than 0 g/day.

- Shoreline Exposure—Enter the shoreline exposure from the biota in hours per year (hr/yr). The allowable range for values in this field is greater than 0 hr/yr.

- Swimming Exposure—Enter the swimming exposure from the biota in hr/yr. The allowable range for values in this field is greater than 0 hr/yr.

BNWL-1754, "Models and Computer Codes for Evaluating Environmental Radiation Doses," issued February 1974 [Ref. 22], Section 6, describes the modeling used in LADTAP for the biota calculations. Table 6.1-1 in that report presents the exposure assumptions for the various primary and secondary biota.

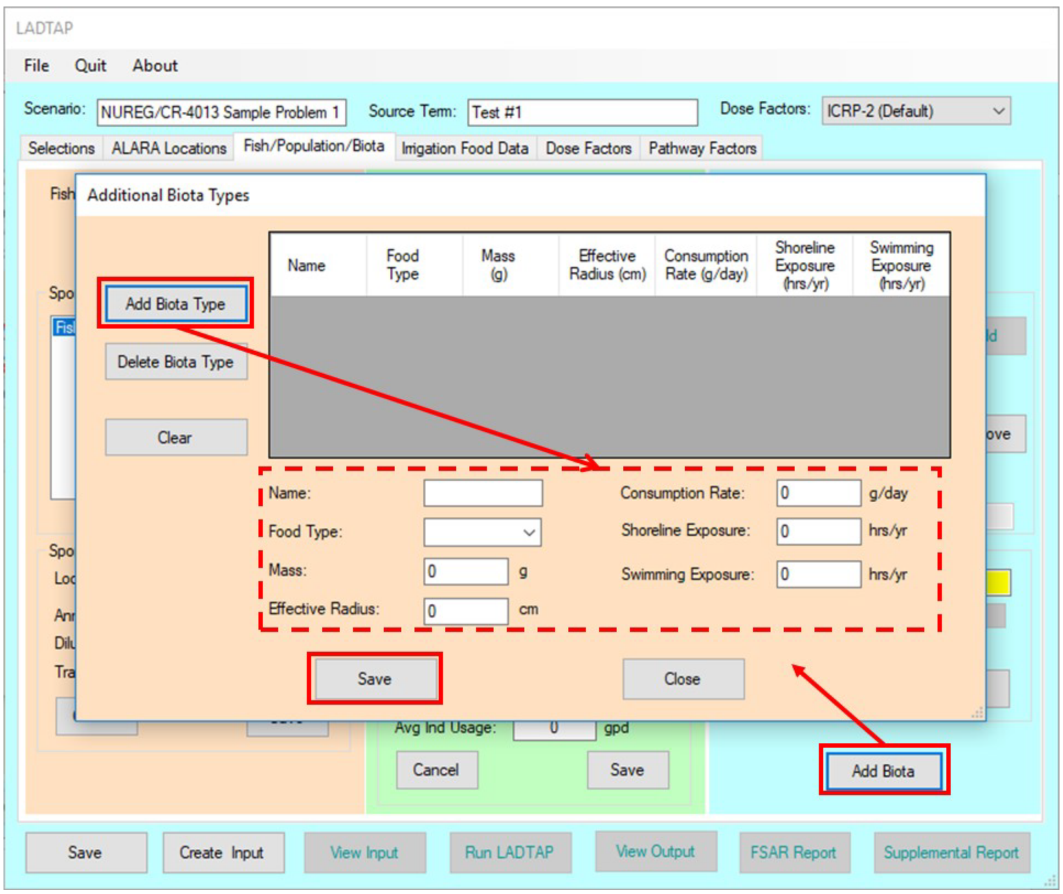


Figure 3-21 Additional Biota Types Screen

After entering the required input parameters for the new biota, select the “Save” button to add the biota type to the LADTAP dose calculation input file. To remove a biota type, select (highlight) it in the upper portion of the Additional Biota Types screen, as shown in Figure 3-21, and select the “Delete Biota Type” button. Select the “Close” button to return to the Biota Locations section of the Fish/Population/Biota tab.

3.2.4 Irrigation Food Data Tab

The Irrigation Food Data tab is used to enter the parameters for calculating human exposure from consumption of vegetables, leafy vegetables, milk, and meat that have been irrigated with water contaminated with radioactive effluents. As shown in Figure 3-22, the Irrigation Food Data tab contains two main data input sections: (1) Irrigated Food Pathways, and (2) Water Usage Locations. Additional data for these sections can be entered in the Irrigated Food Data and Water Usage Data subsections.

** **User Note** **—For every irrigated food pathway defined in the Irrigation Food Data tab, at least one water usage location must be defined on this tab as well.

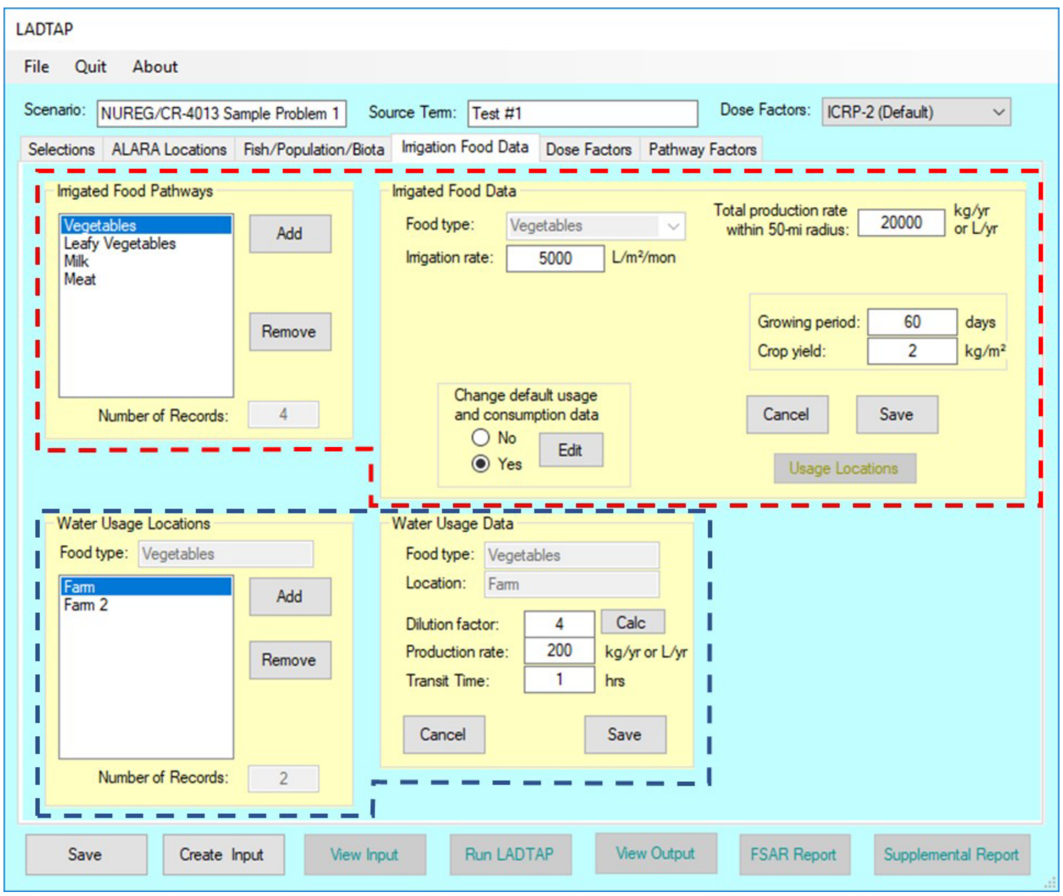


Figure 3-22 Irrigation Food Data Tab

3.2.4.1 *Irrigated Food Pathways*

This section is for adding or removing data on irrigated food pathways for the LADTAP dose calculations. To add an irrigated food pathway, select the “Add” button; this will open the information screen and user note shown in Figure 3-23. Select the “OK” button to activate the Irrigated Food Data subsection, as shown in Figure 3-24 and as discussed in Section 3.2.4.1.1 below. To remove an irrigated food pathway, select (highlight) it, and select the “Remove” button. The Irrigated Food Pathways section also displays the total number of irrigated food pathway records entered.

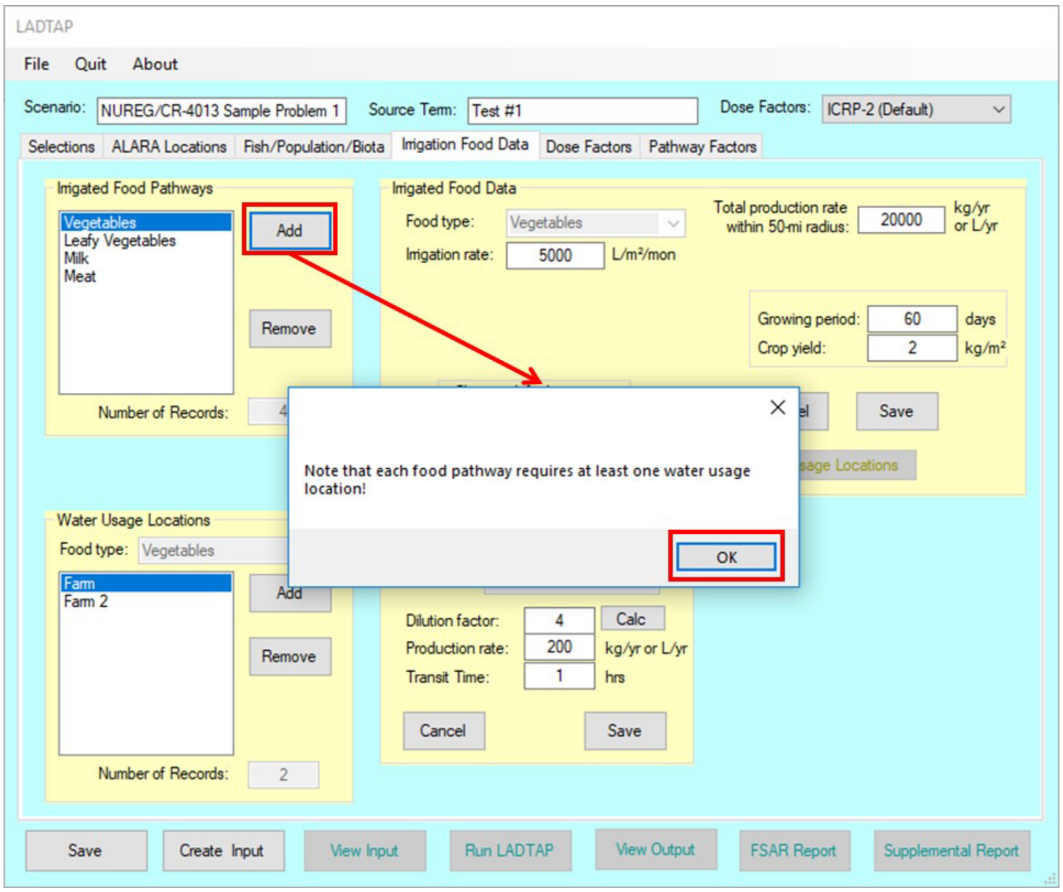


Figure 3-23 Irrigation Food Data Note Screen

3.2.4.1.1 *Irrigated Food Data*

Once the Irrigated Food Data subsection is activated, as shown in Figure 3-24, enter the following input parameters for the new irrigated food type:

- Food Type—Choose the irrigated food type from the four options in the drop-down menu (“Vegetables,” “Leafy Vegetables,” “Milk,” and “Meat”).

- Irrigation Rate—Enter the irrigation rate for the food type, in liters per square meter per month (L/m²/mon). The allowable range for values in this field is greater than 0 L/m²/mon.

- Total Production Rate—Enter the production rate for the irrigated food type within a 50-mile radius, in either kg/yr or liters per year (L/yr). The allowable range for values in this field is greater than 0 kg/yr or 0 L/yr.

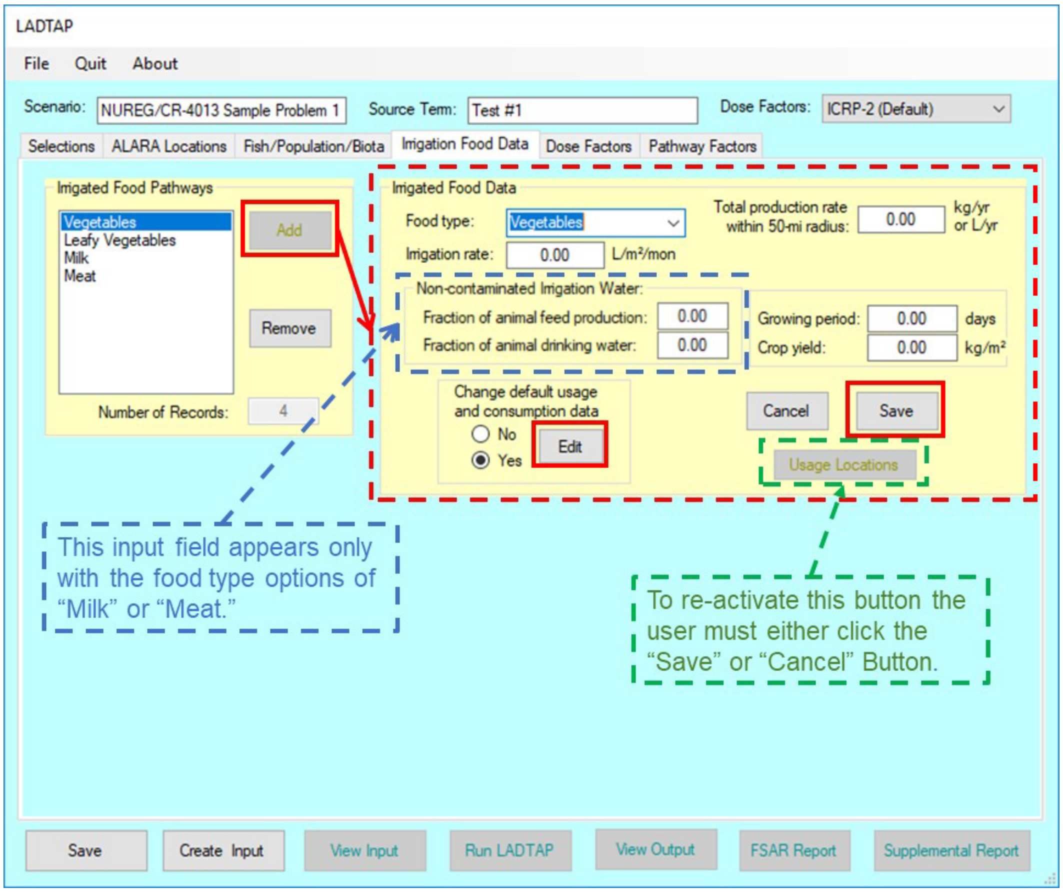


Figure 3-24 Irrigated Food Data Subsection

- Noncontaminated Irrigation Water—These fields are used only for the milk and meat options. They show the fraction of the amount of noncontaminated irrigation water used for livestock feed production. Both fields are unitless, and the allowable range for values in each field is greater than 0.00.

- Growing Period—Enter the length of the growing period for the selected food type, in days. The allowable range for values in this field is greater than 0.00 days. The default values from RG 1.109 are 30 days for milk and meat (reflecting pasture grass) and 60 days for vegetables and leafy vegetables.

- Crop Yield—Enter the crop yield for the selected food type, in kilograms per square meter (kg/m²). The allowable range for values in this field is greater than 0.00 kg/m². The default values from RG 1.109 are 0.7 kg/m^2 for milk and meat (reflecting pasture grass) and 2.0 kg/m^2 for vegetables and leafy vegetables.

To reflect site-specific information, the user can change the individual consumption rates either under the Pathway Factors tab, discussed in Section 3.2.6, or by selecting the “Yes” button and the “Edit” button in the “Change default usage and consumption data” area in Figure 3-24. This will open the Usage/Consumption screen shown in Figure 3-25. Enter the required usage and consumption information following the instructions in Section 3.2.2.1.4 and select the “Save” button when edits are complete to save the revised data.

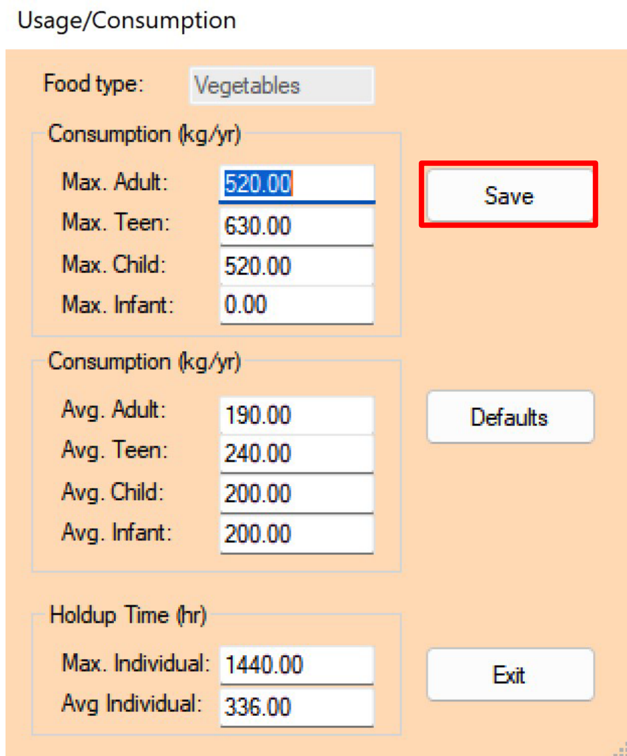


Figure 3-25 Usage/Consumption Screen

After entering the required data for each new irrigated food pathway, select the “Save” button to add to the pathway to the LADTAP dose calculation input file. Selecting either the “Save” or “Cancel” button in the Irrigated Food Data subsection (Figure 3-24) will activate the “Usage Locations” button and allow the user to reopen the Water Usage Locations section of the Irrigation Food Data tab, which is described in Section 3.2.4.2.

3.2.4.2 Water Usage Locations

In the Water Usage Locations section, shown in Figure 3-26, the user can define the water usage location for each irrigated food pathway. To add a location, select the "Add" button, which will activate the Water Usage Data subsection, as shown in Figure 3-26 and as discussed in Section 3.2.4.2.1. To remove a water usage location, select (highlight) the location and select the "Remove" button. The Water Usage Locations section also displays the total number of water usage location records entered.

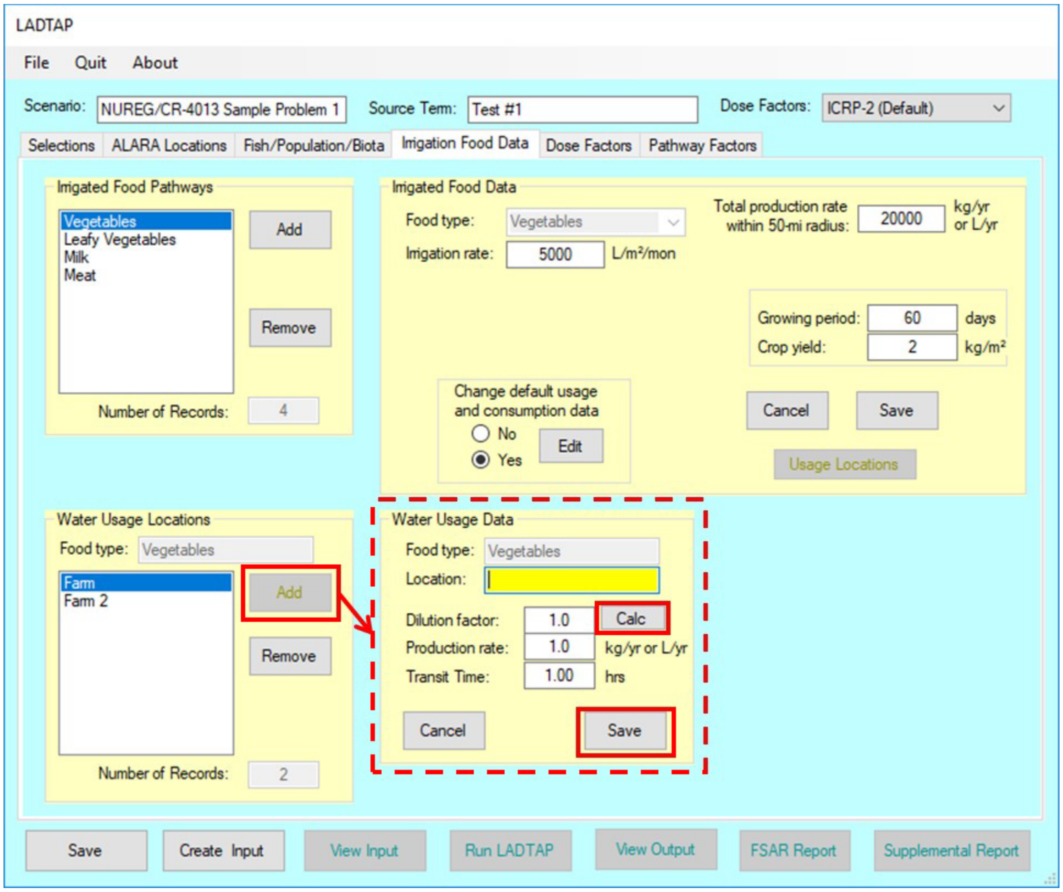


Figure 3-26 Water Usage Data Subsection

3.2.4.2.1 Water Usage Data

Once the Water Usage Data subsection is activated, as shown in Figure 3-26, enter a location name, dilution factor, production rate, and transit time for each irrigated food pathway type. The dilution factor can be calculated as discussed in Section 3.2.2.1.2. (As previously noted, at least one water usage location must be entered for every irrigated food pathway defined; the same water usage location may be used for several irrigated food pathways.) Select "Save" to add the location to the LADTAP case.

** **User Note** **—If multiple water usage locations are listed for a single irrigated food pathway, the LADTAP FSAR Input Report will include only the location with the highest dose.

3.2.5 Dose Factors Tab

The Dose Factors tab, shown in Figure 3-27, is used to view the DCF values selected for the LADTAP dose calculation. The factors displayed will be those for the ICRP dose factor methodology (i.e., ICRP-2 (default), ICRP-30, or ICRP-72) selected from the Dose Factors drop-down menu. To display the DCF values, select the applicable age group and intake pathway (i.e., adult ingestion or inhalation, teen ingestion or inhalation, child ingestion or inhalation, or infant ingestion or inhalation).

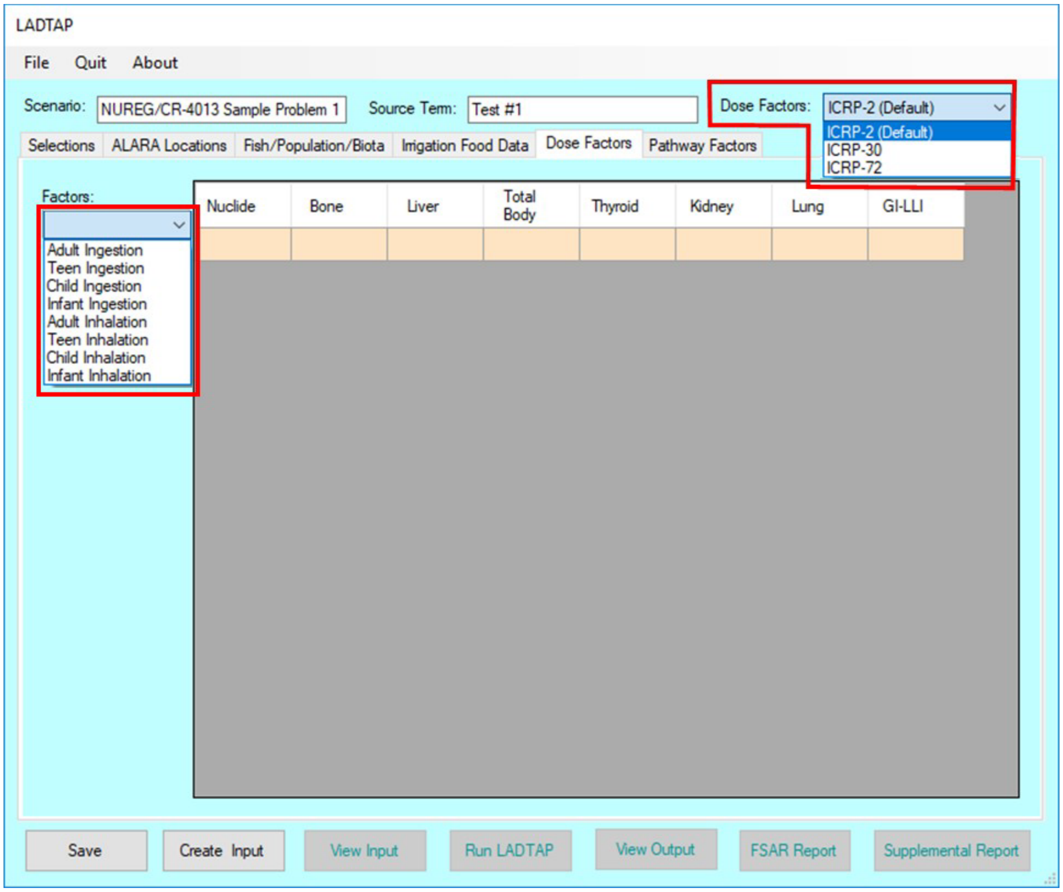


Figure 3-27 Dose Factors Tab with DCF Methodology and Age/Pathway Options

As mentioned above, the Dose Factors drop-down menu provides three DCF sets:

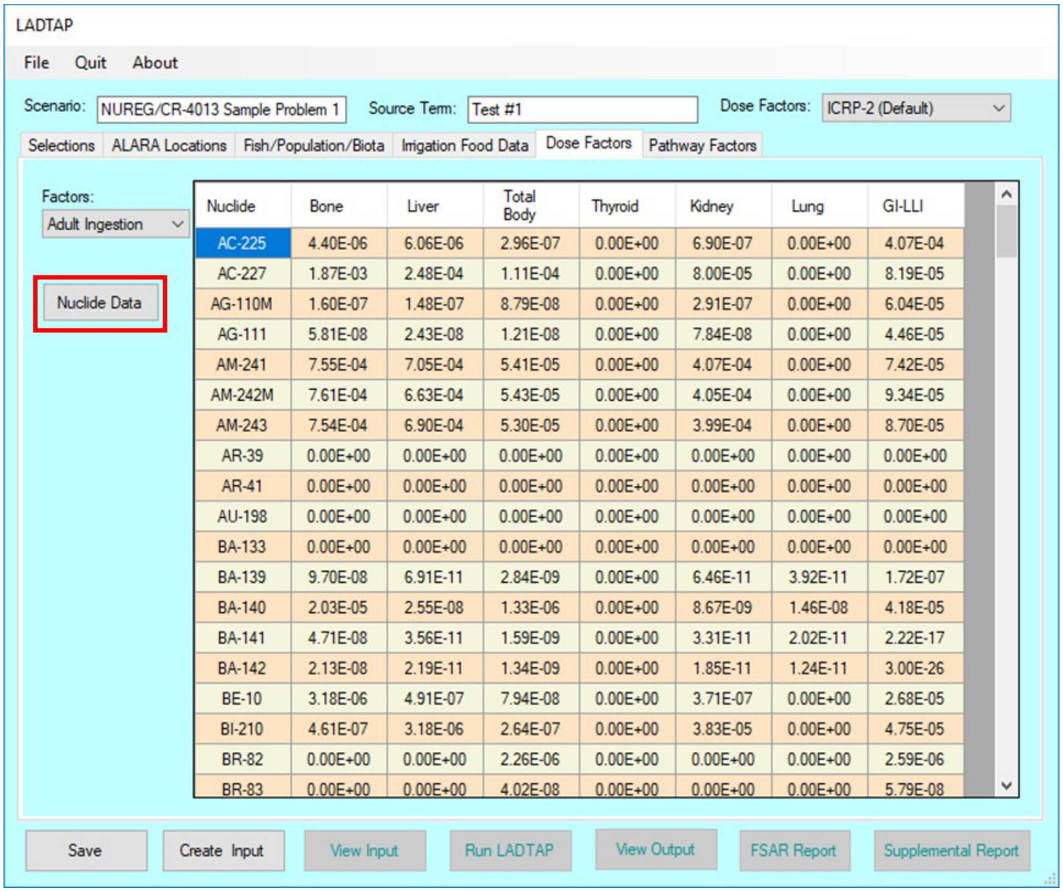
(1) ICRP-2 (Default)—This option provides the default radionuclides and DCF values used by NRCDose3, following the precedent set by the NRC release of LADTAP II and GASPAR II. These DCF values are based on the ICRP-2 methodology, which is the current basis of the NRC regulations in 10 CFR Part 50, Appendix I, and of the EPA regulations in 40 CFR Part 190. ICRP-2 DCF values are included for four age groups (Infant, Child, Teen, and Adult) and seven organs (Bone, Liver, Total Body, Thyroid, Kidney, Lung, and Gastrointestinal-Lower Large Intestine (GI-LLI)). Appendix A to this manual lists the 203 radionuclides covered by the ICRP-2 methodology, as well as the relevant technical references.

(2) ICRP-30—This option provides occupational DCF values for ingestion and inhalation based on the ICRP-30 methodology, which is the current basis of the NRC regulations in 10 CFR Part 20. The ICRP-30 methodology includes DCF values for 24 organs, for adults only (since the values apply only to occupational exposures). The available radionuclides are the same as the 203 radionuclides listed in appendix A and available for the ICRP-2 option. Section 6.1 discusses in detail the selection of the radionuclide inhalation class (i.e., D/M/Y).

(3) ICRP-72—This option provides DCF values based on the methodology in ICRP Publication 60, "1990 Recommendations of the International Commission on Radiological Protection" (ICRP-60), issued 1991 [Ref. 33]. DCF values are included for inhalation and ingestion pathways, for six age groups (Newborn, 1 yr, 5 yr, 10 yr, 15 yr, and Adult) and 27 organs (including Remainder and Effective). The 203 radionuclides listed in appendix A for the ICRP-2 and ICRP-30 options are also available for the ICRP-72 option. Section 6.1 discusses in detail the selection of the radionuclide inhalation class (i.e., F/M/S).

** **User Note** **—An applicant or licensee preparing an NRC LAR should discuss the use of ICRP-72 DCF values with the NRC staff before submitting the request.

After selecting the appropriate ICRP methodology and dose factors from their respective drop-down menus, the user can review all applicable organ DCF values, as shown in Figure 3-28. Select the "Nuclide Data" button to open the Nuclide Data screen shown in Figure 3-29 and view applicable nuclide data, such as atomic weight, isomeric state, decay constant, and external dose factors. Select the "Exit" button to return to the Dose Factors tab.



Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
AC-225	4.40E-06	6.06E-06	2.96E-07	0.00E+00	6.90E-07	0.00E+00	4.07E-04
AC-227	1.87E-03	2.48E-04	1.11E-04	0.00E+00	8.00E-05	0.00E+00	8.19E-05
AG-110M	1.60E-07	1.48E-07	8.79E-08	0.00E+00	2.91E-07	0.00E+00	6.04E-05
AG-111	5.81E-08	2.43E-08	1.21E-08	0.00E+00	7.84E-08	0.00E+00	4.46E-05
AM-241	7.55E-04	7.05E-04	5.41E-05	0.00E+00	4.07E-04	0.00E+00	7.42E-05
AM-242M	7.61E-04	6.63E-04	5.43E-05	0.00E+00	4.05E-04	0.00E+00	9.34E-05
AM-243	7.54E-04	6.90E-04	5.30E-05	0.00E+00	3.99E-04	0.00E+00	8.70E-05
AR-39	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AR-41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU-198	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA-139	9.70E-08	6.91E-11	2.84E-09	0.00E+00	6.46E-11	3.92E-11	1.72E-07
BA-140	2.03E-05	2.55E-08	1.33E-06	0.00E+00	8.67E-09	1.46E-08	4.18E-05
BA-141	4.71E-08	3.56E-11	1.59E-09	0.00E+00	3.31E-11	2.02E-11	2.22E-17
BA-142	2.13E-08	2.19E-11	1.34E-09	0.00E+00	1.85E-11	1.24E-11	3.00E-26
BE-10	3.18E-06	4.91E-07	7.94E-08	0.00E+00	3.71E-07	0.00E+00	2.68E-05
BI-210	4.61E-07	3.18E-06	2.64E-07	0.00E+00	3.83E-05	0.00E+00	4.75E-05
BR-82	0.00E+00	0.00E+00	2.26E-06	0.00E+00	0.00E+00	0.00E+00	2.59E-06
BR-83	0.00E+00	0.00E+00	4.02E-08	0.00E+00	0.00E+00	0.00E+00	5.79E-08

Figure 3-28 Dose Factors Tab with ICRP-2 DCF Values for Review

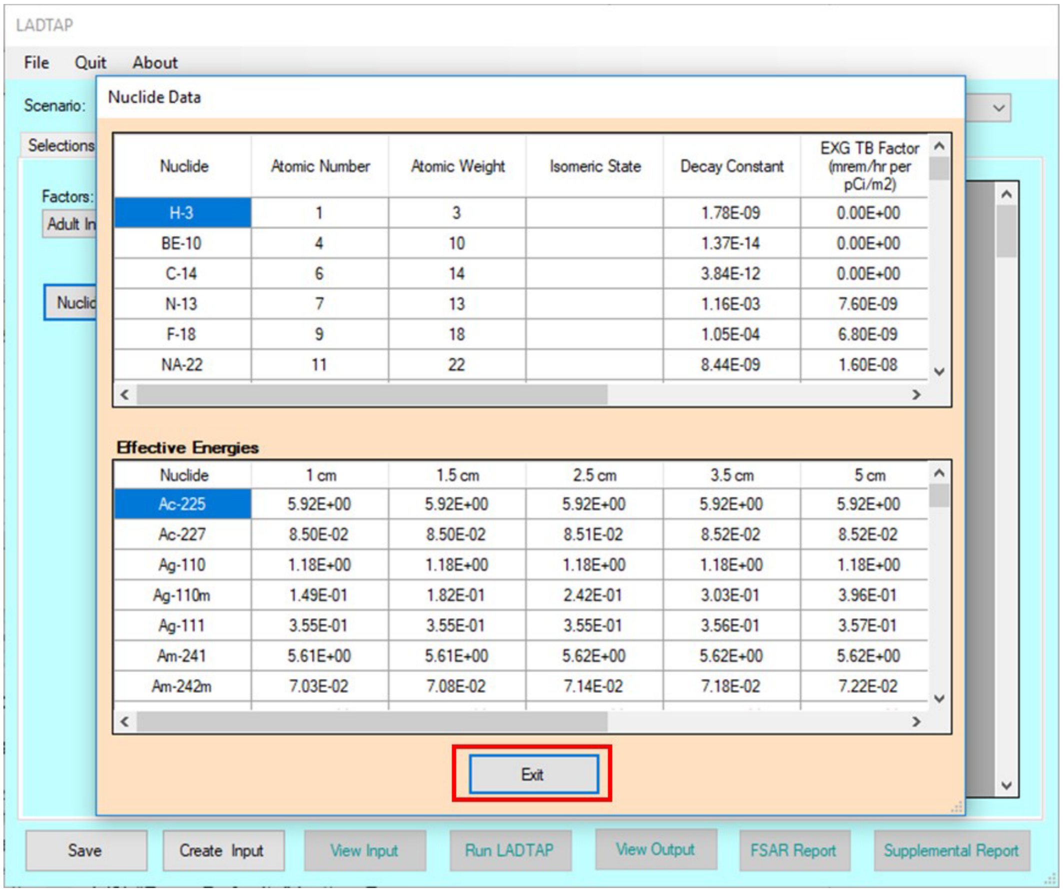


Figure 3-29 Nuclide Data Screen

3.2.6 Pathway Factors Tab

The Pathway Factors tab is used to view and edit the remaining parameters needed to complete the liquid pathway LADTAP dose calculation. As shown in Figure 3-30, the Pathway Factors tab contains the main liquid pathway parameters sections and three option selection buttons. The three option selection buttons are (1) “Bioaccumulation Factors,” (2) “Usage/Consumption,” and (3) “Page Defaults.”

**** User Note ****—The initial install includes the parameter values recommended in RG 1.109, except when the DCFs from ICRP-72 are used, in which case the Usage/Consumption values are taken from the EPA’s EFH. Any change made to the values in this tab will be saved in the program’s main database and will be used for future calculations. Therefore, if values are changed to reflect site-specific information, then after saving the case/file (which will also save all changes applicable to the case/file), the user should reset the values to the defaults so that the changes do not affect future uses and calculations.

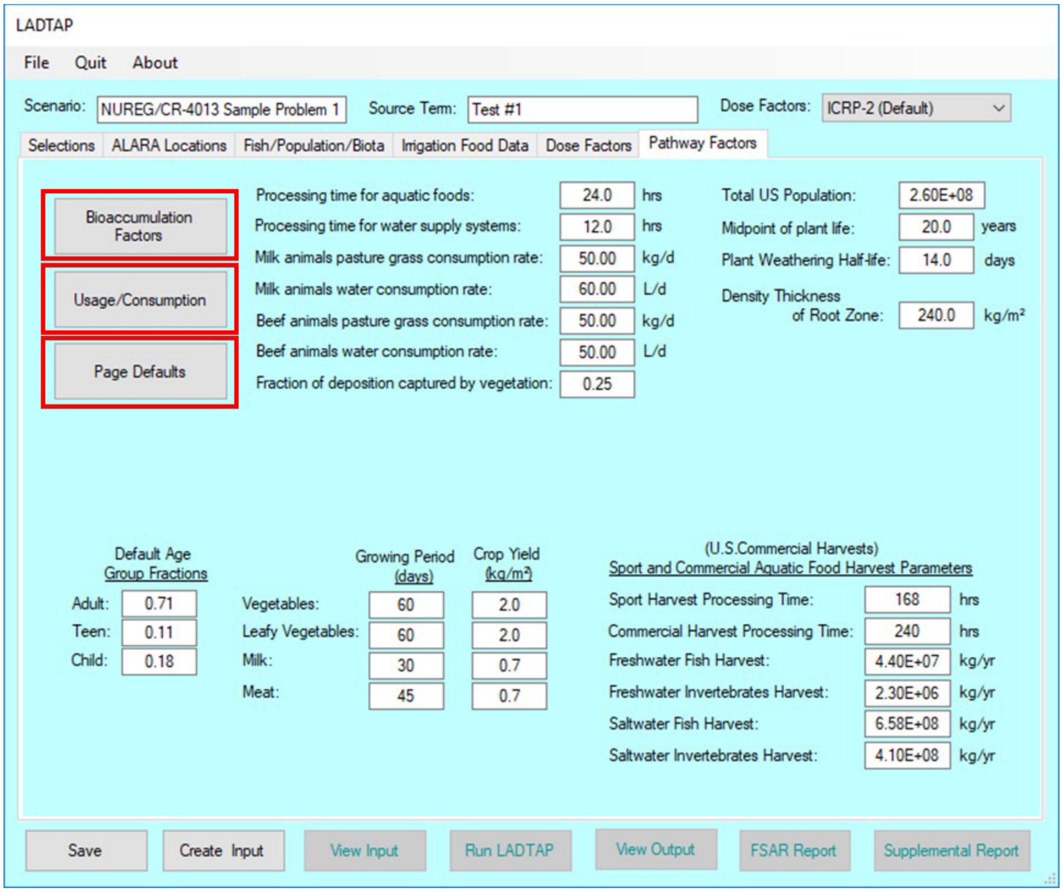


Figure 3-30 Pathway Factors Tab

3.2.6.1 Liquid Pathway Parameters

On the Pathway Factors tab, users can review and edit the following liquid pathway parameters, as shown in Figure 3-30:

- The processing time for aquatic foods is entered in hours. The default value, also used in "NUREG/CR-4013 Sample Problem 1—ICRP-2," is the RG 1.109 value of **24.0** hr. The allowable range for values in this field is greater than 0.0 hrs.
- The processing time for water supply systems is entered in hours. The default value, also used in "NUREG/CR-4013 Sample Problem 1—ICRP-2," is the RG 1.109 value of **12.0** hr. The allowable range for values in this field is greater than 0.0 hrs.
- The pasture grass consumption rate for milk-producing animals is entered in kilograms per day (kg/d). The default value, also used in "NUREG/CR-4013 Sample Problem 1—ICRP-2," is the RG 1.109 value of **50.0** kg/d. The allowable range for values in this field is greater than 0.0 kg/d.
- The water consumption rate for milk-producing animals is entered in liters per day (L/d). The default value, also used in "NUREG/CR-4013 Sample Problem 1—ICRP-2," is the

RG 1.109 value of **60.0** L/d. The allowable range for values in this field is greater than 0.0 L/d.

- The pasture grass consumption rate for beef-producing animals is entered in kg/d. The default value, also used in “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is the RG 1.109 value of **50.0** kg/d. The allowable range for values in this field is greater than 0.0 kg/d.

- The water consumption rate for beef-producing animals is entered in L/d. The default value, also used in “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is the RG 1.109 value of **50.0** L/d. The allowable range for values in this field is greater than 0.0 L/d.

- The fraction of deposition captured by vegetation is unitless. The default value, also used in “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is the RG 1.109 value of **0.25**. The allowable range for values in this field is greater than 0.0 and less than 1.0.

- For the total U.S. population, the default value, also used in “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is the RG 1.109 value of **2.60E+08**. The allowable range for values in this field is greater than 0.0. (**Note:** This value is a carryover from previous LADTAP population dose calculations; it remains a required code factor but is not used for current calculations.)

- The midpoint of the plant life is entered in years, with the default value of **20** years (also used for “NUREG/CR-4013 Sample Problem 1—ICRP-2”). RG 1.109 references a nominal value of 15 years; however, in the LADTAP II and GASPAR II Fortran codes, this value was changed to 20 years to reflect the nominal 40-year expected operating life for a nuclear plant (without license extension). The allowable range for values in this field is greater than 0.0 years.

- The plant weathering half-life is entered in days. The default value, also used in “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is the RG 1.109 value of **14** days. The allowable range for values in this field is greater than 0.0 days.

- The density thickness of the root zone is entered in kg/m^2. The default value, also used in “NUREG/CR-4013 Sample Problem 1—ICRP-2,” is the RG 1.109 value of **240** kg/m^2. The allowable range for values in this field is greater than 0.0 kg/m^2.

- Default age group fractions are entered for “Adult,” “Teen,” and “Child” (unitless). The default values, also used in “NUREG/CR-4013 Sample Problem 1—ICRP-2,” are the RG 1.109 values of **0.71**, **0.11**, and **0.18**, respectively. The allowable range for values in these fields is greater than 0.0. If using the ICRP-30 DCF values, the user should enter fractions of 1.00 for “Adult” and 0 for “Teen” and “Child,” since ICRP-30 contains DCF values only for the adult age range.

- Growing periods for vegetables, leafy vegetables, milk, and meat are entered in days. The default values, also used in “NUREG/CR-4013 Sample Problem 1—ICRP-2,” are the RG 1.109 values of **60**, **60**, **30**, and **45** days, respectively. The allowable range for values in these fields is greater than 0.0 days.

- Crop yields for vegetables, leafy vegetables, milk, and meat are entered in kg/m^2. The default values, also used in “NUREG/CR-4013 Sample Problem 1—ICRP-2,” are the

RG 1.109 values of **2.0**, **2.0**, **0.7**, and **0.7** kg/m^2, respectively. The allowable range for values in these fields is greater than 0.0 kg/m^2.

Additionally, as shown in Figure 3-30, the Pathway Factors tab includes the sport and commercial aquatic food harvest parameters listed below. The RG 1.109 values used as defaults represent the total U.S. harvest data from the 1970s. For commercial harvests, all production within 50 miles of the site is considered part of the total U.S. harvest. Appendix D to RG 1.109 contains equations for computing the average concentration in the U.S. commercial harvest (equation D-2) and the annual population-integrated dose (equation D-4). The parameters to be entered are as follows:

- The sport harvest processing time is entered in hours. The default value, also used in "NUREG/CR-4013 Sample Problem 1—ICRP-2," is the RG 1.109 value of **168** hr. The allowable range for values in this field is greater than 0.0 hrs.

- The commercial harvest processing time is entered in hours. The default value, also used in "NUREG/CR-4013 Sample Problem 1—ICRP-2," is the RG 1.109 value of **240** hr. The allowable range for values in this field is greater than 0.0 hrs.

- The freshwater fish harvest is entered in kg/yr. The default value, also used in "NUREG/CR-4013 Sample Problem 1—ICRP-2," is the RG 1.109 value of **4.40E+07** kg/yr. The allowable range for values in this field is greater than 0.0 kg/yr.

- The freshwater invertebrate harvest is entered in kg/yr. The default value, also used in "NUREG/CR-4013 Sample Problem 1—ICRP-2," is the RG 1.109 value of **2.30E+06** kg/yr. The allowable range for values in this field is greater than 0.0 kg/yr.

- The saltwater fish harvest is entered in kg/yr. The default value, also used in "NUREG/CR-4013 Sample Problem 1—ICRP-2," is the RG 1.109 value of **6.58E+08** kg/yr. The allowable range for values in this field is greater than 0.0 kg/yr.

- The saltwater invertebrate harvest is entered in kg/yr. The default value, also used in "NUREG/CR-4013 Sample Problem 1—ICRP-2," is the RG 1.109 value of **4.10E+08** kg/yr. The allowable range for values in this field is greater than 0.0 kg/yr.

3.2.6.2 Bioaccumulation Factors

To review and edit either the bioaccumulation factors for aquatic biota or the transfer factors for meat, soil, and milk, select the "Bioaccumulation Factors" button shown in Figure 3-30 to open the Bioaccumulation Factors & Transfer Coefficients screen shown in Figure 3-31.

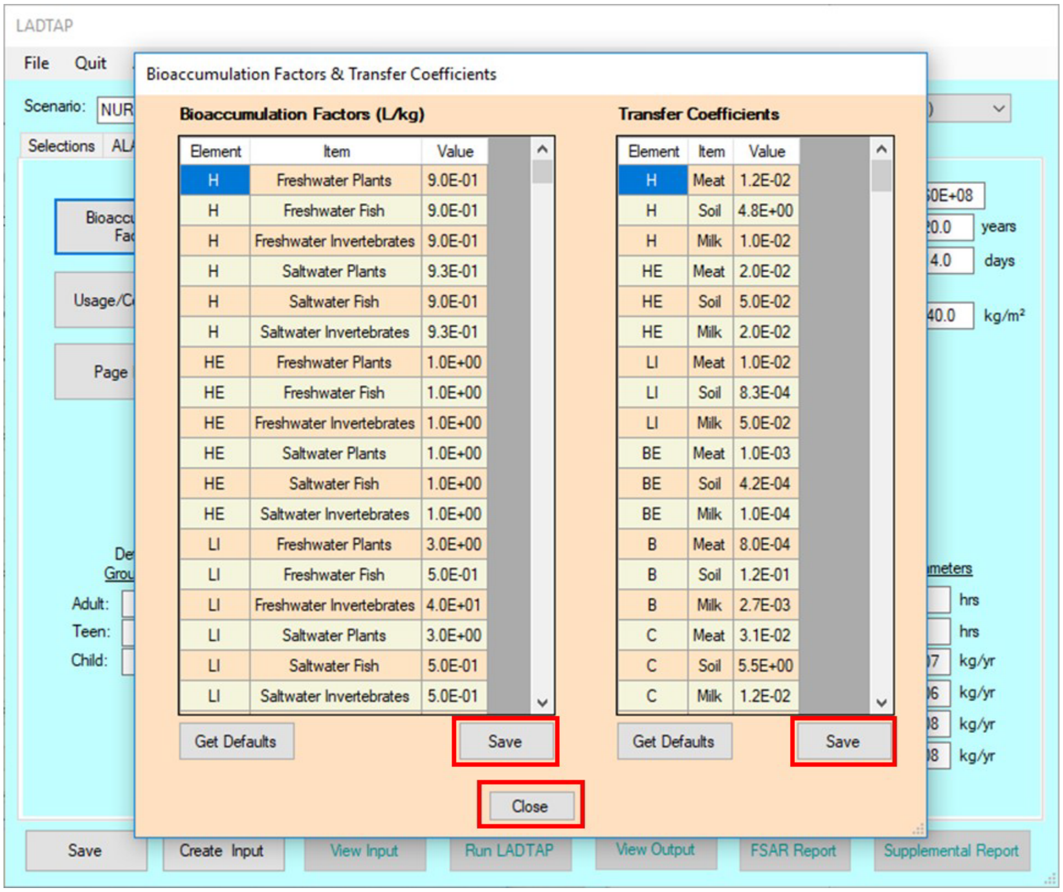


Figure 3-31 Bioaccumulation Factors & Transfer Coefficients Screen

Then use the scrolling tool to review and adjust the bioaccumulation factors for saltwater and freshwater plants and fish, as well as the transfer factors for meat, soil, and milk. The RG 1.109 default values should be used unless site-specific values have been determined and are supported by adequate technical bases. Select the “Save” button to save any edits to the bioaccumulation factors or transfer coefficients. When the database has been updated, NRCDose3 will inform the user as shown in Figure 3-32. After reviewing and adjusting the bioaccumulation factors and transfer coefficients, select the “Close” button to return to the Pathway Factors tab. NRCDose3 will again prompt the user to save any changes, as shown in Figure 3-32. Select the “Yes” button to close the prompt window.

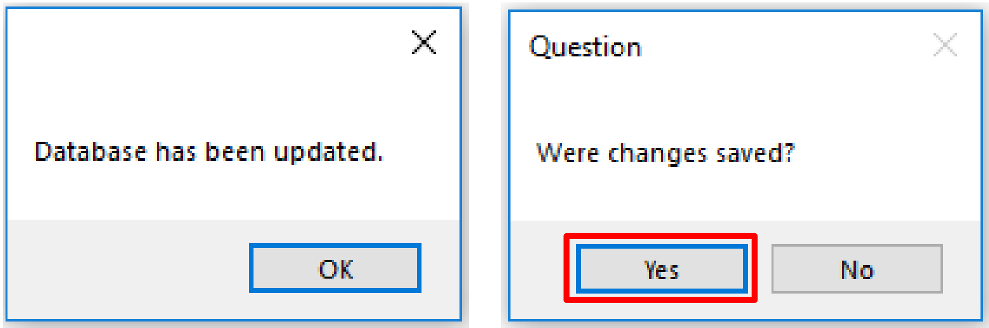


Figure 3-32 Bioaccumulation Factors & Transfer Coefficients Prompt Screens

3.2.6.3 Usage/Consumption

To review and edit the usage and consumption rates for food, drink, and recreation, select the "Usage/Consumption" button shown in Figure 3-30 to open the Usage/Consumption Data screen shown in Figure 3-33. In general, maximum individual factors are used for individual dose evaluations, while average individual factors are used for population dose evaluations. As shown in Figure 3-33, the Usage/Consumption Data screen shows the following tables of data, which correspond to the databases used in the LADTAP dose calculations:

- Maximum Individual Exposure Consumption Data for Selected Dose Factors—This table gives usage/consumption rates, in kg/yr, for four age groups ("Adults," "Teens," "Children," and "Infants") and eight usage/consumption types ("Fish," "Freshwater Invertebrates," "Aquatic Plants," "Drinking Water," "Shoreline Usage," "Swimming Usage," "Boating Usage," and "Saltwater Invertebrates").

- Irrigated Food Type Consumption Data—This table gives the maximum and average consumption rates, in kg/yr, and holdup times, in hours, for four age groups ("Adults," "Teens," "Children," and "Infants") and four food types ("Vegetables," "Leafy Vegetables," "Milk," and "Meat"). "Max Individual Holdup Time (hr)" refers to the holdup time used to calculate the maximum dose, which is the minimum holdup time.

- Average Individual Consumption Data—This table gives the average individual consumption, in kg/yr, for three age groups ("Adults," "Teens," and "Children") and three consumption types ("Fish," "Invertebrates," and "Drinking Water").

The values in these tables depend on the ICRP methodology selected. For the ICRP-2 and ICRP-30 methodologies, the exposure assumption values are generally from RG 1.109; for the ICRP-72 methodology, the exposure assumption values are derived from the EPA's EFH. Appendix C to this manual describes in detail the default usage and consumption rates under each ICRP methodology.

Figure 3-33 Usage/Consumption Data Screen

Select the “Save” button to save any edits made to the usage/consumption data. When the database has been updated, NRCDose3 will inform the user as shown in Figure 3-32. After reviewing and adjusting the usage/consumption data, select the “Close” button to return to the Pathway Factors tab. NRCDose3 will again prompt the user to save any changes made to the usage/consumption data, as shown in Figure 3-32. Select the “Yes” button to close the prompt window.

** **User Note** **—If the ICRP methodology has been changed (e.g., from ICRP-2 to either ICRP-30 or ICRP-72), the user should review the usage and consumption rates to ensure that the proper values are used in the LADTAP dose calculation. An applicant or licensee preparing an NRC LAR should discuss the use of ICRP-72 DCF values with the NRC staff before submitting the request. The code will automatically set the usage/consumption values to those associated with the DCFs being used (i.e., the RG 1.109 generic factors for the ICRP-2 and ICRP-30 DCFs, and the EPA’s EFH for the ICRP-72 DCFs).

3.2.6.4 Page Defaults

Select the “Page Defaults” button on the Pathway Factors tab shown in Figure 3-30 to return all liquid pathway parameters in the LADTAP dose calculation to their default values.

**** User Note****—Remember that any changes made to the pathway factors will be carried forward for future runs. Defaults should be reset using the “Get Default” option. Also remember that saving a case/file will save all configurations and values selected for the case. Resetting to defaults will not affect any changes made for a particular case/file unless this file is again saved after values are changed back to defaults.

3.3 <u>Code Execution and Reports</u>

3.3.1 Executing LADTAP

After all data for the LADTAP dose calculation have been entered, select the “Save” button, as shown in Figure 3-34, to save the data to the data set being used to create the input file, as well as to a file name if one has been created for the case. NRCDose3 will save the data to the LADTAP database, which will be used for the calculation. If a saved file (i.e., a *.LN3 file) is being used, it will also be updated. Select the “OK” button to save the data to the database file (for use in creating the input for the run) and, as applicable, to the open *.LN3 file.

