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NRCDOSE3 CODE

User Guide and Technical Manual

Office of Nuclear Reactor Regulation

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NRCDOSE3 Code

User Guide and Technical Manual

Manuscript Completed: August 2020
Date Published:

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ABSTRACT

The report documents the user guide and technical basis (models and methods) for the NRCDose3 computer code. This manual provides the end user with instructions to use the NRCDose3 code and the bases on updates made to the previous version of the NRCDose 2.3.20 code. The NRCDose3 code is a software suite that integrates the functionality of three individual LADTAP II, GASPAR II, and XOQDOQ Fortran codes that were developed by the NRC in the 1980's and have been in use by the nuclear industry and the NRC staff for assessments of liquid radioactive releases and offsite doses, gaseous radioactive effluents and offsite doses, and meteorological transport and dispersion, respectively. These codes are primarily used to support reactor licensing in the evaluation of the safety and environmental dose impacts from liquid and gaseous radiological effluent releases. In general, the basic calculation methods (algorithms) of the Fortran codes have not been changed. In addition to a more user-friendly graphic user interface for inputting data, 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 New Reactors and Office of Nuclear Reactor Regulations. Specifically, NRC staff: Michael Mazaika, Dr. Donald Palmrose, Eva Hickey, Zachary Gran, and Dr. Elijah Dickson. Additionally, the authors thank the staff of Information Systems Laboratory, Inc., and Dr. Keith Eckerman for their support and efforts in updating the NRCDose3 code.

ABBREVIATIONS

ALARA	As Low As is Reasonably Achievable
AOO	anticipated operational occurrences
ATD	Atmospheric Transport and Dispersion
Bq	Becquerel
cal/s	calories per second
CFR	*Code of Federal Regulations*
cfs	cubic feet per second or ft^3/s
Ci	curies
CMMP	configuration management and maintenance plan
cm	centimeters
cm^3	cubic centimeters
CNS	Chesapeake Nuclear Service, Inc.
DCF	dose conversion factor
d/L	days per liter
D/Q	atmospheric deposition factor
EPA	U.S. Environmental Protection Agency
EFH	Exposure Factors Handbook
FGR	Federal Guidance Report
Fortran	Formula Translation (formerly FORTRAN)
FSAR	Final Safety Analysis Report
ft^3	cubic feet
ft/s	feet per second
g	grams
g/cm^3	gram per cubic centimeter
g/m^3	gram per cubic meter
GASPAR	dose analyses computer code for NPP radioactive effluents to the atmosphere (update to the GASPAR II Fortran code)
GUI	graphical user interface
ICRP	International Commission on Radiological Protection
ISL	Information System Laboratory, Inc.
JFD	joint frequency distributions
keV	kilo-electron volts
kg	kilograms
kg/d	kilograms per day
kg/m^2	kilograms per square meter
kg/yr	kilograms per year
L	liters
LAR	licensing action request
L/d	liters per day
$L/m^2/mon$	liters per square meters per month
LADTAP	dose analyses computer code for NPP radioactive effluents to surface waters (update to the LADTAP II Fortran code)
m	meter
m^2	square meters
m^3	cubic meters
m/s	meters per second
m^3/yr	cubic meters per year
MEI	maximum exposed individual

MeV	Mega-electron volts
mi	miles
mrad/yr	millirad per year
mrem/yr	millirem per year
NEPA	National Environmental Policy Act
NPP	nuclear power plant
NRC	U.S. Nuclear Regulatory Commission
NRCDose	computer code name for the original code integrating the LADTAP II, GASPAR II, and XOQDOQ Fortran codes, Chesapeake Nuclear Services, Inc.
NUREG	U.S. Nuclear Regulatory Commission technical report designation
R-Factor	reconcentration factor
RadToolbox	Radiological Toolbox computer code
RAMP	Radiation Protection Computer Code Analysis and Maintenance Program
RG	Regulatory Guide
SDD	software design document
SI	International System of Units
SQAP	software quality assurance plan
VBnet	Visual Basic.net
XOQDOQ	computer code for atmospheric dispersion modeling for routine releases
X/Q	atmospheric dispersion factor

1.0 INTRODUCTION

The NRCDose3 computer code is a software suite that integrates the functionality of three individual Fortran codes developed for the U.S. Nuclear Regulatory Commission (NRC) under a unified graphical user interface (GUI). The original development of the NRCDose code (version 2.3.20 and earlier) was performed by an NRC contractor, Chesapeake Nuclear Services (CNS), Inc. for end users including the NRC staff, applicants, and licensees. The original NRCDose code contained the LADTAP II, GASPAR II, and XOQDOQ Fortran codes that were developed by and for the NRC in the 1980's. These codes have been in use by the nuclear industry and the NRC staff for assessments and evaluations of liquid radioactive releases and offsite doses, gaseous radioactive effluents and offsite doses, and meteorological transport and dispersion, respectively. These codes are primarily used to support domestic and international reactor licensing in the assessment and evaluation of the safety and environmental dose impacts from liquid and gaseous radioactive effluent releases associated with routine (normal) plant operations and anticipated operational occurrences (AOOs).

The NRCDose3 code, with its underlying LADTAP, GASPAR, and XOQDOQ Fortran codes, implement the calculation methodologies as described in this manual and 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 [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 [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 [Ref. 3].

These dose assessment methods are applied by the NRC staff in its safety and environmental reviews and evaluations as prescribed in:

- RG 4.2, "Preparation of Environmental Reports for Nuclear Power Stations", Revision 3 [Ref. 4].
- NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan", Revision 1 [Ref. 5].
- NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Revision 6 [Ref. 6].

1.1 LADTAP II Code

The LADTAP II Fortran code, described in NUREG/CR-4013 [Ref. 7], implements the liquid pathway modeling described in RG 1.109 and RG 1.113. The LADTAP II Fortran code estimates the radiation dose to individuals, population groups, and biota from ingestion (aquatic foods, water, and terrestrial irrigated foods) and external exposure (shoreline, swimming, and boating) recreational pathways. 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 of 10 *Code of Federal Regulations* (CFR) Part 50 [Ref. 8].

1.2 GASPAR II Code

The GASPAR II Fortran code, described in NUREG/CR-4653 [Ref. 9], implements the atmospheric pathway modeling described in RG 1.109 and RG 1.111. The GASPAR II Fortran code 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 of 10 CFR Part 50. The GASPAR II Fortran code does not estimate radiation doses to biota.

1.3 XOQDOQ Code

The XOQDOQ Fortran code described in NUREG/CR-2919 [Ref. 10] implements the atmospheric pathway modeling described in RG 1.111. XOQDOQ calculates the relative atmospheric dispersion (X/Q) and relative atmospheric relative 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 via dry deposition and radioactive decay, and adjustments to consider non-straight trajectories.

1.4 NRCDose3 Code Update

The basic calculation methods (algorithms) of the LADTAP II, GASPAR II, and XOQDOQ Fortran codes have not been changed with this update to the NRCDose code. In general, this update to the code improves upon the GUI to make it more user-friendly for inputting data while also including significant changes to the data management and code operation to support expanded capabilities for the NRCDose3 code. The more significant changes and revisions to the NRCDose3 code are summarized below and explained in greater detail in Section 4 of this manual.

1. Support for updated Dose Conversion Factor (DCF). Previous versions of the NRCDose code containing the LADTAP II and GASPAR II Fortran codes only utilized one set of DCF values, largely those contained in RG 1.109 and based on International Commission on Radiological Protection Report No. 2 (ICRP-2) [Ref. 11] methodology. The NRCDose3 code allows the user to select the ICRP-2 (Default) DCF values, those for exposure to workers from ICRP Report No. 30 (ICRP-30) [Ref. 12], or those for public exposure from ICRP Report No. 72 (ICRP-72) [Ref. 13].

2. Updated age groups. ICRP-72 uses 6 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 4 age groups (infant, child, teen, and adult). The NRCDose3 code utilizes all 6 age groups, when ICRP-72 DCF values are selected.

   ** **User Note** ** — ICRP-30 based DCF values are only provided for the adult worker; other age group DCF values are not provided. Use of ICRP-72 DCF values by an applicant or licensee for a proposed NRC licensing action request (LAR) should be discussed with the NRC staff prior to submitting the license request.

3. Updated default usage factors. When ICRP-72 DCF values are selected, the NRCDose3 code utilizes updated usage (consumption and exposure) factors based on data in the U.S. Environmental Protection Agency's (EPA) EPA/600/R-090/052F (EFH), "Exposure Factor Handbook; 2011 Edition" [Ref. 14].

   **** User Note** ** ─ The EPA EFH usage factors are different than those in RG 1.109. Use of EPA EFH usage factors by an applicant or licensee for a proposed NRC LAR should be discussed with the NRC staff prior to submitting the license request.

4. Updated LADTAP biota dose calculations. The LADTAP II Fortran code had limited provisions and was revised to update the biota dose model for estimating the radiation dose to biota from liquid radioactive effluent releases. Updated in NRCDose3 are effective radius dose factors (as used for calculating the internal doses to biota) and ability for inclusion of user defined biota. For every special location defined in LADTAP, biota doses may be calculated for the following species:

   - Fish,
   - Muskrat,
   - Raccoon,
   - Duck,
   - Heron, and
   - User Defined species.

   Refer to Section 6.3 and Appendix D of this manual for technical basis of the biota dose model applied in the NRCDose3 code for estimating the radiation dose to biota from liquid effluent releases.

5. Added GASPAR biota dose calculations. The GASPAR II Fortran code was revised to include biota dose models for estimating the radiation dose to biota from gaseous radioactive effluent releases. The GASPAR II Fortran code had no provision for estimating biota doses. For every special location defined in GASPAR, biota doses are calculated for the same species as those defined in LADTAP above:

   - Muskrat,
   - Raccoon,
   - Duck,
   - Heron,
   - Cow,
   - Fox, and
   - User Defined species.

   Refer to Section 6.3 and Appendix D of this manual for technical basis of the biota dose model applied in the NRCDose3 code for estimating the radiation dose to biota from gaseous radioactive effluent releases.

6. In addition to the changes and revisions described above, other functional improvements to the NRCDose3 code include:

   - Updated VBNet GUI,
   - Radionuclide library expanded to 203 radionuclides,
   - Fully user-modifiable parameters for LADTAP, GASPAR, and XOQDOQ, and

- Compatibility using Windows 7 and above, and Internet Explorer Version 7 and above.

1.5 Software Quality Assurance and Configuration Management Plans

CNS-19001, “NRCDose3 Computer Code: Software Quality Assurance Plan,” issued July 2019 [Ref. 15] documents the NRCDose3 code software quality assurance plan (SQAP). CNS-19003, “NRCDose3 Computer Code: Configuration Management and Maintenance Plan,” issued July 2019 [Ref. 16] documents the NRCDose3 code configuration management and maintenance plan (CMMP). The NRC has defined three levels of software, per NUREG/BR-0167, “Software Quality Assurance Program and Guidelines,” issued February 1993 [Ref. 17]:

(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 quality assurance documents are written to conform to the Level 2 requirements. Code development on the NRCDose3 code has proceeded under the SQAP and code 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 to the SQAP and CMMP described above, the NRCDose3 code was developed under a software design document (SDD). CNS-19002, “NRCDose3 Computer Code: Software Design Document,” issued July 2019 [Ref. 19] presents detailed information on the code and databases 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 the NRCDose3 code along with the required computing requirements.

2.1 Distribution

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

2.2 Installation

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

The initial install will create a user-specified directory (e.g., C:/NRCDose3 used as default) for use by the NRCDose3 code. If installing an updated version, the install routine will automatically delete the current version before installing the updated version. Only the updated program files are replaced. User created cases files ("*.Inp," "*.gnp", or "*.xnp" files) will not be deleted from the directory; however, as a back-up, it is recommended that all case files be saved to a different folder or storage device.

The NRCDose code (version 2.3.20 or earlier) is a separate program. LADTAP and GASPAR files created in NRCDose (version 2.3.20 or earlier) are not compatible with the NRCDose3 code. However, XOQDOQ files created in NRCDose (version 2.3.20 or earlier) are compatible with NRCDose3. Existing NRCDose code installations are not affected by installing 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_v113_Setup.exe, from the RAMP web site (https://ramp.nrc-gateway.gov/). To start the installation process double click (open) NRCDose3_v113_Setup.exe file, which will start the installation process and open the Welcome Screen as shown in Figure 2-1. Select the "Next" button to continue with the installation process.

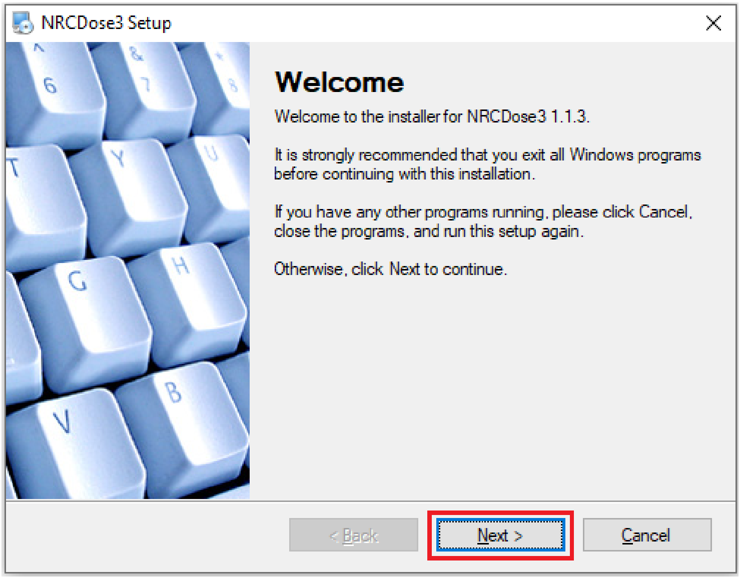


Figure 2-1 Installation Welcome Screen

2. The NRCDose3 installer will then allow a user-specified 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 directory, as needed, for the installation or install using the default directory. Additionally, the installer will display the computer hard drive space needed for the NRCDose3 code and the available space on the drive selected for installation (i.e., "C:/"). Select the "Next" button to continue with the installation process.

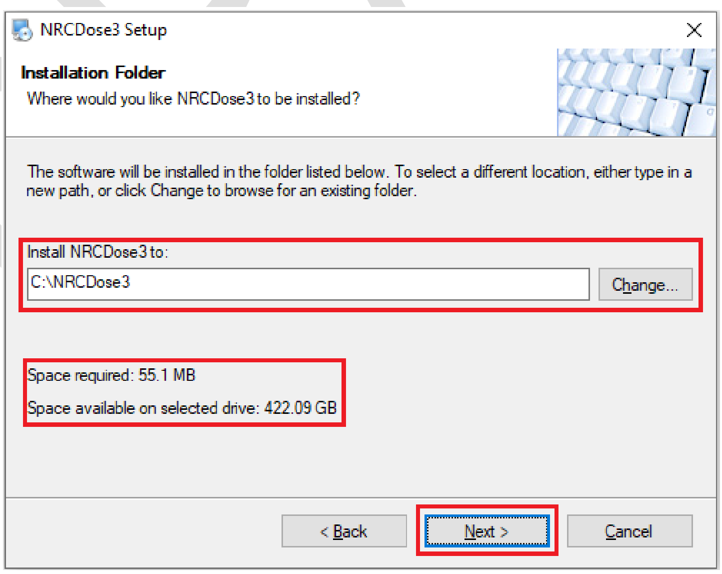


Figure 2-2 Installation Folder Screen

3. The NRCDose3 installer will then request the user 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) and the user may select a different directory using the dropdown menu arrow next 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 the installation process.

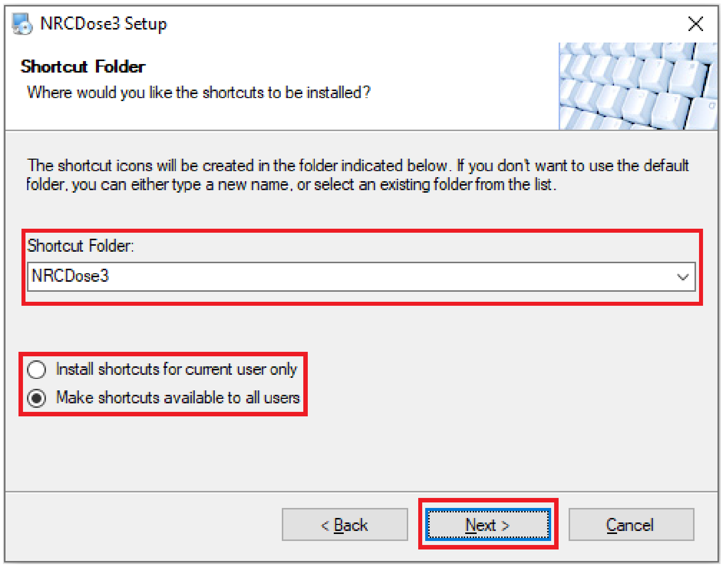


Figure 2-3 Shortcut Folder Screen

4. The NRCDose3 installer now has enough information to install the code and will display settings used to install the code on the computer as shown in Figure 2-4. Select the “Next” button to continue with the installation process. The user should see the installation progress screen as shown in Figure 2-5. If the user decides to terminate the installation of NRCDose3 at this point they can do so by selecting the “Cancel” button shown in Figure 2-5.

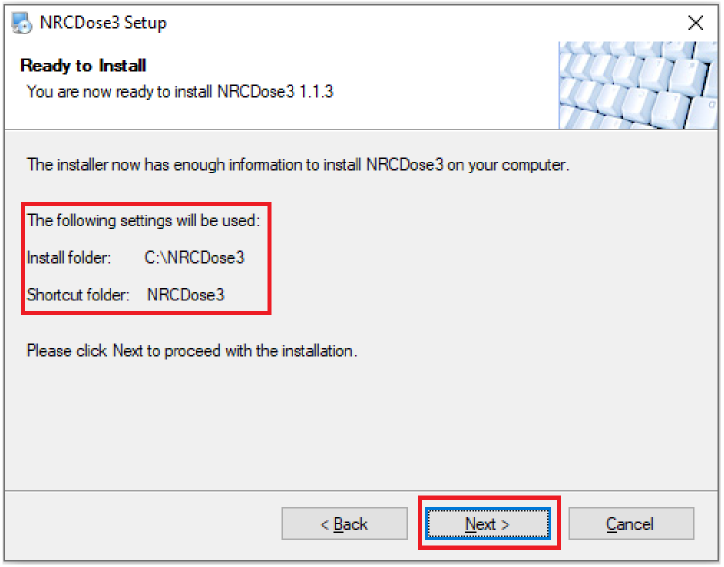


Figure 2-4 Installation Confirmation Screen

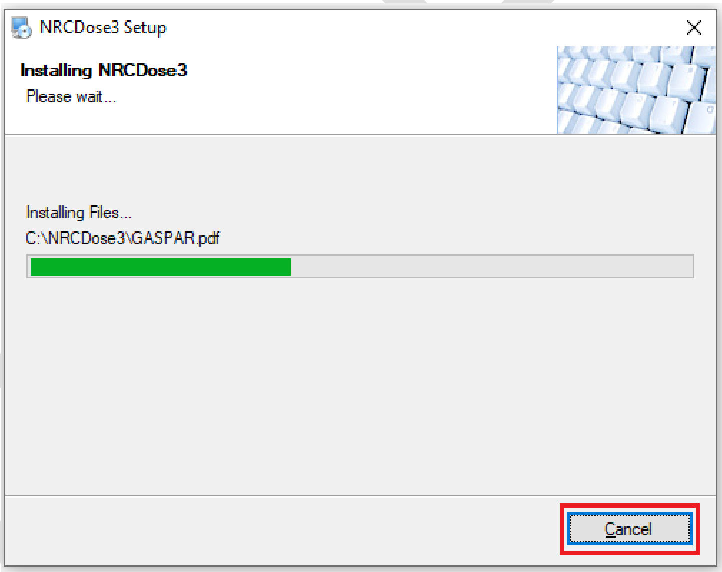


Figure 2-5 Installation Progress Screen

5. When the installer has completed installing NRCDose3, the Installation Completion Screen as shown in Figure 2-6 will appear. Select the "Finish" button to exit the installer.

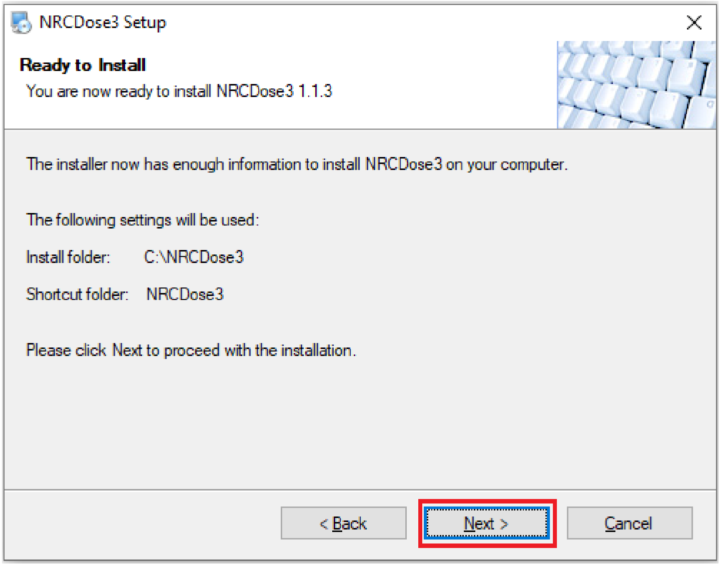


Figure 2-6 Installation Completion Screen

6. The NRCDose3 shortcut icon will appear on the Windows operating system (OS) desktop as shown in Figure 2-7. Double click on the NRCDose3 shortcut icon to open the code and display the NRCDose3 Main Selection Screen as shown in Figure 2-8.

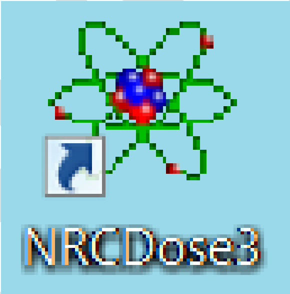


Figure 2-7 NRCDose3 Shortcut Icon

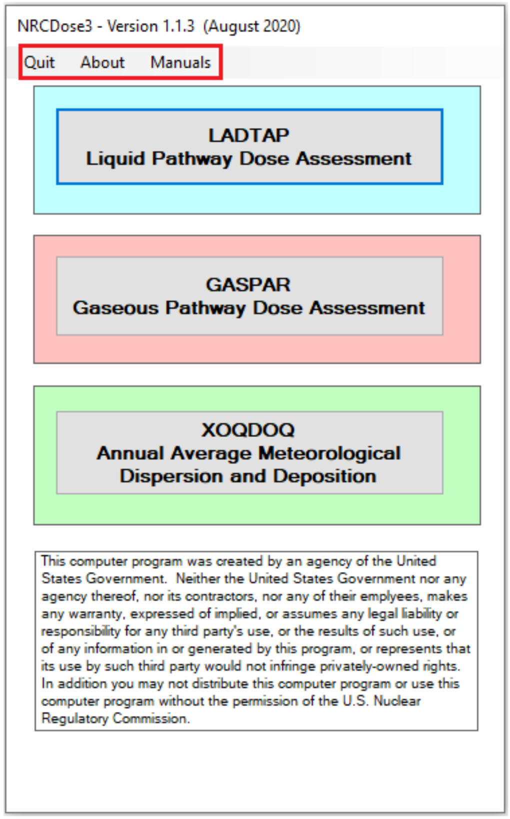


Figure 2-8 NRCDose3 Main Selection Screen

7. As shown n Figure 2-8, the NRCDose3 Main Selection Screen shows the LADTAP, GASPAR, and XOQDOQ Modules, and the toolbar on top of the screen containing three tool/menu options for NRCDose3. These three tool/menu options are:

- Quit — Select this tool to exit out of the NRCDose3 code.
- About — Select this tool to open the About NRCDose3 Screen as shown in Figure 2-8. This displays information about the version of the NRCDose3 code. Select the "OK" button to return to the NRCDose3 Main Selection Screen as shown in Figure 2-9.
- Manuals — Select this tool to open a dropdown menu as shown in Figure 2-10 listing the following technical references included with NRCDose3:
    - NRCDose3 Quick Start Guide
    - User's Manual (for Draft NUREG-XXXX, NRCDose3 Code: User Guide and Technical Manual)
    - GASPAR II Manual, NUREG/CR-4653
    - LADTAP II Manual, NUREG/CR-4013
    - XOQDOQ Manual, NUREG/CR-2919

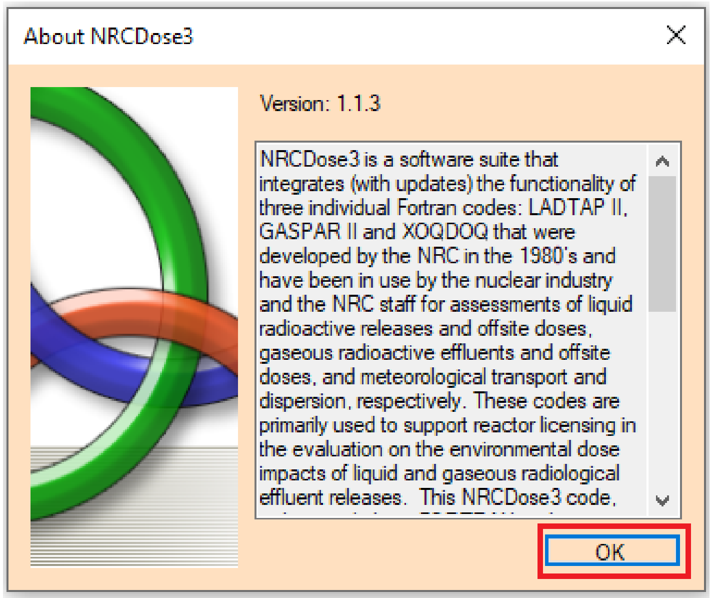


Figure 2-9 About NRCDose3 Screen

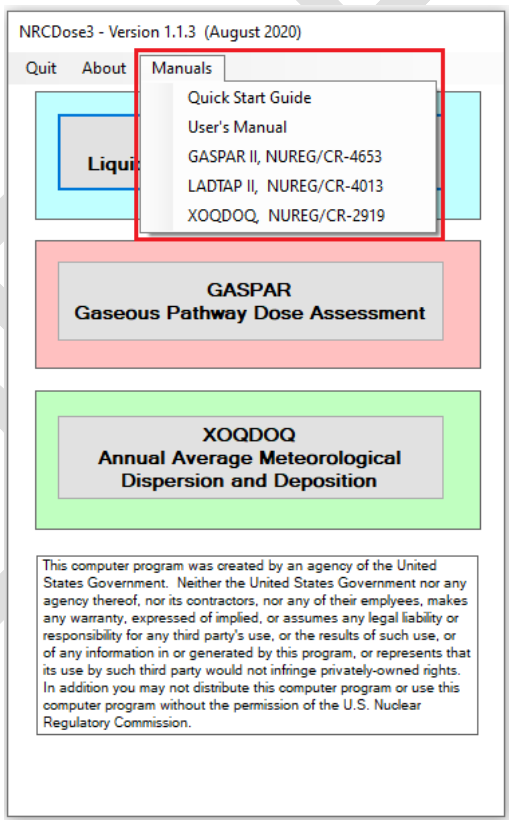


Figure 2-10 Manuals Tool dropdown menu

2.2.2 Code Support

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

2.2.3 Code Error and Problem Reporting

While extensive testing has been performed and effort directed toward minimizing (non-computational) errors in NRCDose3, there may be unanticipated circumstances that lead to errors and problems (bugs). To report errors and bugs with the program, first collect as much information as possible about the error or bug. This information should include answers to the following questions:

- What computer OS is NRCDose3 being executed on?
- 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, etc.)?
- Save the case files and attach them to if possible.

To report a problem, send a zip file with the case files and answers to the above questions to the NRCDose3 Forum webpage under the NRCDose3 Support link on the NRC RAMP website (https://ramp.nrc-gateway.gov/content/nrcdose-support).

3.0 LADTAP

The LADTAP Module within the NRCDose3 code executes a modified version of the LADTAP II Fortran code. The basic calculation methods (algorithms) of the LADTAP II Fortran code, as described in NUREG/CR-4013, have not been changed with this update to the NRCDose3 code, 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 expanded capabilities of NRCDose3. The LADTAP II Fortran code performs the environmental dose assessments for releases of liquid radioactive effluents from NPPs in surface waters and implements the dose assessment methods described in RG 1.109. The LADTAP II Fortran code 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 exposure 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 [Ref. 20], the EPA public dose limits in 40 CFR Part 190 [Ref. 21], and the NRC ALARA design objectives and numerical guides in 10 CFR Part 50, Appendix I.

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

On the NRCDose3 Main Selection Screen as shown in Figure 3-1, select the “LADTAP Liquid Pathway Dose Assessment” button to open the LADTAP Module Main Screen as shown in Figure 3-2.

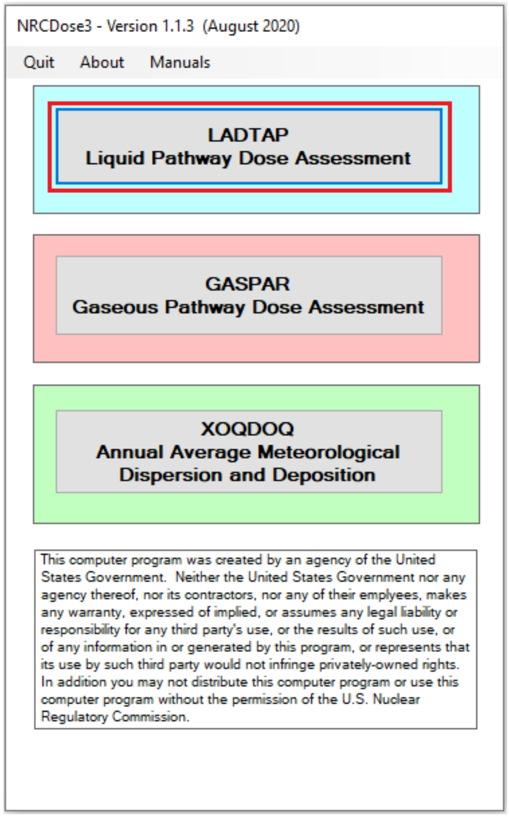


Figure 3-1 NRCDose3 Main Selection Screen (LADTAP Module)

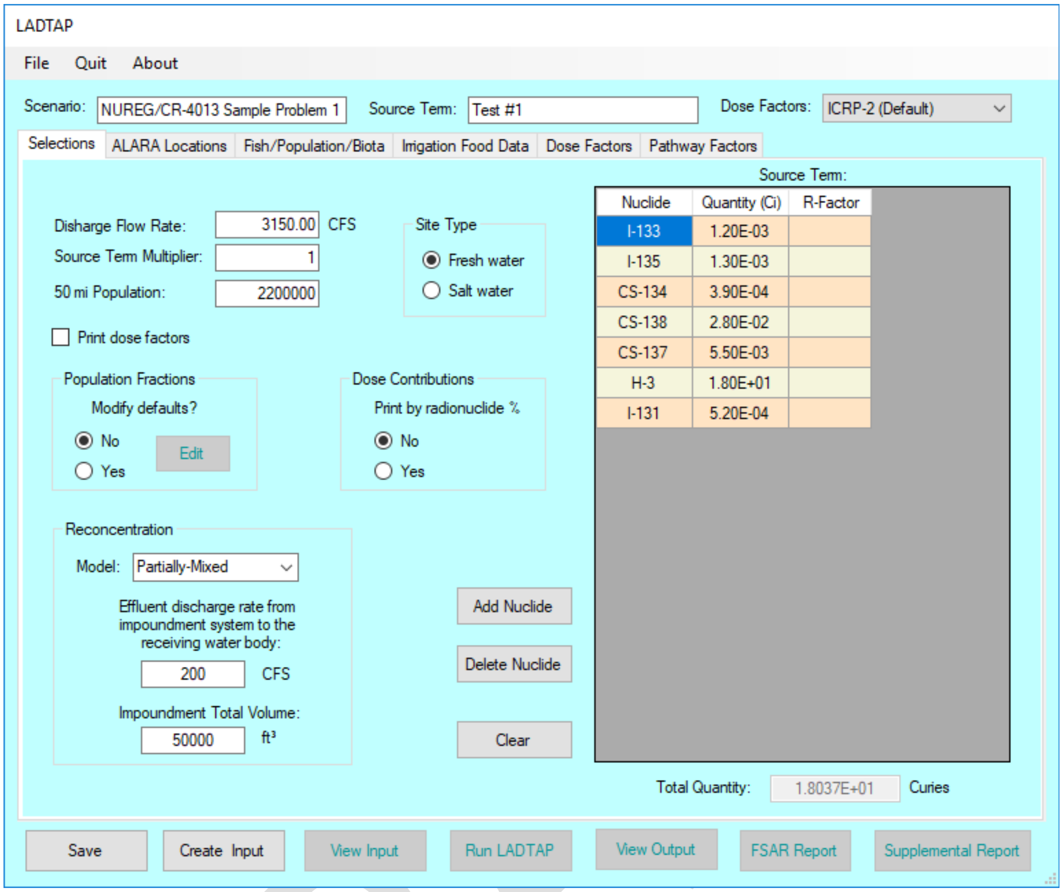


Figure 3-2 LADTAP Module Main Screen

The LADTAP Module Main Screen as shown in Figure 3-2 opens with the case data as last saved in the database. On initial install, the program loads with an example test case. Three main functional areas for inputting data and performing LADTAP dose calculations shown are: (1) the toolbar and initial setup area, (2) data input tabs area and (3) code execution and reports area. Each of these functional areas of the LADTAP Module Main Screen is discussed in the following sections with a description of the options and capabilities contained therein.

3.1 <u>Toolbar and Initial Setup Functional Area</u>

This portion of the LADTAP Module Main Screen contains three tools and three initial setup input fields as shown in Figure 3-2. The menu three tools are the File, Quit and About. The initial setup fields include the Scenario, Source Term, and Dose Factors (dropdown menu).

3.1.1 File Menu Tool

The File Menu Tool provides the functionality to manage the LADTAP files as shown in Figure 3-3. The File Tool dropdown menu options are:

- <u>New</u> — Select this option to begin a new LADTAP case. This will clear the database from any previously input information.

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

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

- Save to LN3 File — Choose this option to save the completed case to a "*.LN3" file. This allows the file to be saved for later use, or for sharing with others.

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

**** User Note **** — The "*.LN3" file type and format is used for NRCDose3 LADTAP files. Files of other formats for example "*.LNP" files generated under the NRCDose (version 2.3.20 and earlier) of LADTAP (i.e., NRCDose 2.3.20 LADTAP II files) are not compatible with NRCDose3.

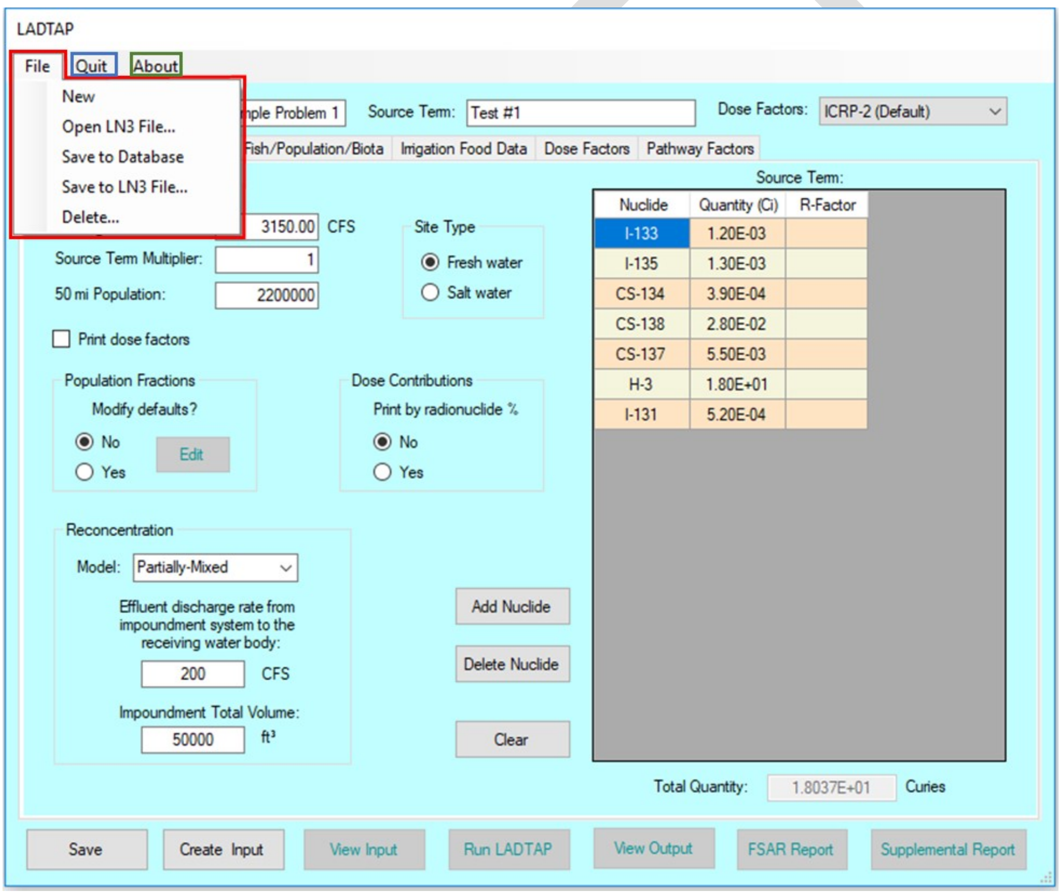


Figure 3-3 LADTAP Toolbar with File Tool dropdown menu

3.1.2 Quit Tool

Selecting the Quit Tool from the toolbar as shown in Figure 3-3 will terminate the LADTAP Module operation. There is a Question prompt screen as shown in Figure 3-4 to ensure that the user wants to quit and exit the module. If the “Yes” button is selected the LADTAP Module will terminate and any unsaved changed/edited data will not be saved. Select the “No” button and then the appropriate entry from the File Tool dropdown menu to ensure that any information has been saved (to the database and/or a *.LN3 file) prior to quitting.

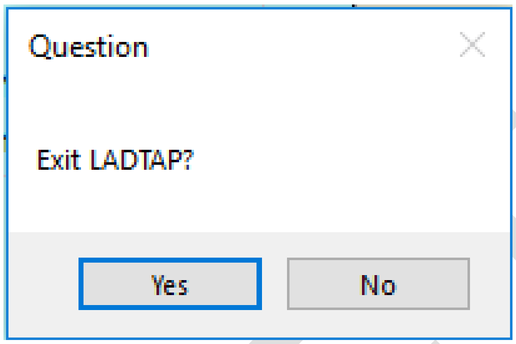


Figure 3-4 LADTAP Module Quitting Tool Screen

3.1.3 About Tool

Selecting the About Tool from the Toolbar the About LADTAP screen as shown in Figure 3-5. This displays information about the LADTAP II code. Select the “OK” button as shown in Figure 3-5 to return to the LADTAP Module Main Screen as shown in Figure 3-2.

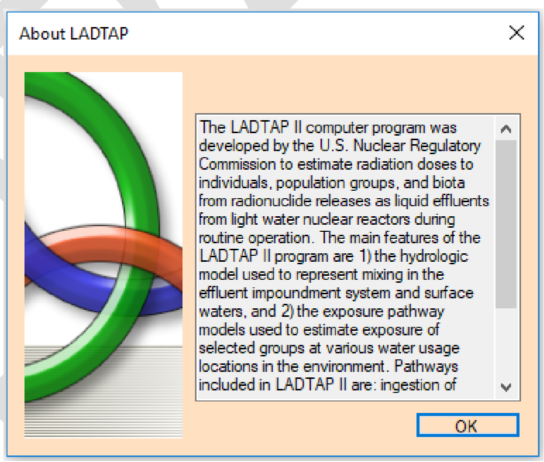


Figure 3-5 About LADTAP Screen

3.1.4 Scenario Input Field

Enter a title in the Scenario Field for the LADTAP case. This is a descriptive text field only and the data in this field are not used for any LADTAP dose calculations. Appropriate text should be selected to assist user in identifying the facility/site and release point information (i.e., Facility XYZ and Miscellaneous Waste Discharge). As shown in Figure 3-2, the scenario title for the initial install is “NUREG/CR-4013 Sample Problem 1 – ICRP-2,” which is included in the installation and loaded as the initial test case. Subsequent opening of LADTAP will show the last saved case scenario.

3.1.5 Source Term Input Field

Enter a descriptive name for the Source Term in this field. This is a text field only and the data in this field are not used for any LADTAP dose calculations. Appropriate text should be selected to assist user in identifying the facility/site and release point information (e.g., Facility XYZ and Miscellaneous Waste Discharge). As shown in Figure 3-2, the source term is "Test #1," which is the source term name from "NUREG/CR-4013 Sample Problem 1 – ICRP-2.ln3" test case file.

3.1.6 Dose Factors Dropdown Menu

As shown in Figure 3-6, the Dose Factors dropdown menu 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," or "ICRP-72" DCF values. The user should note that if the DCF values are changed, the assumed source term (if any has been entered) will be cleared. In addition, the assumed usage and consumption factors will update to the DCF values associated with the selected ICRP methodology. Test cases using the ICRP-30 and ICRP-72 DCFs are included in the installation, having the same data, except for the DCFs, as the "NUREG/CR-4013 Sample Problem 1 – ICRP-2.ln3" test case file.

** **User Note** ** – For purposes of demonstrating compliance with 10 CFR Part 50, Appendix I, and 40 CFR Part 190, the ICRP-2 DCF values should be selected. Likewise, for demonstrating compliance with 10 CFR Part 20, the ICRP-30 DCF values should be selected. Use of ICRP-72 DCF values by an applicant or licensee for a proposed NRC LAR request should be discussed with the NRC staff prior to submitting the license request.

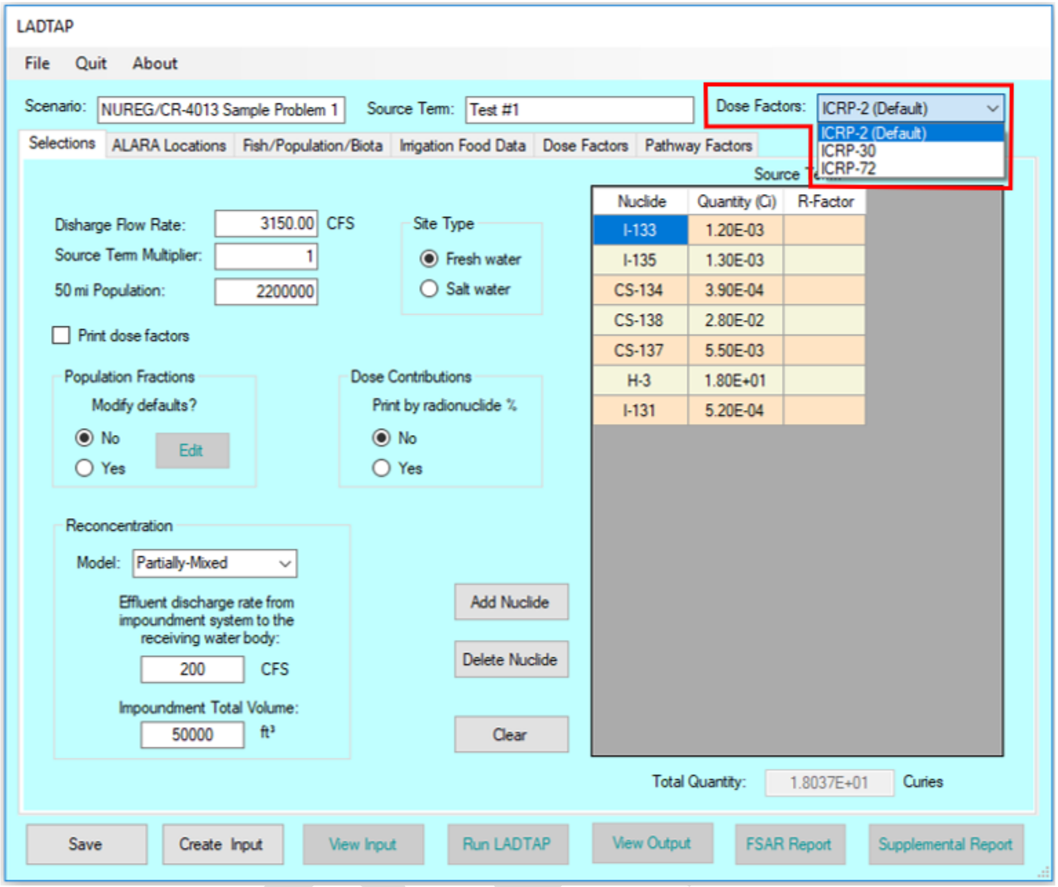


Figure 3-6 LADTAP Dose Factors dropdown menu

3.2 Data Input Tabs

The six LADTAP Data Input Tabs as shown in Figure 3-2 are:

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

Though not required when generating the input for LADTAP, it is recommended that the user enter the necessary parameters and data to the case in order of the Data Input Tabs as they are listed in the LADTAP Module Main Screen as shown in Figure 3-2.

3.2.1 Selections Tab

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

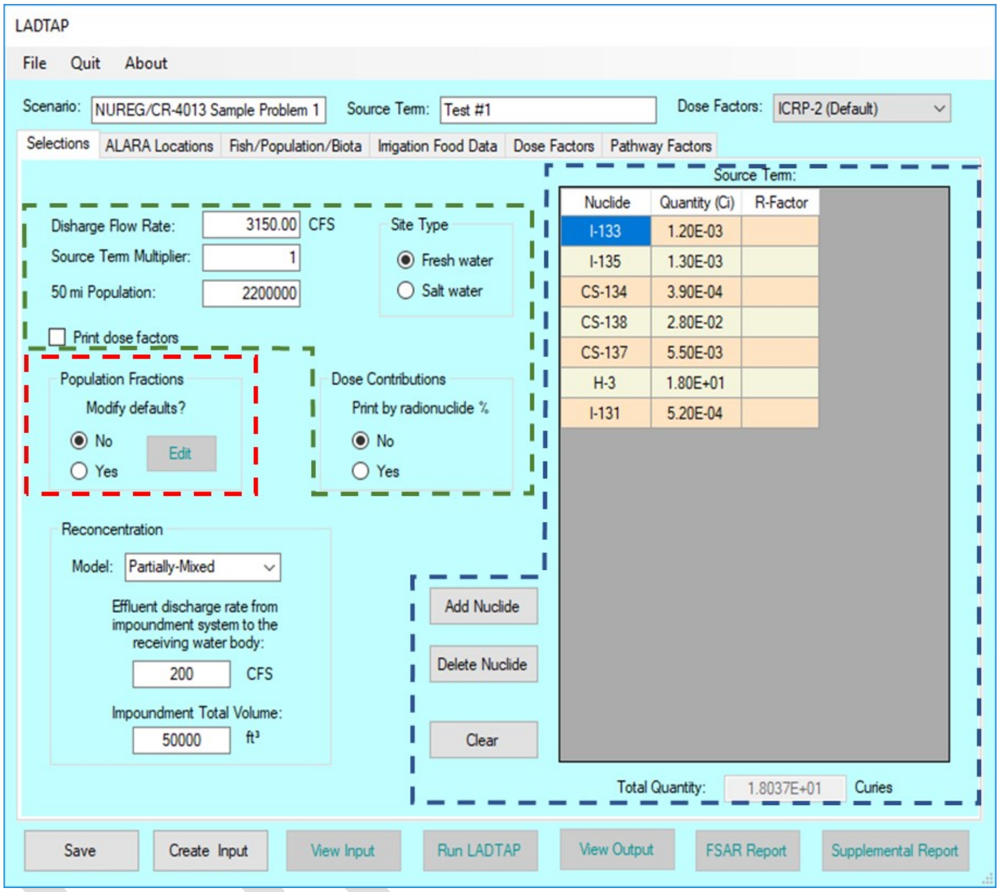


Figure 3-7 Selections Tab

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 units of cubic feet per second (cfs). The value from "NUREG/CR-4013 Sample Problem 1.In3" 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 this Selections Tab. The default value is **1** and the allowable range for values in this field is 1 or greater. Typically, this will remain at 1.0, but can be adjusted to account for multi-unit sites, if the entered source term is on a per unit basis.

3.2.1.1.3 50 mi Population

Enter the total human population within 50 miles of the site, as specified in 10 CFR 50, Appendix I. The value from the “NUREG/CR-4013 Sample Problem 1.In3” is “**2200000**” with the allowable range for values in this field being greater than 0.

3.2.1.1.4 Print Dose Factors

This check box is to be selected by the user 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

This setting selects either “Fresh water” or “Saltwater” as appropriate for the site. This selection controls the identification of the bioaccumulation factors that are to be used as different sets exist for fresh and saltwater species, as well as certain consumption values, e.g., saltwater invertebrate. The value from the “NUREG/CR-4013 Sample Problem 1.In3” for this setting is “**Fresh water**,” which is also the selection when creating a new case/file.

3.2.1.1.6 Dose Contributions

This setting determines if the dose contribution per radionuclide in percent is printed in the LADTAP output file. The value from the “NUREG/CR-4013 Sample Problem 1.In3” for this setting is “**No**,” which is also the setting when creating a new case/file.

3.2.1.2 Population Fractions Section

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

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

If the user needs to change or adjust these default values, select the “Yes” button and the “Edit” button on the Populations Fraction Section of the Selections Tab becomes active (not greyed 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. A justification should be provided 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 an adult age range; therefore, only adult doses are calculated.

