NRCDose3 v 1.1.5

Software Release Notes

September 30, 2025

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1 Introduction

NRCDose3 is a user-friendly Windows-based graphical user interface (GUI) that integrates LADTAP II, GASPAR II, and XOQDOQ to model liquid and gaseous radioactive effluent pathways and atmospheric dispersion, supporting NRC regulatory compliance for dose assessments from nuclear power plants.

This release note details the updates and bug fixes introduced in NRCDose3 version 1.1.5, a patch release following version 1.1.4. The primary goal of this update was to address various bugs identified in both the graphical user interface (GUI) and the backend Fortran executables.

During benchmarking with the Kyung Hee University (KHU) Code, a tool developed to meet environmental and regulatory requirements in Korea, five discrepancies were found [1]. These have been resolved in this patch. In addition, several issues reported by NRCDose3 users have been fixed.

Please note that while some known GUI bugs remain unresolved, all current issues and possible workarounds are tracked on GitHub: https://github.com/NRC-RAMP/NRCDose3/issues.

Finally, although XOQDOQ remains part of NRCDose3, it has been modernized and integrated into the Routine Release model within the Atmospheric Transport and Diffusion (ATD) module of the Software Integration for Environmental Radiological Release Assessments (SIERRA) computer code (as of May 2025). Going forward, XOQDOQ will receive minimal maintenance.

2 Changes

The following sub-sections outline the changes made from NRCDose3 version 1.1.4 to NRCDose3 version 1.1.5. An overview of the major changes expected are given below:

- International Commission on Radiological Protection (ICRP) Report No. 30 (ICRP 30) and ICRP Report No. 72 (ICRP 72) coefficients now correctly match the F1 values and absorption types specified in the source term instead of the default configuration.
- Correct age-specific consumption rates are now used for GASPAR C-14 and H-3 calculations.
- Total dose summaries at the end of GASPAR outputs are now correctly reset between groups/pathways.
- GASPAR population dose calculations with ICRP 72 now use 3 age groups with correct mapping of population fractions and consumption rates.
- GASPAR population dose calculations for ICRP 30 are now correctly mapped to appropriate age groups and no longer yield zero.
- LADTAP now processes all relevant age groups for saltwater sites, including newborns (previously skipped).
- Organ/tissue labels in GASPAR output now align with the correct dose coefficients.

A summary of changes is provided in Table 3-1.

Table 2 1 Summary of Resolved Issues

Issue #	Description	Section
A1†	GASPAR/LADTAP dose coefficient libraries only load in defaults	2.1
A2†	GASPAR ICRP 72 carbon age groups offset	2.2
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A7	XOQDOQ desert sigmas and percents	2.7
A8	GASPAR ICRP 30 reading infant rates instead of adults for tritium calculations	2.8
A9	GASPAR dose totals incorrect at bottom of output	2.9
A10	GASPAR FSAR Report organ/tissue mismatch	2.10
A11	NRCDose3 says input was not created when program runs successfully	2.11
A12	GASPAR ICRP 72 population doses	2.12
A13	GASPAR ICRP 30 population group misalignment	2.13
AA	Various compiler differences	2.14

Notes

† Documented in the Chang and Cheong paper [1]

2.1 Issue A1: GASPAR/LADTAP dose coefficient libraries only load in defaults

A bug in previous versions caused NRCDose3 to always write out the default dose coefficient set for nuclides in ICRP 30 and ICRP 72, regardless of which configuration was selected in the source term input. In version 1.1.5, dose coefficients are now properly loaded based on the F1 value and absorption type specified in the source term. This issue contributed to the first three discrepancies in the KHU code comparisons [1].

2.2 Issue A2: GASPAR ICRP 72 carbon age groups offset

There was a typo in the indexing of the CARBON subroutine that pulled in the incorrect consumption rates for each age group (for example, 15 yr old values were being used for adults). This also caused newborn values to not be printed for the nuclide carbon (C)-14. This has been corrected in version 1.1.5. Note that this issue contributed to the second discrepancy in the KHU code comparisons [1].