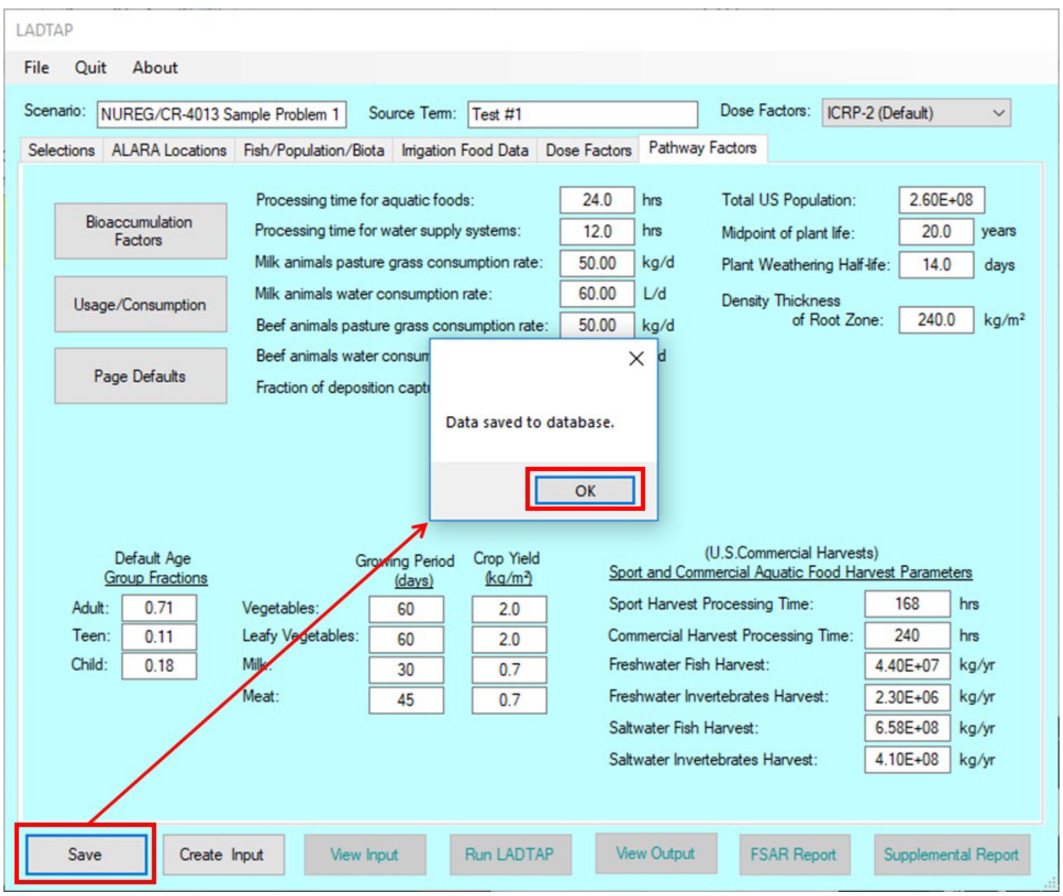


Figure 3-34 Saving LADTAP Inputs

If the data are to be saved to a different *.LN3 database file, then open the File drop-down menu and select “Save to LN3 File…” as shown in Figure 3-3. This will open a Windows Explorer directory, as shown in Figure 3-35. Name the *.LN3 file and choose the directory location as desired. Future saves within NRCDose3 will save to this file name, as well as to the database used for code execution.

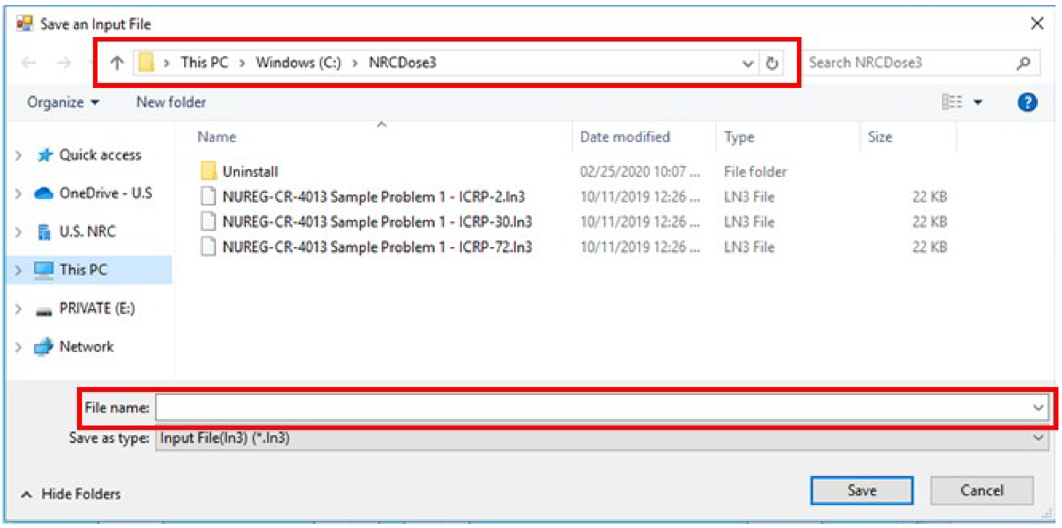


Figure 3-35 Windows Explorer Directory for Saving LADTAP Inputs to a New File

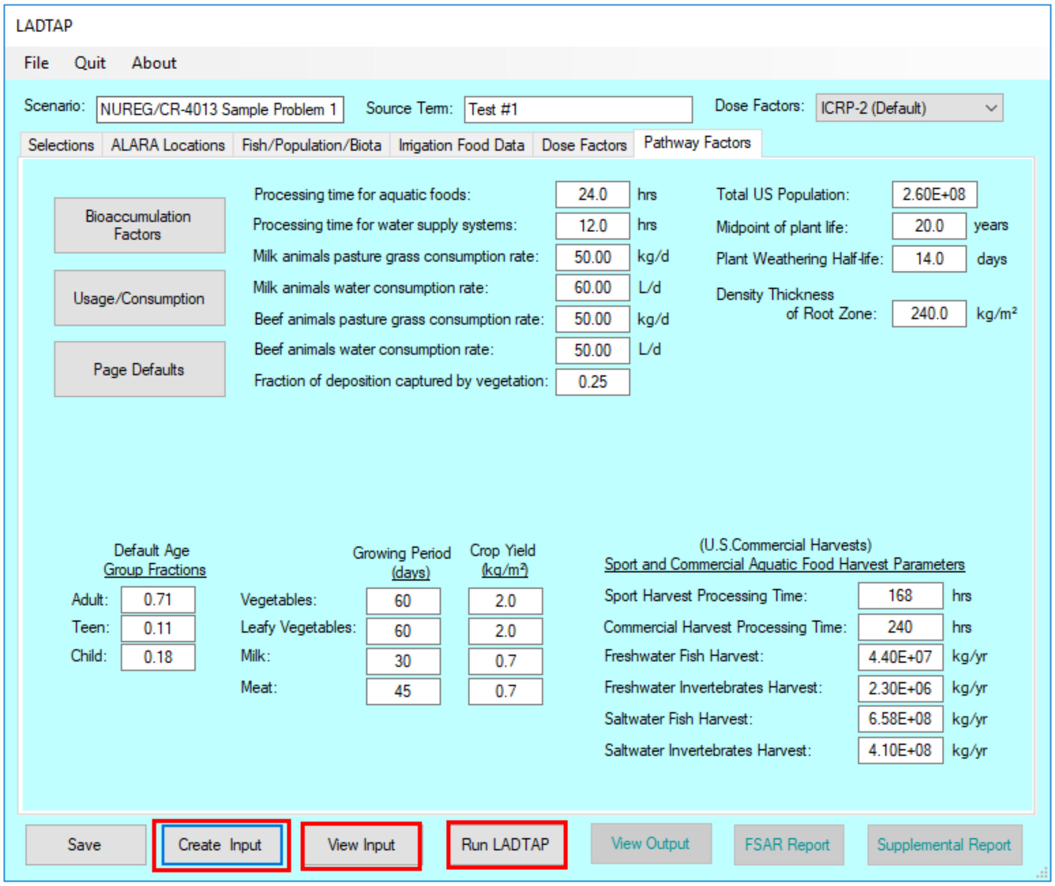


Figure 3-36 LADTAP Module Main Screen—"Create Input" Button

Select the "Create Input" button to activate the "View Input" and "Run LADTAP" buttons on the LADTAP module main screen, as shown in Figure 3-36. Select the "View Input" button to display the Text Viewer screen and review the text file of input data, as shown in Figure 3-37. Select the "Save As…" button to open a Windows Explorer directory and save the input as an input field file (*.LN3). Select the "Print" button to print the input text file, and the "Close" button to close the Text Viewer screen and return to the LADTAP module main screen.

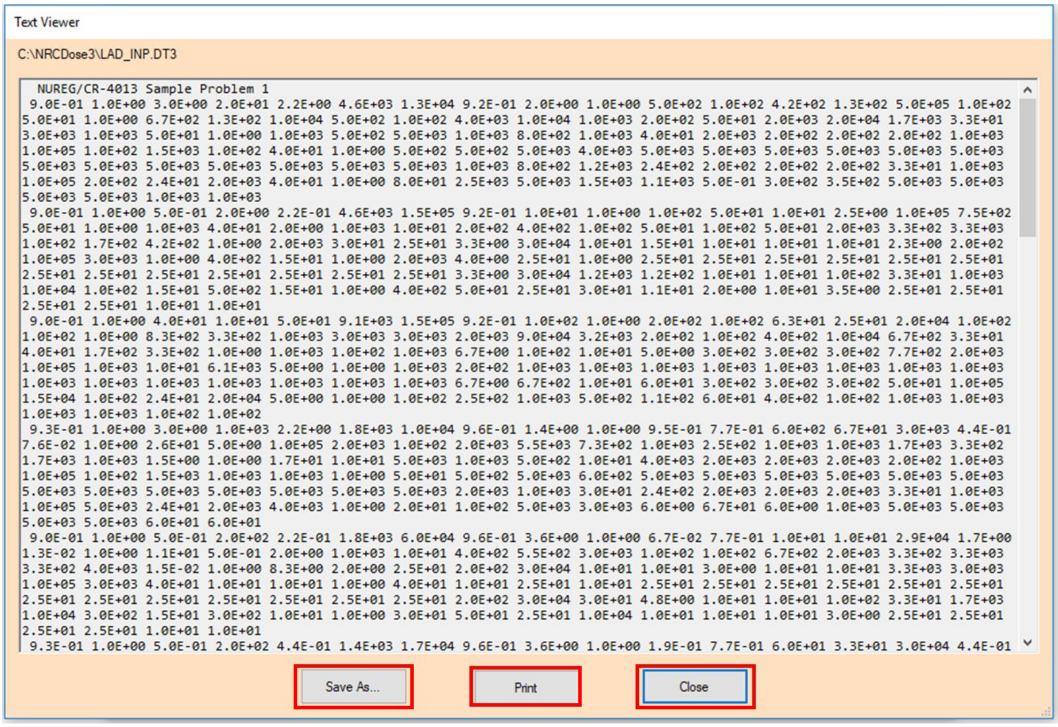


Figure 3-37 Viewing LADTAP Input—Text Viewer Screen

Select the "Run LADTAP" button shown in Figure 3-36 to execute the code and generate the output report. This will also activate the "View Output," "FSAR Report," and "Supplemental Report" buttons on the LADTAP module main screen, as shown in Figure 3-38. After NRCDose3 completes the LADTAP dose calculation, the output will automatically appear as a text output file, as shown in Figure 3-39. Select the "Save As…" button shown in Figure 3-39 to open a Windows Explorer directory and save the output as a text file (*.txt). Select the "Print" button to print the output text file, and the "Close" button to close the Text Viewer screen and return to the LADTAP module main screen. The user can also access the output text file by selecting the "View Output" button.

**** User Note ****—Though it is not required, users should consider saving LADTAP files in a user-specified directory other than the NRCDose3 directory, so that future users can access and share the files without having to navigate to the NRCDose3 directory.

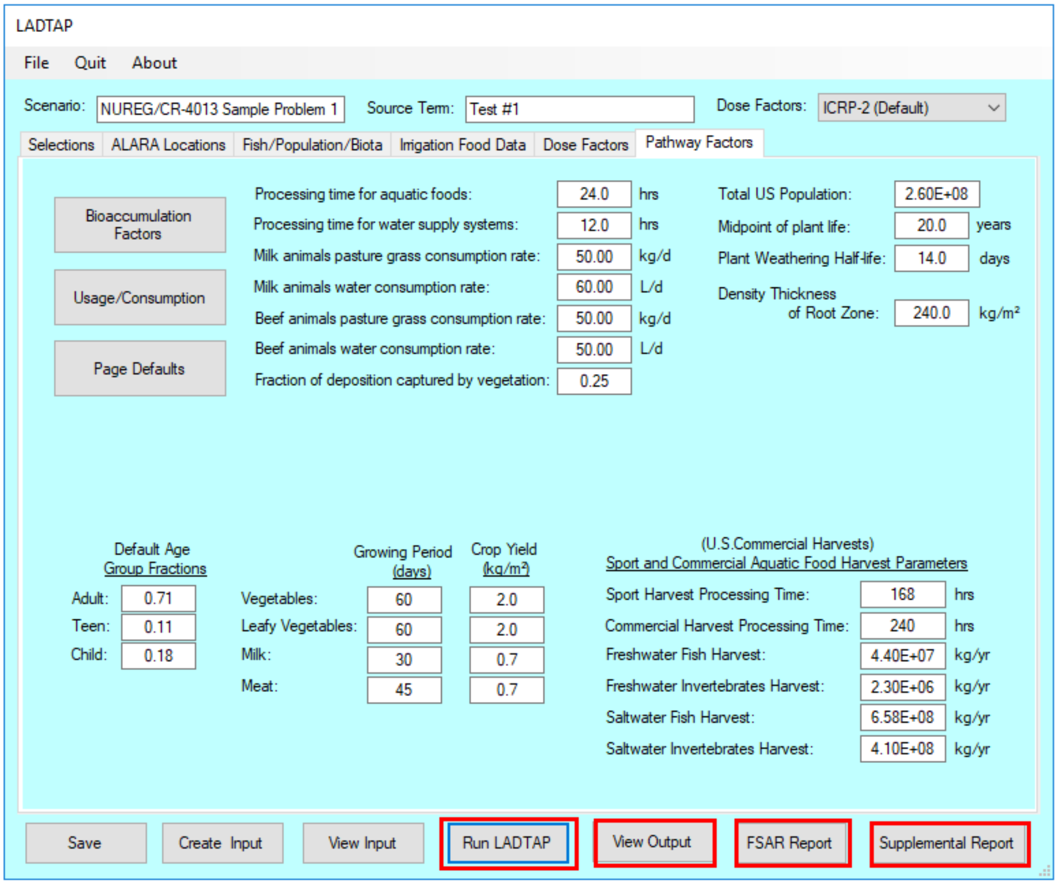


Figure 3-38 LADTAP Module Main Screen—“Run LADTAP” Button

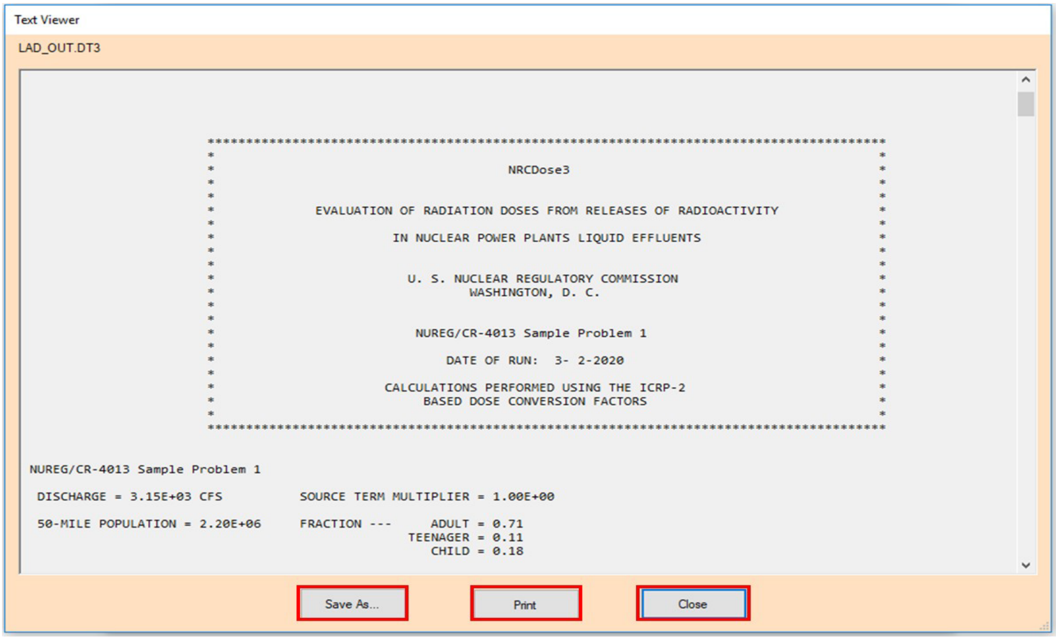
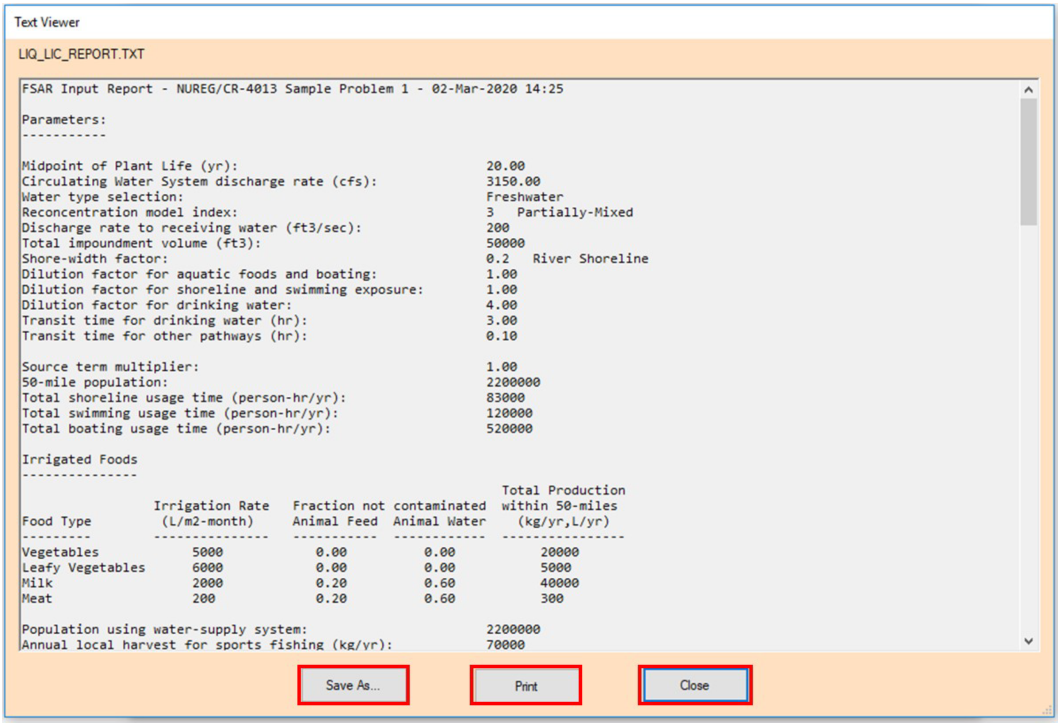


Figure 3-39 Viewing LADTAP Output—Text Viewer Screen

3.3.2 LADTAP Reports

LADTAP creates two additional reports: the FSAR Input Report and the Supplemental Report. As shown in Figure 3-40, the FSAR Input Report consolidates the input data and dose calculations into a single text report that provides the information considered most important for the preparation and review of results for licensing documents. Select the “Save As…” button shown in Figure 3-40 to open a Windows Explorer directory and save the FSAR Input Report output as a text file (*.txt). Select the “Print” button to print the FSAR Input Report, and the “Close” button to close the Text Viewer screen and return to the LADTAP module main screen.



FSAR Input Report - NUREG/CR-4013 Sample Problem 1 - 02-Mar-2020 14:25

Parameters:

Midpoint of Plant Life (yr):	20.00
Circulating Water System discharge rate (cfs):	3150.00
Water type selection:	Freshwater
Reconcentration model index:	3 Partially-Mixed
Discharge rate to receiving water (ft3/sec):	200
Total impoundment volume (ft3):	50000
Shore-width factor:	0.2 River Shoreline
Dilution factor for aquatic foods and boating:	1.00
Dilution factor for shoreline and swimming exposure:	1.00
Dilution factor for drinking water:	4.00
Transit time for drinking water (hr):	3.00
Transit time for other pathways (hr):	0.10
Source term multiplier:	1.00
50-mile population:	2200000
Total shoreline usage time (person-hr/yr):	83000
Total swimming usage time (person-hr/yr):	120000
Total boating usage time (person-hr/yr):	520000

Irrigated Foods

Food Type	Irrigation Rate (L/m2-month)	Fraction not contaminated Animal Feed	Fraction not contaminated Animal Water	Total Production within 50-miles (kg/yr,L/yr)
Vegetables	5000	0.00	0.00	20000
Leafy Vegetables	6000	0.00	0.00	5000
Milk	2000	0.20	0.60	40000
Meat	200	0.20	0.60	300

Population using water-supply system:	2200000
Annual local harvest for sports fishing (kg/yr):	70000

Figure 3-40 LADTAP FSAR Input Report Screen

As shown in Figure 3-41, the Supplemental Report provides additional documentation of the modeling assumptions used for the calculations, such as bioaccumulation factors, transfer factors, and various pathway constants. Select the “Save As…” button shown in Figure 3-41 to open a Windows Explorer directory and save the Supplemental Report output as a text file (*.txt). Select the “Print” button to print the Supplemental Report, and the “Close” button to close the Text Viewer screen and return to the LADTAP module main screen.

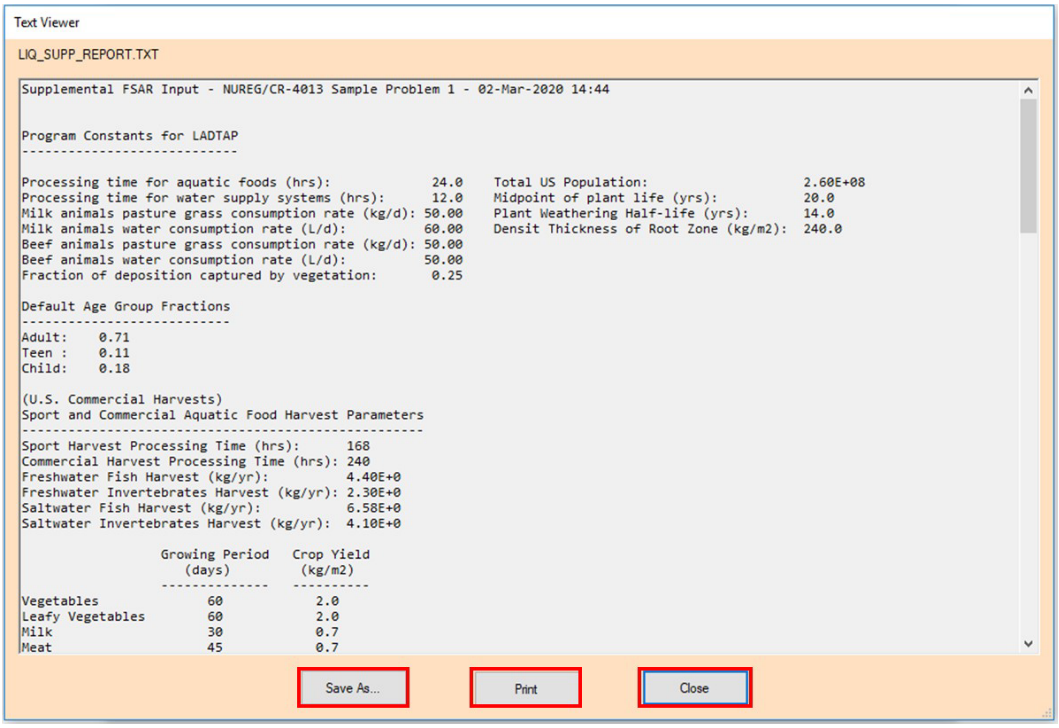


Figure 3-41 LADTAP Supplemental Report Screen

** **User Note** **—Only one report is viewable at a time. A report may be either printed or saved as a text file, which can then be further edited or saved in different formats using standard text editor functions.

4.0 GASPAR

The GASPAR module within NRCDose3 executes a modified version of the GASPAR II Fortran code. This update to the NRCDose code has not changed the basic calculation methods (algorithms) of GASPAR II, as described in NUREG/CR-4653. However, significant changes have been made to the data management and operation to support the expanded capabilities of NRCDose3. GASPAR II performs environmental dose assessments for releases of gaseous radioactive effluents from nuclear power plants into the atmosphere, implementing the dose assessment methods described in RG 1.109. GASPAR II calculates the radiation dose to individuals, population groups, and biota from inhalation of contaminated air, direct exposure from contaminated ground, and consumption of contaminated foods. The calculated doses provide information for NEPA evaluations and for determining compliance with the NRC public dose limits in 10 CFR Part 20, the EPA public dose limits in 40 CFR Part 190, and the NRC ALARA design objectives and numerical guides in 10 CFR Part 50, Appendix I.

The following sections discuss the steps for setting up and performing GASPAR dose calculations using NRCDose3. The user is directed to NUREG/CR-4653 for the GASPAR II Fortran code user guide and for technical bases and detailed discussion of the assumptions, limitations, and methods of the GASPAR dose calculations.

To open the GASPAR module, select the “GASPAR Gaseous Pathway Dose Assessment” button on the NRCDose3 main selection screen, shown in Figure 4-1. This will open the GASPAR module main screen, shown in Figure 4-2.

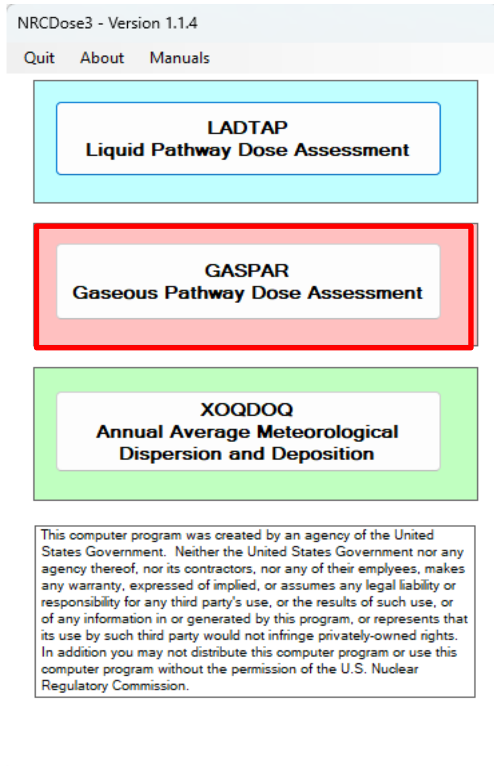


Figure 4-1 NRCDose3 Main Selection Screen (GASPAR Module)

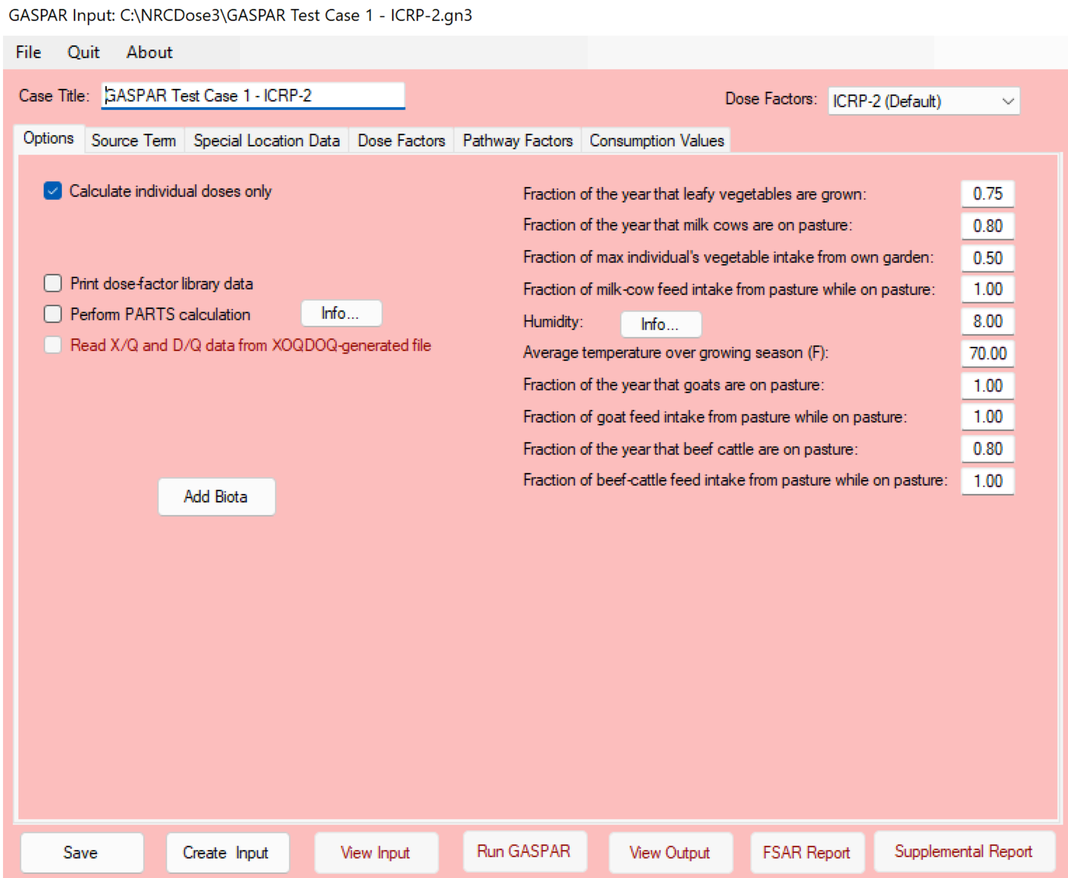


Figure 4-2 GASPAR Module Main Screen

The GASPAR module main screen opens with the case data last saved in the database. It contains three main functional areas for entering data and performing GASPAR dose calculations: (1) the toolbar and initial setup area, (2) the data input tabs, and (3) code execution and reports. The following sections discuss these areas and describe the options and capabilities in each.

4.1 Toolbar and Initial Setup

This portion of the GASPAR module main screen contains three tools and two initial setup input fields, as shown in Figure 4-2. The three tools are File, Quit, and About. The initial setup fields are Case Title and Dose Factors (drop-down menu).

4.1.1 File Tool

The File tool provides the functionality for managing the GASPAR files, as shown in Figure 4-3. The File drop-down menu offers the following options:

- New—Select this option to begin a new GASPAR case. This will clear the database that is used for creating the input for a run (i.e., it will clear the existing input data).

- Open GN3 File—Select this option to access and open a *.GN3 file previously created with NRCDose3.

- Save to Database—Select this option to save the current case to the input database. When GASPAR is opened, the data that were last saved (typically from the previous run) are loaded, populating all GASPAR screens and windows.

- Save to GN3 File—Select this option to save the completed case to a *.GN3 file, for later use or for sharing with others.

- Delete—Select this option to open an Explorer window that will allow the user to delete any previously saved *.GN3 files.

** **User Note** **—NRCDose3 uses the *.GN3 file type and format for GASPAR files. Files in other formats (for example, *.GNP files generated by GASPAR under NRCDose (version 2.3.20 or earlier)) are not compatible with NRCDose3.

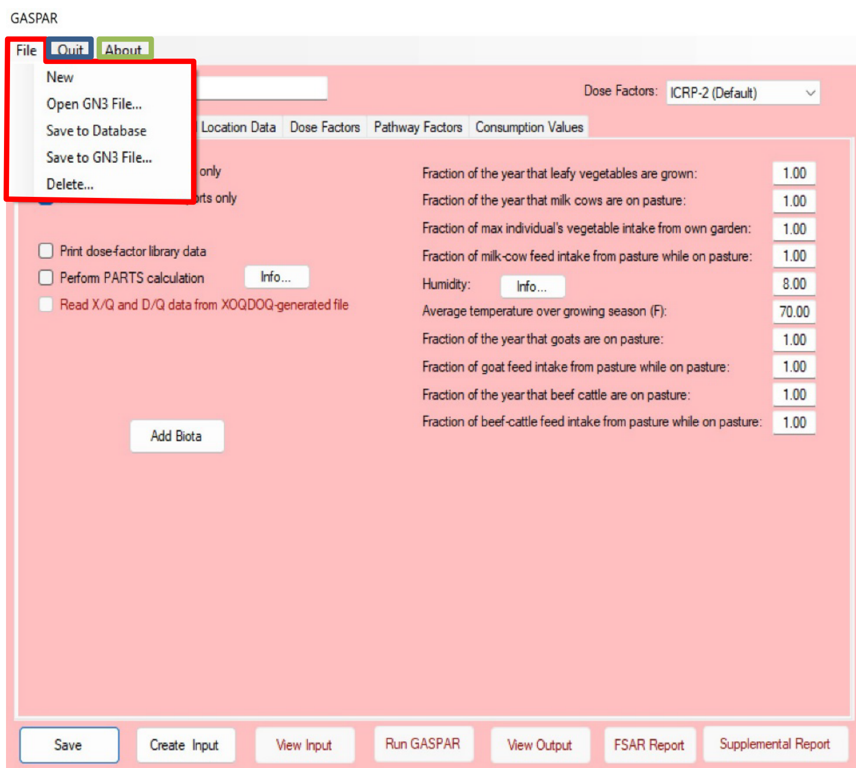


Figure 4-3 GASPAR Toolbar with File Drop-down Menu

4.1.2 Quit Tool

The Quit tool allows the user to terminate the operation of the GASPAR module. When the Quit tool is selected, the Question prompt screen (shown in Figure 4-4) will be displayed to verify that the user wants to exit the module. Select the “Yes” button to terminate the GASPAR module without saving any changes to the data not previously saved. To save changes (to the database and/or a *.GN3 file) before quitting, select the “No” button, then choose the appropriate entry from the File drop-down menu.

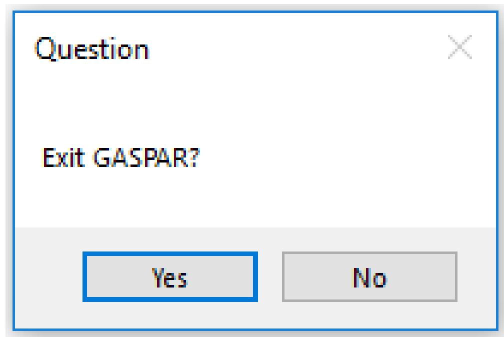


Figure 4-4 GASPAR Module Quit Tool Screen

4.1.3 About Tool

Selecting the About tool brings up the About GASPAR screen shown in Figure 4-5, which displays information about GASPAR II. Select the “OK” button to return to the GASPAR module main screen shown in Figure 4-2.

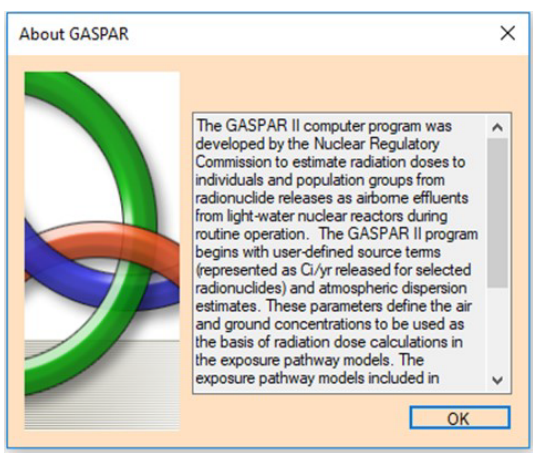


Figure 4-5 About GASPAR Screen

4.1.4 Case Title Field

In the Case Title field, enter a title for the GASPAR case. This is a descriptive text field only; the data in this field are not used for any GASPAR dose calculations. The title should help users identify the facility/site and release point (e.g., "Facility XYZ and Miscellaneous Waste Discharge"). As shown in Figure 4-2, the initial test case included in the NRCDose3 installation (which is loaded when the GASPAR module is first opened) is entitled "GASPAR Test Case 1—ICRP-2." This file is included in the installation directory (i.e., the default directory C:/NRCDose3) and serves as verification for installation.

4.1.5 Dose Factors Drop-Down Menu

The Dose Factors drop-down menu, shown in Figure 4-6, allows the user to select the DCF values to be used for the GASPAR dose calculations. The options available are "ICRP-2 (Default)," "ICRP-30," and "ICRP-72." Note that if the DCF values are changed, then the assumed source term (if any has been entered) will be cleared, and the assumed usage and consumption factors will be updated to the values associated with the selected ICRP methodology.

** **User Note** **—For the purposes of demonstrating compliance with 10 CFR Part 50, Appendix I, and 40 CFR Part 190, the ICRP-2 DCF values should be selected. For demonstrating compliance with 10 CFR Part 20, the ICRP-30 DCF values should be selected. An applicant or licensee preparing an NRC LAR should discuss the use of ICRP-72 DCF values with the NRC staff before submitting the request.

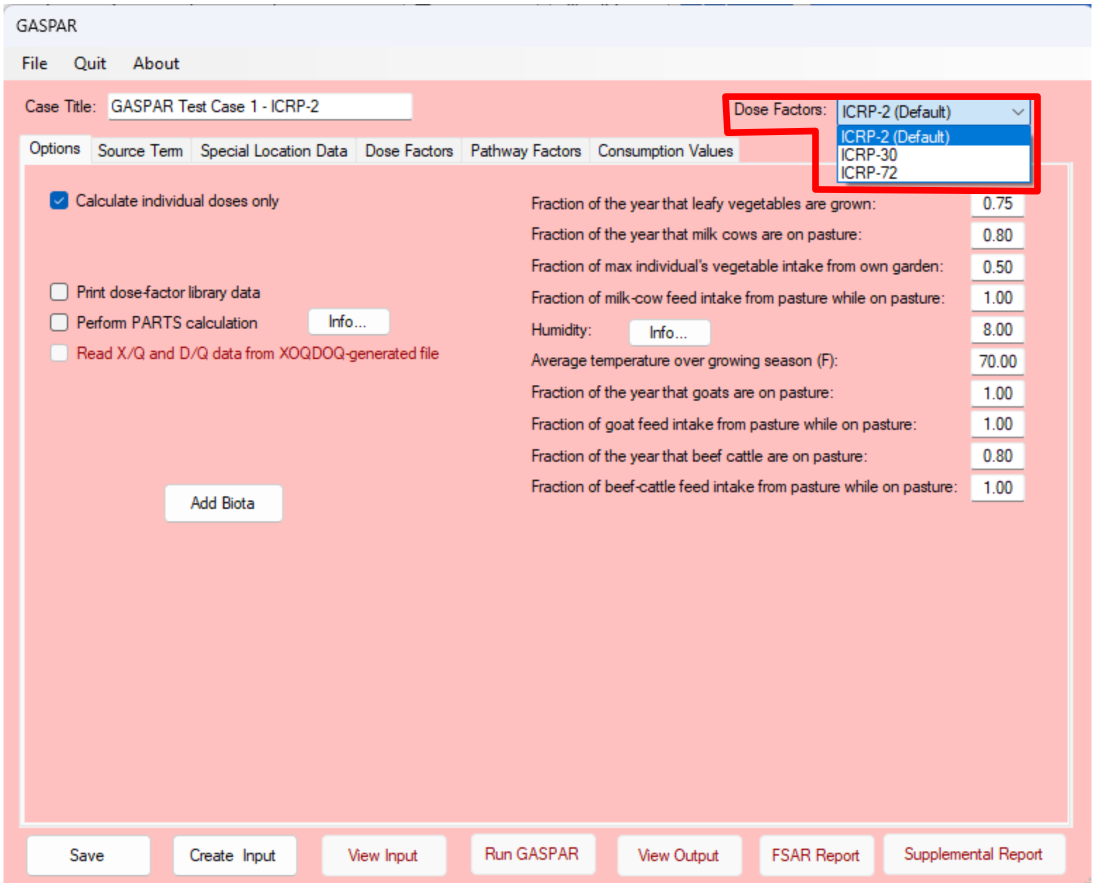


Figure 4-6 GASPAR Dose Factors Drop-down Menu

4.2 Data Input Tabs

The six GASPAR data input tabs, shown in Figure 4-2, are as follows:

(1) Options

(2) Source Term

(3) Special Location Data

(4) Dose Factors

(5) Pathway Factors

(6) Consumption Values

It is recommended, though not required, that the user enter the necessary case parameters and data into the data input tabs in the order in which they are listed.

4.2.1 Options Tab

The Options tab is used to enter various parameters for the GASPAR dose calculations. It includes several check boxes (left-hand side of tab) and input fields (right-hand side of tab), as shown in Figure 4-7. Refer to NUREG/CR-4653 for more information on the inputs in this tab.

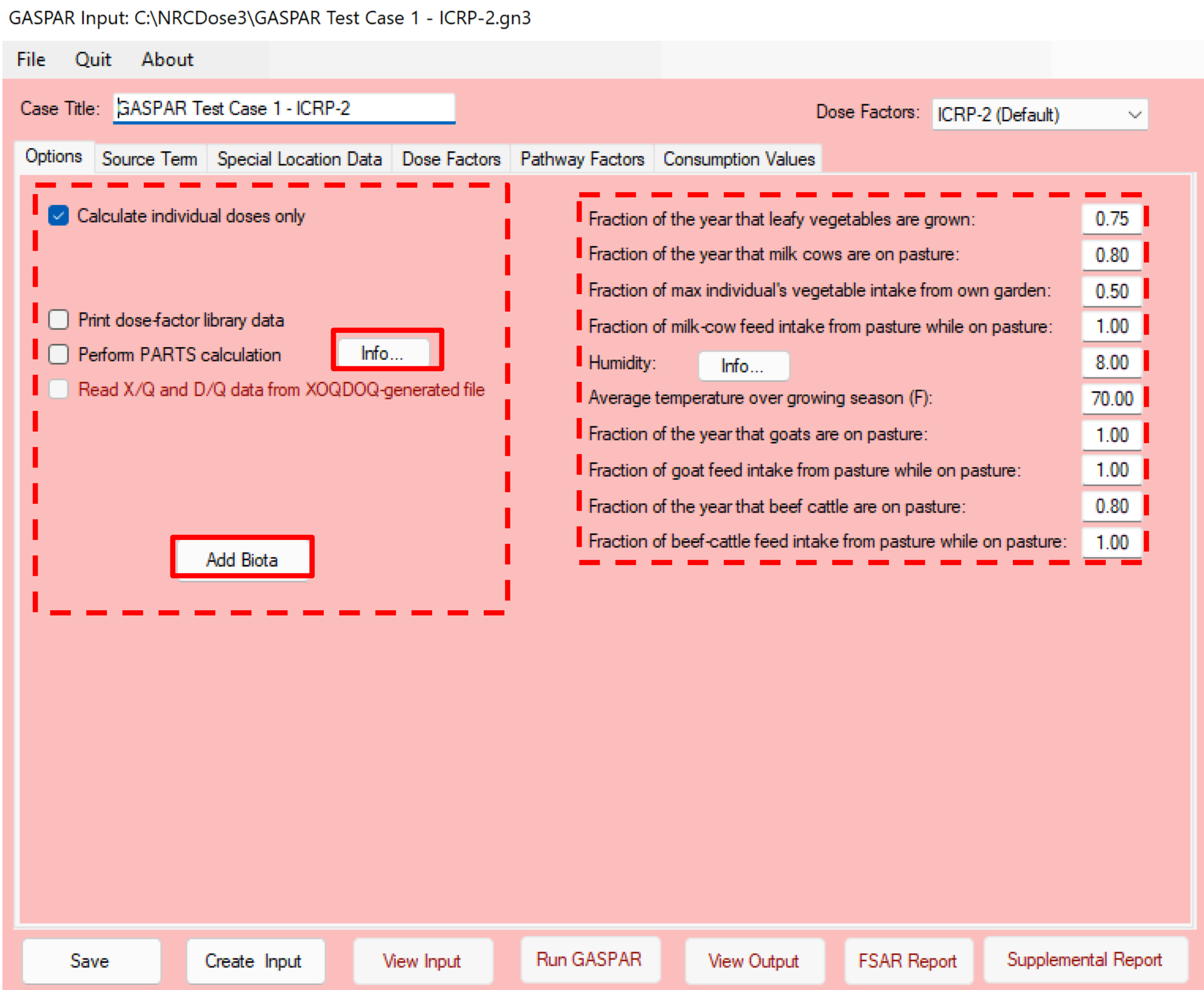


Figure 4-7 Options Tab

4.2.1.1 Options Tab—Left-Hand Side Options

As shown in Figure 4-7, the following check boxes appear on the left side of the Options tab:

- <u>Calculate individual doses only</u>—Check this option (box) to have GASPAR calculate only the individual doses from gaseous effluents. If this option (box) is unchecked, GASPAR will perform population dose calculations in addition to individual dose calculations. The value from "GASPAR Test Case 1—ICRP-2" for this option is **checked**. Population dose calculations require additional data on population; meteorology; and milk, meat, and vegetable production, which should be entered in the Pop/Prod Data tab. Selecting this option will open the population data warning screens shown in Figure 4-8. Selecting the “OK” button on both warning screens will return the user to the Options tab.

** **User Note** **—If the user does not enter data for the population or for milk, meat, or vegetable production, a value of **1.0** is automatically entered; the program requires a value to perform the calculations. The term “meteorological” as used in the guidance pertaining to GASPAR refers to the relative concentration (X/Q) and relative deposition (D/Q) values produced by the XOQDOQ module of NRCDose3, but not to the actual meteorological data input to that code.

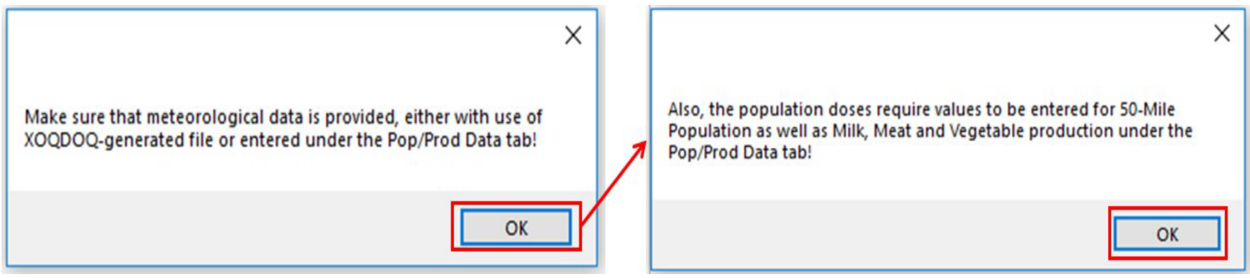


Figure 4-8 Population Data Warning Screens

- Print dose-factor library data—Check this option (box) to print all applicable DCF values in the GASPAR dose calculation output file. The value from “GASPAR Test Case 1—ICRP-2” for this option is **unchecked**.

- Perform PARTS calculation—Check this option (box) only if the code should perform calculations with the PARTS subroutine. These calculations represent site-specific dose factors normalized to unit release in microcuries per second (μCi/s), atmospheric dispersion in seconds per cubic meter (s/m^3), and deposition measured per square meter (m^{-2}). The value from “GASPAR Test Case 1—ICRP-2” for this option is **unchecked**. Selecting this option will open the PARTS calculation information screens shown in Figure 4-9. Selecting the “OK” button on both warning screens will return the user to the Options tab. Selecting the “Info…” button next to this option will open the PARTS information screen shown in Figure 4-10. Selecting the “OK” button on both warning screens will return the user to the Options tab. This option is functional only with the ICRP-2 DCFs.

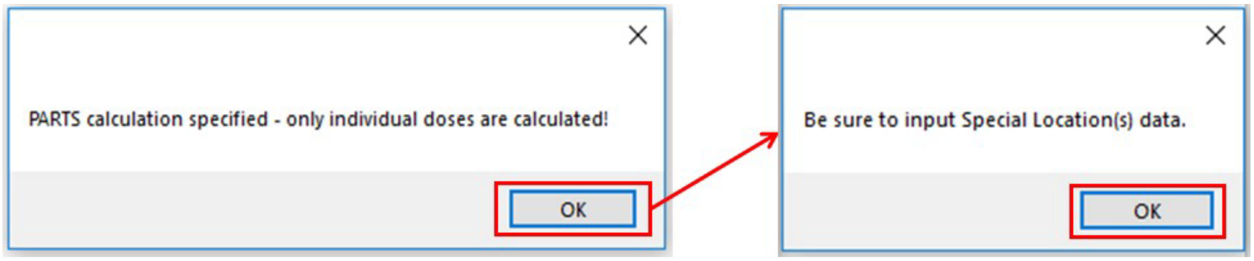


Figure 4-9 PARTS Calculation Information Screens

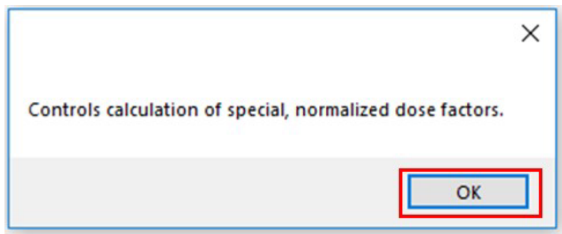


Figure 4-10 PARTS Information Screen

- Read X/Q and D/Q data from XOQDOQ-generated file—Check this option (box) to use meteorological dispersion parameters generated by the XOQDOQ code. If this option is checked, the dispersion parameters for population dose calculations and the special locations will be read from a file created by XOQDOQ. Section 5.3 further explains this function in XOQDOQ. The value from "GASPAR Test Case 1—ICRP-2" for this option is **unchecked**.

4.2.1.2 Biota Dose Modeling and "Add Biota" Button

Biota dose modeling is an addition to GASPAR that did not exist in the GASPAR II Fortran code. The same modeling methodology as used in LADTAP II has been employed. Section 6.0 gives additional details. GASPAR includes six assumed terrestrial species: those assumed in LADTAP (muskrat, raccoon, heron, and duck) plus cow (surrogate herbivore) and fox (surrogate carnivore). As described below, more species can be added with user-defined exposure assumptions.

The internal dose component for terrestrial biota is calculated using the same methodology as in LADTAP II, using the models in BNWL-1754. Similarly to LADTAP, which uses environmental transfer factors (bioaccumulation factors) for fish, invertebrates, and algae, GASPAR uses transfer factors for vegetation and meat. The GASPAR modeling is based on defining each species as either herbivore or carnivore (eating plants or meat, respectively), with radionuclide concentrations calculated using the RG 1.109 model.

The internal dose component for all herbivores (cow, muskrat, raccoon, duck, and heron) is calculated considering the radionuclide concentration in the meat, as modeled by RG 1.109, equation C-12, for cows, and applying the nuclide-specific absorbed dose coefficients for the appropriate effective radius. (See the user note below on effective radius.) For herbivores other than cows, the internal dose is calculated by taking the ratio of the assumed ingestion rate to the biota mass and applying the adult human ingestion DCF, adjusting for the difference in absorbed energy between an adult human (30 cm effective radius) and the biota in question.

The internal dose to a carnivore is calculated similarly but correlated to the calculated (cow) meat concentration, with adjustments for differences in mass, consumption rate, and effective radius. For both herbivores and carnivores, the adult human inhalation dose is added (as an approximation of the inhalation exposure component) to yield the total internal dose.

The external dose component is the same as the adult human ground-plane dose multiplied by a factor of 2 to account for proximity to the ground and divided by 0.7 to remove the shield factor assumed for human exposure. Thus, the external component for the biota dose is 2.86 times that calculated for adult humans. Table 4-1 lists the parameters used to calculate the biota dose in GASPAR.

Table 4-1 Biota Dose Parameters for GASPAR II in NRCDose3

Species	Mass (g)	Effective Radius* (cm)	Primary Food Eaten	Consumption Rate (g/d)
Muskrat (from LADTAP II)	1,000	5	Terrestrial plants	100
Raccoon (from LADTAP II)	12,000	15	Terrestrial plants	200
Duck (from LADTAP II)	1,000	5	Terrestrial plants	100
Heron (from LADTAP II)	4,600	10	Terrestrial plants	600
Cow (herbivore)	N/A	30	Terrestrial plants	N/A
Fox (carnivore)[a]	5,700	10	Meat (cow)	520
User-defined	As defined	As defined	As defined	As defined

Notes:
* For GASPAR, the effective radius chosen must be one of the eight radius values tabulated. The radii assigned are those considered most representative for the species, out of the available values.
a. *Fox modeling assumptions are derived from http://www.britannica.com/animal/red-fox-mammal and http://www.hse.gov.uk/pesticides/resources/R/Research_PN0908.pdf.*

- "Add Biota" Button—Select the "Add Biota" button shown in Figure 4-7 to open the Additional Biota Types screen shown in Figure 4-11 and enter the required exposure parameters for any new biota. To define a new biota type, select the "Add Biota Type" button to activate the biota information section at the bottom of the screen. For each new biota type, enter the name, the primary food type (carnivore or herbivore), the mass in grams, the effective radius in centimeters, and the consumption rate in g/yr. Select the "Save" button to save the new biota type and return to the Options tab. To remove a biota type, select (highlight) the biota type in the upper portion of the screen, and select the "Delete Biota Type" button. Select the "Clear" button to remove all biota types from the file. Select the "Close" button to close the Additional Biota Types screen and return to the Options tab.

** **User Note** **—The code can address only a single food type, either plant or meat. While the raccoon is recognized to be an omnivore, by default it is modeled as a herbivore; this is consistent with the assumptions in LADTAP and BNWL-1754. The raccoon may also be modeled as a carnivore by using the "Add Biota Type" function with appropriate inputs for consumption.