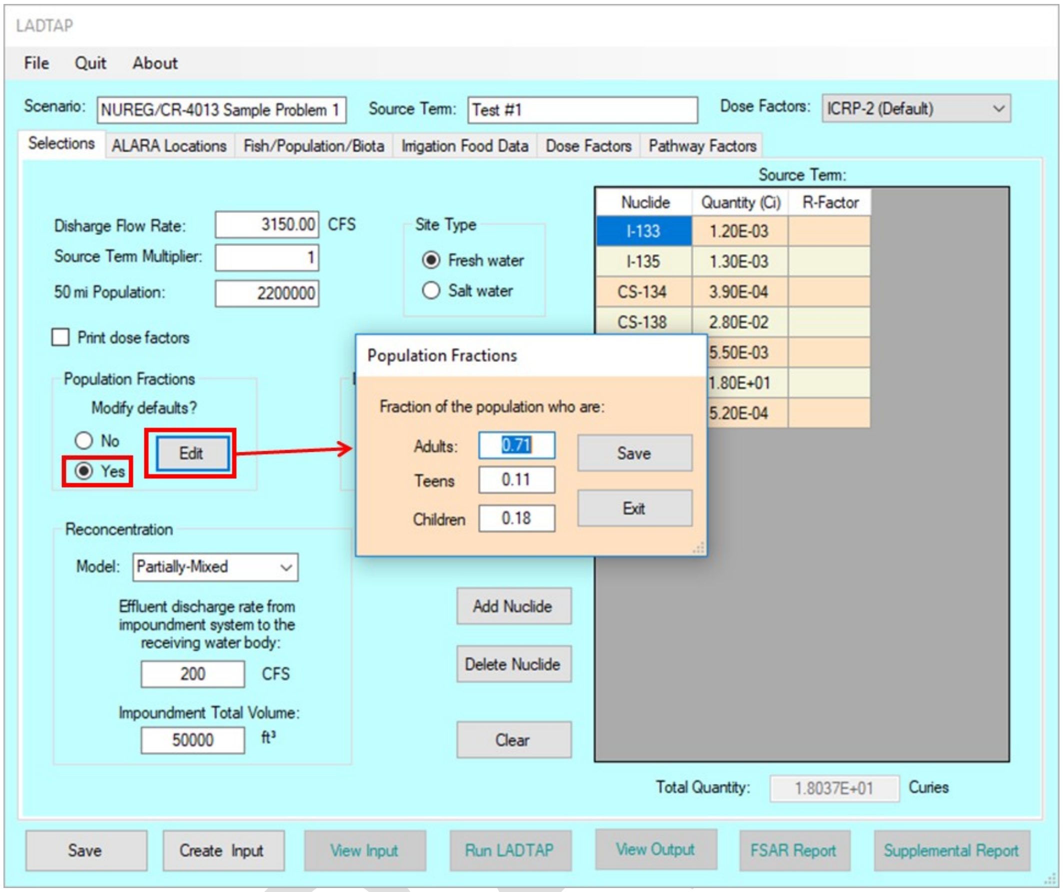


Figure 3-8 Population Fractions Screen

3.2.1.3 Reconcentration Section

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 as 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.

- None — This model assumes no additional decay or dilution of the liquid effluents, prior to them reaching the main receiving water body. The discharge point radioactivity concentration is determined simply by the activity release rate and the discharge flow rate.

- 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.

- Plug-Flow — This model assumes that radioactive effluents are released to an impoundment system (pond), where it is naturally diluted and delayed until it is 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 a comparison is made between the blowdown rate and the reactor effluent discharge rate (entered at the top of the Selections Tab). If the blow-down 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.

- Partially Mixed — This model is derived from a mass balance for steady-state conditions described in RG 1.113. This model 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 from the "NUREG/CR-4013 Sample Problem 1" for this setting is "**Partially-Mixed**." The calculated R-Factor is site and radionuclide specific and a detailed description of each of these models can be found in Section 3.3.3 of NUREG/CR-4013.

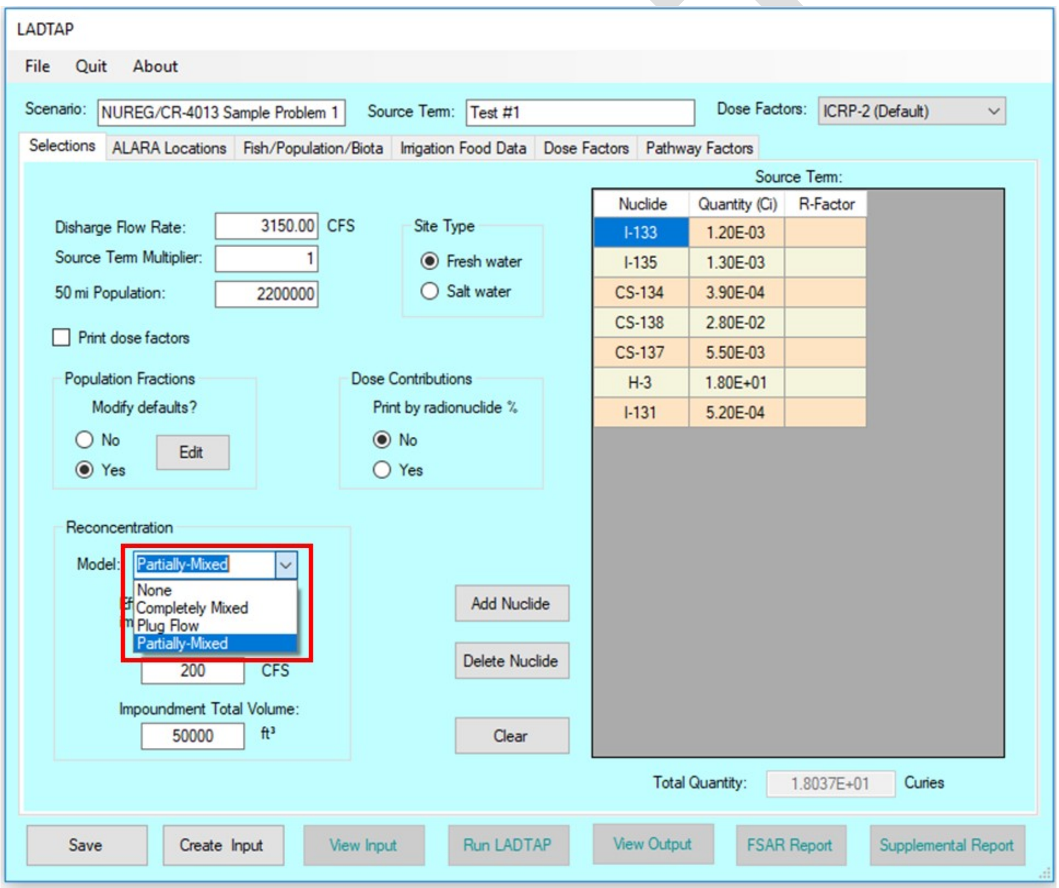


Figure 3-9 R-Factor Model Options

Additionally, for all the impoundment or reconcentration models except for the "None" option requires the user to input two additionally parameters as shown in Figure 3-7. Those parameters are:

- Effluent discharge rate from impoundment system to the receiving water body in units of cfs. The value from the "NUREG/CR-4013 Sample Problem 1" is "**200**" cfs, and the allowable range for values in this field is greater than 0 cfs.

- Impoundment total volume in units of cubic feet (ft^3). The value from the "NUREG/CR-4013 Sample Problem 1" 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 Section

The final section on the Selections Tab is the Source Term Section as shown in Figure 3-7. The user can enter the annual released activity in units of curies (Ci) and 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. Only enter the R-Factors if the reconcentration model option of "**None**" has been selected in the Reconcentration Section (Section 3.2.1.3). Selecting any other reconcentration model ("**Completely Mixed**," "**Plug-Flow**," or "**Partially Mixed**") will override any manually entered R-Factors.

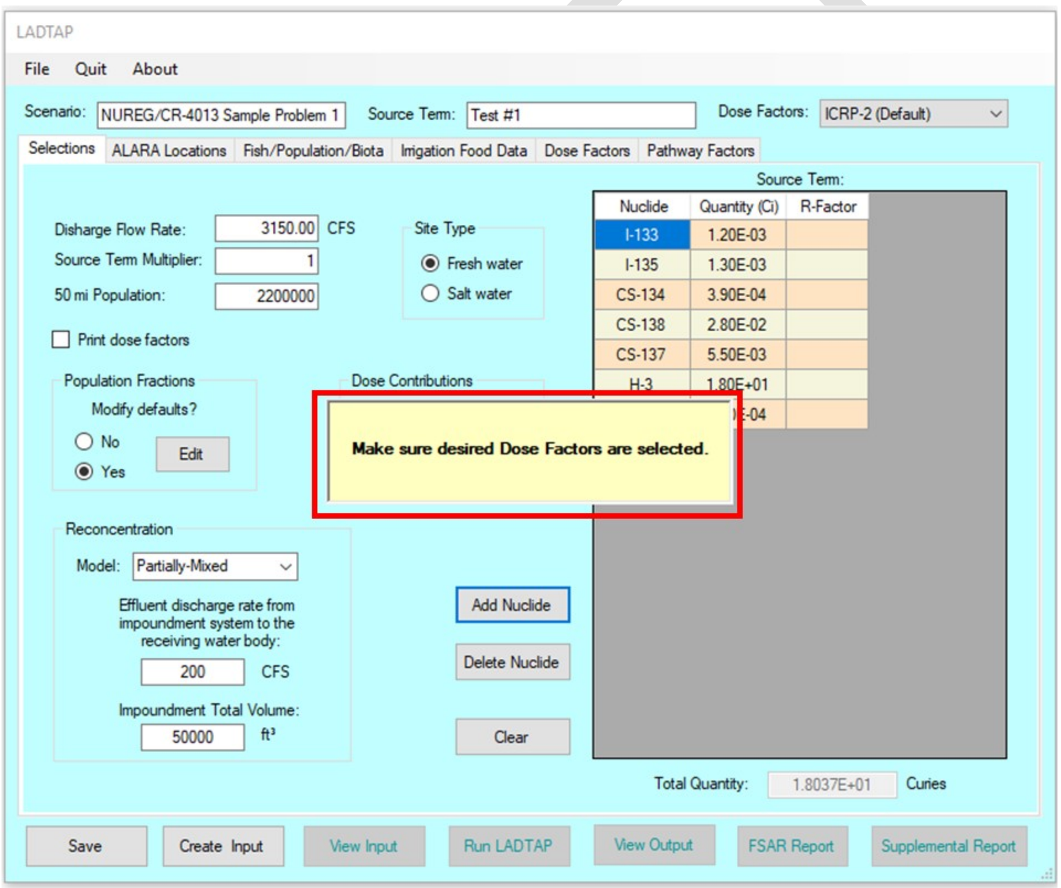


Figure 3-10 DCF Warning Message

Additional radionuclides can be added to the bottom of the list by selecting "Add Nuclide" button, which will flash the DCF Warning Screen Message as shown in Figure 3-10 and then open the Select Nuclide Screen as shown in Figure 3-11. Select the radionuclide (highlighting the radionuclide) to be added to the source term by and then click the "Add" button as shown in

Figure 3-11 to add the radionuclide to the source term on the Selections Tab. Holding the “Ctrl” key during radionuclide selection will allow for the selection of multiple radionuclides.

** **User Note** ** — Prior to adding any additional radionuclides the user should ensure that the proper ICRP methodology is properly selected so that the proper forms of the radionuclides are selected by the code.

Likewise, the user can remove radionuclides from the Source Term Section by selecting the radionuclide to be removed (highlighting the radionuclide) and then clicking the “Delete Nuclide” button as shown in Figure 3-7. Selecting the “Clear” button clears out all source term data (Nuclide, Quantity and R-factor) for all radionuclides in the Source Term Section of the Selections Tab.

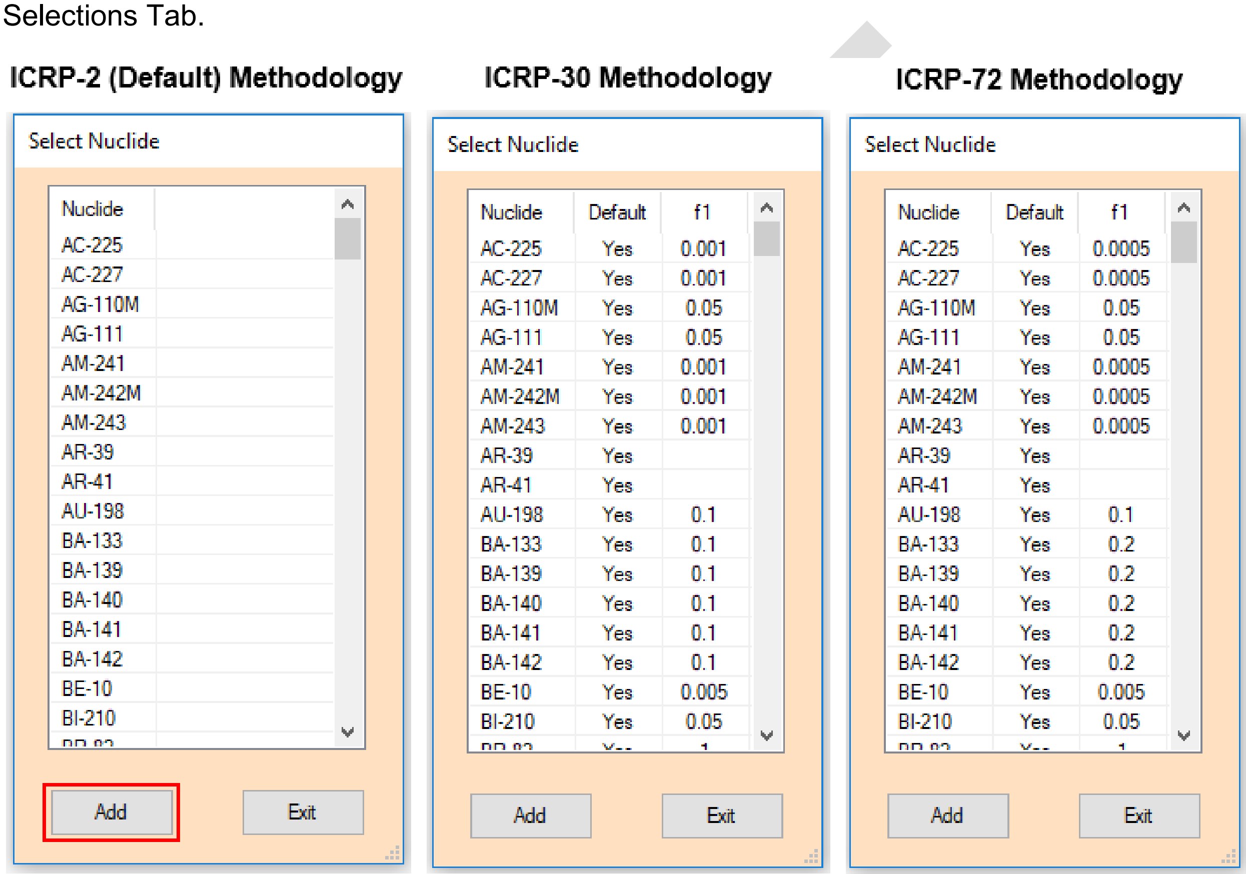


Figure 3-11 Select Nuclide Screen

** **User Note** ** — The input data should be periodically saved, using the “Save” at bottom of the LADTAP Module Main Screen as shown in Figure 3-2. This will save the inputted data to the database as well as the file name, as designated by the user. Saved values (and the saved file) are then available should the program inadvertently terminate or otherwise quit. Remember that upon initial opening of the LADTAP Module (and XOQDOQ and GASPAR Modules), the data, which is loaded, is whatever data was last saved to the database. Additionally, for this situation it will not be linked to any file name; data should be saved to an existing or new file depending on the situation. To ensure the data is what desired, the user should open the case (file name) corresponding the case desired, edit an existing case and save 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 used for the calculation of the maximum exposed individual (MEI) in the LADTAP dose calculation. As shown in Figure 3-12, the ALARA Location Tab contains two sections: (1) the ALARA - Max Individual Section and (2) the Additional Usage Locations Section, with the ALARA - Additional Location Section being used to enter the exposure assumptions for the Additional Usage Locations.

3.2.2.1 ALARA – Max Individual Section

The ALARA – Max Individual Section of the ALARA Locations Tab is subdivided into four data input sections. These data input sections are: (1) the Shore-Width Factor options, (2) the Dilution Factor Section, (3) the Transit Time Section, and (4) the Change Default Usage and Consumption Data Section.

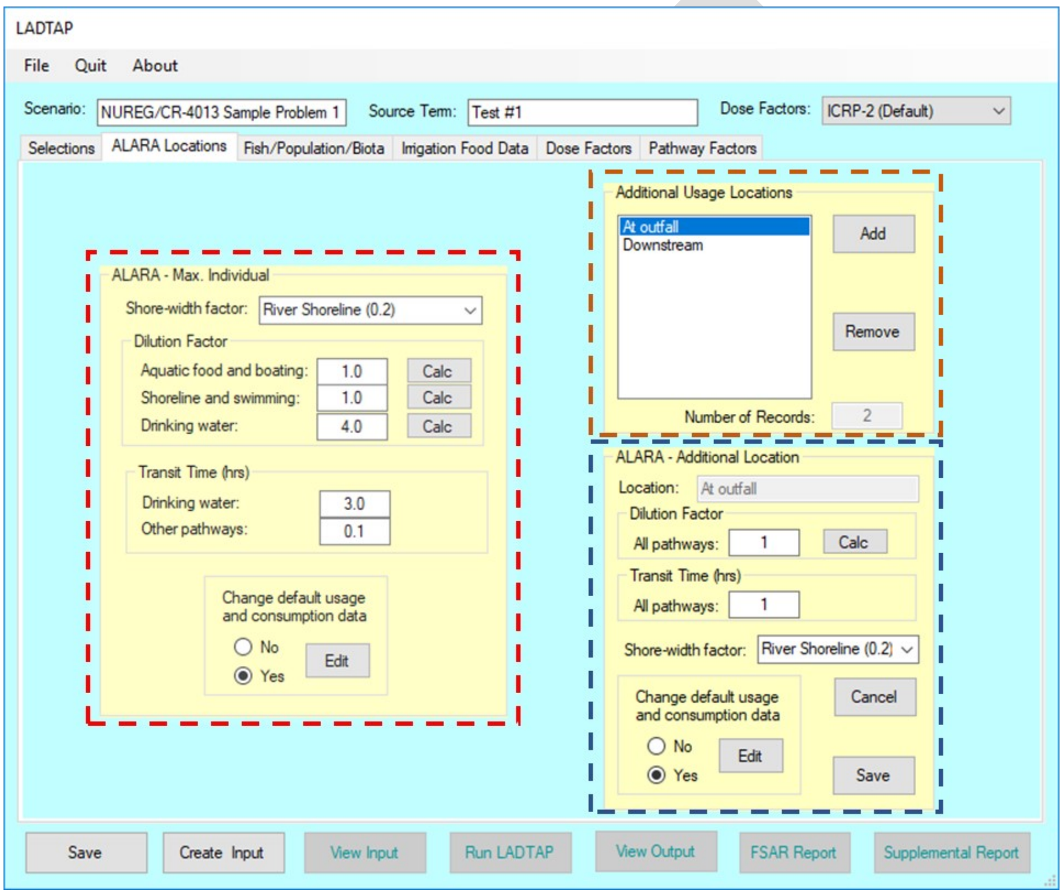


Figure 3-12 ALARA Locations Tab

3.2.2.1.1 Shore-Width Factor Option

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. Select the location that will be used to determine the shore-width factor. The exposure situations and the assumed shore-width factors from RG 1.109 are shown in Table 3-2.

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 Section

The dilution factors represent the amount of dilution expected between the discharge point to the receiving water body and the usage location for the pathway. In practice, the radionuclide concentration, as calculated from the Source Term (activity released), the Discharge Flow Rate, and any R-Factor, is divided by the dilution factor to determine the concentration at the point of exposure. 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 manually inputted. Alternatively, a value may be calculated using characteristics of the receiving water body. For each pathway type, select the "Calc" button to open the Dilution Factor Calculation Screen as shown in Figure 3-13. Section 3.1 of NUREG/CR-4013 provides additional information regarding the calculation of dilution factors based on applicable parameters and a hydrological surface water model.

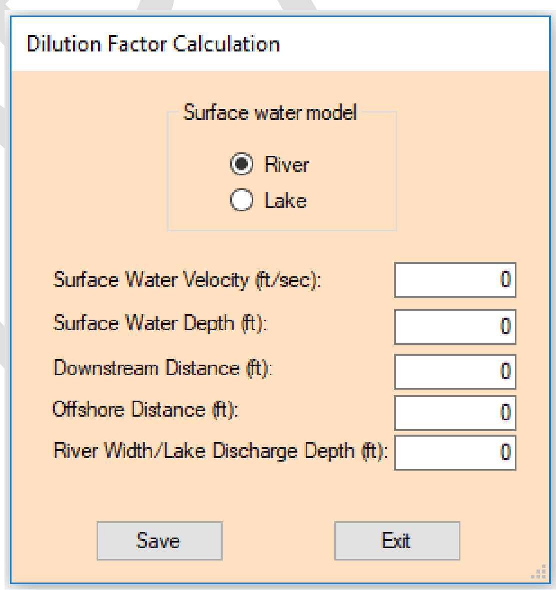


Figure 3-13 Dilution Factor Calculation Screen

As shown in Figure 3-13, depending on the model selected the user must input the parameters discussed below to calculate a dilution factor:

- Surface Water Model ─ Select the appropriate hydrological model by clicking on either the “River” or “Lake” model option.

- Surface Water Velocity ─ This field is used to enter surface water velocity in units of feet per second (ft/s) and the allowable range for values in this field is greater than 0 ft/s.

- Surface Water Depth ─ This field is used to enter surface water depth in units of ft and the allowable range for values in this field is greater than 0 ft.

- Downstream Distance ─ This field is used to enter downstream distance in units of ft and the allowable range for values in this field is greater than 0 ft.

- Offshore Distance ─ This field is used to enter offshore distance in units of ft and the allowable range for values in this field is greater than 0 ft.

- River Width/Lake Discharge Depth ─ This field is used to enter either the river width or lake discharge depth depending on the model selected in units of ft and the allowable range for values in this field is greater than 0 ft.

The calculation of dilution is based on user input of receiving water body characteristics (flow, depth and downstream distance) in the selected water model.

** **User Note** ** ─ If the discharge flow rate is large compared to those receiving water body characteristics, the LADTAP code could return a dilution calculation with a value less than 1, which reflects that the defined parameters are not compatible with the selected water model. If this occurs, dose calculations would not be correct. The LADTAP output will issue the following error message and the program will terminate at that point.

> **“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 units of hours (hrs) from the discharge point of the receiving water body to the usage location. As shown in Figure 3-12, one transit time can be entered for the drinking water pathway, while all other pathways have the same transit time. The value from the “NUREG/CR-4013 Sample Problem 1” is “**1**” for the drinking water pathway and “**3**” for the other pathways. The allowable range for values in this field is greater than 0 hrs.

3.2.2.1.4 Change Default Usage and Consumption Data Section

This section allows the user the option to change the default usage and consumption data for the MEI. The default usage and consumption data are taken from RG 1.109, Revision 1, when using the ICRP-2 (Default) and ICRP-30 DCF values and from EPA EFH when using the ICRP-72 DCF values. To change usage and consumption data information, select the “Yes” radio button and the “Edit” button shown in Figure 3-12 to open the Max Individual Consumption Screen as shown in Figure 3-14.

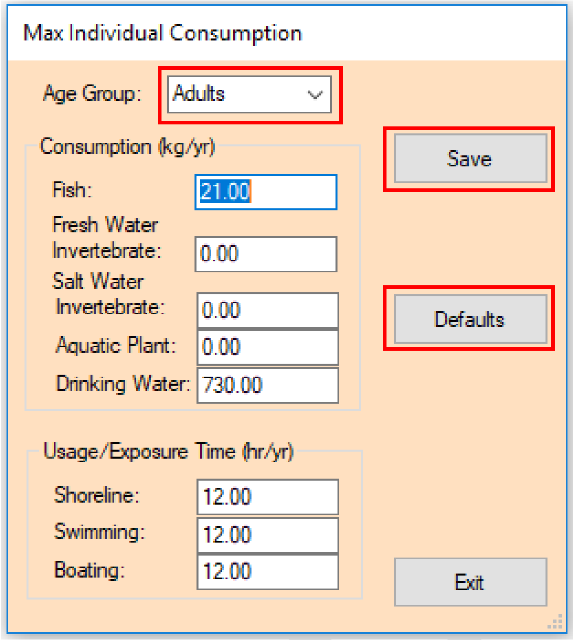


Figure 3-14 Max Individual Consumption Screen

Using the drop-down menu, select the appropriate age group from RG 1.109, and enter the applicable consumption rates of Fish, Invertebrates, Aquatic Plants and Drinking Water in units of 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. Select the "Save" button when edits are completed to save the revised usage and consumption data. Save each age group separately while progressing through the different age groups. Selecting the "Defaults" restores the default usage and consumption data from RG 1.109.

3.2.2.2 Additional Usage Locations Section

As shown in Figure 3-12, the Additional Usage Locations Section in the ALARA Location Tab allows the user to enter additional locations for calculating doses. The user can add and remove usage locations to the LADTAP dose calculation. The value from the "NUREG/CR-4013 Sample Problem 1" displays the information for two additional usage locations (i.e., "At outfall" and "Downstream"). To add an additional ALARA usage locations select the "Add" button to activate the ALARA - Additional Location Section below as shown in Figure 3-15. To remove an ALARA usage locations select the location to be removed (highlighting the location) and click the "Remove" button.

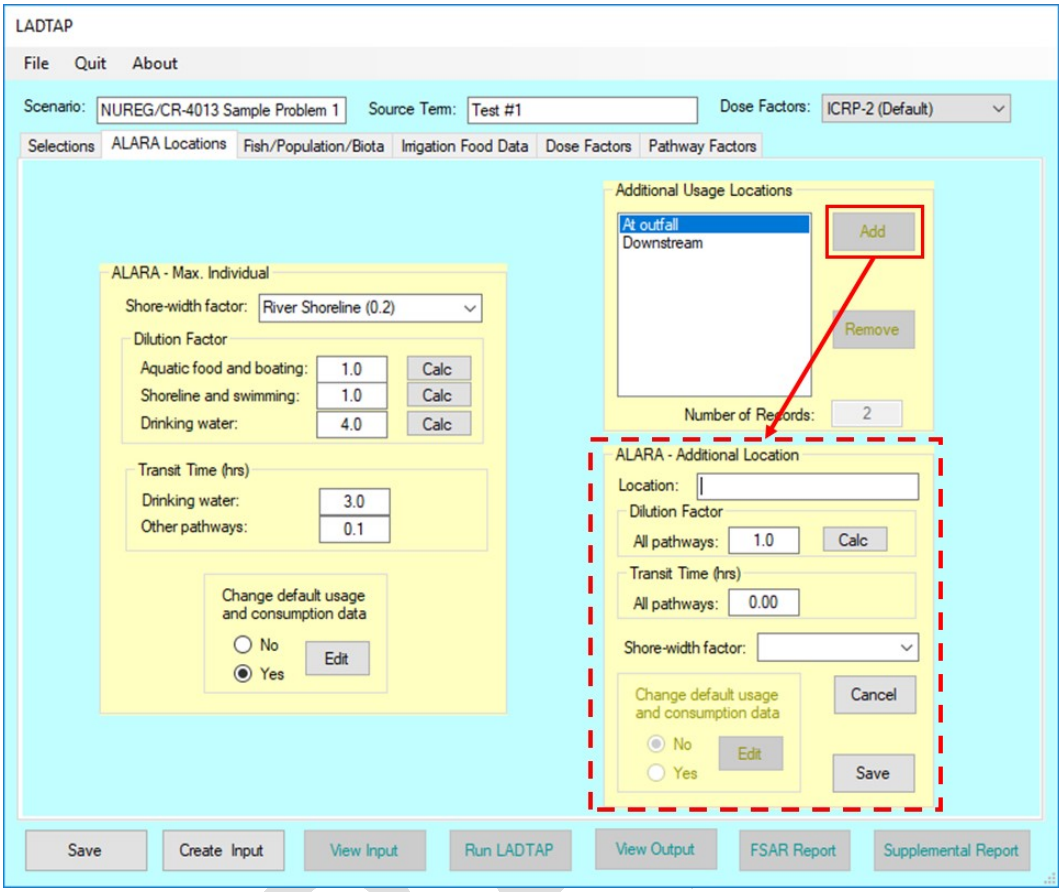


Figure 3-15 Additional Location Section activated screen

3.2.2.3 ALARA - Additional Location Section

Once the ALARA - Additional Location Section of the ALARA Location Tab is activated by selecting the “Add” button in Section 3.2.2.2, the user can input the information required for the ALARA usage location. As discussed in Section 3.2.2.1, enter the name of the “Location”, the pathway “Dilution Factor,” the “Transit Time,” and the “Shore-width Factor. Only a single pathway “Dilution Factor” and “Transit Time” can be entered for additional ALARA usage locations. Additionally, location specific usage and consumption data can be entered by selecting the “Yes” radio button then the “Edit” button as shown in Figure 3-15 to open the Max Individual Consumption Screen as shown in Figure 3-16.

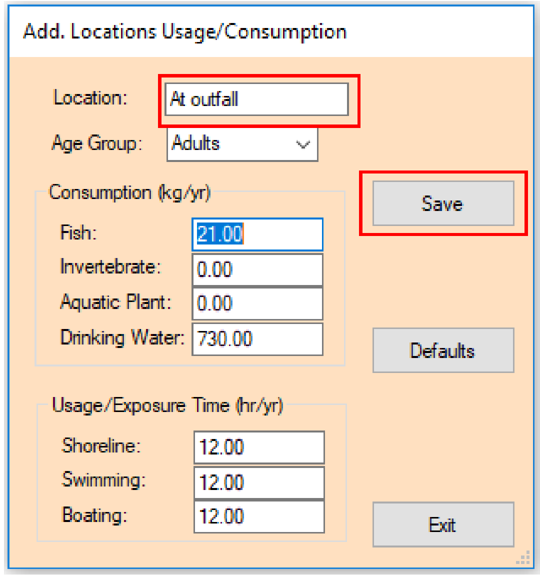


Figure 3-16 Add. Locations Usage/Consumption Screen

Similar to Section 3.2.2.1.4, enter the required usage and consumption information and select the “Save” button when edits are completed to save the revised usage and consumption data. Save each age group separately while progressing through the different age groups.

3.2.3 Fish/Population/Biota Tab

The Fish/Population/Biota Tab is used to enter the parameters used for the annual aquatic animal harvest and consumption as well as the total population drinking water consumption and recreation time for the LADTAP dose calculation. 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 menu dropdown options for the Fish Usage Section (sport/commercial fishing and sport/commercial invertebrate harvest and the four menu dropdown options for the Population Usage Section (drinking water and recreational activities).

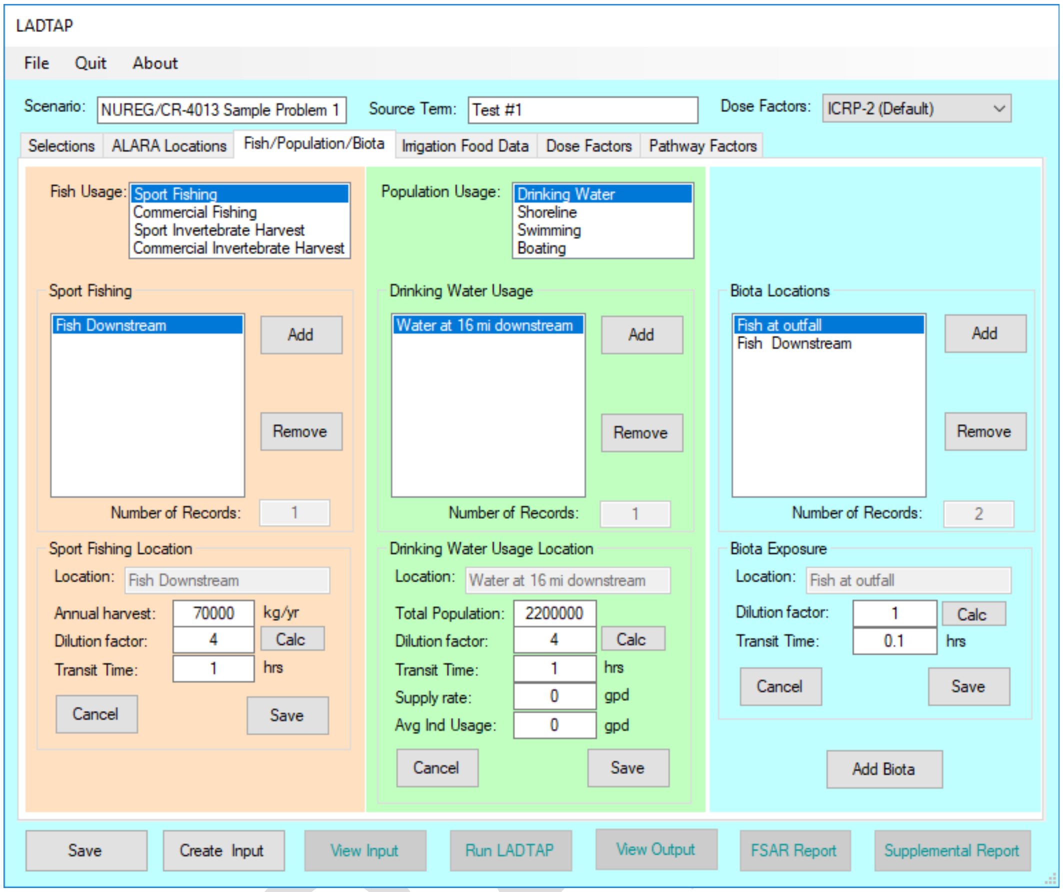


Figure 3-17 Fish/Population/Biota Tab

3.2.3.1 Fish Usage Section

This section is where the total fish and invertebrate harvests at user designated locations are entered for determination of population doses. From the displayed options, select the usage type from one of the four options as shown in Figure 3-17:

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

Once selected, the user can enter data, adding or editing an existing location identification and entering the annual harvest (catch), dilution and transit time, unique for each location, as shown in Figure 3-18. To define a new fishing or invertebrate harvesting location select the "Add" button, which will activate the fishing/harvesting location at the bottom of the Fish Usage Section. For each type of fishing or invertebrate harvesting location, enter the name of the location, the amount of the annual harvest in units of kg/yr, a dilution factor (unitless) and the transit time in unit of hours (hrs). The values from the "NUREG/CR-4013 Sample Problem 1" are "**Fish Downstream**," "**70000**" kg/yr, "**4**" hr and "**1**" hr, respectively. If necessary, select the

"Calc" button to open Dilution Factor Calculation Screen as 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.

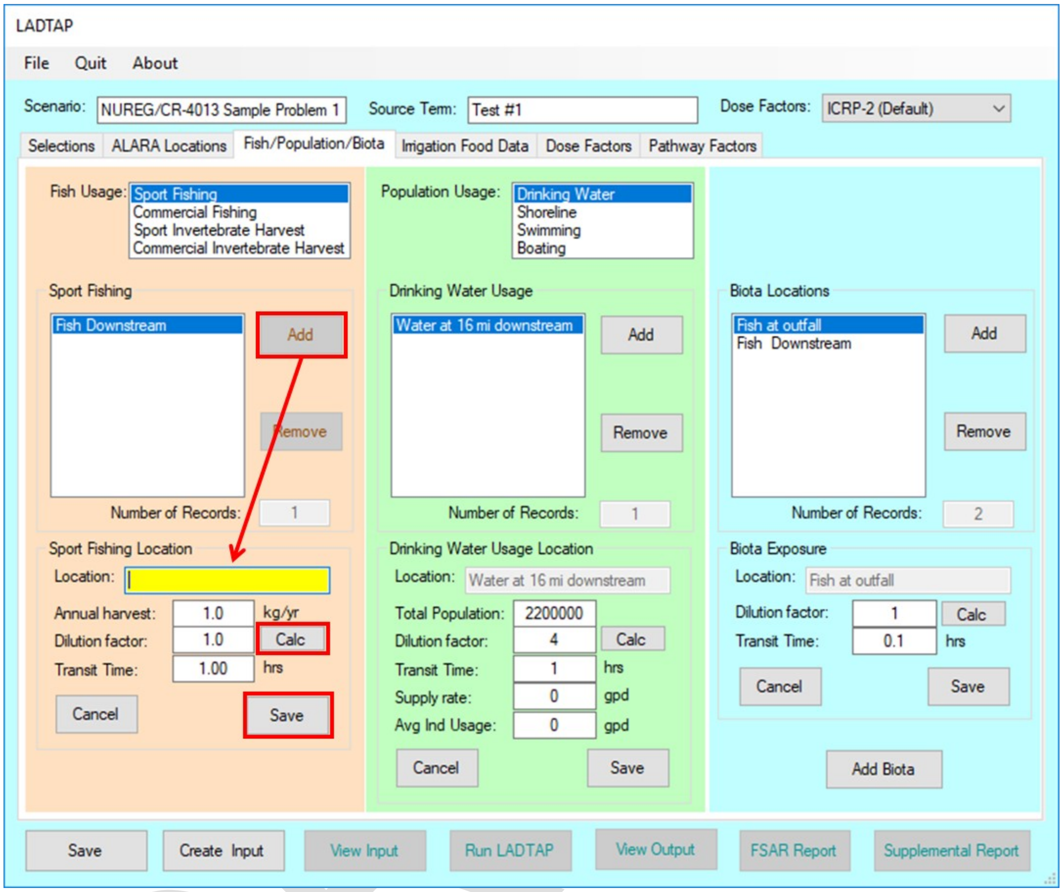


Figure 3-18 Fish Usage Section of the Fish/Population/Biota Tab

When the required input parameters have been entered for the type of fishing or invertebrate harvesting location, select the "Save" button to add to the location to the LADTAP dose calculation input file. To remove a type fishing or invertebrate harvesting location, select (highlight) the location from the "Records" (upper) portion of the Fish Usage Section and select the "remove" button to delete the location. Repeat this process for any additional locations for the types (sport or commercial) of fishing or invertebrate harvesting.

3.2.3.2 Population Usage Section

This section is where the total drinking water usage and recreation (shoreline, swimming and boating) times at locations are entered for determination of population doses. From the menu choices, select the desired population usage parameter from one of the four options as shown in Figure 3-17:

- Drinking Water
- Shoreline

- Swimming
- Boating

Once selected, the input parameters for the selected pathway can be entered by the user, as shown in Figure 3-19. To define a new population usage location, select the "Add" button to activate the usage location at the bottom of the Population Usage Section.

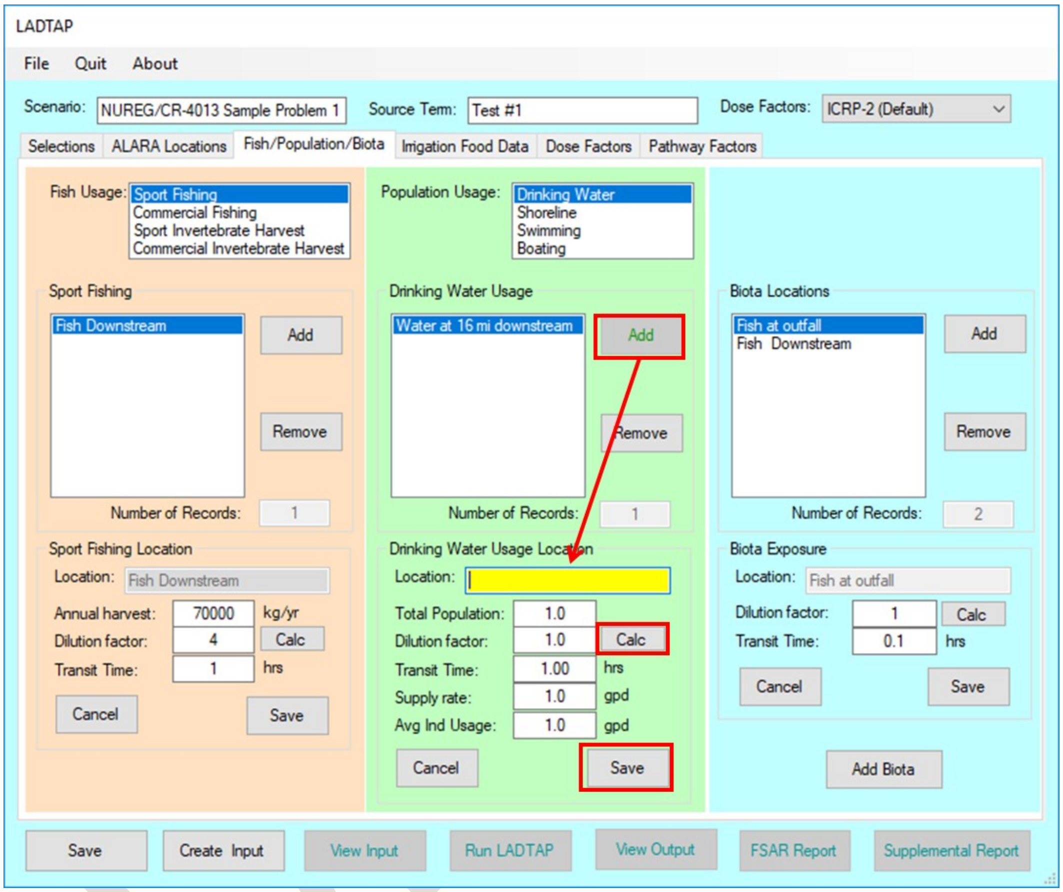


Figure 3-19 Population Usage Section of the Fish/Population/Biota Tab

The input required in the usage location sections are different depending upon the population usage option chosen from the dropdown 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 unit of hrs. The default average individual consumption rates will be used along with the population age group distribution for the dose calculation. Alternatively, the user can enter the supply rate in units of gallons per day (gpd) and an average individual usage in gpd. The code will then calculate the exposed population for the calculation. The values from the "NUREG/CR-4013 Sample Problem 1" are "**Water at 16 mi downstream**," "**2200000**," "**4**" hr and "**1**" hr, respectively. If necessary, select the "Calc" button to open Dilution Factor Calculation Screen as 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 units of person-hr per year (person-hr/yr), the dilution factor (unitless), the transit time in unit of hrs, and shore-width factor from the dropdown menu. The shore-width factor dropdown menu options are listed in Table 3-2 and described in Section 3.2.2.1.1. The values from the “NUREG/CR-4013 Sample Problem 1” are “**Downstream Shore**,” “**83000**” person-hr/yr, “**4**” hr and “**1**” hr, respectively. If necessary, select the “Calc” button to open Dilution Factor Calculation Screen as 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 units of person-hr/yr, the dilution factor (unitless), and the transit time in unit of hrs. The values from the “NUREG/CR-4013 Sample Problem 1” are “**Water at 16 mi downstream**,” “**120000**” person-hr/yr, “**4**” hr and “**1**” hr, respectively. If necessary, select the “Calc” button to open Dilution Factor Calculation Screen as 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 units of person-hr/yr, the dilution factor (unitless), and the transit time in unit of hrs. The values from the “NUREG/CR-4013 Sample Problem 1” are “**Downstream boating**,” “**520000**” person-hr/yr, “**4**” hr and “**1**” hr, respectively. If necessary, select the “Calc” button to open Dilution Factor Calculation Screen as 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 required input parameters have been entered for the type of population usage location, select the “Save” button to add to the location to the LADTAP dose calculation input file. To remove a type population usage location, select (highlight) the location from the “Records” (upper) portion of the Population Usage Section and the select the “remove” button to delete the location. Repeat this process for any additional locations for the types (sport or commercial) of fishing or invertebrate harvesting.

3.2.3.3 Biota Locations Section

This section is where any biota exposure locations are identified and defined for use in LADTAP dose calculations. To define a biota exposure location, select the “Add” button to activate the biota exposure location at the bottom of the Biota Locations Section. For each biota exposure location, enter the name of the location, the dilution factor (unitless) and the transit time (hrs). The values from the “NUREG/CR-4013 Sample Problem 1” are “**Fish at outfall**,” “**1**” hr and “**1**” hr, respectively. If necessary, select the “Calc” button to open Dilution Factor Calculation Screen as 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 an explanation on the biota dose function in the LADTAP II Fortran code.

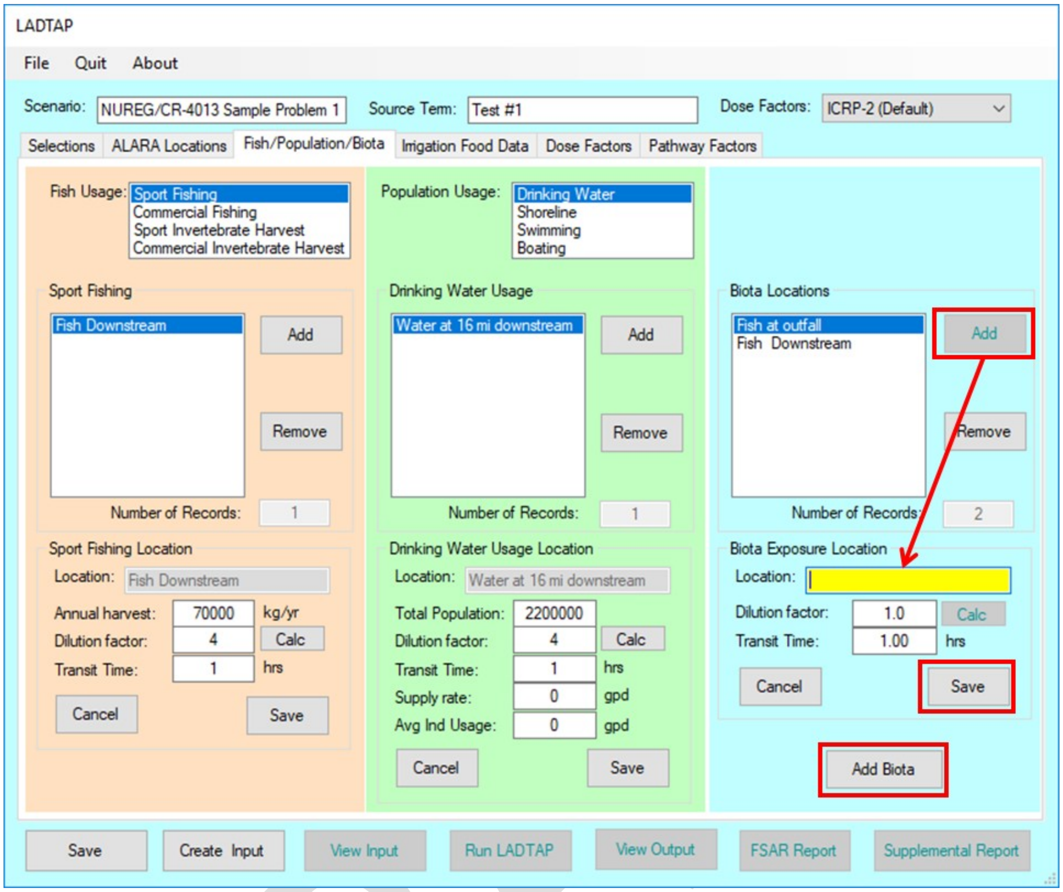


Figure 3-20 Biota Locations Section of the Fish/Population/Biota Tab

There are three (3) primary aquatic species (fish, invertebrate and algae) and four (4) secondary terrestrial species (muskrat, racoon, heron and duck) included in the LADTAP code. As described below, additional 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 3 primary and 4 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, determining an assimilated concentration in the biota mass. The dose is determined by multiplying this biota mass concentration by nuclide-specific effective energy deposited in the biota, based on a defined effective radius for the biota. Tables 3-3 and 3-4 below summarize the modeling and exposure assumptions.

The effective radius is used to model the biota as a sphere geometry, such that different dose absorption values can be applied for different size/mass biota. Effective radius is the radius of a sphere (considered muscle) that has the same mass as the biota in question, based on an assumed uniformly distributed mass. For an assumed nominal density of 1 gram per cubic centimeter (g/cm^3) for muscle, the effective radius can be approximated as the cubic root of the quantity (mass (in grams) divided by 4.19, where 4.19 = 4/3 * π). Refer to Appendix D for a description of 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	1000	100	Aquatic plants
Racoon	14	1200	200	Invertebrate
Heron	11	4600	600	Fish
Duck	5	1000	100	Aquatic plants

Table 3-4 Biota Exposure Assumptions

Biota	Shoreline (sediment) Exposure Time (h/y)	Swimming Exposure Time (h/y)
Fish	4380	8760
Invertebrate	8760	8760
Algae	0	8760
Muskrat	2922	2922
Racoon	2191	0
Heron	2922	2920
Duck	4383	4383

If a new biota type will be used, select the "Add Biota" button on the Biota Locations Section as shown in Figure 3-20 to open the Additional Biota Types Screen as shown in Figure 3-21.

Once the Additional Biota Types Screen opens, 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 for the new biota:

- Name ─ Enter the name of the biota to be added to the LADTAP dose calculation.
- Food Type ─ This field is used to enter the classification of food type for the new biota and contains a dropdown menu with three food type options. The food type options are "Algae," "Fish," and "Invertebrate."
- Mass ─ Enter the mass of the biota in units of grams (g) and the allowable range for values in this field is greater than 0 g.

- Effective Radius — This field is used to enter effective radius in units of centimeters (cm) and the allowable range for values in this field is greater than 0 cm.

- Consumption Rate — This field is used to enter consumption rate of the biota in units of gram per day (g/d) and the allowable range for values in this field is greater than 0 g/d.

- Shoreline exposure — This field is used to enter the shoreline exposure from the biota in units of hrs/yr and the allowable range for values in this field is greater than 0 hrs/yr.

- Swimming exposure — This field is used to enter the swimming exposure from the biota in units of hrs/yr and the allowable range for values in this field is greater than 0 hrs/yr.

BNWL-1754 [Ref. 22], Section 6 provides the modeling used in LADTAP for the biota calculations; Table 6.1-1 presents the exposure assumptions for the various primary and secondary biota.