2.3 Issue A3: GASPAR ICRP 72 organ/tissue order switched

The labels printed in the GASPAR outputs for ICRP 72 did not match the order of the dose coefficients. The dose coefficients were listed, loaded, and computed in the following order: colon, kidneys, liver, muscle, ovaries, pancreas, red marrow and extratrachial airways. However, the labels in the output were as follows: colon, liver, muscle, ovaries, pancreas, red marrow, extratrachial airways, kidneys. The printed labels were corrected in version 1.1.5. This issue was responsible for the fourth discrepancy in the KHU code comparisons [1].

2.4 Issue A4: LADTAP saltwater sites only printing 3 age groups

There was a check in the LADTAP code that terminated the calculations after three age groups for saltwater sites, skipping the newborn calculations for ICRP 2 and 5 yr, 1 yr, and newborn calculations for ICRP 72. This check was removed in version 1.1.5. This issue was responsible for the fifth discrepancy in the KHU code comparison [1].

2.5 Issue A5: XOQDOQ plume temperature limited to 5 digits

The heat emission rate (both HEATR in the Fortran and “vent/stack heat emission rate” input field in the NRCDose3 GUI) was limited to 5 digits. Both the NRCDose3 GUI and Fortran input were expanded to allow up to 9 digits to accommodate larger heat values in version 1.1.5.

2.6 Issue A6: LADTAP Fortran assumes decimal inputs

The Fortran inputs for certain fields on the Pathway Factors tab in LADTAP (depicted in Figure 1) expect the supplied value to be in decimal form. If an integer is input, the code will assume that a decimal should be between the last two digits, effectively dividing the integer input by 10. For example, inputting 240 would result in the number 24 being used in calculations.
Version 1.1.5 was updated so that integer values will be converted to a decimal when writing the input file to be fed into the LADTAP Fortran code.

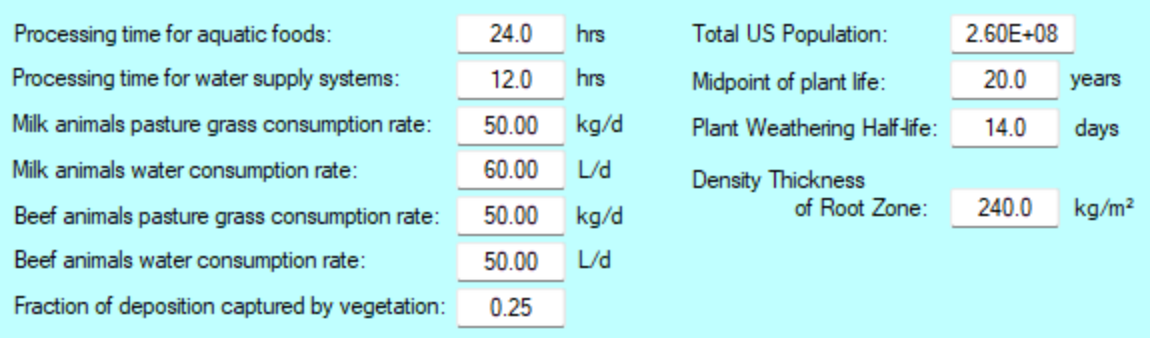

Figure 2-1 The Input Fields in LADTAP that were Impacted by Issue A6

2.7 Issue A7: XOQDOQ desert sigmas and percents

XOQDOQ processes the input joint frequency distribution data from frequency counts to percents. When selecting the desert sigma diffusion curves (KOPT(10) = 1 in the Fortran), this conversion is skipped. Therefore, the XOQDOQ calculations will only be correct if KOPT(2) = 1. An error message was added to prohibit the scenario where desert sigma curves are used with input JFDs that have not been converted to percents.

2.8 Issue A8: GASPAR ICRP 30 reading infant rates instead of adults for tritium calculations

There was an indexing error where the infant consumption rates were being used in the tritium (H-3) dose calculations instead of the adult rates when using ICRP 30 coefficients. Since the infant inhalation rates were mostly zero or lower than the adult rates, the H-3 doses were lower than expected. This issue has been corrected in version 1.1.5.