** **User Note** **—Species-specific modeling can be performed by modifying the exposure and uptake assumptions and transfer factors unique to the species (e.g., defining transfer factors for chickens).

** **User Note** **—The effective radius is used to model organisms as spheres, so that different dose absorption values can be applied for organisms of different sizes or masses. The effective radius is the radius of a sphere (considered muscle) that has the same mass as the organism in question, assuming the mass is uniformly distributed. For an assumed nominal density of 1 gram per cubic centimeter (g/cm^3) for muscle, the effective radius can be approximated by dividing the organism's mass (in grams) by 4.19 (where 4.19 is an approximation of 4/3 * π), then taking the cube root. Appendix D describes the modeling and calculations for the nuclide-specific deposited energy (dose) values based on effective radius.

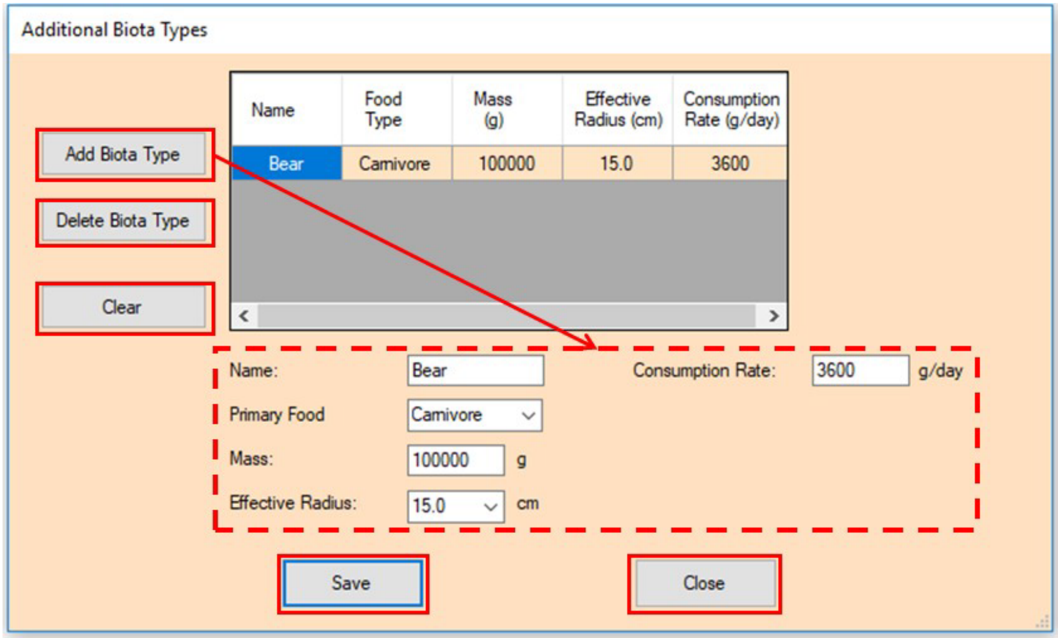


Figure 4-11 Additional Biota Types Screen

4.2.1.3 Options Tab—Right-Hand Side Options

As shown in Figure 4-7, the right side of the Options tab contains the following site-specific parameters, which capture the particular characteristics of the environment where the facility is currently or will be located:

- The fraction of the year that leafy vegetables are grown is unitless, with the value in "GASPAR Test Case 1—ICRP-2" set to **0.75**. The allowable range for values in this field is greater than 0.0.
- The fraction of the year that milk cows are on pasture is unitless, with the value in "GASPAR Test Case 1—ICRP-2" set to **0.80**. The allowable range for values in this field is greater than 0.0.
- The fraction of the maximum individual's vegetable intake from their own garden is unitless, with the value in "GASPAR Test Case 1—ICRP-2" set to **0.50**. The allowable range for values in this field is greater than 0.0.
- The fraction of milk-cow feed intake from pasture while on pasture is unitless, with the value in "GASPAR Test Case 1—ICRP-2" set to **1.00**. The allowable range for values in this field is greater than 0.0.

** **User Note** **—The milk transfer factors in GASPAR, taken from RG 1.109, Table E-1, are specific to dairy cows. It may be appropriate to apply them to other, similar milk-producing animals, but the user should consider the particular animal's characteristics.

- Humidity is entered as relative humidity (i.e., percentage of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated), provided that a value other than zero (0) is entered for "Average temperature over growing season" (the next entry in this column). If "Average temperature over growing season" is entered as zero (0), then the value entered for humidity represents the absolute humidity, i.e., the weight of water present in a unit volume of moist air, measured in grams per cubic meter. The value in "GASPAR Test Case 1—ICRP-2," which is set to **8.00**, is treated as relative humidity in the GASPAR calculations, since the temperature is set at 70, a value other than zero. The allowable range for values in this field is greater than 0.0, as either an absolute value (absolute humidity) or a percentage (relative humidity).

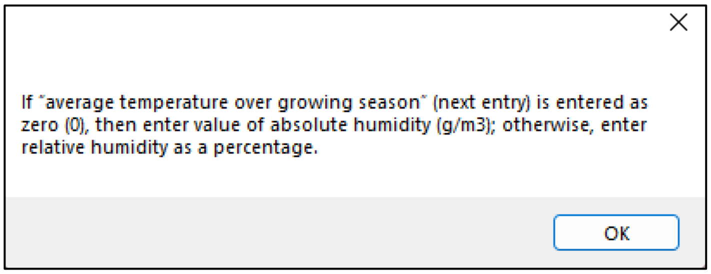


Figure 4-12 Humidity Information Screen

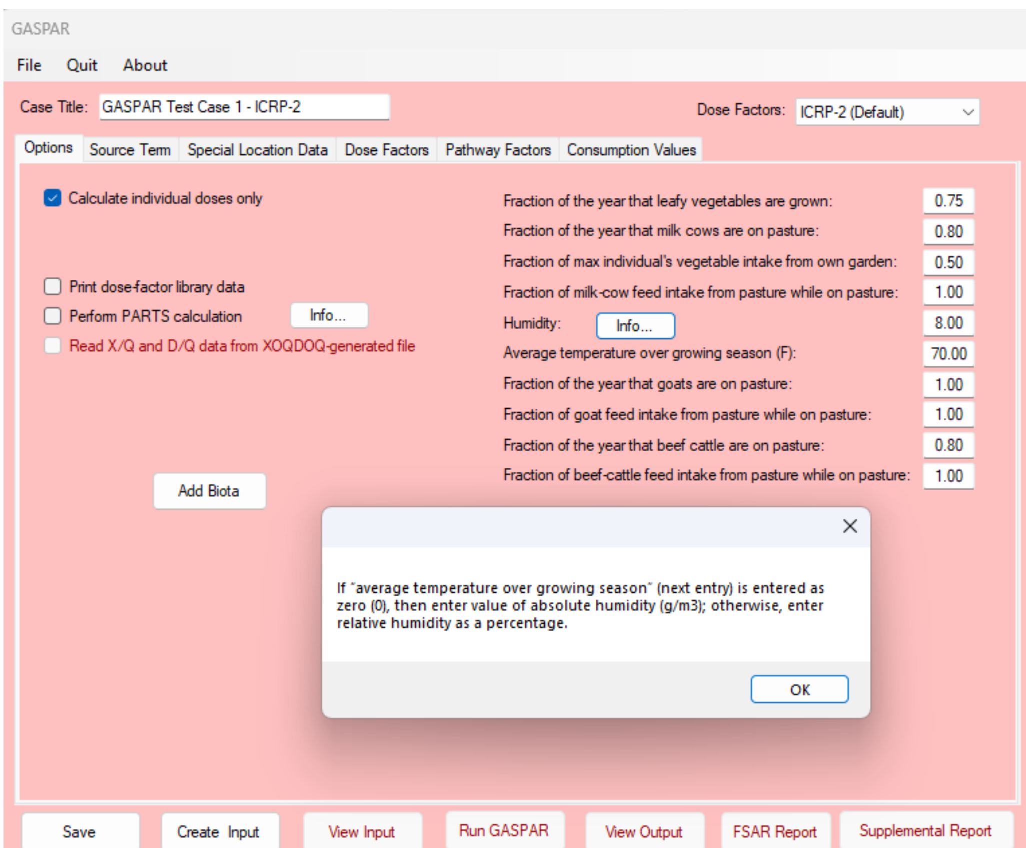


Figure 4-13 Humidity Alert Screen

- The average temperature over the growing season is in degrees Fahrenheit (F), with the value in “GASPAR Test Case 1—ICRP-2” set to **70.00** degrees F. The allowable range for values in this field is greater than 0.0 degrees F. If the value is set to zero (0), then the humidity value will be treated as an absolute humidity (see above).

- The fraction of the year that goats are on pasture is unitless, with the value in “GASPAR Test Case 1—ICRP-2” set to **1.00**. The allowable range for values in this field is greater than 0.0.

** **User Note** **—Some of the milk transfer factors taken from RG 1.109, Table E-1, are specific to goats. It may be appropriate to apply them to other, similar milk-producing animals, but the user should consider the particular animal’s characteristics.

- The fraction of goat feed intake from pasture while on pasture is unitless, with the value in “GASPAR Test Case 1—ICRP-2” set to **1.00**. The allowable range for values in this field is greater than 0.0.

- The fraction of the year that beef cattle are on pasture is unitless, with the value in “GASPAR Test Case 1—ICRP-2” set to **0.80**. The allowable range for values in this field is greater than 0.0.

** **User Note** **—The meat transfer factors in GASPAR, taken from RG 1.109, Table E-1, are specific to beef cattle. It may be appropriate to apply them to other, similar animals, but the user should consider the particular animal’s characteristics.

- The fraction of beef cattle feed intake from pasture while on pasture is unitless, with the value in “GASPAR Test Case 1—ICRP-2” set to **1.00**. The allowable range for values in this field is greater than 0.0.

4.2.2 Source Term Tab

The Source Term tab, shown in Figure 4-16, is used to enter the source terms for the GASPAR dose calculations. Typically, there is a unique source term for each release type. For this version of GASPAR, as incorporated into NRCDose3, only a single source term may be used for each case/run. If a facility has different source terms for multiple release points, additional cases (*.GN3 files) will be needed. For each source term, enter a title (e.g., “Reactor Vent,” “Aux. Bldg. Vent”), the source term multiplication factor (unitless, with the default value of **1.00**) that will be applied to the input release activity for each radionuclide, and the annual release time for purges in hours (with the default value of **0.0** hr).

The “Release time for purges” entry is used for C-14 dose calculations only. It is used to adjust the total time available for plant uptake through photosynthesis. The maximum value allowed is 4380 hr, which reasonably approximates the maximum possible amount of daylight over a year (one-half of 8760 hr per year). NUREG/CR-4653 provides the following explanation:

The fractional equilibrium ratio, p, is used to account for the fractional equilibrium achieved between atmospheric and plant carbon concentrations for intermittent releases, such as purges of gaseous waste decay tanks. The equilibrium ratio is defined as the ratio of the total annual release time to the total annual time during which photosynthesis occurs (taken to be 4,380 hr). For continuous releases, p is set to unity.

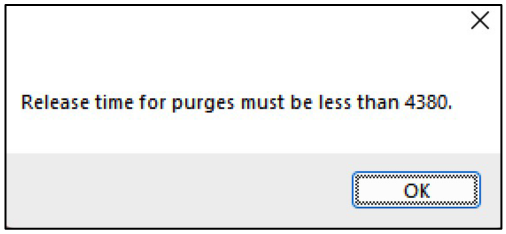


Figure 4-14   Purge Information Screen

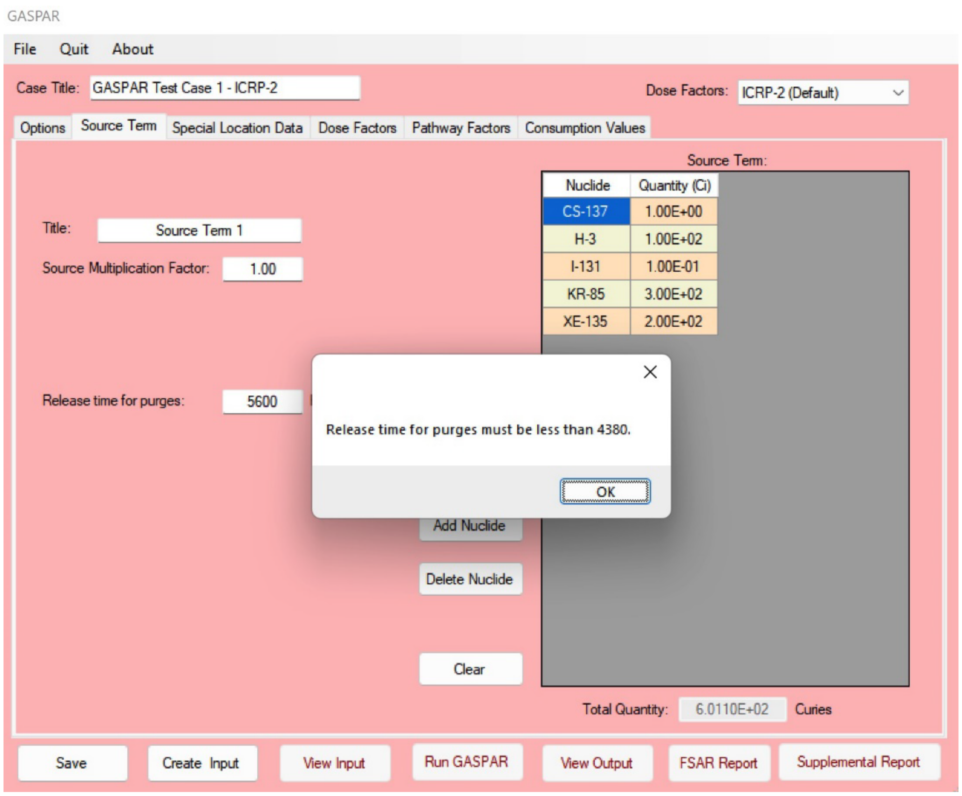


Figure 4-15   Excess Purge Warning

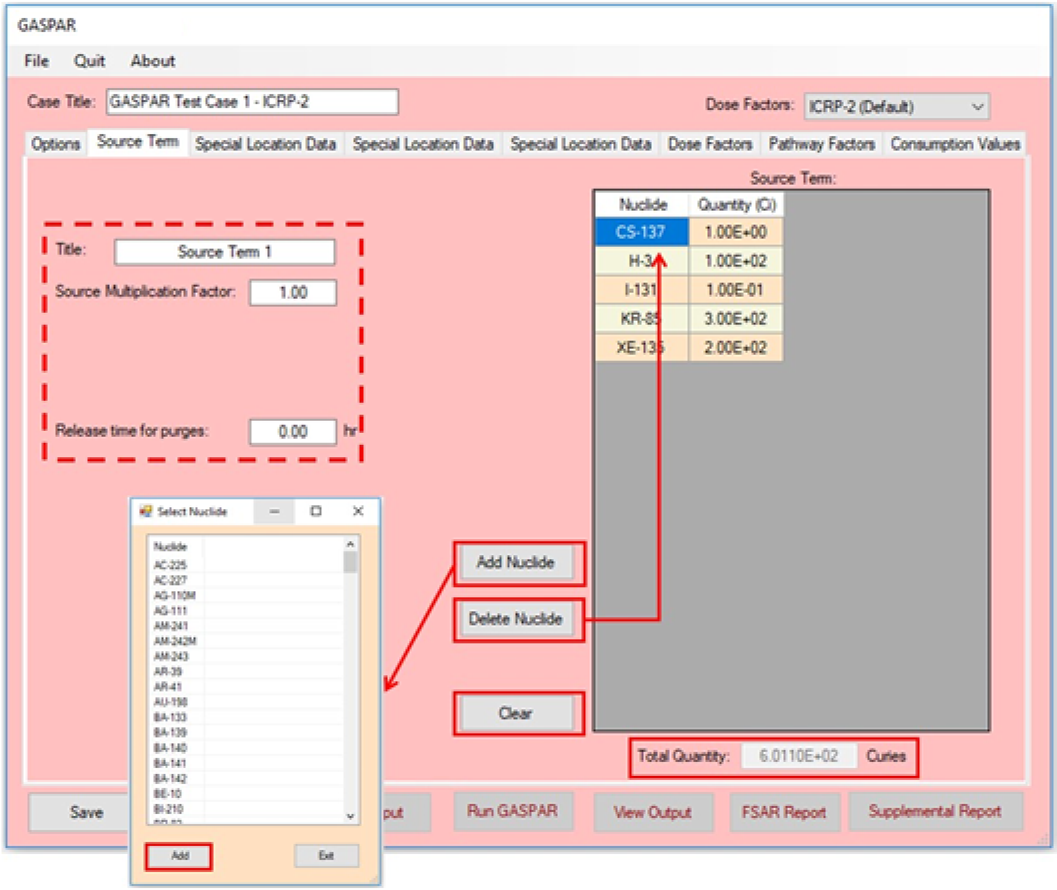


Figure 4-16 Source Term Tab

The radionuclides in the source term, along with the quantity of each (in curies), are displayed on the right-hand portion of the Source Term tab, as shown in Figure 4-16. To add a radionuclide to the source term, select the “Add Nuclide” button.

**** User Note ****—Verify that the desired ICRP methodology has been selected before entering any additional radionuclide data. When the “Add Nuclide” button on the Source Term tab is selected, a warning message will flash to remind the user about DCF values, as shown in Figure 4-17, and then the Select Nuclide screen will appear. Changing the ICRP methodology will cause the source term to be cleared.

Select (highlight) the radionuclide to be added, and then click the “Add” button to add the radionuclide to the source term. By holding down the “Ctrl” key during radionuclide selection, the user can select multiple radionuclides. The individual radionuclides, activity release, and total quantity in curies will be continuously updated. It is recommended that after entering the source term data, the user save the input to the *.GN3 file by selecting the “Save” button.

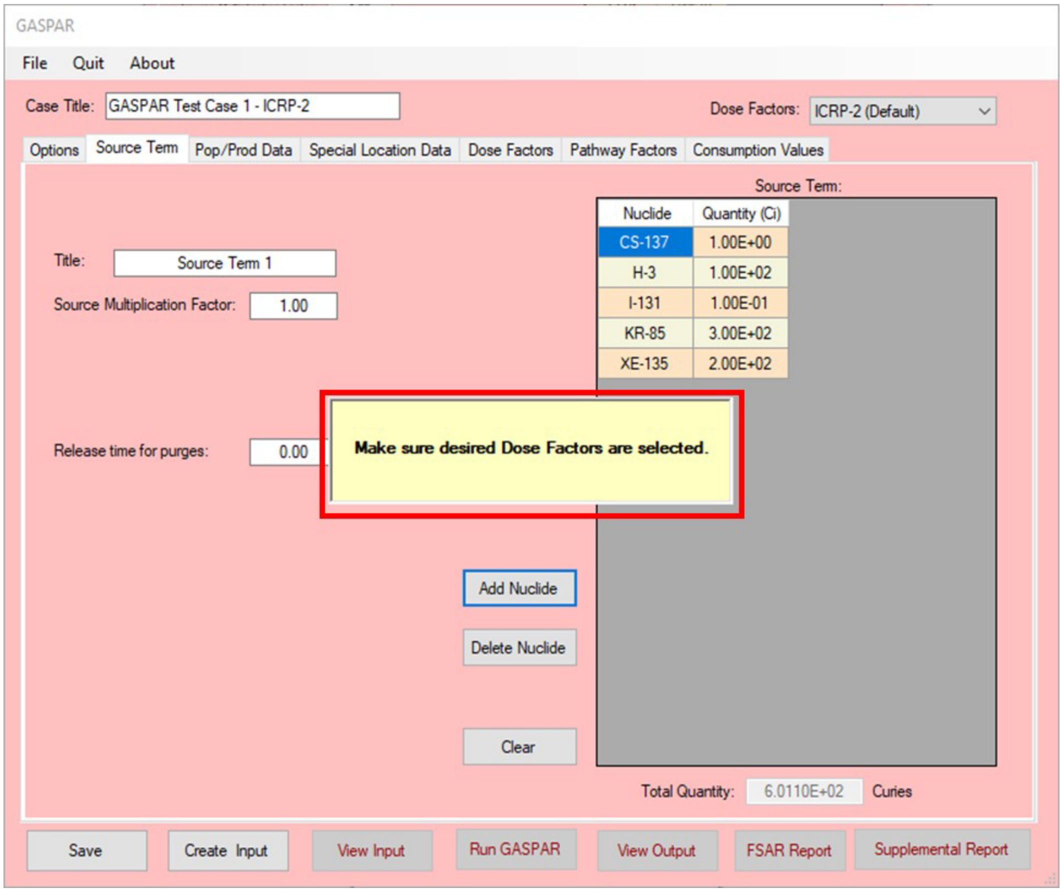


Figure 4-17 Source Term Warning Message

To remove radionuclides from the source term, select (highlight) the radionuclide to be removed and then click the "Delete Nuclide" button, as shown in Figure 4-12. Selecting the "Clear" button clears all source term data (nuclide, class, f_1 value, and quantity) for all radionuclides in the Source Term tab.

4.2.3 Pop/Prod Data Tab

In the Pop/Prod Data tab, shown in Figure 4-18, the user can enter extensive information about demographics, food production, and meteorology (if necessary) around the site. The Pop/Prod Data tab appears when the "Calculate individual doses only" box is unchecked in the Options tab (see Section 4.2.1). The Data Type drop-down menu contains five options for entering demographic data: (1) "Population," (2) "Milk Production," (3) "Meat Production," (4) "Vegetable Production," and (5) "Meteorological" (note that sector dispersion and deposition values will need to be entered manually unless an XOQDOQ-generated input file is created). The demographic and production data can be entered either as total values within a 50-mile radius or on a per-sector basis at varying distances from 1 to 50 miles.

To enter per-sector data, select the "Input by distance and direction" check box. This activates the per-sector input table, with entries for each radial distance (1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles) and each of the 16 meteorological sectors, as shown in Figure 4-18.

**** User Note ****—Data are required for each Data Type drop-down menu option; if the user does not enter a value, a value of 1.0 is automatically added to support the calculations required by the code.

4.2.3.1 Population

Select the Population option from the Data Type drop-down menu to enter the total population within 50 miles of the site. The allowable range for values in this field is greater than 0.0. To enter the population data on a per-sector basis, select the check box to open the per-sector input table for population data, as shown in Figure 4-18. Enter the population data for each radial distance (1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles) and each of the 16 downwind direction sectors. Note that the value entered for each distance should represent the population in the range from one distance to the next. For example, the value for "1 mile" represents the population in the 0-to-1-mile distance range; the value for "10 miles" represents the population in the 5-to-10-mile distance range. Select the "Update" button to save the per-sector population data. Use the "Clear" button to delete the population data from the sector table; this will open the Clear Data warning screen shown in Figure 4-19.

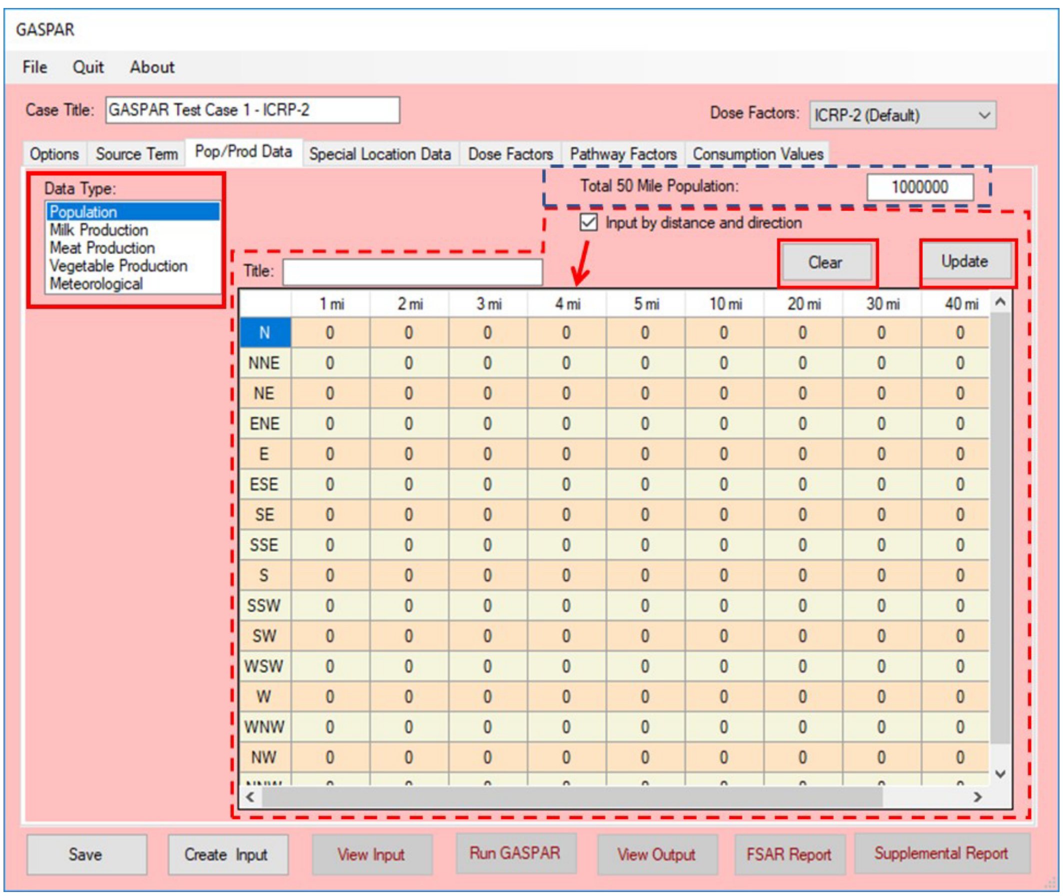


Figure 4-18 Pop/Production Data Tab

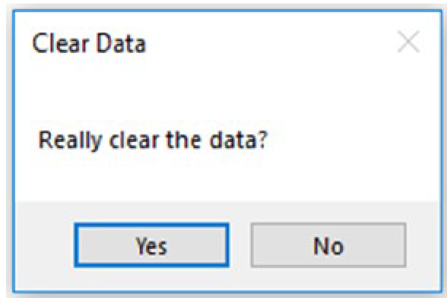


Figure 4-19   Clear Data Warning Screen

4.2.3.2   Milk Production

Select the Milk Production option from the Data Type drop-down menu to enter the total milk production in L/yr within 50 miles of the site. The allowable range for values in this field is greater than 0.0 L/yr. To enter the milk production data on a per-sector basis, select the check box to open the per-sector input table, as shown in Figure 4-18. Enter the milk production data for each radial distance (1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles, with each value representing a distance range as discussed above) and each of the 16 downwind direction sectors. Select the “Update” button to save the per-sector milk production data. Use the “Clear” button to delete the milk production data from the sector table; this will open the Clear Data warning screen shown in Figure 4-19.

4.2.3.3   Meat Production

Select the Meat Production option from the Data Type drop-down menu to enter the total meat production in kg/yr within 50 miles of the site. The allowable range for values in this field is greater than 0.0 kg/yr. To enter the meat production data on a per-sector basis, select the check box to open the per-sector input table, as shown in Figure 4-18. Enter the meat production data for each radial distance (1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles) and each of the 16 downwind direction sectors. Select the “Update” button to save the per-sector meat production data. Use the “Clear” button to delete the meat production data from the sector table; this will open the Clear Data warning screen shown in Figure 4-19.

4.2.3.4   Vegetable Production

Select the Vegetable Production option from the Data Type drop-down menu to enter the total vegetable production in kg/yr within 50 miles of the site. (The default value for this field, also used in “GASPAR Test Case 1—ICRP-2,” is **1.00+03** kg/yr.) The allowable range for values in this field is greater than 0.0 kg/yr. To enter the vegetable production data on a per-sector basis, select the check box to open the per-sector input table, as shown in Figure 4-18. Enter the vegetable production data for each radial distance (1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles) and each of the 16 downwind direction sectors. Select the “Update” button to save the per-sector vegetable production data. Use the “Clear” button to delete the vegetable production data from the sector table; this will open the Clear Data warning screen shown in Figure 4-19.

4.2.3.5   Meteorological

Select the Meteorological option from the Data Type menu if the meteorological data (dispersion and deposition values) need to be manually entered into GASPAR, rather than imported from a completed XOQDOQ run (see Section 5.3). As discussed in Section 4.2.1.1, this menu option is required only if “Read Met data from XOQDOQ-generated file” is **not** selected (the box is unchecked) on the Options tab. The calculated dispersion and deposition values depend on the release point characteristics, as specified in the XOQDOQ code inputs. The user should verify that the dispersion and deposition data, as entered or imported here, are representative of the source term for the modeled release point.

To enter dispersion and deposition data, select the appropriate option for either dispersion (i.e., “Undecayed, Undepleted,” “Decayed, Undepleted,” or “Decayed, Depleted”) or ground deposition, as discussed in Section 2.2.6 of NUREG/CR-4653. Enter the applicable dispersion (in s/m^3) or deposition (in m^{-2}) for each radial distance (1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles, with each value representing a distance range as discussed above) and each of the 16 downwind meteorological sectors, as shown in Figure 4-20. The corresponding values from the XOQDOQ output are those given in the tables titled “SEGMENT BOUNDARIES IN MILES FROM SITE.” Select the “Update” button to save the data. Select the “Clear” button to delete the total data set from the sector table; this will open the Clear Data warning screen shown in Figure 4-19. Repeat this process for the other dispersion and deposition parameters.

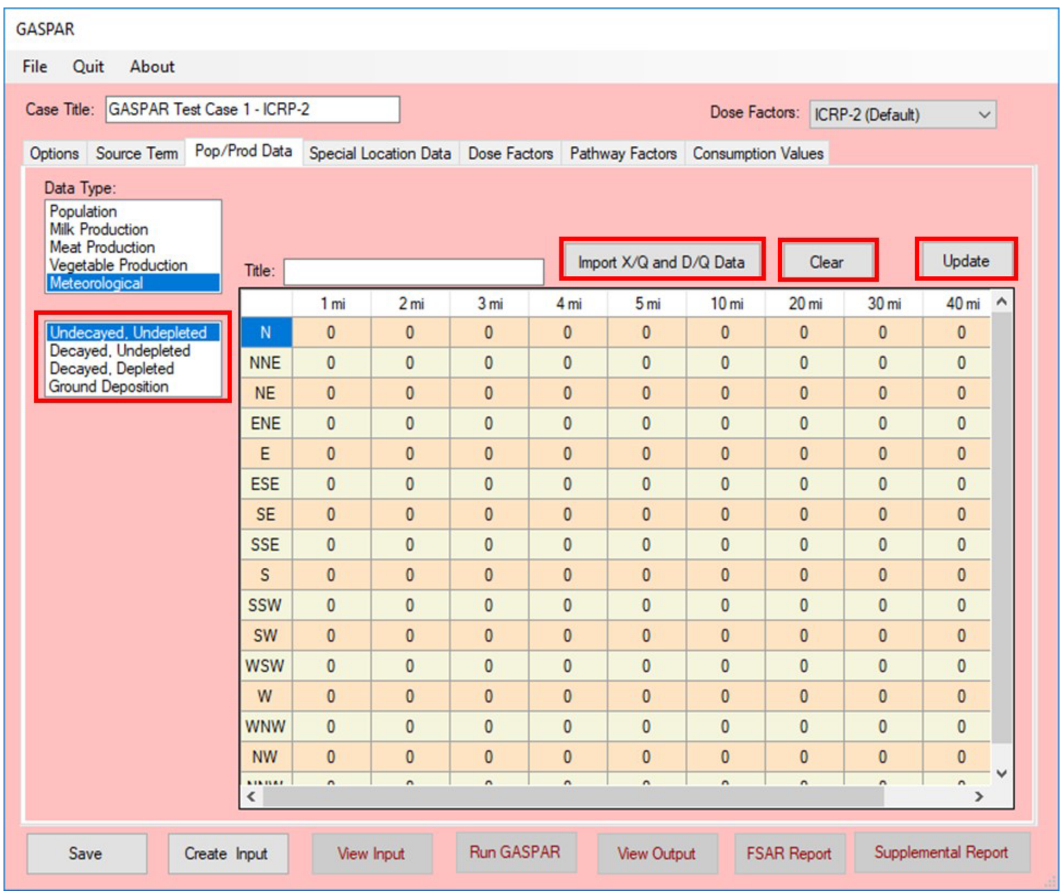


Figure 4-20 Pop/Production Data Tab—Meteorological Data

As an alternative to manually entering the dispersion and deposition data, the user can import these data from a Microsoft (MS) Excel (*.xlsx) file by selecting the “Import X/Q and D/Q Data” button, as shown in Figure 4-20. This will open a Windows Explorer directory allowing the user to navigate to the appropriate file to be imported, as shown in Figure 4-21. Select the file to be imported; NRCDose3 will then automatically import the data and populate the sector table shown in Figure 4-20. After the data have been imported, select the “Update” button shown in Figure 4-20 to save the data.

A separate MS Excel (*.xlsx) file is required for **each** of the three dispersion parameters and the single deposition parameter, so this process must be performed four times for the four meteorological data sets (“Undecayed/Undepleted,” “Decayed/Undepleted,” “Decayed/Depleted,” and “Ground Deposition”). A template MS Excel example file, as shown in Figure 4-22, is included in the NRCDose3 installation. Only the values in the cells shaded yellow are imported into GASPAR.

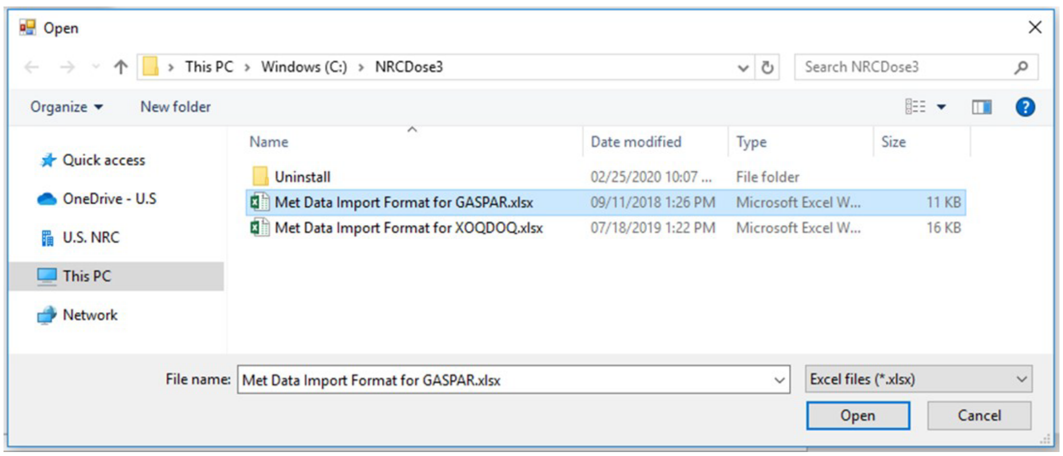
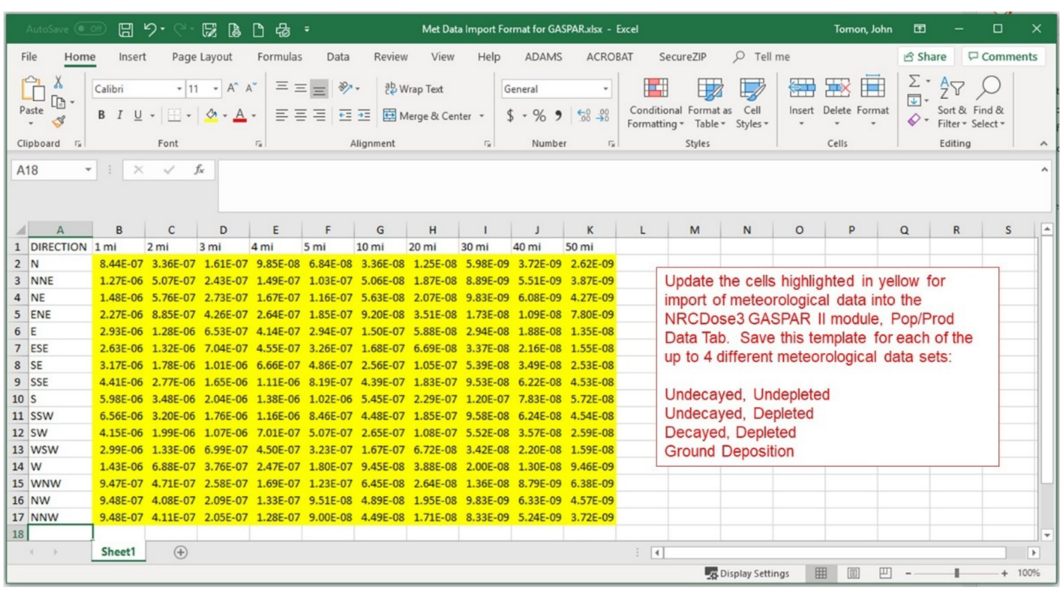


Figure 4-21 Windows Explorer Directory for Importing Meteorological Data to GASPAR



DIRECTION	1 mi	2 mi	3 mi	4 mi	5 mi	10 mi	20 mi	30 mi	40 mi	50 mi
N	8.44E-07	3.36E-07	1.61E-07	9.85E-08	6.84E-08	3.36E-08	1.25E-08	5.98E-09	3.72E-09	2.62E-09
NNE	1.27E-06	5.07E-07	2.43E-07	1.49E-07	1.03E-07	5.06E-08	1.87E-08	8.89E-09	5.51E-09	3.87E-09
NE	1.48E-06	5.76E-07	2.73E-07	1.67E-07	1.16E-07	5.63E-08	2.07E-08	9.83E-09	6.08E-09	4.27E-09
ENE	2.27E-06	8.85E-07	4.26E-07	2.64E-07	1.85E-07	9.20E-08	3.51E-08	1.73E-08	1.09E-08	7.80E-09
E	2.93E-06	1.28E-06	6.53E-07	4.14E-07	2.94E-07	1.50E-07	5.88E-08	2.94E-08	1.88E-08	1.35E-08
ESE	2.63E-06	1.32E-06	7.04E-07	4.55E-07	3.26E-07	1.68E-07	6.69E-08	3.37E-08	2.16E-08	1.55E-08
SE	3.17E-06	1.78E-06	1.01E-06	6.66E-07	4.86E-07	2.56E-07	1.05E-07	5.39E-08	3.49E-08	2.53E-08
SSE	4.41E-06	2.77E-06	1.65E-06	1.11E-06	8.19E-07	4.39E-07	1.83E-07	9.53E-08	6.22E-08	4.53E-08
S	5.98E-06	3.48E-06	2.04E-06	1.38E-06	1.02E-06	5.45E-07	2.29E-07	1.20E-07	7.83E-08	5.72E-08
SSW	6.56E-06	3.20E-06	1.76E-06	1.16E-06	8.46E-07	4.48E-07	1.85E-07	9.58E-08	6.24E-08	4.54E-08
SW	4.15E-06	1.99E-06	1.07E-06	7.01E-07	5.07E-07	2.65E-07	1.08E-07	5.52E-08	3.57E-08	2.59E-08
WSW	2.99E-06	1.33E-06	6.99E-07	4.50E-07	3.23E-07	1.67E-07	6.72E-08	3.42E-08	2.20E-08	1.59E-08
W	1.43E-06	6.88E-07	3.76E-07	2.47E-07	1.80E-07	9.45E-08	3.88E-08	2.00E-08	1.30E-08	9.46E-09
WNW	9.47E-07	4.71E-07	2.58E-07	1.69E-07	1.23E-07	6.45E-08	2.64E-08	1.36E-08	8.79E-09	6.38E-09
NW	9.48E-07	4.08E-07	2.09E-07	1.33E-07	9.51E-08	4.89E-08	1.95E-08	9.83E-09	6.33E-09	4.57E-09
NNW	9.48E-07	4.11E-07	2.05E-07	1.28E-07	9.00E-08	4.49E-08	1.71E-08	8.33E-09	5.24E-09	3.72E-09

Figure 4-22 Example MS Excel File for Meteorological Data

**** User Note ****—Make sure the dispersion or deposition data sets are entered into the template and dialog box for the correct downwind directions, starting with sector N and ending with sector NNW.

4.2.4 Special Location Data Tab

In the Special Location Data tab, shown in Figure 4-23, the user can enter the parameters needed to define the atmospheric dispersion and deposition values at any special receptor locations. As discussed in Section 4.2.1.1, this tab is available only if "Read X/Q and D/Q data from XOQDOQ-generated file" is **not** selected (unchecked box) on the Options tab. (Otherwise, the special locations will be taken from the XOQDOQ-generated file, where they are already defined.) The Special Location Data tab includes the Special Locations section (left-hand side of tab) and the Location for Individual Doses section (right-hand side of tab), as shown in Figure 4-23.

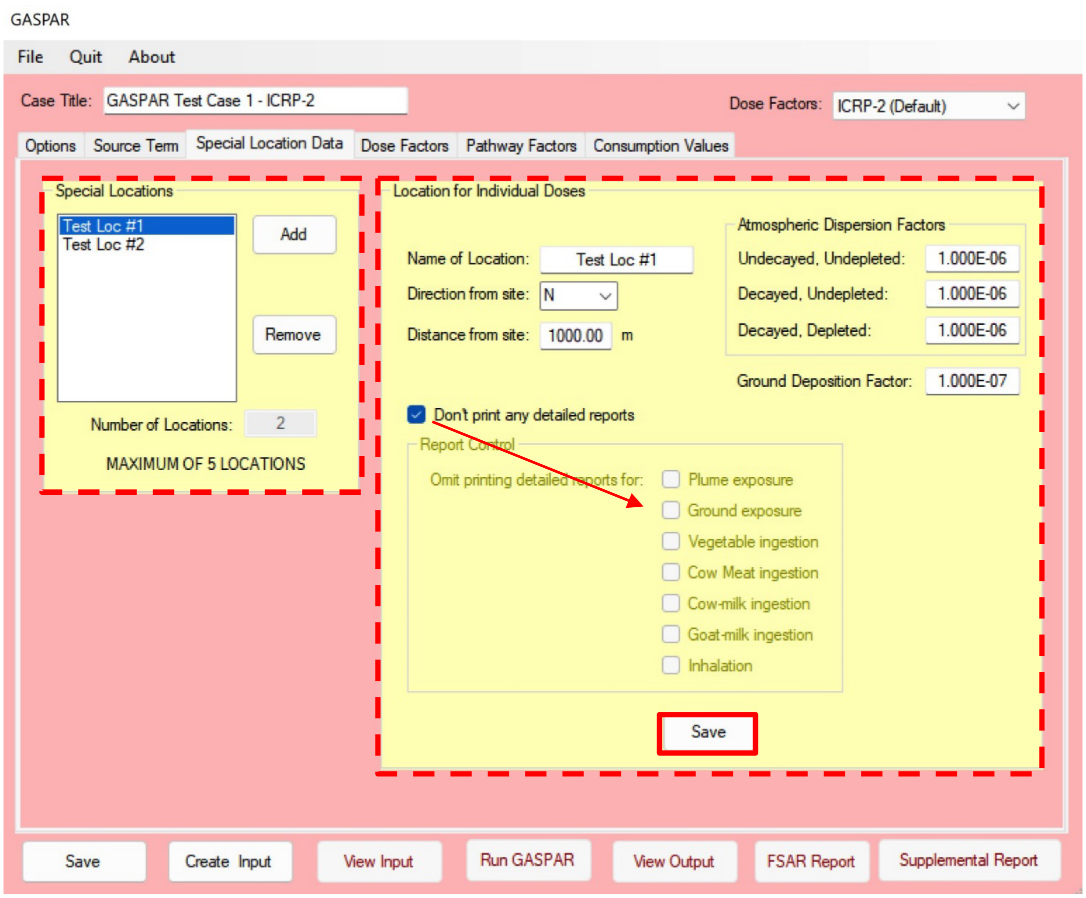


Figure 4-23 Special Location Data Tab

The Special Locations section (left-hand side of tab) lists the name and number of records for each special location. A maximum of five special locations is allowed; multiple cases/runs should be used if more than five locations are needed. To review or edit a special location, select (highlight) it and review or modify the entries in the Location for Individual Doses section (right-hand side of tab). To delete a special location record, select (highlight) it and then click the

“Remove” button, as shown in Figure 4-23. To add a special location record, select the “Add” button and enter the parameters listed in the Location for Individual Doses section.

In the Location for Individual Doses section (right-hand side of tab), each special location is defined by the following parameters:

- Name of Location—This field contains the name of the special location to be used in the GASPAR dose calculation.

- Direction from Site—This field contains a drop-down menu from which the user can select one of the 16 downwind direction sectors.

- Distance from Site—This field contains the distance of the special location from the site, as modeled in XOQDOQ, in meters. The allowable range for values in this field is greater than 0.0 m.

- Atmospheric Dispersion Factors—This field contains the atmospheric dispersion factors, in s/m^3, for the three atmospheric dispersion types (i.e., “Undecayed, Undepleted,” “Decayed, Undepleted,” and “Decayed, Depleted”). The allowable range for values in this field is greater than 0.0 s/m^3.

- Ground Deposition Factor—This field contains the ground deposition factor in m^{-2}. The allowable range for values in this field is greater than 0.0 m^{-2}.

Select the “Don’t print any detailed reports” option (check box) if no detailed reports need to be printed. Uncheck this option if a report of the pathway dose contribution by radionuclide is desired. Detailed reports will be included for all unchecked pathway boxes. Select the “Save” button when edits to the special location have been completed. This will save the data for the specific location only, not for the total input file.

4.2.5 Dose Factors Tab

In the Dose Factors tab, shown in Figure 4-24, the user can select, review, and modify DCF values for the GASPAR dose calculation. The tab is identical to the Dose Factors tab in the LADTAP module, which is discussed in Section 3.2.5 (see Section 6.1 for a discussion of how the DCF values were determined). After selecting the appropriate ICRP methodology (i.e., ICRP-2 (default), ICRP-30, or ICRP-72) from the Dose Factors drop-down menu, open the Factors drop-down menu and select the applicable age group and pathway (i.e., adult ingestion or inhalation, teen ingestion or inhalation, child ingestion or inhalation, or infant ingestion or inhalation).

At this point, all applicable organ DCF values will be available for review, as shown in Figure 4-24. Select the “Nuclide Data” button to open the Nuclide Data screen, which contains two tables of data, as shown in Figure 4-25. The top table contains applicable nuclide data, including atomic weight, isomeric state, and decay constant. The scrolling tool on the top table allows the user to view the DCF values, which are summarized in Table 4-2. The bottom table provides the effective energy (MeV/nt) deposited for each given effective radius; see appendix D to this manual for a detailed description of this table. Select the “Exit” button to return to the Dose Factors tab.

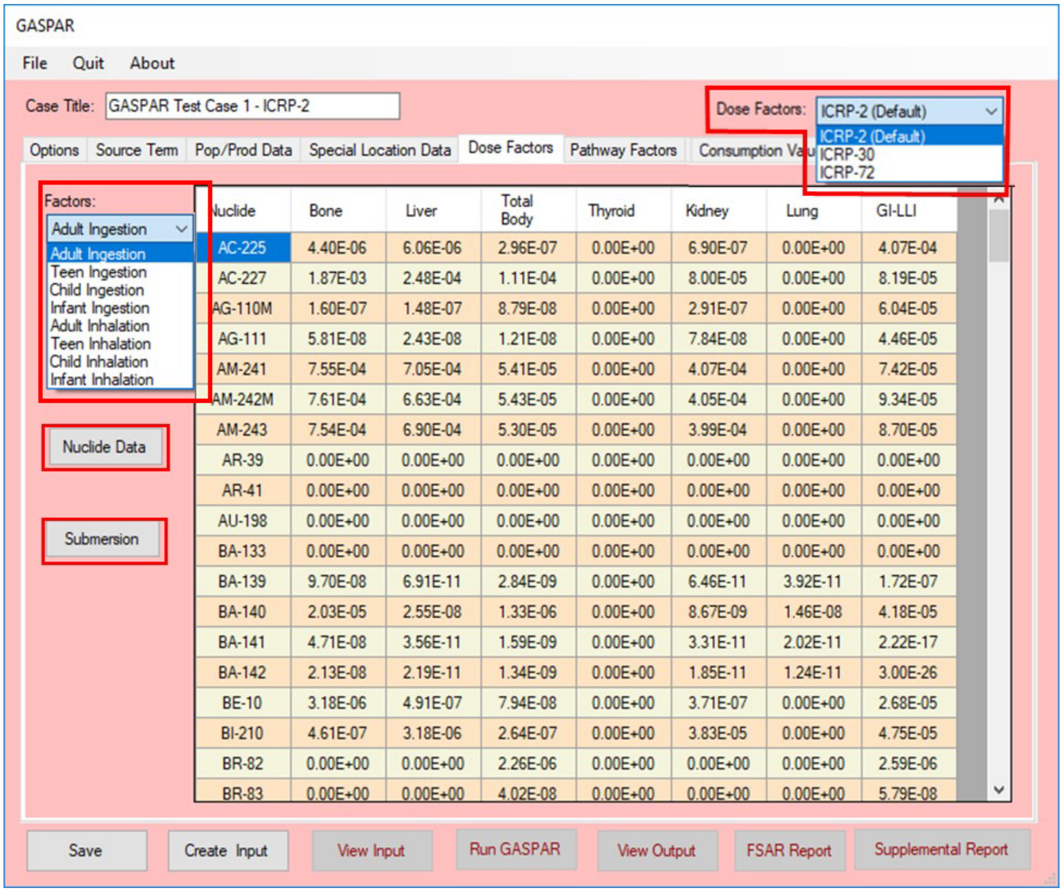
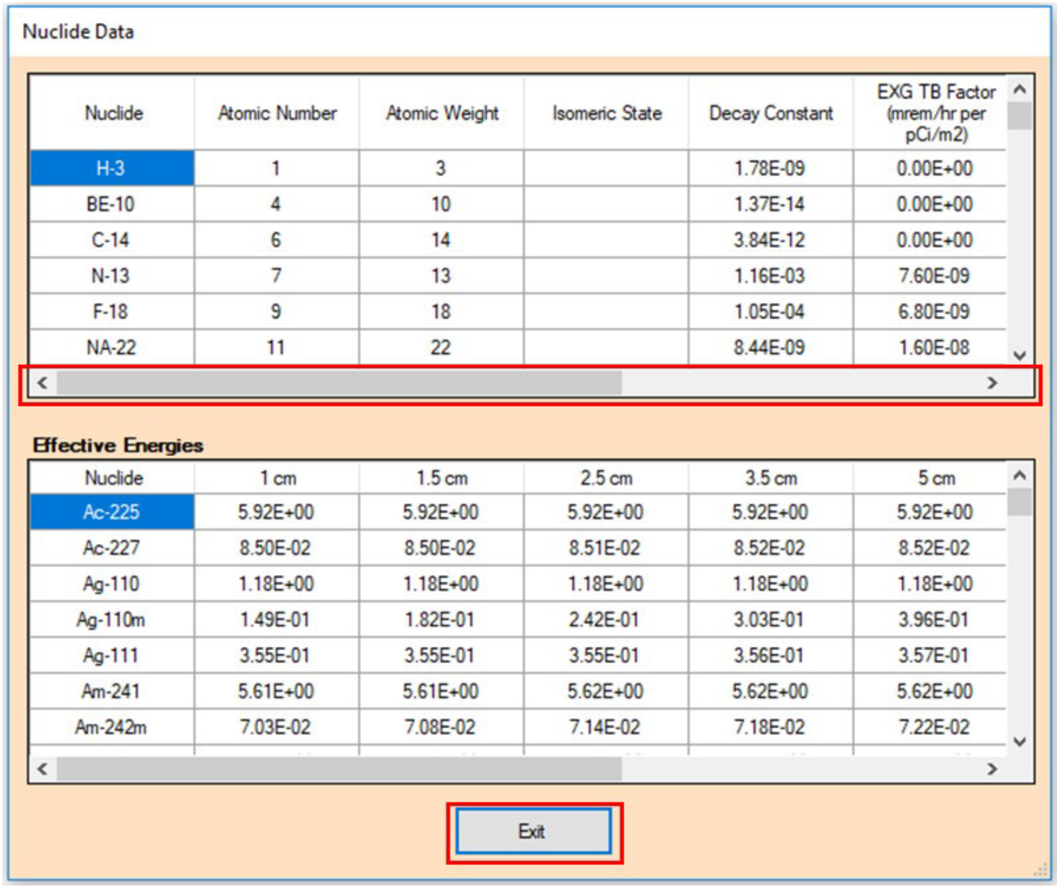


Figure 4-24 Dose Factors Tab

Table 4-2 Description of GASPAR DCF Values

DCF	Description	Units
EXG TB Factor	Total body (or effective) DCF from ground-plane exposure	$\frac{\text{mrem/hr}}{\rho\text{Ci/m}^2}$
EXS TB Factor	Total body (or effective) DCF from submersion in contaminated water	$\frac{\text{mrem/hr}}{\rho\text{Ci/L}}$
EXG Skin Factor	Skin DCF from ground-plane exposure	$\frac{\text{mrem/hr}}{\rho\text{Ci/m}^2}$
EXS Skin Factor	Skin DCF from submersion in contaminated water	$\frac{\text{mrem/hr}}{\rho\text{Ci/L}}$



Nuclide Data

Nuclide	Atomic Number	Atomic Weight	Isomeric State	Decay Constant	EXG TB Factor (mrem/hr per pCi/m2)
H-3	1	3		1.78E-09	0.00E+00
BE-10	4	10		1.37E-14	0.00E+00
C-14	6	14		3.84E-12	0.00E+00
N-13	7	13		1.16E-03	7.60E-09
F-18	9	18		1.05E-04	6.80E-09
NA-22	11	22		8.44E-09	1.60E-08

Effective Energies

Nuclide	1 cm	1.5 cm	2.5 cm	3.5 cm	5 cm
Ac-225	5.92E+00	5.92E+00	5.92E+00	5.92E+00	5.92E+00
Ac-227	8.50E-02	8.50E-02	8.51E-02	8.52E-02	8.52E-02
Ag-110	1.18E+00	1.18E+00	1.18E+00	1.18E+00	1.18E+00
Ag-110m	1.49E-01	1.82E-01	2.42E-01	3.03E-01	3.96E-01
Ag-111	3.55E-01	3.55E-01	3.55E-01	3.56E-01	3.57E-01
Am-241	5.61E+00	5.61E+00	5.62E+00	5.62E+00	5.62E+00
Am-242m	7.03E-02	7.08E-02	7.14E-02	7.18E-02	7.22E-02

Exit

Figure 4-25 Nuclide Data Screen

If ICRP-2 DCF values are selected, then the total body DCF values from ICRP-2 are used, as in the original releases of LADTAP II, GASPAR II, and NRCDose version 2.3.20. If ICRP-30 DCF values are selected, then GASPAR uses effective and skin DCF values based on ICRP Publication 26, "Recommendations of the International Commission on Radiological Protection" (ICRP-26), issued 1977 [Ref. 23], as found in Federal Guidance Report No. 12, "External Exposure to Radionuclides in Air, Water, and Soil" (FGR 12), issued September 1993 [Ref. 24]. If ICRP-72 DCF values are selected, then GASPAR uses effective DCF values based on ICRP-60 (also from FGR 12) and skin DCF values based on ICRP-26.