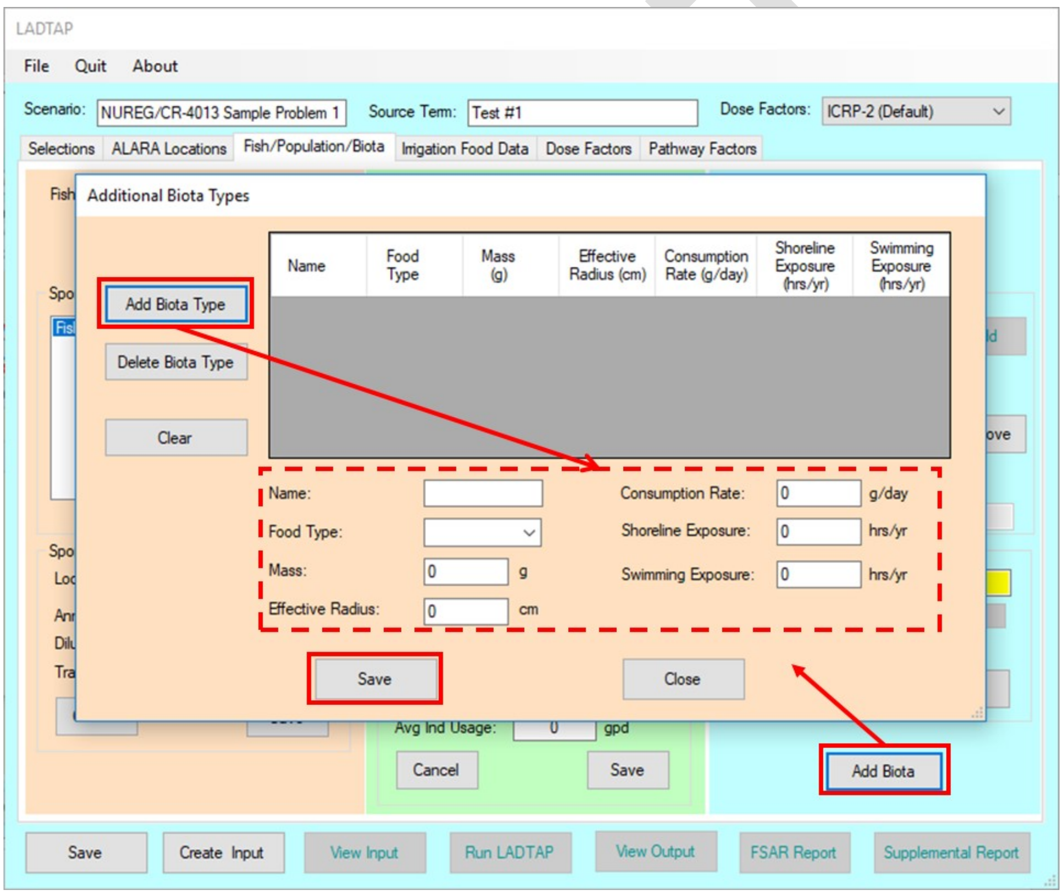


Figure 3-21 Additional Biota Types Screen

When the required input parameters for the new biota are entered, select the “Save” button to add to the location to the LADTAP dose calculation input file. To remove a biota type, select (highlight) the location from the upper portion of the Additional Biota Types Screen as shown in Figure 3-21 and select the “Delete Biota Type” button to delete the biota type. Select the “close” button to return to the Biota Locations Section of the Fish/Population/Biota Tab as shown in Figure 3-20.

3.2.4 Irrigation Food Data Tab

The Irrigation Food Data Tab is used to enter the parameters used to calculate the exposure to humans 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 Pathway Section, and (2) Water Usage Locations Section. Additionally, as shown in Figure 3-22, each of these two-main data input section contains a subsection for the additional of input data: (1) Irrigated Food data subsection, and (2) Water Usage Data subsection.

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

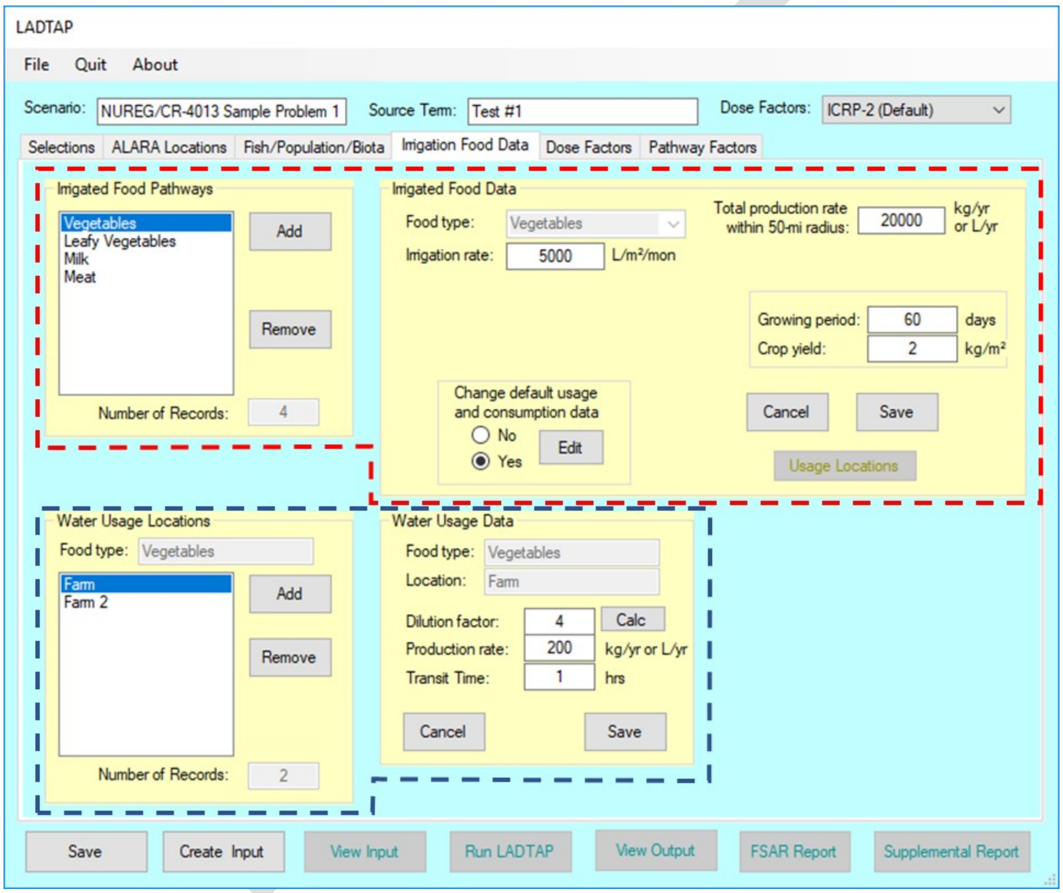


Figure 3-22 Irrigation Food Data Tab

3.2.4.1 Irrigated Food Pathways Section

This section is where the irrigated food data for the LADTAP dose calculations can be added or removed. To add an irrigated food pathway to the calculation, select the "Add" button which will open the information screen with the user note mentioned above as 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 type, select (highlight) the pathway type from the "Records" Irrigated Food Pathway Section and select the "remove" button to delete the location. There is also a display of the number of irrigated food pathway records in this section.

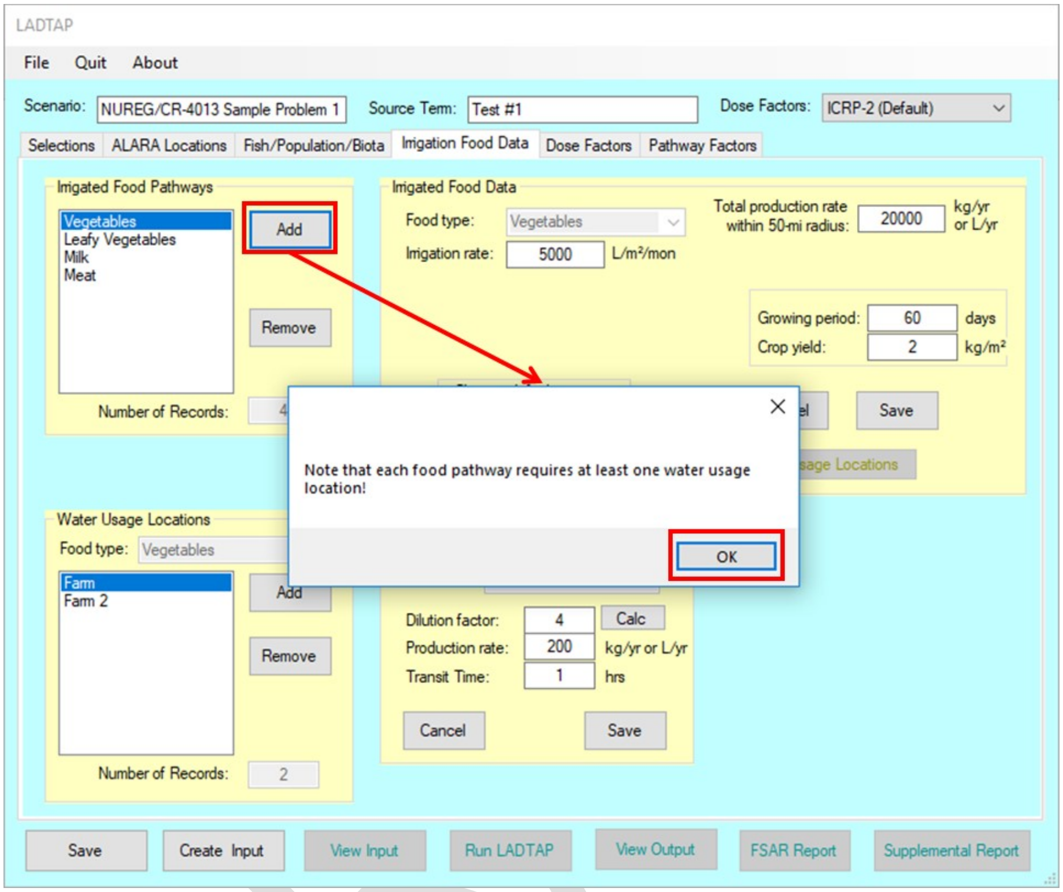


Figure 3-23   Irrigation Food Data Note Screen

3.2.4.1.1   Irrigated Food Data Subsection

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

- <u>Food Type</u> — This field is used to enter the classification of irrigation food type and contains a dropdown menu with four food type options. The irrigation food type options are "Vegetables," "Leafy Vegetables," "Milk," and "Meat."

- <u>Irrigation Rate</u> — This field is used to enter the irrigation rate for the food type in units of liters per square meters per month (L/m^2/mon) and the allowable range for values in this field is greater than 0 L/m^2/mon.

- <u>Total Production Rate</u> — This field is used to enter the production rate for the irrigated food type within a 50-mile radius in units of kg/yr or liters per year (L/yr) and the allowable range for values in this field is greater than 0 kg/yr or 0 L/yr.

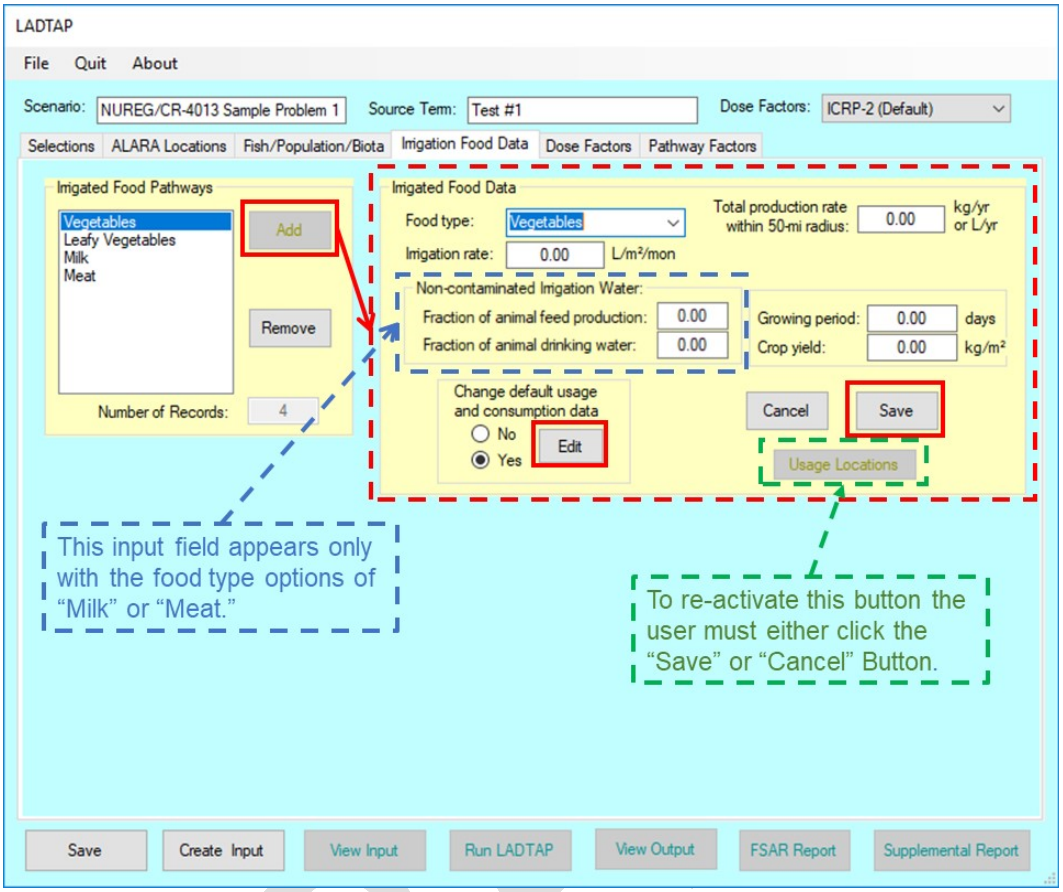


Figure 3-24 Irrigation Food Data Subsection

- Non-contaminated Irrigation Water ─ These fields are used only when the "Milk" and "Meat" irrigation food type options are selected, and they are fraction of the amount of non-contaminated irrigation water used for feed livestock feed production. This field is unitless and the allowable range for values in this field is greater than 0.00.

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

- Crop Yield ─ Enter the crop yield for the irrigated food type in this field in units of kilograms per square meter (kg/m^2) and the allowable range for values in this field is greater than 0.00 kg/m^2. Default values from RG 1.109 are 0.7 kg/m^2 for milk and meat pathway (reflecting pasture grass) and 2.0 kg/m^2 for vegetables and leafy vegetables.

If needed to reflect site-specifics, the user can change the individual consumption rates under either the Pathway Factors Tab, Section 3.2.6, or by selecting the "Yes" button and the "Edit" button on the "Change default usage and consumption data" portion of Figure 3-24. This will open the Usage/Consumption Screen as shown in Figure 3-25. Similar to Section 3.2.2.1.4, enter the required usage/consumption information and select the "Save" button when edits are completed, to save the revised usage and consumption data.

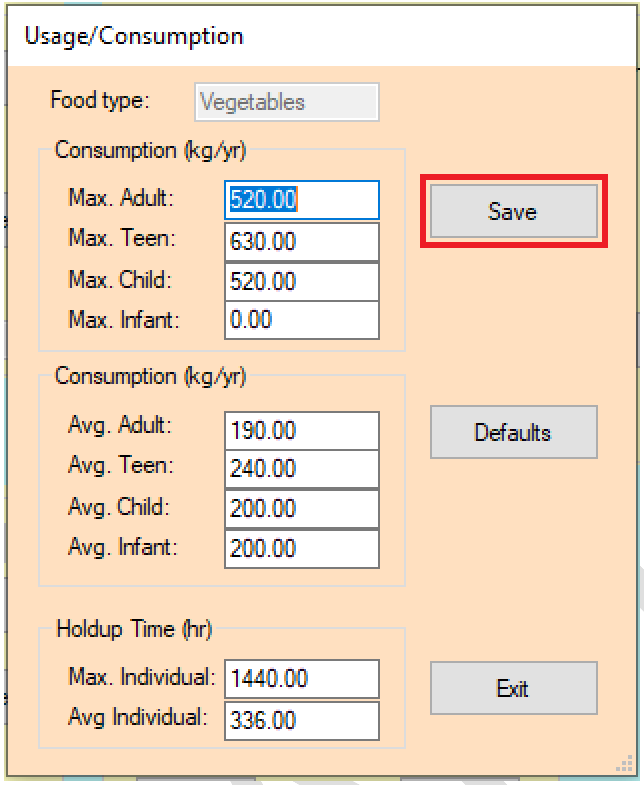


Figure 3-25 Usage/Consumption Screen

When the required data for the new irrigated food pathways are entered, select the "Save" button to add to the pathway to the LADTAP dose calculation input file. Selecting the 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 Location Section of the Irrigation Food Data Tab described in Section 3.2.4.2.

3.2.4.2 Water Usage Locations Section

The Water Usage Location Section of the Irrigation Food Data Tab is where the water usage location for each irrigated food pathway is defined as shown in Figure 3-26. 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 from the "Records" Water Usage Locations Section and select the "remove" button to delete the location. There is also a display of the number of water usage location records in this section.

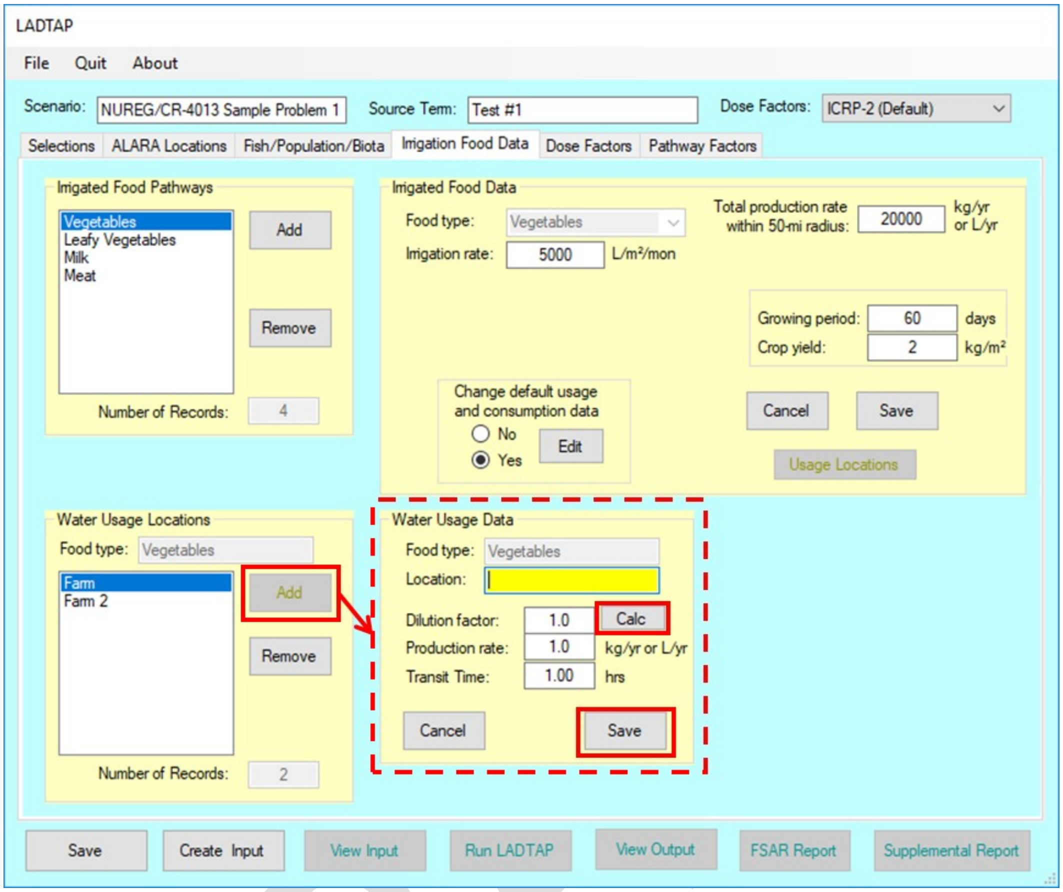


Figure 3-26 Water Usage Data Subsection

3.2.4.2.1 Water Usage Data Subsection

Once the Water Usage Data subsection is activated, as shown in Figure 3-26, enter for each irrigation food pathway type a location name, a dilution factor, production rate and transit time. The dilution factor can be calculated as discussed in Section 3.3.1.2. It is important to remember that for every irrigated food pathway defined there must be at least one water usage location and one water usage location may be used for several irrigation food pathways. Select the "Save" to add this location to the LADTAP case.

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

3.2.5 Dose Factors Tab

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

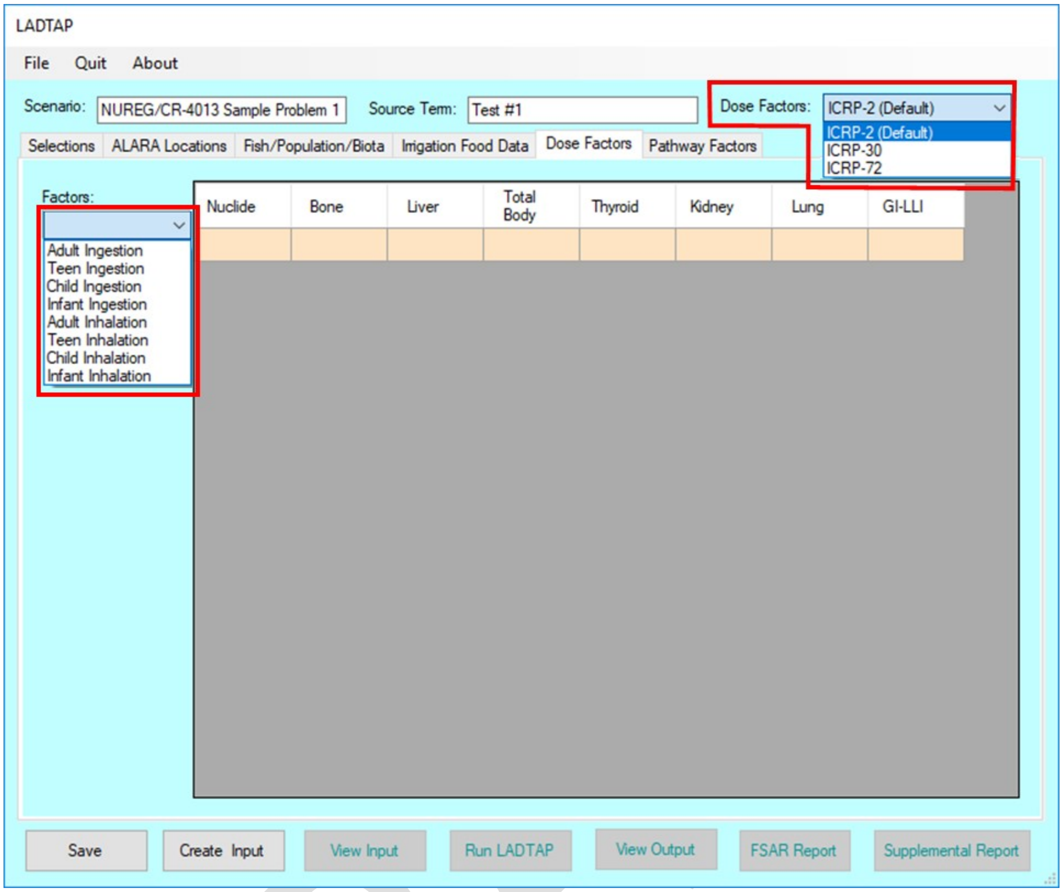


Figure 3-27 Dose Factors Tab with DCF methodology and age/pathway options

As mentioned above the three DCF sets that can be selected by the Dose Factors dropdown menu are:

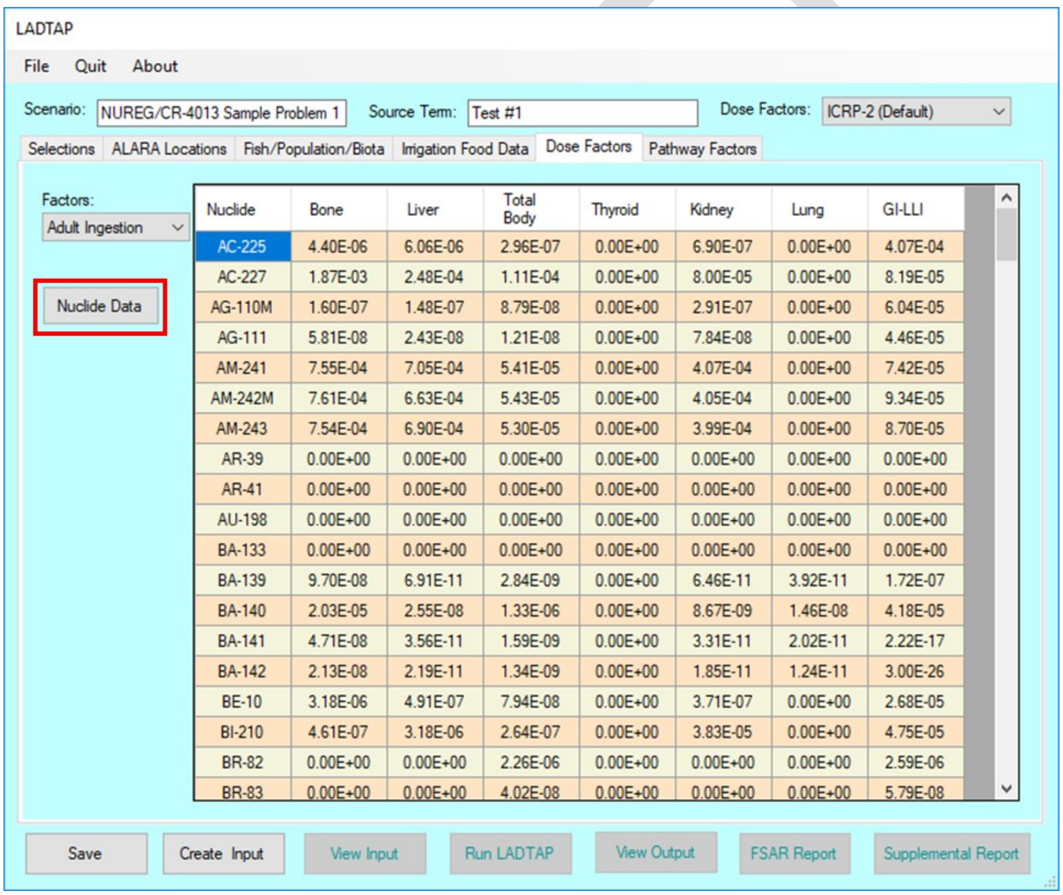
- ICRP-2 (Default) ─ This DCF methodology option contains the default radionuclides and DCF values used by NRCDose3, following the precedent set by the NRC release of LADTAP II and GASPAR II. These DCF values are based on the ICRP-2 methodology, which is the current basis of the NRC regulations in 10 CFR Part 50, Appendix I, and the EPA regulations in 40 CFR Part 190. ICRP-2 DCF values are included for four age groups (Infant, Child, Teen, and Adult) and 7 organs (Bone, Liver, Total Body, Thyroid, Kidney, Lung, and GI-LLI). Appendix A of this manual lists the 203 radionuclides and the technical references for the use of the ICRP-2 DCF values.

- ICRP-30 ─ This DCF methodology utilizes occupational DCF values for ingestion and inhalation. These DCF values are based on the ICRP-30 methodology, which is the current basis of the NRC regulations in 10 CFR Part 20. Since these are occupational DCF values, only adult factors are included for 24 organs. The same 203 radionuclides listed in Appendix A and available for the ICRP-2 methodology DCF values are also available for the ICRP-30 methodology option. Section 6.1 provides detail discussions on the selection of the radionuclide inhalation class (i.e., D/M/Y).

- ICRP-72 — This DCF methodology utilizes DCF values in accordance with ICRP Report No. (ICRP-60) methodologies. The DCF values are included for inhalation and ingestion pathways, for 6 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 both the ICRP-2 and ICRP-30 methodologies are also the same radionuclides available for the ICRP-72 methodology option. Section 6.1 provides detail discussions on the selection of the radionuclide inhalation class (i.e., F/M/S).

** **User Note** ** — Use of ICRP-72 DCF values by an applicant or licensee for a proposed NRC LAR should be discussed with the NRC staff prior to submitting the license request.

After selecting the appropriate ICRP methodology and Dose Factors from their respective dropdown menus all applicable organ DCF values are available for review as shown in Figure 3-28. Select the “Nuclide Data” button to open the Nuclide Data Screen as 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

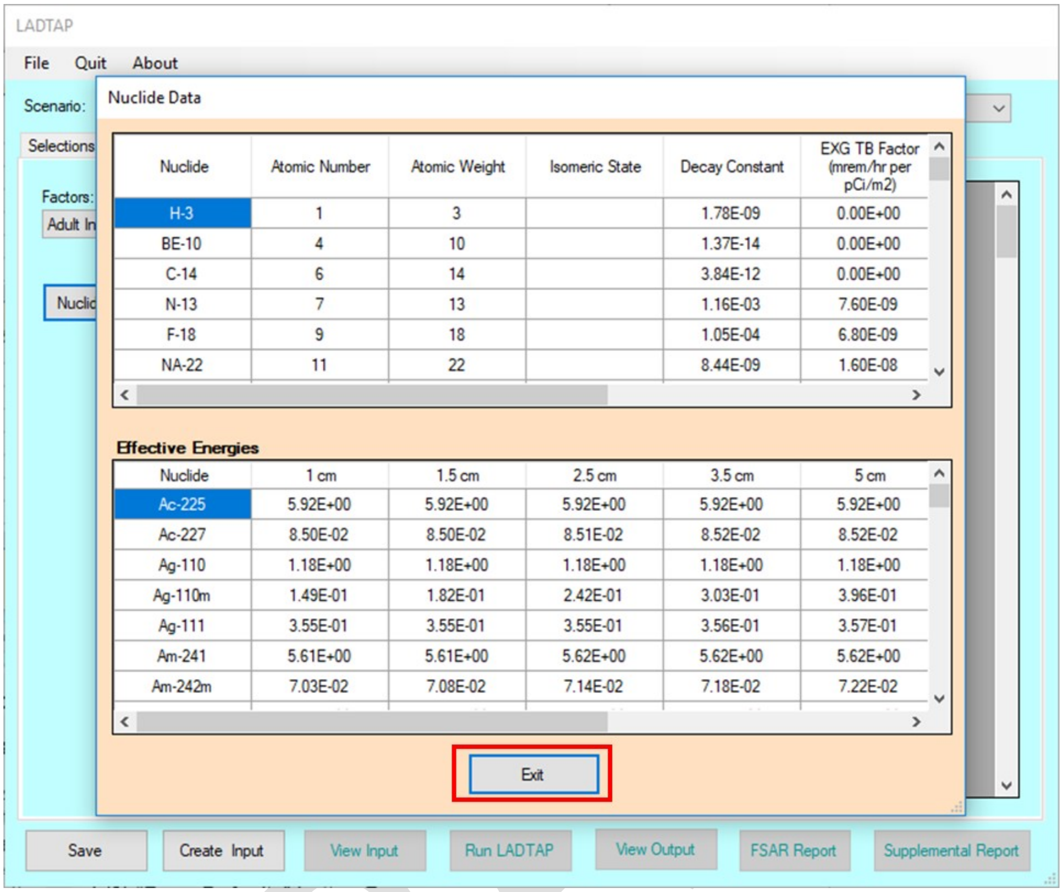


Figure 3-29 Nuclide Data Screen

3.2.6 Pathway Factors Tab

The Pathway Factors Tab is used to view and edit, as needed, the remaining parameters used for completing 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” button, (2) Usage/Consumption” button, and (3) “Page Defaults” button.

**** User Note ** —** The values for the parameters included for the initial install are those recommended in RG 1.109, except when using the ICRP-72 DCFs, the values for the Usage/Consumption reflect values taken from EPA EFH. Any changed made to the values in this tab will be saved in the program’s main database and will be used for future calculations. Therefore, it is recommended that if values are changed to reflect site-specifics, that after the case/file is saved, which will also save these changes applicable for the case/file, the defaults be reset so as not to inadvertently affect future uses and calculations.

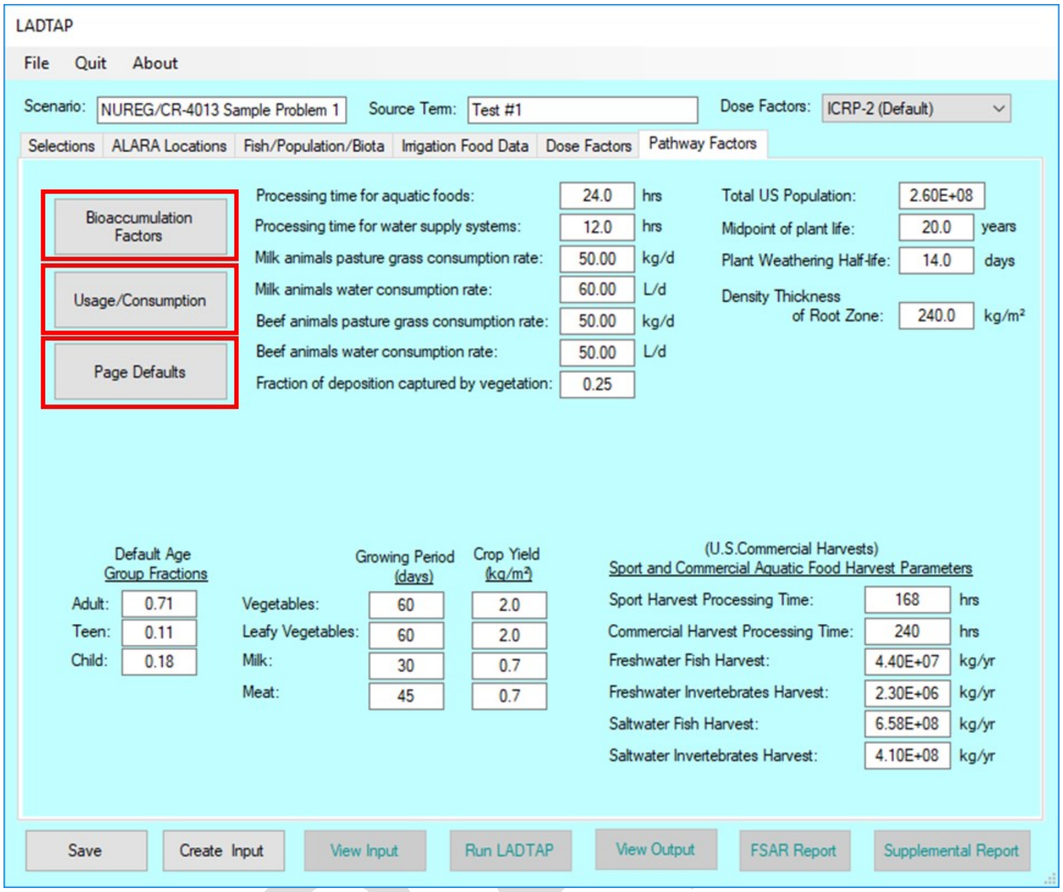


Figure 3-30 Pathway Factors Tab

3.2.6.1 Liquid Pathway Parameters

The following liquid pathway parameters can be reviewed and/or edited on Pathway Factors Tab as shown in Figure 3-30. The liquid pathway parameters that can be reviewed and/or edited are:

- Processing time for aquatic foods is entered in units of hrs with the RG 1.109 default value of "**24.0**" hrs, which has also been used for "NUREG/CR-4013 Sample Problem 1." The allowable range for values in this field is greater than 0.0 hrs.

- Processing time for water supply systems entered in units of hrs with the RG 1.109 default value of "**12.0**" hrs, which is the same as used for "NUREG/CR-4013 Sample Problem 1." The allowable range for values in this field is greater than 0.0 hrs.

- Pasture grass consumption rate for milk producing animals is entered in units of kilograms per day (kg/d) with the RG 1.109 default value of "**50.0**" kg/d, which is the same as used for "NUREG/CR-4013 Sample Problem 1." The allowable range for values in this field is greater than 0.0 kg/d.

- Water consumption rate for milk producing animals is entered in units of liters per day (L/d) with the RG 1.109 default value of "**60.0**" L/d, which is same as used for

"NUREG/CR-4013 Sample Problem 1." The allowable range for values in this field is greater than 0.0 L/d.

- Pasture grass consumption rate for beef producing animals is entered in units of kg/d with the RG 1.109 default value of "**50.0**" kg/d, which is same as used for "NUREG/CR-4013 Sample Problem 1." The allowable range for values in this field is greater than 0.0 kg/d.

- Water consumption rate for beef producing animals is entered in units of L/d with the RG 1.109 default value of "**60.0**" L/d, which is same as used for NUREG/CR-4013 Sample Problem 1." The allowable range for values in this field is greater than 0.0 L/d.

- Fraction of deposition captured by vegetation is unitless with the RG 1.109 default value of "**0.25,**" which is same as used for "NUREG/CR-4013 Sample Problem 1." The allowable range for values in this field is greater than 0.0 and less than 1.0.

- Total U.S. population with the RG 1.109 default value of "**2.60E+08,**" which is same as used for "NUREG/CR-4013 Sample Problem 1." 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 though not used for current population dose calculations.)

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

- Plant weathering half-life is entered in units of days with the RG 1.109 default value of "**14**" d, which is same as used for "NUREG/CR-4013 Sample Problem 1." The allowable range for values in this field is greater than 0.0 d.

- Density thickness of root zone is entered in units of kg/m^2 with the RG 1.109 default value of "**240**" kg/m^{2,} which is the same as used for "NUREG/CR-4013 Sample Problem 1." The allowable range for values in this field is greater than 0.0 kg/m^2.

- Default age group fractions are entered for the "Adult," "Teen," and "Child" (unitless) with the RG 1.109 default values of "**0.71**," "**0.11**," and "**0.18**," respectively. These are the same values as used for "NUREG/CR-4013 Sample Problem 1". The allowable range for values in these fields are greater than 0.0. If the calculation to be performed is using ICRP-30 DCF values, the population fraction should be 1.00 for adults and 0 for teens and children as ICRP-30 contains DCF values for only the adult age range.

- Growing periods are entered for the "Vegetables," "Leafy Vegetables," "Milk," and "Meat" in units of d with the RG 1.109 default values of "**60**," "**60**," "**30**," and "**30**" d, respectively. These are the same as used for "NUREG/CR-4013 Sample Problem 1." The allowable range for values in these fields is greater than 0.0 d.

- Crop yields are entered for the "Vegetables", "Leafy Vegetables," "Milk," and "Meat" in units of kg/m^2 with the RG 1.109 default values of "**2.0**," "**2.0**," "**0.7**," and "**0.7**" kg/m^2, respectively. These are the same values as used for “NUREG/CR-4013 Sample Problem 1.” The allowable range for values in these fields is greater than 0.0 kg/m^2.

Additionally, the sport and commercial aquatic food harvest parameters (U.S. Commercial Harvest) listed below are entered on the Pathway Factors Tab as shown in Figure 3-30. The following RG 1.109 default values represent the total U.S. harvest data from the 1970’s. For commercial harvests, the production within 50 miles from the site is considered as part of the total U.S. harvest. Appendix D of RG 1.109 contains equations to compute the average concentration in the U.S. commercial harvest (Equation D-2 of RG 1.109) and the annual population-integrated dose (Equation D-4 of RG 1.109).

- Sport harvest processing time is entered in units of hrs with the RG 1.109 default value of “**168**” hrs, which is the same as used for “NUREG/CR-4013 Sample Problem 1.” The allowable range for values in this field is greater than 0.0 hrs.

- Commercial harvest processing time is entered in units of hrs with the RG 1.109 default value of “**240**” hrs, which is same as used for “NUREG/CR-4013 Sample Problem 1.” The allowable range for values in this field is greater than 0.0 hrs.

- Freshwater fish harvest is entered in units of kg/yr with the RG 1.109 default value of “**4.40E+07**” kg/yr, which is same as used for “NUREG/CR-4013 Sample Problem 1.” The allowable range for values in this field is greater than 0.0 kg/yr.

- Freshwater invertebrates harvest is entered in units of kg/yr with the RG 1.109 default value of “**2.30E+06**” kg/yr, which is same as used for “NUREG/CR-4013 Sample Problem 1.” The allowable range for values in this field is greater than 0.0 kg/yr.

- Saltwater fish harvest is entered in units of kg/yr with the RG 1.109 default value of “**6.58E+08**” kg/yr, which is same as used for “NUREG/CR-4013 Sample Problem 1.” The allowable range for values in this field is greater than 0.0 kg/yr.

- Saltwater invertebrates harvest is entered in units of kg/yr with the RG 1.109 default value of “**4.10E+08**” kg/yr, which is same as used for “NUREG/CR-4013 Sample Problem 1.” The allowable range for values in this field is greater than 0.0 kg/yr.

3.2.6.2 *Bioaccumulation Factors Button*

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

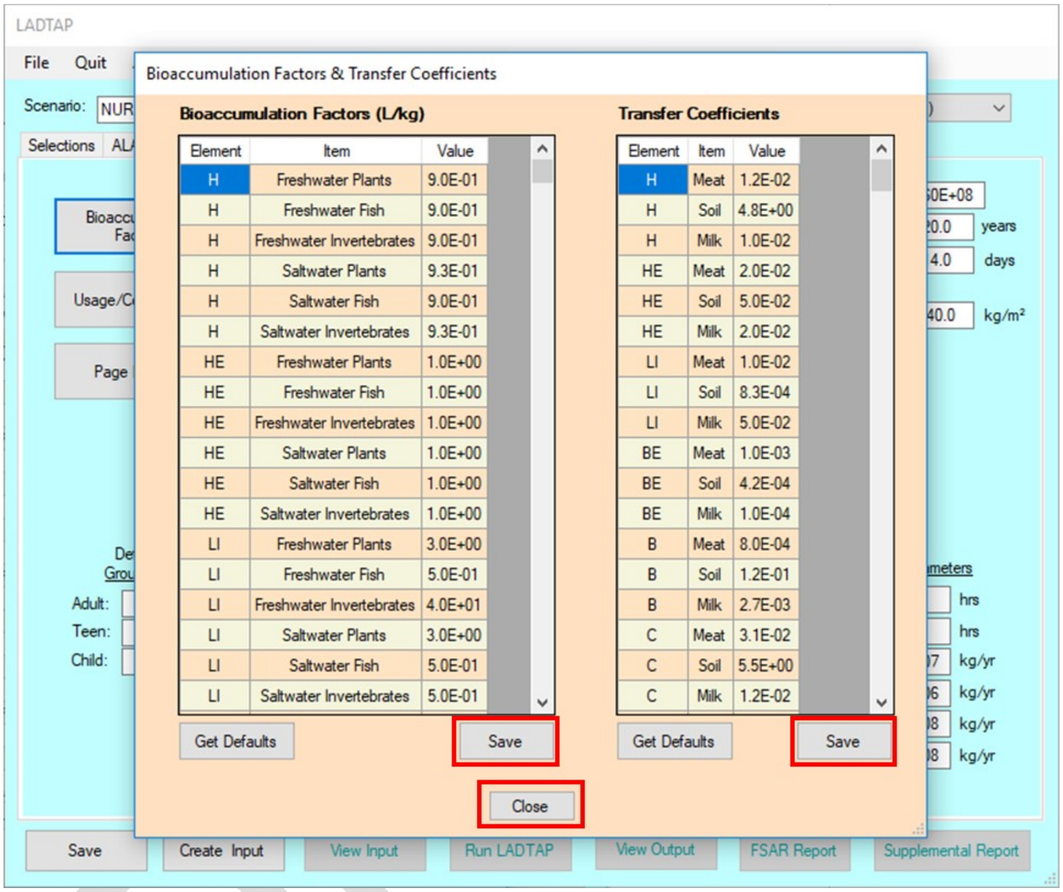


Figure 3-31 Bioaccumulation Factors & Transfer Coefficients Screen

With the Bioaccumulation Factors & Transfer Coefficients Screen open use the scrolling tool to review and adjust bioaccumulation factors for saltwater or freshwater plants and fish, and review and adjust meat, soil or milk transfer factors. The RG 1.109 default values should be used unless there are site-specific values that have been determined and supported by adequate technical bases. The “Save” button allows the user to save any edits made to either the bioaccumulation factors or transfer coefficients and when the database has been updated NRCDose3 will inform the user as shown in Figure 3-32. Additionally, when the review and/or adjustments to either the bioaccumulation factors, transfer coefficients, or both are completed, select the “Close” button to return to the Pathway Factors Tab. The NRCDose3 code will again prompt the user regarding the status of saving any changes made to either the bioaccumulation factors, transfer coefficients, or both as shown in Figure 3-32, select the “Yes” button to close the prompt window.

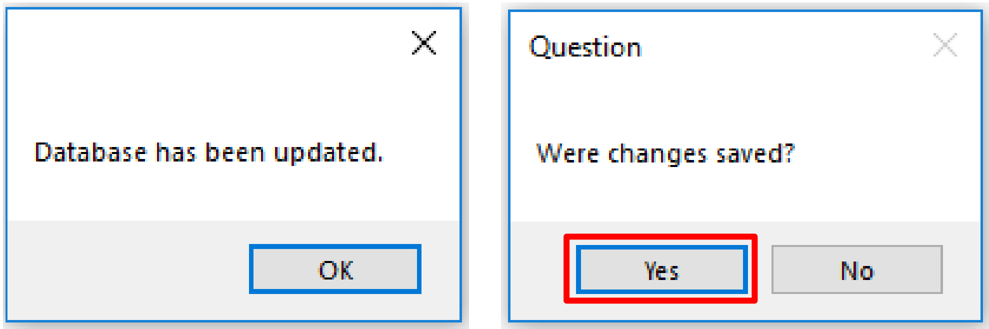


Figure 3-32 Bioaccumulation Factors & Transfer Coefficients Prompt Screens

3.2.6.3 Usage/Consumption Button

To review and edit any of the maximum or average, per age group, usage and consumption rates for food, drink and recreation, select the “Usage/Consumption” button as shown on Figure 3-30 to open the Usage/Consumption Data Screen as shown in Figure 3-33. As shown in Figure 3-33 there are three different tables of data corresponding to the databases used in the LADTAP dose calculations. The three usage/consumption tables are:

- Maximum Individual Exposure Consumption Data for selected Dose Factors ─ Data in this table includes the four age groups (i.e., “Adults,” “Teens,” “Children,” and “Infants”) and eight usage/consumption rates (i.e., “Fish,” “Freshwater Invertebrates,” “Aquatic Plants,” “Drinking Water,” “Shoreline Usage,” “Swimming Usage,” “Boating Usage,” and “Saltwater Invertebrates”) in units of kg/yr.

- Irrigated Food Type Consumption Data ─ Data in this table includes the maximum and average consumption rates in units of kg/yr for three age groups (i.e., “Adults,” “Teens,” and “Children”) and the maximum and average holdup times in units of hrs for four food types (i.e., “Vegetables,” “Leafy Vegetables,” “Milk,” and “Meat”). The “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 ─ Data in this table includes average individual consumption in units of kg/yr for three age groups (i.e., “Adults,” “Teens,” and “Children”) for three consumption types (i.e., “Fish,” “Invertebrates,” and “Drinking Water”).

There are different values depending on the ICRP methodology (i.e., ICRP-2 (Default), ICRP-30 and ICRP-72) selected. For the ICRP-2 and ICRP-30 methodology selected, the exposure assumption values are generally from RG 1.109; and when the ICRP-72 methodology is selected the exposure assumption values have been derived from the EPA EFH. Appendix C of this manual provides a detailed description of the default usage and consumption rates under the different ICRP methodologies.

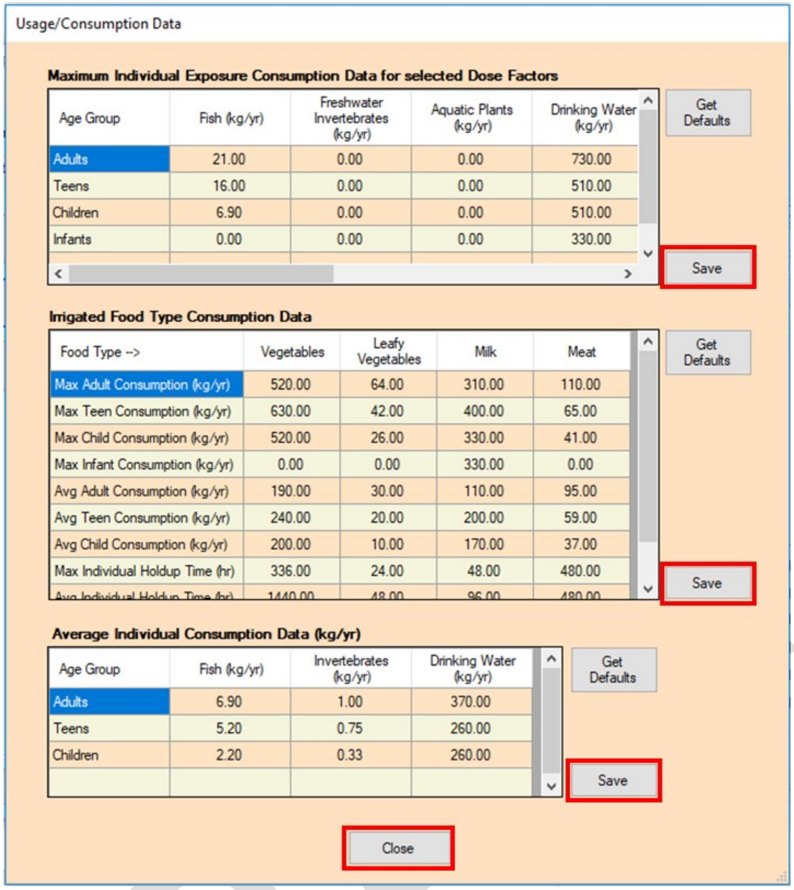


Figure 3-33 Usage/Consumption Data Screen

The “Save” button allows the user to save any edits made to any of the usage/consumption data and when the database has been updated the NRCDose3 code will inform the user as shown in Figure 3-32. Additionally, when the review and/or adjustments to any of the usage/consumption data are completed, select the “Close” button to return to the Pathway Factors Tab. The NRCDose3 code will again prompt the user regarding the status of saving any changes made to any of the usage/consumption data as shown in Figure 3-32, select the “Yes” button to close the prompt window.

** **User Note** ** **—** It is recommended that if the ICRP methodology has been changed (e.g., from ICRP-2 (Default), to either ICRP-30 or ICRP-72), the user review the usage and consumption rates to ensure the proper values are used in the LADTAP dose calculation. Use of ICRP-72 DCF values by an applicant or licensee for a proposed NRC LAR should be discussed with the NRC staff prior to submitting the license request. The code will automatically set the usage/consumption values to those associated with the DCFs being used (e.g., ICRP-2 and ICRP-30 DCFs using the RG 1.109 generic factors and ICRP-72 DCFs using the EPA EFH.

