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SRNL All-Pathways Application

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INTRODUCTION

The Environmental Analysis and Performance Modeling group of Savannah River National Laboratory (SRNL) performs performance assessments of the Savannah River Site (SRS) low-level waste facilities to meet the requirements of DOE Order 435.1. One of the performance objectives in the DOE Order is that the radiological dose to representative members of the public shall not exceed 25 mrem in a year total effective dose equivalent from all exposure pathways, excluding radon. Analysis to meet this performance objective is generally referred to as all-pathways analysis. SRNL performs detailed transient groundwater transport analysis for the waste disposal units, which has been used as input for the groundwater part of all-pathways analysis. The desire to better integrate all-pathways analysis with the groundwater transport analysis lead to the development of a software application named the SRNL All-Pathways Application.

Another requirement of DOE Order 435.1 is to assess the impact of nuclear waste disposal on water resources, which SRS has interpreted for groundwater protection as meeting the EPA regulations for radionuclides in drinking water. EPA specifies four separate criteria as part of their implementation guidance for radionuclides, which are specified as maximum contaminant levels (MCL).

1. Beta/gamma emitters have a combined dose limit of 4 mrem/year.
2. Alpha emitters have a combined concentration limit of 15 pCi/L (called gross alpha), excluding uranium and radon, but including radium-226.
3. Combined radium-226 and radium-228 have a concentration limit of 5 pCi/L.
4. Isotopes of uranium have a combined concentration limit of 30 μg/L.

The All-Pathways Application was designed to be an easy-to-use software application that utilizes transient concentration results from groundwater transport analysis to (1) calculate the groundwater part of all-pathways dose and to (2) evaluate the four EPA criteria for groundwater protection.

DESCRIPTION OF THE ALL-PATHWAYS APPLICATION

In addition to calculating the groundwater part of all-pathways dose and evaluating the four EPA criteria for groundwater protection, the functional requirements for the All-Pathways Application specified that the application have a graphical user interface (GUI) that makes the application easy to use, that standard input values be specified in an Excel file and kept under configuration control, and that output results be written to Excel. Given these requirements, the application was developed in Visual Basic 6 (VB) since VB is a good programming environment to create the graphical user interface and it interfaces easily with the Microsoft Office product Excel. Visual Basic also produces compiled program code that executes quickly.

Another functional requirement is that the All-Pathways Application read transient groundwater transport results in the form of "ideal" files. There is an ideal file for each parent where an ideal file is defined as the transient groundwater transport result for a single parent and its entire decay chain, resulting from an initial inventory of one curie of the parent, written as a single text file with time in the first column followed by columns of concentrations for the decay chain given in pCi/L. These concentrations from the transport calculation represent the maximum concentration over a specified region of space at each time. Note that by using results in ideal file format, the All-Pathways Application can process results from any groundwater transport code (PORFLOW is used at SRS).

The all-pathways dose from groundwater is based upon exposure pathways used in LADTAP, which is a surface water all-pathways spreadsheet calculation that meets NRC Regulatory Guide 1-109 guidelines. Exposure pathways in LADTAP include fish ingestion, water ingestion, shoreline exposure, swimming exposure, boating exposure, vegetable consumption, milk consumption, and meat consumption. For use with the All-Pathways Application, LADTAP was modified to use parameters appropriate for groundwater rather than surface water. LADTAP is run for a 1 pCi/L concentration of each nuclide in the groundwater and the resulting dose per unit concentration for each pathway becomes part of the input to the All-Pathways Application. This input is contained in the Excel file *AllPathwaysInput.xls*, which is a required input file for the All-Pathways Application.

Required inputs to the All-Pathways Application for the EPA calculations are a list of the beta/gamma and alpha emitters, which are also contained in the Excel file *AllPathwaysInput.xls*. For the beta/gamma emitters, EPA

provides a concentration equivalent to 4 mrem/year for many radionuclides. For those beta/gamma emitters not provided by EPA, a concentration equivalent is determined from the ingestion dose conversion factor. The list of beta/gamma and alpha emitters is determined from Brookhaven National Laboratory's 2005 Wallet Cards.