** **User Note** **—An applicant or licensee preparing an NRC LAR should discuss the use of ICRP-72 DCF values with the NRC staff before submitting the request.

If ICRP-30 or ICRP-72 DCF values are selected, then external DCF values have been modified to account for short-lived progeny radionuclides. See Sections 6.1 and 6.2 for more details and Tables 6-1 and 6-2 for the adjusted radionuclides.

Select the "Submersion" button to open the Noble Gas Submersion DFs—Default screen shown in Figure 4-26 and review the DCF values used for air submersion calculations. The gamma air and beta air DCF values from RG 1.109 have not been changed since the original release of GASPAR II. The gamma T-body and beta skin DCF values are based on the ICRP-26 values when either ICRP-30 or ICRP-72 is selected. (See Section 6.1 for a discussion of the source of these DCF values.) Select the “Close” button to return to the Dose Factors tab.

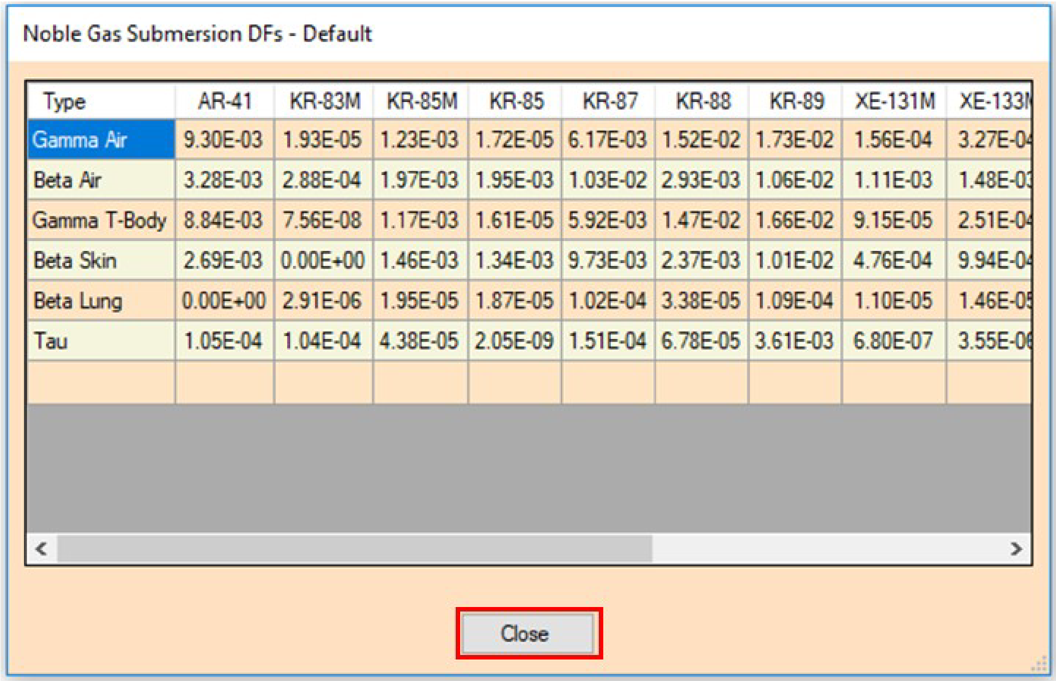


Figure 4-26 Noble Gas Submersion DFs—Default Screen

4.2.6 Pathway Factors Tab

The Pathway Factors tab is used to modify the default RG 1.109 environmental transport and exposure assumptions used for the GASPAR dose calculation. In general, the values for the parameters on this tab should be changed only if there are suitable data supporting a site-specific change. As shown in Figure 4-27, the Pathway Factors tab contains four main parameter input sections: (1) the general input parameters (upper left), (2) Holdup and Transport Times, (3) Goat Feed to Milk Transfer Factors, and (4) Physical Parameters. Additionally, this tab contains two selection buttons: (1) “Transfer Factors” and (2) “Page Defaults.”

**** User Note****—Remember that any changes made to the pathway factors will be carried forward for future runs. Defaults should be reset using the “**Get Default**” option. Also remember that saving a case/file will save all configurations and values selected for the case. Resetting to defaults will not affect any changes made for a particular case/file unless this file is again saved after values are changed back to defaults. Therefore, if there is any question about the saved values, it is best to reset to defaults before initiating a new case.

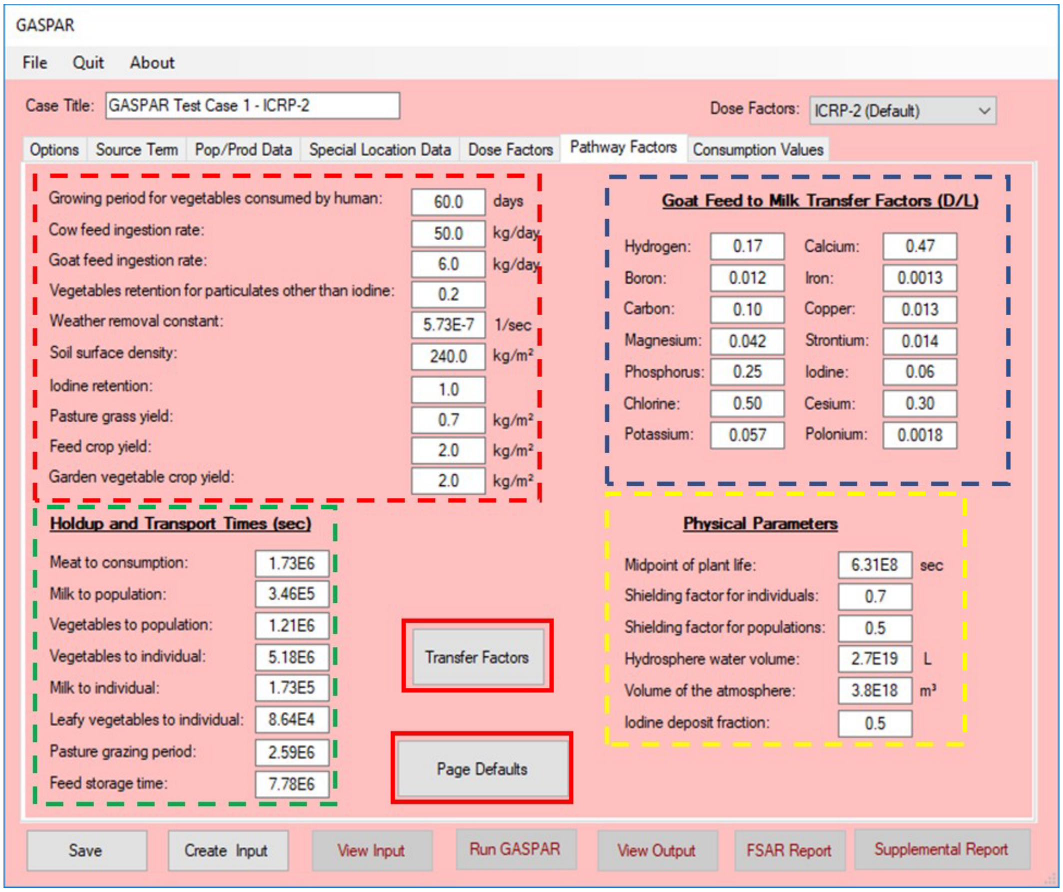


Figure 4-27 Pathway Factors Tab

4.2.6.1 General Pathway Parameters

The following pathway parameters are entered in the upper left-hand side of the Pathway Factors tab, as shown in Figure 4-27:

- The growing period for vegetables consumed by a human is entered in days. The default value, also used in “GASPAR Test Case 1—ICRP-2,” is the RG 1.109 value of **60.0** days. The allowable range for values in this field is greater than 0.0 days.

- The cow feed ingestion rate is entered in kg/d. The default value, also used in “GASPAR Test Case 1—ICRP-2,” is the RG 1.109 value of **50.0** kg/d. The allowable range for values in this field is greater than 0.0 kg/d.

- The goat feed ingestion rate is entered in kg/d. The default value, also used in “GASPAR Test Case 1—ICRP-2,” is the RG 1.109 value of **6.0** kg/d. The allowable range for values in this field is greater than 0.0 kg/d.

- The parameter “Vegetables retention for particulates other than iodine” is unitless. The default value, also used in “GASPAR Test Case 1—ICRP-2,” is the RG 1.109 value of **0.2**. The allowable range for values in this field is greater than 0.0 and not exceeding 1.0.

- The weather removal constant is the vegetation weathering removal for a radionuclide in inverse seconds (s^{-1}). The default value, also used in “GASPAR Test Case 1—ICRP-2,” is the RG 1.109 value of **5.73E-07** s^{-1} (corresponding to a 14-day half-life). The allowable range for values in this field is greater than 0.0 s^{-1}.

- The soil surface density is entered in kg/m^2. The default value, also used in “GASPAR Test Case 1—ICRP-2,” is the RG 1.109 value of **240.0** kg/m^2. The allowable range for values in this field is greater than 0.0 kg/m^2.

- The iodine retention is unitless. The default value, also used in “GASPAR Test Case 1—ICRP-2,” is the RG 1.109 value of **1.0**. The allowable range for values in this field is 0.0 to 1.0.

- The pasture grass yield is entered in kg/m^2. The default value, also used in “GASPAR Test Case 1—ICRP-2,” is the RG 1.109 value of **0.7** kg/m^2. The allowable range for values in this field is greater than 0.0 kg/m^2.

- The feed crop yield is entered in kg/m^2. The default value, also used in “GASPAR Test Case 1—ICRP-2,” is the RG 1.109 value of **2.0** kg/m^2. The allowable range for values in this field is greater than 0.0 kg/m^2.

- The garden vegetable crop yield is entered in kg/m^2. The default value, also used in “GASPAR Test Case 1—ICRP-2,” is the RG 1.109 value of **2.0** kg/m^2. The allowable range for values in this field is greater than 0.0 kg/m^2.

4.2.6.2 Holdup and Transport Times

The input parameters listed below are entered in the Holdup and Transport Times section of the Pathway Factors tab shown in Figure 4-27. All default values come from RG 1.109 and are also used in “GASPAR Test Case 1—ICRP-2.” For all fields, the allowable range of values is greater than 0.0 sec. The holdup and transport time parameters are as follows:

- “Meat to consumption” is entered in seconds (sec), with the default value of **1.73E+06** sec.

- “Milk to the population” is entered in seconds, with the default value of **3.46E+05** sec.

- “Vegetables to the population” is entered in seconds, with the default value of **1.21E+06** sec.

- “Vegetables to the individual” is entered in seconds, with the default value of **5.18E+06** sec.

- “Milk to the individual” is entered in seconds, with the default value of **1.73E+05** sec.

- “Leafy vegetables to the individual” is entered in seconds, with the default value of **8.64E+04** sec.

- “Pasture grazing period” is entered in seconds, with the default value of **2.59E+06** sec.

- “Feed storage time” is entered in seconds, with the default value of **7.78E+06** sec.

4.2.6.3 Goat Feed to Milk Transfer Factors

The Goat Feed to Milk Transfer Factors section displays the transfer factors for the elements listed in Table 4-3, in days per liter (d/L). Table 4-3 displays the default values from RG 1.109, which are also used in “GASPAR Test Case 1—ICRP-2.” The allowable range for values in each field is greater than 0.0 d/L.

Table 4-3 Goat Feed to Milk Transfer Factors

Element	Transfer Factor (d/L)	Element	Transfer Factor (d/L)	Element	Transfer Factor (d/L)
Hydrogen	0.17	Chlorine	0.50	Strontium	0.014
Boron	0.012	Potassium	0.057	Iodine	0.06
Carbon	0.10	Calcium	0.47	Cesium	0.30
Magnesium	0.042	Iron	0.0013	Polonium	0.0018
Phosphorus	0.25	Copper	0.013		

4.2.6.4 Physical Parameters

The input parameters listed below are entered in the Physical Parameters section of the Pathway Factors tab shown in Figure 4-27. All default values come from RG 1.109 and are also used in “GASPAR Test Case 1—ICRP-2,” except for the midpoint of the plant life, as discussed below. The physical parameters are as follows:

- The midpoint of the plant life is entered in seconds, with the default value of **6.31E+08** sec. This value corresponds to 20 years, which differs from the RG 1.109 default value of 15 years and reflects the current 40-year operating license period for nuclear power plants. The allowable range for values in this field is greater than 0.0 seconds.

- The shielding factor for individuals is unitless, with the default value of **0.7**. The allowable range for values in this field is 0.0 to 1.0. As used for the calculation, this factor is in the numerator, so its value should not exceed 1.0, where 1.0 would indicate no reduction for shielding.

- The shielding factor for populations is unitless, with the default value of **0.5**. The allowable range for values in this field is 0.0 to 1.0.

- The hydrosphere water volume is entered in liters (L), with the default value in GASPAR (see NUREG/CR-4653) of **2.7E+19** L. The allowable range for values in this field is greater than 0.0 L.

- The volume of the atmosphere is entered in cubic meters (m^3), with the default value in GASPAR (see NUREG/CR-4653) of **3.8E+18** m^3. The allowable range for values in this field is greater than 0.0 m^3.

- The iodine deposition fraction is unitless, with the default value of **0.5**. The allowable range for values in this field is greater than 0.0.

4.2.6.5 Transfer Factors

To review and edit the transfer factors for meat, soil, and milk, select the “Transfer Factors” button shown in Figure 4-27 to open the Transfer Factors screen shown in Figure 4-28. To edit the transfer factor for an element, select the cell to be changed and type in the desired value. After any edits to the transfer factors, select the “Save” button to save the changes. Select the “Get Defaults” button to revert all transfer factors to their default values. When edits are complete, select the “Close” button; this will open the Question screen, as shown in Figure 4-28. Select the “Yes” button to return to the Pathway Factors tab shown in Figure 4-27.

** **User Note****—Remember that any changes made to the transfer factors will be carried forward for future runs. Defaults should be reset using the “**Get Default**” option. Also remember that saving a case/file will save all configurations and values selected for the case. Resetting to defaults will not affect any changes made for a particular case/file unless this file is again saved after values are changed back to defaults. Therefore, if there is any question about the saved values, it is best to reset to defaults before initiating a new case.

4.2.6.6 Page Defaults

Select the “Page Defaults” button on the Pathway Factors tab shown in Figure 4-27 to return all pathway parameters in the GASPAR database to their default values.

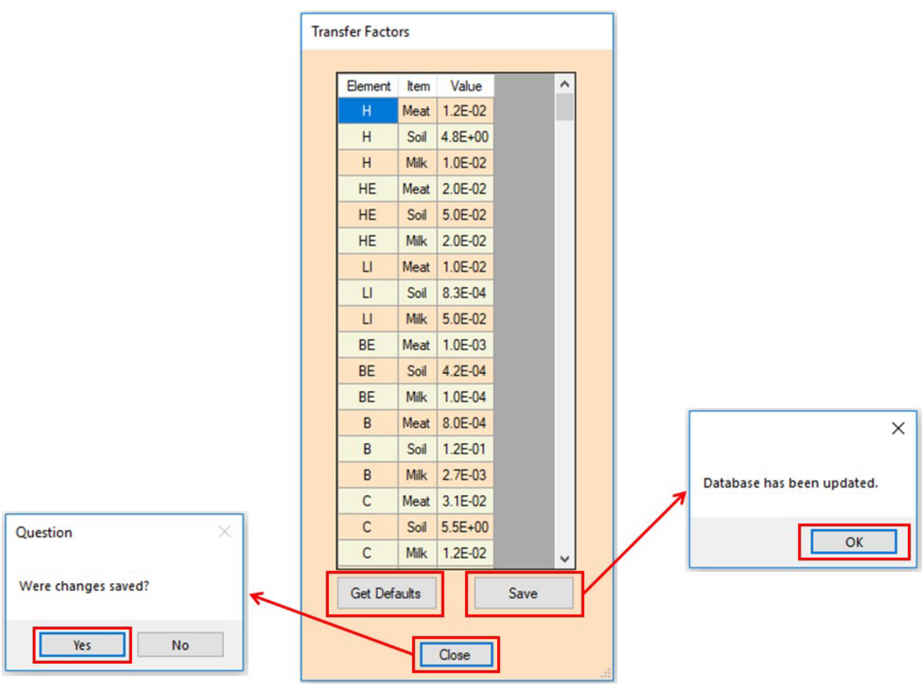


Figure 4-28 Transfer Factors Screen

4.2.7 Consumption Values Tab

The Consumption Values tab, shown in Figure 4-29, presents the consumption and usage parameters for individuals and the overall population. This tab contains the Usage Parameters section (upper portion of tab) and the Intake Consumption Data section. The intake and consumption assumptions used in the code depend on the ICRP methodology (i.e., ICRP-2 (default), ICRP-30, or ICRP-72) selected from the Dose Factors drop-down menu. The assumptions for ICRP-2 and ICRP-30 are taken from RG 1.109, and the assumptions for ICRP-72 are derived from the EPA's EFH.

**** User Note ****—For population doses, the average consumption rates are used in distributing the production across the different age groups, so that the appropriate DCF values for each age group can be applied. Population doses are not calculated for leafy vegetables, only for total vegetables.

The Usage Parameters section contains the 2000 U.S. population and the fractions of the population comprising adults, teenagers, and children. The default value for the 2000 U.S. population is **2.8E+08**. The default population fractions depend on the ICRP methodology (i.e., ICRP-2 (default), ICRP-30, or ICRP-72) selected from the Dose Factors drop-down menu. If the calculation is to be performed using ICRP-2 or ICRP-72 DCF values, the population fractions will be **0.71**, **0.11**, and **0.18** for adults, teenagers, and children, respectively. If using the ICRP-30 DCF values, the user should enter a population fraction of **1.00** for adults and **0.0** for teenagers and children, since the ICRP-30 DCF values apply only to adults.

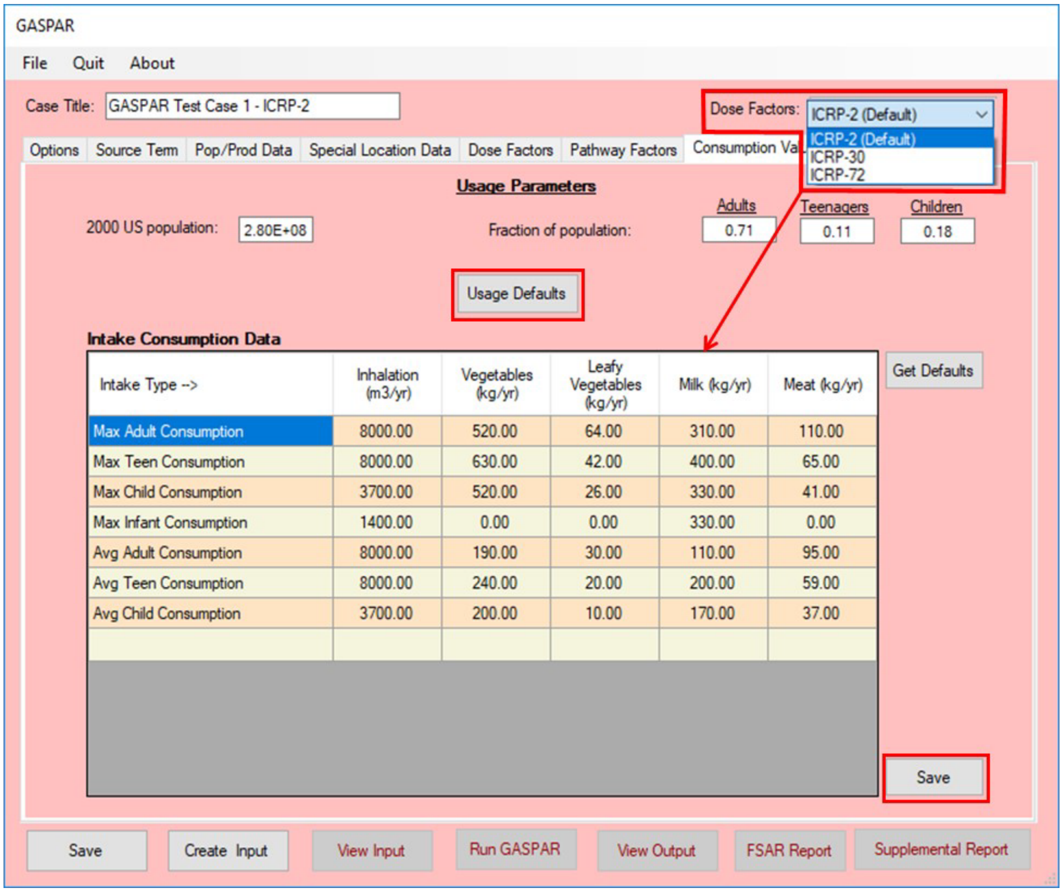


Figure 4-29 Consumption Values Tab

- In the Intake Consumption Data section, the parameter values depend on the ICRP methodology selected. The ICRP-2 (default) and ICRP-30 values are from RG 1.109, and the ICRP-72 values are derived from the EPA's EFH. The parameters in this section are as follows:
- The Intake Type column displays either the maximum or the average consumption rate for each age group, depending on the ICRP methodology.
- The maximum and average inhalation rates are displayed in cubic meters per year (m3/yr). The default values depend on the ICRP methodology.
- The maximum and average vegetable intake rates are displayed in kg/yr, with the default values depending on the ICRP methodology.
- The maximum and average leafy vegetable intake rates are displayed in kg/yr, with the default values depending on the ICRP methodology.
- The maximum and average milk intake rates are displayed in kg/yr, with the default values depending on the ICRP methodology.

- The maximum and average meat intake rates are displayed in kg/yr, with the default values depending on the ICRP methodology.

Select the "Save" button to save any changes. Select the "Usage Defaults" button to restore the maximum individual defaults. See appendix C to this manual for further discussion of the default intake and consumption assumptions for each ICRP methodology.

** **User Note****—Remember that any changes made to the consumption values will be carried forward for future runs. Defaults should be reset using the "**Get Default**" option. Also remember that saving a case/file will save all configurations and values selected for the case. Resetting to defaults will not affect any changes made for a particular case/file unless this file is again saved after values are changed back to defaults. Therefore, if there is any question about the saved values, it is best to reset to defaults before initiating a new case.

4.3 Code Execution and Reports

4.3.1 Executing GASPAR

After all data for the GASPAR dose calculation have been entered, select the "Save" button, as shown in Figure 4-30, to save the data to the data set being used to create the input file, as well as to a file name if one has been created for the case. NRCDose3 will save the data to the GASPAR database, which will be used for the calculation. If a saved file (i.e., a *.GN3 file) is being used, it will also be updated. Select the "OK" button to save the data to the database file (for use in creating the input for the run) and, as applicable, to the open *.GN3 file.

If the data are to be saved to a different *.GN3 database file, then open the File drop-down menu and select "Save to GN3 File…" as shown in Figure 4-3. This will open a Windows Explorer directory, as shown in Figure 4-31. Name the *.GN3 file and choose the directory location as desired. Future saves within NRCDose3 will save to this file name, as well as to the database used for code execution.

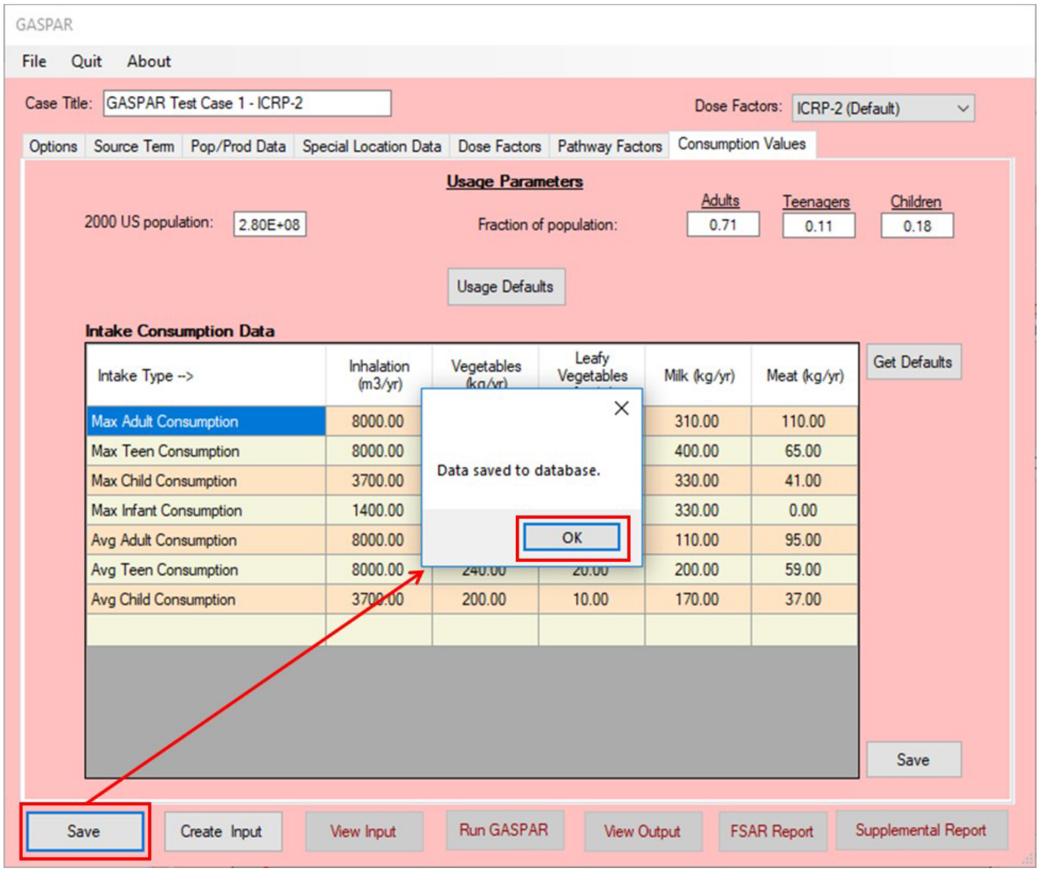


Figure 4-30 Saving GASPAR Inputs

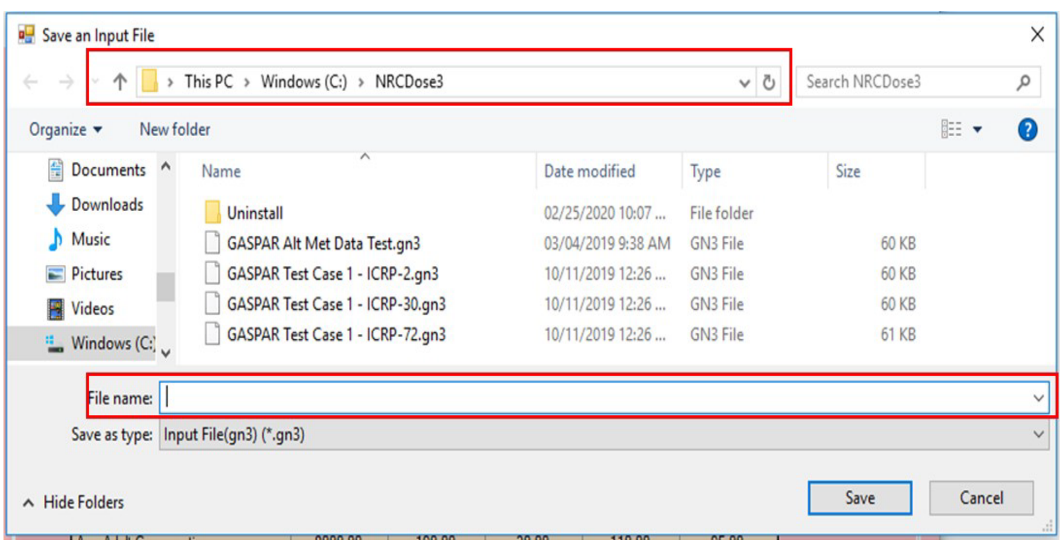


Figure 4-31 Windows Explorer Directory for Saving GASPAR Inputs to a New File

Select the “Create Input” button to activate the “View Input” and “Run GASPAR” buttons on the GASPAR module main screen, as shown in Figure 4-32. Select the “View Input” button to display the Text Viewer screen and review the text file of input data, as shown in Figure 4-34. Select the “Save As…” button to open a Windows Explorer directory and save the input as an input field file (*.GN3). Select the “Print” button to print the input text file, and the “Close” button to close the Text Viewer screen and return to the GASPAR module main screen.

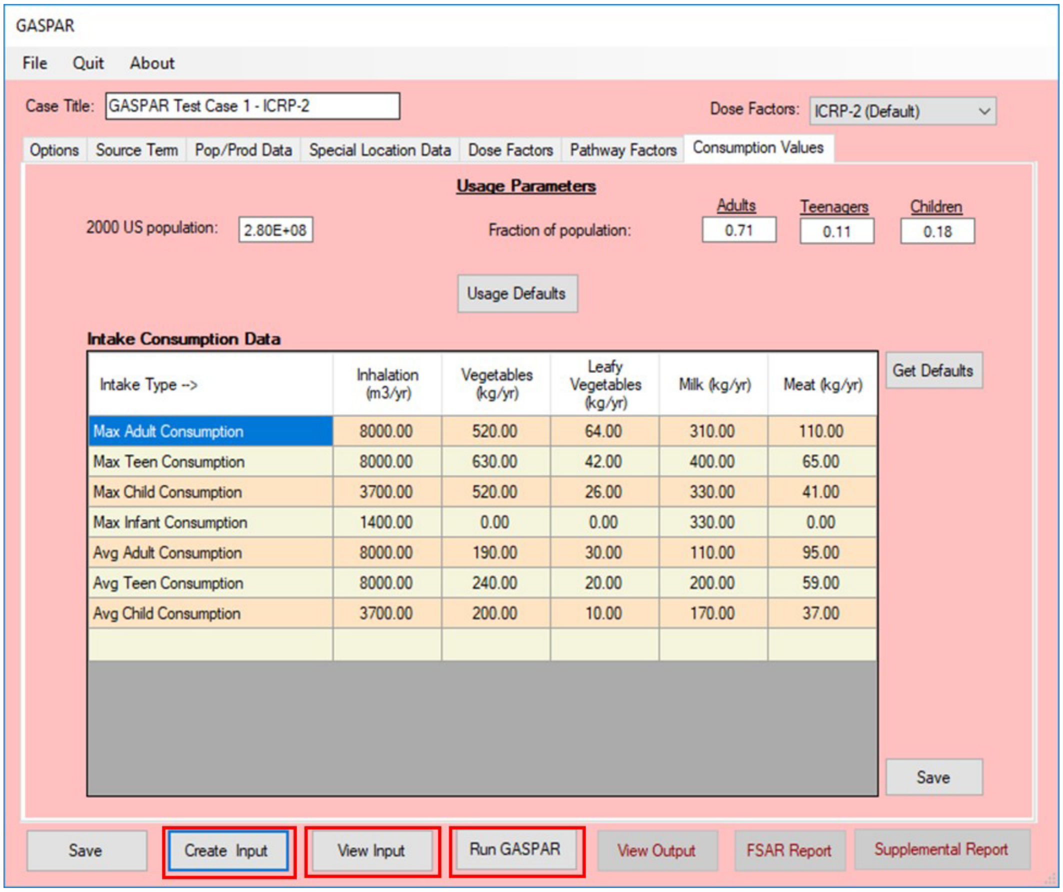


Figure 4-32 GASPAR Module Main Screen—“Create Input” Button

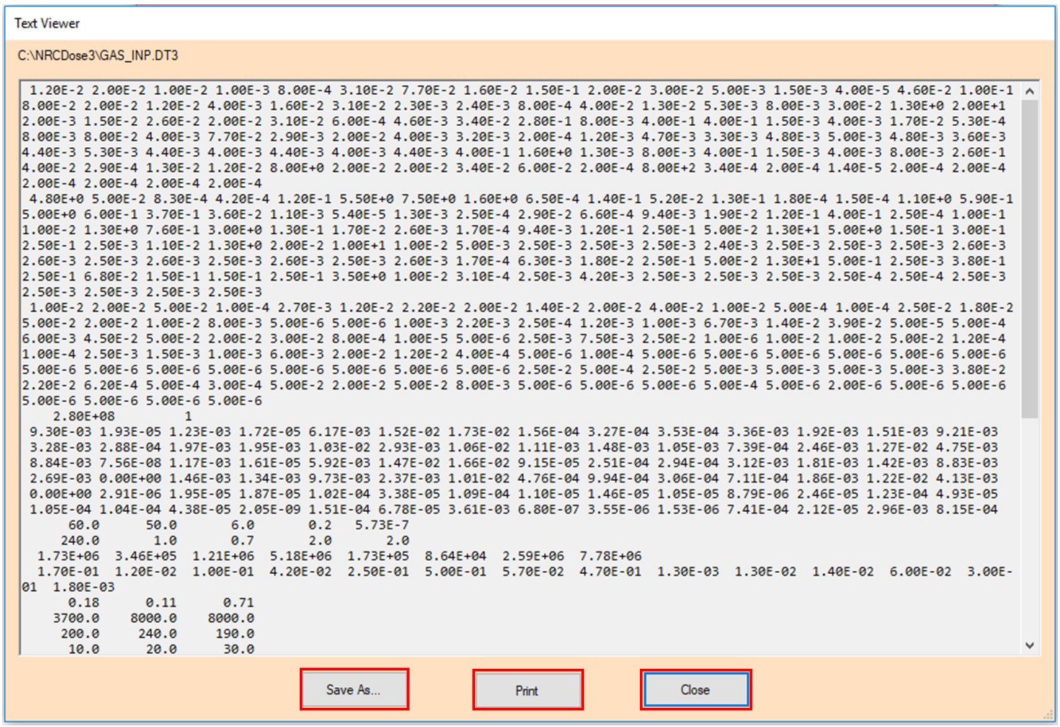


Figure 4-33 Viewing GASPAR Input—Text Viewer Screen

Select the “Run GASPAR” button to execute the code and generate the output report. This will also activate the “View Output,” “FSAR Report,” and “Supplemental Report” buttons on the GASPAR module main screen, as shown in Figure 4-34. After NRCDose3 completes the GASPAR dose calculation, the output will appear as a text output file, as shown in Figure 4-35. Select the “Save As…” button shown in Figure 4-35 to open a Windows Explorer directory and save the output as a text file (*.txt). Select the “Print” button to print the output text file, and the “Close” button to close the Text Viewer screen and return to the GASPAR module main screen. The user can also access the output text file by selecting the “View Output” button.

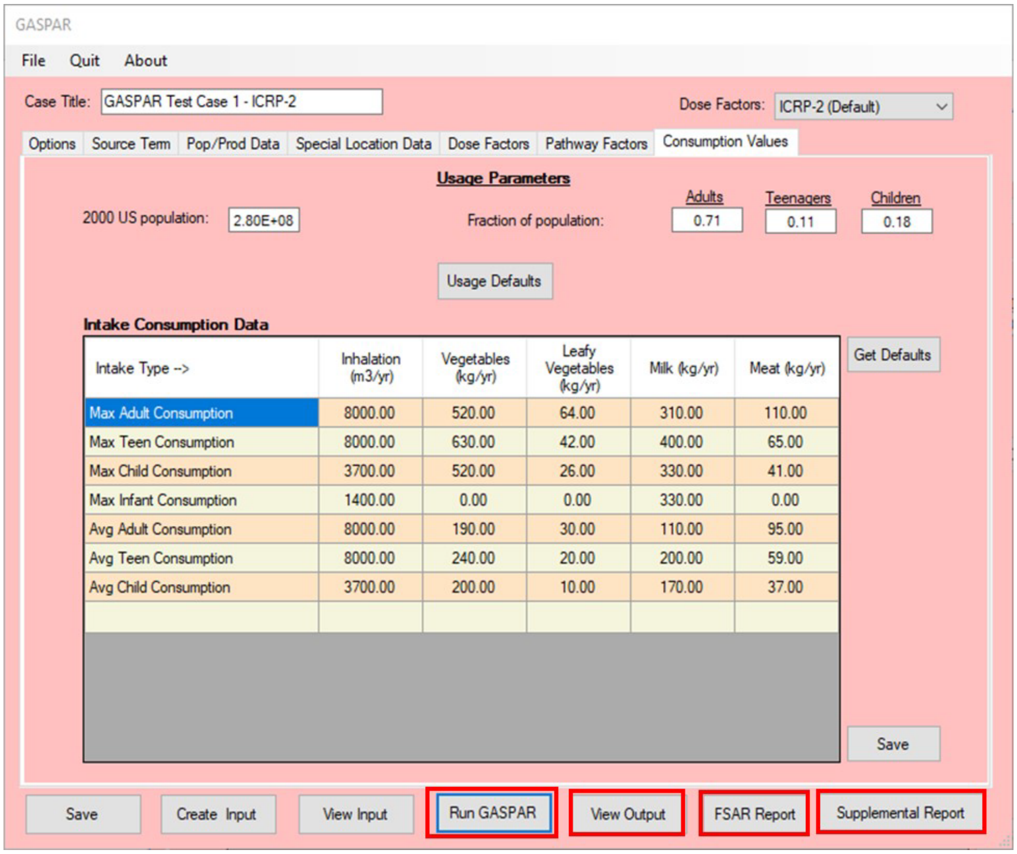


Figure 4-34 GASPAR Module Main Screen—"Run GASPAR" Button

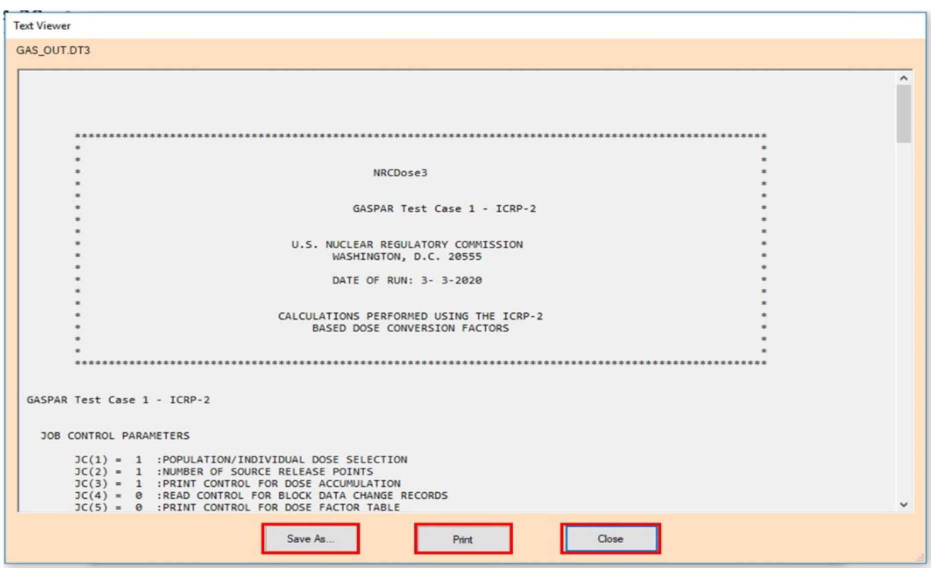
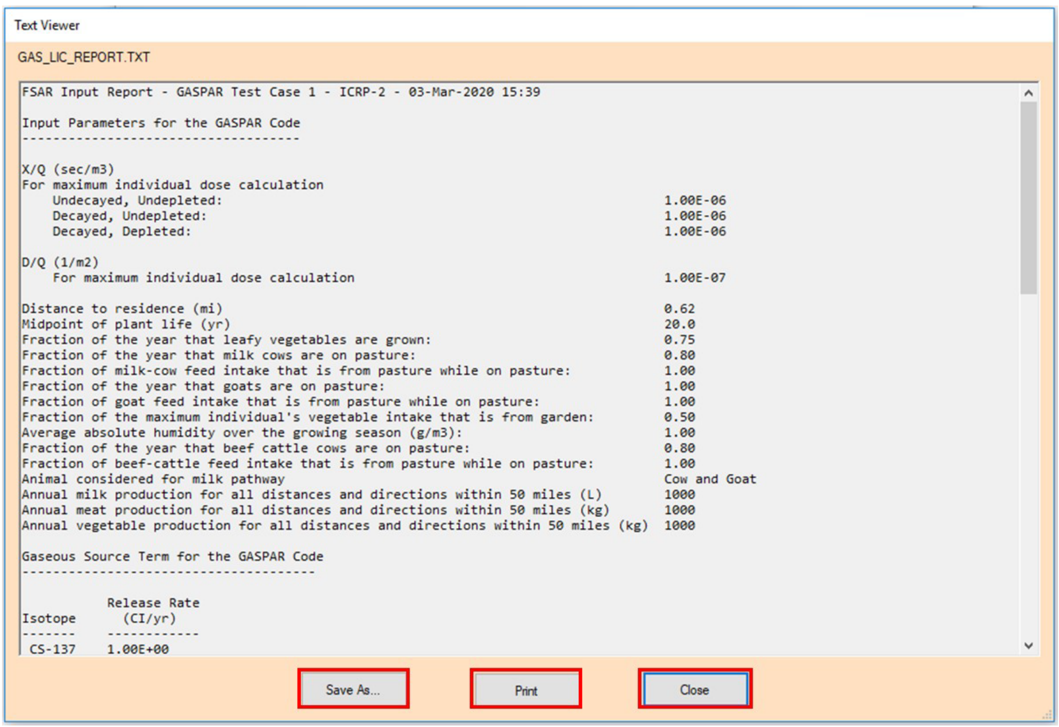


Figure 4-35 Viewing GASPAR Output—Text Viewer Screen

**** User Note ****—Though it is not required, users should consider saving GASPAR files in a user-specified directory other than the NRCDose3 directory, so that future users can access and share the files without having to navigate to the NRCDose3 directory.

4.3.2 GASPAR Reports

GASPAR creates two additional reports: the FSAR Input Report and the Supplemental Report. As shown in Figure 4-36, the FSAR Input Report consolidates the input data and dose calculations into a single text report that provides the information considered most important for the preparation and review of results for licensing documents. Select the “Save As…” button shown in Figure 4-36 to open a Windows Explorer directory and save the FSAR Input Report output as a text file (*.txt). Select the “Print” button to print the FSAR Input Report, and the “Close” button to close the Text Viewer screen and return to the GASPAR module main screen.




```
FSAR Input Report - GASPAR Test Case 1 - ICRP-2 - 03-Mar-2020 15:39

Input Parameters for the GASPAR Code
------------------------------------

X/Q (sec/m3)
For maximum individual dose calculation
    Undecayed, Undepleted:                                                   1.00E-06
    Decayed, Undepleted:                                                     1.00E-06
    Decayed, Depleted:                                                       1.00E-06

D/Q (1/m2)
    For maximum individual dose calculation                                  1.00E-07

Distance to residence (mi)                                                   0.62
Midpoint of plant life (yr)                                                  20.0
Fraction of the year that leafy vegetables are grown:                        0.75
Fraction of the year that milk cows are on pasture:                          0.80
Fraction of milk-cow feed intake that is from pasture while on pasture:      1.00
Fraction of the year that goats are on pasture:                              1.00
Fraction of goat feed intake that is from pasture while on pasture:          1.00
Fraction of the maximum individual's vegetable intake that is from garden:   0.50
Average absolute humidity over the growing season (g/m3):                    1.00
Fraction of the year that beef cattle cows are on pasture:                   0.80
Fraction of beef-cattle feed intake that is from pasture while on pasture:   1.00
Animal considered for milk pathway                                           Cow and Goat
Annual milk production for all distances and directions within 50 miles (L)  1000
Annual meat production for all distances and directions within 50 miles (kg) 1000
Annual vegetable production for all distances and directions within 50 miles (kg)  1000

Gaseous Source Term for the GASPAR Code
---------------------------------------

           Release Rate
Isotope      (CI/yr)
-------    ------------
 CS-137    1.00E+00
```

Figure 4-36 GASPAR FSAR Input Report Screen

As shown in Figure 4-37, the Supplemental Report provides additional documentation of the modeling assumptions used for the calculations, such as exposure, transfer factors, and various pathway constants. Select the “Save As…” button shown in Figure 4-33 to open a Windows Explorer directory and save the Supplemental Report output as a text file (*.txt). Select the “Print” button to print the Supplemental Report, and the “Close” button to close the Text Viewer screen and return to the GASPAR module main screen.

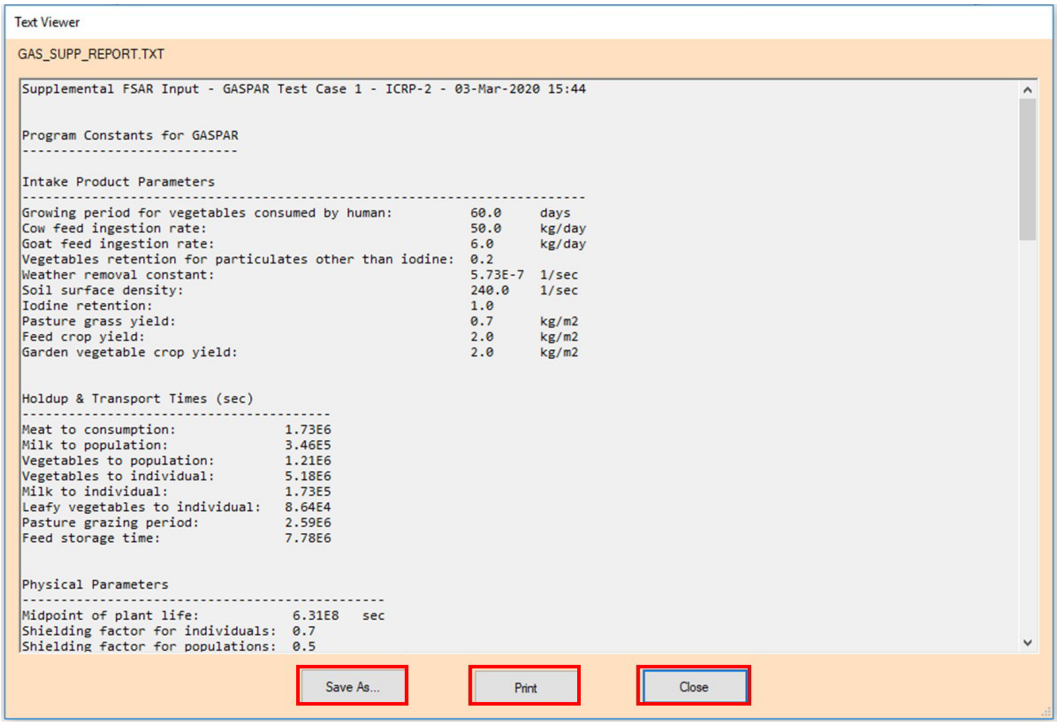


Figure 4-37 GASPAR Supplemental Report Screen

** **User Note** **—Only one report is viewable at a time. A report may be either printed or saved as a text file, which can then be further edited or saved in different formats using standard text editor functions.

5.0 XOQDOQ

The XOQDOQ module within NRCDose3 executes a modified version of the XOQDOQ Fortran code. This update to the NRCDose code has not changed the basic calculation methods (algorithms) of XOQDOQ, as described in NUREG/CR-2919. However, significant changes have been made to the data management and operation to support the expanded capabilities of NRCDose3. XOQDOQ calculates the relative atmospheric dispersion (X/Q) and relative atmospheric deposition (D/Q) values at locations specified by the user, for various standard radial distances and downwind direction sectors. The model is based on a straight-line Gaussian model, and the code can account for variation in the location of release points, additional plume dispersion due to building wakes, plume depletion through dry deposition and radioactive decay, and nonstraight trajectories.

The following sections discuss the steps for using XOQDOQ in NRCDose3. The user is directed to NUREG/CR-2919 for the XOQDOQ Fortran code user guide and technical bases, which discuss in detail the assumptions, limitations, and methods of the XOQDOQ code.

To open the XOQDOC module, select the “XOQDOQ Annual Average Meteorological Dispersion and Deposition” button, shown in Figure 5-1, on the NRCDose3 main selection screen. This will open the XOQDOQ module main screen, shown in Figure 5-2.

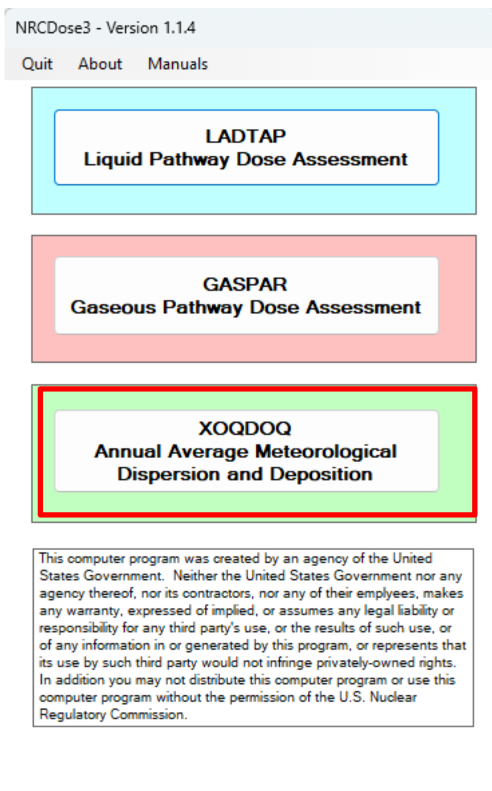


Figure 5-1 NRCDose3 Main Selection Screen (XOQDOQ Module)

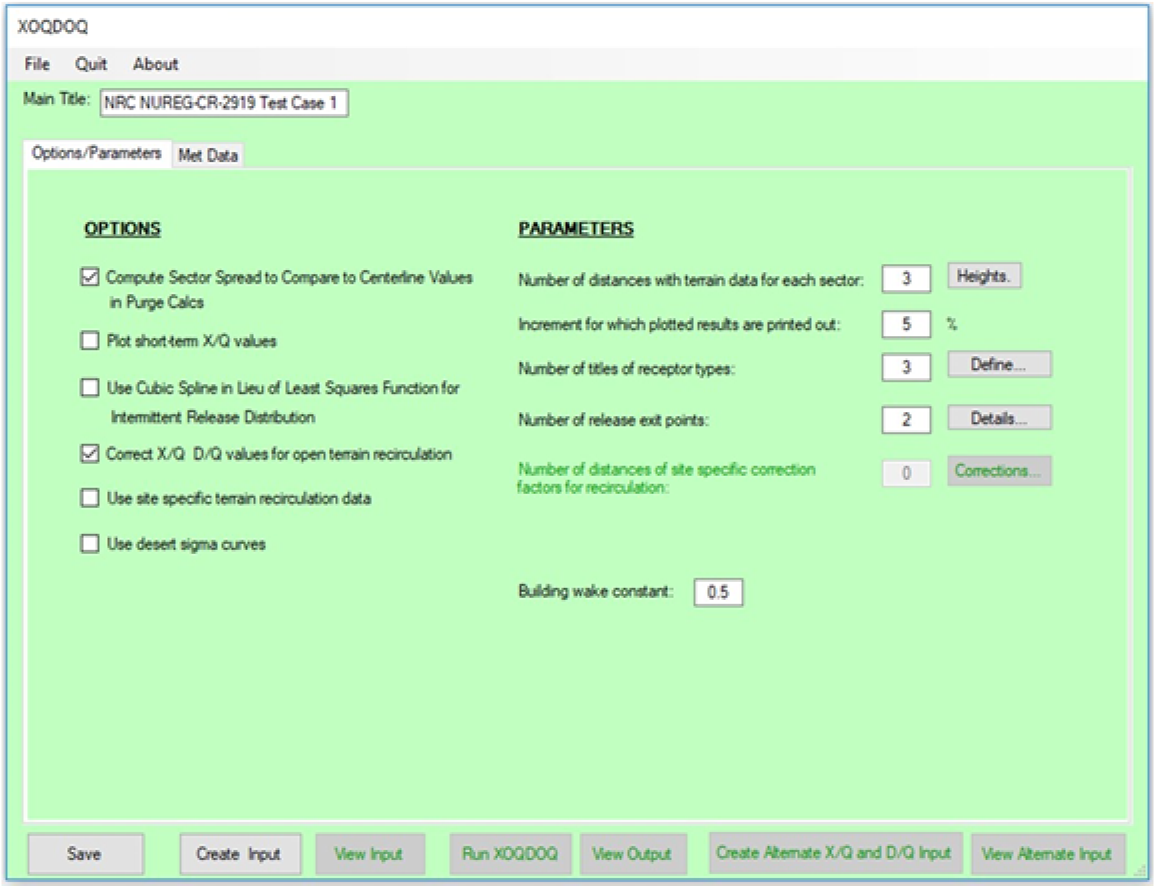


Figure 5-2 XOQDOQ Module Main Screen

The XOQDOQ module main screen opens with the case data last saved in the database. It contains three main functional areas for entering data and performing XOQDOQ dispersion and deposition calculations: (1) the toolbar and initial setup area, (2) the data input tabs, and (3) code execution and reports. The following sections discuss these areas and describe the options and capabilities in each.

5.1 Toolbar and Initial Setup

As shown in Figure 5-2, this portion of the XOQDOQ module main screen contains three tools and one initial setup input field: the File, Quit, and About tools, and the Main Title field.