3.2.6.4 Page Defaults Button

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

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

3.3 Code Execution and Reports

3.3.1 Executing LADTAP

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

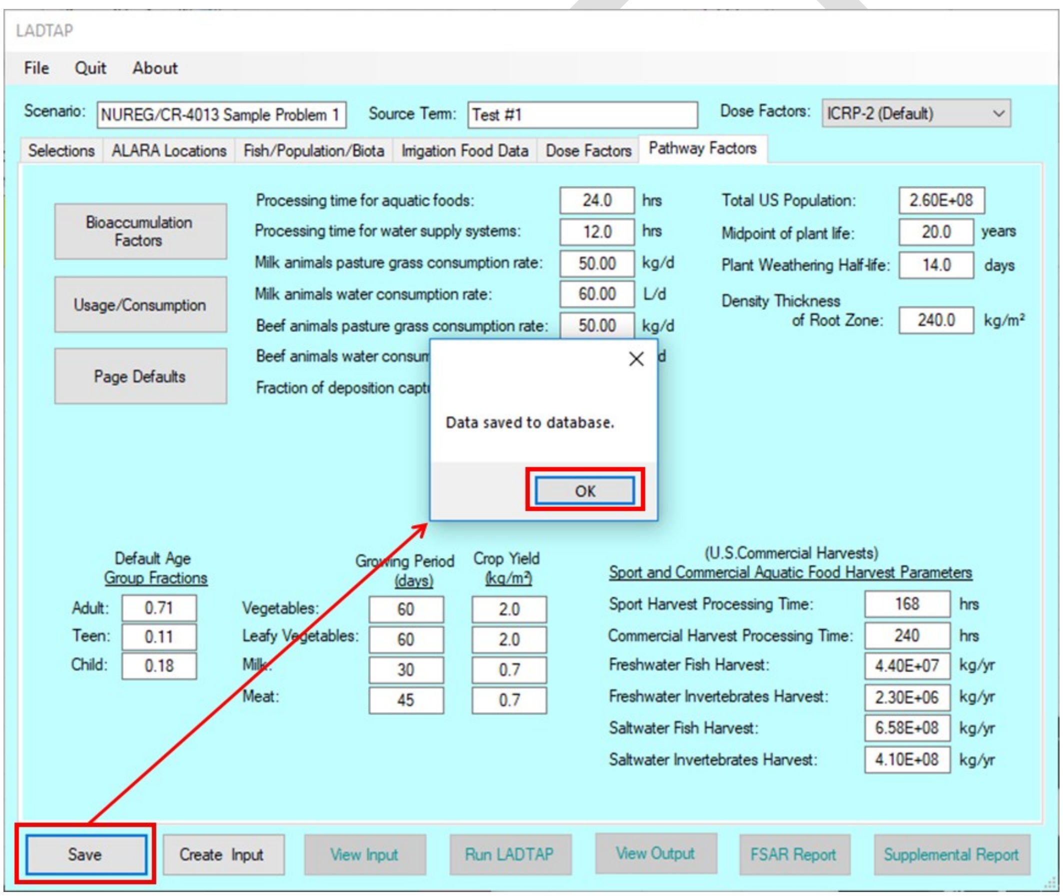


Figure 3-34 Saving LADTAP Inputs

If the data is to be saved to different "*.LN3" database file, then select the "Save to LN3 File…" as shown in Figure 3-3. The File Tool dropdown menu option (Figure 3-3) is used to open a Windows Explorer directory as shown in Figure 3-35. At this point, name the *.LN3" file and directory location as desired. Future saves will save to this new file name, as well as the database used for the code execution.

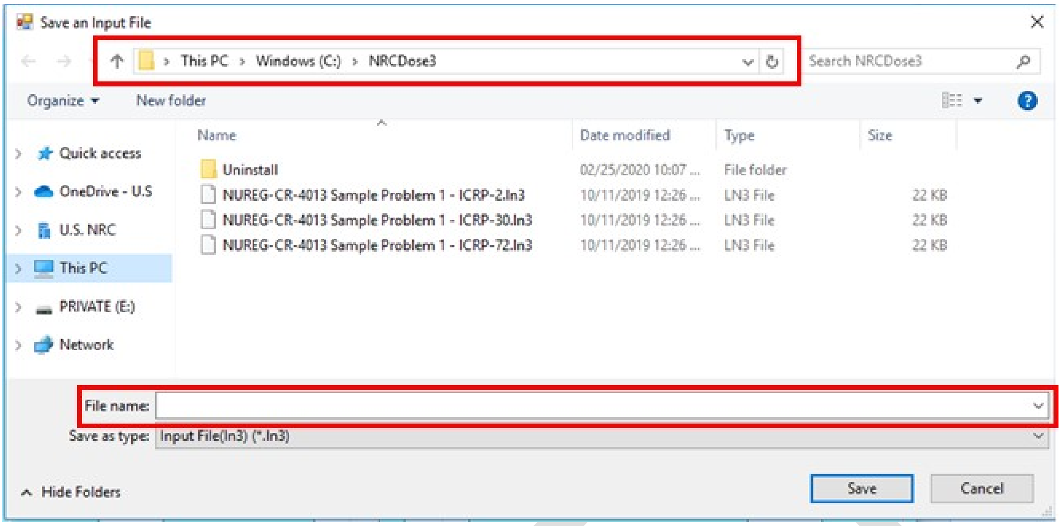


Figure 3-35   Windows Explorer directory for saving LADTAP inputs to a new file

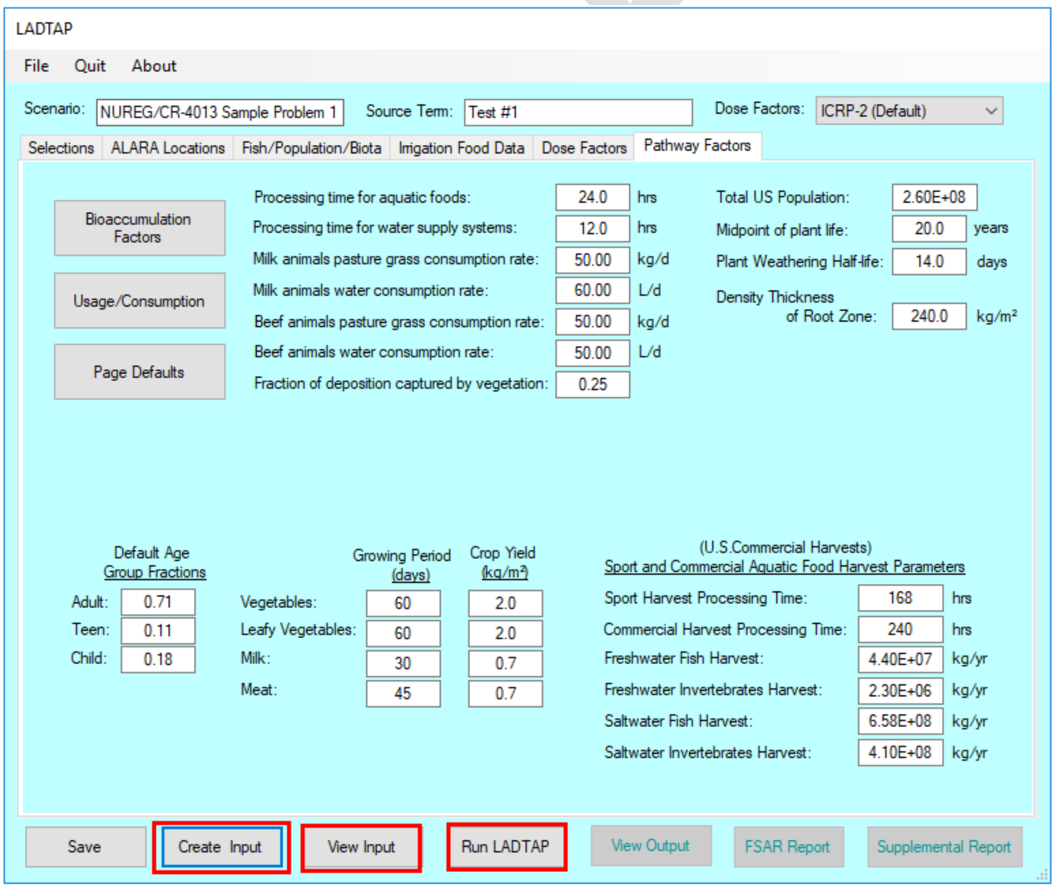


Figure 3-36   LADTAP Module Main Screen — Create Input

Select the “Create Input” button to activate the “View Input” and the “Run LADTAP” buttons on the LADTAP Module Main Screen shown in Figure 3-36. Select the “View Input” button to display and review text file data input, as shown in Figure 3-37. The “Save As..” button opens a Windows Explorer directory and allows the user to save the input as an input field file (“*.In3”). The “Print” button prints the input text file and the “Close” button closes the Text Viewer Screen as shown in Figure 3-37 and returns to the LADTAP Module Main Screen as shown in Figure 3-36.

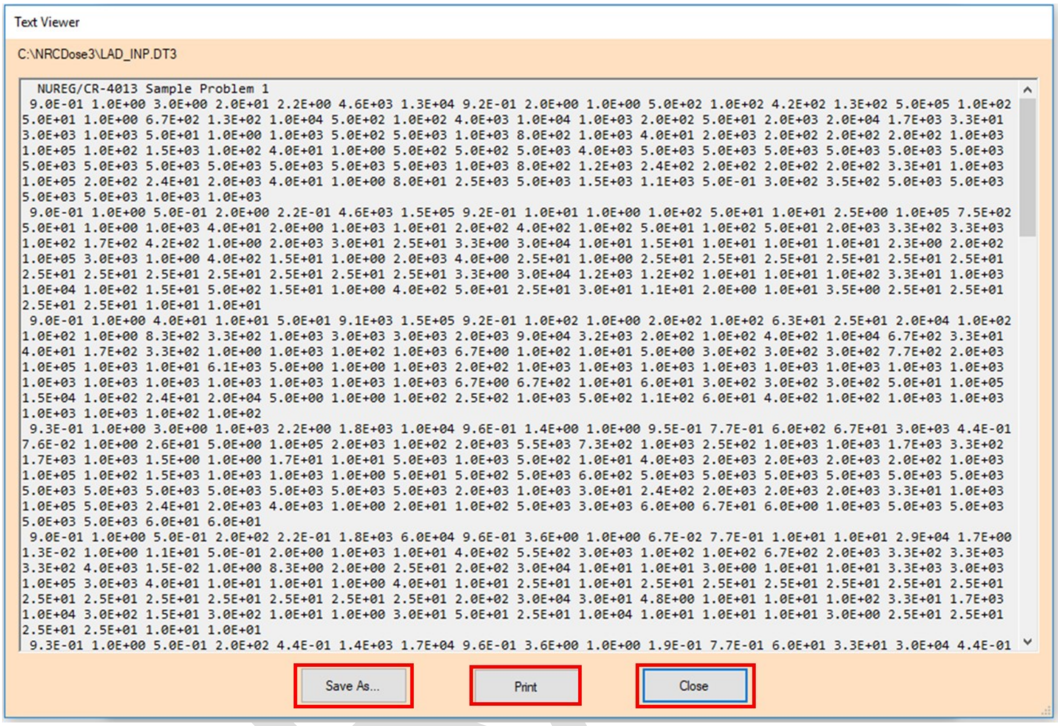


Figure 3-37 View LADTAP Input ─ Text Viewer Screen

Select the “Run LADTAP” button to execute the code and generate the output report. Selecting the “Run LADTAP” button will also activate the “View Output, the “FSAR Report,” and the “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. The “Save As..” button as shown in Figure 3-39 opens a Windows Explorer directory and allows the user to save the output as a text file (“*.txt”). The “Print” button prints the output text file and the “Close” button closes the Text Viewer Screen and returns to the LADTAP Module Main Screen as shown in Figure 3-38. The user can also the access the output text file by selecting the “View Output” button.

**** User Note ** ─** Though not required, users should consider saving LADTAP files in a user-specified directory other than the NRCDose3 directory, which would facilitate future use and sharing without having to navigate to the NRCDose3 directory.

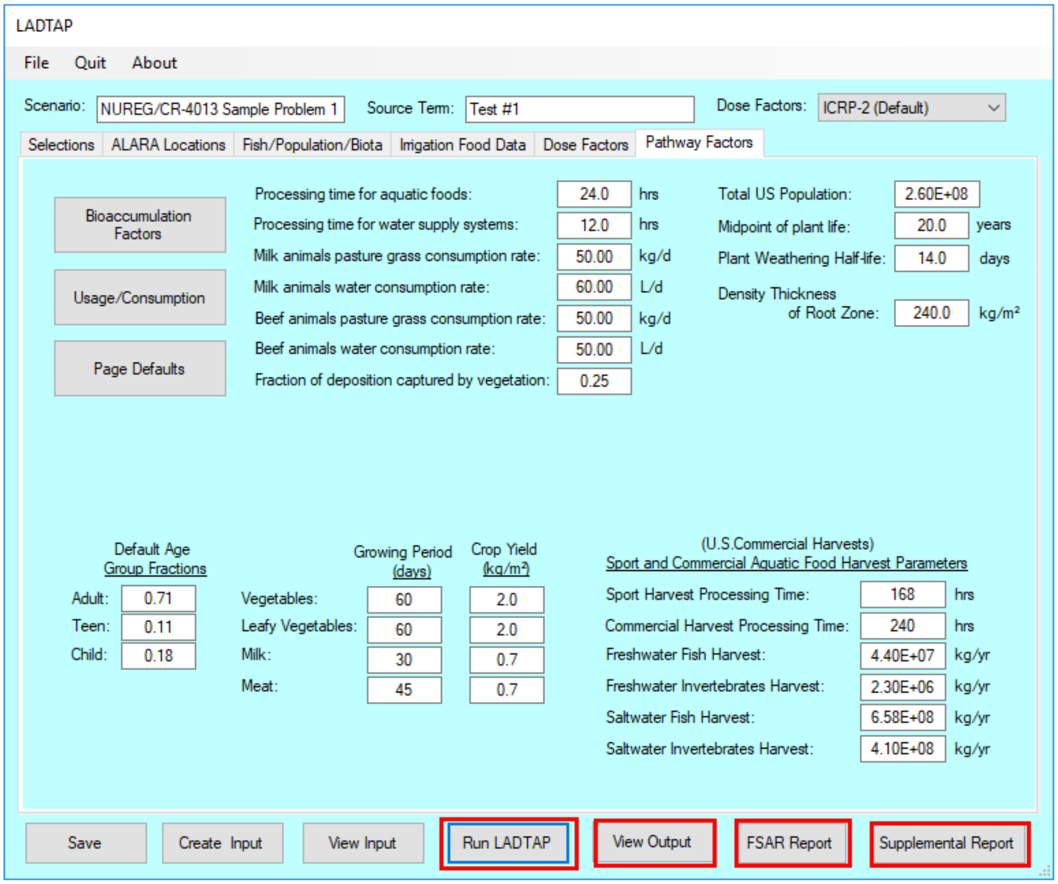


Figure 3-38 LADTAP Module Main Screen — Run LADTAP

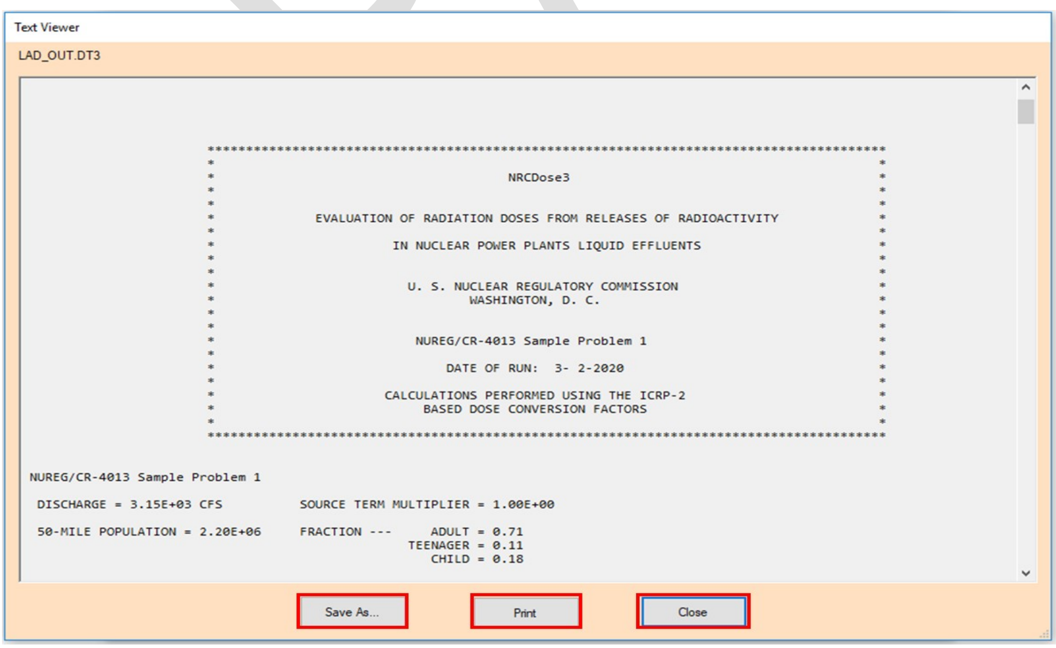
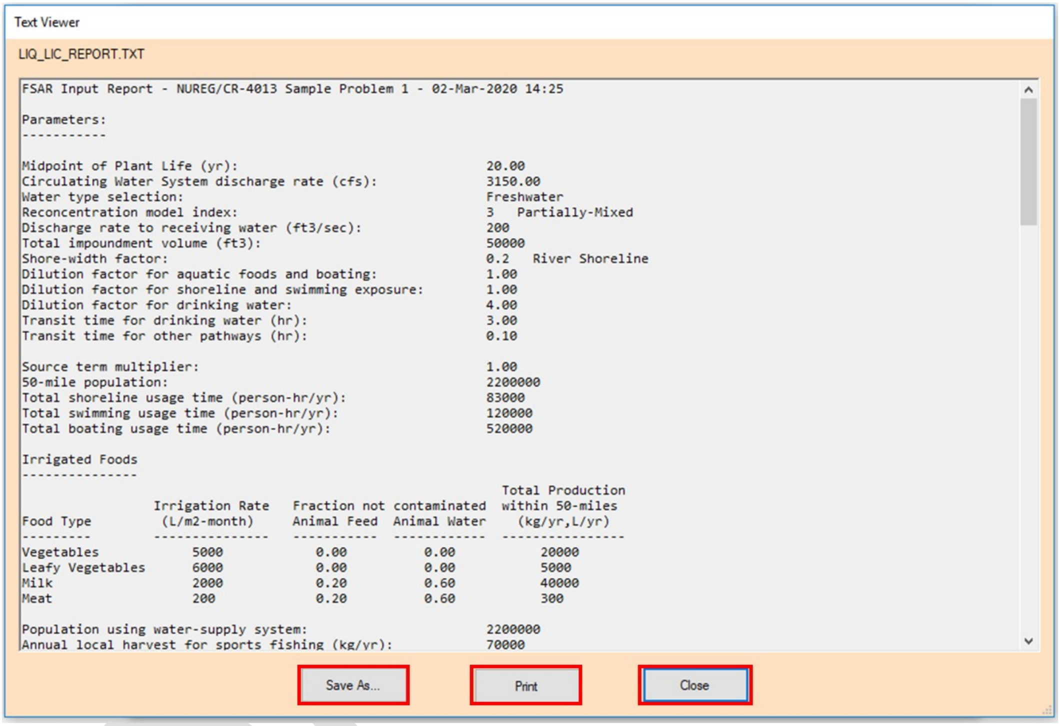


Figure 3-39 View LADTAP Output — Text Viewer Screen

3.3.2 LADTAP Reports

There are two additional reports that are created – FSAR Report and Supplemental Report. As shown in Figure 3-40, the FSAR Report consolidates the input data and dose calculations into a single text report that provides the information that is considered most important for the preparation and review of results for licensing documents. The “Save As..” button as shown in Figure 3-40 opens a Windows Explorer directory and allows the user to save the output as a text file (“*.txt”). The “Print” button prints the FSAR Report and the “Close” button closes the Text Viewer Screen and returns to the LADTAP Module Main Screen as shown in Figure 3-38.


Text Viewer

LIQ_LIC_REPORT.TXT

```
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
---------------
                                                            Total Production
                 Irrigation Rate    Fraction not contaminated  within 50-miles
Food Type         (L/m2-month)     Animal Feed  Animal Water    (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
```

Save As... Print Close

Figure 3-40 LADTAP FSAR Report Screen

As shown in Figure 3-41, the Supplemental Report provides additional documentation of the modeling assumptions that were used for the calculations, such as bioaccumulation factors, transfer factors, and various pathway constants. The “Save As..” button as shown in Figure 3-41 opens a Windows Explorer directory and allows the user to save the output as a text file (“*.txt”). The “Print” button prints the FSAR Report and the “Close” button closes the Text Viewer Screen and returns to the LADTAP Module Main Screen as shown in Figure 3-38.

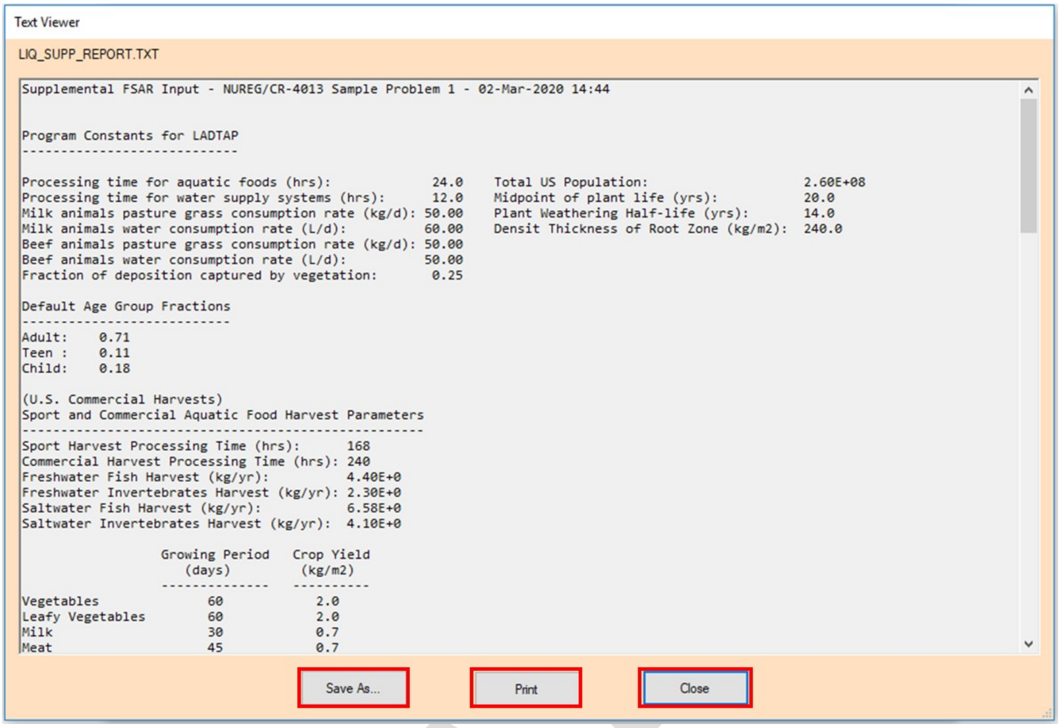


Figure 3-41 LADTAP Supplemental Report Screen

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

4.0 GASPAR

The GASPAR Module within the NRCDose3 code executes a modified version of the GASPAR II Fortran code. The basic calculation methods (algorithms) of the GASPAR II Fortran code, as described in NUREG/CR-4653, have not been changed with this update to the NRCDose3 code. However, significant changes have been made to the data management and operation to support expanded capabilities of NRCDose3. The GASPAR II Fortran code performs the environmental dose assessments for releases of gaseous radioactive effluents from NPPs into the atmosphere and implements the dose assessment methods described in RG 1.109. The GASPAR II Fortran code 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 will discuss the steps for establishing and performing GASPAR dose calculations using NRCDose3. The user is directed to NUREG/CR-4653, for the GASPAR II Fortran code user guide and technical bases, and this manual which provides additional detailed discussion on the assumptions, limitations and methods for the GASPAR dose calculations. On the NRCDose3 Main Selection Screen as shown in Figure 4-1, select the "GASPAR – Gaseous Pathway Dose Assessment" button to open the GASPAR Module Main Screen as shown in Figure 4-2.

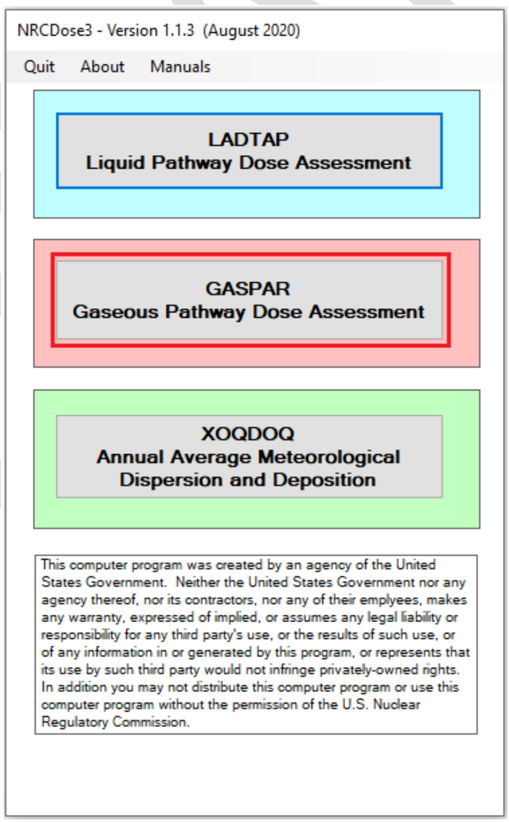


Figure 4-1 NRCDose3 Main Selection Screen (GASPAR Module)

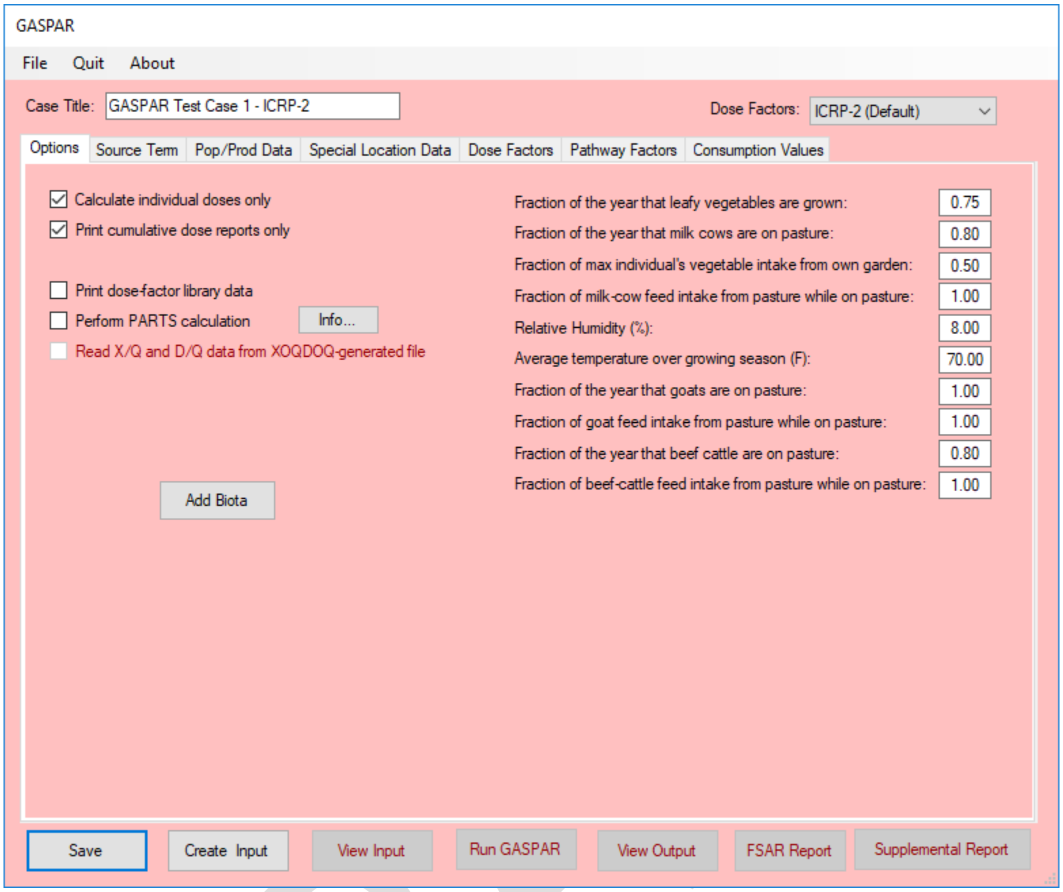


Figure 4-2 GASPAR Module Main Screen

The GASPAR Module Main Screen as shown in Figure 4-2 opens with case data saved in the database and contains three main functional areas for inputting data and conducting GASPAR dose calculations using NRCDose3. These functional areas are: (1) the toolbar and initial setup area, (2) data input tabs area and (3) code execution and reports area. Each of these functional areas of the GASPAR Module Main Screen is discussed in the following sections with a description of the options and capabilities contained therein.

4.1 Toolbar and Initial Setup Functional Area

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 the File Menu Tool, Quit Tool and About Tool. The initial setup fields include the Case Title and Dose Factors dropdown menu.

4.1.1 File Menu Tool

The File Menu Tool provides the functionality to manage the GASPAR files as shown in Figure 4-3. The File Tool dropdown menu options are:

- 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., clearing the existing input information.

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

- Save to Database — Choose this option to save the current case to the input database. When GASPAR is opened, the information in the database is that as last saved before exiting and is used to populate all GASPAR screens and windows.

- Save to GN3 File — Choose this option to save the completed case to a "*.GN3" file. This allows the file to be saved for later use, or for sharing with others.

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

** **User Note** ** — The "*.GN3" file type and format is used for NRCDose3 GASPAR files. Files of other formats for example "*.GNP" files generated under the NRCDose (version 2.3.20 and earlier) of GASPAR (i.e., NRCDose 2.3.20 GASPAR II files) are not compatible with NRCDose3.

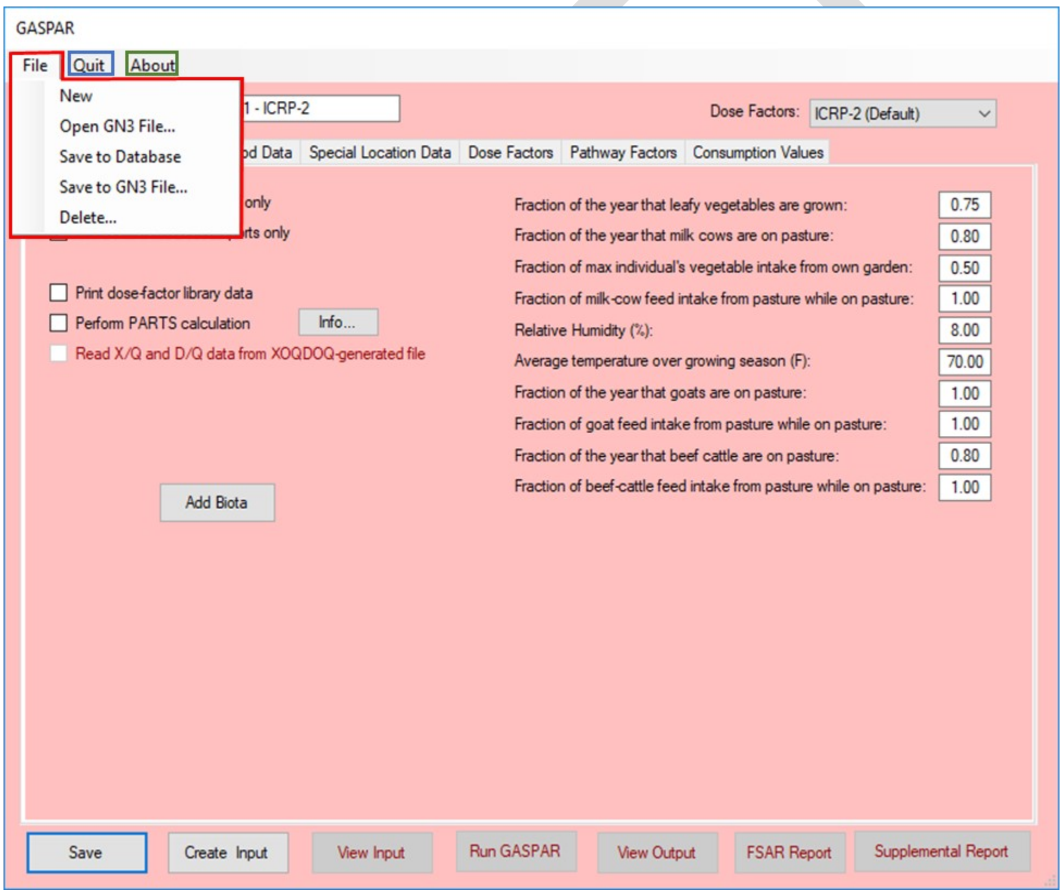


Figure 4-3 GASPAR Toolbar with File Tool dropdown menu

4.1.2 Quit Tool

Selecting the Quit Tool from the toolbar as shown in Figure 4-3 will terminate the GASPAR Module operation. There is a Question prompt screen as shown in Figure 4-4 to ensure that the user wants to quit and exit the module. If the “Yes” button is selected the GASPAR Module will terminate and any unsaved changed/edited data will not be saved. Select the “No” button and then the appropriate entry from the File Tool dropdown menu to ensure that any information has been saved (to the database and/or a *.GN3 file) prior to quitting.

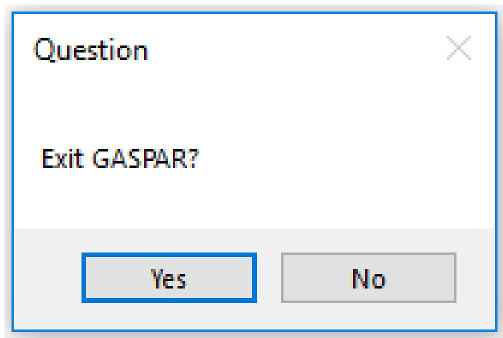


Figure 4-4 GASPAR Module Quitting Tool Screen

4.1.3 About Tool

Select the About Tool from the toolbar the About GASPAR screen as shown in Figure 4-5. This displays information about the GASPAR II code. Select the “OK” button as shown in Figure 4-5 to return to the GASPAR Module Main Screen as shown in Figure 4-2.

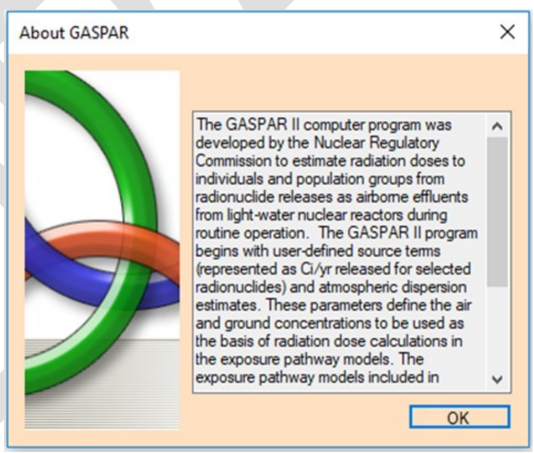


Figure 4-5 About GASPAR Screen

4.1.4 Case Title Field

Enter a title in the Case Title Field for the GASPAR case. This is a descriptive text field only and the data in this field are not used for any GASPAR dose calculations. Appropriate text should be selected to assist user in identifying the facility/site and release point information (e.g., Facility XYZ and Miscellaneous Waste Discharge). As shown in Figure 4-2, the scenario title, “GASPAR Test Case 1 – ICRP 2,” is used for the initial installation of the NRCDose3 code.

This file is included in the install directory (i.e., default directory C:/NRCDose3) and serves as a test case and verification for install.

4.1.5 Dose Factors Dropdown Menu

As shown in Figure 4-6, the Dose Factors dropdown menu 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," or "ICRP-72" DCF values. The user should note that if the DCF values are changed, the assumed source term (if any has been entered) will be cleared. In addition, the assumed usage and consumption factors will update to the DCF values associated with the selected ICRP methodology.

**** User Note ** —** For purposes of demonstrating compliance with 10 CFR Part 50, Appendix I, and 40 CFR Part 190, the ICRP-2 DCF values should be selected. Likewise, for demonstrating compliance with 10 CFR Part 20, the ICRP-30 DCF values should be selected. Use of ICRP-72 DCF values by an applicant or licensee for a proposed NRC LAR request should be discussed with the NRC staff prior to submitting the license request.

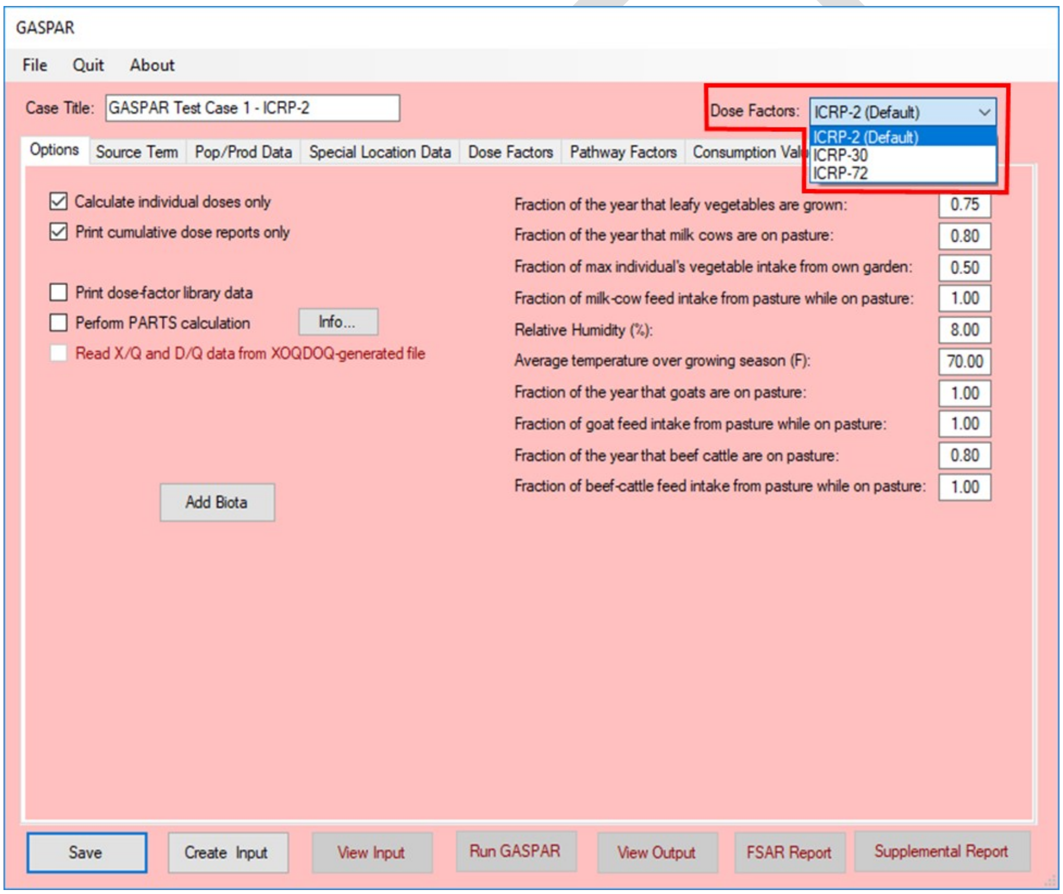


Figure 4-6 GASPAR Dose Factors dropdown menu

4.2 Data Input Tabs

The seven GASPAR Data Input Tabs as shown in Figure 4-2 are:

1. Options
2. Source Term
3. Pop/Prod Data
4. Special Locations
5. Dose Factors
6. Pathway Factors
7. Consumption Values

Though not required when generating the input for GASPAR, it is recommended that the user enter the necessary parameters and data to the case in order of the Data Input Tabs as they are listed in the GASPAR Module Main Screen as shown in Figure 4-2.

4.2.1 Options Tab

The Options Tab is used to enter various parameters for the GASPAR dose calculations. The Options Tab includes a combination of 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 additional information on the input values in this tab.

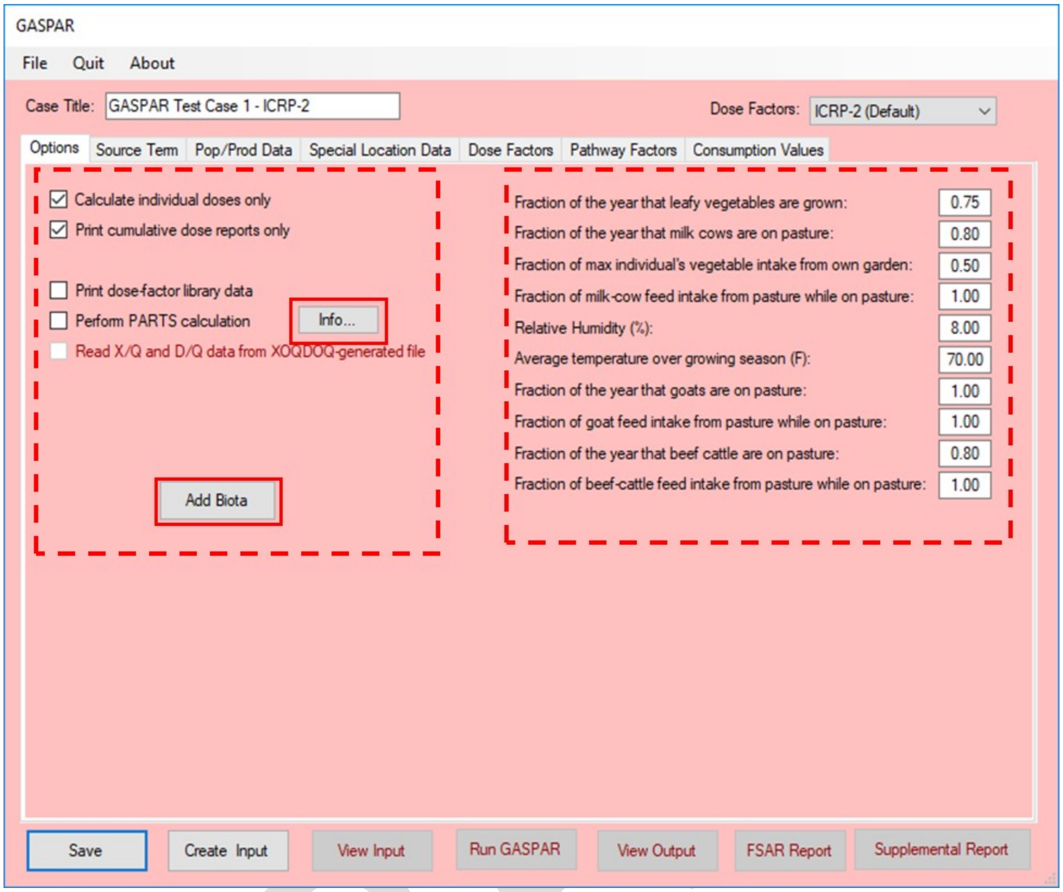


Figure 4-7 Options Tab

4.2.1.1 Option Tab — Left-Hand Side Options

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

- Calculate Individual doses only — This option (box) is checked by the user when only the individual dose calculations from gaseous effluents will be performed by GASPAR. If this option (box) is unchecked, population dose calculations from gaseous effluents will be performed in addition to the individual dose calculations. The value from the "GASPAR Test Case 1 – ICRP-2" for this option is "**checked**." To perform population doses, additional data is required for population, meteorological, 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 as 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 population, milk, meat, or vegetable, a value of "**1.0**" is automatically entered; a value is required for the program to perform the required 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.

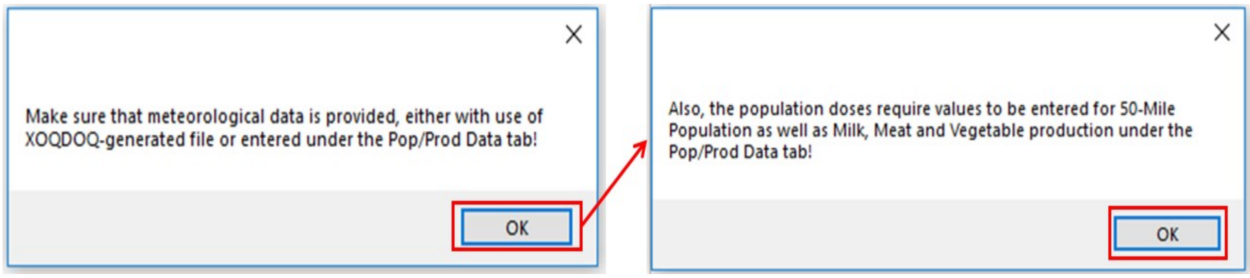


Figure 4-8 Population data warning screens

- Print cumulative dose reports only ― This option (box) is checked by the user to print only the cumulative dose reports without the reporting of dose contribution by radionuclide in the standard GASPAR output. The value from the "GASPAR Test Case 1 – ICRP-2" for this option is "**checked**."
- Print dose-factor library data ― This option (box) is checked by the user to print all applicable DCF values in the GASPAR dose calculation output file. The value from the "GASPAR Test Case 1 – ICRP-2" for this option is "**unchecked**."
- Perform PARTS calculation ― This option (box) is checked by the user when the code performs 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 units of second per cubic meters (s/m^3) and deposition in units of (m^{-2}). The value from the "GASPAR Test Case 1 – ICRP-2" for this option is "**unchecked**." Selecting this option will open the PARTS calculation information screens as shown in Figure 4-9. Selecting the "OK" button on both warning screens will return the user to the Options Tab. Additionally, selecting the "Info." button next to this option will open the PARTS information screen as shown in Figure 4-10. Selecting the "OK" button on both warning screens will return the user to the Options Tab. This option is only functional with the ICRP-2 DCFs.

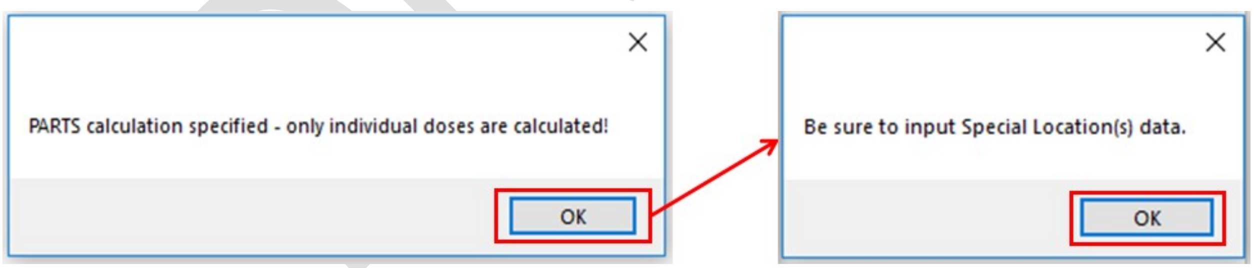


Figure 4-9 PARTS calculation information screens

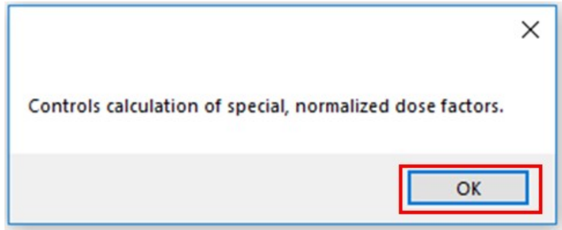


Figure 4-10 PARTS information screen

- <u>Read X/Q and D/Q data from XOQDOQ-generated file</u> — This option (box) is checked by the user to use meteorological dispersion parameters that were generated by the XOQDOQ code. This option will result in the dispersion parameters for population dose calculations and the Special Locations to be read from a file that is created by XOQDOQ. Section 5.3 provides additional information and an explanation of this function in the XOQDOQ code. The value from the "GASPAR Test Case 1 – ICRP-2" for this option is "**unchecked**."

4.2.2 Biota Dose Modeling

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. Additional modeling details are included in Section 6.0. In GASPAR, there are six (6) assumed terrestrial species -- those assumed in LADTAP (muskrat, racoon, heron and duck) plus cow (herbivore) and fox (carnivore). As described below, additional species can be added with user defined exposure assumptions.

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

The internal dose component for all herbivores (cow, muskrat, racoon, 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 User Note below on effective radius. For other herbivores, the internal dose is calculated based on a ratio of the assumed ingestion rate to the biota mass and applying the adult human ingestion DCF, with an adjustment for the difference in absorbed energy between an adult (30 cm effective radius) and the biota effective radius.

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

The external dose component is the same as the adult ground plane dose multiplied by a factor of 2 to account for proximity to ground and divided by 0.7 to remove the shield factor assumed for human exposure. The effect of this is that the external component of the biota dose is 2.86 times that calculated for adults. Table 4-1 lists the parameters used to calculate the biota dose in GASPAR in NRCDose3.

Table 4-1 Biota dose parameters for the GASPAR code 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

* For GASPAR, the selection of effective radius must correspond to one of the eight radii values that have been tabulated. The values as assigned are considered most representative for the species, considering the available values.

- New Biota Button – Select the New Biota button to open the Additional Biota Types Screen as shown in Figure 4-11 and enter the required parameters for any new biota exposure. To define a new biota type, select the “Add Biota Type” button to activate the biota information section at the bottom as shown in Figure 4-11. For each new biota type, enter the name, the primary food type from dropdown menu options (carnivore or herbivore), the mass in units of g, the effective radius for the biota in units of cm and the consumption rate in units of kg/yr. Select the “Save” button to save the new biota type and return to the Options Tab as shown in Figure 4-7. To remove a biota type, select (highlight) the biota type from the upper portion as shown in Figure 4-11 and select the “Delete Biota Type” button to delete the biota type. Selecting the “Clear” button will remove all biota types from the file and selecting the “Close” button will close the Additional Biota Types Screen and return the user to the Options Tab.

  ** **User Note** ** – The code can only address a single food type, either plant or meat. While it is recognized that a racoon is an omnivore, the default modeling assumes a plant-based diet for the racoon, which is consistent with that assumed in LADTAP and consistent with BNWL-1754 modeling. Modeling as a carnivore may be performed by using the “Add Biota Type” function with appropriate inputs on consumption.