2.9 Issue A9: GASPAR dose totals incorrect at bottom of output

There was a bug where the ICRP 2 and ICRP 72 dose totals were not resetting between age group and pathway in the “Annual Individual Dose Summary by Pathway and Nuclide” section at the bottom of the output files. This was corrected in version 1.1.5.

2.10 Issue A10: GASPAR FSAR Report organ/tissue mismatch

In the FSAR Report section "Airborne Population Doses (person-rem/yr)" (output when running calculating population doses with ICRP 2), the column titles are mismatched with the data. The first four columns read: GI Tract, Bone, Liver, Total Body but the data is actually printed in this order (which aligns with that of the Fortran output): Total Body, GI Tract, Bone, Liver. The FSAR Report columns were renames to match the data.

2.11 Issue A11: NRCDose3 says input was not created when program runs successfully

In previous versions of NRCDose3, a pop-up window would frequently appear during execution, stating that output had not been created, even though the program would typically complete

successfully and generate valid results. This premature warning was caused by NRCDose3 not properly waiting for the Fortran executables to finish running before checking for output. As of version 1.1.5, NRCDose3 includes improved synchronization with the Fortran backend. The program now waits longer for the executables to complete and will only display the warning if the output files are truly missing.

2.12 Issue A12: GASPAR ICRP 72 population doses

The ICRP 72 dose coefficients are broken up into 6 age groups. However, the population fractions and average consumption rates read into the GASPAR Fortran code only have 3 values. Therefore, it is speculated that instead of throwing an out of bounds exception, version 1.1.4 pulled data from adjacent spaces in memory, resulting in large numbers for population doses. In version 1.1.5, the code was updated so that population doses are only calculated from 3 age groups: adults, 15-year-olds (pulling the teen population fraction), and 5-year-olds (pulling the child population fraction). Population doses are much smaller in version 1.1.5, but the values can be traced to the correct dose coefficients, population fraction, and consumption rate for the particular age group.

2.13 Issue A13: GASPAR ICRP 30 population group misalignment

When calculating population doses with ICRP 30, the child population fractions, and average consumptions rates are being pulled into the calculations. Since ICRP 30 dose coefficients only include adult values, the population fraction for children is 0; therefore, all ICRP 30 population doses were being calculated as 0. Version 1.1.5 correctly uses the adult population fraction to result in non-zero dose calculations.

2.14 Issues AA: Various Compiler Differences

Some inconsistent behaviors were observed in previous builds of NRCDose3 when compiled with Silverfrost Fortran, which did not occur when the same source code was compiled using the Intel Fortran compiler. These differences appeared to stem from compiler-specific handling rather than issues within the codebase itself. An overview of these issues is given below.

- In one LADTAP run, the following error was raised by the execution of the Fortran code: Run-time Error: Error 94, Unit has neither been OPENed nor preconnected, indicating that the program is trying to access a file before it has been opened or assigned. Running this same case through version 1.1.5 yields a successful completion.
- There will be a difference between version 1.1.4 and version 1.1.5 regarding some nuclides with shorter half-lives when calculating population doses. The decay constant is used to calculate the total activity reaching each food type.
    - In version 1.1.4, numbers on the order of 1E-44 were set to 0 (single precision underflow); there was a check in the code when calculating the meat total activity that set the decay correction factor to 1E-20 if it were 0 to avoid dividing by zero. Therefore, for certain radionuclides, the decay correction factor would underflow and cause NRCDose3 to use a higher value for this. For an example problem, iodine (I)-132 had a decay correction factor of 3.7E-44, meaning that the calculated total activity in meat should have been on the order of 1E-56.

However, in version 1.1.4, the underflow caused this to be set to 2.5E-32, which is a much larger factor.
- This caused a value of 4.32E-30 to be calculated for person-rem, where in version 1.1.5 this value would underflow and be set to 0.

3 References

[1] Chang, I. G., & Cheong, J. H. (2025). Potential Errors in NRCDose3 Code Version 1.1. 4 and Correction Methods for Resulting Calculation Errors. *방사성폐기물학회지*, *23*(1), 107-129.