5.1.1 File Tool

The File tool provides the functionality for managing the XOQDOQ files, as shown in Figure 5-3. The File drop-down menu offers the following options:

- New—Select this option to begin a new XOQDOQ case. This will clear any previously entered information from the database.

- Open XN3 File—Select this option to access and open a *.XN3 file previously created with NRCDose3.

- Open Legacy Input File—Select this option to open a Windows Explorer directory and navigate to an XOQDOQ legacy *.dat file. This option allows a user to load input files created in text format for use with the original XOQDOQ Fortran code. If the user opens a legacy file, the file structure will already be in the format needed for running the code. There is no need to create input; simply select the "Run XOQDOQ" button. The input screens and options in NRCDose3 cannot be used to edit or update a legacy file. To edit a legacy file, use a text editor, following the format and file structure described in NUREG/CR-2919, and save the file as a *.dat file for future use.

- Save to Database—Select this option to save the current case to the database. When XOQDOQ is opened with "Current Project" selected, the information in the database, as last saved before exiting, will populate all XOQDOQ screens and windows.

- Save to XN3 File—Select this option to save the completed case to a *.XN3 file, for later use or for sharing with others.

- Delete—Select this option to open an Explorer window that will allow the user to delete any previously saved *.XN3 files.

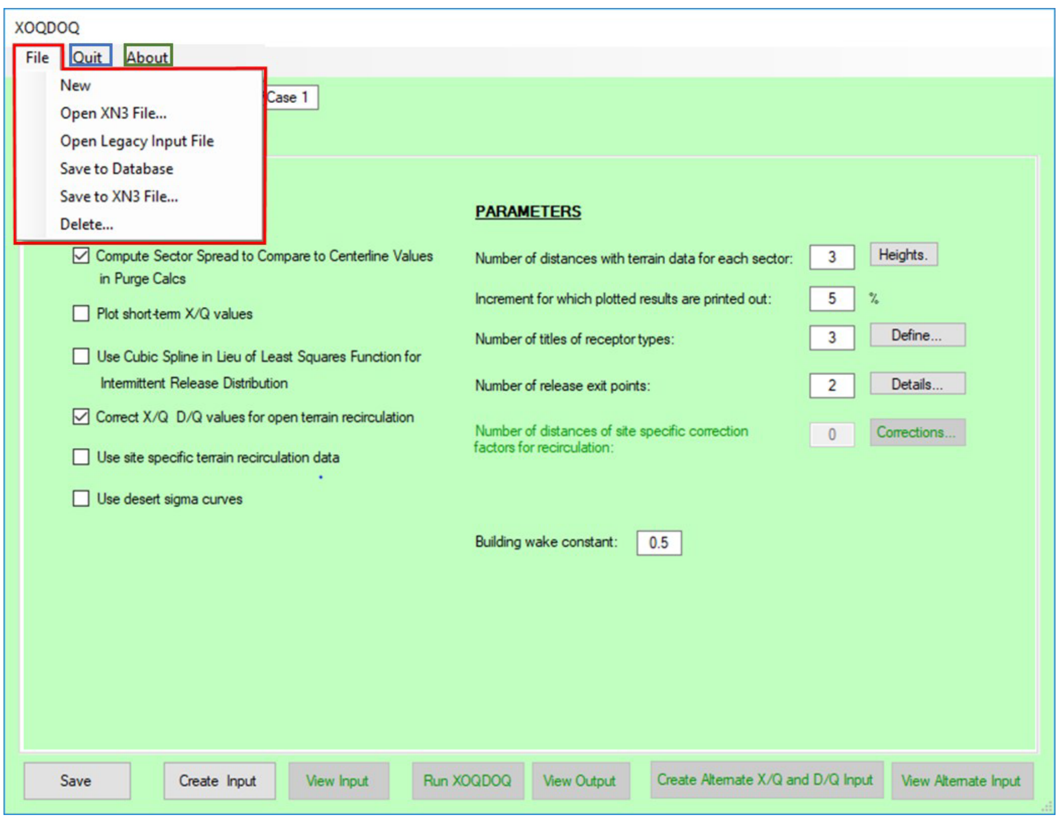


Figure 5-3 XOQDOQ Toolbar with File Drop-down Menu

5.1.2 Quit Tool

The Quit tool allows the user to terminate the operation of the XOQDOQ module. When the Quit tool is selected, the Question prompt screen (shown in Figure 5-4) will be displayed to verify that the user wants to exit the module. Select the “Yes” button to terminate the XOQDOQ module without saving any changes to the data not previously saved. To save changes (to the database and/or a *.XN3 file) before quitting, select the “No” button, then choose the appropriate entry from the File drop-down menu.

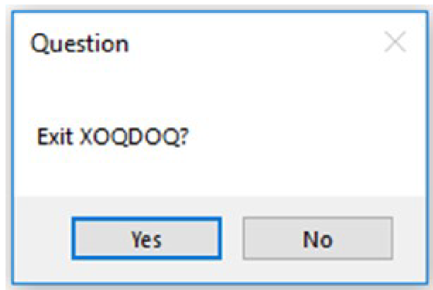


Figure 5-4 XOQDOQ Module Quit Tool Screen

5.1.3 About Tool

Selecting the About tool brings up the About XOQDOQ screen shown in Figure 5-5, which displays information about XOQDOQ. Select the “OK” button to return to the XOQDOQ module main screen shown in Figure 5-2.

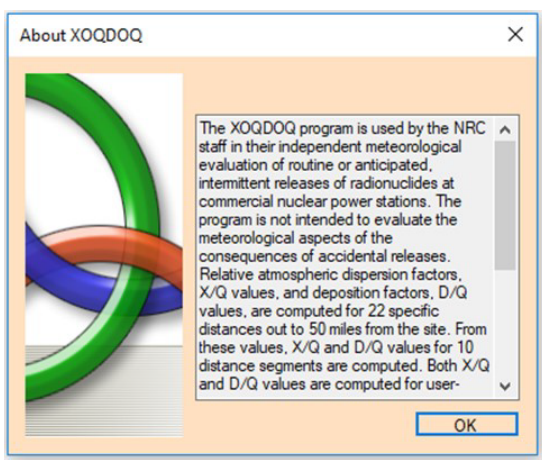


Figure 5-5 About XOQDOQ Screen

5.1.4 Main Title Field

In the Main Title field, enter a title for the XOQDOQ calculation. This is a descriptive text field limited to 80 characters. The title should help users identify, for example, the facility/site, the period of record of the meteorological input data, and the release point. As shown in Figure 5-2, the example scenario included in the NRCDose3 installation (in the installation directory, that is, C:/NRCDose3) is entitled "NRC NUREG-CR-2919 Test Case 1."

5.2 Data Input Tabs

The two XOQDOQ data input tabs, shown in Figure 5-2, are (1) Options/Parameters and (2) Met Data.

It is recommended, though not required, that the user enter the necessary case parameters and data into the data input tabs in the order in which they are listed.

5.2.1 Options/Parameters Tab

The Options/Parameters tab is used to enter various parameters for the XOQDOQ calculations. The tab includes the Options section (left-hand side) and the Parameters section (right-hand side), as shown in Figure 5-6. Refer to NUREG/CR-2919 and Table B-3 of appendix B to this manual for more information on the inputs in this tab.

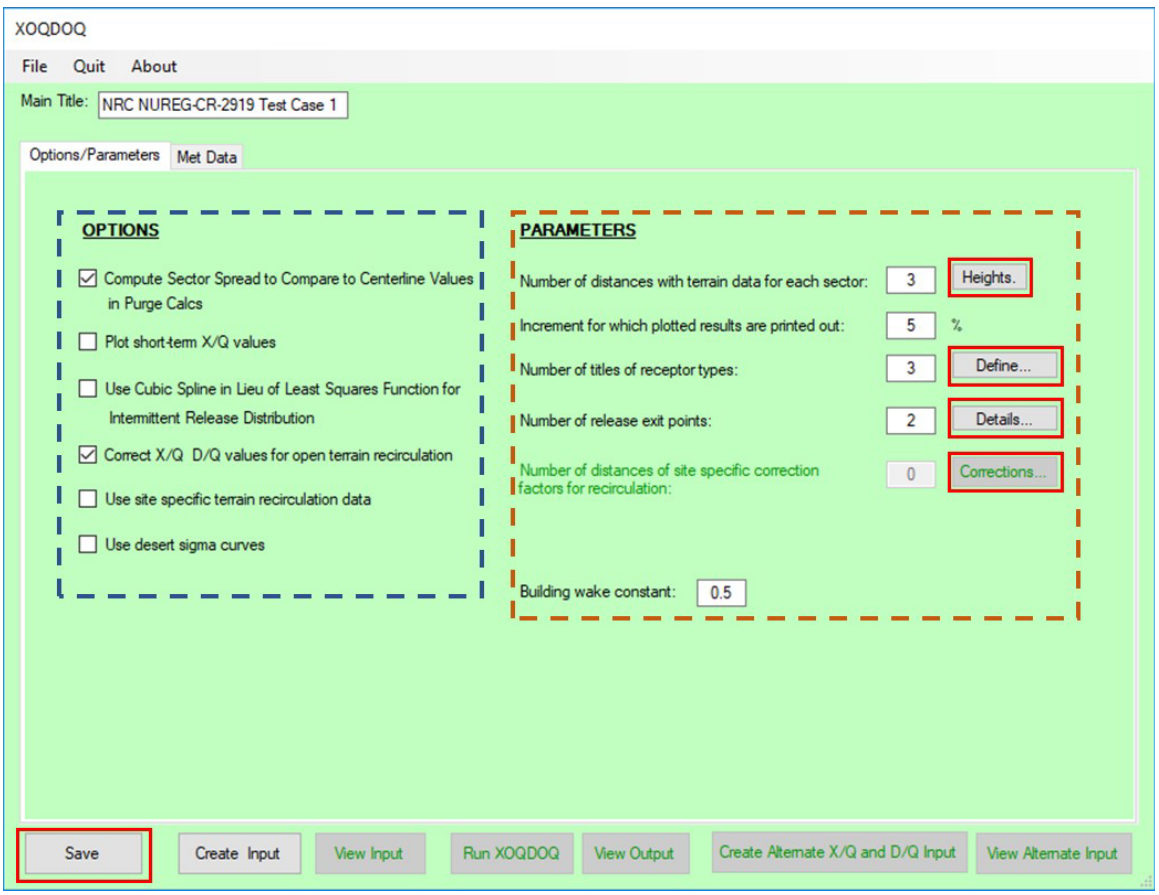


Figure 5-6 Options/Parameters Tab

5.2.1.1 Options

As shown in Figure 5-6, the following check boxes appear in the Options section of this tab:

- Compute Sector Spread to Compare to Centerline Values in Purge Calcs—Select this option to distribute the associated X/Q values across the entire width of the downwind sector. The default value should be **checked**, as in the example case, “NRC NUREG-CR-2919 Test Case 1.” The option is normally checked in program execution (see KOPT (3) in NUREG/CR-2919).

- Plot short-term X/Q values—Select this option to plot short-term X/Q values versus probability of occurrence. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this option is **unchecked.** The option is normally unchecked in program execution (see KOPT (4) in NUREG/CR-2919).

- Use Cubic Spline in Lieu of Least Squares Function for Intermittent Release Distribution—Select this option to use a cubic spline in lieu of a least squares function for fitting an intermittent-release distribution. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this option is **unchecked**. The option is normally checked in program execution (see KOPT (5) in NUREG/CR-2919).

- Correct X/Q D/Q values for open terrain recirculation—Select this option to use the default correction for open terrain recirculation, based on Figure 3.2 of NUREG/CR-2919. If both this option and “Use site specific terrain recirculation data” (next option) are **unchecked**, then the calculations will include no recirculation. The value from “NRC NUREG-CR-2919 Test Case 1” for this option is **checked**, but its use should be based on site-specific conditions (see KOPT (8) in NUREG/CR-2919).

- Use site specific terrain recirculation data—When using site-specific recirculation factors, **check** this option, and **uncheck** the option for “Correct X/Q D/Q values for open terrain recirculation.” Recirculation correction factors will be based on the information entered in the Parameters section under “Number of distances of site-specific correction factors for recirculation.” Otherwise, both the site-specific and the default recirculation values will be applied. When entering the site-specific terrain recirculation factors, the user must provide values for all 16 downwind direction sectors. If the recirculation factor for a given sector and distance is left at zero, then XOQDOC will calculate dispersion and deposition values of zero for that sector and distance. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this option is **unchecked**, but its use should be based on site-specific conditions and the availability of site-specific recirculation factors (see KOPT (9) in NUREG/CR-2919).

- Use desert sigma curves—Select this option to use desert sigma curves for continuous ground-level releases in a desert environment. Desert sigma curves include the effect of plume meander. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this option is **unchecked**. The option is normally unchecked in program execution (see KOPT (10) in NUREG/CR-2919).

Some options are hard-coded into XOQDOQ and are not adjustable by the user. One such option is the output of X/Q and D/Q values for each radial segment, discussed and identified as KOPT (6) in NUREG/CR-2919. In NRCDose3, the output always provides the X/Q and D/Q values for all radial segments. Similarly, if special receptor locations have been identified, the output will always provide the X/Q and D/Q values for those locations (KOPT (7) in NUREG/CR-2919). The option for uneven sector sizes (KOPT (11) as described in NUREG/CR-2919) is also not adjustable and is not used in the Fortran code calculations. Refer to appendix B to this manual for more information.

5.2.1.2 Parameters

In the Parameters section, the user can enter the factors that influence how the release will be characterized. The "Increment for which plotted results are printed out" field defaults to 15 percent and is used in computing the X/Q values for a purge release. As shown in Figure 5-6, the following inputs appear in the Parameters section:

- Number of distances with terrain data for each sector—For this parameter, enter the number of distances from the plant that have terrain data to be entered. The value from the example case, "NRC NUREG-CR-2919 Test Case 1," is **3**. If this option is selected, a numerical value must be entered in this field.

** **User Note** **—Do not enter a value greater than 10 for the number of distances with terrain data.

- Next, select the "Heights" button to open the Terrain Height Values screen, as shown in Figure 5-7, and enter the terrain height and distance in meters for each downwind direction sector. Select the "Save" button when the terrain heights and distances for all 16 sectors have been entered. If the plant elevation is set to zero on the Met Data tab (see Section 5.2.2), then the terrain height and distance values are in meters. If the plant elevation is set to a value greater than zero, then the distances are in miles from the plant release point, and the terrain height is in feet above sea level (Figure 5-7).

** **User Note** **—If the user changes the plant elevation so as to cause the units for terrain data to change, any previously entered terrain values will not be adjusted to reflect the change in units.

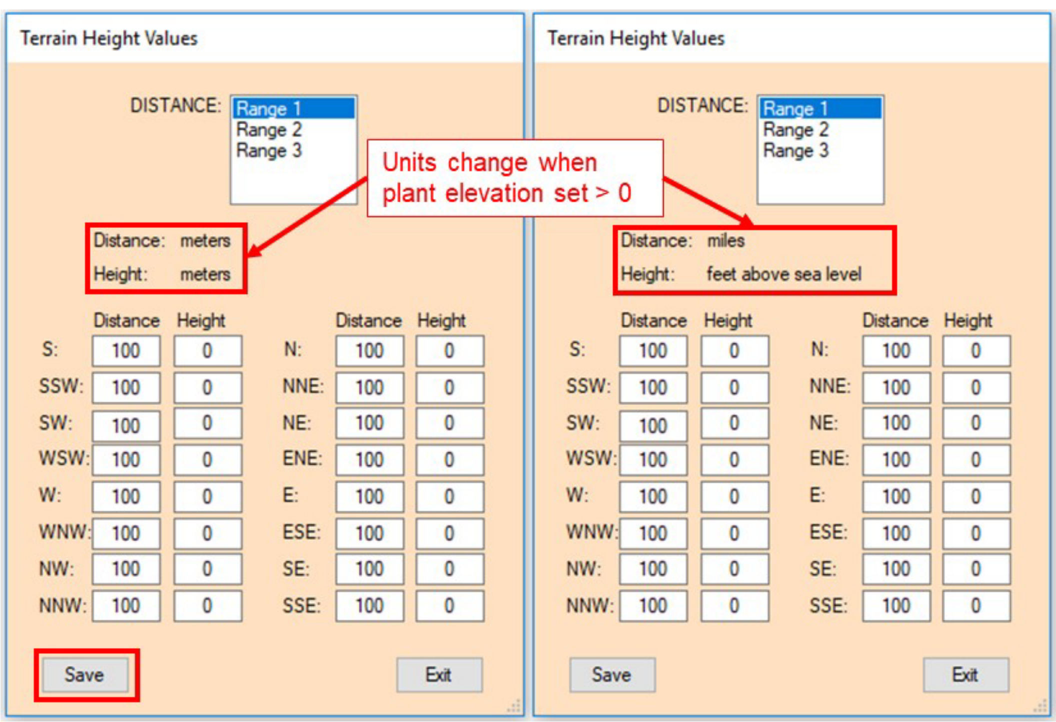


Figure 5-7 Terrain Height Values Screen

- Increment for which plotted results are printed out—This parameter specifies the level of short-term X/Q percentile values to be used. The value from the example case, "NRC NUREG-CR-2919 Test Case 1," is **5** percent, and the allowable range for values in this field is greater than 0.0 percent. This feature applies to purge releases. See Section 4.4 of NUREG/CR-2919 for a more detailed explanation of this parameter.

- Number of titles of receptor types—Enter the number of receptor types that will be used in the XOQDOQ analysis. Typically, there are three receptor points: "Residence," "Garden," and "Site Boundary." However, the user can define fewer receptor points or add more as needed. The value from the example case, "NRC NUREG-CR-2919 Test Case 1," is **3**, and the allowable range for values in this field is between 1 and 30 receptor points. After entering the number, select the "Define" button to open the Receptor Types screen shown in Figure 5-8. For each receptor type, enter the title and location, then select the "Define" button to open the Receptor Locations screen shown in Figure 5-8. On the Receptor Locations screen, select the direction from among the 16 direction sector options in the drop-down menu, and enter the distance in meters. Then select the "Save" button to return to the Options/Parameters tab.

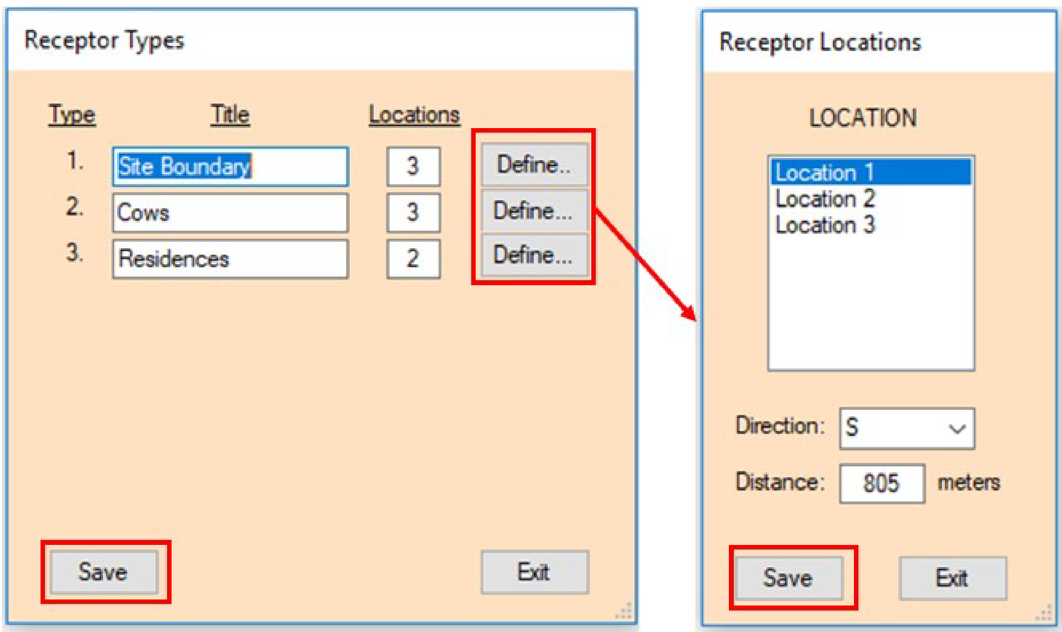


Figure 5-8 Receptor Types and Receptor Locations Screens

- Number of Release Exit Points—Enter the number of release exit points to be modeled using XOQDOQ. The value from the example case, "NRC NUREG-CR-2919 Test Case 1," for this option is **2**, and the allowable range for values in this field is between 1 and 5 release points. Select the "Details" button to open the Location Selection screen shown in Figure 5-8, which allows the user to enter a descriptive title for each release point.

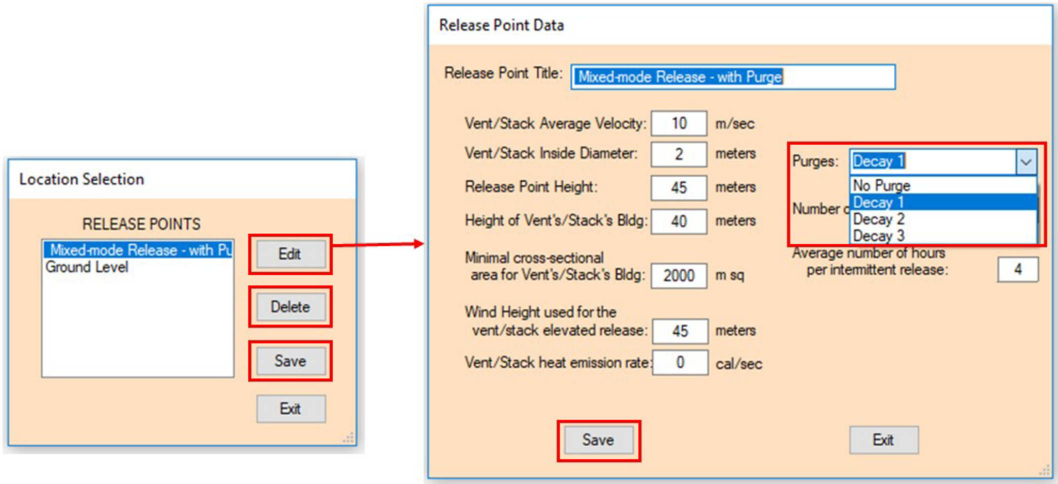


Figure 5-9 Location Selection and Release Point Data Screens

- Select (highlight) the release point and the "Edit" button to open the Release Point Data screen shown in Figure 5-9.
- Release Point Title—In this text field, shown in Figure 5-9, enter a descriptive title for the release point.
- Vent/Stack Average Velocity—Enter the average velocity of the effluent from the plant vent or stack in meters per second (m/s). The allowable range for values in this field is greater than 0.0 m/s.
- Vent/Stack Inside Diameter—Enter the inside diameter of the plant vent or stack in meters. The allowable range for values in this field is greater than 0.0 m.
- Release Point Height—Enter the height of the release point from the plant vent or stack, in meters. The allowable range for values in this field is greater than 0.0 m.
- Height of Vent's/Stack's Bldg—Enter the height of the building containing the plant vent or stack, in meters above plant grade. The allowable range for values in this field is greater than 0.0 m.
- Minimum cross-sectional area for Vent's/Stack's Bldg—Enter the minimum cross-sectional area of the building with the plant vent or stack in square meters (m^2). The allowable range for values in this field is greater than 0.0 m^2.
- Wind Height used for the vent/stack Elevated Release—Enter the wind height used for an elevated plant vent or stack release, in meters. The allowable range for values in this field is greater than 0.0 m.
- Vent/Stack heat emission rate—Enter the heat emission rate of the plant vent or stack in calories per second (cal/s). The allowable range for values in this field is greater than 0.0 cal/s. Normally, this value should be 0 for power plants. Section 4.20 of NUREG/CR-2919 discusses when this parameter may need to be adjusted.

- Purges—From the drop-down menu options, select whether there are purges. The drop-down menu options, shown in Figure 5-9, are “No Purge” and the purge options of “Decay 1,” “Decay 2,” and “Decay 3.” The “Number of intermittent releases” and “Average number of hours per intermittent release” options are deactivated if “No Purge” is selected, and activated if “Decay 1,” “Decay 2,” or “Decay 3” is selected. In the latter case, enter the number of intermittent releases and the average number of hours per release. “Decay 1,” “Decay 2,” and “Decay 3” correspond to the Card Type 4 (i.e., DECAY(1), DECAY(2), and DECAY(3)) options in the XOQDOQ Fortran code; each of them represents a different way of handling decay. Typically, for “Decay 1” (DECAY(1)), no decay is considered; this is the standard choice. For “Decay 2” (DECAY(2)), a 2.26-day decay is considered, and for “Decay 3” (DECAY(3)), an 8-day decay (with deposition through depletion) is considered. This decay is only for the calculation of the short-term X/Q values and does not affect the long-term dispersion calculations as shown in the sector tables or for special locations.

**** User Note ****—If a release point is deleted on the Location Selection screen shown in Figure 5-9, the number of release points identified on the Options/Parameters tab will automatically be updated.

- Number of distances of site-specific correction factors for recirculation—As noted in Section 5.2.1.1, this option is activated when the user selects (checks) the “Use site specific terrain recirculation data” option in the Options section of the Options/Parameters tab. Enter the number of distances of site-specific correction factors for recirculation. (This value must be between 1 and 10.) Then select the “Corrections…” button to open the Distance Corrections screen shown Figure 5-10. For each distance, enter the distance in meters and the correction factor for each of the 16 direction sectors. Each value entered must be greater than 1.0. This is because each value is used as a direct multiplier in the dispersion and deposition calculations; therefore, an entry less than 1.0 will cause a proportional reduction, and an entry of zero will yield values of zero for X/Q and D/Q. Select “Save” when data have been entered for all distances.

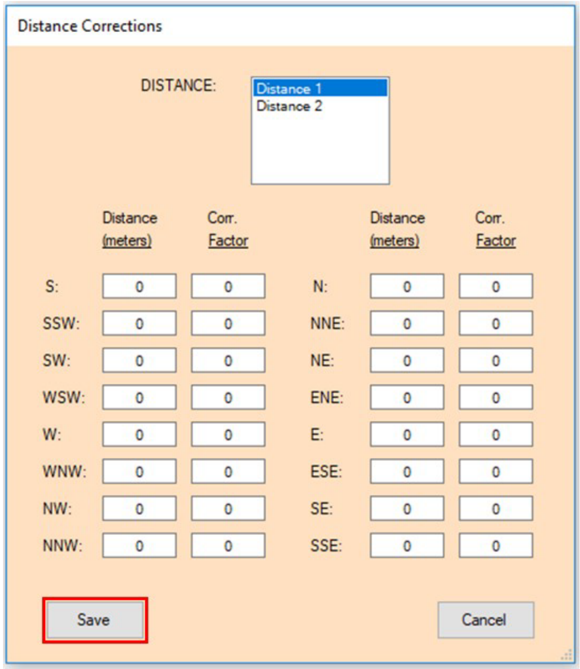


Figure 5-10 Distance Corrections Screen

- Building Wake Constant—In the example case, "NRC NUREG-CR-2919 Test Case 1," the value of the building wake constant is **0.5**; the allowable range for values in this field is greater than 0.0. If desired, the building wake constant can be changed from the default value. However, it should not be changed without supporting dispersion and building dimension data. If it is changed, a warning window will open as shown in Figure 5-11, stating, "For regulatory submittals to the NRC, an applicant is expected to provide technical justification for using an alternate value for the building wake constant." Select the "OK" button to acknowledge this warning and return to the Options/Parameters tab.

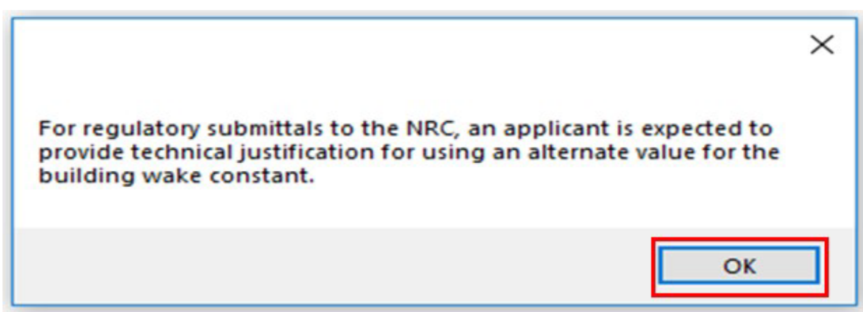


Figure 5-11 Building Wake Constant Warning Window

5.2.2 Met Data Tab

The Met Data tab is used to enter the meteorological information and data parameters needed for XOQDOQ to determine the relative dispersion (X/Q) and relative deposition (D/Q) values. As shown in Figure 5-12, the tab includes a section for inputs and options (upper portion) and a joint frequency distribution (JFD) table (lower portion). The inputs and options are as follows (for more information about them, see NUREG/CR-2919):

- Distribute calms as first wind-speed class—Select this option to distribute calms as the first windspeed class; this activates the “Number of hours, or percent, of calm for each stability category” input fields. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this option is **checked**.

- Input joint frequency distribution data as percent frequency—Select this option to change the units of the JFD for each stability class from hours to percent. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this option is **unchecked**.

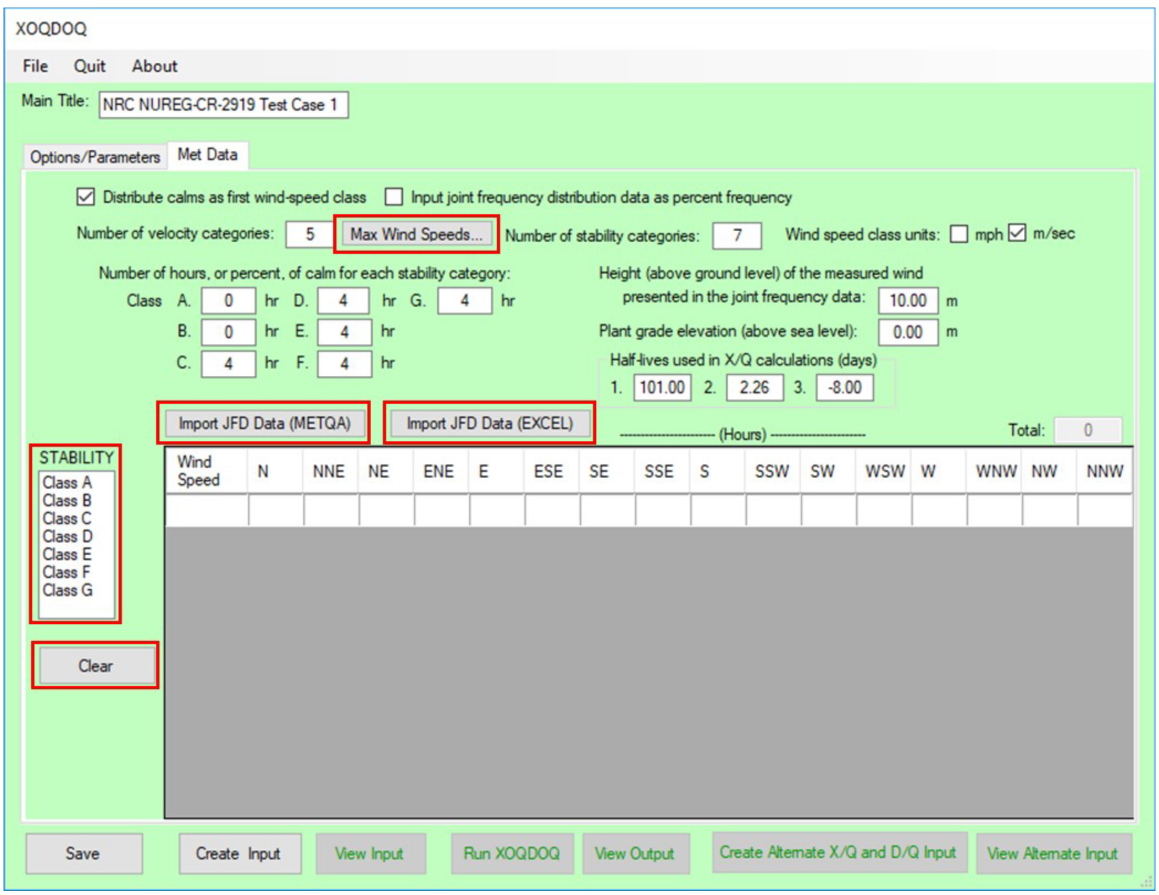


Figure 5-12 Met Data Tab

- Number of velocity categories—In this field, enter the number of velocity categories. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this field is **5**, and the allowable range for values in this field is between 1 and 14. Consistent with NRC guidance, it is desirable to have finer resolution (i.e., more windspeed classes) in summarizing windspeed data for the lower windspeed classes. Select the “Max Wind Speeds…” button to open the Maximum Wind Speeds screen shown in Figure 5-13. (Before doing so, the user should make sure that the desired units of measure—either miles per hour (mph) or meters per second (m/sec)—are selected for the “Wind speed class units” option. These units will be applied to all velocity categories and need to be consistent with the units of measure in the JFD table.) Select the “Save” button on the Maximum Wind Speeds screen to save any changes to the database.

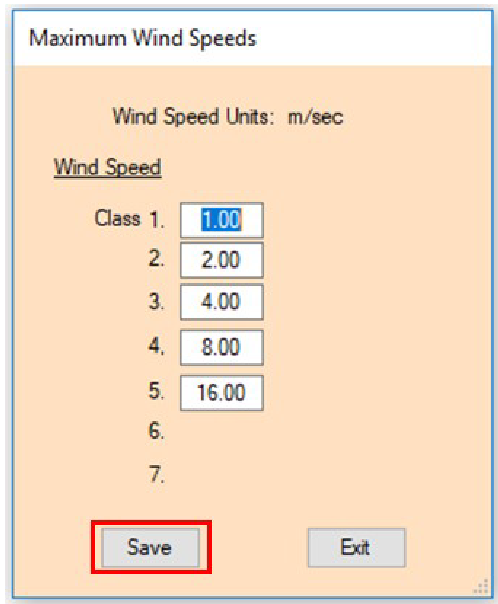


Figure 5-13 Maximum Wind Speeds Screen

- Number of stability categories—In this field, enter the number of stability categories. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this field is **7**, and the allowable range for values in this field is between 1 and 7.

**** User Note ****—As described in RG 1.111, the NRC uses seven stability classes (A through G), which are based on vertical temperature differences as in RG 1.23, Revision 1, “Meteorological Monitoring Programs for Nuclear Power Plants,” issued March 2007 [Ref. 25]. By contrast, the EPA recognizes just six classes (A through F) and allows for several approaches to categorization.

- Wind speed class units—Select the windspeed class option in either mph or m/sec. This will simultaneously change the units for the entries in the JFD table and for the “Number of hours, or percent, of calm for each stability category” input fields. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this option is **m/sec**.

- Number of hours, or percent, of calm for each stability category—Enter either the number of hours or the percentage of calm for each stability category.

- Height (above ground level) of the measured wind presented in the joint frequency data—Enter the height (above ground level) of the measured windspeed, in meters. For ground-level or elevated/ground-level mixed release, use winds at the 10 m level. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this parameter is **10** m, and the allowable range for values in this field is greater than or equal to 0.0 m.

- Plant grade elevation (above sea level)—Enter the plant elevation in meters (NUREG/CR-2919 calls for feet). As discussed in Section 5.2.1.2, if the plant elevation is set to zero, then the terrain height and distance range values will be in meters. If the plant elevation is set to a value greater than zero, then the distance ranges will be given in miles from the plant release point, and the terrain height will be given in feet above sea level. The value from the example case, “NRC NUREG-CR-2919 Test Case 1,” for this option is **0.0** m, and the allowable range for values in this field is greater than or equal to 0.0 m.

- Half-lives used in X/Q calculations (days)—Enter the half-lives to be used in the X/Q calculations, in days, for the three decay and depletion parameters. Typically, these should not be changed from the default values:

    - 101 days for “Undecayed, Undepleted”

    - 2.26 days for “Decayed, Undepleted”

    - −8.00 days for “Decayed, Depleted”

**** User Note ****—The default values are used in the XOQDOQ Fortran code to control certain functions and the decay time. Any value over 100 for “DECAY(1)” is used to designate that there is no decay and no depletion, as reflected in the option “Undecayed, Undepleted.” The value for DECAY(2), with a default of 2.26 days, reflects decay during transport and is used for the “Decayed, Undepleted” option. The DECAY(3) value of −8.00 days reflects a decay of 8 days, as well as a plume depletion, and is used for the “Decayed, Depleted” option. NUREG/CR-2919 contains more information on these values. To ensure the correct use of the XOQDOQ results by GASPAR II, these values should not be changed.

In the lower portion of the Met Data tab, as shown in Figure 5-12, the user can enter data in the JFD table. To enter data manually, select (highlight) the desired stability class (from Class A through Class G), and enter either the number of hours or the percentage that the wind blows in each of the 16 downwind sectors. Repeat this process for each stability class up to Class G.

Alternatively, JFD data can be imported into XOQDOQ from a file generated by either MS Excel or the NRC’s METQA application. To import JFD data from an MS Excel file, select the “Import JFD Data (EXCEL)” button. This will open the windows shown in Figure 5-14. Select the “Yes” button on the Check screen to open the Met Data Import screen. Then double-click on the Input File field to open Windows Explorer and navigate to the directory containing the file to be imported. Select the “Open” button to enter the file in the Input File field. Finally, select the “Import” button to import the file.

To import JFD data generated by METQA, select the “Import JFD Data (METQA)” button, then follow the same steps as for importing from an MS Excel file. METQA is an internal (NRC) application (currently at version 2.0) implementing the guidance in NUREG-0917, “Nuclear Regulatory Commission Staff Computer Programs for Use with Meteorological Data,” issued July 1982 [Ref. 26]. Output from METQA is used in evaluating the quality and completeness (i.e., data recovery) of the parameters measured by an applicant’s or licensee’s onsite meteorological monitoring program. METQA generates meteorological data inputs for atmospheric dispersion models such as XOQDOQ, which are suitable for use with NRCDose3. In practice, many applicants and licensees have adapted and expanded the guidance in NUREG-0917, which is primarily related to quality assurance, to suit their own internal quality assurance practices and procedures and meteorological monitoring programs.

The JFD portion of the XOQDOQ input file, whether entered manually or imported from a suitable file (from MS Excel or METQA), must conform to the formatting requirements specified in NUREG/CR-2919 (see Card Type 6 in that guidance). The JFD data are organized in an array according to wind direction, windspeed range, and atmospheric stability class. The seven stability classes range from extremely unstable (Class A) through extremely stable (Class G).

Each row of the array has 16 entries, corresponding to the 16 standard wind direction sectors (N, NNE, NE, and so on, proceeding clockwise through NNW). Each entry represents the frequency of occurrence for a particular sector, windspeed range, and stability class; it is entered either as a number of hours or as a percentage relative to the total number of hours in the meteorological data set, depending on the option selected in the Met Data tab. The data set used to generate the JFD may consist of 1 year (i.e., one annual cycle) of measurements (i.e., as many as 8,760 hours if no values are missing), or it may be a composite of multiple years (annual cycles) of measurements.

The sequence of rows in the array is as follows. The first row contains data for the first stability class (Class A) and the first windspeed range. The second row contains data for the same stability class and the next windspeed range, and so on until all windspeed ranges for the first stability class have been covered. The array then covers all of the windspeed ranges in turn for the second stability class, then the third, and so on through the last stability class. The number of windspeed ranges for each stability class is user-specified, up to a maximum of 14.

As shown infigure 5-14, the JFD entries begin on the fifth row (the first four rows are generated by METQA); frequency values appear on 91 rows, representing 13 windspeed groups for each of the seven stability classes. Therefore, an XOQDOQ run under NRCDose3 would require 1,456 frequency entries (16 in each row) as input data for a new JFD.

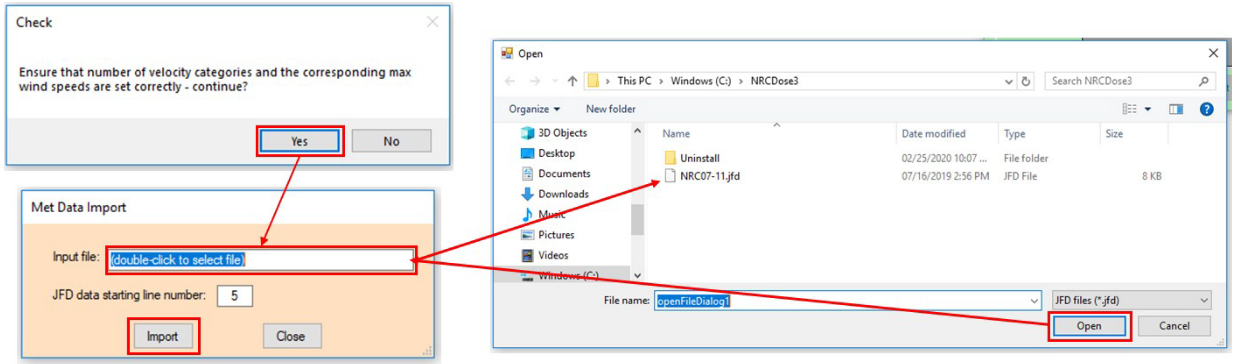


Figure 5-14 Importing JFD Information

Selecting the "Clear" button shown in Figure 5-12 opens the Clear Grid JFDs screen shown in Figure 5-15. Select the "Yes" button, as shown in Figure 5-15, to clear all JFD table information from the Met Data tab.

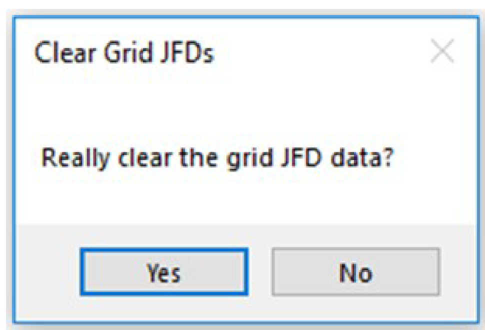


Figure 5-15 Clear Grid JFDs Screen

5.3 <u>Code Execution and Reporting</u>

After all data for the XOQDOQ calculation have been entered, select the "Save" button, as shown in Figure 5-16, to save the data to the data set being used to create the input file, as well as to a file name if one has been created for the case. NRCDose3 will save the data to the XOQDOQ database, which will be used for the calculation. If a saved file (i.e., a *.XN3 file) is being used, it will also be updated. Select the "OK" button to save the data to the database file (for use in creating the input for the run) and, as applicable, to the open *.XN3 file.

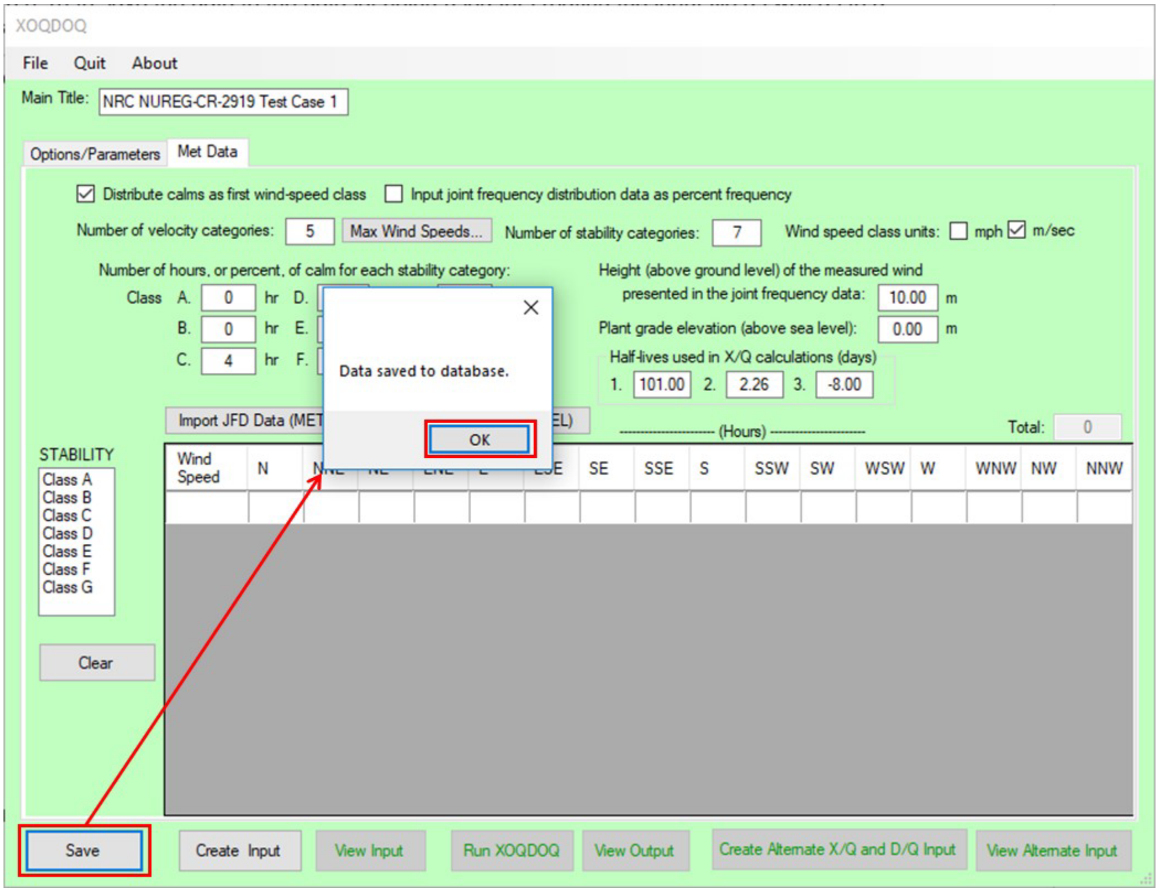


Figure 5-16 Saving XOQDOQ Inputs

If the data are to be saved to a different *.XN3 database file, then open the File drop-down menu and select “Save to XN3 File…” as shown in Figure 5-3. This will open a Windows Explorer directory, as shown in Figure 5-17. Name the *.XN3 file and choose the directory location as desired. Future saves within NRCDose3 will save to this new file name, as well as to the database used for code execution.

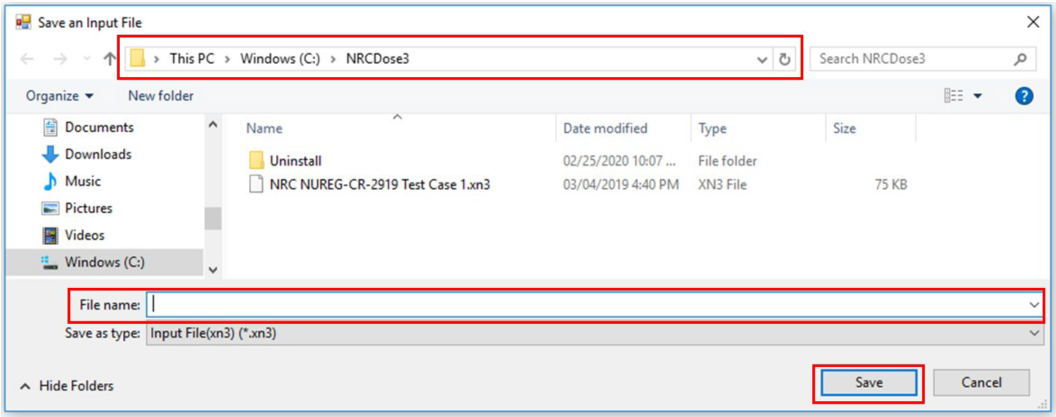


Figure 5-17 Windows Explorer Directory for Saving XOQDOQ Inputs to a New File

**** User Note ****—If XOQDOQ is being run from an open or saved file, then selecting "Save" will save both to the data set being used to create the input and to the file name. Otherwise, "Save" will save only to the data set being used to create the input, as no file name has been identified.

Selecting the "Create Input" button will open the Check screen shown in Figure 5-18; select the "Yes" button to continue. Selecting the "Create Input" button will also have activated the "View Input" and "Run XOQDOQ" buttons on the XOQDOQ module main screen, as shown in Figure 5-19. Select the "View Input" button to display the Text Viewer screen and review the text file of input data, as shown in Figure 5-20. Select the "Save As…" button to open a Windows Explorer directory and save the input as an input field file (*.DT3). Select the "Print" button to print the input text file, and the "Close" button to close the Text Viewer screen and return to the XOQDOQ module main screen.

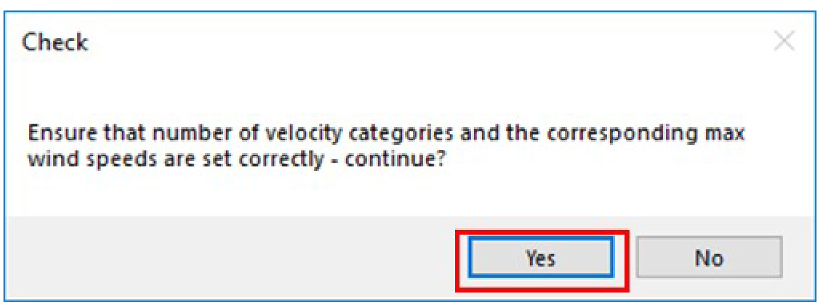


Figure 5-18 XOQDOQ Check Screen

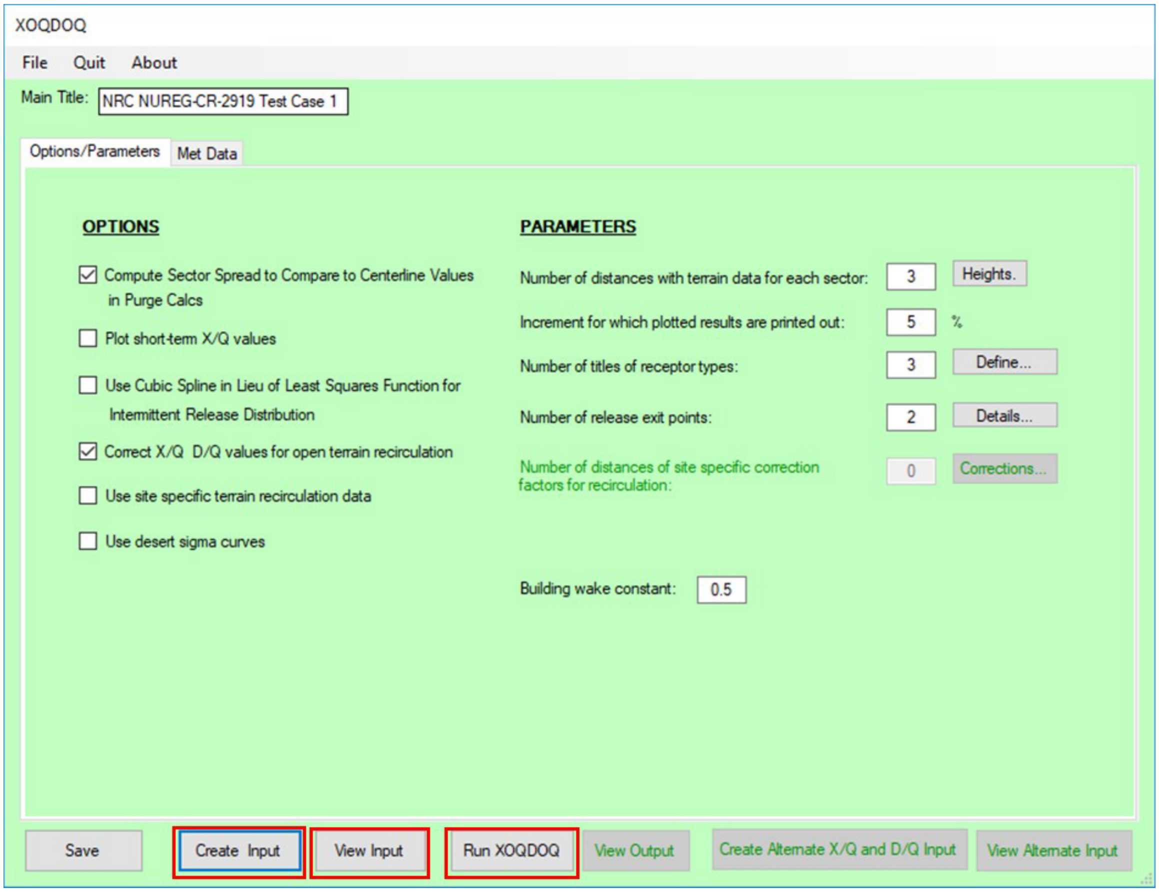


Figure 5-19 XOQDOQ Module Main Screen—"Create Input" Button

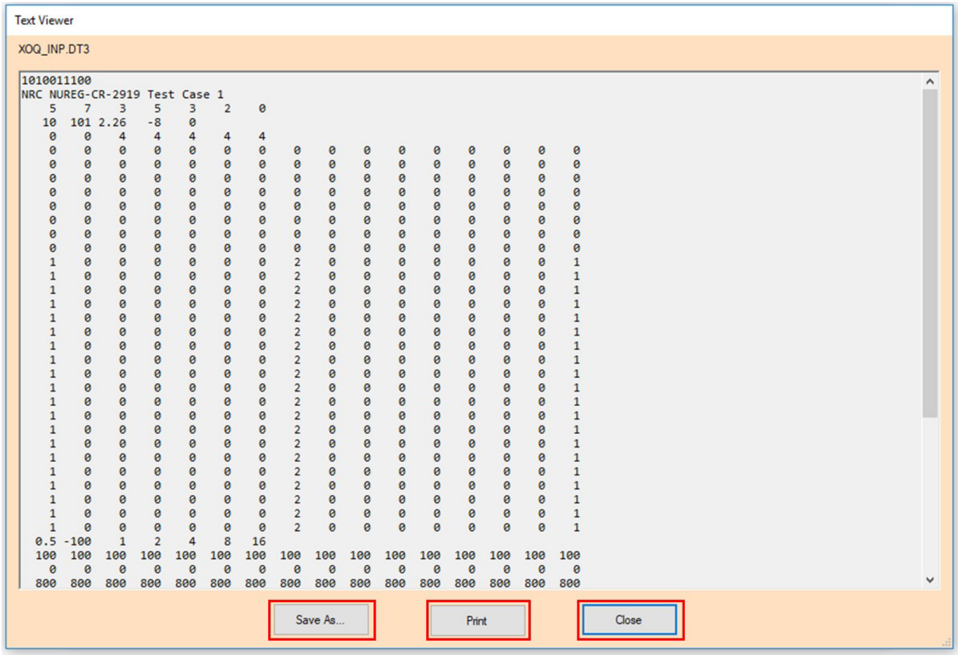


Figure 5-20 Viewing XOQDOQ Input—Text Viewer Screen

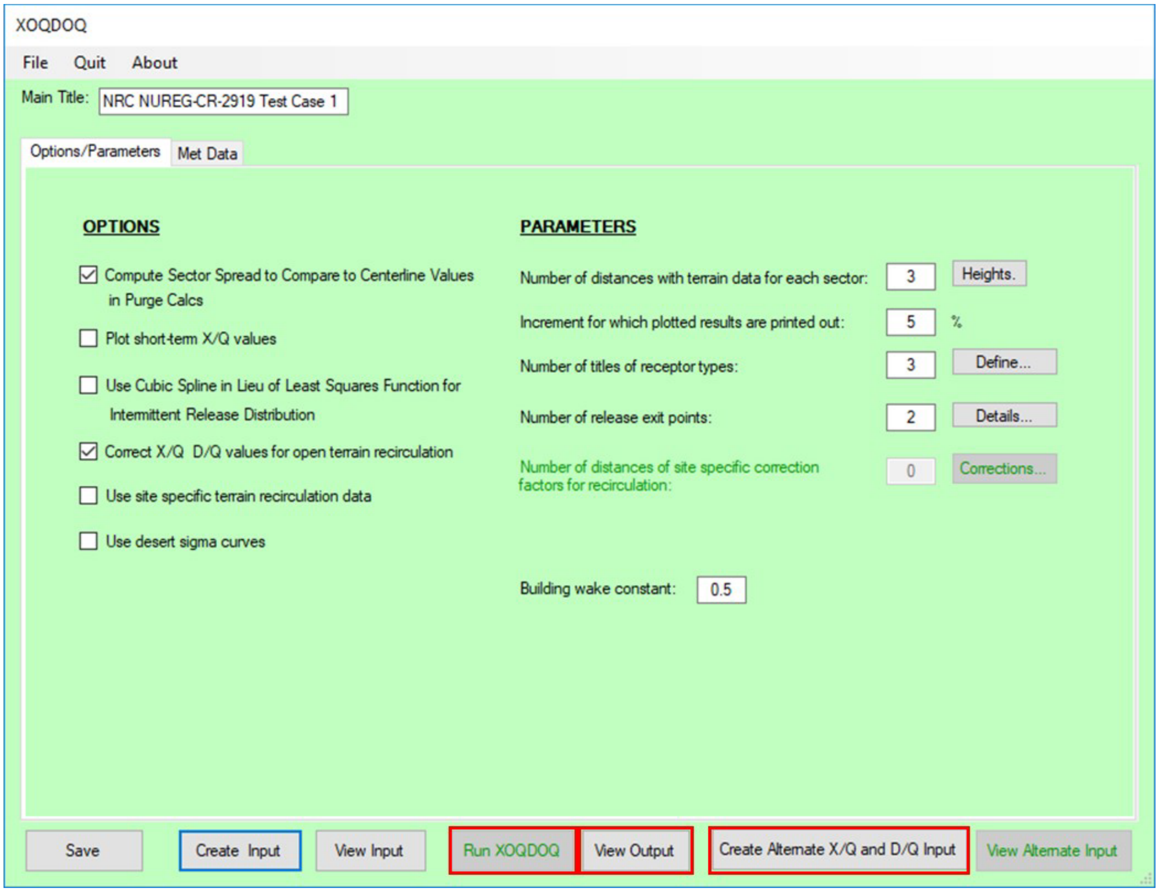


Figure 5-21 XOQDOQ Module Main Screen—"Run XOQDOQ" Button

Select the "Run XOQDOQ" button to execute the code and generate the output report. This will also activate the "View Output" and "Create Alternate X/Q and D/Q Input" buttons on the XOQDOQ module main screen, as shown in Figure 5-21. After NRCDose3 completes the XOQDOQ calculation, the output will appear as a text output file, as shown in Figure 5-22. Select the "Save As…" button shown in Figure 5-22 to open a Windows Explorer directory and save the output as a text file (*.txt). Select the "Print" button to print the output text file, and the "Close" button to close the Text Viewer screen and return to the XOQDOQ module main screen. The user can also access the output text file by selecting the "View Output" button.