**** User Note ** —** A user could perform species-specific modeling by modifying the exposure and uptake assumptions and transfer factors that are unique for the species (e.g., transfer factors for chickens).

**** User Note ** —** The effective radius is used to model the biota as a sphere geometry, such that different dose absorption values can be applied for different size/mass biota. Effective radius is the radius of a sphere (considered muscle) that has the same mass as the biota in question, based on an assumed uniformly distributed mass. For an assumed nominal density of 1 gram per cubic centimeter (g/cm^3) for muscle, the effective radius can be approximated as the cubic root of the quantity (mass (in grams) divided by 4.19, where 4.19 = 4/3 * π). Refer to Appendix D for a description of the modeling and calculations for the nuclide-specific deposited energy (dose) values based on effective radius.

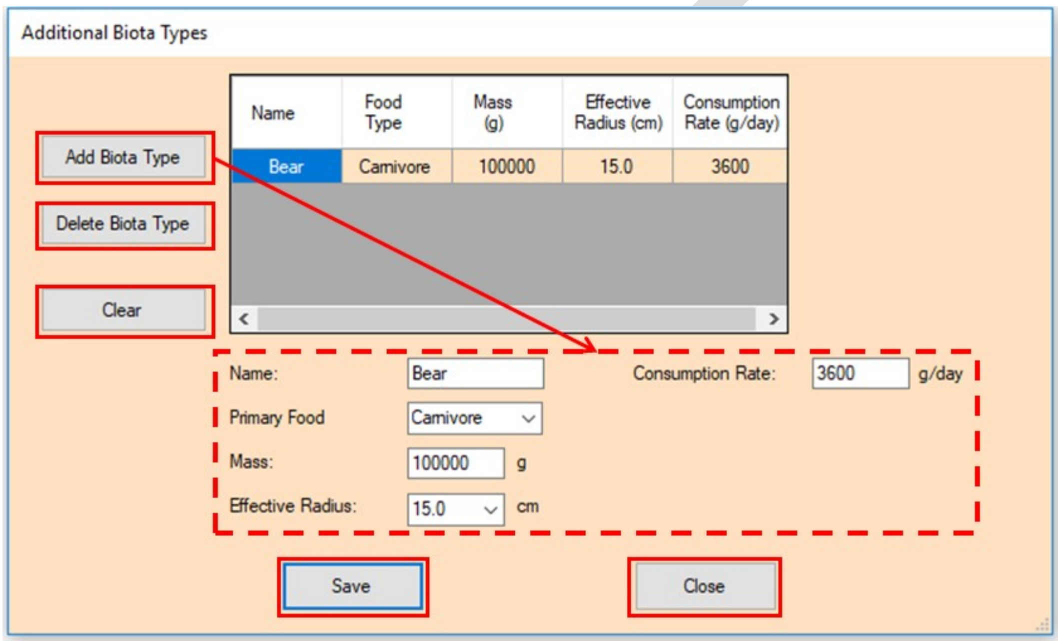


Figure 4-11 Additional Biota Types Screen

4.2.2.1 Option Tab — Right-Hand Side Options

As shown in Figure 4-7, the following input parameters appear on the right-side of the Options Tab. These parameters are considered site-specific and are used to reflect the particular characteristics of the environment where the facility is currently or is to be located.

- Fraction of the year that leafy vegetables are grown is unitless with the value from the "GASPAR Test Case 1 – ICRP-2" set to "**0.75**" and the allowable range for values in this field is greater than 0.0.

- Fraction of the year that milk cows are on pasture is unitless with the value from the "GASPAR Test Case 1 – ICRP-2" set to "**0.80**" and the allowable range for values in this field is greater than 0.0.

- Fraction of max. individual's vegetable intake from own garden is unitless with the value from the "GASPAR Test Case 1 – ICRP-2" set to "**0.50**" and the allowable range for values in this field is greater than 0.0.

- Fraction of milk cows feed intake from pasture while on pasture is unitless with the value from the "GASPAR Test Case 1 – ICRP-2" set to "**1.00**" and 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. Application to other, similar milk animals may be appropriate but should consider the particular animal characteristics.

- Average absolute humidity is entered in units of percent with the value from the "GASPAR Test Case 1 – ICRP-2" set to "**8.00**." The allowable range for values in this field is greater than 0.0.

- Average temperature over growing season is in units of degrees Fahrenheit (°F) with the value from the "GASPAR Test Case 1 – ICRP-2" set to "**70.00**" °F. The allowable range for values in this field is greater than 0.0 °F.

- Fraction of the year that goats are on pasture is unitless with the value from the "GASPAR Test Case 1 – ICRP-2" set to "**1.00**" and the allowable range for values in this field is greater than 0.0.

  **** User Note ** —** There are a limited number of milk transfer factors, taken from RG 1.109, Table E-1, specifically for goats. Application to other, similar milk animals may be appropriate but should consider the particular animal characteristics.

- Fraction of goat feed intake from pasture while on pasture is unitless with the value from the "GASPAR Test Case 1 – ICRP-2" set to "**1.00**" and the allowable range for values in this field is greater than 0.0.

- Fraction of the year that beef cattle are on pasture is unitless with the value from the "GASPAR Test Case 1 – ICRP-2" set to "**0.80**" and 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. Application to other, similar milk animals may be appropriate but should consider the particular animal characteristics.

- Fraction of beef-cattle feed intake from pasture while on pasture is unitless with the value from the "GASPAR Test Case 1 – ICRP-2" set to "**1.00**" and the allowable range for values in this field is greater than 0.0.

4.2.3 Source Term Tab

The Source Term Tab is used to enter the different source terms for the GASPAR dose calculations as shown in Figure 4-12. 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 default value of “**1.00**”) that will be applied to the input release activity for each radionuclide, and annual release time for purges in units of hr (default value of “**0.0**” hr).

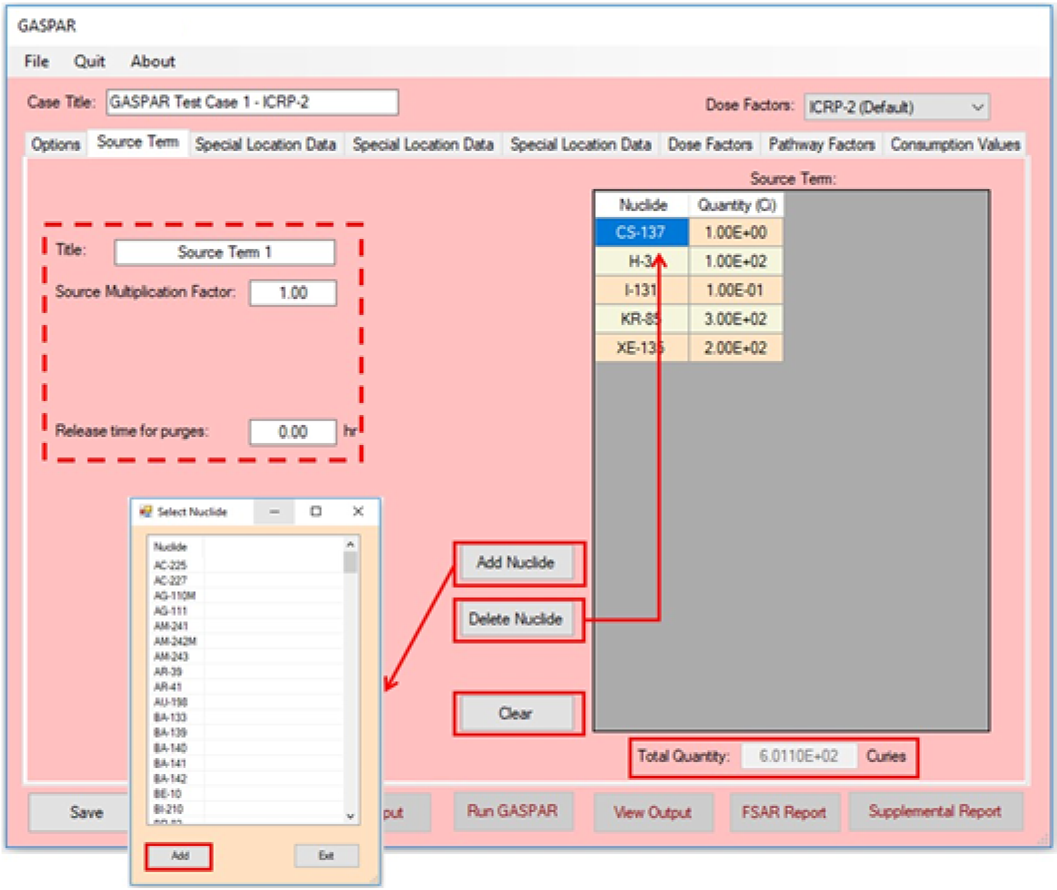


Figure 4-12 Source Term Tab

The radionuclides in the source term along with their quantity in Ci are displayed on the right-hand portion of the Source Term Tab as shown in Figure 4-12. To add an additional radionuclide to the source term, select the “Add Nuclide” button as shown in Figure 4-12.

**** User Note ** —** The user must ensure that the desired ICRP methodology has been selected before entering any additional radionuclide data. Selecting the “Add Nuclide” button on the Source Term Tab will flash open a warning message reminding the users about DCF values as shown in Figure 4-13 and then open the Select Nuclide Screen as shown in Figure 4-12. Changing the ICRP methodology will cause the source term to be cleared.

Select the radionuclide (highlighting the radionuclide) to be added to the source term and then click the “Add” button as shown in Figure 4-12 to add the radionuclide to the source term on the Source Term Tab. Holding the “control” key during radionuclide selection will allow for the selection of multiple radionuclides. The individual radionuclides, activity release and total quantity in units of Ci will be continuously updated. When the source term data has been entered, it is recommended to save the input to the “*.GN3” file by selecting the “Save” button.

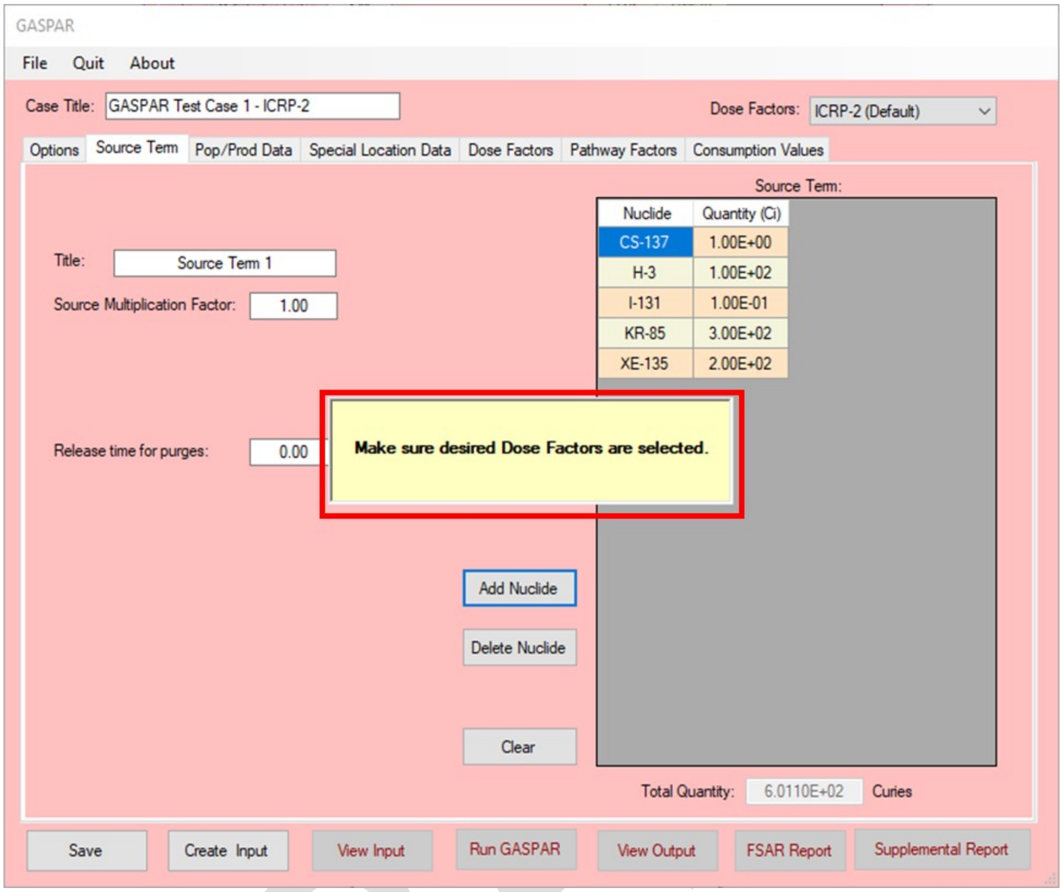


Figure 4-13 Source Term Warning Message

Likewise, the user can remove radionuclides from the source term by selecting the radionuclide to be removed (highlighting the radionuclide) and then clicking the “Delete Nuclide” button as shown in Figure 4-12. Selecting the “Clear” button clears out all source term data (Nuclide, Class, f1 value and Quantity) for all radionuclides in the Source Term Tab.

4.2.4 Pop/Prod Data Tab

The Pop/Prod Data Tab is where extensive information about demographics, food production and meteorology (if necessary) around the site is entered as shown in Figure 4-14. The Data Types contain five options for entering demographic data, which are: (1) Population, (2) Milk Production, (3) Meat Production, (4) Vegetable Production, and (5) Meteorological (note: sector dispersion and deposition values will need to be manually inputted unless an XOQDOQ generated input file is created). The demographic and production data can be entered either as a total within a 50-mile radius, or on a per sector basis at varying distances from 1 to 50 miles. The entry format/table for the sector and distance data only appears if the “Input by distance and direction” box is checked.

Selecting the “Input by distance and direction” check box activates the radial distance (1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles) and each of the 16 meteorological sectors input table as shown in Figure 4-14.

**** User Note ** —** Data is required for each Data Type dropdown 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.

4.2.4.1 Population

Select the Population option from the Data Type dropdown 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 population data sectors input table as shown in Figure 4-14. 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: the demographic data represents the value in the sector bounded by the distances. For example, 1 mile represents the population in the 0 to 1-mile distance; 10 miles represents the population in the 5 to 10-mile distance. Select the “Update” button to save the population data sector data. Use the “Clear” button to delete the population data from the sector table and open the Clear Data Warning Screen as shown in Figure 4-15.

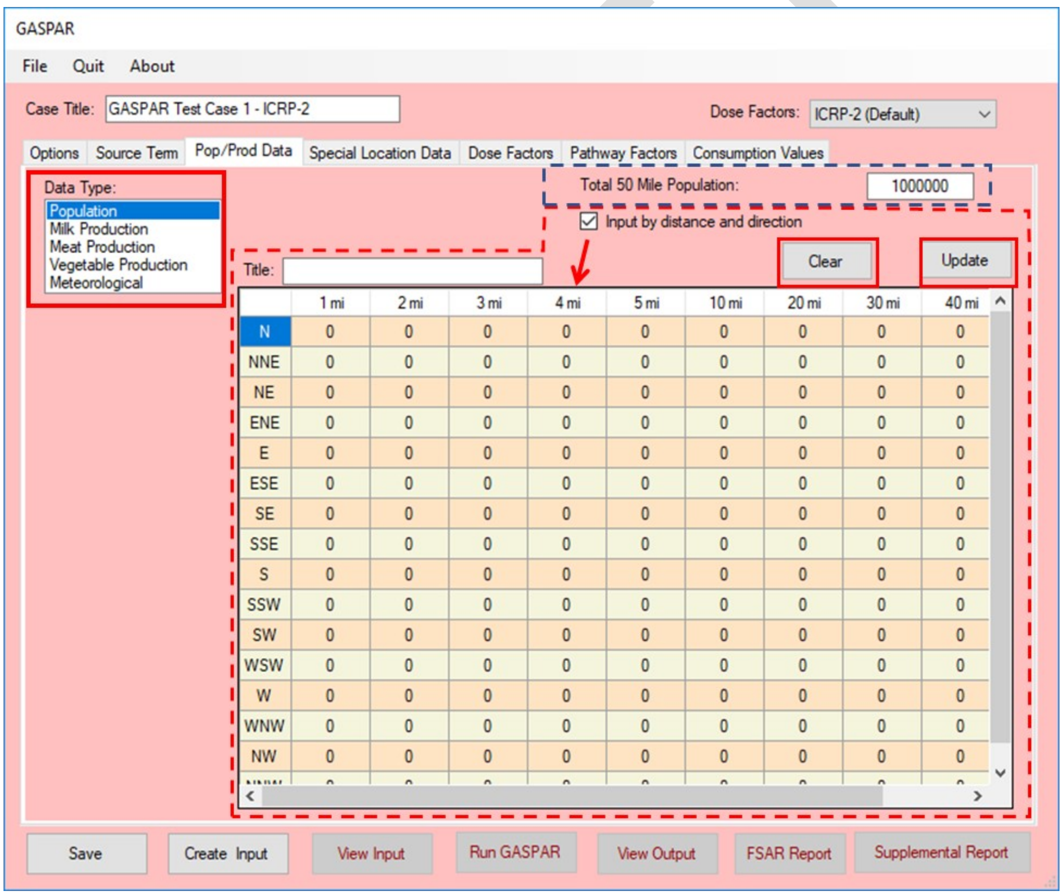


Figure 4-14 Pop/Prod Data Tab

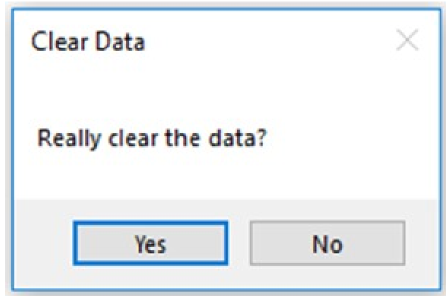


Figure 4-15 Clear Data Warning Screen

4.2.4.2 Milk Production

Select the Milk Production option from the Data Type dropdown menu to enter the total milk production in units of L/yr within 50 miles of the site. The allowable range for values in this field is greater than 0.0. To enter the total milk production data on a per sector basis, select the check box to open the milk production data sectors input table as shown in Figure 4-14. Enter the total milk production data for each radial distance (1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles, representing the distance ranges as discussed above) for each of the 16 downwind direction sectors. Select the “Update” button to save the total milk production sector data. Use the “Clear” button to delete the population data from the sector table and open the Clear Data Warning Screen as shown in Figure 4-15.

4.2.4.3 Meat Production

Select the Meat Production option from the Data Type dropdown menu to enter the total meat production in units of kg/yr within 50 miles of the site. The allowable range for values in this field is greater than 0.0. To enter the total meat production data on a per sector basis, select the check box to open the meat production data sectors input table as shown in Figure 4-14. Enter the total 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 distance sectors. Select the “Update” button to save the total meat production sector data. Use the “Clear” button to delete the total meat production data from the sector table and open the Clear Data Warning Screen as shown in Figure 4-15.

4.2.4.4 Vegetable Production

Select the Vegetable Production option from the Data Type dropdown menu to enter the total vegetable production in units of kg/yr within 50 miles of the site. The default value from the “GASPAR Test Case 1 – ICRP-2” of “**1.00+03**” kg/yr and the allowable range for values in this field is greater than 0.0. To enter the total vegetable production data on a per sector basis, select the check box to open the vegetable production data sectors input table as shown in Figure 4-14. Enter the total vegetable production data for each radial distance (1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles, representing the distance ranges as discussed above) for each of the 16 downwind distance sectors. Select the “Update” button to save the total vegetable production sector data. Use the “Clear” button to delete the total vegetable production data from the sector table and open the Clear Data Warning Screen as shown in Figure 4-15.

4.2.4.5 Meteorological

Select the Meteorological option from the Data Type menu if the meteorological data (dispersion and deposition values) need to be manually entered within GASPAR, and not imported from a completed XOQDOQ run (see Section 5.3). As discussed in Section 4.2.1.1, this menu option is only required if the "Read Met data from XOQDOQ-generated file" is **NOT** selected (unchecked box) on the Options Tab. Calculated dispersion and deposition values are dependent of the release point characteristics as specified in the XOQDOQ code inputs. Care should be exercised in verifying that the dispersion and deposition data, as entered or imported here, is representative of the source term for the modeled release point.

Select the dispersion and deposition data to be entered from either dispersion (i.e., "Undecayed, Undepleted;" "Decayed, Undepleted;" and "Decayed, Depleted") or Ground Deposition as discussed in Section 2.2.6 of NUREG/CR-4653. Enter the applicable dispersion in units of s/m^3 or deposition in units of m^{-2} for each radial distance (1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles representing the distance ranges as discussed above) for each of the 16 downwind meteorological sectors, as shown on Figure 4-16. Corresponding values from the XOQDOQ output are those represented in the tables titled, "SEGMENT BOUNDARIES IN MILES FROM SITE." Select the "Update" button to save the data. Use the "Clear" button to delete the total data set from the sector table, which will open a Clear Data Warning Screen as shown in Figure 4-15. Repeat this above described process for the other dispersion or deposition parameters.

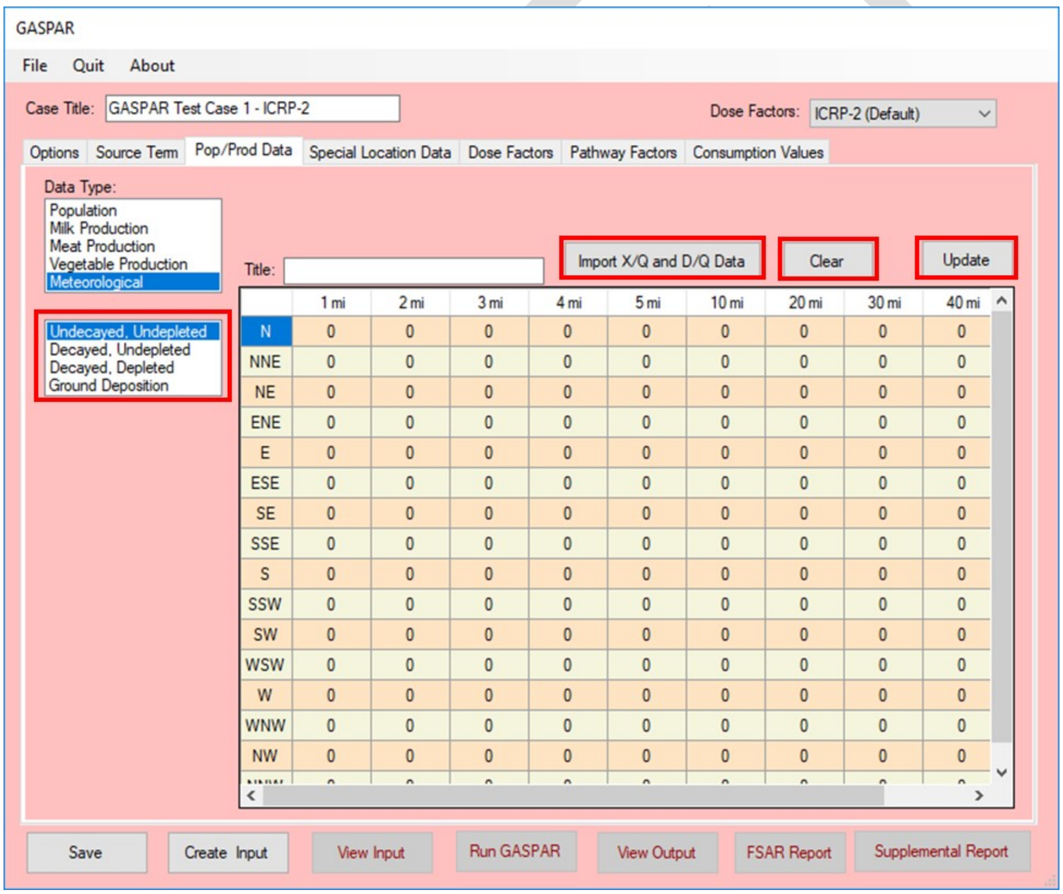


Figure 4-16 Pop/Prod Data Tab — Meteorological Data Type

As an alternative to manually entering the dispersion and deposition data, select the "Import X/Q and D/Q Data" button, as shown on Figure 4-16 to import these data from an appropriate MS

Excel ("*.xlsx") file. Selecting the "Import X/Q and D/Q Data" button will open a Windows Explorer directory allowing the user to navigate to the appropriate file to be imported as shown in Figure 4-17. Selecting the MS Excel file to be imported and the NRCDose 3 code will automatically import the data and populate the sector table as shown in Figure 4-16. After the data has been imported, select the "Update" button as shown in Figure 4-16 to save the data.

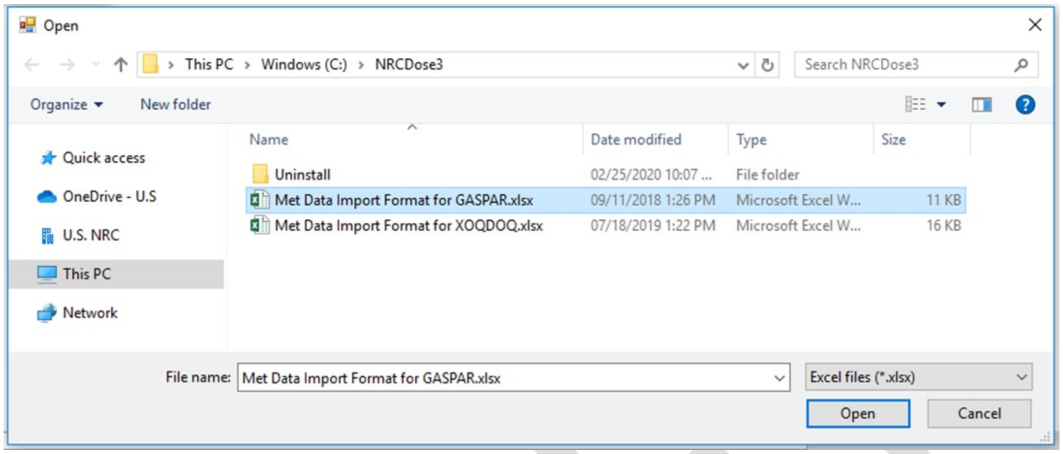
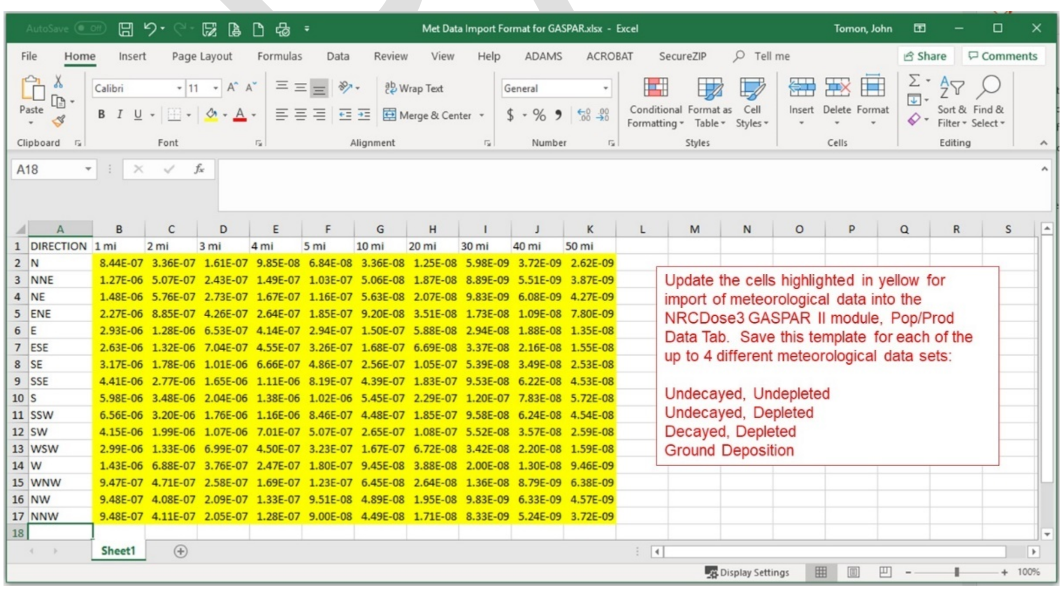


Figure 4-17 Windows Explorer directory for meteorological data import to GASPAR

A separate MS Excel ("*.xlsx") file is required for **EACH** of the 3 dispersion parameters and the single deposition parameter, so this process must be repeated four times for each of the four meteorological data sets (Undecayed/Undepleted, Decayed/Undepleted, Decayed/Depleted and Ground Deposition). A template MS Excel example file, as shown in Figure 4-18, is included in the NRCDose3 code installation. Only the values in the shaded yellow cells are imported into 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 4-18 Meteorological Data Example MS Excel File

** **User Note** ** — Ensure that the dispersion or deposition data sets are input into the template and dialog box for the correct downwind direction, starting with Sector N and ending with Sector NNW.

4.2.5 Special Location Data Tab

The Special Location Data Tab is where the parameters used to define the atmospheric dispersion and deposition values at any special receptor locations are entered as shown in Figure 4-19. As discussed in Section 4.2.1.1, this tab is only available if the "Read X/Q and D/Q data from XOQDOQ-generated file" is **NOT** selected (unchecked box) on the Options Tab. This tab is not available if the "Read X/Q and D/Q data from XOQDOQ-generated file" is selected on the "Options" screen, as the special locations are already defined in that file. The Special Location Data Tab includes the Special Location Records Section (left-hand side of tab) and the Location for Individual Doses Section (right-hand side of tab) as shown in Figure 4-19.

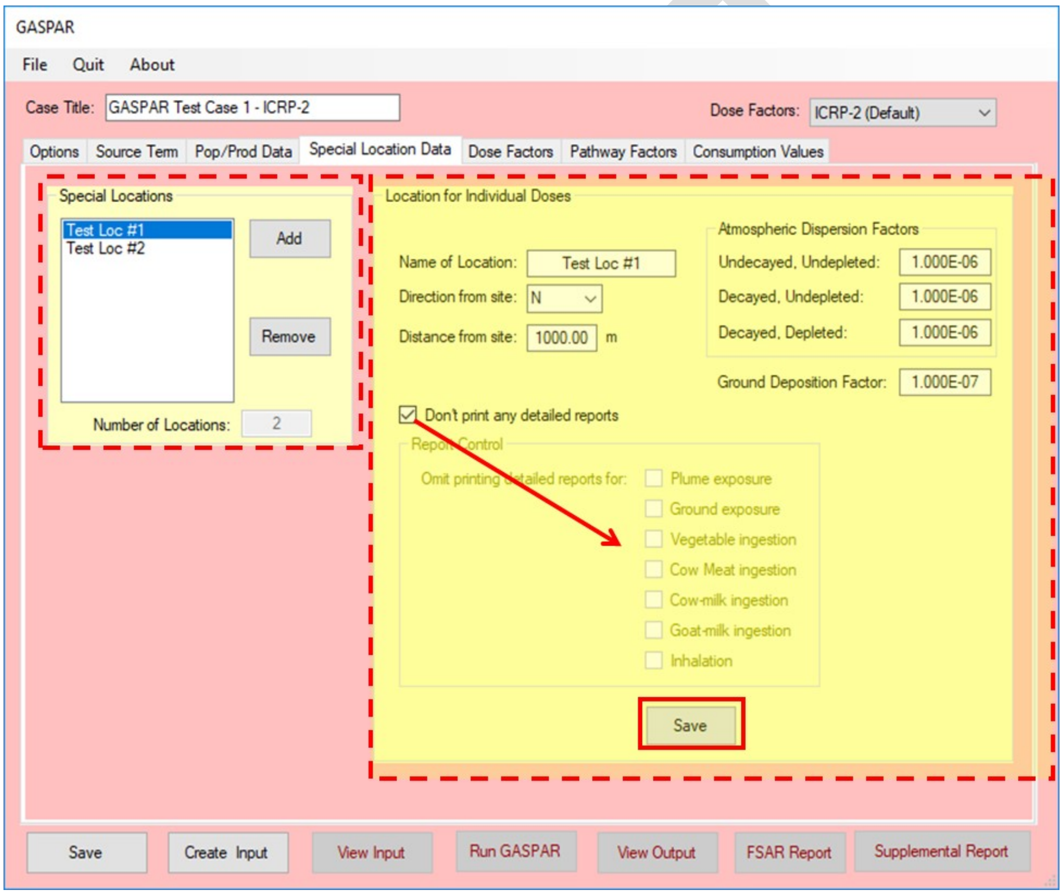


Figure 4-19 Special Location Tab

The Special Locations Records Section (left-hand side of tab) lists the name and number of records of each special location. The user can review and edit special locations by selecting (highlighting) the special location and reviewing the entries in the Location for Individual Doses Section (right-hand side of tab). The user can delete a special location record by selecting the special location record to be removed (highlight) and then clicking the "Remove" button as shown in Figure 4-19. Likewise, a special location record can be added by selecting the "Add" button and entering the parameters listed in the Location for Individual Doses Section (right-hand side of tab).

In the Location for Individual Doses Section (right-hand side of tab) of the 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 dropdown menu with options to select from the 16 downwing direction sectors.

- Distance from site (meters) ─ This field contains the distance of the special location from the site, as modeled in XOQDOQ, in units of meters and the allowable range for values in this field is greater than 0.0.

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

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

Select the “Don’t print any detailed reports” option (check box) if none of the detailed reports are required to be printed. If a report of the pathway dose contribution by radionuclide is desired then uncheck this selection. Detailed reports will be included for all unchecked pathway boxes. Select the “Save” button when edits to the special location have been completed. This “Save” will save the data for the specific location only, not for the total input file.

4.2.6 Dose Factors Tab

The Dose Factors Tab is where DCF values for the GASPAR dose calculation can be selected, reviewed and modified as necessary as shown in Figure 4-20, and is identical to the Dose Factors Tab in the LADTAP Module. See Section 3.2.5 for the discussion on the details of the Dose Factors Tab, and Section 6.1 for a discussion on how the DCF values were determined. After selecting the appropriate ICRP methodology (i.e., ICRP-2 (Default), ICRP-30, and ICRP-72), from the Dose Factors dropdown menu, select the Factors dropdown menu arrow to open and select the applicable age group and pathway (e.g., Adult Ingestion, Adult Inhalation, Teen Ingestion, Teen Inhalation, Child Ingestion, Child Inhalation, infant Ingestion, Infant Inhalation) DCF values.

After selecting the appropriate ICRP methodology and Factors from their respective dropdown menus all applicable organ DCF values are available for review as shown in Figure 4-20. Select the “Nuclide Data” button to open the Nuclide Data Screen which contains two tables of data as shown in Figure 4-21. The top table contains applicable Nuclide data, such as Atomic Weight, Isomeric State, and Decay Constant. Additionally, using 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 describes the effective energy (MeV/nt) deposited for a given effective radius. See Appendix D of this manual for a detailed description of the bottom table of Figure 4-21. Select the “Exit” button to return to the Dose Factors Tab.

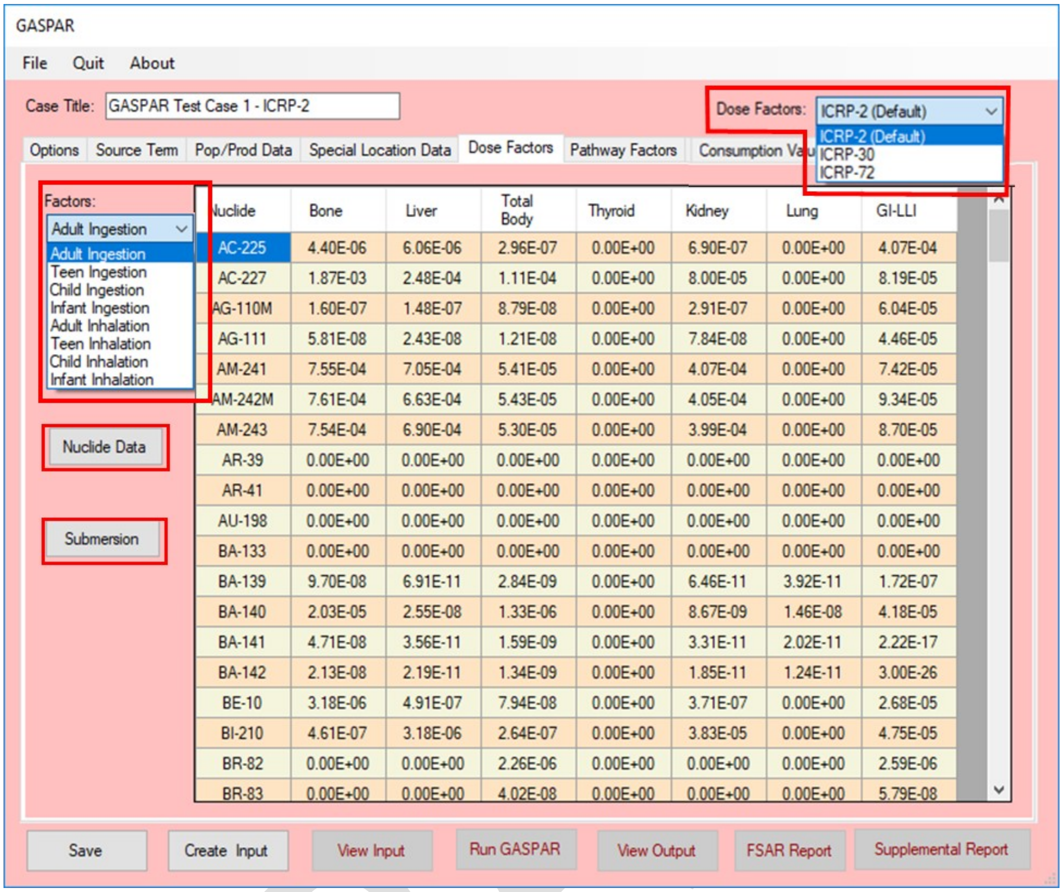


Figure 4-20 Dose Factors Tab

Table 4-2 Description of GASPAR DCF Values

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

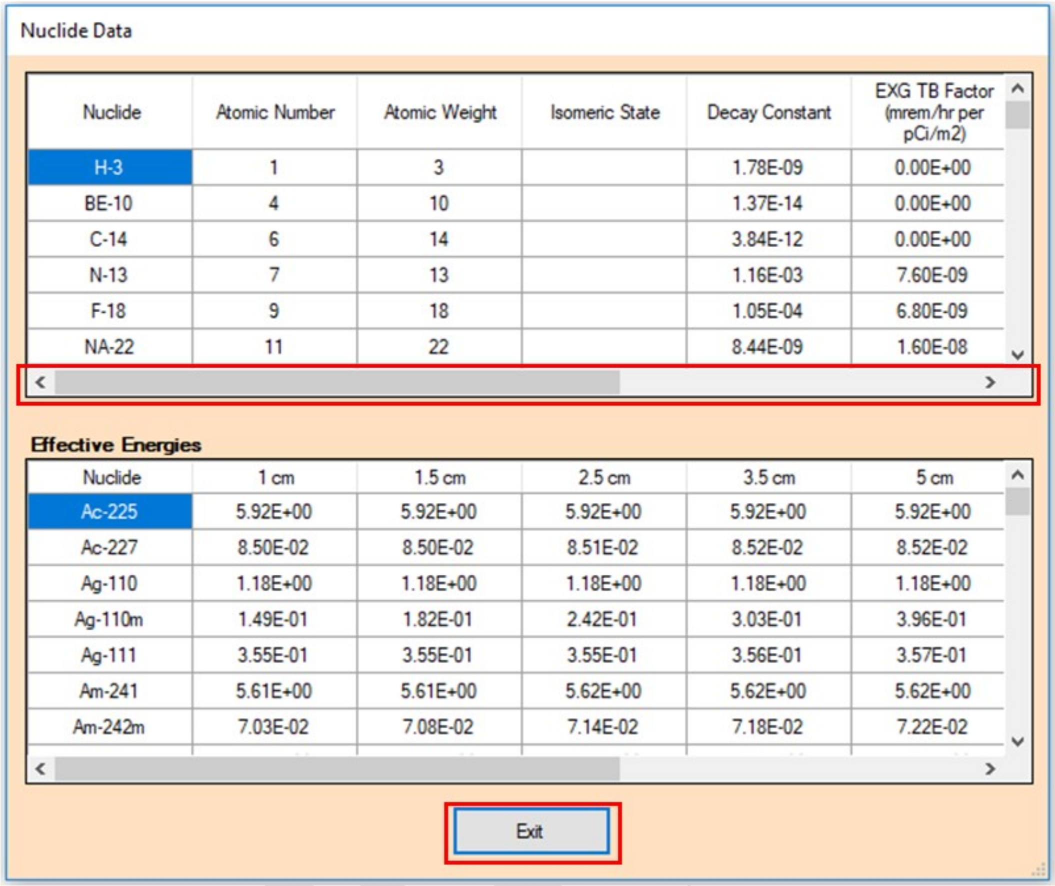


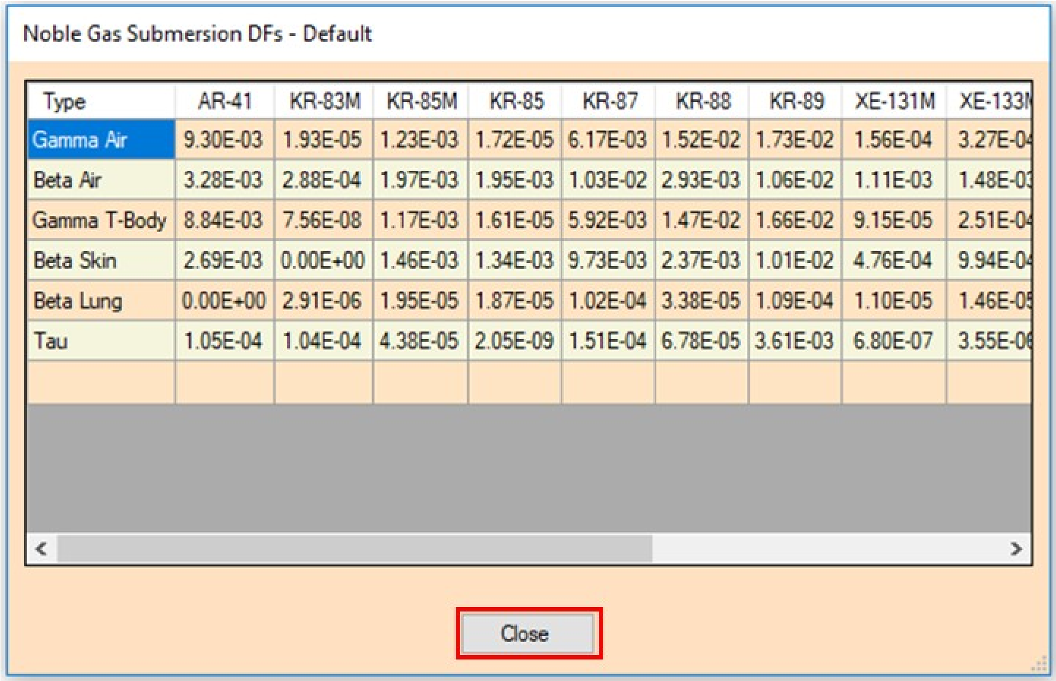
Figure 4-21 Nuclide Data Screen

If ICRP-2 DCF values are selected, the ICRP total body DCF values from ICRP-2 are used, which is no change from the original releases of LADTAP II, GASPAR II and NRCDose version 2.3.20. If ICRP-30 DCF values are selected, ICRP Report No. 26 (ICRP-26) [Ref. 23] based effective and skin DCF values are used, as found in Federal Guidance Report No. 12 (FGR 12) [Ref. 24]. If ICRP-72 DCF values are selected, ICRP-60 based effective DCF values (also from FGR 12) and ICRP-26 based skin DCF values are used.

**** User Note ** —** Use of ICRP-72 DCF values by an applicant or licensee for a proposed NRC LAR should be discussed with the NRC staff prior to submitting the license request.

These external DCF values have been modified, if ICRP-30 or ICRP-72 DCF values are selected, 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 as shown in Figure 4-22 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 from the original release of GASPAR II. The Gamma T-Body and Beta Skin DCF values have been updated to ICRP-26 methodology DCF values when either ICRP-30 or ICRP-72 methodologies are selected. See Section 6.1 for a discussion on the source of these DCF values. Select the "Close" button to return to the Dose Factors Tab.



Noble Gas Submersion DFs - Default

Type	AR-41	KR-83M	KR-85M	KR-85	KR-87	KR-88	KR-89	XE-131M	XE-133M
Gamma Air	9.30E-03	1.93E-05	1.23E-03	1.72E-05	6.17E-03	1.52E-02	1.73E-02	1.56E-04	3.27E-04
Beta Air	3.28E-03	2.88E-04	1.97E-03	1.95E-03	1.03E-02	2.93E-03	1.06E-02	1.11E-03	1.48E-03
Gamma T-Body	8.84E-03	7.56E-08	1.17E-03	1.61E-05	5.92E-03	1.47E-02	1.66E-02	9.15E-05	2.51E-04
Beta Skin	2.69E-03	0.00E+00	1.46E-03	1.34E-03	9.73E-03	2.37E-03	1.01E-02	4.76E-04	9.94E-04
Beta Lung	0.00E+00	2.91E-06	1.95E-05	1.87E-05	1.02E-04	3.38E-05	1.09E-04	1.10E-05	1.46E-05
Tau	1.05E-04	1.04E-04	4.38E-05	2.05E-09	1.51E-04	6.78E-05	3.61E-03	6.80E-07	3.55E-06

Close

Figure 4-22 Noble Gas Submersion DFs - Default Screen

4.2.7 Pathway Factors Tab

The Pathway Factors Tab is used to modify the default RG 1.109 environmental transport and exposure assumptions as used for the GASPAR dose calculation. In general, the values for the parameters included on this tab should only be changed if there is suitable data supporting a site-specific change. As shown in Figure 4-23, the Pathway Factors Tab contains four main parameter input sections: (1) general input parameters (upper left-hand portion), (2) Holdup and Transport Times Section, (3) Goat Feed to Milk Transfer Factors Section, and (4) Physical Parameter Section. Additionally, this tab contains two selection buttons: (1) the “Transfer Factors” button, and (2) the “Page Defaults” button.

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

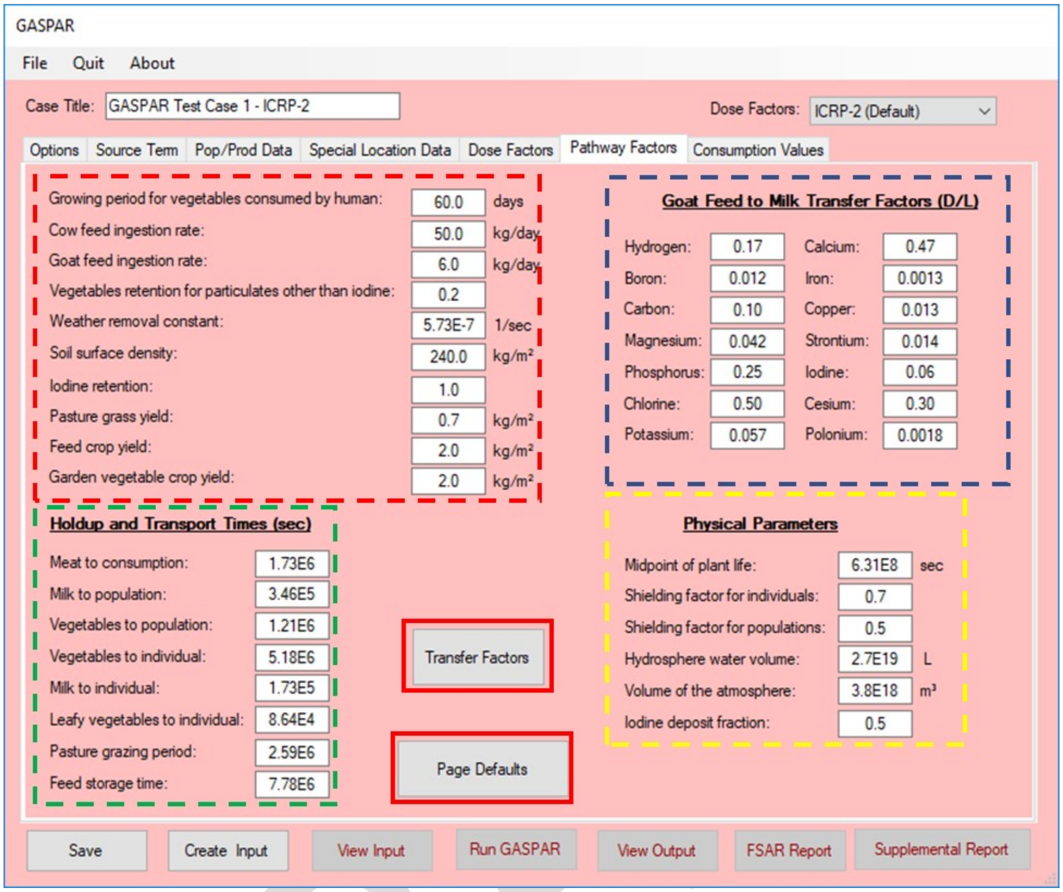


Figure 4-23 Pathway Factors Tab

4.2.7.1 General Pathway Parameters Section

The following pathway input parameters are entered in the upper left-hand side of the Pathway Factors Tab as shown in Figure 4-23. These pathway parameters include:

- Growing period for vegetables consumed by a human is entered in units of d with the default value from RG 1.109 of **"60"** d, which is the value used in the "GASPAR Test Case 1 – ICRP-2." The allowable range for values in this field is greater than 0.0 d.

- Cow feed ingestion rate entered in units of kg/d with the default value from RG 1.109 of "**50.0**" kg/d, which is the value used in "GASPAR Test Case 1 – ICRP-2." The allowable range for values in this field is greater than 0.0 kg/d.

- Goat feed ingestion rate is entered in units of kg/d with the default value from RG 1.109 of "**6.0**" kg/d, which is the value used in "GASPAR Test Case 1 – ICRP-2." The allowable range for values in this field is greater than 0.0 kg/d.

- Vegetables retention for particulates other than iodine is unitless with the default value from RG 1.109 of "**0.2,**" which is the value used in "GASPAR Test Case 1 – ICRP-2." The allowable range for values in this field is greater than 0.0 and should not exceed 1.0.

- Weather removal constant is the vegetation weathering removal for a radionuclide in units of inverse seconds (1/sec) with the default value from RG 1.109 of "**5.73E-07**" 1/sec (corresponding to a 14 day half-life), which is the value used in "GASPAR Test Case 1 – ICRP-2." The allowable range for values in this field is greater than 0.0 1/sec.

- Soil surface density is entered in units of kg/m^2 with the default value from RG 1.109 of "**240.0**" kg/m^2, which is the value used in "GASPAR Test Case 1 – ICRP-2." The allowable range for values in this field is greater than 0.0 kg/m^2.

- Iodine retention is unitless with the default value from RG 1.109 of "**0.5,**" which is the value used in "GASPAR Test Case 1 – ICRP 2." The allowable range for values in this field is greater than 0.0 and should not exceed 1.0.

- Pasture grass yield is entered in units of kg/m^2 with the default value from RG 1.109 of "**0.5**" kg/m^{2,} which is the value used in "GASPAR Test Case 1 – ICRP-2." The allowable range for values in this field is greater than 0.0 kg/m^2.

- Feed crop yield is entered in units of kg/m^2 with the default value from RG 1.109 of "**2.0**" kg/m^2, which is the value used in "GASPAR Test Case 1 – ICRP-2." The allowable range for values in this field is greater than 0.0 kg/m^2.

- Garden vegetable crop yield is entered in units of kg/m^2 with the default value from RG 1.109 of "**2.0**" kg/m2, which is the value used in "GASPAR Test Case 1 – ICRP-2." The allowable range for values in this field is greater than 0.0 kg/m^2.

4.2.7.2 Holdup and Transport Times Section

The following input parameters are entered in the Holdup and Transport Times Section of the Pathway Factors Tab as shown in Figure 4-23. All default values come from RG 1.109, which have also been used in "GASPAR Test Case 1 – ICRP-2." These holdup and transport time parameters include:

- Meat to consumption is entered in units of seconds (sec) with the default value of "**1.73E+06**" sec and the allowable range for values in this field is greater than 0.0 sec.

- Milk to the population is entered in units of sec with the default value of "**3.46E+05**" sec and the allowable range for values in this field is greater than 0.0 sec.

- Vegetables to the population is entered in units of sec with the default value of "**1.21E+06**" sec and the allowable range for values in this field is greater than 0.0 sec.

- Vegetables to the individual is entered in units of sec with the default value of "**5.18E+06**" sec and the allowable range for values in this field is greater than 0.0 sec.

- Milk to the individual is entered in units of sec with the default value of "**1.73E+05**" sec and the allowable range for values in this field is greater than 0.0 sec.

- Leafy vegetables to the individual are entered in units of sec with the default value from the "GASPAR Test Case 1 – ICRP-2" of "**8.64E+04**" sec and the allowable range for values in this field is greater than 0.0 sec.

- Pasture grazing period is entered in units of sec with the default value of "**2.59E+06**" sec and the allowable range for values in this field is greater than 0.0 sec.

- Feed storage time is entered in units of sec with the default value of "**7.78E+06**" sec and the allowable range for values in this field is greater than 0.0 sec.

4.2.7.3 Goat Feed to Milk Transfer Factors Section

The Goat Feed to Milk Transfer Factors Section displays the transfer factors for the elements listed in Table 4-3 in units of days per liter (d/L). Table 4-3 displays the default values for the elements from RG 1.109 and as used in "GASPAR Test Case 1 – ICRP-2." and 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	0.14
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		

4.2.7.4 Physical Parameter Section

The following input parameters are entered in the Physical Parameters Section of the Pathway Factors Tab as shown in Figure 4-23. All default values come from RG 1.109, which have also been used in "GASPAR Test Case 1 – ICRP-2," except for midpoint of plant life, as discussed below. These parameters include:

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

- Shielding factor for individuals is unitless with the default value of "**0.7**" and the allowable range for values in this field is less than or equal to 1.0 and greater than 0.0. 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.

- Shielding factor for populations is unitless with the default value of "**0.5**" and the allowable range for values in this field is less than or equal to 1.0 and greater than 0.0.

- Hydrosphere water volume is entered in units of L with the default value in GASPAR (see NUREG/CR-4653) of "**2.7E+19**" L and the allowable range for values in this field is greater than 0.0 L.
- Volume of the atmosphere is entered in units of cubic meters (m^3) with the default value in GASPAR (see NUREG/CR-4653) of "**3.8E+18**" m^3 and the allowable range for values in this field is greater than 0.0 m^3.
- Iodine deposition fraction is unitless with the default value of "**0.5**" and the allowable range for values in this field is greater than 0.0.

4.2.7.5 Transfer Factors Button

To review and edit the transfer factors for meat, soil and milk, select the "Transfer Factors" button shown on Figure 4-23 to open the Transfer Factors Screen as shown in Figure 4-24. To edit the transfer factor for an element, select the cell to be changed and type in the edited value. If any of the transfer factors are updated, select the "Save" button to save edits to the transfer factors. Additionally, select the "Get Defaults" button to revert all transfer factors back to their default values. Finally, select the "Close" button when edits are complete which will open the question screen as shown in Figure 4-24. Select the "Yes" button to return to the Pathway Factors Tab as shown in Figure 4-23.

**** User Note** ─** Remember that if a change is made to the transfer factors, this change will be carried forward for future runs. Defaults should be reset by using the "Get Default" option. Users should remember that saving a case/file will save all configurations and values as selected for the case. Changing back to defaults will not affect any changes made for a particular case/file unless this file is again saved after values changed back to defaults. Therefore, if any question about saved values, it is good to reset to defaults prior to initiating new cases.

4.2.7.6 Page Defaults Button

Select the "Page Defaults" button on the Pathway Factors Tab as shown in Figure 4-23 to return all pathway parameters in the GASPAR database to their RG 1.109 default values.

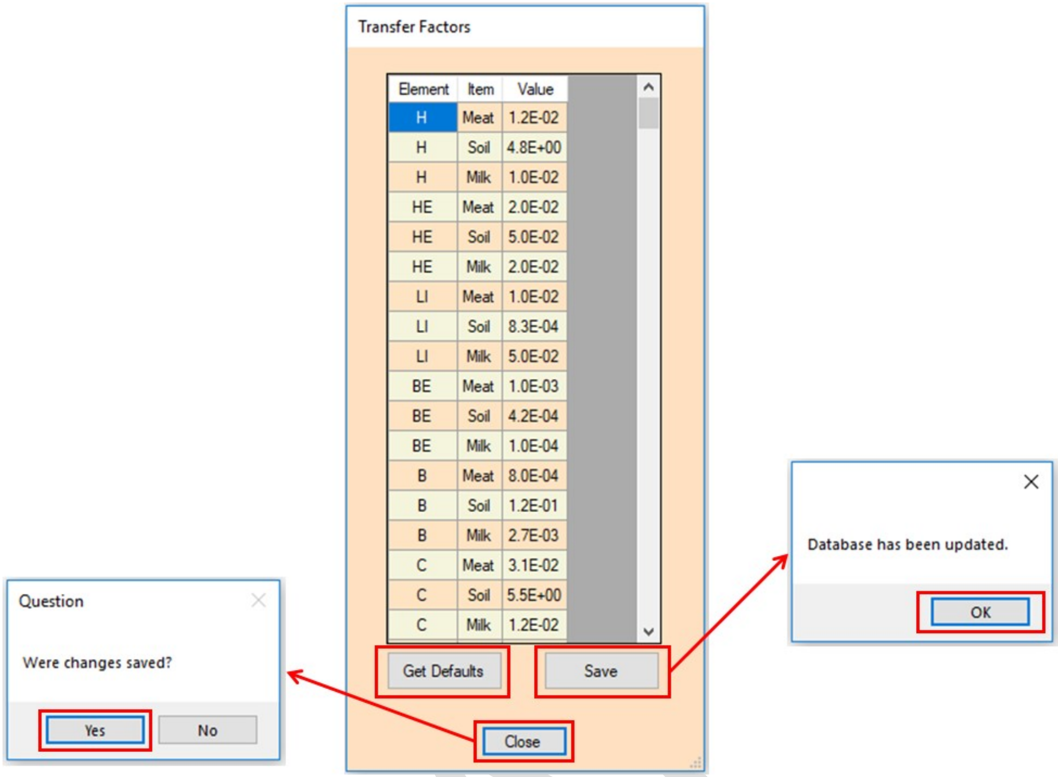


Figure 4-24 Transfer Factors Screen

4.2.8 Consumption Values Tab

The Consumption Values Tab presents the demographic and usage parameters for individuals and the average population as shown in Figure 4-25. This tab contains the Usage Parameters Section (upper portion of tab) and the Intake Consumption Data Section. Two different intake and consumption assumptions are used in the code depending upon the ICRP methodology (i.e., ICRP-2 (Default), ICRP-30, and ICRP-72) as selected from the Dose Factors dropdown menu. One set of intake and consumption assumptions for ICRP-2 (Default) and ICRP-30 are taken from RG 1.109 and the second set of intake and consumption assumptions for ICRP-72 have been derived from EPA EFH.

**** User Note ** —** For population doses, the average consumption rates are used for distributing the production between the different age groups for application of the appropriate age group DCF values. No population doses are calculated for leafy vegetables, total vegetables only.

The Usage Parameters Section contains the 2000 U.S. population and the fractions of population for adults, teenagers and children. The default value for the 2000 U.S. population is "**2.8E+08**" and the fractions of population are defaulted depending upon the ICRP methodology (i.e., ICRP-2 (Default), ICRP-30, and ICRP-72) as selected from the Dose Factors dropdown menu. If the calculation to be performed is using ICRP-2 (Default) and ICRP-72 DCF values, the population fractions will "**0.71**," "**0.18**," and "**0.11**" for adults, teenagers and children, respectively. If the calculation to be performed is using ICRP-30 DCF values, the population fraction will be "**1.00**" for adults and "**0.0**" for teenagers and children. ICRP-30 contains DCF values only for an adult age range.

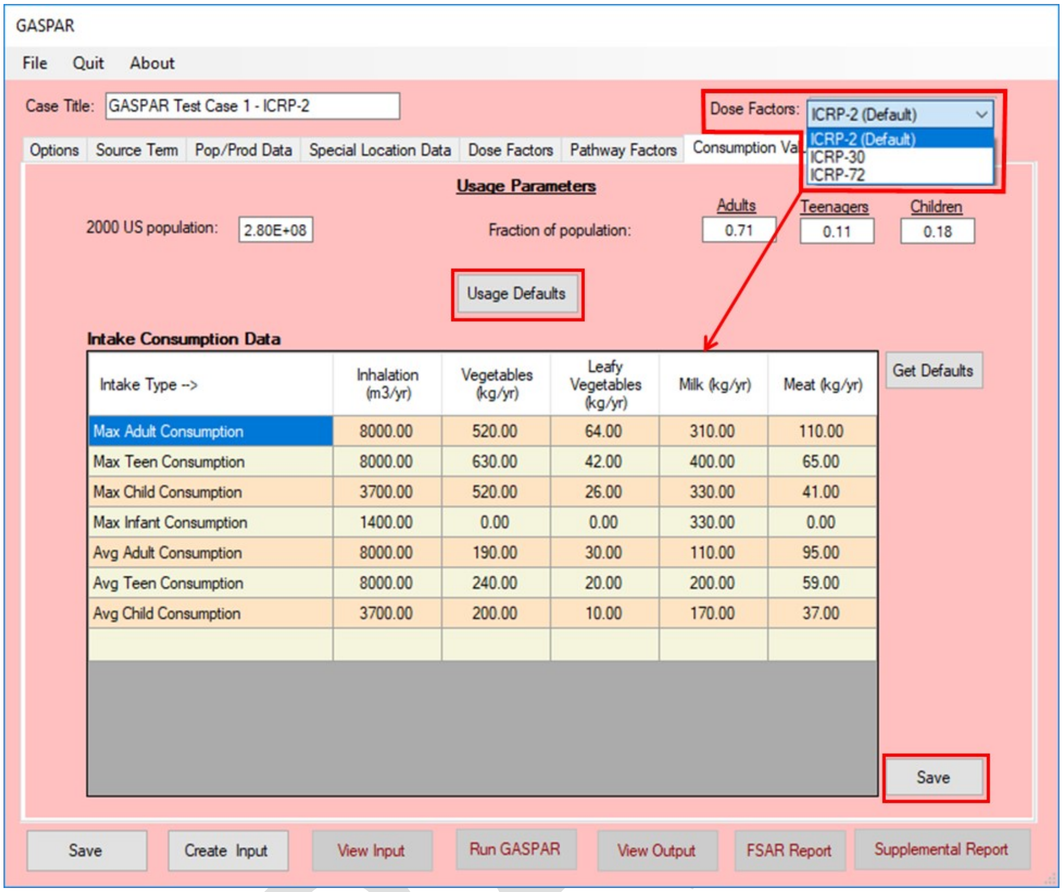


Figure 4-25 Consumption Values Tab

- The Intake Consumption Data Section includes the following parameters. Values are dependent on the ICRP methodology selected, where the ICRP-2 (Default) and ICRP-30 values are from RG 1.109 and the ICRP-72 values have been derived from the EPA EFH.

- The intake type displays either the maximum or average age-group consumption type depending upon the ICRP methodology.

- The maximum and average inhalation rate is displayed in units of cubic meters per year (m^3/yr). The default values vary depending upon the ICRP methodology.

- The maximum and average vegetable intake is displayed in units of kg/yr with the default values varying depending upon the ICRP methodology.

- The maximum and average leafy vegetable intake is displayed in units of kg/yr with the default values varying depending upon the ICRP methodology.

- The maximum and average milk intake is displayed in units of kg/yr with the default values varying depending upon the ICRP methodology.

- The maximum and average meat intake is displayed in units of kg/yr with the default values varying depending upon the ICRP methodology.

Select the “Save” button to save any changes and select the “Usage Defaults” button to restore the maximum individual defaults. See Appendix C of this manual for further discussion of the default intake and consumption assumptions depending on the ICRP methodology.

**** User Note** ─** Remember that if a change is made to the consumption values, this change will be carried forward for future runs. Defaults should be reset by using the **“Get Default”** option. Users should remember that saving a case/file will save all configurations and values as selected for the case. Changing back to defaults will not affect any changes made for a particular case/file unless this file is again saved after values changed back to defaults. Therefore, if any question about saved values, it is good to reset to defaults prior to initiating new cases.

4.3 Code Execution and Reports

4.3.1 Executing GASPAR

After all data for the GASPAR dose calculation is entered, select the “Save” button as shown in Figure 4-26 to save the data to the dataset being used for creating the input file as well as to a file name if one has been created for the case. As shown in Figure 4-26 the NRCDose3 code will save the data to the GASPAR database, which is used for the calculation. If working with a saved file name, the saved file will also be updated (i.e., *.GN3). Select the “OK” button to save the data to the database file, as used for creating the input for the run, and, as applicable, to the open “*.GN3” file.

If the data is to be saved to a different “*.GN3” database file, then select the “Save to GN3 File…” as shown in Figure 4-3. The File Tool dropdown menu option (Figure 4-3) is used to open a Windows Explorer directory as shown in Figure 4-27. At this point, name the *.GN3” file and directory location as desired. Future saves will save to this new file name, as well as the database used for the code execution.

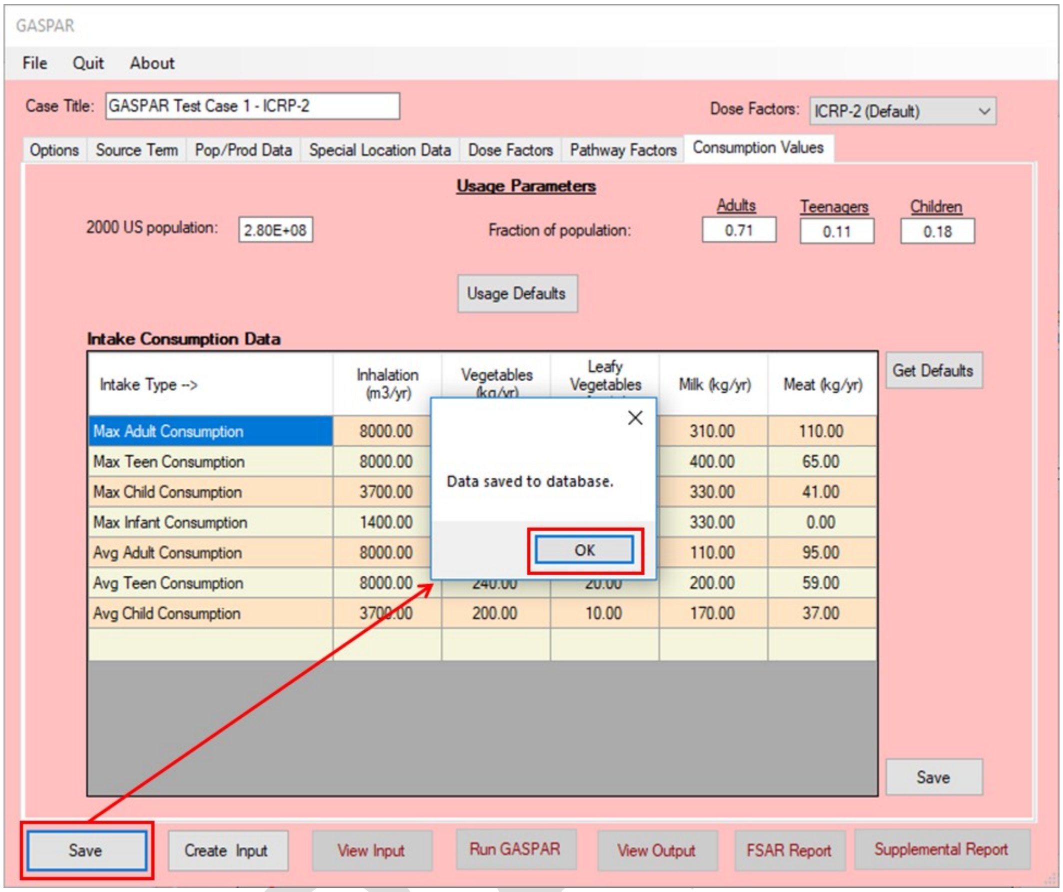


Figure 4-26 Saving GASPAR Inputs

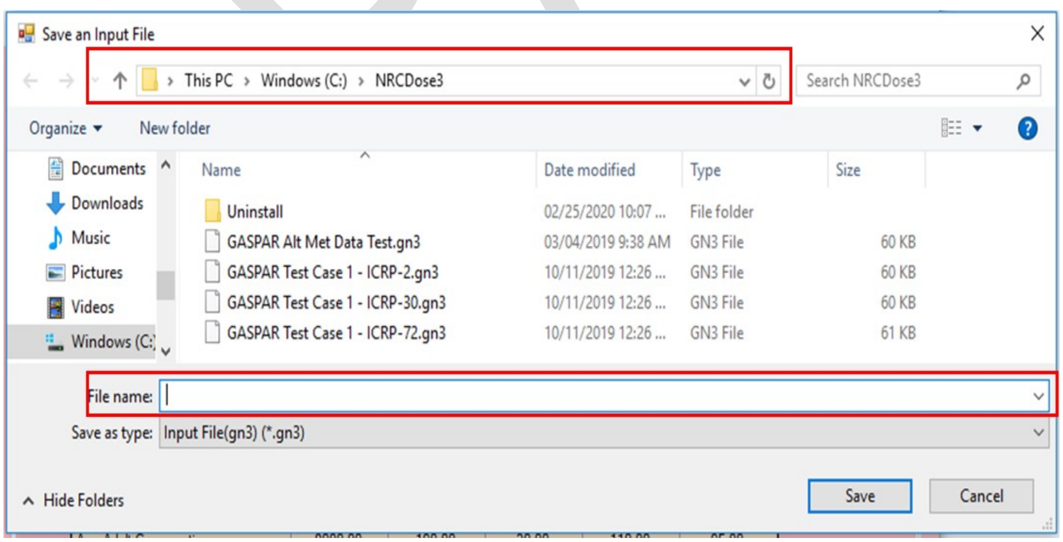
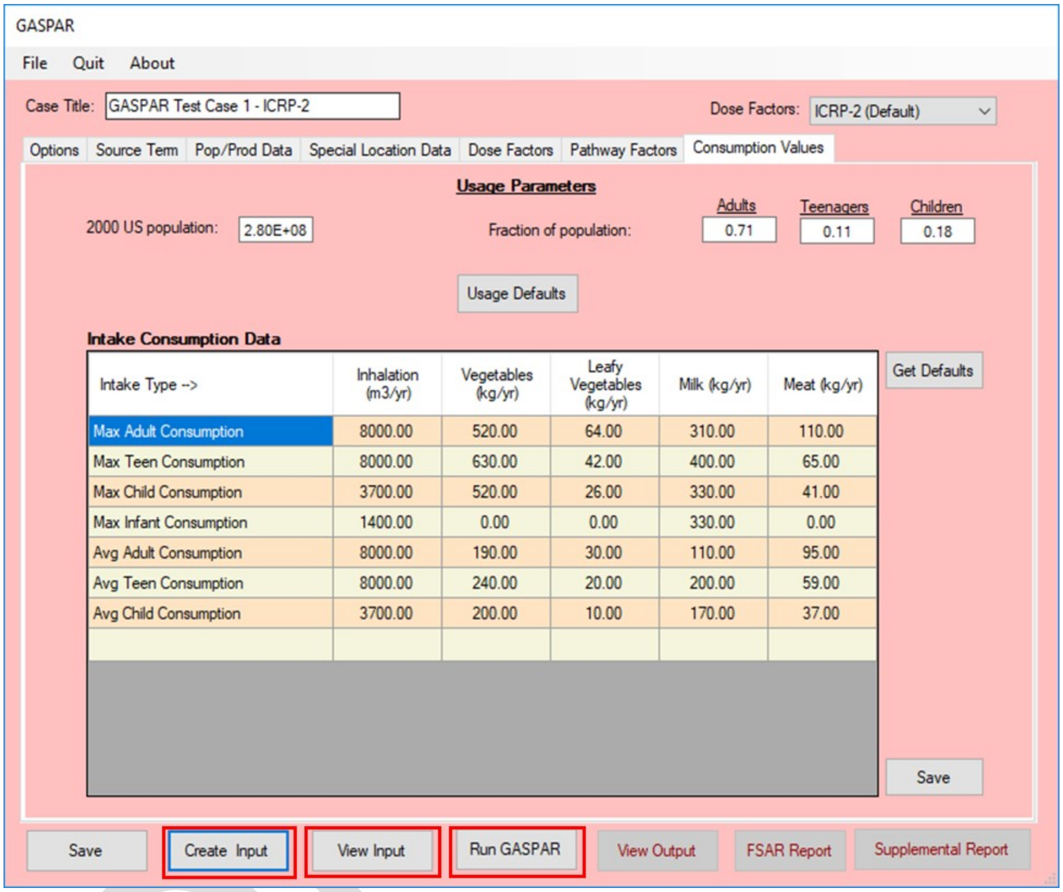


Figure 4-27 Windows Explorer directory for saving GASPAR inputs to a new file

Select the “Create Input” button to activate the “View Input” and “Run GASPAR” buttons on the GASPAR Module Main Screen as shown in Figure 4-28. Select the “View Input” button to display and review text file data input as shown in Figure 4-29. The “Save As..” button opens a

Windows Explorer directory and allows the user to save the input as an input field file ("*.gn3"). The "Print" button prints the input text file and the "Close" button closes the Text Viewer Screen as shown in Figure 4-29 and returns to the GASPAR Module Main Screen as shown in Figure 4-26.



Intake Type -->	Inhalation (m3/yr)	Vegetables (kg/yr)	Leafy Vegetables (kg/yr)	Milk (kg/yr)	Meat (kg/yr)
Max Adult Consumption	8000.00	520.00	64.00	310.00	110.00
Max Teen Consumption	8000.00	630.00	42.00	400.00	65.00
Max Child Consumption	3700.00	520.00	26.00	330.00	41.00
Max Infant Consumption	1400.00	0.00	0.00	330.00	0.00
Avg Adult Consumption	8000.00	190.00	30.00	110.00	95.00
Avg Teen Consumption	8000.00	240.00	20.00	200.00	59.00
Avg Child Consumption	3700.00	200.00	10.00	170.00	37.00

Figure 4-28 GASPAR Module Main Screen ─ Create Input

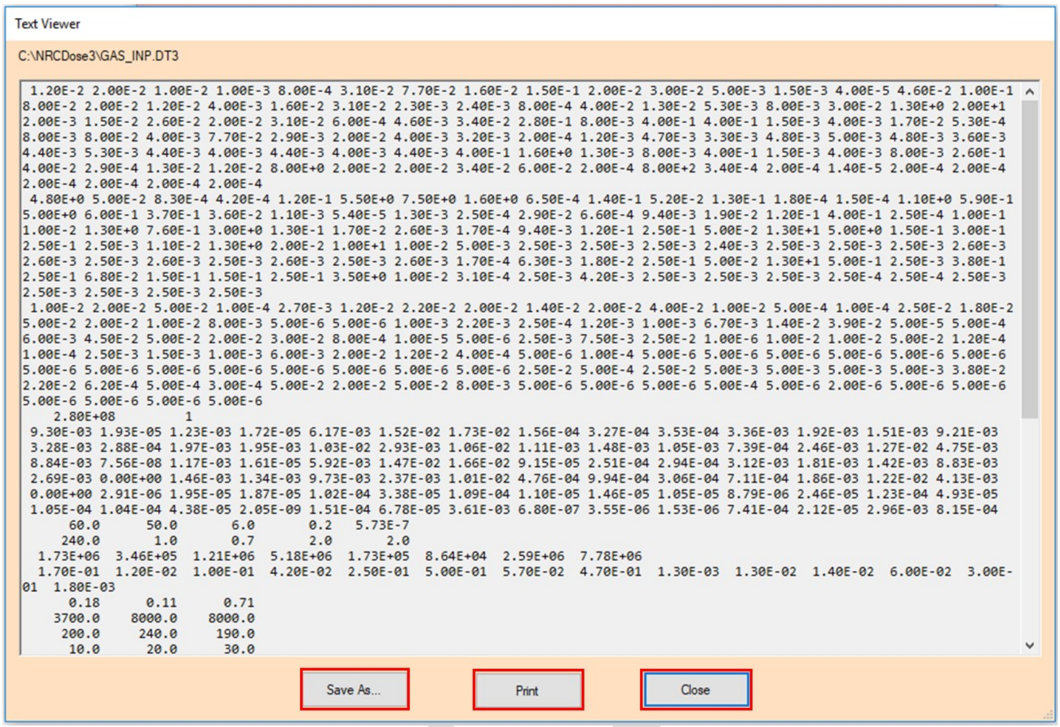
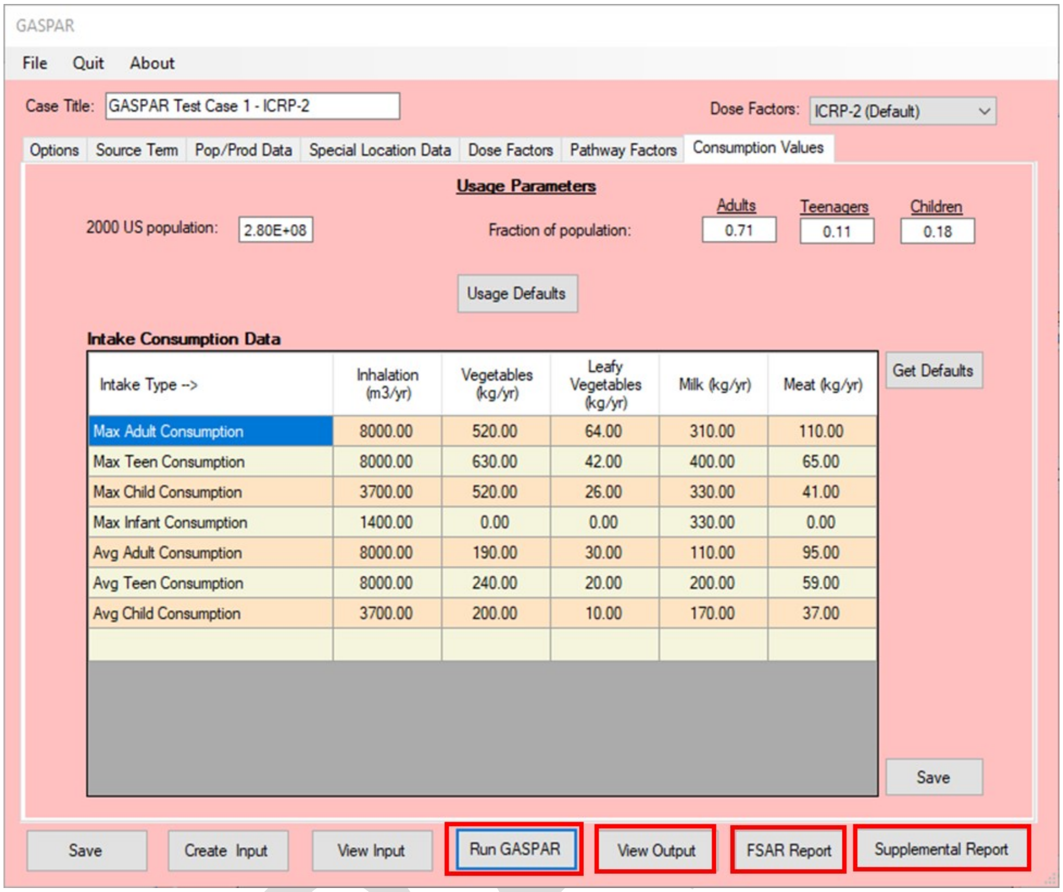


Figure 4-29 View GASPAR Input ― Text Viewer Screen

Select the “Run GASPAR” button to execute the code and generate the output report. Selecting the “Run GASPAR” button will also activate the “View Output,” “FSAR Report,” and the “Supplemental Report” buttons on the GASPAR Module Main Screen as shown in Figure 4-30. After NRCDose3 completes the GASPAR dose calculation the output will appear as a text output file as shown in Figure 4-31. The “Save As..” button as shown in Figure 4-31 opens a Windows Explorer directory and allows the user to save the output as a text file (“*.txt”). The “Print” button prints the output text file and the “Close” button closes the Text Viewer Screen as shown in Figure 4-31 and returns to the GASPAR Module Main Screen as shown in Figure 4-30. The user can also the access the output text file by selecting the “View Output” button.



Intake Type -->	Inhalation (m3/yr)	Vegetables (kg/yr)	Leafy Vegetables (kg/yr)	Milk (kg/yr)	Meat (kg/yr)
Max Adult Consumption	8000.00	520.00	64.00	310.00	110.00
Max Teen Consumption	8000.00	630.00	42.00	400.00	65.00
Max Child Consumption	3700.00	520.00	26.00	330.00	41.00
Max Infant Consumption	1400.00	0.00	0.00	330.00	0.00
Avg Adult Consumption	8000.00	190.00	30.00	110.00	95.00
Avg Teen Consumption	8000.00	240.00	20.00	200.00	59.00
Avg Child Consumption	3700.00	200.00	10.00	170.00	37.00

Figure 4-30 GASPAR Module Main Screen — Run GASPAR

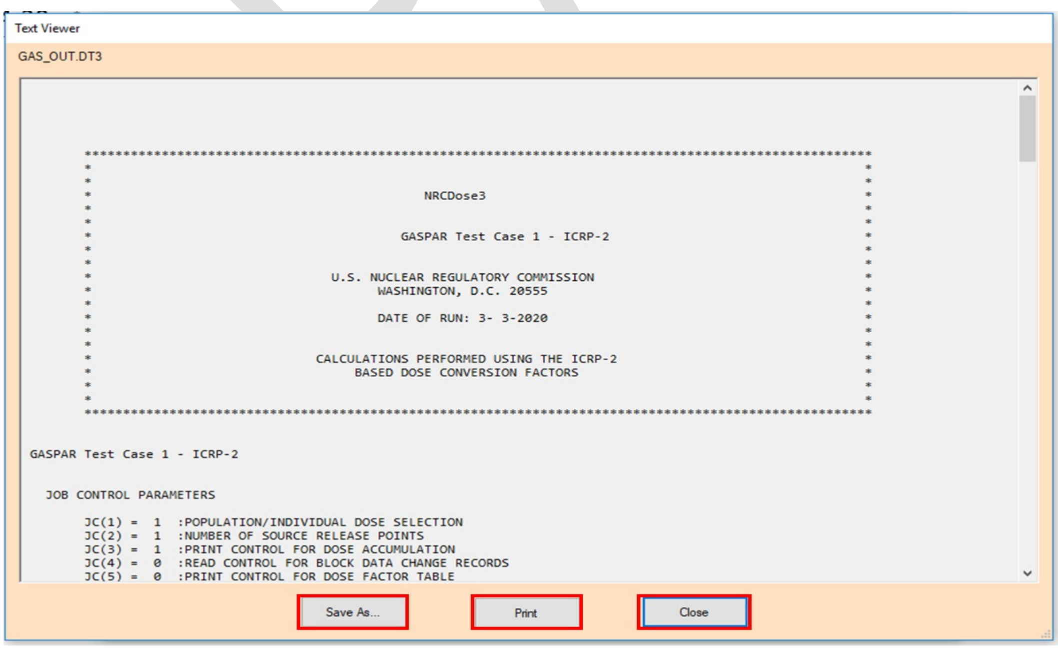


Figure 4-31 View GASPAR Output — Text Viewer Screen

** **User Note** ** — Though not required, users should consider saving GASPAR files in a user-specified directory other than the NRCDose3 directory, which would facilitate future use and sharing without having to navigate to that directory.

4.3.2 GASPAR Reports

There are two additional reports that are created – FSAR Report and Supplemental Report. As shown in Figure 4-32, the FSAR Report consolidates the input data and dose calculations into a single text report that provides the information that is considered most important for the preparation and review of results for licensing documents. The “Save As..” button as shown in Figure 4-32 opens a Windows Explorer directory and allows the user to save the output as a text file (“*.txt”). The “Print” button prints the FSAR Report and the “Close” button closes the Text Viewer Screen and returns to the GASPAR Module Main Screen as shown in Figure 4-30.

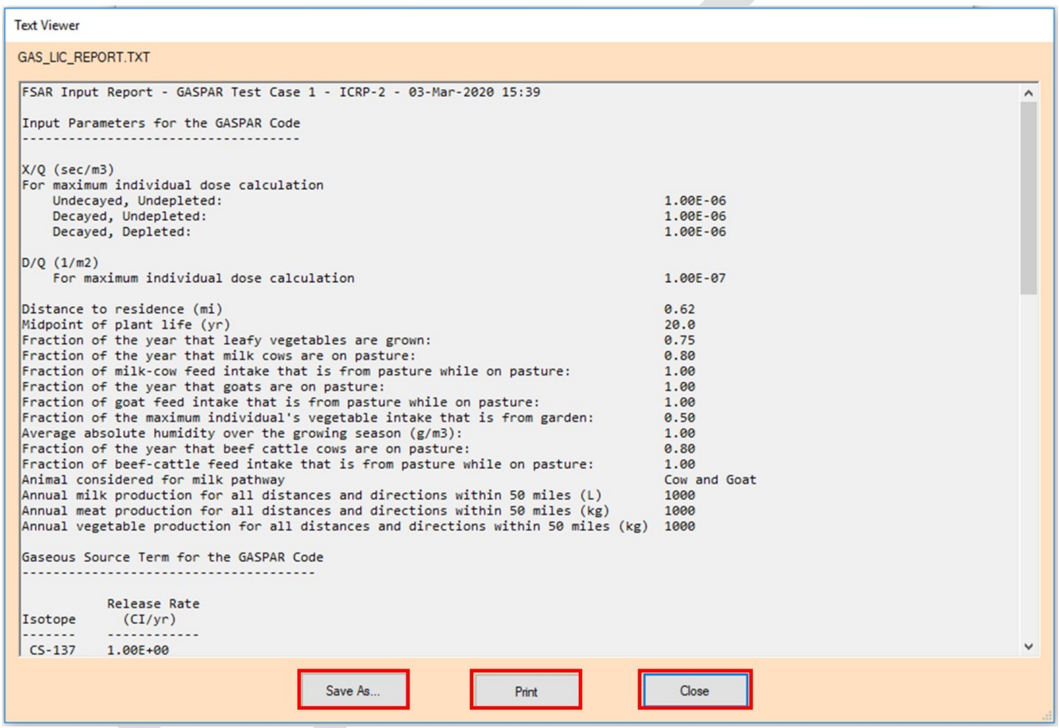
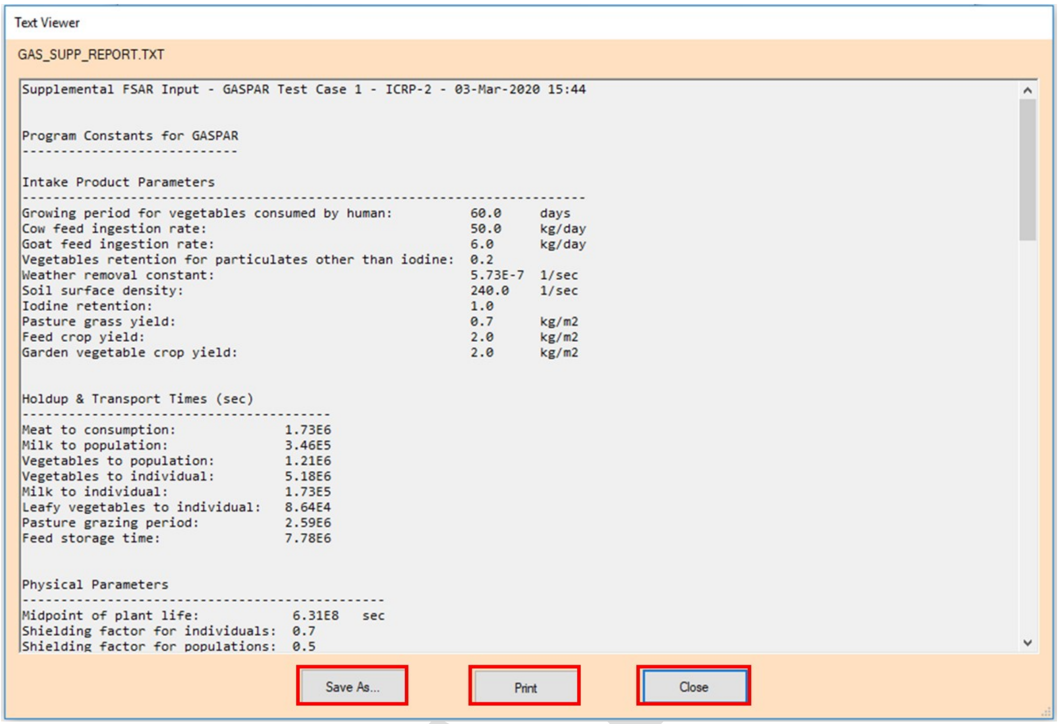


Figure 4-32 GASPAR FSAR Report Screen

As shown in Figure 4-33, the Supplemental Report provides additional documentation of the modeling assumptions that were used for the calculations, such as exposure and modeling assumptions, transfer factors, and various pathway constants. The “Save As..” button as shown in Figure 4-33 opens a Windows Explorer directory and allows the user to save the output as a text file (“*.txt”). The “Print” button prints the FSAR Report and the “Close” button closes the Text Viewer Screen and returns to the GASPAR Module Main Screen as shown in Figure 4-30.




```
Supplemental FSAR Input - GASPAR Test Case 1 - ICRP-2 - 03-Mar-2020 15:44


Program Constants for GASPAR
----------------------------

Intake Product Parameters
-------------------------------------------------------------------------
Growing period for vegetables consumed by human:          60.0      days
Cow feed ingestion rate:                                  50.0      kg/day
Goat feed ingestion rate:                                 6.0       kg/day
Vegetables retention for particulates other than iodine:  0.2
Weather removal constant:                                 5.73E-7   1/sec
Soil surface density:                                     240.0     1/sec
Iodine retention:                                         1.0
Pasture grass yield:                                      0.7       kg/m2
Feed crop yield:                                          2.0       kg/m2
Garden vegetable crop yield:                              2.0       kg/m2


Holdup & Transport Times (sec)
----------------------------------------
Meat to consumption:              1.73E6
Milk to population:               3.46E5
Vegetables to population:         1.21E6
Vegetables to individual:         5.18E6
Milk to individual:               1.73E5
Leafy vegetables to individual:   8.64E4
Pasture grazing period:           2.59E6
Feed storage time:                7.78E6


Physical Parameters
-----------------------------------------------
Midpoint of plant life:            6.31E8    sec
Shielding factor for individuals:  0.7
Shielding factor for populations:  0.5
```

Figure 4-33 GASPAR Supplemental Report Screen

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

5.0 XOQDOQ

The XOQDOQ Module within NRCDose3 executes a modified version of the XOQDOQ Fortran code. The basic calculation methods (algorithms) of the XOQDOQ Fortran code, as described in NUREG/CR-2919, have not been changed with this update to the NRCDose code. However, significant changes have been made to the data management and operation to support 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, and at various standard radial distances and distance segments for downwind distance 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 via dry deposition and radioactive decay, and adjustments to consider non-straight trajectories.

The following sections will 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 provide additional detailed discussion on the assumptions, limitations and methods implemented by the XOQDOQ code.

After opening the NRCDose3 code, select the “XOQDOQ – Annual Average Meteorological Dispersion and Deposition” button as shown in Figure 5-1 to open the XOQDOQ Module Main Screen as shown in Figure 5-2.

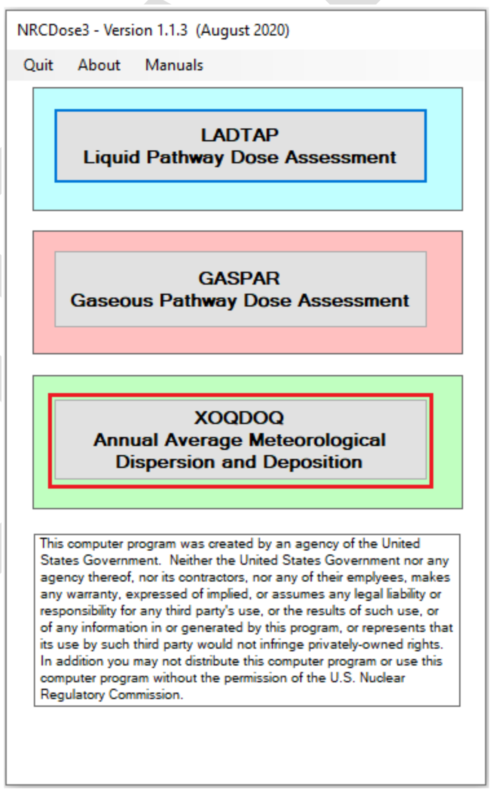


Figure 5-1 NRCDose3 Main Selection Screen (XOQDOQ Module)

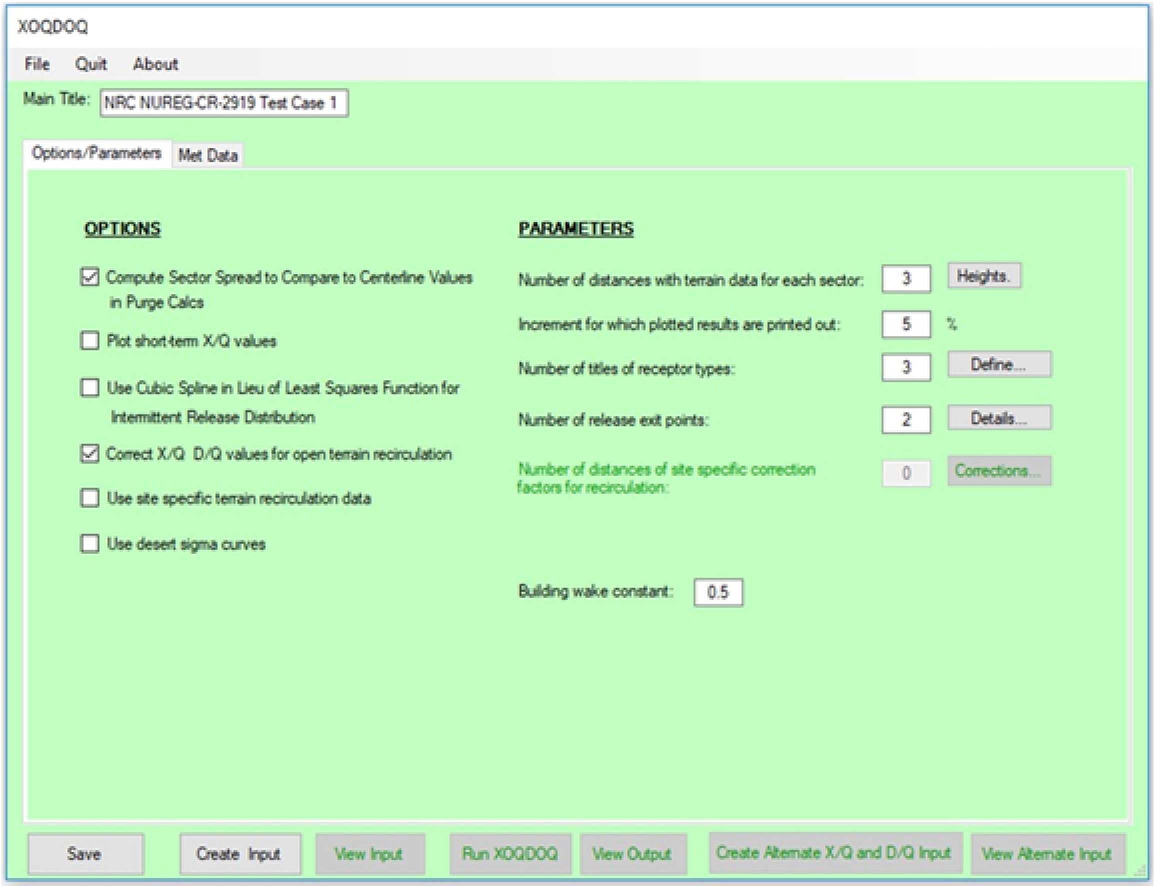


Figure 5-2 XOQDOQ Module Main Screen

The XOQDOQ Module Main Screen as shown in Figure 5-2 opens with case data that is saved in the database and it contains three main functional areas for inputting data and performing XOQDOQ dispersion and deposition calculations. These functional areas are: (1) the toolbar and initial setup area, (2) data input tabs area and (3) code execution and reports area. Each of these functional areas of the XOQDOQ Module Main Screen is discussed in the following sections with a description of the options and capabilities contained therein.

5.1 Toolbar and Initial Setup Functional Area

This portion of the XOQDOQ Module Main Screen contains three tools and one initial setup input fields as shown in Figure 5-2. The three tools are the File Menu Tool, Quit Tool and About Tool. The only initial setup field is the Case Title..

5.1.1 File Menu Tool

The File Menu Tool provides the functionality to manage the XOQDOQ files as shown in Figure 5-3. The File Tool dropdown menu options are:

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

- Open XN3 File — Select this option to access and open a "*.XN3" file that was 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 file option allows a user to load input files that may have been created in text file format for use with the original Fortran XOQDOQ code. If the user opens a legacy file, the file structure is already in the format needed for running the code. There is no need to create input; simply select run XOQDOQ. The input screens and options cannot be used for editing and updating a legacy file. Any editing will need to be done using a text editor, following the format and file structure as described in NUREG/CR-2919, and saved as a "*.dat" file for future use.

- Save to Database — Choose 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, initially populates all XOQDOQ screens and windows.

- Save to XN3 File — Choose this option to save the completed case to a "*.XN3" file. This allows the file to be saved for later use, or for sharing with others.

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

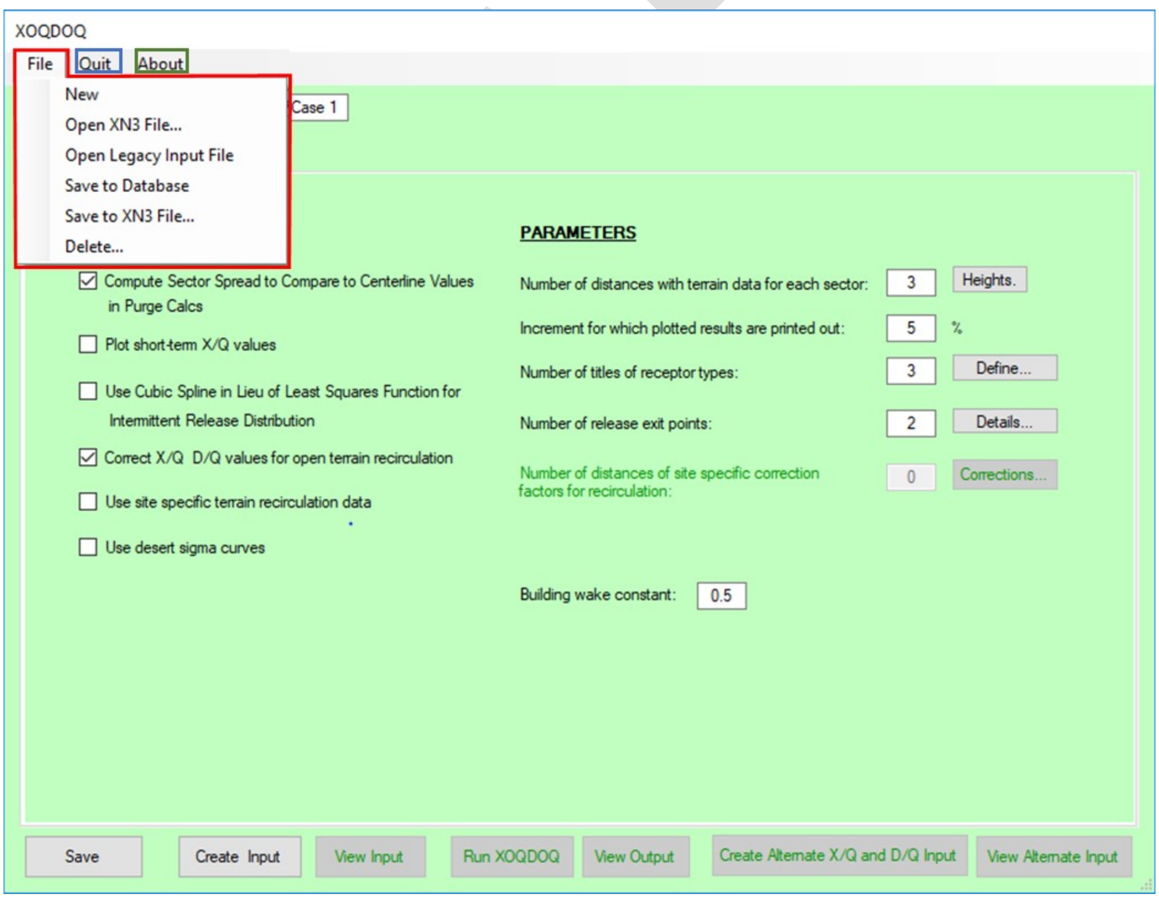


Figure 5-3 XOQDOQ Toolbar with File Tool dropdown menu

5.1.2 Quit Tool

Selecting the Quit Tool from the toolbar as shown in Figure 5-3 will terminate the XOQDOQ module operation. There is a Question prompt screen as shown in Figure 5-4 to ensure that the user wants to quit and exit the module. If the “Yes” button is selected the XOQDOQ Module will terminate and any changed/edited data will not be saved. Select the “No” button and then the appropriate entry from the File Tool dropdown menu to ensure that any information has been saved (to the database and/or a “*.XN3” file) prior to quitting.