**** User Note ****—Though it is not required, users should consider saving XOQDOQ files in a user-specified directory other than the NRCDose3 directory, so that future users can access and share the files without having to navigate to the NRCDose3 directory.

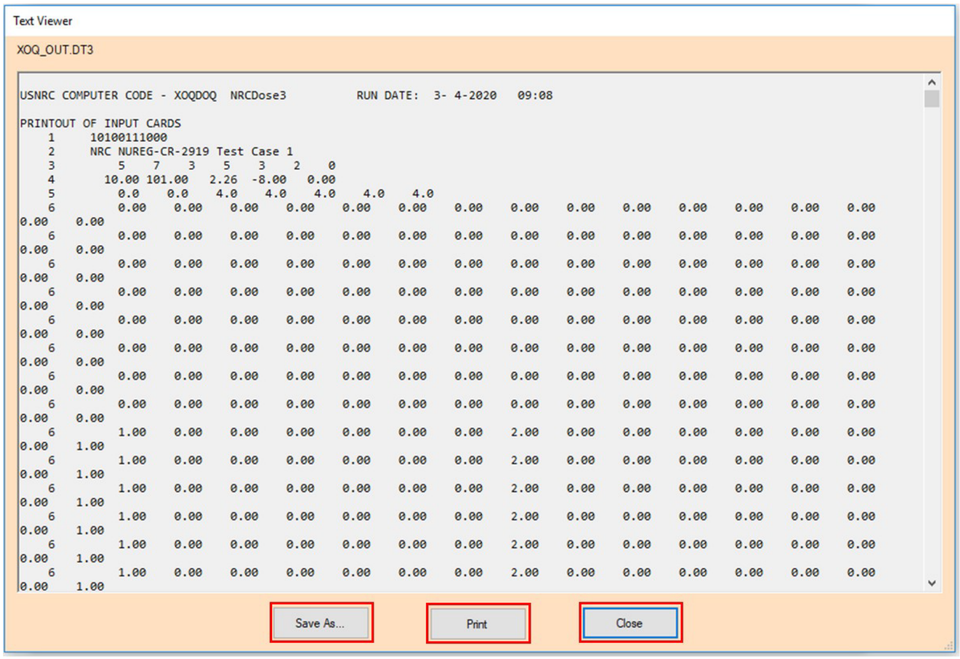


Figure 5-22 Viewing XOQDOQ Output—Text Viewer Screen

Select the “Create Alternate X/Q and D/Q Input” button to create an input file containing the alternate meteorological data (i.e., dispersion and deposition results) for use in GASPAR II. Note that if the value in the “Number of release exit points” field is greater than 1, the popup message “Cannot create alternative met data file with more than one release point!” will appear (see Figure 5-23). If the number of release exit points is 1, then selecting the “Create Alternate X/Q and D/Q Input” button will open the Alt Met Input screen shown in Figure 5-24. Here, select (highlight) up to five individual records from the specific points of interest, then select the “OK” button to view the GASPAR II input file, as shown in Figure 5-24.

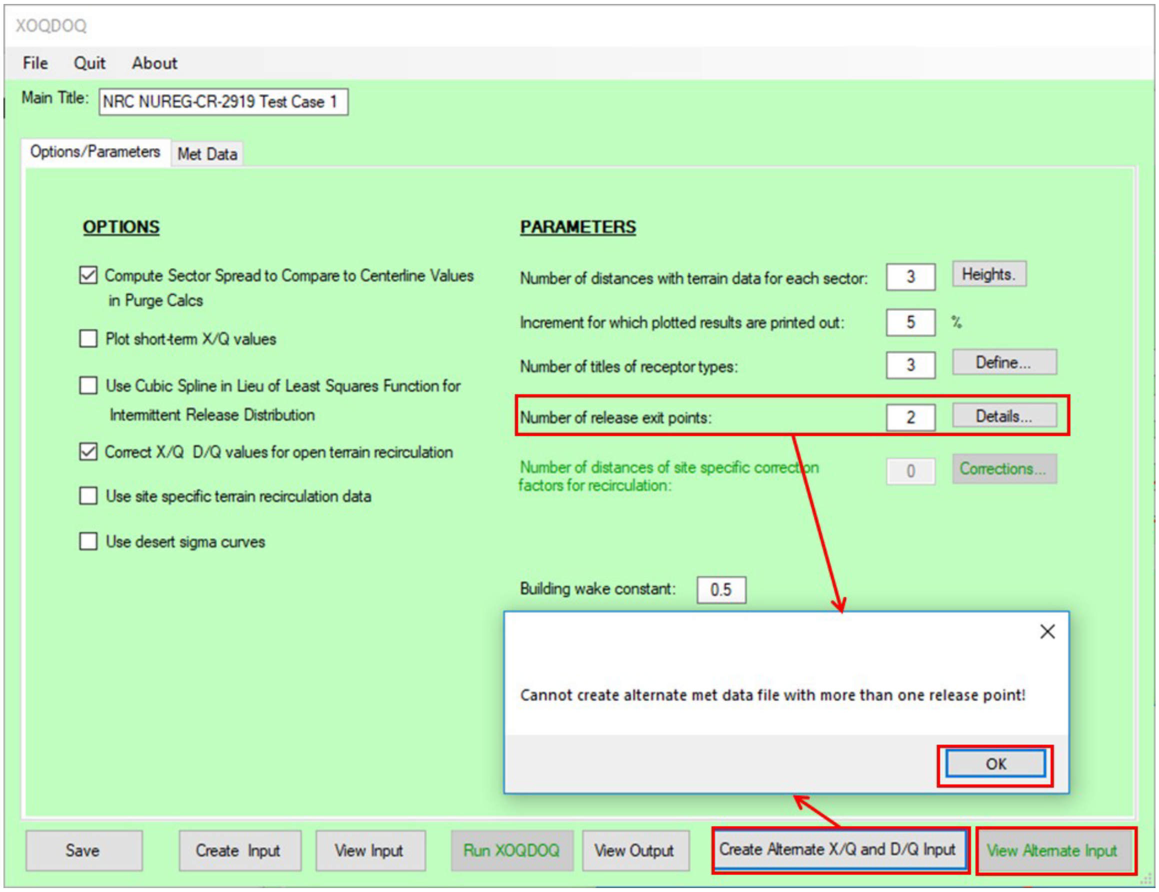


Figure 5-23 XOQDOQ Module Main Screen—"Create Alternate X/Q and D/Q Input" Button

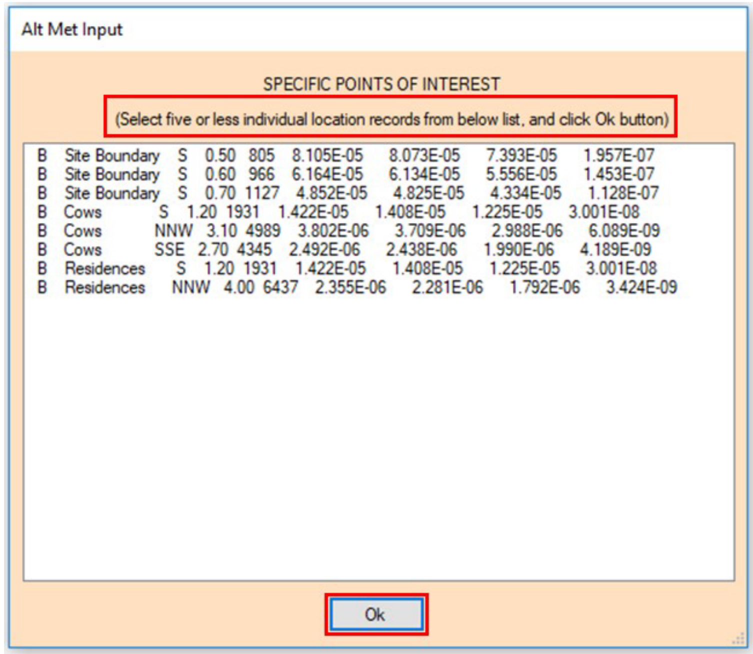


Figure 5-24 Alt Met Input Screen

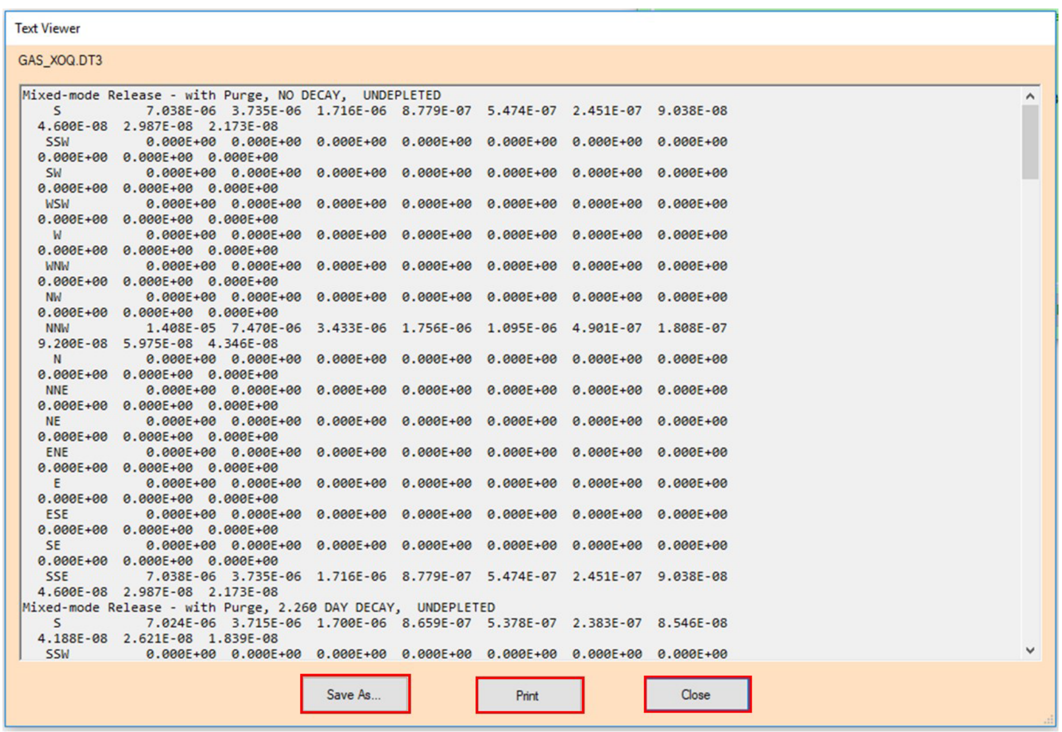


Figure 5-25 Viewing Alternate Meteorological Input—Text Viewer Screen

Select the “Save As…” button shown in Figure 5-25 to open a Windows Explorer directory and save the output in a text file format suitable for use by XOQDOQ as an alternate meteorological data input file (*.DT3). Select the “Print” button to print the output text file, and the “Close” button to close the Text Viewer screen and return to the XOQDOQ module main screen. The user can also access the output text file by selecting the “View Alternate Input” button.

6.0 SIGNIFICANT REVISIONS IN NRCDose3

The previously released NRC versions of the LADTAP II and GASPAR II Fortran codes, along with the CNS versions of NRCDose, all used the same DCF library. This library included DCF values for 170 radionuclides, four age groups, and seven organs. These DCF values were all based on the ICRP-2 methodology but came from various sources. They were primarily taken from RG 1.109, with many updated based on NUREG-0172, “Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake,” issued November 1977 [Ref. 27]. Some of the DCF values for strontium-90, holmium-166m, lead-210, thorium-229, and thorium-232 were updated based on the errata in the Battelle memorandum, “Changes and Corrections for NUREG-0172,” issued August 1983 [Ref. 28]. Other DCF values, notably some transuranic organ (i.e., bone and liver) DCF values, were taken from EMP-155, “Review and Expansion of USNRC Regulatory Guide 1.109 Models for Computing Dose Conversion Factors,” issued February 1983 [Ref. 29].

NRCDose3 retains the DCF libraries used in LADTAP II, GASPAR II, and NRCDose (version 2.3.20) in their original forms, as previously released. It can also calculate external skin exposure from water submersion, for which the DCF libraries in the original LADTAP II code did not contain the necessary values. In addition, NRCDose3 allows the user to select updated DCF values for dose calculations, notably those based on the ICRP-30 and ICRP-72 methodologies. NRCDose3 includes DCF values for a total of 203 radionuclides, encompassing all radionuclides appearing in the original LADTAP II and GASPAR II DCF library references from RG 1.109, NUREG-0172 (and errata), and EMP-155.

6.1 ICRP-30 DCF Values

The software package Radiological Toolbox (RadToolbox), version 3.0 (https://ramp.nrc-gateway.gov/), was used to obtain the ICRP-30 DCF values for NRCDose3. These values are used for occupational exposures and apply only to adults, so NRCDose3 calculates only adult doses if the ICRP-30 methodology is selected.

For some ingestion radionuclides and nearly all inhalation radionuclides, multiple sets of DCF values are available. For ingestion, the DCF values depend on the assumed f_1 value. For inhalation, there are different DCF values corresponding to the day (D), month (M), and year (Y) clearance classes in ICRP-30. NRCDose3 allows the user either to select the form and the corresponding DCF to be used for each radionuclide, or simply to use the default form. To determine the default chemical forms, the radionuclides are generally assumed to be in oxide form, because contamination in reactor coolant systems (the source of most nuclear power plant effluent releases) is commonly found in oxide form. Nuclear fuel is also in oxide form, and corrosion products activated in the core are incorporated in extra-core oxides. Therefore, all radionuclides are assumed to be oxides. Table 3, “Gastrointestinal Absorption Fractions (f_1) and Lung Clearance Classes for Chemical Compounds,” in EPA Federal Guidance Report No. 11 “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion” (FGR 11), issued September 1988 [Ref. 30], was consulted to determine the ingestion and lung clearance class for the oxide form of each element, as either days (D), weeks (W), or years (Y). That form has been identified as the default class in ICRP-30.

Changes were also made to the external DCF values used when ICRP-30 is selected in NRCDose3. For air submersion, the total body and skin DCF values are taken from FGR 12. FGR 12 does not include DCF values for krypton-89 and xenon-137, so these were obtained from the U.S. Department of Energy (DOE) report DOE/EH-0070, “External Dose-Rate Conversion Factors for Calculation of Dose to the Public,” issued July 1988 [Ref. 31]. The gamma air and beta air DCF values have not been changed from the values based on RG 1.109 that were used in the original release of LADTAP II and GASPAR II.

FGR 12 was used for the DCF values for external exposure from ground contamination or water submersion, for both skin dose and effective dose, based on the ICRP-26 methodology. For these DCF values, contributions from progeny radionuclides were included, as shown in Table 6-1.

Table 6-1 Radionuclides with Included Progeny for External DCF Values Based on ICRP-26

Radionuclide	Progeny Contribution Included	Radionuclide	Progeny Contribution included	Radionuclide	Progeny Contribution Included
Br-83	Kr-83m	Ru-106	Rh-106	I-131	Xe-131m
Zr-95	Nb-95m	Ag-110m	Ag-110	I-133	Xe-133m
Zr-97	Nb-97m	Sb-126m	Sb-126	I-135	Xe-135m
Ru-103	Rh-103m	Te-133m	Te-133	Cs-137	Ba-137m
				Ce-144	Pr-144m

6.2 ICRP-72 DCF Values

The software package RadToolbox version 3.0 (https://ramp.nrc-gateway.gov/) was used to obtain the ICRP-72 DCF values for NRCDose3. The ICRP-72 DCF values cover six age groups (Newborn, 1 yr, 5 yr, 10 yr, 15 yr, and Adult). NRCDose3 calculates values for all six age groups when the ICRP-72 methodology is selected.

As with ICRP-30, multiple sets of ICRP-72 DCF values are available for some ingestion radionuclides and nearly all inhalation radionuclides. For ingestion, the DCF values depend on the assumed f_1 value. For inhalation, there are DCF values corresponding to fast (F), medium (M), and slow (S) inhalation classes, plus a vapor form (V) in some instances. NRCDose3 allows the user either to select the form of each radionuclide to be used, or simply to use the default form. Section 6.1 describes how the default form of each radionuclide was determined. The D/W/Y lung clearance classes were directly correlated to the ICRP-72 F/M/S inhalation classes. For hydrogen-3 (tritium) and carbon-14, the vapor forms of tritium oxide (HTO) and carbon dioxide (CO_2), respectively, were selected.

Changes were also made to the external DCF values used when ICRP-72 is selected in NRCDose3. For air submersion, the total body and skin DCF values for the applicable noble gases are taken from FGR 12. FGR 12 does not include DCF values for krypton-89 and xenon-137, so the skin factors were obtained from DOE/EH-0070. The gamma total body DCF values for krypton-89 and xenon-137 used under ICRP-72 in NRCDose3 were obtained from

DOE-STD-1196-2011, “Derived Concentration Technical Standard,” issued April 2011 [Ref. 32]. The gamma air and beta air DCF values have not been changed from the values based on RG 1.109 that were used in the original release of LADTAP II and GASPAR II.

FGR 12 was used for the DCF values for external exposure from ground contamination or water submersion, for both skin dose and effective dose, based on the methodology in ICRP-60, “1990 Recommendations of the International Commission on Radiological Protection,” issued 1991 [Ref. 33]. For these DCF values, contributions from progeny radionuclides were included, as shown in Table 6-2.

Table 6-2 Radionuclides with Included Progeny for External DCF Values Based on ICRP-60

Radionuclide	Progeny Contribution Included	Radionuclide	Progeny Contribution Included	Radionuclide	Progeny Contribution Included
Br-83	Kr-83m	Ru-106	Rh-106	I-131	Xe-131m
Zr-95	Nb-95m	Ag-110m	Ag-110	I-133	Xe-133m
Zr-97	Nb-97m	Sb-126m	Sb-126	I-135	Xe-135m
Ru-103	Rh-103m	Te-133m	Te-133	Cs-137	Ba-137m
				Ce-144	Pr-144m

6.3 Biota Dose in GASPAR

In NRCDose3, biota dose calculations have been added to GASPAR. They are performed for every special location defined in GASPAR, and for all species considered in previous versions of LADTAP II and NRCDose (version 2.3.20 and earlier), with the exception of algae, and with the addition of cow and fox as surrogate land-based herbivore and carnivore, respectively.

Pathways of exposure assumed include plume (submersion noble gases), ground plane, inhalation, and ingestion (plants for herbivores, and meat assumed equivalent to cow meat concentrations for carnivores). Since GASPAR considers exposures only from gaseous effluents, the assumptions made for plant and (cow) meat concentrations are based on the RG 1.109 modeling for accumulation in feed (assumed representative of plant-based foods), as reflected in equations (C-5) and (C-8) for carbon-14, equation (C-9) for hydrogen-3, and equation (C-12) for the resulting concentration in (cow) meat. Equations (6-1), (6-2), and (6-3) below show how the plant and meat concentrations are integrated into the dose calculations. Table 6-3 lists the parameters used to calculate the biota dose.

Table 6-3 Biota Dose Parameters for GASPAR II in NRCDose3

Species	Mass (g)	Effective Radius (cm)	Primary Food Eaten	Consumption Rate (g/d)
Muskrat (from LADTAP II)	1,000	6	Plants	100
Raccoon (from LADTAP II)	12,000	14	Plants	200
Duck (from LADTAP II)	1,000	5	Plants	100
Cow (herbivore)			Plants	
Fox (carnivore)[a]	5,700	10	Meat	520
User-defined				

Note:
a. Fox modeling assumptions *are* derived from http://www.britannica.com/animal/red-fox-mammal and http://www.hse.gov.uk/pesticides/resources/R/Research_PN0908.pdf.

** **User Note** **—The code can address only a single food type, either plant or meat. While the raccoon is recognized to be an omnivore, by default it is modeled as a herbivore; this is consistent with the assumptions in LADTAP and BNWL-1754. The raccoon may also be modeled as a carnivore by using the “Add Biota Type” function with appropriate inputs for consumption.

The total dose to any organism is the sum of the external and internal dose components. The external dose component is the same as the adult human ground-plane dose multiplied by a factor of 2 to account for proximity to the ground and divided by 0.7 to remove the shield factor assumed for human exposure. Thus, the external component of the biota dose is 2.86 times that calculated for adult humans.

The internal dose is the adult human inhalation dose plus an ingestion dose component that depends on the food type. The GASPAR II and LADTAP II codes in NRCDose3 employ the same modeling as in BNWL-1754. Similarly to LADTAP, which uses environmental transfer factors (bioaccumulation factors) for fish, invertebrates, and algae, GASPAR uses transfer factors for vegetation and meat. The GASPAR modeling is based on defining each species as either herbivore or carnivore. For a carnivore, because there are only meat transfer factors, the meat concentration ingested is assumed to be the same as it would be for cow meat.

** **User Note** **—Species-specific modeling can be performed by modifying the exposure and uptake assumptions and transfer factors unique to the species (e.g., defining transfer factors for chickens).

The ingestion dose to the muskrat, raccoon, or duck is determined using equation (6-1):

$$Dose\ \left(\frac{rad}{yr}\right) = Veg.Conc.\times \frac{Consumption\ Rate_{Species}}{Mass_{Species}} \times 70 \times \frac{EFF_{Species}}{EFF_{Adult}} \times DCF_i \qquad (6\text{-}1)$$

where Veg. Conc. = the vegetable (produce) concentration for radionuclide *i* as calculated by GASPAR II for each location (pCi/kg),

$Consumption\ Rate_{Species}$ = the mass of food consumed by the species (kg/yr),

$Mass_{Species}$ = the mass of a member of the species (kg),

70 = a constant for the assumed mass of an adult, as used to derive the ICRP-2 DCFs (kg),

$EFF_{Species}$ = the energy for the effective radius identified for the species (MeV),

EFF_{Adult} = the energy for the effective radius for an adult human (MeV), and

DCF_i = the total body ingestion DCF for an adult human for radionuclide *i* (mrem/pCi).

GASPAR calculates radionuclide concentrations in cow meat, so the effective radius dose coefficients are used to calculate the internal dose component through the cow meat ingestion pathway using equation (6-2):

$$Dose\ \left(\frac{rad}{yr}\right) = 0.0187 \times Meat\ Conc.\times EFF_i \qquad (6\text{-}2)$$

where 0.0187 = the conversion factor (dis-kg-mrad per pCi-yr-MeV),

Meat Conc. = the cow meat concentration for radionuclide *i* as calculated by GASPAR II for each location (pCi/kg),

$Mass_{Species}$ = the mass of a member of the species (kg), and

EFF_i = the energy per decay for the effective radius identified for the species (MeV/dis).

The ingestion dose to the fox is determined using equation (6-3):

$$Dose\left(\frac{rad}{yr}\right) = Meat\ Conc. \times \frac{Consumption\ Rate_{Fox}}{Mass_{Fox}} \times 70 \times \frac{EFF_{Fox}}{EFF_{Adult}} \times DCF_i \qquad (6\text{-}3)$$

where

Meat Conc.	=	the meat concentration for radionuclide *i* as calculated by GASPAR for each location (pCi/kg),
Consumption $Rate_{Fox}$	=	the mass of food consumed by the fox (kg/yr),
$Mass_{Fox}$	=	the mass of the fox (kg),
70	=	a constant for the assumed mass of an adult human (kg),
EFF_{Fox}	=	the energy for the effective radius identified for the fox (MeV),
EFF_{Adult}	=	the energy for the effective radius for an adult human (MeV), and
DCF_i	=	the total body ingestion DCF for an adult human for radionuclide *i* (mrem/pCi).

GASPAR calculates the vegetable and meat concentrations using the PARTS subroutine, with specific modeling for carbon-14 and hydrogen-3 (tritium) performed in the CARBON and TRITIUM subroutines, respectively.

For all biota, the inhalation dose is approximated as equal to the adult inhalation (total body) dose at the specific location. The ground-plane dose to biota is approximated as equal to the adult ground-plane dose, multiplied by a factor of 2 to conservatively account for the possibility that non-human organisms are closer to the ground, and divided by 0.7 to remove the shield factor assumed for human exposure.

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20. *U.S. Code of Federal Regulations*, "Standards for Protection Against Radiation," Part 20, Chapter I, Title 10, "Energy."

21. *U.S. Code of Federal Regulations,* "Environmental Radiation Protection Standards for Nuclear Power Operations," Part 190, Title 40, "Protection of Environment."

22. **BNWL-1754**, "Models and Computer Codes for Evaluating Environmental Radiation Doses," Pacific Northwest Laboratories, Richland, Washington, February 1974.

23. **ICRP Publication 26**, "Recommendations of the International Commission on Radiological Protection," *Annals of the ICRP*, Vol. 1, No. 3, ICRP, Pergamon Press, London, 1977.

24. **Federal Guidance Report No. 12**, EPA-402-R-93-081, "External Exposure to Radionuclides in Air, Water, and Soil," U.S. Environmental Protection Agency, Washington, DC, September 1993.

25. **RG 1.23**, **Revision 1**, "Meteorological Monitoring Programs for Nuclear Power Plants," NRC, Washington, DC, March 2007. ML070350028.

26. **NUREG-0917**, "Nuclear Regulatory Commission Staff Computer Programs for Use with Meteorological Data," NRC, Washington, DC, July 1982. ML12061A136.

27. **NUREG-0172**, "Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake," NRC, Washington, DC, November 1977. ML14083A242.

28. **NUREG-0172 errata** (Battelle memorandum), "Changes and Corrections for NUREG-0172," Pacific Northwest Laboratories, Richland, Washington, August 1983. ML16277A102.

29. **EMP-155**, "Review and Expansion of USNRC Regulatory Guide 1.109 Models for Computing Dose Conversion Factors," F.W. Boone and J.M. Palms, February 1983.

30. **Federal Guidance Report No. 11**, EPA-520/1-88-020, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," U.S. Environmental Protection Agency, Washington, DC, September 1988.

31. **DOE/EH-0070**, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public," U.S. Department of Energy (DOE), Washington, DC, July 1988.

32. **DOE-STD-1196-2011**, "Derived Concentration Technical Standard," DOE, Washington, DC, April 2011.

33. **ICRP Publication 60**, "1990 Recommendations of the International Commission on Radiological Protection," *Annals of the ICRP*, Vol. 21, Nos. 1–3, ICRP, Pergamon Press, London, 1991.

APPENDIX A
RADIONUCLIDES IN REACTOR EFFLUENTS IN NRCDose3

The range of radionuclides covered by NRCDose3 has been expanded from those available in the original versions of the LADTAP II, GASPAR II, and XOQDOQ Fortran codes. The radionuclides and dose conversion factor (DCF) values in the original versions of the codes are largely (but not all) based on Regulatory Guide (RG) 1.109, Revision 1, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I,” issued October 1977 [Ref. 1]. To determine the sources of the DCF values in the original versions of the codes, the U.S. Nuclear Regulatory Commission (NRC) staff compared the values in the LADTAP.LIB file with those in the following sources, which are based on International Commission on Radiological Protection (ICRP) Publication 2, “Report of Committee II on Permissible Dose for Internal Radiation” (ICRP-2), issued 1960 [Ref. 2]:

- RG 1.109, Revision 1
- NUREG-0172, “Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake,” issued November 1977 [Ref. 3]
- NUREG-0172 errata (Battelle memorandum), “Changes and Corrections for NUREG-0172,” issued August 1983 [Ref. 4]
- NUREG/CR-2384, “Age-Specific Inhalation Radiation Dose Commitment Factors for Selected Radionuclides,” issued August 1982 [Ref. 5]
- EMP-155, “Review and Expansion of USNRC Regulatory Guide 1.109 Models for Computing Dose Conversion Factors,” February 1983 [Ref. 6]

Table A-1 lists the radionuclides for which DCF values are included in the identified source documents. Highlighted entries indicate radionuclides that are not in the original LADTAP.LIB file as used in NRCDose (version 2.3.20).

Table A-1 NRCDose3 Radionuclides, DCF Values, and Reference Documents

No.	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
1	H-3	H-3	H-3		H-3
2	Be-10		Be-10		Be-10
3	C-14	C-14	C-14		C-14
4	N-13		N-13		
5	F-18		F-18		
6	Na-22		Na-22		
7	Na-24	Na-24	Na-24		
8	P-32	P-32	P-32		
9				S-35	
10				Cl-36	
11			Ar-39		
12			Ar-41		
13	Ca-41		Ca-41		
14				Ca-45	
15	Sc-46		Sc-46		
16	Cr-51	Cr-51	Cr-51		Cr-51
17	Mn-54	Mn-54	Mn-54		Mn-54
18	Mn-56	Mn-56	Mn-56		
19	Fe-55	Fe-55	Fe-55		
20	Fe-59	Fe-59	Fe-59		Fe-59
21	Co-57		Co-57		
22	Co-58	Co-58	Co-58		Co-58
23	Co-60	Co-60	Co-60		Co-60
24	Ni-59		Ni-59		
25	Ni-63	Ni-63	Ni-63		

Notes:

a. NUREG-0172 contains only inhalation lung DCF values for Kr and Xe isotopes. No ingestion or other organ DCF values are included.

Radionuclides highlighted above are not contained in the original versions of LADTAP II, GASPAR II, and NRCDose, but have been added to the database files for NRCDose3 and are available when ICRP-2 DCF values are selected.

Table A-1 NRCDose3 Radionuclides, DCF Values, and Reference Documents (cont.)

No.	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
26	Ni-65	Ni-65	Ni-65		
27	Cu-64	Cu-64	Cu-64		
28				Ga-67	Ga-67
29	Zn-65	Zn-65	Zn-65		
30	Zn-69m		Zn-69m		Zn-69m
31	Zn-69	Zn-69	Zn-69		
32				Se-75	
33	Se-79		Se-79		
34	Br-82		Br-82		
35	Br-83	Br-83	Br-83		
36	Br-84	Br-84	Br-84		
37	Br-85	Br-85	Br-85		
38			Kr-83m[a]		
39			Kr-85m[a]		
40			Kr-85[a]		
41			Kr-87[a]		
42			Kr-88[a]		
43			Kr-89[a]		
44	Rb-86	Rb-86	Rb-86		
45	Rb-87		Rb-87		
46	Rb-88	Rb-88	Rb-88		
47	Rb-89	Rb-89	Rb-89		
48				Sr-85	
49	Sr-89	Sr-89	Sr-89		Sr-89
50	Sr-90	Sr-90	Sr-90		Sr-90

Notes:

a. NUREG-0172 contains only inhalation lung DCF values for Kr and Xe isotopes. No ingestion or other organ DCF values are included.

Radionuclides highlighted above are not contained in the original versions of LADTAP II, GASPAR II, and NRCDose, but have been added to the database files for NRCDose3 and are available when ICRP-2 DCF values are selected.

Table A-1 NRCDose3 Radionuclides, DCF Values, and Reference Documents (cont.)

No.	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
51	Sr-91	Sr-91	Sr-91		
52	Sr-92	Sr-92	Sr-92		
53	Y-90	Y-90	Y-90		Y-90
54	Y-91m	Y-91m	Y-91m		
55	Y-91	Y-91	Y-91		Y-91
56	Y-92	Y-92	Y-92		
57	Y-93	Y-93	Y-93		
58	Zr-93		Zr-93		Zr-93
59	Zr-95	Zr-95	Zr-95		Zr-95
60	Zr-97	Zr-97	Zr-97		
61	Nb-93m		Nb-93m		
62	Nb-95	Nb-95	Nb-95		Nb-95
63	Nb-97		Nb-97		
64	Mo-93		Mo-93		
65	Mo-99	Mo-99	Mo-99		
66	Tc-99m	Tc-99m	Tc-99m		
67	Tc-99		Tc-99		Tc-99
68	Tc-101	Tc-101	Tc-101		
69	Ru-103	Ru-103	Ru-103		Ru-103
70	Ru-105	Ru-105	Ru-105		
71	Ru-106	Ru-106	Ru-106		Ru-106
72	Rh-105		Rh-105		
73	Pd-107		Pd-107		
74	Pd-109		Pd-109		
75				Cd-109	

Notes:

a. NUREG-0172 contains only inhalation lung DCF values for Kr and Xe isotopes. No ingestion or other organ DCF values are included.

Radionuclides highlighted above are not contained in the original versions of LADTAP II, GASPAR II, and NRCDose, but have been added to the database files for NRCDose3 and are available when ICRP-2 DCF values are selected.

Table A-1 NRCDose3 Radionuclides, DCF Values, and Reference Documents (cont.)

No.	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
76	Ag-110m	Ag-110m	Ag-110m		Ag-110m
77	Ag-111		Ag-111		
78	Cd-113m		Cd-113m		
79	Cd-115m		Cd-115m		Cd-115m
80				Sn-113	
81	Sn-123		Sn-123		Sn-123
82	Sn-125		Sn-125		
83	Sn-126		Sn-126		
84	Sb-124		Sb-124		Sb-124
85	Sb-125		Sb-125		Sb-125
86	Sb-126		Sb-126		
87	Sb-127		Sb-127		
88	Te-125m	Te-125m	Te-125m		Te-125m
89	Te-127m	Te-127m	Te-127m		
90	Te-127	Te-127	Te-127		
91	Te-129m	Te-129m	Te-129m		
92	Te-129	Te-129	Te-129		
93	Te-131m	Te-131m	Te-131m		
94	Te-131	Te-131	Te-131		
95	Te-132	Te-132	Te-132		
96	Te-133m		Te-133m		
97	Te-134		Te-134		
98				I-125	
99	I-129		I-129		I-129
100	I-130	I-130	I-130		

Notes:

a. NUREG-0172 contains only inhalation lung DCF values for Kr and Xe isotopes. No ingestion or other organ DCF values are included.

Radionuclides highlighted above are not contained in the original versions of LADTAP II, GASPAR II, and NRCDose, but have been added to the database files for NRCDose3 and are available when ICRP-2 DCF values are selected.

Table A-1 NRCDose3 Radionuclides, DCF Values, and Reference Documents (cont.)

No.	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
101	I-131	I-131	I-131		I-131
102	I-132	I-132	I-132		
103	I-133	I-133	I-133		
104	I-134	I-134	I-134		
105	I-135	I-135	I-135		
106			Xe-131m[a]		
107			Xe-133m[a]		
108			Xe-133[a]		
109			Xe-135m[a]		
110			Xe-135[a]		
111			Xe-137[a]		
112			Xe-138[a]		
113	Cs-134m		Cs-134m		
114	Cs-134	Cs-134	Cs-134		Cs-134
115	Cs-135		Cs-135		
116	Cs-136	Cs-136	Cs-136		
117	Cs-137	Cs-137	Cs-137		Cs-137
118	Cs-138	Cs-138	Cs-138		
119	Cs-139		Cs-139		
120				Ba-133	
121	Ba-139	Ba-139	Ba-139		
122	Ba-140	Ba-140	Ba-140		Ba-140
123	Ba-141	Ba-141	Ba-141		
124	Ba-142	Ba-142	Ba-142		
125	La-140	La-140	La-140		La-140

Notes:

a. NUREG-0172 contains only inhalation lung DCF values for Kr and Xe isotopes. No ingestion or other organ DCF values are included.

Radionuclides highlighted above are not contained in the original versions of LADTAP II, GASPAR II, and NRCDose, but have been added to the database files for NRCDose3 and are available when ICRP-2 DCF values are selected.

Table A-1 NRCDose3 Radionuclides, DCF Values, and Reference Documents (cont.)

No.	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
126	La-141		La-141		
127	La-142	La-142	La-142		
128	Ce-141	Ce-141	Ce-141		Ce-141
129	Ce-143	Ce-143	Ce-143		
130	Ce-144	Ce-144	Ce-144		Ce-144
131	Pr-143	Pr-143	Pr-143		
132	Pr-144	Pr-144	Pr-144		
133	Nd-147	Nd-147	Nd-147		
134	Pm-147		Pm-147		Pm-147
135	Pm-148m		Pm-148m		
136	Pm-148		Pm-148		
137	Pm-149		Pm-149		
138	Pm-151		Pm-151		
139	Sm-151		Sm-151		Sm-151
140	Sm-153		Sm-153		
141	Eu-152		Eu-152		
142	Eu-154		Eu-154		Eu-154
143	Eu-155		Eu-155		Eu-155
144	Eu-156		Eu-156		
145	Tb-160		Tb-160		
146	Ho-166m		Ho-166m		Ho-166m
147				Tm-170	
148				Yb-169	
149	W-181		W-181		
150	W-185		W-185		

Notes:

a. NUREG-0172 contains only inhalation lung DCF values for Kr and Xe isotopes. No ingestion or other organ DCF values are included.

Radionuclides highlighted above are not contained in the original versions of LADTAP II, GASPAR II, and NRCDose, but have been added to the database files for NRCDose3 and are available when ICRP-2 DCF values are selected.

Table A-1 NRCDose3 Radionuclides, DCF Values, and Reference Documents (cont.)

No.	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
151	W-187	W-187	W-187		
152				Ta-182	
153				Ir-192	
154				Au-198	
155				Tl-201	Tl-201
156				Tl-204	
157	Pb-210		Pb-210		Pb-210
158	Bi-210		Bi-210		Bi-210
159	Po-210		Po-210		
160			Rn-222		
161	Ra-223		Ra-223		
162	Ra-224		Ra-224		
163	Ra-225		Ra-225		
164	Ra-226		Ra-226		
165	Ra-228		Ra-228		
166	Ac-225		Ac-225		
167	Ac-227		Ac-227		
168	Th-227		Th-227		
169	Th-228		Th-228		
170	Th-229		Th-229		Th-229
171	Th-230		Th-230		
172	Th-232		Th-232		Th-232
173	Th-234		Th-234		
174	Pa-231		Pa-231		
175	Pa-233		Pa-233		

Notes:

a. NUREG-0172 contains only inhalation lung DCF values for Kr and Xe isotopes. No ingestion or other organ DCF values are included.

Radionuclides highlighted above are not contained in the original versions of LADTAP II, GASPAR II, and NRCDose, but have been added to the database files for NRCDose3 and are available when ICRP-2 DCF values are selected.

Table A-1 NRCDose3 Radionuclides, DCF Values, and Reference Documents (cont.)

No.	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
176	U-232		U-232		U-232
177	U-233		U-233		
178	U-234		U-234		U-234
179	U-235		U-235		U-235
180	U-236		U-236		U-236
181	U-237		U-237		
182	U-238		U-238		U-238
183	Np-237		Np-237		Np-237
184	Np-238		Np-238		
185	Np-239	Np-239	Np-239		Np-239
186				Pu-236	Pu-236
187	Pu-238		Pu-238		Pu-238
188	Pu-239		Pu-239		Pu-239
189	Pu-240		Pu-240		Pu-240
190	Pu-241		Pu-241		Pu-241
191	Pu-242		Pu-242		Pu-242
192	Pu-244		Pu-244		Pu-244
193	Am-241		Am-241		Am-241
194	Am-242m		Am-242m		Am-242m
195	Am-243		Am-243		Am-243
196	Cm-242		Cm-242		Cm-242
197	Cm-243		Cm-243		Cm-243
198	Cm-244		Cm-244		Cm-244
199	Cm-245		Cm-245		

Notes:

a. NUREG-0172 contains only inhalation lung DCF values for Kr and Xe isotopes. No ingestion or other organ DCF values are included.

Radionuclides highlighted above are not contained in the original versions of LADTAP II, GASPAR II, and NRCDose, but have been added to the database files for NRCDose3 and are available when ICRP-2 DCF values are selected.

Table A-1 NRCDose3 Radionuclides, DCF Values, and Reference Documents (cont.)

No.	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
200	Cm-246		Cm-246		
201	Cm-247		Cm-247		
202	Cm-248		Cm-248		
203	Cf-252		Cf-252		Cf-252

Notes:
a. NUREG-0172 contains only inhalation lung DCF values for Kr and Xe isotopes. No ingestion or other organ DCF values are included.

Radionuclides highlighted above are not contained in the original versions of LADTAP II, GASPAR II, and NRCDose, but have been added to the database files for NRCDose3 and are available when ICRP-2 DCF values are selected.

The radionuclides that are highlighted in the table above are not contained in the original versions of LADTAP II, GASPAR II, or NRCDose, but have been added to the database files for NRCDose3 and are available when ICRP-2 DCF values are selected.

The 203 radionuclides listed are the same as those available when the DCF values selected in NRCDose3 are from ICRP Publication 30, “Limits for Intakes of Radionuclides by Workers,” issued 1979 [Ref. 7], or ICRP Publication 72, “Age-Dependent Dose to Members of the Public from Intake of Radionuclides,” issued 1996 [Ref. 8].

A.1 References

1. **Regulatory Guide 1.109**, **Revision 1**, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I,” NRC, Washington, DC, October 1977. Agencywide Documents Access and Management System Accession No. ML003740384.

2. **ICRP Publication 2**, “Report of Committee II on Permissible Dose for Internal Radiation,” International Commission on Radiological Protection (ICRP), Pergamon Press, London, 1960.

3. **NUREG-0172**, “Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake,” NRC, Washington, DC, November 1977. ML14083A242.

4. **NUREG-0172 errata** (Battelle memorandum), “Changes and Corrections for NUREG-0172,” Pacific Northwest Laboratories, Richland, Washington, August 1983. ML16277A102.

5. **NUREG/CR-2384**, “Age-Specific Inhalation Radiation Dose Commitment Factors for Selected Radionuclides,” NRC, Washington, DC, August 1982. ML17200D138.

6. **EMP-155**, “Review and Expansion of USNRC Regulatory Guide 1.109 Models for Computing Dose Conversion Factors,” F.W. Boone and J.M. Palms, September 1983.

7. **ICRP Publication 30**, “Limits for Intakes of Radionuclides by Workers,” *Annals of the ICRP*, Vol. 2, Nos. 3/4, ICRP, Pergamon Press, London, 1979.

8. **ICRP Publication 72**, "Age-Dependent Dose to Members of the Public from Intake of Radionuclides, Part 5: Compilation of Ingestion and Inhalation Dose Coefficients," *Annals of the ICRP*, Vol. 26, No. 1, ICRP, Pergamon Press, London, 1996.

APPENDIX B
USER-MODIFIABLE PARAMETERS

The LADTAP II, GASPAR II, and XOQDOQ Fortran codes rely on many parameters and assumptions as inputs to perform their dose assessments. One of the design objectives of the updated NRCDose3 was to allow users increased flexibility to modify and adjust these parameters as needed. Therefore, all parameters used in XOQDOQ, LADTAP II, and GASPAR II have been identified, including all radiological and nonradiological parameters that are either user-modifiable or hardwired in the codes.

The LADTAP II, GASPAR II, and XOQDOQ Fortran input cards were reviewed for modifiable parameters, and it was confirmed that these input card parameters could be modified through the existing NRCDose code (version 2.3.20). Tables B-1 through B-3 identify the modifiable parameters in LADTAP II, GASPAR II, and XOQDOQ. Also, the LADTAP II, GASPAR II, and XOQDOQ Fortran codes were reviewed to identify the variables and parameters hardwired into the original codes. Tables B-4 through B-6 identify the hardwired parameters in the LADTAP II, GASPAR II, and XOQDOQ Fortran codes that can now be modified by the user in NRCDose3.

Table B-1 LADTAP II Modifiable Parameters

Parameter/Information	Description	LADTAP II Notation	Where Adjusted in NRCDose3
Plant Title	Text of plant title or run	N/A	Main Screen. “Scenario”
Water Type Selection	Determines saltwater vs. freshwater site	LT	Selections -> “Site Type”
Discharge	Liquid effluent discharge rate to impoundment system	CFS	Selections -> “Discharge Flow Rate”
Source Term Multiplier		UML	Selections -> “Source Term Multiplier”
	Control printing percent contribution by nuclide	LCT	Selections -> “Dose Contributions”
Blockdata	Changing and printing block data parameters	IFLAG	Not used in NRCDose3
Population	Total population within 50 miles	POP	Selections -> “50-mile Population”
	Control parameter for reading record	TR	
Population Fraction	Fraction of population adult	PERA	Selections -> Modify defaults -> Edit
Population Fraction	Fraction of population teen	PERT	Selections -> Modify defaults -> Edit

Table B-1 LADTAP II Modifiable Parameters (cont.)

Parameter/Information	Description	LADTAP II Notation	Where Adjusted in NRCDose3
Population Fraction	Fraction of population child	PERC	Selections -> Modify defaults -> Edit
Release Nuclide	Nuclide released; element symbol	IA	Source Term -> Add Nuclide; parameters combined into a drop-down selection menu for the nuclides
Release Nuclide	Nuclide released; mass including M for metastable	IM	
Release Rate	Annual release (Ci/yr)	QQ	Selections -> Source Term -> Add Nuclide
Reconcentration Factor	Radionuclide reconcentration factor; option for user input of value for each nuclide	R	Selections -> Source Term
Reconcentration Model		M	Selections -> Reconcentration. Model.
Discharge Rate	Effluent discharge rate	QSUBB	Selections -> Reconcentration.
Impoundment Volume	Total volume (ft^3)	VSUBT	Selections -> Reconcentration.
Shore-Width Factor		SWF	ALARA Locations -> ALARA – Max. Individual (or Additional Usage Locations) -> Shore-width factor
Dilution Factor (DF)	DF for aquatic food and boating	DILU, BDIL	ALARA Locations -> ALARA – Max. Individual -> Dilution Factor. Aquatic food and boating.
Dilution Factor	DF for shoreline and swimming	SHD	ALARA Locations -> ALARA – Max. Individual -> Dilution Factor. Shoreline and swimming
Dilution Factor	DF for drinking water	DWD	ALARA Locations -> ALARA – Max. Individual -> Dilution Factor. Drinking water.
Transit Time	Time from discharge to receiving water body to exposure location (hr)	T	ALARA Locations -> ALARA – Max. Individual (or Additional Usage Locations) -> Transit Time. Other pathways (All pathways).
Transit Time	Time from discharge to receiving water body to drinking water (hr)	TD	ALARA Locations -> ALARA – Max. Individual -> Transit Time. Drinking water.

Table B-1 LADTAP II Modifiable Parameters (cont.)

Parameter/Information	Description	LADTAP II Notation	Where Adjusted in NRCDose3
Fish Consumption	Annual fish consumption (adult, teen, child, infant) (kg/yr)	FIUS, TAF, CHF, TDF	ALARA Locations -> ALARA – Max. Individual -> Change default usage and consumption data. Edit.
Invertebrate Consumption	Annual invertebrate consumption (adult, teen, child, infant) (kg/yr)	CRUS, TAC, CHC, TDC	ALARA Locations -> ALARA – Max. Individual -> Change default usage and consumption data. Edit.
Aquatic Plant Consumption	Annual algae consumption (adult, teen, child, infant) (kg/yr)	ALUS, TAA, CHA, TDA	ALARA Locations -> ALARA – Max. Individual -> Change default usage and consumption data. Edit.
Drinking Water	Annual drinking water consumption (adult, teen, child, infant) (kg/yr)	WUSE, TAW, CHW, TDW	ALARA Locations -> ALARA – Max. Individual -> Change default usage and consumption data. Edit.
Shoreline Usage	Annual shoreline usage (adult, teen, child, infant) (hr/yr)	SHU, TAS, CHS, TDS	ALARA Locations -> ALARA – Max. Individual -> Change default usage and consumption data. Edit.
Swimming Exposure	Annual swimming exposure time (adult, teen, child, infant) (hr/yr)	SWU, TASW, CHSW, TDSW	ALARA Locations -> ALARA – Max. Individual -> Change default usage and consumption data. Edit.
Boating Usage	Annual boating usage time (adult, teen, child, infant) (hr/yr)	BUSE, TAB, CHB, TDB	ALARA Locations -> ALARA – Max. Individual -> Change default usage and consumption data. Edit.
Flow Velocity	Average flow velocity (ft/s)	UR	ALARA Locations -> ALARA – Max. Individual (or Additional Usage Locations) -> Dilution Factor -> Calc -> Surface Water Velocity
Average Depth	Depth of water body (ft)	HR	ALARA Locations -> ALARA – Max. Individual (or Additional Usage Locations) -> Dilution Factor -> Calc -> Surface Water Depth

Table B-1 LADTAP II Modifiable Parameters (cont.)

Parameter/Information	Description	LADTAP II Notation	Where Adjusted in NRCDose3
Distance	Downshore distance from discharge point to usage location (ft)	XR	ALARA Locations -> ALARA – Max. Individual (or Additional Usage Locations) -> Dilution Factor -> Calc -> Downstream Distance
Distance	Offshore distance to water usage location (ft)	YR	ALARA Locations -> ALARA – Max. Individual (or Additional Usage Locations) -> Dilution Factor -> Calc -> Offshore Distance
River Width	Width of river or depth of discharge point in the lake (ft)	BW	ALARA Locations -> ALARA – Max. Individual (or Additional Usage Locations) -> Dilution Factor -> Calc -> River Width
Sport Fishing Usage	Annual sport fish harvest (kg/yr)	CATH	Fish/Population/Biota -> Fish Usage Location -> Sport Fishing…Add
Sport Fishing Usage	Dilution factor	DILU	Fish/Population/Biota -> Fish Usage Location -> Sport Fishing…Add
Sport Fishing Usage	Transit time	T	Fish/Population/Biota -> Fish Usage Location -> Sport Fishing…Add
Commercial Fishing Usage Location	(see Sport Fishing above)	CATH, DILU, T	Fish/Population/Biota -> Fish Usage Location->Commercial Fishing…Add
Sport Invertebrate Harvest Location	(see Sport Fishing above)	CATH, DILU, T	Fish/Population/Biota -> Fish Usage Location -> Sport Invertebrate Harvest…Add
Commercial Invertebrate Harvest Location Data	(see Sport Fishing above)	CATH, DILU, T	Fish/Population/Biota -> Fish Usage Location -> Commercial Invertebrate Harvest…Add
Population	Population served by drinking water location	P	Fish/Population/Biota -> Population Usage -> Drinking Water…Add
Dilution Factor	DF at the intake location	DILU	Fish/Population/Biota -> Population Usage -> Drinking Water…Add

Table B-1 LADTAP II Modifiable Parameters (cont.)