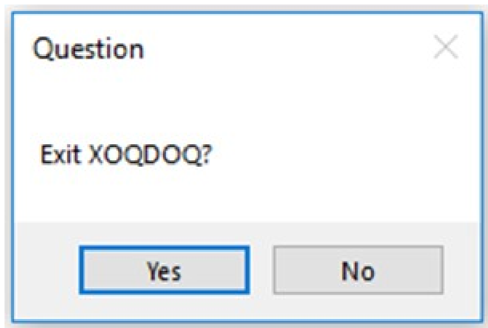


Figure 5-4 XOQDOQ Module Quitting Tool Screen

5.1.3 About Tool

Selecting the About Tool from the Toolbar as shown in Figure 5-5 displays information about the XOQDOQ Fortran code. Select the “OK” button as shown in Figure 5-5 to return to the XOQDOQ Module Main Screen as shown in Figure 5-2.

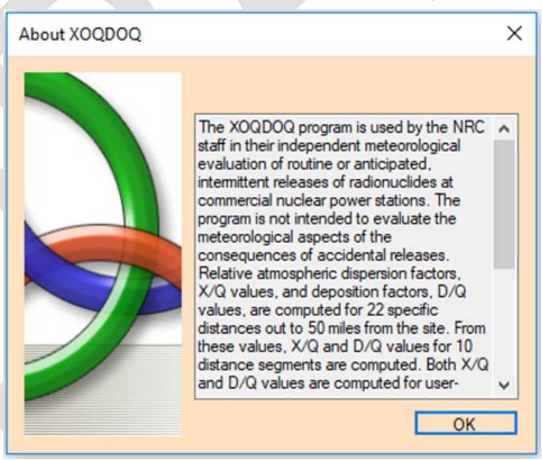


Figure 5-5 About XOQDOQ Screen

5.1.4 Main Title Field

Enter a title in the Main Title Field for the XOQDOQ calculation. This is a descriptive text field that will only save up to 80 characters. The appropriate text should be selected to assist user in identifying, for example, the facility/site, period of record of meterological input data, and release point information. As displayed in Figure 5-2, the example scenario Main Title is “NRC NUREG-CR-2919 Test Case 1,” which is installed along with the NRCDose3 code in the installation directory (i.e., C:/NRCDose3).

5.2 Data Input Tabs

The two XOQDOQ Data Input Tabs as shown in Figure 5-2 are:

1. Options/Parameters

2. Met Data

Though not required when generating the input for XOQDOQ, it is recommended that the user enter the necessary parameters and data to the case in order of the Data Input Tabs as they are listed in the XOQDOQ Module Main Screen as shown in Figure 5-2.

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 of the tab, and the Parameters Section, right-hand side of tab as shown in Figure 5-6. Refer to NUREG/CR-2919 and Table B-3 of Appendix B to this user guide for additional information on the inputs in this tab.

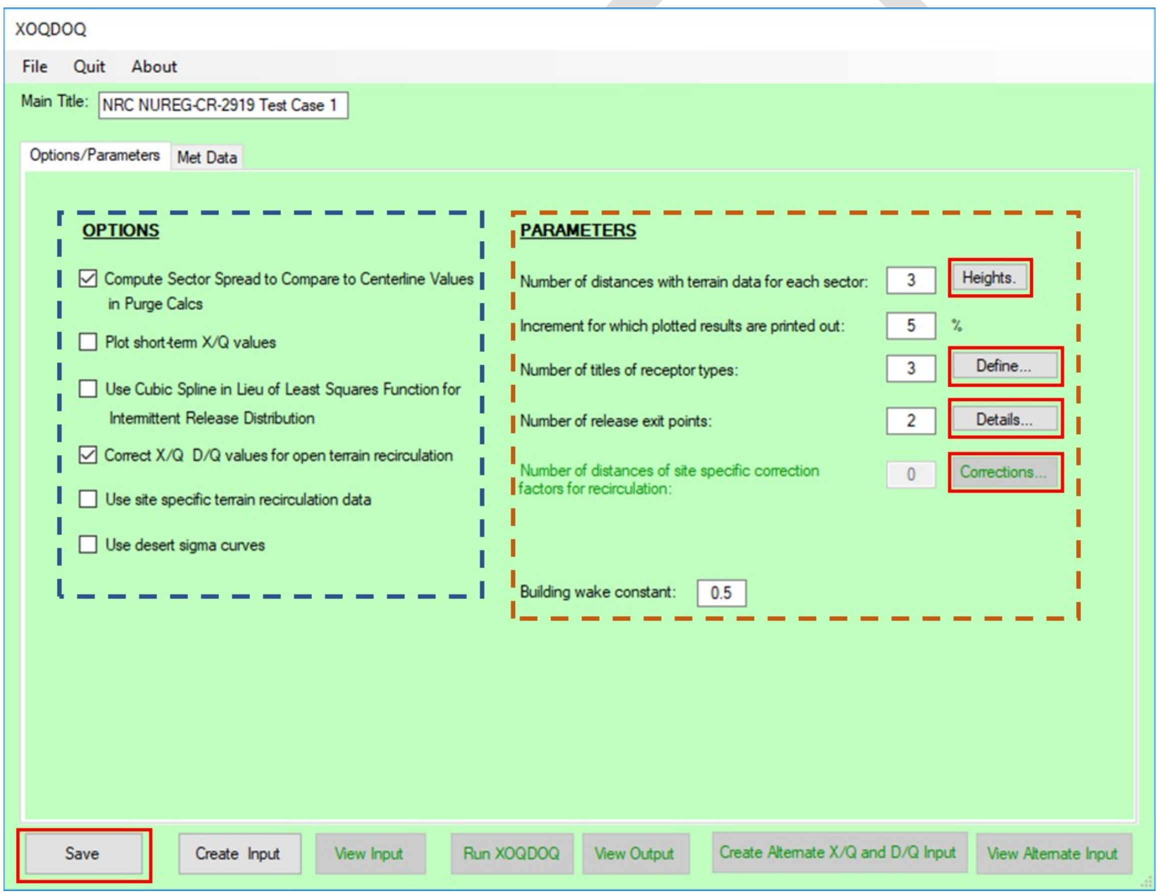


Figure 5-6 Options/Parameters Tab

5.2.1.1 Options Section

As shown in Figure 5-6, the following option 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 used for the example case**,** "NRC NUREG-CR-2919 Test Case 1" and is normally "checked" in program execution (see KOPT (3)).

- 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**" and is normally "unchecked" in program execution (see KOPT (4)).

- Use Cubic Spline in Lieu of Least Square Function for Intermittent Release Distribution – Select this option to use cubic spline in lieu of a least square 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**" and is normally "checked" in program execution (see KOPT (5)).

- Correct X/Q and D/Q values for open terrain recirculation – Select this option to utilize the default correction for open terrain recirculation, based on Figure 3.2 of NUREG/CR-2919. If this option is not checked, and the "Use site specific terrain recirculation data" (next option) is **"unchecked,"** then no recirculation is included in the calculations. . The default value from the "NRC NUREG-CR-2919 Test Case 1" is for this option to be "**checked**" but its use should be based on site-specific conditions (see KOPT (8)).

- 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 factors." Recirculation correction factors will be based on 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. Additionally, when inputting the site-specific terrain recirculation factors, it is necessary to input values for all 16 downwind distance sectors. If a zero (0) is left as a value for the recirculation factor in a sector at a specific distance, it will result in the calculation of zero (0) dispersion and deposition values 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 whether site-specific recirculation factors are available (see KOPT (9)).

- 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," is "**unchecked**" and is normally "unchecked" in program execution (see KOPT (10)).

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 radial segments, discussed and identified as KOPT(6) in NUREG/CR-2919. In NRCDose3, the X/Q and D/Q values for the radial segments are always provided in the output. Similarly, if special receptor locations have been identified, the X/Q and D/Q values for those locations will always be provided in the output (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 not used in the Fortran code calculations. Refer to Appendix B for additional information.

5.2.1.2 Parameters Section

The Parameters Section is where the factors that influence how the release will be characterized are entered. The "Increment for which plotted results are printed out 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 of this tab:

- 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 units of meters for each downwind direction sector. Select the "Save" button when the terrain heights and distances for the 16 sectors are entered. If the plant grade elevation is set at a value of zero on the Met Data Tab (see Section 5.2.2), then terrain height and distance values are in units of meters. If the plant elevation is set to a value greater than zero, the distances are in units of miles from the plant release point; and the terrain height is in units of feet above sea level (Figure 5-7).

  ** **User Note** ** **─** If the user changes plant grade elevation, such as to cause the units for terrain data to change, any prior entered terrain values will not change to reflect the change in units.

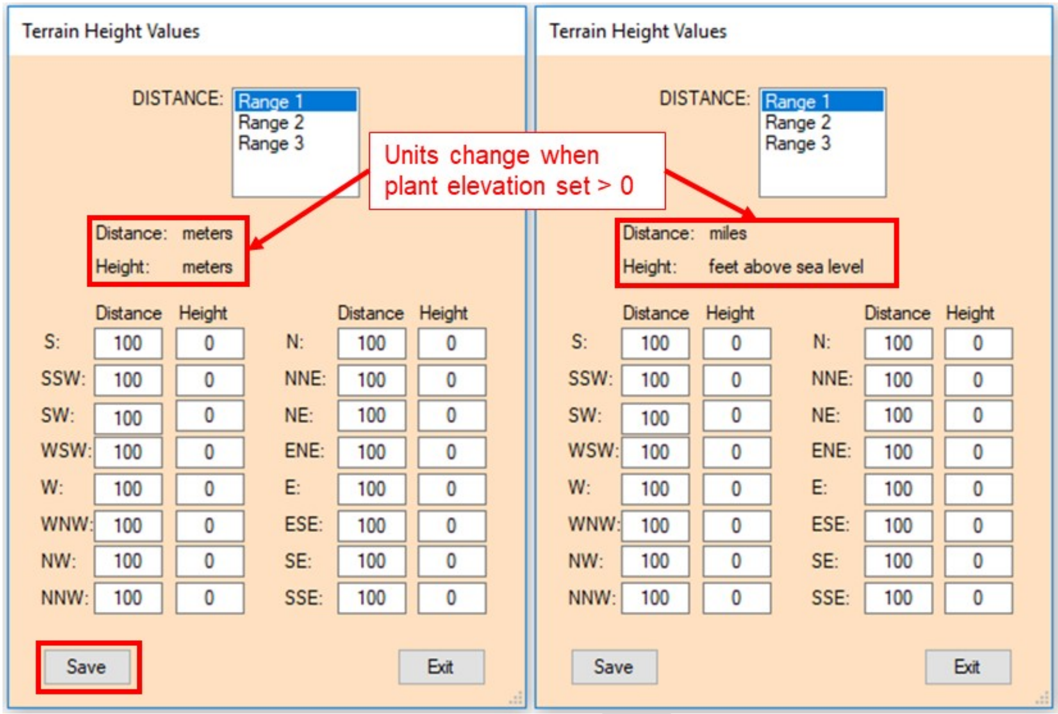


Figure 5-7 Terrain Height Values Screen

- Increment for which plotted results are printed out: ─ This parameter specifies what level short-term X/Q percentile values is 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 the different 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 additional receptor points 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 a maximum of 30 receptor points. After entering the number, select the “Define” button to open the Receptor Types Screen, as shown Figure 5-8. Enter the Title and Location for each receptor type and select the “Define” button for each receptor type to open the Receptor Locations Screen as shown in Figure 5-8. On the Receptor Locations Screen, select the Distance from the 16 directional sector options in the dropdown menu and the Distance in units of meters for each receptor location. When completed, select the “Save” button as needed to return to the “Options/Parameters” Tab.

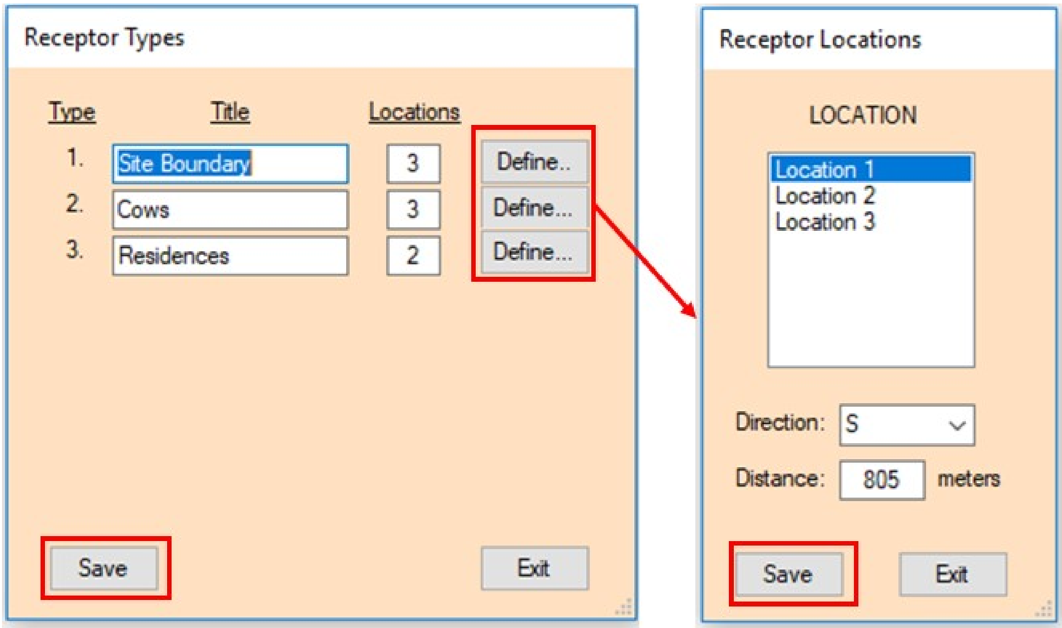


Figure 5-8 Receptor Types and Receptor Locations Screens

- Number of Release Exit Points: — Enter the number of the different release exit points on the Options/Parameters Tab that will 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 to a maximum of 5 release points. Select the "Details" button to open the Location Selection Screen, as shown in Figure 5-8, and enter a descriptive title for each release point.

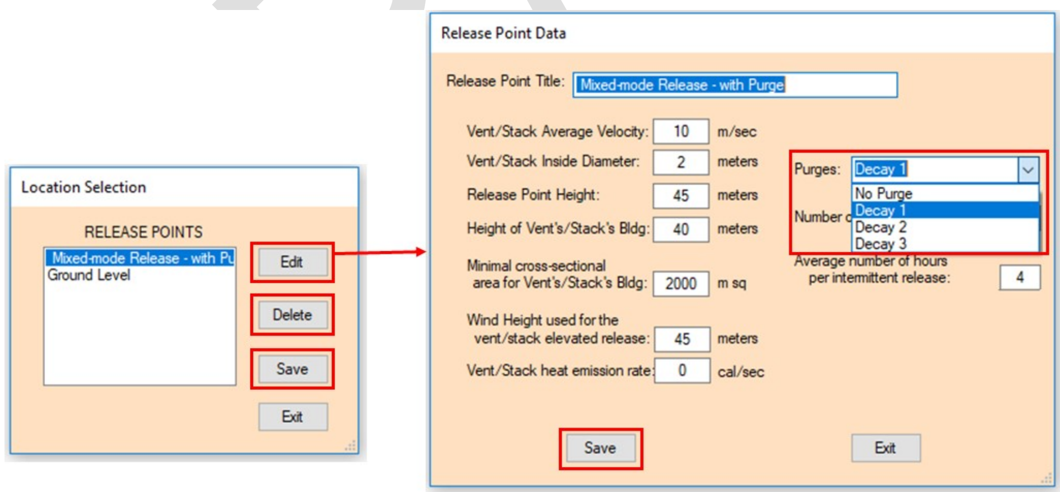


Figure 5-9 Location Selection and Release Point Data Screens

Select the release point (highlight) and the "Edit" button to open the Release Point Data Screen as shown in Figure 5-9.

- Release Exit Point Title — Enter a descriptive title for the release point in this text field.

- Vent/Stack Average Velocity ─ Enter the average velocity of the effluent from the plant vent or stack in units of meters per second (m/s) with an allowable range for values in this field of greater than 0.0 m/s.

- Vent/Stack Inside Diameter ─ Enter the inside diameter of the plant vent or stack in units of meters with an allowable range for values in this field of greater than 0.0 m.

- Release Exit Point Height ─ Enter the height of the release point from the plant vent or stack in units of meters with an allowable range for values in this field of greater than 0.0 m.

- Height of Vent's/Stack's Bldg ─ Enter the height of the building with the plant vent or stack in units of meters above plant grade with an allowable range for values in this field of greater than 0.0 m.

- Minimum Cross-Sectional Area for Vent/Stack Building ─ Enter the minimum cross-sectional area of the building with the plant vent or stack in units of square meters (m^2) with an allowable range for values in this field of greater than 0.0 m^2.

- Wind Height Used for the Vent's/Stack's Elevated Release ─ Enter the wind height used for an elevated plant vent or stack release in units of meters with an allowable range for values in this field of greater than 0.0 m.

- Vent/Stack Heat Emission Rate ─ Enter the heat emission rate of the plant vent or stack in units of calories per second (cal/s) with an allowable range for values in this field of greater than 0.0 cal/s. Normally, this value should be 0 for power plants. Section 4.20 of NUREG/CR-2919 provides additional information on when this parameter may need to be adjusted.

- Purges ─ This field provides the user with the dropdown menu options to select whether there are purges or not. The dropdown menu options, as shown on Figure 5-9, are "No Purge" and the purge options of "Decay 1," "Decay 2," and "Decay 3." If the "No Purge" option is selected, the "Number of intermittent releases" and "Average number of hours per intermittent release" options are deactivated. If the purge options of "Decay 1," "Decay 2," and "Decay 3" are selected the "Number of intermittent releases" and "Average number of hours per intermittent release" field are activated. Enter the number of intermittent releases and the average number of hours per each release. Each of the purge options of "Decay 1," "Decay 2," and "Decay 3" are the Card Type 4 (i.e., DECAY(1), DECAY(2), and DECAY(3)) options in the XOQDOQ Fortran code and each represents how decay is handled. Typically, for purge option "Decay 1" (DECAY(1)), no decay is considered, which is the standard application. For purge option "Decay 2" (DECAY(2)), a 2.26-day decay is considered; and for purge option "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, as 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 becomes 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. The allowable range for the number of site-specific recirculation factors is between 1 and a maximum of 10 recirculation factors. After entering the number of site-specific recirculation factors, select the "Corrections…" button to open the Distance Corrections Screen, as shown Figure 5-10. For each of distance site-specific correction factors, enter the distance in meters for the 16 directional sectors and the correction factors as shown in Figure 5-10. A value greater than 1.0 is needed for each entry; this recirculation value is a direct multiplier in the dispersion and deposition calculations; therefore, a value less than 1.0 will cause a proportional reduction and a value of zero (0) will result in calculation of zero (0) X/Q and D/Q values. Select the "Save" when done for each distance of site-specific correction factors for recirculation.

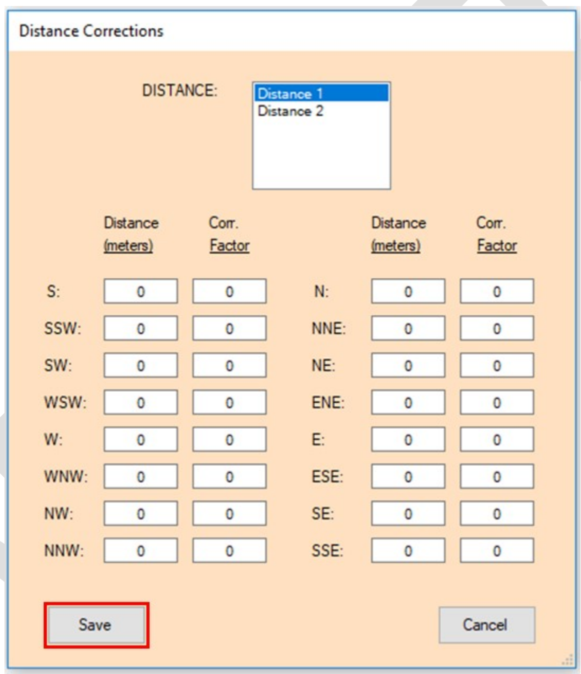


Figure 5-10 Distance Corrections Screen

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

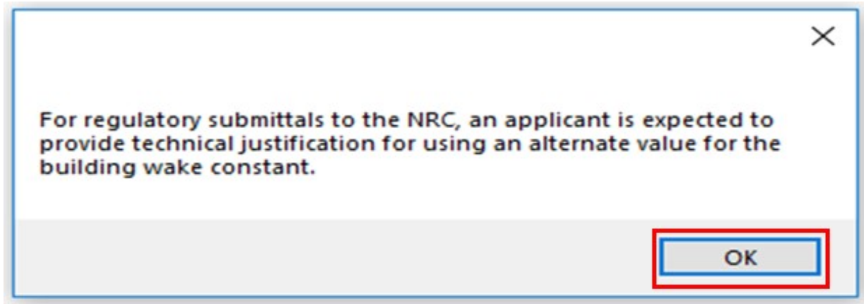


Figure 5-11 Building Wake Constant Warning Window

5.2.2 Met Data Tab

The Met Data Tab is used to enter the meteorological information and data parameters to determine the applicable relative dispersion (X/Q) and relative deposition (D/Q) values in the XOQDOQ calculations. As shown in Figure 5-12, the tab includes an input option section in the upper portion of the tab and a joint frequency distribution (JFD) table in the lower portion of the tab. For additional information regarding the inputs on this tab refer to NUREG/CR-2919. The inputs and options on this tab include:

- Distribute calms as first wind-speed class – This option distributes calms as the first wind class and 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 – This option changes 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**."

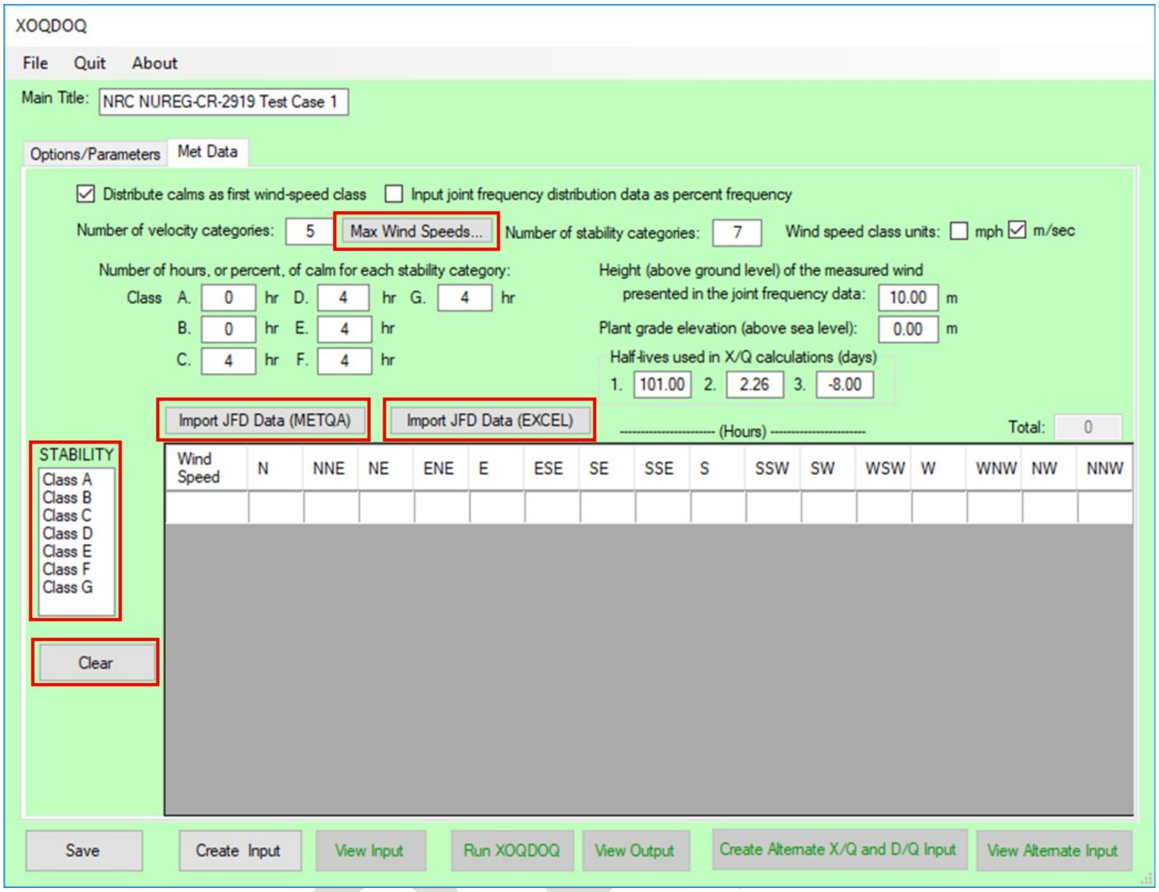


Figure 5-12 Met Data Tab

- Number of velocity categories: ─ Enter the number of velocity categories in this field. 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 a maximum of 14 velocity categories. Consistent with NRC guidance, finer resolution (i.e., more wind speed classes) is desirable in summarizing wind speed data for the lower wind speed classes. Select the "Max Wind Speeds" button to open the Maximum Wind Speeds Screen as shown in Figure 5-13. Before selecting the "Max Wind Speeds" button, the user should specify on the Met Data Tab the maximum wind speed units of measure as either miles per hour (mph) or meters per second (m/sec) to be applied to all velocity categories. The units of measure need to be consistent with the wind speeds units of measure in the JFD. Select the "Save" button on the "Maximum Wind Speeds" screen to save any changes to the database.

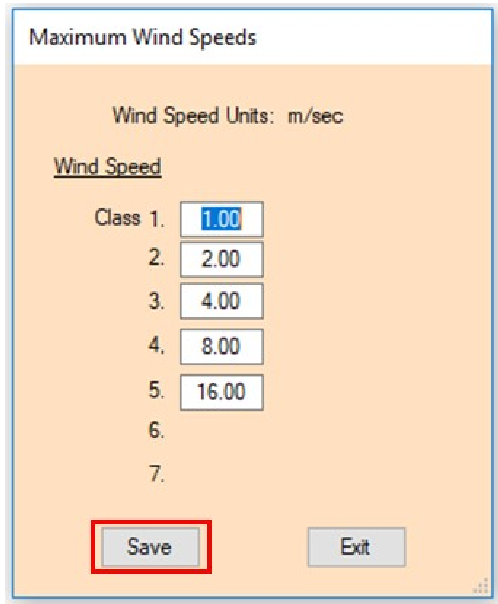


Figure 5-13 Maximum Wind Speeds Screen

- Number of stability categories: ─ Enter the number of stability categories in this field. 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 a maximum of 7 stability categories.

  ** **User Note** ** ─ The NRC in RG 1.111 utilizes 7 stability classes (A through G) based on vertical temperature difference in RG 1.23 [Ref. 25] whereas the EPA recognizes just 6 classes (A through F) an allows for several categorization approaches.

- Wind speed class units: ─ Select the wind speed class option in units of either mph or m/sec. This will change the units for the entries in the JFD table (lower portion of the Met Data tab) and the units for the "Number of Hours, or Percent of Calm for Each Stability Category" input fields simultaneously. The value from the example case, "NRC NUREG-CR-2919 Test Case 1," for this parameter is "**m/sec**."

- Number of hours, or percent of calm for each stability category: ─ Enter either the number of hours or percent of calm for each of the stability categories.

- Height (above ground level) of the measured wind presented in the joint frequency data: ─ Enter the height (above ground level) of the measured wind speed in units of meters. For ground level or elevated/ground-level mixed release, use winds at the 10-meter 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). If the plant elevation is set at a value of zero, as discussed Section 5.2.1.2, then terrain height and distance range values are in units of meters. If the plant elevation is set to a value greater than zero, the range distances are in units of miles from the plant release point; and the terrain height is in units of 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 used for X/Q calculations in units of days for the three-different decay and depletion parameters. Typically, these should not be changed from the default values:

  - 101 days to be used for undecayed, undepleted X/Q calculations
  - 2.26 days to be used for decayed, undepleted X/Q calculations
  - -8.00 days (to be used for decayed, depleted X/Q calculations

  ** **User Note** ** ─ The default values are used in the XOQDOQ Fortran code in a manner for controlling certain functions and the decay time. Any value over 100 for “DECAY(1)” is used to designate no decay and no depletion, reflected in the “No Decay and Undepletion” X/Q calculations. The value for DECAY(2), with a default of 2.26 days, reflects the value used for decay during transport and used for the “Decayed, Undepleted” X/Q calculations. Finally, the DECAY(3) value of -8.00 days reflects a decay of 8 days as well a plume depletion as used for the “Decayed and Depleted” X/Q calculations. Further information on these values can be found in NUREG/CR-2919 and for correct use of results in the GASPAR II Fortran code, these values should not be changed.

The lower portion of the Met Data Tab includes the input options for the JFD table as shown in Figure 5-12. Select (highlight) the appropriate Stability (i.e., Class A through Class G) and enter either the number of hours or percent the wind blows in each of the 16 downwind sectors of the JFD table. This process should be repeated for each stability class up to Class G.

Alternatively, JFD data can be imported using one of the two import file formats. If the user has a suitable MS Excel file with JFD information, this file can be imported to XOQDOQ by selecting the “Import JFD Data (EXCEL)” button. This will open the windows as shown in Figure 5-14. To use information from a JFD file, select the “Yes” button on the Check Screen to open the Met Data Import Screen. On the Met Data Import Screen double click on the “Input File” field to open Windows Explorer and navigate to the directory containing the JFD 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.

Similarly, JFD data may be imported using the file format of the output as generated by an internal (NRC) application referred to as MetQA (currently at Version 2.0), which represents the NRC staff’s implementation of NUREG-0917 (Nuclear Regulatory Commission Staff Computer Programs for Use with Meteorological Data), dated July 1982 [Ref. 26]. The MetQA application generates various summaries that assist in evaluating the quality and completeness (i.e., data recovery) of the meteorological parameters measured by an applicant’s or licensee’s onsite meteorological monitoring program. The MetQA application generates meteorological data inputs to atmospheric dispersion models including the XOQDOQ code, suitable for use with NRCDose3. In practice, many applicants and licensees have adapted and expanded the primarily quality assurance-related guidance in NUREG-0917, depending on their own internal QA practices and procedures and meteorological monitoring program.

The JFD portion of the XOQDOQ input file, whether generated by importing a suitable file (MS Excel or the NRC staff's MetQA application) must follow the formatting requirements specified in the user's guidance for the XOQDOQ dispersion model (i.e., NUREG/CR-2919) (see Card Type 6 of that guidance). JFD formatting is structured, as follows, into an array by wind direction, wind speed range, and by one of seven atmospheric stability classes ranging, in sequence, from extremely unstable (Class A) thru extremely stable (Class G).

Each line of the array has sixteen (16) entries corresponding to the 16 standard wind direction sectors (i.e., N, NNE, NE, etc. proceeding clockwise thru the NNW sector). Each of the 16 values on this line represents the frequency of occurrence for a designated wind speed range and stability class and is entered either as the number of hours or percent frequency of occurrence (which is a user selectable option elsewhere in the model input file) relative to the total hours in the meteorological data set. The data set used to generate the JFD can consist of one year (or annual cycle) of measurements (i.e., as many as 8,760 hours if no values are missing) or be a composite of multiple years (annual cycles) of measurements.

The next line in the array represents the frequencies of occurrence for the sixteen wind direction sectors but this time corresponding to the next wind speed range and for the same stability class. The number of wind speed ranges for each stability class is user specified up to a maximum of fourteen (14). The JFD entries cycle thru the remaining number wind speed ranges for the first stability class. The same sequence is repeated for the next stability class until frequency values for all seven stability classes have been accounted.

In the attached file, the JFD entries begin on the fifth line (the first four lines are generated by the MetQA program); frequency values appear on 91 lines. So, based on the description above, the JFD in this case represents 13 wind speed groups for each of the seven stability classes. Accounting, then, for all 16 wind direction sectors, 1,456 frequency entries would need to be made for a new JFD as part of the input data required for an XOQDOQ run under the NRCDose3.

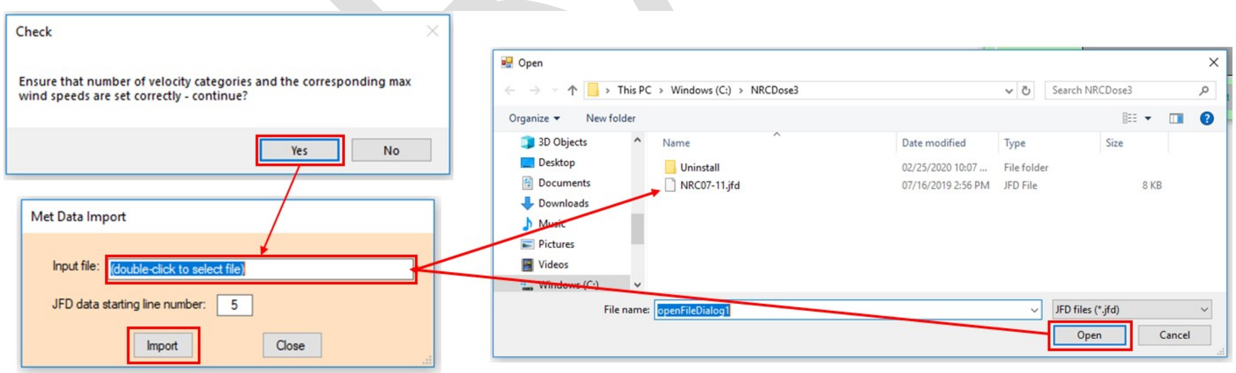


Figure 5-14 Importing JFD Information

Selecting the "Clear" button on Figure 5-12 opens the Clear Grid JFDs Screen as 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.

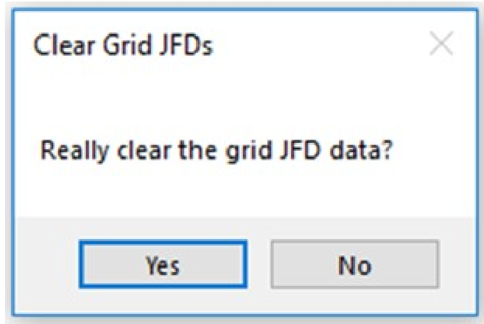


Figure 5-15 Clear Grid JFDs Screen

5.3 Code Execution and Reporting

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

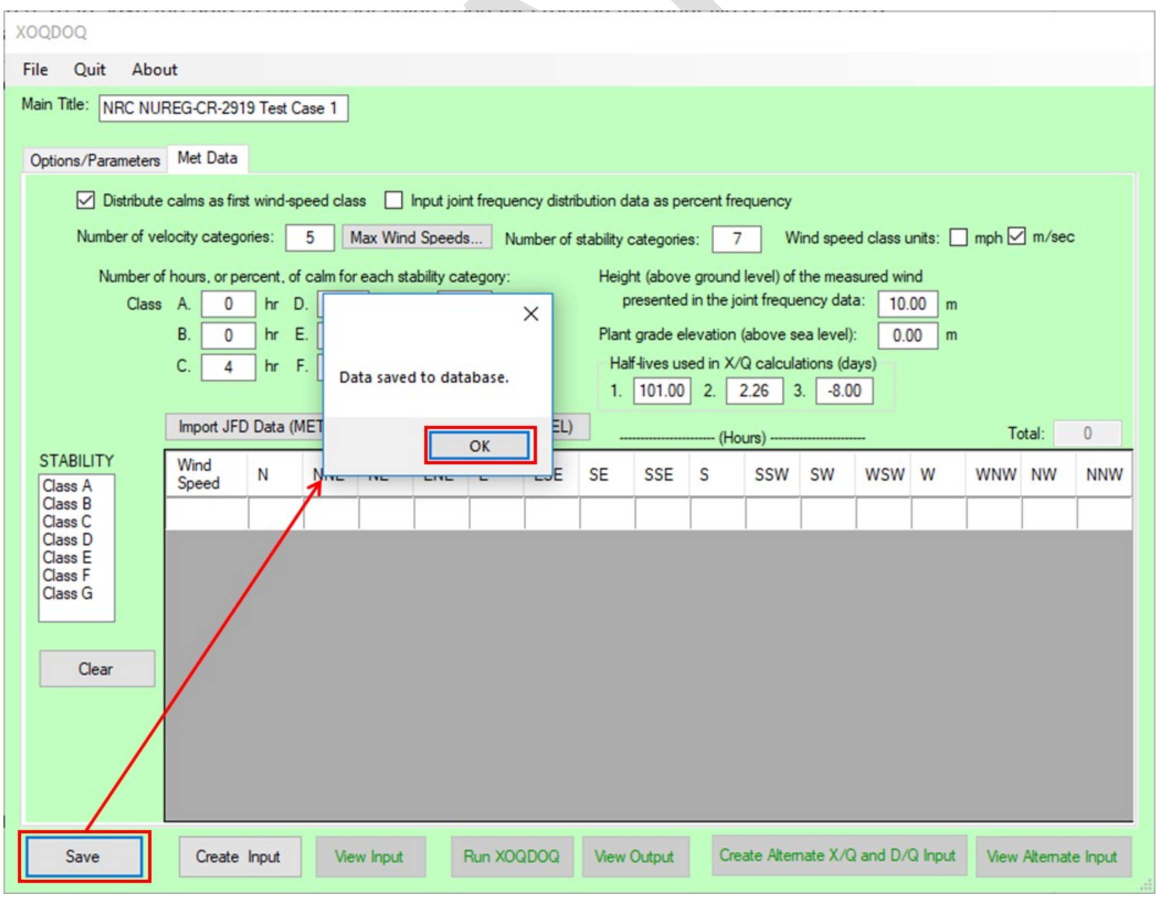


Figure 5-16 Saving XOQDOQ Inputs

If the data is to be saved to different "*.XN3" database file, then select the "Save to XN3 File…" as shown in Figure 5-3. The File Tool dropdown menu option (Figure 5-3) is used to open a Windows Explorer directory as shown in Figure 5-17. At this point, name the *.XN3" file and directory location as desired. Future saves will save to this new file name, as well as the database used for the code execution.

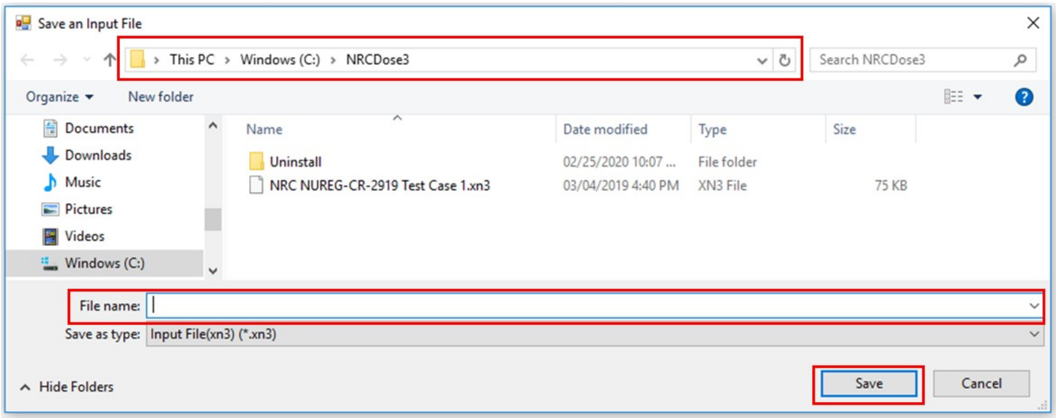


Figure 5-17 Windows Explorer directory for saving XOQDOQ inputs to a new file

**** User Note ** —** If running XOQDOQ from an open or saved file, then selecting "Save" will save to both the dataset used for creating the input as well as the file name. Otherwise, "Save" will only save to the dataset for the input file, as no file name has been previously identified.

Selecting the "Create Input" button will open the XOQDOQ Check Screen as shown in Figure 5-18, select the "Yes" button to continue. Additionally, selecting the "Create Input" button will also activate the "View Input" and the "Run XOQDOQ" buttons on the XOQDOQ Module Main Screen as shown in Figure 5-19. Select the "View Input" button to display and review text file data input as shown in Figure 5-20. The "Save As.." button as shown in Figure 5-20 opens a Windows Explorer directory and allows the user to save the input as an input field file ("*.dt3"). The "Print" button prints the input text file and the "Close" button closes the Text Viewer Screen as shown Figure 5-20 and returns to the XOQDOQ Module Main Screen as shown in Figure 5-19.

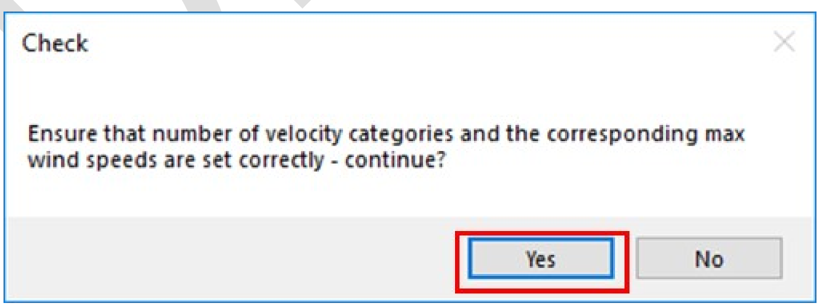


Figure 5-18 XOQDOQ Check Screen

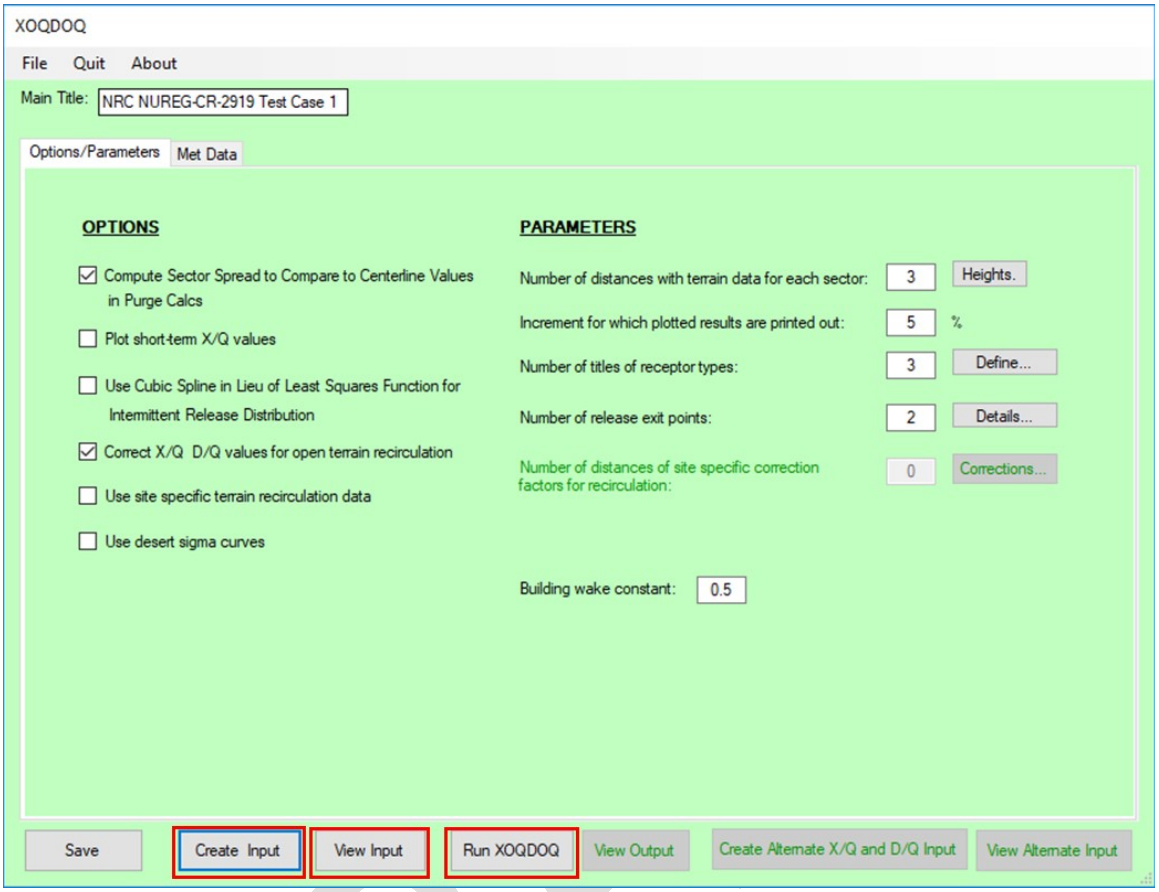


Figure 5-19 XOQDOQ Module Main Screen — Create Input

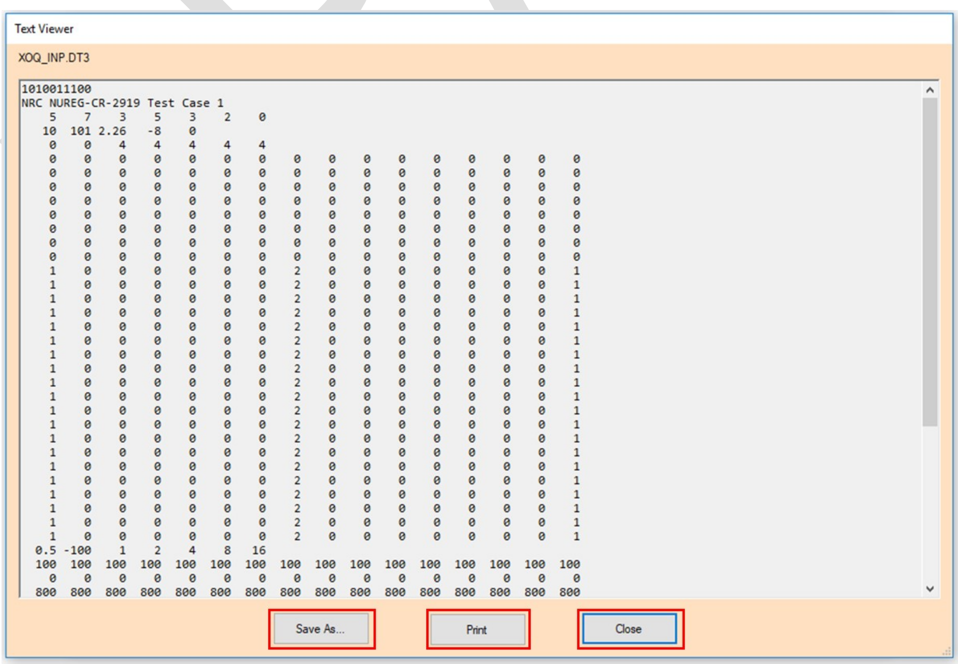


Figure 5-20 View XOQDOQ Input — Text Viewer Screen

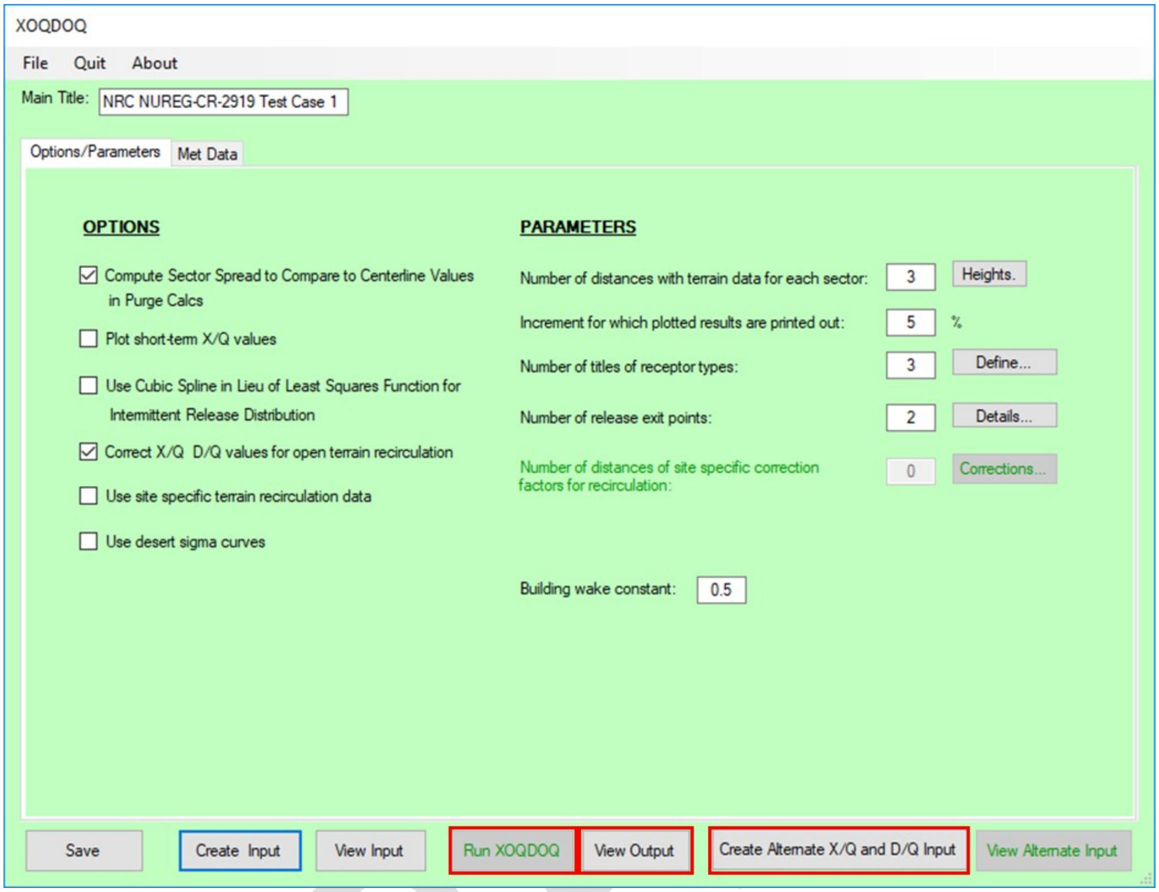


Figure 5-21 XOQDOQ Module Main Screen — Run XOQDOQ

Select the "Run XOQDOQ" button to execute the code and generate the output report. Selecting the "Run XOQDOQ" button will also activate the "View Output" and the "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. The "Save As.." button as shown in Figure 5-22 opens a Windows Explorer directory and allows the user to save the output as a text file ("*.txt"). The "Print" button prints the input text file and the "Close" button closes the Text Viewer Screen as shown Figure 5-22 and returns to the XOQDOQ Module Main Screen as shown in Figure 5-21. Users can also the access the output text file by selecting the "View Output" button.