Parameter/Information	Description	LADTAP II Notation	Where Adjusted in NRCDose3
Distance	Offshore distance to water usage location (ft)	YR	ALARA Locations -> ALARA – Max. Individual (or Additional Usage Locations) -> Dilution Factor -> Calc -> Offshore Distance
River Width	Width of river or depth of discharge point in the lake (ft)	BW	ALARA Locations -> ALARA – Max. Individual (or Additional Usage Locations) -> Dilution Factor -> Calc -> River Width
Sport Fishing Usage	Annual sport fish harvest (kg/yr)	CATH	Fish/Population/Biota -> Fish Usage Location -> Sport Fishing…Add
Sport Fishing Usage	Dilution factor	DILU	Fish/Population/Biota -> Fish Usage Location -> Sport Fishing…Add
Sport Fishing Usage	Transit time	T	Fish/Population/Biota -> Fish Usage Location -> Sport Fishing…Add
Commercial Fishing Usage Location	(see Sport Fishing above)	CATH, DILU, T	Fish/Population/Biota -> Fish Usage Location->Commercial Fishing…Add
Sport Invertebrate Harvest Location	(see Sport Fishing above)	CATH, DILU, T	Fish/Population/Biota -> Fish Usage Location -> Sport Invertebrate Harvest…Add
Commercial Invertebrate Harvest Location Data	(see Sport Fishing above)	CATH, DILU, T	Fish/Population/Biota -> Fish Usage Location -> Commercial Invertebrate Harvest…Add
Population	Population served by drinking water location	P	Fish/Population/Biota -> Population Usage -> Drinking Water…Add
Dilution Factor	DF at the intake location	DILU	Fish/Population/Biota -> Population Usage -> Drinking Water…Add
Transit Time	Time from discharge point to water supply intake (hr)	T	Fish/Population/Biota -> Population Usage -> Drinking Water…Add

Table B-1 LADTAP II Modifiable Parameters (cont.)

Parameter/Information	Description	LADTAP II Notation	Where Adjusted in NRCDose3
Volume	Supply rate of drinking water (gal/d)	GAL	Fish/Population/Biota -> Population Usage -> Drinking Water…Add
Drinking Water Usage	Average rate of drinking water usage by individuals (gal/d)	GUS	Fish/Population/Biota -> Population Usage -> Drinking Water…Add
Population Shoreline	Population shoreline usage (person-hr/yr)	SHU, DILU, T, SWF	Fish/Population/Biota -> Population Usage-Shoreline…Add
Population Swimming	Population Swimming Usage (person-hr/yr)	SWU, DILU, T	Fish/Population/Biota -> Population Usage-Swimming…Add
Population Boating	Population Boating Usage (person-hr/yr)	BTUSE, DILU, T	Fish/Population/Biota -> Population Usage -> Boating…Add
Irrigated Foods	Irrigation rate (L/m^2/month)	IRRIG	Irrigated Food Data -> Irrigation Food Data -> Add
Irrigated Foods	Fraction of animal feed NOT produced with contaminated water	FFED	Irrigated Food Data -> Irrigation Food Data -> Add
Irrigated Foods	Fraction of animal drinking water NOT contaminated	FDH20	Irrigated Food Data -> Irrigation Food Data -> Add
Irrigated Foods	Total production rate of food product (kg/yr)	TFMG	Irrigated Food Data -> Irrigation Food Data -> Add
Irrigated Foods	Growing period for food product (d)	TGRW	Irrigated Food Data -> Irrigation Food Data -> Add
Irrigated Foods	Crop yield for food product (kg/m^2)	YLD	Irrigated Food Data -> Irrigation Food Data -> Add
Food Consumption	Maximum current food consumption rate (adult, teen, child) (kg/yr)	ACON, TCON, CCON	Irrigated Food Data -> Irrigation Food Data -> Add. Modify Food Consumption Default data. Edit.

Table B-1 LADTAP II Modifiable Parameters (cont.)

Parameter/Information	Description	LADTAP II Notation	Where Adjusted in NRCDose3
Food Consumption	Average current food consumption rate (adult, teen, child) (kg/yr)	AC, TC, CC	Irrigated Food Data -> Irrigation Food Data -> Add. Modify Food Consumption Default data. Edit.
Holdup Time	Holdup time to average person (h)	HOLD	Irrigated Food Data -> Irrigation Food Data -> Add. Modify Food Consumption Default data. Edit.
Holdup Time	Holdup time to maximum person (h)	HOLD1	Irrigated Food Data -> Irrigation Food Data -> Add. Modify Food Consumption Default data. Edit.
Production Rate	Production rate for current food product (kg/yr or L/yr)	PROD	Irrigated Food Data -> Irrigation Food Data -> Add -> Usage Locations
Food Product Water Usage Location Data	DF, transit time	DILU, T	Irrigated Food Data -> Irrigation Food Data -> Add -> Usage Locations
Biota Exposure Location Data	DF, transit time	DILU, T	Fish/Population/Biota -> Biota Exposures -> Add
Miscellaneous Pathways and Consumption Factors	Numerous factors on Pathway Factors tab that can be modified, reflecting site-specific conditions	Various; refer to Table B-4	Pathways Factors

Table B-2 GASPAR II Modifiable Parameters

Parameter/Information	Description	GASPAR II Notation	Where Adjusted in NRCDose3
Plant Title	Text of plant title or run	N/A	Main Screen. “Case Title”
Input Deck Type	Determines population dose, individual dose, or both	JC(1)	Options -> “Calculate Individual doses only”
Number of Source Terms	Number of release points (with associated source terms)	JC(2)	NOTE: NRCDose3 limited to a single source term.
Cumulative Doses	Prints cumulative doses from each source term, or only total dose from all source terms	JC(3)	Options -> “Print cumulative dose reports only”
Block Data Records	Block data changes	JC(4)	Not used in NRCDose3
Dose Factor Library	Dose factor report selection	JC(5)	Options -> Print dose-factor library data
Vegetable Growth	Fraction of year leafy vegetables are grown	FV	Options -> “Fraction of the year leafy vegetables are grown"
Cow Pasture	Fraction of year cows are on pasture	FP	Options -> “Fraction of the year milk cows are on pasture”
Crop from Garden	Fraction of crop from garden	FG	Options -> ”Fraction of max individual’s vegetable intake from own garden”
Cow Intake	Fraction of cow intake from pasture, while on pasture	FPF	Options -> “Fraction of milk-cow feed intake from pasture while on pasture”
Humidity	Relative humidity provided a value other than zero (0) is entered for “Average temperature over growing season” (next entry in this column). However, with the “Average temperature over growing season” entered as zero (0), this represents absolute humidity,	H	Options -> “Humidity”
Temperature	Average temperature over growing season (degrees Fahrenheit)	T	Options -> “Average temperature over growing season”
Goat Pasture	Fraction of year goats on pasture	FGT	Options -> “Fraction of the year goats are on pasture”

Table B-2 GASPAR II Modifiable Parameters (cont.)

Parameter/Information	Description	GASPAR II Notation	Where Adjusted in NRCDose3
Goat Intake	Fraction of goat intake from pasture, while on pasture	FPG	Options -> “Fraction of goat feed intake from pasture while on pasture”
Beef Cow Pasture	Fraction of year beef cows are on pasture	FB	Options -> “Fraction of the year beef cows are on pasture”
Beef Cow Intake	Fraction of beef cow intake from pasture, while on pasture	FBF	Options -> “Fraction of beef cow feed intake from pasture while on pasture”
Population	Total population within 50 miles	LS, PERSON	Pop/Prod Data tab -> Population Data. Population Control. Uncheck “Input by distance and direction” -> Data Entry
Population	Population in given downwind direction sector and annular distance	POP(160)	Pop/Prod Data tab -> Population Data. Population Control. Check “Input by distance and direction” -> Data Entry
Milk Production	Milk production in given downwind direction sector and annular distance	ZMILK(160)	Pop/Prod Data tab -> Milk Production Data. Milk Production Control. Check “Input by distance and direction” -> Data Entry
Milk Production	Total milk production within 50 miles	ZMLKT	Pop/Prod Data tab -> Milk Production Data. Milk Production Control. Uncheck “Input by distance and direction” -> Data Entry
Meat Production	Meat production in given downwind direction sector and annular distance	ZMEAT(160)	Pop/Prod Data tab -> Meat Production Data. Meat Production Control. Check “Input by distance and direction” -> Data Entry
Meat Production	Total meat production within 50 miles	ZMETT	Pop/Prod Data tab -> Meat Production Data. Meat Production Control. Uncheck “Input by distance and direction” -> Data Entry
Vegetable Production	Vegetable production in given downwind direction sector and annular distance	ZVEGT(160)	Pop/Prod Data tab -> Vegetable Production Data. Vegetable Production Control. Check “Input by distance and direction” -> Data Entry

Table B-2 GASPAR II Modifiable Parameters (cont.)

Parameter/Information	Description	GASPAR II Notation	Where Adjusted in NRCDose3
Vegetable Production	Total vegetable production within 50 miles	ZVEGTT	Pop/Prod Data tab -> Vegetable Production Data. Vegetable Production Control. Uncheck “Input by distance and direction” -> Data Entry
Source Term Multiplier	Multiplier to account for multiunit sites with same release	UML	Variables -> Source Term. Source Data. “Source Multiplication Factor” **Note:** NRCDose3 limited to a single source term.
New MET Data	Determines whether last MET data can be reused	JC1	**Note:** Not used in NRCDose3. NRCDose3 limited to a single source term.
New Release Data	Determines whether last release data can be reused	JC2	**Note:** Not used in NRCDose3. NRCDose3 limited to a single source term.
Purge Duration	Total annual purge release time	PURGE	Source Term -> Source Data “Release time for purges”
Release Nuclide	Nuclide released; element symbol	IA	Source Term -> Add Nuclide; parameters combined into a drop-down selection menu for the nuclides
Release Nuclide	Nuclide released; mass including M for metastable	IM	
Annual Release	Annual release (Ci)	QQ, Q(33)	Source Term -> Add Nuclide
Release Point—	Title for data source, date, height, release point, etc.		Pop/Prod Data -> Meteorological -> Title
Undecayed, Undepleted X/Q	X/Q at each downwind sector and annular distance	XQ(160)	Pop/Prod Data -> Meteorological -> Undecayed, Undepleted -> Data Entry
Decayed, Undepleted X/Q	Decayed, undepleted X/Q at each downwind sector and annular distance	XQD	Pop/Prod Data -> Meteorological -> Decayed, Undepleted ->Title
Decayed, Depleted X/Q	Decayed, depleted X/Q at each downwind sector and annular distance	XQDD(160)	Pop/Prod Data -> Meteorological -> Decayed, Depleted -> Data Entry
Deposition D/Q	Deposition D/Q at each downwind sector and annular distances.	DEP(160)	Pop/Prod Data -> Meteorological -> Ground Deposition ->Data Entry

Table B-2 GASPAR II Modifiable Parameters (cont.)

Parameter/Information	Description	GASPAR II Notation	Where Adjusted in NRCDose3
Special Location Data	Determines whether detailed pathway reports are printed	JS(n)	Special Location Data -> Add. "Don't print any detailed reports"
Special Location Name	Name identifier	Name	Special Location Data -> Add. "Name of Location"
Special Location Downwind Direction Sector	Meteorological sector for special location	(DIR)	Special Location Data -> Add. "Downwind direction from site"
Special Location Distance	Distance to special location	DIST	Special Location Data -> Add. "Distance from Site (m)"
Special Location X/Q	Special location undecayed, undepleted X/Q	X/Q, XQ1	Special Location Data -> Add -> Atmospheric Dispersion Factors -> Undecayed, Undepleted
Special Location XQD	Special location decayed, undepleted X/Q	XQD, XQD1	Special Location Data -> Add -> Atmospheric Dispersion Factors -> Decayed, Undepleted
Special Location XQDD	Special location decayed, depleted X/Q	XQDD, XQDD1	Special Location Data -> Add -> Atmospheric Dispersion Factors -> Decayed, Depleted
Special Location DEP	Special location D/Q	DEP1	Special Location Data -> Add -> Atmospheric Deposition Factors -> Ground Deposition Factor
Miscellaneous Pathways Factors	Numerous factors on Pathway Factors tab that can be modified, reflecting site-specific conditions	Various; refer to Table B-5	Pathways Factors
Consumption Values	Usage (inhalation and intake) values on Consumption Values tab for the various pathways and age groups, which may be modified to reflect site-specific conditions.	Various; refer to Table B-5	Consumption Values

Table B-3 XOQDOQ Modifiable Parameters

Parameter/Information	Description	XOQDOQ Notation	Where Adjusted in NRCDose3
Calms selection Option	Distribute calms as first windspeed class	KOPT(1)	Met Data tab
JFD input Option	Input joint frequency distribution as percent frequency	KOPT(2)	Met Data tab -> Input joint frequency distribution data as percent frequency
Sector spread Option	Compute sector spread	KOPT(3)	Options/Parameters tab, Options
Short-term x/Q Option	Plot short-term X/Q values	KOPT(4)	Options/Parameters tab, Options
Cubic Spline Option	Use cubic spline	KOPT(5)	Options/Parameters tab, Options
Radial segment Option	Punch radial segment X/Q	KOPT(6)	Not included on screen. Not adjustable in NRCDose3.
Output Option	Punch output X/Q at point of interest	KOPT(7)	Not included on screen. Not adjustable in NRCDose3.
Open terrain Option	Correct value for open terrain	KOPT(8)	Options/Parameters tab, Options
Site specific terrain Option	Site specific terrain recirculation data	KOPT(9)	Options/Parameters tab, Options
Desert sigma Option	Desert sigma curves	KOPT(10)	Options/Parameters tab, Options
30 degree sector Option	Uneven sector sizes—30 degrees in N, E, S, W and 20 degrees elsewhere	KOPT(11)	Not included on screen. Not adjustable in NRCDose3. Not used in Fortran code.
Number wind velocities	Number of velocity categories	NVEL	Met Data tab
Number stabilities	Number of stability categories	NSTA	Met Data tab
Units for wind speed	Windspeed class units (mph or m/s)	User selectable	Met Data tab
Number distances terrain data	Number of distances with terrain data for each downwind sector	NDIS	Options/Parameters tab, Parameters

Table B-3 XOQDOQ Modifiable Parameters (cont.)

Parameter/Information	Description	XOQDOQ Notation	Where Adjusted in NRCDose3
Selection for plotting	Increment for which plotted results are printed out (in percent)	INC	Options/Parameters tab, Parameters
Receptors	Number of titles of receptor types	NPTYPE	Options/Parameters tab, Parameters
Release points	Number of release exit points	NEXIT	Options/Parameters tab, Parameters
Distances for recirculation	Number of distances of site-specific correction factors for recirculation	NCOR	Options/Parameters tab, Parameters
Wind Measurement Height	Height above ground level (m) of measured windspeed presented in the JFD	PLEV	Met Data tab, Misc.
X/Q Half-Lives	Half-lives used in undecayed, decayed, and decayed/depleted X/Q calculations	DECAYS	Met Data tab. Half-lives used in X/Q calculations (days) (with explanations of departures from typical values)
Plant Grade Elevation	Plant grade elevation above sea level	PLGRAD	Met Data tab, Misc.
Calms Data	Time (hours) or percent frequency of calms for each stability class	CALM	Met Data tab
Joint Frequency Data	Time (hours) or percent frequency for each of the 16 standard wind direction sectors, for each stability class and windspeed category	FREQ	Met Data tab, select stability class, enter the frequencies of occurrence for each wind direction sector (i.e., direction from relative to True North) and windspeed category
Maximum Windspeeds	Maximum speed in each windspeed class (mph or m/s)	UMAX	Met Data tab -> Max Windspeeds
Correction Factor Distance	Distance to site-specific correction factor in each of the 16 downwind direction sectors (m)	VRDIST	Options/Parameters tab, Parameters -> Corrections, select distance number, enter site-specific distance for each correction factor for each downwind sector

Table B-3 XOQDOQ Modifiable Parameters (cont.)

Parameter/Information	Description	XOQDOQ Notation	Where Adjusted in NRCDose3
Correction Factor	Site specific correction factor in each downwind direction sector for the specified distance	VRCR	Options/Parameters tab, Parameters -> Corrections, select distance number, enter site-specific correction factor for each downwind sector
Terrain Factor	Distance range for which terrain heights are given in each of the 16 downwind direction sectors	DIST	Options/Parameters tab, Parameters -> Heights, select distance range, enter distance range with terrain data for each downwind sector
Terrain Factor	Terrain height per distance range in each of the 16 downwind direction sectors	HT	Options/Parameters tab, Parameters -> Heights, select distance range, enter terrain height for each downwind sector
Receptors	Number of receptor locations for a particular receptor type	NPOINT	Options/Parameters tab, Parameters -> Number of titles of receptor types -> Define, enter number of receptor locations (points) per receptor type
Receptors	Titles of receptor types	TITLPT	Options/Parameters tab, Parameters -> Number of titles of receptor types -> Define, enter titles of receptor types
Receptors	Receptor downwind direction and distance (m)	KDIR, PTDIST	Options/Parameters tab, Parameters -> Number of titles of receptor types -> Define -> Define, enter downwind direction and distance per receptor location (point)
Release Points	Vent/stack average velocity (m/s)	EXIT	Options/Parameters tab, Parameters -> Number of release exit points -> Details, select Release Point -> Edit
Release Points	Vent/stack inside diameter (m)	DIAMTR	Options/Parameters tab, Parameters -> Number of release exit points -> Details, select Release Point -> Edit
Release Points	Release point height (m)	HSTACK	Options/Parameters tab, Parameters -> Number of release exit points -> Details, select Release Point -> Edit
Release Points	Height of vent/stack building (m)	HBLDG	Options/Parameters tab, Parameters -> Number of release exit points -> Details, select Release Point -> Edit
Release Points	Minimum cross section area for vent/stack building (m^2)	CRSEC	Options/Parameters tab, Parameters -> Number of release exit points -> Details, select Release Point -> Edit

Table B-3 XOQDOQ Modifiable Parameters (cont.)

Parameter/Information	Description	XOQDOQ Notation	Where Adjusted in NRCDose3
Release Points	Wind height used for vent/stack release (m)	SLEV	Options/Parameters tab, Parameters -> Number of release exit points -> Details, select Release Point -> Edit
Release Points	Vent/stack heat emission rate (cal/s)	HEATR	Options/Parameters tab, Parameters -> Number of release exit points -> Details, select Release Point -> Edit
Release Points	Intermittent release X/Q to use	IPURGE	Options/Parameters tab, Parameters -> Number of release exit points -> Details -> Edit, select No Purge or Decay type
Release Points	Number of intermittent releases per year	NPURGE	Options/Parameters tab, Parameters -> Number of release exit points -> Details, select Release Point -> Edit
Release Points	Average number of hours per intermittent release	NPRGHR	Options/Parameters tab, Parameters -> Number of release exit points -> Details, select Release Point -> Edit

Table B-4 LADTAP II Hardwired Parameters

Name	Description	Location in Fortran Code	Value	Units
FACCA	Bioaccumulation factors for freshwater plants	BLOC 132	Values provided on a chemical element basis	L/kg
FACCF	Bioaccumulation factors for freshwater fish	BLOC 100	Values provided on a chemical element basis	L/kg
FACCI	Bioaccumulation factors for freshwater invertebrates	BLOC 116	Values provided on a chemical element basis	L/kg
SACCA	Bioaccumulation factors for saltwater plants	BLOC 180	Values provided on a chemical element basis	L/kg
SACCF	Bioaccumulation factors for saltwater fish	BLOC 148	Values provided on a chemical element basis	L/kg
SACCI	Bioaccumulation factors for saltwater invertebrates	BLOC 164	Values provided on a chemical element basis	L/kg
PLNTLF, PL	Midpoint of plant life (yr)	BLOC 195	20.0	years
POP	Total population in 50 miles	BLOC 40	260000000.0	people
TPROCF	Processing time for aquatic foods (hr)	BLOC 215	24.0	hours
TPROCW	Processing time for water supply systems	BLOC 215	12.0	hours
DFL	Ingestion dose factors	LADTAP.LIB file	Values provided in separate file for each radionuclide, age range, and organ	
EXS	External dose conversion factors for water immersion for each radionuclide/age group and organ (mrem/hr per pCi/L)	LADTAP.LIB file	Values provided in separate file for each radionuclide, age range, and organ	
EXG	External dose conversion factors for ground exposure for each radionuclide/age group and organ (mrem/hr per pCi/m^2)	LADTAP.LIB file	Values provided in separate file for each radionuclide, age range, and organ	

Table B-4 LADTAP II Hardwired Parameters (cont.)

Name	Description	Location in Fortran Code	Value	Units
Q1	Milk animal pasture grass consumption rate (kg/d)	BLOC 44	50.0	
Q2	Milk animal water consumption rate	BLOC 44	60.0	
Q3	Beef animal pasture grass consumption rate (kg/d)	BLOC 44	50.0	
Q4	Beef animal water consumption rate (L/d)	BLOC 44	50.0	
FRAC	Fraction of deposition captured by vegetation	BLOC 48	0.25	
ZMET	Meat transfer coefficient	BLOC 50	Values provided in code for each chemical element	
SOIL	Soil-to-plant transfer factors	BLOC 68	Values provided in code for each chemical element	
ZMLK	Milk transfer coefficient	BLOC 84	Values provided in code for each chemical element	

Table B-5 GASPAR II Hardwired Parameters

Name	Description	Location in Fortran Code	Value	Units	RG 1.109 Notation
AREA	Total area within 50 miles (mi^2)	BLKDATA17	2.00E+10	m^2	
AVMET	Average meat intake: child, teen, adult	BLKDATA16	37, 59, 95	kg/yr	U_a
AVMLK	Average milk intake: child, teen, adult	BLKDATA15	170, 200, 110	L/yr	U_a
AVVEG	Average vegetable intake: child, teen, adult	BLKDATA15	200, 240, 190	kg/yr	U_a
POPF	Population fractions: child, teen, adult	BLKDATA15	0.18, 0.11, 0.71		f_a
USPOP	U.S. population	BLKDATA15	2.80E+08	people	
AVINH	Average inhalation rate: child, teen, adult	BLKDATA15	3700, 8000, 8000	L/yr	U_a
AVLVEG	Average leafy vegetable intake: child, teen, adult	BLKDATA15	10, 20, 30	kg/yr	U_a
SPINH	Max inhalation rate: infant, child, teen, adult	BLKDATA16	1400, 3700, 8000, 8000	L/yr	U_a
SPVEG	Max vegetable intake: infant, child, teen, adult	BLKDATA16	0, 520, 630, 520	kg/yr	U_a
SLVEG	Max leafy vegetable intake: infant, child, teen, adult	BLKDATA16	0, 26, 42, 64	kg/yr	U_a
SPMLK	Max milk intake: infant, child, teen, adult	BLKDATA16	330, 330, 400, 310	L/y	U_a
SPMET	Max meat intake: infant, child, teen, adult	BLKDATA16	0, 41, 65, 110	kg/yr	U_a
BLDAY	Growing period for veg. consumed by an individual	BLKDATA10	60	day	t_e
COWIN	Cow feed ingestion rate	BLKDATA10	50	kg/d	Q_F
DFA	Inhalation dose factors	BLKDATA19	Values provided in separate file for each radionuclide, age range, and organ		

Table B-5 GASPAR II Hardwired Parameters (cont.)

Name	Description	Location in Fortran Code	Value	Units	RG 1.109 Notation
FID	Fraction of iodine that deposits	BLKDATA17	0.5		
GOATIN	Goat feed ingestion rate	BLKDATA10	6	kg/d	Q_F
PARTUP	Retention factor of vegetables for particulates other than iodine	BLKDATA10	0.2		r
PLIFE	Midpoint of plant life	BLKDATA17	6.31E+08	s	t_b
REMVEG	Weather removal constant	BLKDATA10	5.73E-07	sec^{-1}	λ_w
SD	Soil surface density	BLKDATA10	240	kg/m^2	P
SOIL	Soil-to-plant transfer factors	BLKDATA14	Values provided in code for each chemical element		B_{iv}
SF	Shielding factor for individuals	BLKDATA17	0.7		S_F
SSF	Shielding factor for populations	BLKDATA17	0.5		S_F
TAU	Rad. decay constant	BLKDATA21	Values provided in code for each radionuclide	sec^{-1}	λ_i
TIM(1)	Holdup and transport time: meat to consumption	BLKDATA10	1.73E+06	sec	t_s and t_p
TIM(2)	Holdup and transport time: milk to population	BLKDATA10	3.46E+05	sec	t_h and t_p
TIM(3)	Holdup and transport time: vegetable to population	BLKDATA10	1.21E+06	sec	t_h and t_p
TIM(4)	Holdup and transport time: vegetable to individual	BLKDATA10	5.18E+06	sec	t_h and t_p
TIM(5)	Holdup and transport time: milk to individual	BLKDATA10	1.73E+05	sec	t_f and t_p

Table B-5 GASPAR II Hardwired Parameters (cont.)

Name	Description	Location in Fortran Code	Value	Units	RG 1.109 Notation
TIM(6)	Holdup and transport time: leafy vegetables to individual	BLKDATA10	8.64E+04	sec	t_h and t_p
TIM(7)	Holdup and transport time: pasture grazing period	BLKDATA10	2.59E+06	sec	t_e
TIM(8)	Holdup and transport time: feed storage time	BLKDATA10	7.78E+06	sec	t_h
VHS	Hydrosphere water volume		2.70E+19	L	
VIORET	Iodine retention	BLKDATA10	1		r
VNA	Volume of the atmosphere	BLKDATA17	3.80E+18	m^3	
YA1	Pasture grass yield	BLKDATA10	0.7	kg/m^2	Y_v
YA2	Feed crop yield	BLKDATA10	2	kg/m^2	Y_v
YV	Garden vegetable crop yield	BLKDATA10	2	kg/m^2	Y_v
ZGMLK	Goat feed to milk transfer factor for each element	BLKDATA10	Values provided for each chemical element	d/L	F_m
ZMET	Feed-to-meat transfer factor for each element	BLKDATA12	Values provided for each chemical element	d/kg	F_f
ZMLK	Feed-to-cow transfer factor for each element	BLKDATA11	Values provided for each chemical element	d/L	F_m
BOTB	Bone correction factor	CARBON19	5 for bone, 1 for all others. Applies to carbon doses only.		
DFL	Ingestion dose factors	DFLIB	Values provided in separate file for each radionuclide, age range, and organ	mrem/μCi	
EXG	External ground dose factors (mrem/hr per pCi/m^2)	PART 6	Values provided in separate file for each radionuclide	(mrem/hr per pCi/m^2)	DFG

Table B 6 XOQDOQ Hardwired Parameters

Name	Description	Location in Fortran Code	Value	Units	NOTE
NDIR	Number of wind direction sectors	Line 124	16		Not included on screen. Not adjustable in NRCDose3.
C	Building wake constant	Line 124	0.5		Default value may be changed on Options/Parameters tab, Parameters, but requires justification.
KOPT(6)	Punch radial segment X/Q				Not included on screen. Not adjustable in NRCDose3.
KOPT(7)	Punch output X/Q at point of interest				Not included on screen. Not adjustable in NRCDose3.
KOPT(11)	Uneven sector sizes— 30 degrees in N, E, S, W and 20 degrees elsewhere	Line 501	0		Not adjustable in NRCDose3. Not used in Fortran code.
UCOR	Correction for windspeed from mph to m/s		0.44704	m/s per mph	

APPENDIX C
USAGE PARAMETERS

C.1 ICRP-30 Usage and Consumption Factors

In NRCDose3, the assumed usage and consumption values depend on the dose conversion factor (DCF) values chosen, regardless of whether the calculation is for a maximum or average individual or for a population or individual dose. When the DCF values used are those of International Commission on Radiological Protection (ICRP) Publication 2, “Report of Committee II on Permissible Dose for Internal Radiation” (ICRP-2), issued 1960 [Ref. 1], or ICRP Publication 30, “Limits for Intakes of Radionuclides by Workers” (ICRP-30), issued 1979 [Ref. 2], the default usage and consumption values are based on Regulatory Guide (RG) 1.109, Revision 1, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I,” issued October 1977 [Ref. 3]. Tables C-1 and C-2 display the usage and consumption values for the ICRP-2 and ICRP-30 DCF values from Tables E-4 and E-5 of RG 1.109.

Table C-1 ICRP-2 and ICRP-30 DCF Average Individual Exposure Assumptions

Pathway	Units	Infant	Child	Teen	Adult	Source
Drinking Water	L/yr		260	260	370	RG 1.109, Table E-4
Inhalation	m^3/yr		3700	8000	8000	RG 1.109, Table E-4
Fruit/Vegetables/Grain	kg/yr		200	240	190	RG 1.109, Table E-4
Leafy Vegetables	kg/yr		10	20	30	Original LADTAP II code
Milk	L/yr		170	200	110	RG 1.109, Table E-4
Meat	kg/yr		37	59	95	RG 1.109, Table E-4
Fish	kg/yr		2.2	5.2	6.9	RG 1.109, Table E-4
Other Seafood	kg/yr		0.33	0.75	1.0	RG 1.109, Table E-4

Table C-2 ICRP-2 and ICRP-30 DCF Maximum Individual Exposure Assumptions

Pathway	Units	Infant	Child	Teen	Adult	Source
Drinking Water	L/yr	330	510	510	730	RG 1.109, Table E-5
Inhalation	m^3/yr	1400	3700	8000	8000	RG 1.109, Table E-5
Fruit/Vegetables/Grain	kg/yr	0	520	630	520	RG 1.109, Table E-5
Leafy Vegetables	kg/yr	0	26	42	64	RG 1.109, Table E-5
Milk	L/yr	330	330	400	310	RG 1.109, Table E-5
Meat	kg/yr	0	41	65	110	RG 1.109, Table E-5
Fish	kg/yr	0	6.9	16	21	RG 1.109, Table E-5
Other Seafood	kg/yr	0	1.7	3.8	5.0	RG 1.109, Table E-5
Shoreline	hr/yr	0	14	67	12	RG 1.109, Table E-5

C.2 ICRP-72 Usage and Consumption Factors

With the DCF values from ICRP Publication 60, “1990 Recommendations of the International Commission on Radiological Protection” (ICRP-60), issued 1991, or ICRP Publication 72, “Age-Dependent Dose to Members of the Public from Intake of Radionuclides, Part 5: Compilation of Ingestion and Inhalation Dose Coefficients” (ICRP-72), issued 1996, NRCDose3 assumes usage and consumption values derived from the U.S. Environmental Protection Agency’s “Exposure Factors Handbook: 2011 Edition,” issued September 2011 [Ref. 6]. For all calculations, the usage and consumption values may be adjusted to account for site-specific behaviors. Tables C-3 and C-4 display the usage and consumption values assumed for the ICRP-60 and ICRP-72 DCF values.

** **User Note** **—An applicant or licensee preparing a U.S. Nuclear Regulatory Commission (NRC) license amendment request should discuss the use of ICRP-72 usage and consumption values with the NRC staff before submitting the request.

Table C-3 ICRP-72 DCF Average Individual Exposure Assumptions

Pathway	Units	Infant	1-year (Child)	5-year (Child)	10-year (Child)	15-year (Teen)	Adult
Drinking Water	L/yr			139		187	448
Inhalation	m^3/yr	1971	3249	3760	4380	5548	5950
Fruit/Vegetables/Grain	kg/yr	71	107	111	123	120	175
Milk	L/yr	26	197	141	125	83	70
Meat	kg/yr	6.4	18	22	29	35	47
Fish	kg/yr			7.1		11	18
Other Seafood	kg/yr			1.8		2.9	4.4

Table C-4 ICRP-72 DCF Maximum Individual Exposure Assumptions

Pathway	Units	Infant	1-year (Child)	5-year (Child)	10-year (Child)	15-year (Teen)	Adult
Drinking Water	L/yr	385	320	350	480	480	1080
Inhalation	m^3/yr	3360	5000	5040	6060	8000	8980
Fruit/Vegetables/Grain	kg/yr	182	249	269	323	296	429
Milk	L/yr	150	477	347	369	340	301
Meat	kg/yr	27	51	58	74	97	120
Fish	kg/yr	8	24	20	25	30	58
Other Seafood (saltwater invert.)	kg/yr	2	6	5	6	7	15
Shoreline	hr/yr	17	48	48	48	48	48
Swimming	hr/yr	19	36	36	36	36	36

C.3 References

1. **ICRP Publication 2**, "Report of Committee II on Permissible Dose for Internal Radiation," International Commission on Radiological Protection (ICRP), Pergamon Press, London, 1960.

2. **ICRP Publication 30**, "Limits for Intakes of Radionuclides by Workers," *Annals of the ICRP*, Vol. 2, Nos. 3/4, ICRP, Pergamon Press, London, 1979.

3. **Regulatory Guide 1.109**, **Revision 1**, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," U.S. Nuclear Regulatory Commission, Washington, DC, October 1977. Agencywide Documents Access and Management System Accession No. ML003740384.

4. **ICRP Publication 60,** "1990 Recommendations of the International Commission on Radiological Protection," *Annals of the ICRP*, Vol. 21, Nos. 1–3, ICRP, Pergamon Press, London, 1991.

5. **ICRP Publication 72**, "Age-Dependent Dose to Members of the Public from Intake of Radionuclides, Part 5: Compilation of Ingestion and Inhalation Dose Coefficients," *Annals of the ICRP*, Vol. 26, No. 1, ICRP, Pergamon Press, London, 1996.

6. **EPA/600/R-090/052F**, "Exposure Factors Handbook: 2011 Edition," U.S. Environmental Protection Agency, Washington, DC, September 2011. Available at https://www.epa.gov/expobox/about-exposure-factors-handbook.

APPENDIX D
EFFECTIVE RADIUS

D.1 Absorbed Energy in Spheres of Various Sizes

In LADTAP II and GASPAR II, the calculation of doses to aquatic and terrestrial biota is based on the energy absorbed in a unit-density sphere (considered muscle) due to nuclear transformation (decay) of an incorporated radionuclide. In earlier versions of NRCDose, LADTAP II and GASPAR II addressed a limited number of radionuclides, with the absorbed energy derived using dated analytical methods for computing the energies and intensities of the emitted radiations and the absorbed fraction of the photon emissions. The methodology in NRCDose3 has been updated to use nuclear decay data from International Commission on Radiological Protection (ICRP) Publication 107, “Nuclear Decay Data for Dosimetric Calculations” (ICRP-107), issued 2008 [Ref. 1], and photon absorbed fraction data from Stabin and Konijnenberg [Ref. 2] to tabulate the absorbed energy for eight unit-density spheres, ranging in radius from 1.0 to 30 centimeters (cm), for 203 radionuclides of interest.

The absorbed energy is computed using equation (D-1):

$$E_{abs} = \sum_r \sum_i^{N_r} Y_{r,i}\, E_{r,i}\, AF_{r,i} \qquad \text{(D-1)}$$

where

$\sum_r$ = summation over the various radiation types *r*,

$\sum_i^{N_r}$ = summation over the N_r radiations of type *r* emitted in the decay of the radionuclide,

$Y_{r,i}$ = the yield per decay in becquerel-seconds (Bq s),

$E_{r,i}$ = the energy per decay in megaelectron volts (MeV), and

$AF_{r,i}$ = the absorbed fraction in the sphere (unitless).

The value of $AF_{r,i}$ for all radiations other than photons, and for photons of energy less than 10 kiloelectronvolts (keV), is assumed to be 1. For photons of energy greater than 10 keV, the absorbed fraction is based on Stabin and Konijnenberg [Ref. 2]. For spheres of radius 15 or 30 cm, Monte Carlo calculations were undertaken using the Monte Carlo N-Particle (MCNP) Transport Code [Ref. 3]. The resulting quantity is in units of MeV/Bq s. The computations use no relative biological effectiveness factors. Table D-1 gives the radius, in centimeters, and the mass, in kilograms, of each of the eight spheres considered. Table D-2 gives the absorbed energies derived for the 203 radionuclides.

Table D-1 Radii and Masses of Unit-Density Spheres

Radius (cm)	Mass (kg)
1.0	0.0042
1.5	0.014
2.5	0.065
3.5	0.18
5.0	0.52
10	4.2
15	14
30	113

Table D-2 Effective Energy Deposited (MeV/nt) in Tissue of Given Radius

Nuclide	Radius (cm)							
	1	1.5	2.5	3.5	5	10	15	30
H-3	5.68E-03	5.68E-03	5.68E-03	5.68E-03	5.68E-03	5.68E-03	5.68E-03	5.68E-03
Be-10	2.52E-01	2.52E-01	2.52E-01	2.52E-01	2.52E-01	2.52E-01	2.52E-01	2.52E-01
C-14	4.95E-02	4.95E-02	4.95E-02	4.95E-02	4.95E-02	4.95E-02	4.95E-02	4.95E-02
N-13	5.14E-01	5.27E-01	5.51E-01	5.76E-01	6.14E-01	7.30E-01	8.01E-01	1.01E+00
F-18	2.64E-01	2.77E-01	3.00E-01	3.24E-01	3.61E-01	4.73E-01	5.42E-01	7.42E-01
Na-22	2.39E-01	2.64E-01	3.12E-01	3.60E-01	4.34E-01	6.63E-01	8.15E-01	1.24E+00
Na-24	6.06E-01	6.43E-01	7.16E-01	7.90E-01	9.03E-01	1.25E+00	1.52E+00	2.22E+00
P-32	6.95E-01	6.95E-01	6.95E-01	6.95E-01	6.95E-01	6.95E-01	6.95E-01	6.95E-01
S-35	4.87E-02	4.87E-02	4.87E-02	4.87E-02	4.87E-02	4.87E-02	4.87E-02	4.87E-02
Cl-36	2.73E-01	2.73E-01	2.73E-01	2.73E-01	2.73E-01	2.73E-01	2.73E-01	2.73E-01
Ar-39	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01
Ar-41	4.87E-01	5.01E-01	5.27E-01	5.54E-01	5.93E-01	7.18E-01	8.07E-01	1.05E+00
Ca-41	3.23E-03	3.23E-03	3.23E-03	3.23E-03	3.23E-03	3.23E-03	3.23E-03	3.23E-03
Ca-45	7.72E-02	7.72E-02	7.72E-02	7.72E-02	7.72E-02	7.72E-02	7.72E-02	7.72E-02
Sc-46	1.53E-01	1.76E-01	2.19E-01	2.63E-01	3.29E-01	5.33E-01	6.75E-01	1.07E+00
Cr-51	5.70E-03	6.09E-03	6.85E-03	7.62E-03	8.85E-03	1.27E-02	1.48E-02	2.14E-02

Table D-2 Effective Energy Deposited (MeV/nt) in Tissue of Given Radius (cont.)

Nuclide	Radius (cm)							
	1	1.5	2.5	3.5	5	10	15	30
Mn-54	2.35E-02	3.37E-02	5.22E-02	7.11E-02	9.98E-02	1.87E-01	2.47E-01	4.14E-01
Mn-56	8.60E-01	8.78E-01	9.13E-01	9.47E-01	1.00E+00	1.16E+00	1.28E+00	1.60E+00
Fe-55	5.83E-03	5.83E-03	5.83E-03	5.83E-03	5.83E-03	5.83E-03	5.83E-03	5.83E-03
Fe-59	1.41E-01	1.54E-01	1.79E-01	2.03E-01	2.41E-01	3.58E-01	4.41E-01	6.71E-01
Co-57	2.55E-02	2.69E-02	2.98E-02	3.29E-02	3.79E-02	5.41E-02	6.09E-02	9.02E-02
Co-58	5.69E-02	6.89E-02	9.07E-02	1.13E-01	1.47E-01	2.51E-01	3.20E-01	5.16E-01
Co-60	1.44E-01	1.70E-01	2.22E-01	2.74E-01	3.52E-01	5.96E-01	7.70E-01	1.25E+00
Ni-59	6.89E-03	6.89E-03	6.89E-03	6.89E-03	6.89E-03	6.89E-03	6.89E-03	6.90E-03
Ni-63	1.74E-02	1.74E-02	1.74E-02	1.74E-02	1.74E-02	1.74E-02	1.74E-02	1.74E-02
Ni-65	6.38E-01	6.44E-01	6.55E-01	6.66E-01	6.84E-01	7.38E-01	7.76E-01	8.82E-01
Cu-64	1.30E-01	1.32E-01	1.37E-01	1.41E-01	1.48E-01	1.69E-01	1.82E-01	2.19E-01
Ga-67	4.47E-02	4.64E-02	5.00E-02	5.39E-02	6.02E-02	8.02E-02	8.96E-02	1.24E-01
Zn-65	2.14E-02	2.79E-02	4.02E-02	5.25E-02	7.13E-02	1.29E-01	1.70E-01	2.83E-01
Zn-69m	3.25E-02	3.77E-02	4.76E-02	5.77E-02	7.36E-02	1.22E-01	1.51E-01	2.34E-01
Zn-69	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01
Se-75	2.78E-02	3.26E-02	4.18E-02	5.13E-02	6.67E-02	1.15E-01	1.38E-01	2.24E-01
Se-79	5.29E-02	5.29E-02	5.29E-02	5.29E-02	5.29E-02	5.29E-02	5.29E-02	5.29E-02
Br-82	2.01E-01	2.32E-01	2.90E-01	3.49E-01	4.39E-01	7.15E-01	9.00E-01	1.42E+00
Br-83	3.26E-01	3.26E-01	3.26E-01	3.26E-01	3.27E-01	3.27E-01	3.28E-01	3.29E-01
Br-84	1.26E+00	1.28E+00	1.31E+00	1.34E+00	1.40E+00	1.55E+00	1.67E+00	1.97E+00
Br-85	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.05E+00	1.05E+00	1.06E+00	1.07E+00
Kr-83m	4.09E-02	4.10E-02	4.12E-02	4.13E-02	4.14E-02	4.15E-02	4.15E-02	4.15E-02
Kr-85m	2.59E-01	2.61E-01	2.64E-01	2.68E-01	2.75E-01	2.94E-01	3.04E-01	3.40E-01
Kr-85	2.51E-01	2.51E-01	2.51E-01	2.51E-01	2.51E-01	2.51E-01	2.51E-01	2.52E-01
Kr-87	1.34E+00	1.35E+00	1.36E+00	1.38E+00	1.40E+00	1.48E+00	1.53E+00	1.67E+00
Kr-88	3.98E-01	4.16E-01	4.52E-01	4.88E-01	5.44E-01	7.16E-01	8.47E-01	1.19E+00
Kr-89	1.40E+00	1.42E+00	1.46E+00	1.50E+00	1.56E+00	1.73E+00	1.86E+00	2.21E+00
Rb-86	6.70E-01	6.71E-01	6.73E-01	6.75E-01	6.78E-01	6.87E-01	6.94E-01	7.12E-01
Rb-87	1.15E-01	1.15E-01	1.15E-01	1.15E-01	1.15E-01	1.15E-01	1.15E-01	1.15E-01
Rb-88	2.08E+00	2.09E+00	2.10E+00	2.11E+00	2.13E+00	2.19E+00	2.23E+00	2.35E+00
Sr-85	2.52E-02	3.20E-02	4.44E-02	5.66E-02	7.55E-02	1.32E-01	1.66E-01	2.66E-01
Rb-89	9.91E-01	1.01E+00	1.06E+00	1.10E+00	1.17E+00	1.38E+00	1.54E+00	1.95E+00

Table D-2 Effective Energy Deposited (MeV/nt) in Tissue of Given Radius (cont.)

Nuclide	Radius (cm)							
	1	1.5	2.5	3.5	5	10	15	30
Sr-89	5.85E-01	5.85E-01	5.85E-01	5.85E-01	5.85E-01	5.85E-01	5.85E-01	5.85E-01
Sr-90	1.96E-01	1.96E-01	1.96E-01	1.96E-01	1.96E-01	1.96E-01	1.96E-01	1.96E-01
Sr-91	6.70E-01	6.78E-01	6.94E-01	7.09E-01	7.33E-01	8.07E-01	8.56E-01	9.97E-01
Sr-92	2.27E-01	2.40E-01	2.68E-01	2.95E-01	3.36E-01	4.65E-01	5.57E-01	8.09E-01
Y-89m	2.67E-02	3.76E-02	5.73E-02	7.73E-02	1.08E-01	2.01E-01	2.65E-01	4.45E-01
Y-90	9.33E-01	9.33E-01	9.33E-01	9.33E-01	9.33E-01	9.33E-01	9.33E-01	9.33E-01
Y-91m	4.02E-02	4.69E-02	5.93E-02	7.19E-02	9.15E-02	1.51E-01	1.88E-01	2.95E-01
Y-91	6.03E-01	6.03E-01	6.03E-01	6.03E-01	6.04E-01	6.04E-01	6.04E-01	6.05E-01
Y-92	1.45E+00	1.46E+00	1.46E+00	1.47E+00	1.48E+00	1.50E+00	1.52E+00	1.57E+00
Y-93	1.17E+00	1.17E+00	1.18E+00	1.18E+00	1.18E+00	1.19E+00	1.20E+00	1.22E+00
Zr-93	1.94E-02	1.94E-02	1.94E-02	1.94E-02	1.94E-02	1.94E-02	1.94E-02	1.94E-02
Zr-95	1.35E-01	1.44E-01	1.60E-01	1.77E-01	2.03E-01	2.81E-01	3.33E-01	4.81E-01
Zr-97	7.40E-01	7.51E-01	7.71E-01	7.91E-01	8.21E-01	9.15E-01	9.77E-01	1.15E+00
Nb-93m	3.04E-02	3.06E-02	3.08E-02	3.10E-02	3.11E-02	3.13E-02	3.13E-02	3.14E-02
Nb-95	6.13E-02	7.08E-02	8.79E-02	1.05E-01	1.32E-01	2.14E-01	2.68E-01	4.22E-01
Nb-95m	1.84E-01	1.86E-01	1.88E-01	1.90E-01	1.93E-01	2.02E-01	2.06E-01	2.20E-01
Nb-97	4.83E-01	4.92E-01	5.07E-01	5.22E-01	5.46E-01	6.19E-01	6.65E-01	8.00E-01
Nb-97m	4.83E-01	4.92E-01	5.07E-01	5.22E-01	5.46E-01	6.19E-01	6.65E-01	8.00E-01
Mo-93	1.01E-02	1.12E-02	1.27E-02	1.36E-02	1.44E-02	1.53E-02	1.56E-02	1.59E-02
Mo-99	3.96E-01	3.98E-01	4.02E-01	4.05E-01	4.11E-01	4.27E-01	4.37E-01	4.68E-01
Tc-99m	1.94E-02	2.08E-02	2.39E-02	2.71E-02	3.23E-02	4.87E-02	5.60E-02	8.65E-02
Tc-99	1.01E-01	1.01E-01	1.01E-01	1.01E-01	1.01E-01	1.01E-01	1.01E-01	1.01E-01
Tc-101	4.80E-01	4.84E-01	4.92E-01	5.01E-01	5.14E-01	5.54E-01	5.76E-01	6.47E-01
Ru-103	7.76E-02	8.38E-02	9.55E-02	1.07E-01	1.26E-01	1.83E-01	2.17E-01	3.17E-01
Ru-105	4.58E-01	4.67E-01	4.85E-01	5.02E-01	5.30E-01	6.12E-01	6.64E-01	8.16E-01
Ru-106	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
Rh-103m	3.83E-02	3.85E-02	3.87E-02	3.88E-02	3.90E-02	3.92E-02	3.93E-02	3.93E-02
Rh-105	1.55E-01	1.56E-01	1.58E-01	1.60E-01	1.63E-01	1.72E-01	1.77E-01	1.93E-01
Rh-105m	1.55E-01	1.56E-01	1.58E-01	1.60E-01	1.63E-01	1.72E-01	1.77E-01	1.93E-01
Pd-107	9.58E-03	9.58E-03	9.58E-03	9.58E-03	9.58E-03	9.58E-03	9.58E-03	9.58E-03
Pd-109	4.40E-01	4.41E-01	4.42E-01	4.43E-01	4.44E-01	4.46E-01	4.46E-01	4.48E-01
Cd-109	8.85E-02	9.07E-02	9.41E-02	9.64E-02	9.89E-02	1.03E-01	1.04E-01	1.07E-01

Table D-2 Effective Energy Deposited (MeV/nt) in Tissue of Given Radius (cont.)

Nuclide	Radius (cm)							
	1	1.5	2.5	3.5	5	10	15	30
Ag-110	1.18E+00	1.18E+00	1.18E+00	1.18E+00	1.18E+00	1.19E+00	1.19E+00	1.20E+00
Ag-110m	1.33E-01	1.66E-01	2.26E-01	2.87E-01	3.80E-01	6.66E-01	8.60E-01	1.41E+00
Ag-111	3.55E-01	3.55E-01	3.55E-01	3.56E-01	3.57E-01	3.60E-01	3.62E-01	3.68E-01
Cd-113m	1.85E-01	1.85E-01	1.85E-01	1.85E-01	1.85E-01	1.85E-01	1.85E-01	1.85E-01
Cd-115m	6.05E-01	6.06E-01	6.06E-01	6.07E-01	6.08E-01	6.11E-01	6.14E-01	6.20E-01
Sn-113	1.00E-02	1.16E-02	1.41E-02	1.59E-02	1.81E-02	2.19E-02	2.33E-02	2.61E-02
Sn-123	5.23E-01	5.23E-01	5.23E-01	5.23E-01	5.23E-01	5.24E-01	5.25E-01	5.26E-01
Sn-125	8.10E-01	8.14E-01	8.21E-01	8.28E-01	8.39E-01	8.72E-01	8.96E-01	9.61E-01
Sn-126	1.41E-01	1.42E-01	1.45E-01	1.47E-01	1.50E-01	1.59E-01	1.63E-01	1.75E-01
Sb-124	4.18E-01	4.38E-01	4.77E-01	5.15E-01	5.75E-01	7.58E-01	8.86E-01	1.24E+00
Sb-125	1.13E-01	1.19E-01	1.31E-01	1.42E-01	1.59E-01	2.11E-01	2.41E-01	3.29E-01
Sb-126	4.16E-01	4.50E-01	5.13E-01	5.77E-01	6.76E-01	9.77E-01	1.17E+00	1.73E+00
Sb-126m	6.67E-01	6.86E-01	7.22E-01	7.58E-01	8.15E-01	9.86E-01	1.09E+00	1.41E+00
Sb-127	3.32E-01	3.40E-01	3.56E-01	3.73E-01	3.98E-01	4.75E-01	5.23E-01	6.64E-01
Te-125m	1.14E-01	1.16E-01	1.20E-01	1.23E-01	1.27E-01	1.34E-01	1.37E-01	1.41E-01
Te-127m	8.42E-02	8.48E-02	8.60E-02	8.69E-02	8.81E-02	9.03E-02	9.11E-02	9.24E-02
Te-127	2.25E-01	2.25E-01	2.25E-01	2.25E-01	2.25E-01	2.26E-01	2.26E-01	2.27E-01
Te-129m	2.73E-01	2.74E-01	2.75E-01	2.77E-01	2.78E-01	2.83E-01	2.86E-01	2.93E-01
Te-129	5.46E-01	5.47E-01	5.49E-01	5.51E-01	5.53E-01	5.61E-01	5.65E-01	5.77E-01
Te-131m	2.18E-01	2.35E-01	2.68E-01	3.00E-01	3.51E-01	5.03E-01	6.05E-01	8.94E-01
Te-131	7.22E-01	7.27E-01	7.36E-01	7.46E-01	7.62E-01	8.10E-01	8.38E-01	9.26E-01
Te-132	1.19E-01	1.22E-01	1.29E-01	1.36E-01	1.48E-01	1.79E-01	1.94E-01	2.45E-01
Te-133	7.13E-01	7.26E-01	7.52E-01	7.78E-01	8.18E-01	9.41E-01	1.02E+00	1.26E+00
Te-133m	4.26E-01	4.48E-01	4.89E-01	5.30E-01	5.93E-01	7.85E-01	9.14E-01	1.28E+00
Te-134	2.47E-01	2.58E-01	2.79E-01	3.00E-01	3.33E-01	4.33E-01	4.92E-01	6.72E-01
I-125	2.55E-02	2.80E-02	3.26E-02	3.63E-02	4.10E-02	4.96E-02	5.23E-02	5.76E-02
I-129	6.80E-02	6.92E-02	7.15E-02	7.35E-02	7.62E-02	8.16E-02	8.33E-02	8.69E-02
I-130	3.26E-01	3.53E-01	4.01E-01	4.51E-01	5.28E-01	7.62E-01	9.11E-01	1.34E+00
I-131	2.01E-01	2.06E-01	2.15E-01	2.24E-01	2.39E-01	2.84E-01	3.10E-01	3.88E-01
I-132	5.41E-01	5.69E-01	6.19E-01	6.70E-01	7.48E-01	9.87E-01	1.15E+00	1.60E+00
I-133	4.28E-01	4.35E-01	4.50E-01	4.64E-01	4.86E-01	5.54E-01	5.97E-01	7.20E-01
I-134	6.31E-01	6.62E-01	7.18E-01	7.75E-01	8.63E-01	1.13E+00	1.31E+00	1.83E+00

Table D-2 Effective Energy Deposited (MeV/nt) in Tissue of Given Radius (cont.)

Nuclide	Radius (cm)							
	1	1.5	2.5	3.5	5	10	15	30
I-134m	1.01E-01	1.05E-01	1.14E-01	1.22E-01	1.35E-01	1.72E-01	1.91E-01	2.51E-01
I-135	3.75E-01	3.92E-01	4.24E-01	4.57E-01	5.06E-01	6.59E-01	7.68E-01	1.07E+00
Xe-131m	1.49E-01	1.50E-01	1.52E-01	1.54E-01	1.56E-01	1.60E-01	1.61E-01	1.64E-01
Xe-133m	1.95E-01	1.96E-01	1.99E-01	2.01E-01	2.03E-01	2.10E-01	2.13E-01	2.20E-01
Xe-133	1.40E-01	1.42E-01	1.44E-01	1.46E-01	1.49E-01	1.58E-01	1.61E-01	1.70E-01
Xe-135m	1.11E-01	1.16E-01	1.27E-01	1.37E-01	1.53E-01	2.02E-01	2.32E-01	3.17E-01
Xe-135	3.27E-01	3.30E-01	3.35E-01	3.42E-01	3.51E-01	3.82E-01	3.98E-01	4.52E-01
Xe-137	1.70E+00	1.70E+00	1.71E+00	1.71E+00	1.72E+00	1.74E+00	1.75E+00	1.79E+00
Xe-138	6.79E-01	6.90E-01	7.13E-01	7.35E-01	7.69E-01	8.76E-01	9.52E-01	1.16E+00
Cs-134m	1.15E-01	1.15E-01	1.17E-01	1.18E-01	1.20E-01	1.24E-01	1.26E-01	1.31E-01
Cs-134	1.98E-01	2.17E-01	2.53E-01	2.88E-01	3.44E-01	5.11E-01	6.21E-01	9.35E-01
Cs-135	8.94E-02	8.94E-02	8.94E-02	8.94E-02	8.94E-02	8.94E-02	8.94E-02	8.94E-02
Cs-136	1.90E-01	2.15E-01	2.62E-01	3.09E-01	3.81E-01	6.04E-01	7.53E-01	1.18E+00
Cs-137	1.88E-01	1.88E-01	1.88E-01	1.88E-01	1.88E-01	1.88E-01	1.88E-01	1.88E-01
Cs-138	1.29E+00	1.31E+00	1.36E+00	1.41E+00	1.48E+00	1.70E+00	1.86E+00	2.30E+00
Cs-139	1.66E+00	1.67E+00	1.67E+00	1.68E+00	1.69E+00	1.72E+00	1.74E+00	1.79E+00
Ba-133	6.85E-02	7.48E-02	8.70E-02	9.91E-02	1.18E-01	1.71E-01	1.97E-01	2.79E-01
Ba-137m	7.89E-02	8.65E-02	1.00E-01	1.14E-01	1.36E-01	2.01E-01	2.43E-01	3.64E-01
Ba-139	9.02E-01	9.03E-01	9.04E-01	9.05E-01	9.07E-01	9.13E-01	9.16E-01	9.26E-01
Ba-140	3.26E-01	3.28E-01	3.33E-01	3.38E-01	3.45E-01	3.66E-01	3.79E-01	4.16E-01
Ba-141	9.82E-01	9.92E-01	1.01E+00	1.03E+00	1.07E+00	1.17E+00	1.23E+00	1.42E+00
Ba-142	4.36E-01	4.49E-01	4.72E-01	4.95E-01	5.31E-01	6.42E-01	7.14E-01	9.23E-01
La-140	5.76E-01	6.00E-01	6.47E-01	6.94E-01	7.67E-01	9.90E-01	1.15E+00	1.58E+00
La-141	9.88E-01	9.88E-01	9.89E-01	9.89E-01	9.90E-01	9.93E-01	9.95E-01	1.00E+00
La-142	9.04E-01	9.26E-01	9.70E-01	1.01E+00	1.08E+00	1.29E+00	1.45E+00	1.87E+00
Ce-141	1.73E-01	1.74E-01	1.76E-01	1.78E-01	1.82E-01	1.92E-01	1.97E-01	2.15E-01
Ce-143	4.44E-01	4.48E-01	4.56E-01	4.64E-01	4.76E-01	5.11E-01	5.30E-01	5.87E-01
Ce-144	9.23E-02	9.25E-02	9.31E-02	9.38E-02	9.48E-02	9.76E-02	9.88E-02	1.03E-01
Pr-143	3.15E-01	3.15E-01	3.15E-01	3.15E-01	3.15E-01	3.15E-01	3.15E-01	3.15E-01
Pr-144	1.21E+00	1.21E+00	1.21E+00	1.21E+00	1.21E+00	1.21E+00	1.22E+00	1.22E+00
Pr-144m	4.89E-02	4.93E-02	5.01E-02	5.09E-02	5.20E-02	5.47E-02	5.57E-02	5.78E-02
Nd-147	2.74E-01	2.76E-01	2.80E-01	2.84E-01	2.91E-01	3.10E-01	3.20E-01	3.48E-01

Table D-2 Effective Energy Deposited (MeV/nt) in Tissue of Given Radius (cont.)

Nuclide	Radius (cm)							
	1	1.5	2.5	3.5	5	10	15	30
Pm-147	6.19E-02	6.19E-02	6.19E-02	6.19E-02	6.19E-02	6.19E-02	6.19E-02	6.19E-02
Pm-148m	2.15E-01	2.39E-01	2.85E-01	3.31E-01	4.03E-01	6.23E-01	7.62E-01	1.16E+00
Pm-148	7.40E-01	7.46E-01	7.58E-01	7.70E-01	7.89E-01	8.46E-01	8.86E-01	9.97E-01
Pm-149	3.65E-01	3.65E-01	3.66E-01	3.66E-01	3.67E-01	3.68E-01	3.69E-01	3.71E-01
Pm-151	3.13E-01	3.17E-01	3.25E-01	3.33E-01	3.47E-01	3.87E-01	4.09E-01	4.77E-01
Sm-151	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02
Sm-153	2.73E-01	2.74E-01	2.76E-01	2.78E-01	2.82E-01	2.93E-01	2.98E-01	3.11E-01
Eu-152	1.54E-01	1.68E-01	1.94E-01	2.21E-01	2.61E-01	3.86E-01	4.68E-01	6.99E-01
Eu-154	2.99E-01	3.13E-01	3.40E-01	3.68E-01	4.10E-01	5.39E-01	6.27E-01	8.74E-01
Eu-155	6.67E-02	6.75E-02	6.92E-02	7.10E-02	7.41E-02	8.38E-02	8.78E-02	1.02E-01
Eu-156	4.80E-01	4.93E-01	5.18E-01	5.43E-01	5.81E-01	7.00E-01	7.85E-01	1.02E+00
Tb-160	2.83E-01	2.96E-01	3.21E-01	3.46E-01	3.84E-01	5.02E-01	5.81E-01	8.05E-01
Ho-166m	1.87E-01	2.07E-01	2.44E-01	2.82E-01	3.41E-01	5.21E-01	6.35E-01	9.68E-01
Tm-170	3.28E-01	3.28E-01	3.29E-01	3.29E-01	3.29E-01	3.29E-01	3.30E-01	3.31E-01
Yb-169	1.60E-01	1.64E-01	1.72E-01	1.81E-01	1.97E-01	2.45E-01	2.75E-01	3.46E-01
W-181	1.61E-02	1.66E-02	1.77E-02	1.89E-02	2.10E-02	2.76E-02	3.19E-02	4.00E-02
W-185	1.27E-01	1.27E-01	1.27E-01	1.27E-01	1.27E-01	1.27E-01	1.27E-01	1.27E-01
W-187	3.10E-01	3.16E-01	3.26E-01	3.37E-01	3.54E-01	4.05E-01	4.37E-01	5.28E-01
Ta-182	2.38E-01	2.52E-01	2.80E-01	3.08E-01	3.50E-01	4.84E-01	5.74E-01	8.28E-01
Ir-192	2.37E-01	2.47E-01	2.66E-01	2.86E-01	3.18E-01	4.14E-01	4.69E-01	6.38E-01
Au-198	3.37E-01	3.42E-01	3.52E-01	3.62E-01	3.77E-01	4.24E-01	4.52E-01	5.33E-01
Tl-201	5.10E-02	5.23E-02	5.47E-02	5.73E-02	6.17E-02	7.55E-02	8.17E-02	1.03E-01
Tl-204	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.38E-01	2.38E-01	2.38E-01
Pb-210	4.29E-02	4.32E-02	4.35E-02	4.37E-02	4.39E-02	4.44E-02	4.47E-02	4.51E-02
Bi-210	3.89E-01	3.89E-01	3.89E-01	3.89E-01	3.89E-01	3.89E-01	3.89E-01	3.89E-01
Po-210	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00
Rn-222	5.59E+00	5.59E+00	5.59E+00	5.59E+00	5.59E+00	5.59E+00	5.59E+00	5.59E+00
Ra-223	5.85E+00	5.86E+00	5.86E+00	5.86E+00	5.87E+00	5.89E+00	5.90E+00	5.93E+00
Ra-225	1.07E-01	1.08E-01	1.09E-01	1.09E-01	1.11E-01	1.13E-01	1.15E-01	1.17E-01
Ra-224	5.78E+00	5.78E+00	5.78E+00	5.78E+00	5.78E+00	5.78E+00	5.78E+00	5.78E+00
Ra-226	4.86E+00	4.86E+00	4.86E+00	4.86E+00	4.87E+00	4.87E+00	4.87E+00	4.87E+00
Ra-228	1.50E-02	1.52E-02	1.55E-02	1.57E-02	1.59E-02	1.61E-02	1.61E-02	1.62E-02

Table D-2 Effective Energy Deposited (MeV/nt) in Tissue of Given Radius (cont.)

Nuclide	Radius (cm)							
	1	1.5	2.5	3.5	5	10	15	30
Ac-225	5.92E+00	5.92E+00	5.92E+00	5.92E+00	5.92E+00	5.92E+00	5.92E+00	5.93E+00
Ac-227	8.50E-02	8.50E-02	8.51E-02	8.52E-02	8.52E-02	8.52E-02	8.53E-02	8.53E-02
Th-227	6.07E+00	6.07E+00	6.08E+00	6.08E+00	6.09E+00	6.10E+00	6.11E+00	6.14E+00
Th-228	5.52E+00	5.52E+00	5.52E+00	5.52E+00	5.52E+00	5.52E+00	5.52E+00	5.52E+00
Th-229	5.09E+00	5.09E+00	5.10E+00	5.10E+00	5.10E+00	5.12E+00	5.12E+00	5.14E+00
Th-230	4.77E+00	4.77E+00	4.77E+00	4.77E+00	4.77E+00	4.77E+00	4.77E+00	4.77E+00
Th-232	4.08E+00	4.08E+00	4.08E+00	4.08E+00	4.08E+00	4.08E+00	4.08E+00	4.08E+00
Th-234	6.35E-02	6.37E-02	6.41E-02	6.45E-02	6.50E-02	6.65E-02	6.71E-02	6.92E-02
Pa-231	5.12E+00	5.12E+00	5.12E+00	5.12E+00	5.13E+00	5.13E+00	5.13E+00	5.14E+00
Pa-233	2.25E-01	2.29E-01	2.35E-01	2.41E-01	2.50E-01	2.77E-01	2.91E-01	3.37E-01
U-232	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00
U-233	4.91E+00	4.91E+00	4.91E+00	4.91E+00	4.91E+00	4.91E+00	4.91E+00	4.91E+00
U-234	4.86E+00	4.86E+00	4.86E+00	4.86E+00	4.86E+00	4.86E+00	4.86E+00	4.86E+00
U-235	4.53E+00	4.53E+00	4.54E+00	4.54E+00	4.55E+00	4.57E+00	4.58E+00	4.62E+00
U-236	4.57E+00	4.57E+00	4.57E+00	4.57E+00	4.57E+00	4.57E+00	4.57E+00	4.57E+00
U-237	2.09E-01	2.11E-01	2.16E-01	2.20E-01	2.27E-01	2.46E-01	2.55E-01	2.86E-01
U-238	4.27E+00	4.27E+00	4.27E+00	4.27E+00	4.27E+00	4.27E+00	4.27E+00	4.27E+00
Np-237	4.92E+00	4.93E+00	4.93E+00	4.93E+00	4.93E+00	4.94E+00	4.94E+00	4.94E+00
Np-238	2.67E-01	2.74E-01	2.88E-01	3.01E-01	3.20E-01	3.80E-01	4.21E-01	5.37E-01
Np-239	2.72E-01	2.75E-01	2.80E-01	2.85E-01	2.93E-01	3.17E-01	3.28E-01	3.68E-01
Pu-236	5.87E+00	5.87E+00	5.87E+00	5.87E+00	5.87E+00	5.87E+00	5.87E+00	5.87E+00
Pu-238	5.59E+00	5.59E+00	5.59E+00	5.59E+00	5.59E+00	5.59E+00	5.59E+00	5.59E+00
Pu-239	5.24E+00	5.24E+00	5.24E+00	5.24E+00	5.24E+00	5.24E+00	5.24E+00	5.24E+00
Pu-240	5.25E+00	5.26E+00	5.26E+00	5.26E+00	5.26E+00	5.26E+00	5.26E+00	5.26E+00
Pu-241	5.36E-03	5.36E-03	5.36E-03	5.36E-03	5.36E-03	5.36E-03	5.36E-03	5.36E-03
Pu-242	4.98E+00	4.98E+00	4.98E+00	4.99E+00	4.99E+00	4.99E+00	4.99E+00	4.99E+00
Pu-244	4.89E+00	4.89E+00	4.89E+00	4.89E+00	4.89E+00	4.89E+00	4.89E+00	4.90E+00
Am-241	5.61E+00	5.61E+00	5.62E+00	5.62E+00	5.62E+00	5.62E+00	5.63E+00	5.63E+00
Am-242m	7.03E-02	7.08E-02	7.14E-02	7.18E-02	7.22E-02	7.27E-02	7.29E-02	7.31E-02
Am-243	5.38E+00	5.39E+00	5.39E+00	5.39E+00	5.39E+00	5.40E+00	5.41E+00	5.42E+00
Cm-242	6.21E+00	6.21E+00	6.22E+00	6.22E+00	6.22E+00	6.22E+00	6.22E+00	6.22E+00
Cm-243	6.04E+00	6.04E+00	6.04E+00	6.05E+00	6.05E+00	6.07E+00	6.08E+00	6.10E+00

Table D-2 Effective Energy Deposited (MeV/nt) in Tissue of Given Radius (cont.)

Nuclide	Radius (cm)							
	1	1.5	2.5	3.5	5	10	15	30
Cm-244	5.90E+00	5.90E+00	5.90E+00	5.90E+00	5.90E+00	5.90E+00	5.90E+00	5.90E+00
Cm-245	5.54E+00	5.54E+00	5.54E+00	5.55E+00	5.55E+00	5.57E+00	5.57E+00	5.59E+00
Cm-246	5.52E+00	5.52E+00	5.52E+00	5.52E+00	5.53E+00	5.53E+00	5.53E+00	5.53E+00
Cm-247	5.05E+00	5.05E+00	5.06E+00	5.07E+00	5.08E+00	5.12E+00	5.14E+00	5.20E+00
Cm-248	2.13E+01	2.13E+01	2.13E+01	2.13E+01	2.14E+01	2.15E+01	2.16E+01	2.18E+01
Cf-252	1.24E+01	1.24E+01	1.24E+01	1.24E+01	1.24E+01	1.24E+01	1.25E+01	1.26E+01

D.2 References

1. **ICRP Publication 107**, “Nuclear Decay Data for Dosimetric Calculations,” *Annals of the ICRP*, Vol. 38, No. 3, International Commission on Radiological Protection, Pergamon Press, London, 2008.

2. Stabin, M.G. and M.W. Konijnenberg, “Re-evaluation of absorbed fractions for photons and electrons in spheres of various sizes,” *J. Nucl. Med.*, 41:149–160, 2000.

3. **LA-UR-17-29981**, “MCNP User’s Manual—Code Version 6.2,” C.J. Werner (Ed.), Los Alamos National Laboratory, Los Alamos, New Mexico, 2017.

APPENDIX E
ASSUMED F_1 VALUES AND INHALATION CLASS

NRCDose3 contains data on 203 radionuclides that can be assumed to exist in multiple forms for ingestion and inhalation. This appendix lists the forms of each radionuclide available for selection in NRCDose3.

E.1 NRCDose3—ICRP-30 Dosimetric Methodology

Table E-1 outlines the f_1 values and the ingestion and inhalation classes available for selection in NRCDose3 when the user has selected the methodology of International Commission on Radiological Protection (ICRP) Publication 30, “Limits for Intakes of Radionuclides by Workers” (ICRP-30), issued 1979 [Ref. 1]. The default form is noted for both ingestion and inhalation.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
H-3	1	X	All forms	1	X	V	Water vapor
Be-10	0.005	X	All forms	0.005		W	All others
				0.005	X	Y	Oxides, halides, and nitrates
C-14	1	X	Organic	1		c	Organic forms
				1		m	Monoxides
				1	X	d	Dioxide
N-13		X			X		
F-18	1	X	All forms	1	X	D	See assignment of associated element
				1		W	See assignment of associated element
				1		Y	See assignment of associated element
Na-22	1	X	All forms	1	X	D	All forms
Na-24	1	X	All forms	1	X	D	All forms
P-32	0.8	X	All forms	0.8	X	D	
				0.8		W	Phosphates of particular element
S-35	0.8		All inorganic forms	0.8		D	Sulfides and sulfates of associated elements
	0.1	X	Elemental	0.8		W	Elemental
				1	X	V	Gases
Cl-36	1	X	All forms	1		D	See assignment of associated element
				1	X	W	See assignment of associated element
Ar-39					X		
Ar-41					X		
Ca-41	0.3	X	All forms	0.3	X	W	All forms
Ca-45	0.3	X	All forms	0.3	X	W	All forms
Sc-46	0.0001	X	All forms	0.0001	X	Y	All forms

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
Mn-54	0.1	X	All forms	0.1		D	All others
				0.1	X	W	Oxides, hydroxides, halides, and nitrates
Mn-56	0.1	X	All forms	0.1		D	All others
				0.1	X	W	Oxides, hydroxides, halides, and nitrates
Fe-55	0.1	X	All forms	0.1		D	All others
				0.1	X	W	Oxides, hydroxides, and halides
	0.1	X	All forms	0.1		D	All others
				0.1	X	W	Oxides, hydroxides, and halides
Co-57	0.05	X	Oxides, hydroxides, and trace inorganic	0.05		W	All others
	0.3		Organic complexed and other inorganics	0.05	X	Y	Oxides, hydroxides, halides, and nitrates
Co-58	0.05	X	Oxides, hydroxides, and trace inorganic	0.05		W	All others
	0.3		Organic complexed and other inorganics	0.05	X	Y	Oxides, hydroxides, halides, and nitrates
Co-60	0.05	X	Oxides, hydroxides, and trace inorganic	0.05		W	All others
	0.3		Organic complexed and other inorganics	0.05	X	Y	Oxides, hydroxides, halides, and nitrates
Ni-59	0.05	X	All forms	0.05		D	All others
				0.05	X	W	Oxides, hydroxides, and carbides
				10		V	Vapors
Ni-63	0.05	X	All forms	0.05		D	All others
				0.05	X	W	Oxides, hydroxides, and carbides
				10		V	Vapors
Ni-65	0.05		All forms	0.05		D	All others
				0.05	X	W	Oxides, hydroxides, and carbides
				10		V	Vapors
Cu-64	0.5	X	All forms	0.5		D	All others
				0.5		W	Sulfites, halides, and nitrates
				0.5	X	Y	Oxides and hydroxides
Zn-65	0.5	X	All forms	0.5	X	Y	All forms
Zn-69m	0.5	X	All forms	0.5	X	Y	All forms
Zn-69	0.5	X	All forms	0.5	X	Y	All forms

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
Ga-67	0.001	X	All forms	0.001		D	All others
				0.001	X	W	Oxides, hydroxides, carbides, halides, and nitrates
Se-75	0.8		All others	0.8		D	All others
	0.05	X	Elemental	0.8	X	W	Oxides, hydroxides, carbides, and elemental
Se-79	0.8		All others	0.8		D	All others
	0.05	X	Elemental	0.8	X	W	Oxides, hydroxides, carbides, and elemental
Br-82	1	X	All forms	1	X	D	See bromide assignment of associated element
				1		W	See bromide assignment of associated element
Br-83	1	X	All forms	1	X	D	See bromide assignment of associated element
				1		W	See bromide assignment of associated element
Br-84	1	X	All forms	1	X	D	See bromide assignment of associated element
				1		W	See bromide assignment of associated element
Br-85		X	All forms		X		
Kr-83m		X			X		
Kr-85m		X			X		
Kr-85		X			X		
Kr-87		X			X		
Kr-88		X			X		
Kr-89		X			X		
Rb-86	1	X	All forms	1	X	D	All forms
Rb-87		X	All forms		X		
Rb-88	1	X	All forms	1	X	D	All forms
Rb-89	1	X	All forms	1	X	D	All forms
Sr-85	0.3	X	Soluble salts	0.3	Y	D	All others
	0.01		$SrTiO_3$	0.01		Y	$SrTiO_3$
Sr-89	0.3	X	Soluble salts	0.3	Y	D	All others
	0.01		$SrTiO_3$	0.01		Y	$SrTiO_3$
Sr-90	0.3	X	Soluble salts	0.3	Y	D	All others
	0.01		$SrTiO_3$	0.01		Y	$SrTiO_3$
Sr-91	0.3	X	Soluble salts	0.3	Y	D	All others
	0.01		$SrTiO_3$	0.01		Y	$SrTiO_3$
Sr-92	0.3	X	Soluble salts	0.3	Y	D	All others
	0.01		$SrTiO_3$	0.01		Y	$SrTiO_3$
Y-90	0.0001	X	All forms	0.0001		W	All others
				0.0001	X	Y	Oxides and hydroxides
Y-91m	0.0001	X	All forms	0.0001		W	All others
				0.0001	X	Y	Oxides and hydroxides
Y-91	0.0001	X	All forms	0.0001		W	All others
				0.0001	X	Y	Oxides and hydroxides

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
Y-92	0.0001	X	All forms	0.0001		W	All others
				0.0001	X	Y	Oxides and hydroxides
Y-93	0.0001	X	All forms	0.0001		W	All others
				0.0001	X	Y	Oxides and hydroxides
Zr-93	0.002	X	All forms	0.002		D	All others
				0.002	X	W	Oxides, hydroxides, halides, and nitrates
				0.002		Y	Carbides
Zr-95	0.002	X	All forms	0.002		D	All others
				0.002	X	W	Oxides, hydroxides, halides, and nitrates
				0.002		Y	Carbides
Zr-97	0.002	X	All forms	0.002		D	All others
				0.002	X	W	Oxides, hydroxides, halides, and nitrates
				0.002		Y	Carbides
Nb-93m	0.01	X	All forms	0.01		W	All others
				0.01	X	Y	Oxides and hydroxides
Nb-95	0.01	X	All forms	0.01		W	All others
				0.01	X	Y	Oxides and hydroxides
Nb-97	0.01	X	All forms	0.01		W	All others
				0.01	X	Y	Oxides and hydroxides
Mo-93	0.8	X	All others	0.8		D	All others
	0.05		MoS_2	0.05	X	Y	Oxides, hydroxides, and MoS_2
Mo-99	0.8	X	All others	0.8		D	All others
	0.05		MoS_2	0.05	X	Y	Oxides, hydroxides, and MoS_2
Tc-99m	0.8	X	All forms	0.8		D	All others
				0.8	X	W	Oxides, hydroxides, halides, and nitrates
Tc-99	0.8	X	All forms	0.8		D	All others
				0.8	X	W	Oxides, hydroxides, halides, and nitrates
Tc-101	0.8	X	All forms	0.8		D	All others
				0.8	X	W	Oxides, hydroxides, halides, and nitrates
Ru-103	0.05	X	All forms	0.05		D	All others
				0.05		W	Halides
				0.05	X	Y	Oxides and hydroxides
Ru-105	0.05	X	All forms	0.05		D	All others
				0.05		W	Halides
				0.05	X	Y	Oxides and hydroxides
Ru-106	0.05	X	All forms	0.05		D	All others
				0.05		W	Halides
				0.05	X	Y	Oxides and hydroxides
Rh-105	0.05	X	All forms	0.05		D	All others
				0.05		W	Halides
				0.05	X	Y	Oxides and hydroxides

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
Ru-106	0.05	X	All forms	0.05		D	All others
				0.05		W	Halides
				0.05	X	Y	Oxides and hydroxides
Rh-105	0.05	X	All forms	0.05		D	All others
				0.05		W	Halides
				0.05	X	Y	Oxides and hydroxides
Pd-107	0.005	X	All forms	0.005		D	All others
				0.005		W	Nitrates
				0.005	X	Y	Oxides and hydroxides
Pd-109	0.005	X	All forms	0.005		D	All others
				0.005		W	Nitrates
				0.005	X	Y	Oxides and hydroxides
Ag-110m	0.05	X	All forms	0.05		D	All others
				0.05		W	Nitrates and sulfides
				0.05	X	Y	Oxides and hydroxides
Ag-111	0.05	X	All forms	0.05		D	All others
				0.05		W	Nitrates and sulfides
				0.05	X	Y	Oxides and hydroxides
Cd-109	0.05	X	All forms	0.05		D	All others
				0.05		W	Sulfates, halides, and nitrates
				0.05	X	Y	Oxides and hydroxides
Cd-113m	0.05	X	All forms	0.05		D	All others
				0.05		W	Sulfates, halides, and nitrates
				0.05	X	Y	Oxides and hydroxides
Cd-115m	0.05	X	All forms	0.05		D	All others
				0.05		W	Sulfates, halides, and nitrates
				0.05	X	Y	Oxides and hydroxides
Sn-113	0.02	X	All forms	0.02		D	All others
				0.02	X	W	Oxides, hydroxides, halides, nitrates, sulfides, and $Sn_3(PO_4)_4$
Sn-123	0.02	X	All forms	0.02		D	All others
				0.02	X	W	Oxides, hydroxides, halides, nitrates, sulfides, and $Sn_3(PO_4)_4$
Sn-125	0.02	X	All forms	0.02		D	All others
				0.02	X	W	Oxides, hydroxides, halides, nitrates, sulfides, and $Sn_3(PO_4)_4$
Sn-126	0.02	X	All forms	0.02		D	All others
				0.02	X	W	Oxides, hydroxides, halides, nitrates, sulfides, and $Sn_3(PO_4)_4$

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
Sb-124	0.1		Tartar emetic	0.1		D	All others
	0.01	X	All others	0.01	X	W	Oxides, hydroxides, halides, sulfides, sulfates, and nitrates
Sb-125	0.1		Tartar emetic	0.1		D	All others
	0.01	X	All others	0.01	X	W	Oxides, hydroxides, halides, sulfides, sulfates, and nitrates
Sn-126	0.02	X	All forms	0.02		D	All others
				0.02	X	W	Oxides, hydroxides, halides, nitrates, sulfides, and $Sn_3(PO_4)_4$
Sb-124	0.1		Tartar emetic	0.1		D	All others
	0.01	X	All others	0.01	X	W	Oxides, hydroxides, halides, sulfides, sulfates, and nitrates
Sb-125	0.1		Tartar emetic	0.1		D	All others
	0.01	X	All others	0.01	X	W	Oxides, hydroxides, halides, sulfides, sulfates, and nitrates
Sb-126	0.1		Tartar emetic	0.1		D	All others
	0.01	X	All others	0.01	X	W	Oxides, hydroxides, halides, sulfides, sulfates, and nitrates
Sb-127	0.1		Tartar emetic	0.1		D	All others
	0.01	X	All others	0.01	X	W	Oxides, hydroxides, halides, sulfides, sulfates, and nitrates
Te-125m	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides, and nitrates
Te-127m	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides, and nitrates
Te-127	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides, and nitrates
Te-129m	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides, and nitrates
Te-129	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides and nitrates
Te-131m	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides, and nitrates
Te-131	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides, and nitrates

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
Te-132	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides, and nitrates
Te-133m	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides, and nitrates
Te-134	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides, and nitrates
I-125	1	X	All forms	1	X	D	All forms
I-129	1	X	All forms	1	X	D	All forms
I-130	1	X	All forms	1	X	D	All forms
I-131	1	X	All forms	1	X	D	All forms
I-132	1	X	All forms	1	X	D	All forms
I-133	1	X	All forms	1	X	D	All forms
I-134	1	X	All forms	1	X	D	All forms
I-135	1	X	All forms	1	X	D	All forms
Xe-131m		X			X		
Xe-133m		X			X		
Xe-133		X			X		
Xe-135m		X			X		
Xe-135		X			X		
Xe-137		X			X		
Xe-138		X			X		
Cs-134m	1	X	All forms	1	X	D	All forms
Cs-134	1	X	All forms	1	X	D	All forms
Cs-135	1	X	All forms	1	X	D	All forms
Cs-136	1	X	All forms	1	X	D	All forms
Cs-137	1	X	All forms	1	X	D	All forms
Cs-138	1	X	All forms	1	X	D	All forms
Cs-139	1	X	All forms	1	X	D	All forms
Ba-133	0.1	X	All forms	0.1	X	D	All forms
Ba-139	0.1	X	All forms	0.1	X	D	All forms
Ba-140	0.1	X	All forms	0.1	X	D	All forms
Ba-141	0.1	X	All forms	0.1	X	D	All forms
Ba-142	0.1	X	All forms	0.1	X	D	All forms
La-140	0.001	X	All forms	0.001		D	All others
				0.001	X	W	Oxides and hydroxides
La-141	0.001	X	All forms	0.001		D	All others
				0.001	X	W	Oxides and hydroxides
La-142	0.001	X	All forms	0.001		D	All others
				0.001	X	W	Oxides and hydroxides
Ce-141	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, and fluorides
Ce-143	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, and fluorides

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
Ce-144	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, and fluorides
Pr-143	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, carbide, and fluorides
Pr-144	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, carbide, and fluorides
Nd-147	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, carbides, and fluorides
Pm-147	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, carbides, and fluorides
Pm-148m	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, carbides, and fluorides
Pm-148	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, carbides, and fluorides
Pm-149	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, carbides, and fluorides
Pm-151	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, carbides, and fluorides
Sm-151	0.0003	X	All forms	0.0003	X	W	All forms
Sm-153	0.0003	X	All forms	0.0003	X	W	All forms
Eu-152	0.001	X	All forms	0.001	X	W	All forms
Eu-154	0.001	X	All forms	0.001	X	W	All forms
Eu-155	0.001	X	All forms	0.001	X	W	All forms
Eu-156	0.001	X	All forms	0.001	X	W	All forms
Tb-160	0.0003	X	All forms	0.0003	X	W	All forms
Ho-166m	0.0003	X	All forms	0.0003	X	W	All forms
Tm-170	0.0003	X	All forms	0.0003	X	W	All forms
Yb-169	0.0003	X	All forms	0.0003		W	All others
				0.0003	X	Y	Oxides, hydroxides, and fluorides
Ta-182	0.001	X	All forms	0.001		W	All others
				0.001	X	Y	Oxides, hydroxides, halides, carbides, nitrates, and nitrides
W-181	0.01		Tungstic acid	0.3	X	D	All forms
	0.3	X	All others				
W-185	0.01		Tungstic acid	0.3	X	D	All forms
	0.3	X	All others				
W-187	0.01		Tungstic acid	0.3	X	D	All forms
	0.3	X	All others				

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
Ir-192	0.01	X	All forms	0.01		D	All others
				0.01		W	Halides, nitrates, and metallic form
				0.01	X	Y	Oxides and hydroxides
Au-198	0.1	X	All forms	0.1		D	All others
				0.1		W	Halides and nitrates
				0.1	X	Y	Oxides and hydroxides
Tl-201	1	X	All forms	1	X	D	All forms
Tl-204	1	X	All forms	1	X	D	All forms
Pb-210	0.2	X	All forms	0.2	X	D	All forms
Bi-210	0.05	X	All forms	0.05		D	Nitrates
				0.05	Y	W	All others
Po-210	0.1	X	All forms	0.1		D	All others
				0.1	X	W	Oxides, hydroxides, and nitrates
Rn-222							
Ra-223	0.2	X	All forms	0.2	X	W	All forms
Ra-224	0.2	X	All forms	0.2	X	W	All forms
Ra-225	0.2	X	All forms	0.2	X	W	All forms
Ra-226	0.2	X	All forms	0.2	X	W	All forms
Ra-228	0.2	X	All forms	0.2	X	W	All forms
Ac-225	0.001	X	All forms	0.001		D	All others
				0.001		W	Halides and nitrates
				0.001	X	Y	Oxides and hydroxides
Ac-227	0.001	X	All forms	0.001		D	All others
				0.001		W	Halides and nitrates
				0.001	X	Y	Oxides and hydroxides
Th-227	0.0002	X	All forms	0.0002		W	All others
				0.0002	X	Y	Oxides and hydroxides
Th-228	0.0002	X	All forms	0.0002		W	All others
				0.0002	X	Y	Oxides and hydroxides
Th-229	0.0002	X	All forms	0.0002		W	All others
				0.0002	X	Y	Oxides and hydroxides
Th-230	0.0002	X	All forms	0.0002		W	All others
				0.0002	X	Y	Oxides and hydroxides
Th-232	0.0002	X	All forms	0.0002		W	All others
				0.0002	X	Y	Oxides and hydroxides
Th-234	0.0002	X	All forms	0.0002		W	All others
				0.0002	X	Y	Oxides and hydroxides
Pa-231	0.001	X	All forms	0.001		W	All others
				0.001	X	Y	Oxides and hydroxides
Pa-233	0.001	X	All forms	0.001		W	All others
				0.001	X	Y	Oxides and hydroxides
U-232	0.05		Hexavalent	0.05		D	UF_6, UO_2F_2, and $UO_2(NO_3)_2$
	0.002	X	Insoluble forms	0.05		W	UO_3, UF_4, and UCl_4
				0.002	X	Y	UO_2, U_3O_8

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
U-233	0.05		Hexavalent	0.05		D	UF_6, UO_2F_2, and $UO_2(NO_3)_2$
	0.002	X	Insoluble forms	0.05		W	UO_3, UF_4, and UCl_4
				0.002	X	Y	UO_2, U_3O_8
U-234	0.05		Hexavalent	0.05		D	UF_6, UO_2F_2, and $UO_2(NO_3)_2$
	0.002	X	Insoluble forms	0.05		W	UO_3, UF_4, and UCl_4
				0.002	X	Y	UO_2, U_3O_8
U-235	0.05		Hexavalent	0.05		D	UF_6, UO_2F_2, and $UO_2(NO_3)_2$
	0.002	X	Insoluble forms	0.05		W	UO_3, UF_4, and UCl_4
				0.002	X	Y	UO_2, U_3O_8
U-236	0.05		Hexavalent	0.05		D	UF_6, UO_2F_2, and $UO_2(NO_3)_2$
	0.002	X	Insoluble forms	0.05		W	UO_3, UF_4, and UCl_4
				0.002	X	Y	UO_2, U_3O_8
U-237	0.05		Hexavalent	0.05		D	UF_6, UO_2F_2, and $UO_2(NO_3)_2$
	0.002	X	Insoluble forms	0.05		W	UO_3, UF_4, and UCl_4
				0.002	X	Y	UO_2, U_3O_8
U-238	0.05		Hexavalent	0.05		D	UF_6, UO_2F_2, and $UO_2(NO_3)_2$
	0.002	X	Insoluble forms	0.05		W	UO_3, UF_4, and UCl_4
				0.002	X	Y	UO_2, U_3O_8
Np-237	0.001	X	All forms	0.001	X	W	All forms
Np-238	0.001	X	All forms	0.001	X	W	All forms
Np-239	0.001	X	All forms	0.001	X	W	All forms
Pu-236	0.001		Others	0.001		W	All others
	0.0001		Nitrates	1E-05	X	Y	Oxides
	0.00001	X	Oxides				
Pu-238	0.001		Others	0.001		W	All others
	0.0001		Nitrates	1E-05	X	Y	Oxides
	0.00001	X	Oxides				
Pu-239	0.001		Others	0.001		W	All others
	0.0001		Nitrates	1E-05	X	Y	Oxides
	0.00001	X	Oxides				
Pu-240	0.001		Others	0.001		W	All others
	0.0001		Nitrates	1E-05	X	Y	Oxides
	0.00001	X	Oxides				
Pu-241	0.001		Others	0.001		W	All others
	0.0001		Nitrates	1E-05	X	Y	Oxides
	0.00001	X	Oxides				
Pu-242	0.001		Others	0.001		W	All others
	0.0001		Nitrates	1E-05	X	Y	Oxides
	0.00001	X	Oxides				
Pu-244	0.001		Others	0.001		W	All others
	0.0001		Nitrates	1E-05	X	Y	Oxides
	0.00001	X	Oxides				
Am-241	0.001	X	All forms	0.001	X	W	All forms

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

Table E-1 NRCDose3—ICRP-30 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f_1	Default	Form	f_1	Default	Class	Form
Am-242m	0.001	X	All forms	0.001	X	W	All forms
Am-243	0.001	X	All forms	0.001	X	W	All forms
Cm-242	0.001	X	All forms	0.001	X	W	All forms
Cm-243	0.001	X	All forms	0.001	X	W	All forms
Cm-244	0.001	X	All forms	0.001	X	W	All forms
Cm-245	0.001	X	All forms	0.001	X	W	All forms
Cm-246	0.001	X	All forms	0.001	X	W	All forms
Cm-247	0.001	X	All forms	0.001	X	W	All forms
Cm-248	0.001	X	All forms	0.001	X	W	All forms
Cf-252	0.001	X	All forms	0.001		W	All others
				0.001	X	Y	Oxides and hydroxides

Notes:
ICRP-30 Inhalation Class D, W, and Y corresponds to days, weeks, and years classes, respectively.

E.2 NRCDose3—ICRP-72 Dosimetric Methodology

Table E-2 outlines the f_1 values and the ingestion and inhalation classes available for selection in NRCDose3 when the user has selected the methodology in ICRP Publication 72, "Age-Dependent Dose to Members of the Public from Intake of Radionuclides, Part 5: Compilation of Ingestion and Inhalation Dose Coefficients" (ICRP-72), issued 1996 [Ref. 2]. The default form is noted for both ingestion and inhalation.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
H-3	1 OBT		1 OBT		V
	1	X	1 HT		V
			1 CH_3T		V
			1 HTO	X	V
			1		F
			0.2		M
			0.02		S
Be-10	0.02	X	0.02		M
			0.02	X	S
C-14	1	X	1 CO_2	X	V
			1 CO		V
			1 CH_4		V
			1		V
			1		F
			0.2		M
			0.02		S
N-13		X		X	

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
F-18	1	X	1	X	F
			1		M
			1		S
Na-22	1	X	1	X	F
Na-24	1	X	1	X	F
P-32	1	X	1	X	F
			1		M
S-35	1		1 SO_2	Y	V
	1	X	1 CS_2		V
			1		F
			0.2		M
			0.02		S
Cl-36	1	X	1		F
			1	X	M
Ar-39		X		X	
Ar-41		X		X	
Ca-41	0.6	X	0.6		F
			0.2	X	M
			0.02		S
Ca-45	0.6	X	0.6		F
			0.2	X	M
			0.02		S
Sc-46	0.001	X	0.001	X	S
Cr-51	0.2		0.2		F
	0.02	X	0.2		M
			0.2	X	S
Mn-54	0.2	X	0.2		F
			0.2	X	M
Mn-56	0.2	X	0.2		F
			0.2	X	M
Fe-55	0.6	X	0.6		F
			0.2	X	M
			0.02		S
Fe-59	0.6	X	0.6		F
			0.2	X	M
			0.02		S
Co-57	0.6	X	0.6		F
			0.2		M
			0.02	X	S
Co-58	0.6	X	0.6		F
			0.2		M
			0.02	X	S
Co-60	0.6	X	0.6		F
			0.2		M
			0.02	X	S

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
Ni-59	0.1	X	0.1		V
			0.1		F
			0.1	X	M
			0.02		S
Ni-63	0.1	X	0.1		V
			0.1		F
			0.1	X	M
			0.02		S
Ni-65	0.1	X	0.1		V
			0.1		F
			0.1	X	M
			0.02		S
Cu-64	1	X	1		F
			1		M
			1	X	S
Zn-65	1	X	1		F
			0.2		M
			0.02	X	S
Zn-69	1	X	1		F
			0.2		M
			0.02	X	S
Zn-69m	1	X	1		F
			0.2		M
			0.02	X	S
Ga-67	0.01	X	0.01		F
			0.01	X	M
Se-75	1	X	1		F
			0.2	X	M
			0.02		S
Se-79	1	X	1		F
			0.2	X	M
			0.02		S
Br-82	1	X	1	X	F
			1		M
Br-83	1	X	1	X	F
			1		M
Br-84	1	X	1	X	F
			1		M
Br-85		X		X	
Kr-83M		X		X	
Kr-85M		X		X	
Kr-85		X		X	
Kr-87		X		X	
Kr-88		X		X	
Kr-89		X		X	

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
Rb-86	1	X	1	X	F
Rb-87	1	X	1	X	F
Rb-88	1	X	1	X	F
Rb-89	1	X	1	X	F
Sr-85	0.6	X	0.6	X	F
			0.2		M
			0.02		S
Sr-89	0.6	X	0.6	X	F
			0.2		M
			0.02		S
Sr-90	0.6	X	0.6	X	F
			0.2		M
			0.02		S
Sr-91	0.6	X	0.6	X	F
			0.2		M
			0.02		S
Sr-92	0.6	X	0.6	X	F
			0.2		M
			0.02		S
Y-90	0.001	X	0.001		M
			0.001	X	S
Y-91	0.001	X	0.001		M
			0.001	X	S
Y-91m	0.001	X	0.001		M
			0.001	X	S
Y-92	0.001	X	0.001		M
			0.001	X	S
Y-93	0.001	X	0.001		M
			0.001	X	S
Zr-93	0.02	X	0.02		F
			0.02	X	M
			0.02		S
Zr-95	0.02	X	0.02		F
			0.02	X	M
			0.02		S
Zr-97	0.02	X	0.02		F
			0.02	X	M
			0.02		S
Nb-93m	0.02	X	0.02		F
			0.02		M
			0.02	X	S
Nb-95	0.02	X	0.02		F
			0.02		M
			0.02	X	S

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
Nb-97	0.02	X	0.02		F
			0.02		M
			0.02	X	S
Mo-93	1	X	1		F
			0.2		M
			0.02	X	S
Mo-99	1	X	1		F
			0.2		M
			0.02	X	S
Tc-99	1	X	1		F
			0.2	X	M
			0.02		S
Tc-99m	1	X	1		F
			0.2	X	M
			0.02		S
Tc-101	1	X	1		F
			0.2	X	M
			0.02		S
Ru-103	0.1	X	0.1		V
			0.1		F
			0.1		M
			0.02	X	S
Ru-105	0.1	X	0.1		V
			0.1		F
			0.1		M
			0.02	X	S
Ru-106	0.1	X	0.1		V
			0.1		F
			0.1		M
			0.02	X	S
Rh-105	0.1	X	0.1		F
			0.1		M
			0.1	X	S
Pd-107	0.05	X	0.05		F
			0.05		M
			0.05	X	S
Pd-109	0.05	X	0.05		F
			0.05		M
			0.05	X	S
Ag-110m	0.1	X	0.1		F
			0.1		M
			0.02	X	S
Ag-111	0.1	X	0.1		F
			0.1		M
			0.02	X	S

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
Cd-109	0.1	X	0.1		F
			0.1		M
			0.1	X	S
Cd-113m	0.1	X	0.1		F
			0.1		M
			0.1	X	S
Cd-115m	0.1	X	0.1		F
			0.1		M
			0.1	X	S
Sn-113	0.04	X	0.04		F
			0.04	X	M
Sn-123	0.04	X	0.04		F
			0.04	X	M
Sn-125	0.04	X	0.04		F
			0.04	X	M
Sn-126	0.04	X	0.04		F
			0.04	X	M
Sb-124	0.2	X	0.2		F
			0.02	X	M
			0.02		S
Sb-125	0.2	X	0.2		F
			0.02	X	M
			0.02		S
Sb-126	0.2	X	0.2		F
			0.02	X	M
			0.02		S
Sb-127	0.2	X	0.2		F
			0.02	X	M
			0.02		S
Te-125m	0.6	X	0.6		V
			0.6		F
			0.2	X	M
			0.02		S
Te-127	0.6	X	0.6		V
			0.6		F
			0.2	X	M
			0.02		S
Te-127m	0.6	X	0.6		V
			0.6		F
			0.2	X	M
			0.02		S
Te-129	0.6	X	0.6		V
			0.6		F
			0.2	X	M
			0.02		S

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
Te-129m	0.6	X	0.6		V
			0.6		F
			0.2	X	M
			0.02		S
Te-131	0.6	X	0.6		V
			0.6		F
			0.2	X	M
			0.02		S
Te-131m	0.6	X	0.6		V
			0.6		F
			0.2	X	M
			0.02		S
Te-132	0.6	X	0.6		V
			0.6		F
			0.2	X	M
			0.02		S
Te-133m	0.6	X	0.6		V
			0.6		F
			0.2	X	M
			0.02		S
Te-134	0.6	X	0.6		V
			0.6		F
			0.2	X	M
			0.02		S
I-125	1	X	1 CH_3I		V
			1 I_2		V
			1	X	F
			0.2		M
			0.02		S
I-129	1	X	1 CH_3I		V
			1 I_2		V
			1	X	F
			0.2		M
			0.02		S
I-130	1	X	1 CH_3I		V
			1 I_2		V
			1	X	F
			0.2		M
			0.02		S
I-131	1	X	1 CH_3I		V
			1 I_2		V
			1	X	F
			0.2		M
			0.02		S

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
I-132	1	X	1 CH_3I		V
			1 I_2		V
			1	X	F
			0.2		M
			0.02		S
I-133	1	X	1 CH_3I		V
			1 I_2		V
			1	X	F
			0.2		M
			0.02		S
I-134	1	X	1 CH_3I		V
			1 I_2		V
			1	X	F
			0.2		M
			0.02		S
I-135	1	X	1 CH_3I		V
			1 I_2		V
			1	X	F
			0.2		M
			0.02		S
Xe-131m		X		X	
Xe-133m		X		X	
Xe-133		X		X	
Xe-135m		X		X	
Xe-135		X		X	
Xe-137		X		X	
Xe-138		X		X	
Cs-134	1	X	1	X	F
			0.2		M
			0.02		S
Cs-134m	1	X	1	X	F
			0.2		M
			0.02		S
Cs-135	1	X	1	X	F
			0.2		M
			0.02		S
Cs-136	1	X	1	X	F
			0.2		M
			0.02		S
Cs-137	1	X	1	X	F
			0.2		M
			0.02		S
Cs-138	1	X	1	X	F
			0.2		M
			0.02		S

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
CS-139		X		X	
Ba-133	0.6	X	0.6	X	F
			0.2		M
			0.02		S
Ba-139	0.6	X	0.6	X	F
			0.2		M
			0.02		S
Ba-140	0.6	X	0.6	X	F
			0.2		M
			0.02		S
Ba-141	0.6	X	0.6	X	F
			0.2		M
			0.02		S
Ba-142	0.6	X	0.6	X	F
			0.2		M
			0.02		S
La-140	0.005	X	0.005		F
			0.005	X	M
La-141	0.005	X	0.005		F
			0.005	X	M
La-142	0.005	X	0.005		F
			0.005	X	M
Ce-141	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Ce-143	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Ce-144	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Pr-143	0.005	X	0.005		M
			0.005	X	S
Pr-144	0.005	X	0.005		M
			0.005	X	S
Nd-147	0.005	X	0.005		M
			0.005	X	S
Pm-147	0.005	X	0.005		M
			0.005	X	S
Pm-148	0.005	X	0.005		M
			0.005	X	S
Pm-148m	0.005	X	0.005		M
			0.005	X	S
Pm-149	0.005	X	0.005		M
			0.005	X	S

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
Pm-151	0.005	X	0.005		M
			0.005	X	S
Sm-151	0.005	X	0.005	X	M
Sm-153	0.005	X	0.005	X	M
Eu-152	0.005	X	0.005	X	M
Eu-154	0.005	X	0.005	X	M
Eu-155	0.005	X	0.005	X	M
Eu-156	0.005	X	0.005	X	M
Tb-160	0.005	X	0.005	X	M
Ho-166m	0.005	X	0.005	X	M
Tm-170	0.005	X	0.005	X	M
Yb-169	0.005	X	0.005		M
			0.005	X	S
Ta-182	0.01	X	0.01		M
			0.01	X	S
W-181	0.6	X	0.6	X	F
W-185	0.6	X	0.6	X	F
W-187	0.6	X	0.6	X	F
Ir-192	0.02	X	0.02		F
			0.02		M
			0.02	X	S
Au-198	0.2	X	0.2		F
			0.2		M
			0.2	X	S
Tl-201	1	X	1	X	F
Tl-204	1	X	1	X	F
Pb-210	0.6	X	0.6	X	F
			0.2		M
			0.02		S
Bi-210	0.1	X	0.1		F
			0.1	X	M
Po-210	1	X	0.2		F
			0.2	X	M
			0.02		S
RN-222		X		X	
Ra-223	0.6	X	0.6		F
			0.2	X	M
			0.02		S
Ra-224	0.6	X	0.6		F
			0.2	X	M
			0.02		S
Ra-225	0.6	X	0.6		F
			0.2	X	M
			0.02		S

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
Ra-226	0.6	X	0.6		F
			0.2	X	M
			0.02		S
Ra-228	0.6	X	0.6		F
			0.2	X	M
			0.02		S
Ac-225	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Ac-227	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Th-227	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Th-228	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Th-229	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Th-230	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Th-232	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Th-234	0.005	X	0.005		F
			0.005		M
			0.005	X	S
Pa-231	0.005	X	0.005		M
			0.005	X	S
Pa-233	0.005	X	0.005		M
			0.005	X	S
U-232	0.04	X	0.04		F
			0.04		M
			0.02	X	S
U-233	0.04	X	0.04		F
			0.04		M
			0.02	X	S
U-234	0.04	X	0.04		F
			0.04		M
			0.02	X	S

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
U-235	0.04	X	0.04		F
			0.04		M
			0.02	X	S
U-236	0.04	X	0.04		F
			0.04		M
			0.02	X	S
U-237	0.04	X	0.04		F
			0.04		M
			0.02	X	S
U-238	0.04	X	0.04		F
			0.04		M
			0.02	X	S
Np-237	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Np-238	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Np-239	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Pu-236	0.005	X	0.005		F
			0.005		M
			0.0001	X	S
Pu-238	0.005	X	0.005		F
			0.005		M
			0.0001	X	S
Pu-239	0.005	X	0.005		F
			0.005		M
			0.0001	X	S
Pu-240	0.005	X	0.005		F
			0.005		M
			0.0001	X	S
Pu-241	0.005	X	0.005		F
			0.005		M
			0.0001	X	S
Pu-242	0.005	X	0.005		F
			0.005		M
			0.0001	X	S
Pu-244	0.005	X	0.005		F
			0.005		M
			0.0001	X	S
Am-241	0.005	X	0.005		F
			0.005	X	M
			0.005		S

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

Table E-2 NRCDose3—ICRP-72 f_1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f_1	Default	f_1	Default	Class
Am-242m	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Am-243	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Cm-242	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Cm-243	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Cm-244	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Cm-245	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Cm-246	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Cm-247	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Cm-248	0.005	X	0.005		F
			0.005	X	M
			0.005		S
Cf-252	0.005	X	0.005	X	M

Notes:
ICRP-72 inhalation classes F, M, S, and V correspond to fast, medium, slow, and vapor classes, respectively.

E.3 References

1. **ICRP Publication 30**, "Limits for Intakes of Radionuclides by Workers," *Annals of the ICRP*, Vol. 2, Nos. 3/4, International Commission on Radiological Protection (ICRP), Pergamon Press, London, 1979.

2. **ICRP Publication 72**, "Age-Dependent Dose to Members of the Public from Intake of Radionuclides, Part 5: Compilation of Ingestion and Inhalation Dose Coefficients," *Annals of the ICRP*, Vol. 26, No. 1, ICRP, Pergamon Press, London, 1996.

NRC FORM 335 (12-2010) NRCMD 3.7 — U.S. NUCLEAR REGULATORY COMMISSION	1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)
BIBLIOGRAPHIC DATA SHEET *(See instructions on the reverse)*	NUREG-2267

2. TITLE AND SUBTITLE	3. DATE REPORT PUBLISHED	
NRCDose3 Code Version 1.1.4 User Guide and Technical Manual	MONTH: July	YEAR: 2024
	4. FIN OR GRANT NUMBER	
5. AUTHOR(S) D.B. Lowman, R.S. Clement, D.D. DeMore, J.S. Bland, V. Malafeew	6. TYPE OF REPORT	
	7. PERIOD COVERED (Inclusive Dates)	

8. PERFORMING ORGANIZATION - NAME AND ADDRESS (If NRC, provide Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)

Division of Systems Analysis
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

9. SPONSORING ORGANIZATION - NAME AND ADDRESS (If NRC, type "Same as above", if contractor, provide NRC Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address.)

Same as above

10. SUPPLEMENTARY NOTES

N/A

11. ABSTRACT (200 words or less)

This report contains the user guide and technical basis (models and methods) for the NRCDose3 version 1.1.4 computer code. It provides the end user with instructions for using NRCDose3 and documents the bases for updates made to the previous version of the code, NRCDose 2.3.20. NRCDose3 is a software suite that integrates the functionality of three individual Fortran codes (LADTAP II, GASPAR II, and XOQDOQ) developed by the U.S. Nuclear Regulatory Commission (NRC) in the 1980s. The nuclear industry and the NRC staff have used these codes to assess liquid radioactive releases and offsite doses, gaseous radioactive effluents and offsite doses, and meteorological transport and dispersion, respectively. The codes are primarily used in support of reactor licensing, to evaluate the safety and environmental dose impacts of liquid and gaseous radioactive effluent releases. NRCDose3 uses the same basic calculation methods (algorithms) as the Fortran codes. However, the updated code includes a more user friendly graphical interface for entering data. Also, significant changes have been made to the data management and operation to support expanded capabilities.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)	13. AVAILABILITY STATEMENT
NRCDose3, LADTAP, GASPAR, XOQDOQ, RAMP, radioactive releases, radioactive effluents, meteorological transport and diffusion, offsite doses.	unlimited
	14. SECURITY CLASSIFICATION
	(This Page) unclassified
	(This Report) unclassified
	15. NUMBER OF PAGES
	16. PRICE

Printed
on recycled
paper

Federal Recycling Program

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

OFFICIAL BUSINESS

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NUREG-2267

NRCDose3 Code - Version 1.1.4
User Guide and Technical Manual

July 2024