**** User Note **** — Though not required, users should consider saving XOQDOQ files in a user-specified directory other than the NRCDose3 directory, which would facilitate future use and sharing without having to navigate to that directory.

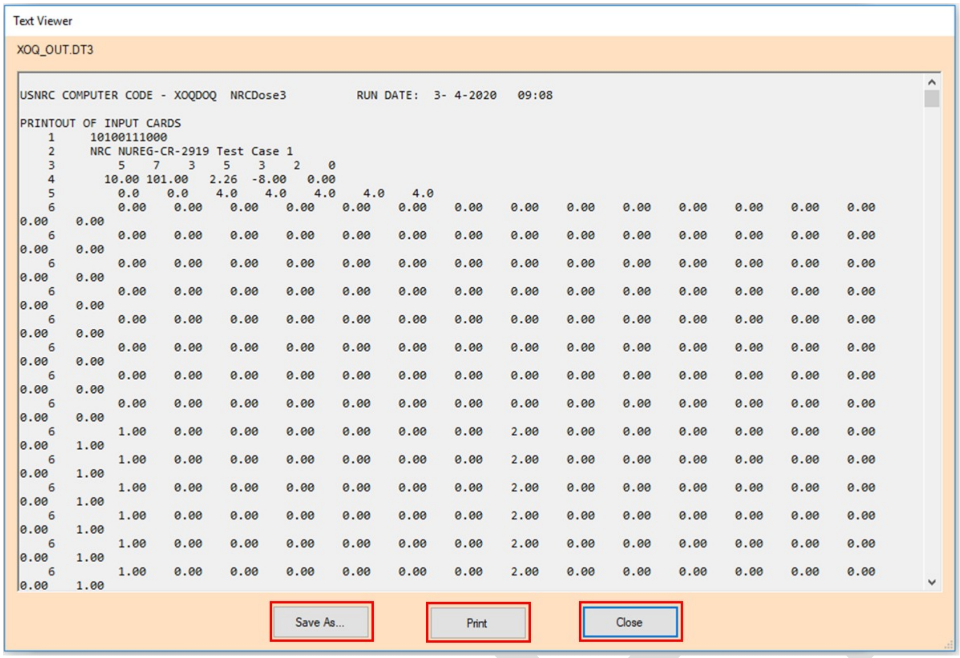


Figure 5-22 View XOQDOQ Output ─ Text Viewer Screen

Select the “Create Alternate X/Q and D/Q Input” button to create a file for use in GASPAR II. Additionally, this button can only be used if the “Number of release exit points:” is no more than one as shown in Figure 5-23. If the number of release point exits is no more than one, select the “Create Alternate X/Q and D/Q Input” button to generate the alternate meteorological (i.e., dispersion and deposition results) input text file to GASPAR. This will open the “Alt Met Input” screen as shown in Figure 5-24 and allow the user to select five or less individual records from the specific points of interest by highlighting the records. Select the “OK” button to open the alternate meteorological dispersion and deposition (GASPAR) input text file viewer as shown in Figure 5-24.

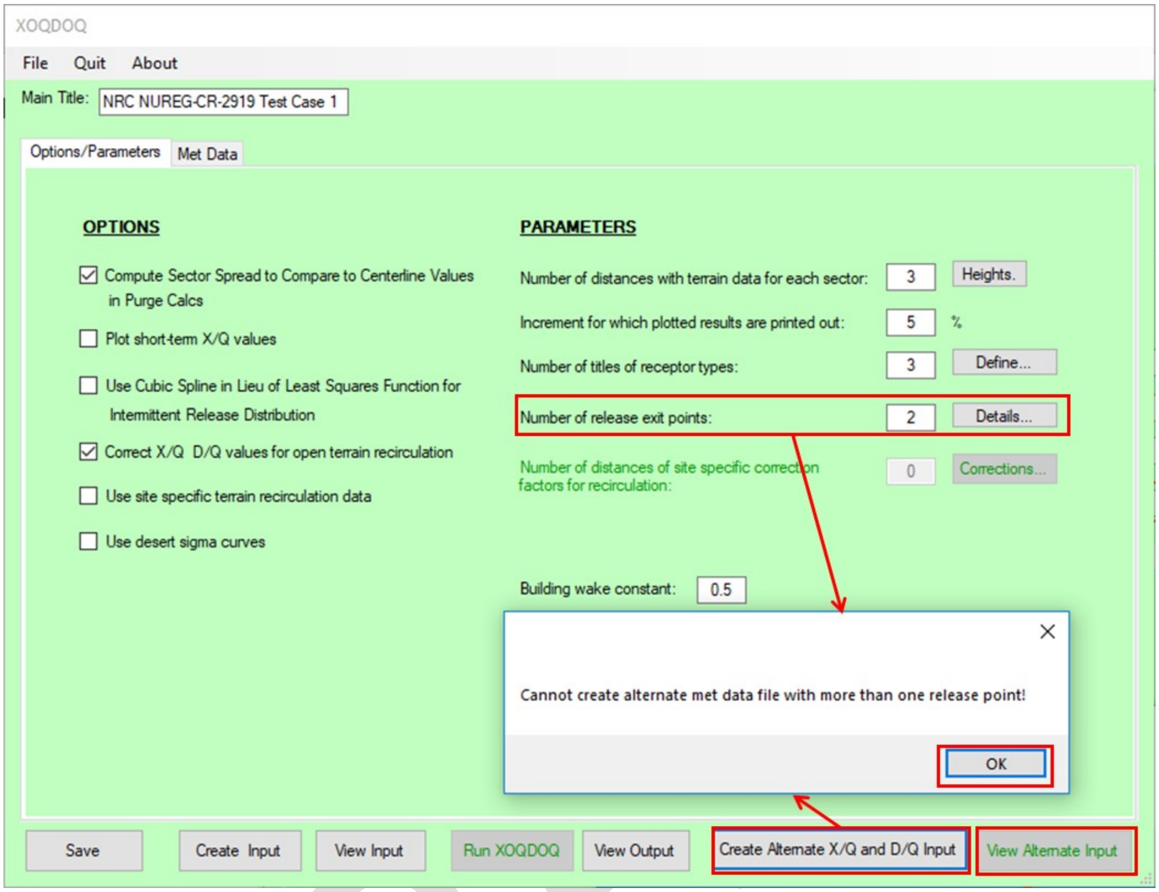


Figure 5-23 XOQDOQ Module Main Screen — Create Alternate Met Input

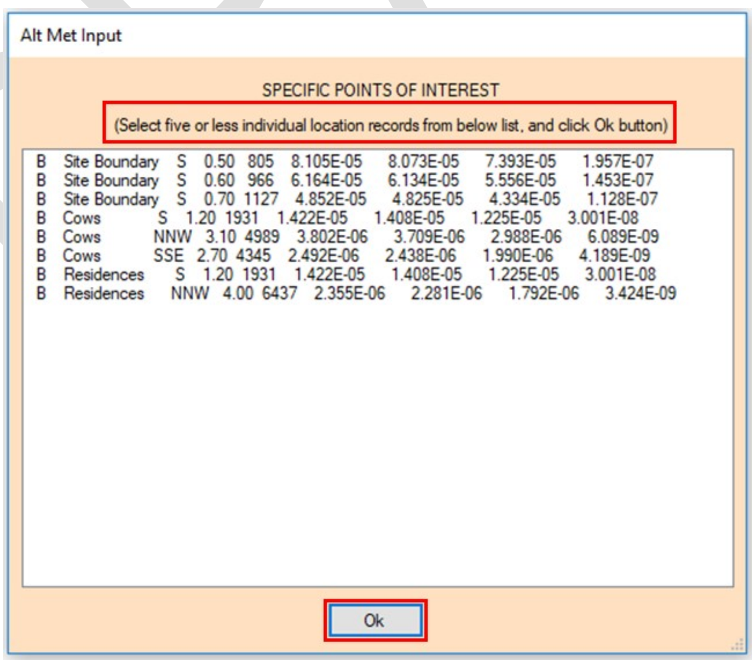


Figure 5-24 Alternate Met Input Screen

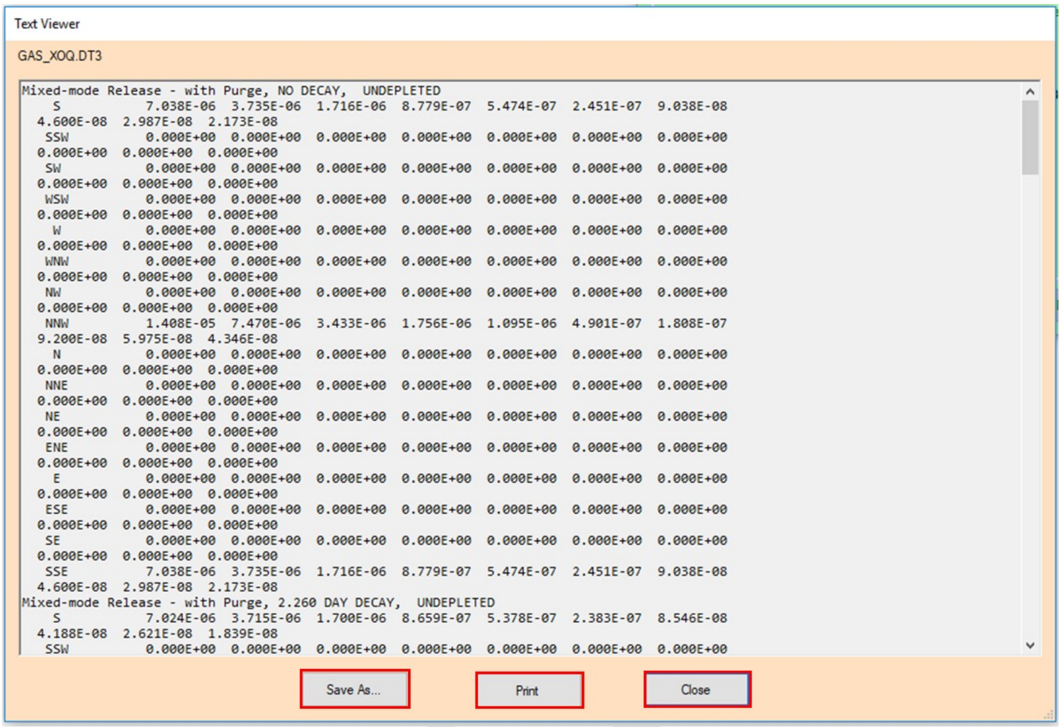


Figure 5-25 View Alternate Meteorological Input ─ Text Viewer Screen

The "Save As.." button as shown in Figure 5-25 opens a Windows Explorer directory and allows the user to save the output in a text file format suitable for use by XOQDOQ as an alt met data input file ("*.dt3"). The "Print" button prints the input text file and the "Close" button closes the Text Viewer Screen as shown in Figure 5-25 and returns to the XOQDOQ Module Main Screen as shown in Figure 5-21. Users can also the access the output text file by selecting the "View Alternate Input" button.

6.0 SIGNIFICANT REVISIONS CONTAINED 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 DCF library included DCF values for 170 radionuclides, 4 age groups, and 7 organs. These DCF values were all based on the ICRP-2 methodology but came from various sources. Primarily, the DCF values were taken from RG 1.109 with many of the radionuclide DCF values using updated values from NUREG-0172, “Age-Specific Radiation Dose Commitment Factors for a one-year Chronic Year” [Ref. 27]. Some of the DCF values for strontium-90, holmium-166m, lead-210, thorium-229 and thorium-232 were updated with the information contained in NUREG-0172 Errata, “Battelle Memorandum, Changes and Correction for NUREG-0172” [Ref. 28]. Additionally, other DCF values, notably some transuranic organ DCF values (i.e., bone and liver), were taken from Report Number EMP-155, “Review and Expansion of USNRC Regulatory Guide 1.109 Models for Computing Dose Conversion Factors” [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. The NRCDose3 code will also calculates external skin exposure from water submersion; whereas the original LADTAP II code’s DCF libraries did not contain values for this calculation. In addition, the NRCDose3 code allows the user to select updated DCF values for dose calculations, notably those based on ICRP 30 or ICRP 72 methodologies. A total of 203 radionuclide DCF values are included in NRCDose3, which accounts for all radionuclides contained in any of 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. The ICRP-30 DCF values are used for occupational exposures, and are only applicable to adults, so NRCDose3 only calculates adult doses if ICRP-30 DCF values are selected.

For some ingestion radionuclides, and nearly all inhalation radionuclides, multiple sets of DCF values are available. For ingestion, there are different DCF values depending on the assumed f1 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 to select which form and corresponding DCF to be used for each radionuclide, or the user can simply use the default form. To determine the default chemical form, the radionuclides are generally assumed to be an oxide form. Contamination in NPP reactor coolant systems, the source for most power plant effluent releases, is commonly found in the oxide form. Nuclear fuel is also in an oxide form, and corrosion products that have been activated in the core are incorporated in extra-core oxides. Therefore, all elements were assumed to be oxides. EPA Federal Guidance Report No. 11 (FGR 11) [Ref. 30], Table 3, “Gastrointestinal Absorption Fractions (f1) and Lung Clearance Classes for Chemical Compounds,” 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), and that form has been identified as the default class in ICRP 30.

There were also changes 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. Krypton-89 and xenon-137 DCF values are not included in FGR 12, so the total body and skin factors were obtained from Department of Energy (DOE) Publication DE88-014691 [Ref. 31].

The gamma air and beta air DCF values have not been changed from the RG 1.109-based values contained in the original release of LADTAP II and GASPAR II.

FGR 12 was used for the external exposure DCF values 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 ICRP-26 based external DCF values

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. The ICRP-72 DCF values include 6 age groups (i.e., Newborn, 1 yr, 5 yr, 10 yr, 15 yr, and Adult), which are all calculated by the NRCDose3 code when ICRP-72 DCF values are selected.

Similar to ICRP-30 DCF values, for some ingestion radionuclides and nearly all inhalation radionuclides multiple sets of DCF values are available. For ingestion, there are different DCF values depending on the assumed f1 value. For inhalation there are DCF values corresponding to Fast (F), Medium (M) or Slow (S) inhalation classes, plus a vapor form (V) in some instances. The NRCDose3 code allows the user to select which form of each radionuclide to be used, or the user can simply use the default form. The way the default form of each radionuclide was determined is described in Section 6.1, but with 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 form of HTO and CO_2 were selected, respectively.

There were also changes to the external DCF values used when ICRP 72 is selected in NRCDose3. For air submersion the total body and skin DCF values are taken from FGR 12 for the applicable noble gases. Krypton-89 and xenon-137 DCF values are not included in FGR 12, so the skin factors were obtained from DOE Publication DE88-014691. 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 [Ref. 32]. The gamma air and beta air DCF values have not been changed from the RG 1.109-based values contained in the original release of LADTAP II and GASPAR II.

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

Table 6-2 Radionuclides with included progeny for ICRP-60 based external DCF values

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

Biota dose calculations have been added to GASPAR in NRCDose3. Biota dose calculations are performed for every defined special location in GASPAR. The species selected are those that were calculated by previous versions of LADTAP II and NRCDose (version 2.3.20), excluding algae and adding cow and fox as additional, surrogate land-based herbivore and carnivore, respectively.

Pathways of exposure assumed include plume (submersion noble gases), groundplane, inhalation, and ingestion (plants for herbivores and meat assumed equivalent to cow meat concentrations for carnivore). Since the exposures are only for the 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 modeled in equations (C-5), (C-8) for C-14, and (C-9) for H-3 and equation (C-12) for resulting concentration in (cow) meat. Equations (7-1), (7-2), and (7-3) below present the modeling for integration of the plant and meat concentrations into the resulting calculation of the biota dose. Table 6-3 lists the parameters used to calculate the biota dose in GASPAR in NRCDose3.

Table 6-3 Biota dose parameters for the GASPAR code 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)	N/A	N/A	Plants	N/A
Fox (carnivore)[a]	5,700	10	Meat	520
User Defined	N/A	N/A	N/A	N/A

** **User Note** ** **—** The code can only address a single food type, either plant or meat. While it is recognized that a racoon is an omnivore, the default modeling assumes a plant-based diet for the racoon, which is consistent with that assumed in LADTAP and modeling in BNWL-1754. Modeling as a carnivore may be performed by using the "Add Biota Type" function with appropriate inputs on consumption.

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

The internal dose is the adult man inhalation dose added to an ingestion dose component. This food consumption internal dose component is dependent on the food type. The GASPAR II and LADTAP II Fortran codes in NRCDose3 employ the same modeling in BNWL-1754. Similar to LADTAP where environmental transfer factors (bioaccumulation factors) are used for fish, invertebrates and algae, in GASPAR there are transfer factors for vegetation and meat. The GASPAR modeling is based on defining a species as herbivore or carnivore. Due to only having meat transfer factors, for any carnivore, it is assumed that the meat concentration (as eaten by a carnivore) is the same as what it would be for a cow.

** **User Note** ** **—** A user could perform species-specific modeling by modifying the exposure and uptake assumptions and transfer factors that are unique for the species (e.g., transfer factors for chickens).

The ingestion dose to the muskrat, raccoon or duck is determined using Equation (7-1):

$$Dose\ \left(\frac{rad}{yr}\right) = Veg.Conc.\times \frac{Consumption\ Rate_{Species}}{Mass_{Species}} \times 70 \times \frac{EFF_{Species}}{EFF_{Adult}} \times DCF_i \qquad (7\text{-}1)$$

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 species (kg/yr);
$Mass_{Species}$	=	the mass of species (kg):
70	=	constant for the assumed mass of an adult as used for derivation of the ICRP-2 DCFs (kg);
$EFF_{Species}$	=	the energy for the identified effective species radius (MeV);
EFF_{Adult}	=	the energy for the effective radius for an adult (MeV);
DCF_i	=	the total body ingestion DCF for an adult for radionuclide *i* (mrem/pCi)

GASPAR calculates radionuclide concentrations in cow meat, so the effective radius dose coefficients are used directly to calculate the cow internal dose component via the ingestion pathway using Equation (7-2):

$$Dose\ \left(\frac{rad}{yr}\right) = 0.0187 \times Meat\ Conc.\times EFF_i \qquad (7\text{-}2)$$

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

The ingestion dose to the fox is determined using Equation (7-3):

$$Dose\ \left(\frac{rad}{yr}\right) = Meat\ Conc.\times \frac{Consumption\ Rate_{Fox}}{Mass_{Fox}} \times 70 \times \frac{EFF_{Fox}}{EFF_{Adult}} \times DCF_i \qquad (7\text{-}3)$$

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	=	constant for the assumed mass of an adult (kg);
EFF_{Fox}	=	the energy for the identified effective fox radius (MeV);
EFF_{Adult}	=	the energy for the effective radius for an adult (MeV);
DCF_i	=	the total body ingestion DCF for an adult for radionuclide *i* (mrem/pCi)

GASPAR performs the calculations for the vegetable and meat concentrations in the PARTS subroutine. The specific modeling of produce and meat concentrations for carbon-14 is performed in the CARBON subroutine, and hydrogen-3 (tritium) in the TRITIUM subroutine.

The inhalation dose to all biota is approximated as equal to the adult inhalation (total body) dose at the specific location. The groundplane dose to biota is approximated as equal to adult groundplane dose with a correction for eliminating the assumed 0.7 shielding factor and adding a factor of 2 multiplier to provide conservatism accounting for biota potentially being in closer proximity to the ground.

7.0 REFERENCES

1. **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,” U.S. Nuclear Regulatory Commission, Washington, DC, October 1977. Available at ADAMS Accession No. ML003740384.

2. **RG 1.111**, **Revision 1**, “Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors,” U.S. Nuclear Regulatory Commission, Washington, DC, July 1977. Available at ADAMS Accession No. ML003740354.

3. **RG 1.113**, **Revision 1**, “Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I,” U.S. Nuclear Regulatory Commission, Washington, DC, April 1977. Available at ADAMS Accession No. ML003740390.

4. **RG 4.2**, **Revision 3**, “Preparation of Environmental Reports for Nuclear Power Stations,” U.S. Nuclear Regulatory Commission, Washington, DC, September 2018. Available at ADAMS Accession No. ML18071A400.

5. **NUREG-1555**, **Revision 1**, “Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan,” U.S. Nuclear Regulatory Commission, Washington, DC, July 2007. Available at ADAMS Accession No. ML071860393.

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APPENDIX A: RADIONUCLIDES IN REACTOR EFFLUENTS IN NRCDOSE3

The radionuclides that are contained in NRCDose3 have been expanded over those that were available in the original versions of LADTAP II, GASPAR II, and XOQDOQ Fortran codes. The radionuclides and DCF values in the original versions of the codes are largely those found in RG 1.109, Revision 1 [Ref. 1], but not in all cases. An evaluation was performed to determine the source of the DCF values contained in the original version of the codes, by comparing the radionuclides and DCF values in the LADTAP.lib file with those contained in the following ICRP-2 [Ref. 2] based sources:

- RG 1.109, Revision 1
- NUREG-0172 (and Errata) [Ref. 3]
- NUREG/CR-2384 [Ref. 4]
- EMP-155 [Ref. 5]

The following table provides a listing of which radionuclides and DCF values are included in the identified source document. Highlighted entries indicate radionuclides that are not contained in the original LADTAP.LIB as used in NRCDose3 (v2.3.20).

Table A-1 NRCDose3 radionuclides, DCF values, and reference documents

	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		

Notes:

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

	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
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		
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		

Notes:

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

	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
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
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.
All 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.)

	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		
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		

Notes:

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

	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
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
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		

Notes:

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

	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
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		
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		

Notes:

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

	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
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		
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

Notes:

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

	LADTAP II Library	RG 1.109	NUREG-0172	NUREG/CR-2384	EMP-155
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		
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.
All 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.

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

This list of 203 radionuclides is the same radionuclides that are available when ICRP-30 or ICRP-72 DCF values are selected in NRCDose3.

A.1 References

1. **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,” U.S. Nuclear Regulatory Commission, Washington, DC, October 1977. Available at ADAMS Accession No. ML003740384.

2. **ICRP Report No. 2**, "Report of Committee II on Permissible Dose for Internal Radiation," ICRP 2, Pergamon Press, London 1960.

3. **NUREG-0172**, “Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake,” U.S. Nuclear Regulatory Commission, Washington, DC, November 1977. Available at ADAMS Accession No. ML14083A242.

4. **NUREG/CR-2384**, “Age-Specific Inhalation Radiation Dose Commitment Factors for Selected Radionuclides,” U.S. Nuclear Regulatory Commission, Washington, DC, August 1982. Available at ADAMS Accession No. ML17200D138.

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

APPENDIX B: USER-MODIFIABLE PARAMETERS

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 each of the code's parameters, as needed. All parameters that are used in XOQDOQ, LADTAP II, and GASPAR II Fortran codes have been identified, including all radiological and non-radiological 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 the ability to modify input card parameters via the existing NRCDose code (version 2.3.20) was confirmed. The LADTAP II, GASPAR II, and XOQDOQ Fortran code modifiable parameters are identified in Tables B-1 through B-3. Additionally, the LADTAP II, GASPAR II, and XOQDOQ Fortran codes were reviewed to identify additional variables and parameters that were hardwired into the Fortran code. The LADTAP II, GASPAR II, and XOQDOQ Fortran code hardwired parameters are identified in Tables B-4 through B-6.

Table B-1 LADTAP II Modifiable Parameters

Name	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, QSUBP	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
Population Fraction	Fraction of population child	PERC	Selections -> Modify defaults -> Edit
Release Nuclide	Nuclide released	IA	Selections -> Source Term -> Add Nuclide
Release Nuclide	Nuclide released	IM	Selections -> Source Term -> Add Nuclide
Release Rate	Annual Release (Ci/yr)	QQ	Selections -> Source Term -> Add Nuclide
Reconcentration Factor	Radionuclide reconcentration factor	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

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

Name	Description	LADTAP II Notation	Where Adjusted in NRCDose3
Dilution Factor	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.
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/sec)	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
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

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

Name	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
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.)

Name	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

Table B-2 GASPAR II Modifiable Parameters

Name	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	Absolute humidity over growing season (g/m^3)	H	Options -> "Average absolute 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"
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

Table B 2 GASPAR II Modifiable Parameters (cont.)

Name	Description	GASPAR II Notation	Where Adjusted in NRCDose3
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
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 multi-unit 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 if last MET data can be reused.	JC(1)	**Note:** Not used in NRCDose3. NRCDose3 limited to a single source term.
New release data	Determines if last release data can be reused.	JC(2)	**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	IA	Source Term -> Add Nuclide
Release Nuclide	Nuclide released	IM	Source Term -> Add Nuclide
Annual Release	Annual Release (Ci)	QQ, Q(33)	Source Term -> Add Nuclide
Release Point - Undecayed, undepleted X/Q	Title for data source, date, height, release point, etc.		Pop/Prod Data -> Meteorological -> Title
Annual Average X/Q	X/Q at each downwind sector and annular distance	XQ(160)	Pop/Prod Data -> Meteorological -> Undecayed, Undepleted -> Data Entry

Table B 2 GASPAR II Modifiable Parameters (cont.)

Name	Description	GASPAR II Notation	Where Adjusted in NRCDose3
Release Point - Decayed, undepleted X/Q	Title for data source, date, height, release point, etc.		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
Release Point - Deposition D/Q	Title for data source, date, height, release point, etc.		Pop/Prod Data -> Meteorological -> Decayed, Depleted ->Title
Deposition D/Q	Deposition factor (D/Q) at each downwind sector and annular distance	DEP	Pop/Prod Data -> Meteorological -> Decayed, Depleted -> Data Entry
Special Location Data	Determines if detailed pathway reports are printed	JS(n)	Special Location Data -> Add. "Don't print any detailed reports"
Special Location Name		Name	Special Location Data -> Add. "Name of Location"
Special Location Downwind Direction Sector		(DIR)	Special Location Data -> Add. "Downwind direction from site"
Special Location Distance		DIST	Special Location Data -> Add. "Distance from Site (m)"
Special Location 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

Table B-3 XOQDOQ Modifiable Parameters

Name	Description	XOQDOQ Notation	Where Adjusted in NRCDose
Options	Distribute calms as first wind speed class	KOPT(1)	Met Data tab
Options	Input joint frequency as percent frequency	KOPT(2)	Met Data tab -> Input joint frequency distribution data as percent frequency
Options	Compute sector spread	KOPT(3)	Options/Parameters tab, Options
Options	Plot short term X/Q values	KOPT(4)	Options/Parameters tab, Options
Options	Use cubic spline	KOPT(5)	Options/Parameters tab, Options
Options	Punch radial segment X/Q	KOPT(6)	Not included on screen. Not adjustable in NRCDose3.
Options	Punch output X/Q at point of interest	KOPT(7)	Not included on screen. Not adjustable in NRCDose3.
Options	Correct value for open terrain	KOPT(8)	Options/Parameters tab, Options
Options	Site specific terrain recirculation data	KOPT(9)	Options/Parameters tab, Options
Options	Desert sigma curves	KOPT(10)	Options/Parameters tab, Options
Options	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.
Parameters	Number of velocity categories	NVEL	Met Data tab
Parameters	Number of stability categories	NSTA	Met Data tab
Parameters	Wind speed class units (mph or m/s)	-	Met Data tab
Parameters	Number of distances with terrain data for each downwind sector	NDIS	Options/Parameters tab, Parameters
Parameters	Increment for which plotted results are printed out (in percent)	INC	Options/Parameters tab, Parameters
Parameters	Number of titles of receptor types	NPTYPE	Options/Parameters tab, Parameters
Parameters	Number of release exit points	NEXIT	Options/Parameters tab, Parameters
Parameters	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 wind speed 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	FREQ	Met Data tab, select stability class, enter the frequencies of occurrence for each wind direction sector (i.e., direction

Name	Description	XOQDOQ Notation	Where Adjusted in NRCDose
	class and wind speed category		from relative to True North) and wind speed category

Table B-3 XOQDOQ Modifiable Parameters (cont.)

Name	Description	XOQDOQ Notation	Where Adjusted in NRCDose
Maximum Wind Speeds	Maximum speed in each wind speed class (mph or m/s)	UMAX	Met Data tab -> Max Wind Speeds
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
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

Table B-3 XOQDOQ Modifiable Parameters (cont.)

Name	Description	XOQDOQ Notation	Where Adjusted in NRCDose
Release Points	Minimum cross section area for vent/stack building (m2)	CRSEC	Options/Parameters tab, Parameters -> Number of release exit points -> Details, select Release Point -> Edit
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/sec)	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/m2)	LADTAP.LIB file	Values provided in separate file for each radionuclide, age range and organ	
Q1	Milk animals pasture grass consumption rate (kg/d)	BLOC 44	50.0	
Q2	Milk Animals water consumption rate	BLOC 44	60.0	
Q3	Beef animals pasture grass consumption rate (kg/d)	BLOC 44	50.0	
Q4	Beef animals 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 mile (m2)	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	US 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		
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

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

Name	Description	Location in Fortran Code	Value	Units	RG 1.109 Notation
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 pop.	BLKDATA10	1.21E+06	sec	t_h and t_p
TIM(4)	Holdup and transport time: veg. 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
TIM(6)	Holdup and transport time: leafy veg. 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		
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 wind speed 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 differ depending on the DCF values used to perform the dose calculations, regardless if the dose calculation is for a maximum or average individual, or it is for a population or individual dose calculation. The default usage and consumption values assumed when ICRP-2 [Ref. 1] or ICRP-30 [Ref. 2] DCF values are used are those from RG 1.109, Revision 1 [Ref. 3]. Tables C-1 and C-2 display the usage and consumption parameter values for 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	N/A	260	260	370	RG 1.109, Table E-4
Inhalation	m^3/yr	N/A	3700	8000	8000	RG 1.109, Table E-4
Fruit/Vegetables/Grain	kg/yr	N/A	200	240	190	RG 1.109, Table E-4
Leafy Vegetables	kg/yr	N/A	10	20	30	Original LADTAP II code
Milk	L/yr	N/A	170	200	110	RG 1.109, Table E-4
Meat	kg/yr	N/A	37	59	95	RG 1.109, Table E-4
Fish	kg/yr	N/A	2.2	5.2	6.9	RG 1.109, Table E-4
Other Seafood	kg/yr	N/A	0.33	0.75	1.0	RG 1.109, Table E-4
Shoreline	hr/yr	N/A	N/A	N/A	N/A	N/A
Swimming	hr/yr	N/A	N/A	N/A	N/A	N/A

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	RG 1.109, Table E-5
Shoreline	hr/yr	0	14	67	12	RG 1.109, Table E-5
Swimming	hr/yr	N/A	N/A	N/A	N/A	N/A

C.2 ICRP-72 Usage and Consumption Factors

Those assumed usage and consumption values for the ICRP-60/72 [Refs. 4 and 5] DCF values were derived from EPA EFH [Ref. 6] (https://www.epa.gov/expobox/about-exposure-factors-handbook). Regardless of the calculation being performed, the usage and consumption parameter values may be adjusted to account for any site-specific behaviors. Tables C-3 and C-4 display the usage and consumption parameter values for ICRP-60/72 DCF values.

** **User Note** ** — Use of ICRP-72 usage and consumption values by an applicant or licensee for a proposed NRC LAR should be discussed with the NRC staff prior to submitting the license 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	203	130	139	187	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	18	22	29	35	47
Fish	kg/yr	3	6	7	9	11	18
Other Seafood	kg/yr	1	2	2	2	3	4
Shoreline	hr/yr	10	20	25	26	23	23
Swimming	hr/yr	19	23	27	30	28	29

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	3358	5001	5037	6059	7994	8979
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	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 Report No. 2**, "Report of Committee II on Permissible Dose for Internal Radiation," ICRP 2, Pergamon Press, London 1960.

2. **ICRP Report No. 30**, "Limits for Intakes of Radionuclides by Workers," ICRP 30, Annals of the ICRP Vol. 2, Nos. 3/4, 1979.

3. **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," U.S. Nuclear Regulatory Commission, Washington, DC, October 1977. Available at ADAMS Accession No. ML003740384.

4. **ICRP Report No. 60,** "1990 Recommendations of the International Commission on Radiological Protection," ICRP 60, Annals of the ICRP Vol. 21, No.1-3, 1991.

5. **ICRP Report No. 72**, "Age-Dependent Dose to Members of the Public from Intake of Radionuclides, Part 5. Compilation of Ingestion and Inhalation Dose Coefficients," ICRP 72, Annals of the ICRP Vol. 21, No.1-3, 1996.

6. **EPA/600/R-090/052F**, "Exposure Factors Handbook: 2011 Edition," EFH, U.S. Environmental Protection Agency, Washington, DC. September 2011.

APPENDIX D: EFFECTIVE RADIUS

D.1 Absorbed Energy in Spheres of Various Sizes

The energy absorbed within unit density spheres (considered muscle) due to nuclear transformation (decay) of an incorporated radionuclide are used in computing the dose to aquatic and terrestrial biota within the LADTAP II and GASPAR II Fortran codes in NRCDose3. Presently these software packages address a limited number of radionuclides with the absorbed energy based on information of the energies and intensities of the emitted radiations and the absorbed fraction of the photon emissions derived using dated analytical methods. In this work, we update the numerical data by using the nuclear decay data of ICRP Report No. 107 (ICRP-107) [Ref. 1] and photon absorbed fraction data of Reference 2 to tabulate the absorbed energy within eight-unit density spheres ranging in radius from 1.0 to 30 cm for 203 radionuclides of interest.

The absorbed energy $E_{abs}$is computed using Equation (D-1):

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

where: $\sum_r$ = the outer summation addresses the various radiation types *r*;
$\sum_i^{N_r}$ = the inner summation extends over 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 Mega-electron volts (MeV); and
$AF_{r,i}$ = the absorbed fraction in the sphere (unit less).

The $AF_{r,i}$ for all radiations other than photons and photons of energy less than 10 kilo-electron volts (keV) is assumed to be 1. For photons of energy greater than 10 keV, the absorbed fraction is based on Reference 2. For photons of energy greater than 10 kev, the absorbed fractions are based on Stable and Konijnenber (Ref. 2). For spheres of 15 and 30 cm radius Monte Carlo calculations were undertaken using MCNP (Ref. 3). The unit of the resultant quantity is MeV/Bq s. No relative biological effectiveness factors have been employed in the computations. The diameter, in centimeters (cm), and the mass, in kilograms (kg), of the eight spheres is given in Table D-1 and the resultant absorbed energies for the 203 radionuclides are contained in Table D-2.

Table D-1 Diameter and mass of the 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
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

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
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
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

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
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
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

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
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
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

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
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
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

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
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
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

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
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
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 Report No. 107,** "Nuclear Decay Data for Dosimetric Calculations," ICRP 107, Annals of the ICRP Vol. 38, No.3, 2008.

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

3. MCNP, 2017. MCNP User's Manual – Code Version 6.2, Ed. C. J. Werner, Los Alamos National Laboratory.

APPENDIX E: ASSUMED F1 VALUES AND INHALATION CLASS

NRCDose3 contains 203 radionuclides which can be assumed to exist in one of multiple ingestion and inhalation forms. The following information outlines the ingestion and inhalation forms that are available for selection in NRCDose3.

E.1 NRCDose3 – ICRP-30 Dosimetric Methodology

Table E-1 outlines the f1 values and the ingestion and inhalation classes that are available for selection in NRCDose3, when the ICRP-30 [Ref. 1] methodology has been selected. The default form is noted, for both ingestion and inhalation.

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	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 sulfides 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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
Sc-46	0.0001	X	All forms	0.0001	X	Y	All forms
Cr-51	0.1		Hexavalent State	0.1		D	All others
	0.01	X	Trivalent state	0.1		W	Halides and nitrates
				0.1	X	Y	Oxides and hydroxides
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
Fe-59	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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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
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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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
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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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
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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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 $Sn_3(PO_4)_4$
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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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
Te-132	0.2	X	All forms	0.2		D	All others
				0.2	X	W	Oxides, hydroxides and nitrates

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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		X	All forms		X		
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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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
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	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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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				
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		X			X		
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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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
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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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
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

Table E-1 NRCDose3 – ICRP-30 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion			Inhalation			
	f1	Default	Form	f1	Default	Class	Form
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

E.2 NRCDose3 – ICRP-72 Dosimetric Methodology

Table E-2 outlines the f1 values and the ingestion and inhalation classes that are available for selection in NRCDose3, when the ICRP-72 [Ref. 2] methodology has been selected. The default form is noted, for both ingestion and inhalation.

Table E-2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
H-3	1 OBT 1	 X	1 OBT 1 HT 1 CH_3T 1 HTO 1 0.2 0.02	X	V V V V F M S
Be-10	0.02	X	0.02 0.02	 X	M S
C-14	1	X	1 CO_2 1 CO 1 CH_4 1 1 0.2 0.02	X	V V V V F M S
N-13		X		X	
F-18	1	X	1 1 1	X	F M S
Na-22	1	X	1	X	F
Na-24	1	X	1	X	F
P-32	1	X	1 1	X	F M
S-35	1 1	 X	1 SO_2 1 CS_2 1 0.2 0.02	Y	V V F M S
Cl-36	1	X	1 1	 X	F M
Ar-39		X		X	
Ar-41		X		X	
Ca-41	0.6	X	0.6 0.2 0.02	X	F M S
Ca-45	0.6	X	0.6 0.2 0.02	X	F M S
Sc-46	0.001	X	0.001	X	S
Cr-51	0.2 0.02	 X	0.2 0.2 0.2	 X	F M S
Mn-54	0.2	X	0.2 0.2	 X	F M
Mn-56	0.2	X	0.2 0.2	 X	F M
Fe-55	0.6	X	0.6 0.2 0.02	X	F M S

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
Fe-59	0.6	X	0.6 0.2 0.02	 X 	F M S
Co-57	0.6	X	0.6 0.2 0.02	 X	F M S
Co-58	0.6	X	0.6 0.2 0.02	 X	F M S
Co-60	0.6	X	0.6 0.2 0.02	 X	F M S
Ni-59	0.1	X	0.1 0.1 0.1 0.02	 X 	V F M S
Ni-63	0.1	X	0.1 0.1 0.1 0.02	 X 	V F M S
Ni-65	0.1	X	0.1 0.1 0.1 0.02	 X 	V F M S
Cu-64	1	X	1 1 1	 X	F M S
Zn-65	1	X	1 0.2 0.02	 X	F M S
Zn-69	1	X	1 0.2 0.02	 X	F M S
Zn-69m	1	X	1 0.2 0.02	 X	F M S
Ga-67	0.01	X	0.01 0.01	 X	F M
Se-75	1	X	1 0.2 0.02	 X 	F M S
Se-79	1	X	1 0.2 0.02	 X 	F M S
Br-82	1	X	1 1	X 	F M
Br-83	1	X	1 1	X 	F M

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
Br-84	1	X	1 1	X	F 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	
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 0.2 0.02	X	F M S
Sr-89	0.6	X	0.6 0.2 0.02	X	F M S
Sr-90	0.6	X	0.6 0.2 0.02	X	F M S
Sr-91	0.6	X	0.6 0.2 0.02	X	F M S
Sr-92	0.6	X	0.6 0.2 0.02	X	F M S
Y-90	0.001	X	0.001 0.001	X	M S
Y-91	0.001	X	0.001 0.001	X	M S
Y-91m	0.001	X	0.001 0.001	X	M S
Y-92	0.001	X	0.001 0.001	X	M S
Y-93	0.001	X	0.001 0.001	X	M S
Zr-93	0.02	X	0.02 0.02 0.02	X	F M S
Zr-95	0.02	X	0.02 0.02 0.02	X	F M S
Zr-97	0.02	X	0.02 0.02 0.02	X	F M S

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
Nb-93m	0.02	X	0.02 0.02 0.02	 X	F M S
Nb-95	0.02	X	0.02 0.02 0.02	 X	F M S
Nb-97	0.02	X	0.02 0.02 0.02	 X	F M S
Mo-93	1	X	1 0.2 0.02	 X	F M S
Mo-99	1	X	1 0.2 0.02	 X	F M S
Tc-99	1	X	1 0.2 0.02	 X 	F M S
Tc-99m	1	X	1 0.2 0.02	 X 	F M S
Tc-101	1	X	1 0.2 0.02	 X 	F M S
Ru-103	0.1	X	0.1 0.1 0.1 0.02	 X	V F M S
Ru-105	0.1	X	0.1 0.1 0.1 0.02	 X	V F M S
Ru-106	0.1	X	0.1 0.1 0.1 0.02	 X	V F M S
Rh-105	0.1	X	0.1 0.1 0.1	 X	F M S
Pd-107	0.05	X	0.05 0.05 0.05	 X	F M S
Pd-109	0.05	X	0.05 0.05 0.05	 X	F M S
Ag-110m	0.1	X	0.1 0.1 0.02	 X	F M S

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
Ag-111	0.1	X	0.1 0.1 0.02	 X	F M S
Cd-109	0.1	X	0.1 0.1 0.1	 X	F M S
Cd-113m	0.1	X	0.1 0.1 0.1	 X	F M S
Cd-115m	0.1	X	0.1 0.1 0.1	 X	F M S
Sn-113	0.04	X	0.04 0.04	 X	F M
Sn-123	0.04	X	0.04 0.04	 X	F M
Sn-125	0.04	X	0.04 0.04	 X	F M
Sn-126	0.04	X	0.04 0.04	 X	F M
Sb-124	0.2	X	0.2 0.02 0.02	 X 	F M S
Sb-125	0.2	X	0.2 0.02 0.02	 X 	F M S
Sb-126	0.2	X	0.2 0.02 0.02	 X 	F M S
Sb-127	0.2	X	0.2 0.02 0.02	 X 	F M S
Te-125m	0.6	X	0.6 0.6 0.2 0.02	 X 	V F M S
Te-127	0.6	X	0.6 0.6 0.2 0.02	 X 	V F M S
Te-127m	0.6	X	0.6 0.6 0.2 0.02	 X 	V F M S
Te-129	0.6	X	0.6 0.6 0.2 0.02	 X 	V F M S

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
Te-129m	0.6	X	0.6 0.6 0.2 0.02	X	V F M S
Te-131	0.6	X	0.6 0.6 0.2 0.02	X	V F M S
Te-131m	0.6	X	0.6 0.6 0.2 0.02	X	V F M S
Te-132	0.6	X	0.6 0.6 0.2 0.02	X	V F M S
Te-133m	0.6	X	0.6 0.6 0.2 0.02	X	V F M S
Te-134	0.6	X	0.6 0.6 0.2 0.02	X	V F M S
I-125	1	X	1 CH_3I 1 I_2 1 0.2 0.02	X	V V F M S
I-129	1	X	1 CH_3I 1 I_2 1 0.2 0.02	X	V V F M S
I-130	1	X	1 CH_3I 1 I_2 1 0.2 0.02	X	V V F M S
I-131	1	X	1 CH_3I 1 I_2 1 0.2 0.02	X	V V F M S
I-132	1	X	1 CH_3I 1 I_2 1 0.2 0.02	X	V V F M S

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion	Inhalation

	f1	Default	f1	Default	Class
I-133	1	X	1 CH_3I 1 I_2 1 0.2 0.02	X	V V F M S
I-134	1	X	1 CH_3I 1 I_2 1 0.2 0.02	X	V V F M S
I-135	1	X	1 CH_3I 1 I_2 1 0.2 0.02	X	V V F M 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 0.2 0.02	X	F M S
Cs-134m	1	X	1 0.2 0.02	X	F M S
Cs-135	1	X	1 0.2 0.02	X	F M S
Cs-136	1	X	1 0.2 0.02	X	F M S
Cs-137	1	X	1 0.2 0.02	X	F M S
Cs-138	1	X	1 0.2 0.02	X	F M S
CS-139		X		X	
Ba-133	0.6	X	0.6 0.2 0.02	X	F M S
Ba-139	0.6	X	0.6 0.2 0.02	X	F M S

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
Ba-140	0.6	X	0.6 0.2 0.02	X 	F M S
Ba-141	0.6	X	0.6 0.2 0.02	X 	F M S
Ba-142	0.6	X	0.6 0.2 0.02	X 	F M S
La-140	0.005	X	0.005 0.005	 X	F M
La-141	0.005	X	0.005 0.005	 X	F M
La-142	0.005	X	0.005 0.005	 X	F M
Ce-141	0.005	X	0.005 0.005 0.005	 X	F M S
Ce-143	0.005	X	0.005 0.005 0.005	 X	F M S
Ce-144	0.005	X	0.005 0.005 0.005	 X	F M S
Pr-143	0.005	X	0.005 0.005	 X	M S
Pr-144	0.005	X	0.005 0.005	 X	M S
Nd-147	0.005	X	0.005 0.005	 X	M S
Pm-147	0.005	X	0.005 0.005	 X	M S
Pm-148	0.005	X	0.005 0.005	 X	M S
Pm-148m	0.005	X	0.005 0.005	 X	M S
Pm-149	0.005	X	0.005 0.005	 X	M S
Pm-151	0.005	X	0.005 0.005	 X	M 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

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
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
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

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
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
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

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
Pu-236	0.005	X	0.005 0.005 0.0001	 X	F M S
Pu-238	0.005	X	0.005 0.005 0.0001	 X	F M S
Pu-239	0.005	X	0.005 0.005 0.0001	 X	F M S
Pu-240	0.005	X	0.005 0.005 0.0001	 X	F M S
Pu-241	0.005	X	0.005 0.005 0.0001	 X	F M S
Pu-242	0.005	X	0.005 0.005 0.0001	 X	F M S
Pu-244	0.005	X	0.005 0.005 0.0001	 X	F M S
Am-241	0.005	X	0.005 0.005 0.005	 X 	F M S
Am-242m	0.005	X	0.005 0.005 0.005	 X 	F M S
Am-243	0.005	X	0.005 0.005 0.005	 X 	F M S
Cm-242	0.005	X	0.005 0.005 0.005	 X 	F M S
Cm-243	0.005	X	0.005 0.005 0.005	 X 	F M S
Cm-244	0.005	X	0.005 0.005 0.005	 X 	F M S
Cm-245	0.005	X	0.005 0.005 0.005	 X 	F M S
Cm-246	0.005	X	0.005 0.005 0.005	 X 	F M S
Cm-247	0.005	X	0.005 0.005 0.005	 X 	F M S

Table E 2 NRCDose3 – ICRP-72 f1 Values and Ingestion and Inhalation Classes (cont.)

Nuclide	Ingestion		Inhalation		
	f1	Default	f1	Default	Class
Cm-248	0.005	X	0.005 0.005 0.005	X	F M S
Cf-252	0.005	X	0.005	X	M

E.3 References

1. **ICRP Report No. 30**, "Limits for Intakes of Radionuclides by Workers," ICRP 30, Annals of the ICRP Vol. 2, Nos. 3/4, 1979.

2. **ICRP Report No. 72**, "Age-Dependent Dose to Members of the Public from Intake of Radionuclides, Part 5. Compilation of Ingestion and Inhalation Dose Coefficients," ICRP 72, Annals of the ICRP Vol. 21, No.1-3, 1996.

NRC FORM 335
(12-2010)
NRCMD 3.7

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER
(Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)

NUREG-XXXX

2. TITLE AND SUBTITLE

NRCDOSE3 Code

User Guide and Technical Manual

3. DATE REPORT PUBLISHED

MONTH	YEAR
Month	

4. FIN OR GRANT NUMBER

5. AUTHOR(S)

R.S. Clement, J.J. Tomon, D.D. DeMore, J.S. Bland, and V. Malafeew

6. TYPE OF REPORT

Technical

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 Risk Assessment
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 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

Richard Clement, NRC Project Manager

11. ABSTRACT (200 words or less)

The report documents the user guide and technical basis (models and methods) for the NRCDose3 computer code. This manual provides the end user with instructions to use the NRCDose3 code and the bases on updates made to the previous version of the NRCDose 2.3.20 code. The NRCDose3 code is a software suite that integrates the functionality of three individual LADTAP II, GASPAR II, and XOQDOQ Fortran codes that were developed by the NRC in the 1980's and have been in use by the nuclear industry and the NRC staff for assessments of liquid radioactive releases and offsite doses, gaseous radioactive effluents and offsite doses, and meteorological transport and dispersion, respectively. These codes are primarily used to support reactor licensing in the evaluation of the safety and environmental dose impacts from liquid and gaseous radiological effluent releases. In general, the basic calculation methods (algorithms) of the Fortran codes have not been changed. In addition to a more user-friendly graphic user interface for inputting data, 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.)

Reactor Effluents, Exposure Pathway Analysis, Radiation Dose, Atmospheric Dispersion, Relative Concentrations, GASPAR II, LADTAP II and XOQDOQ

13. AVAILABILITY STATEMENT

unlimited

14. SECURITY CLASSIFICATION

(This Page)

unclassified

(This Report)

unclassified

15. NUMBER OF PAGES

16. PRICE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

OFFICIAL BUSINESS

@NRCgov

NUREG-XXXX NRCDOSE3 Code Month