The All-Pathways Application performs two types of calculations, which we will discuss for the all-pathways dose criterion. One calculation type, called sum of fractions (SOF) calculation, performs calculations for each parent radionuclide and its decay chain based on an initial inventory of one curie of the parent. The transient concentrations for the parent and daughters resulting from the initial one curie of the parent are contained in the ideal file for the parent. These concentrations for parent and daughters are used at each time step to calculate the all-pathways dose associated with each parent chain. Then the maximum dose in time for each parent chain is determined. For the sum of fractions approach, the maximum doses for two different parent chains typically do not occur at the same time. The maximum dose and the time of the maximum for each parent chain are reported in the output. The SOF calculation applies to the EPA criteria in a similar way, so that a maximum concentration or dose and a time of the maximum are output for each parent chain for each criterion. These SOF results are subsequently used to establish limits on the amount of parent radionuclides that can be placed in the waste disposal unit.

The other calculation type, called inventory calculation, calculates the all-pathways dose based on a specified inventory of parent radionuclides. The total all-pathways dose from all parent chains in this inventory is calculated at each time step. Then the maximum total dose in a time range is computed, which gives the resulting maximum dose for the given inventory. The inventory calculation applies to the EPA criteria in a similar way, so that a maximum concentration or dose is determined for each criterion. The results of the inventory calculation can be used to determine if the specified inventory meets the DOE performance objectives.

The user interface for the All-Pathways Application is shown in Figure 1. Steps are numbered to guide the user through the form from top to bottom.

1. The user locates the directory with the ideal files.
2. The user selects the parents to be analyzed.
3. The ideal files are read for the selected parents.
4. The times from the ideal files are merged so that results are available at each time step.
5. The user specifies a time range for the calculation.
6. The user chooses a calculation type (inventory or SOF).
7. The evaluation criteria are chosen. Note that individual exposure pathways for LADTAP (all-pathways dose) may be selected.
8. An output Excel file name and location is specified with a browser.

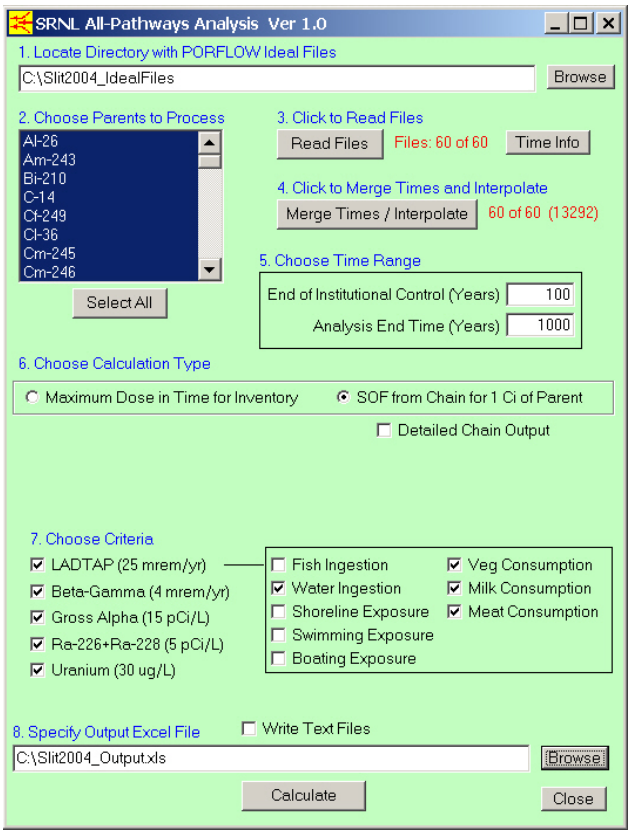

Fig. 1. User Interface for All-Pathways Application.

The Calculate button is clicked and results are written to the output Excel file. Note that there is an option for detailed chain output in the center of the form. The detailed output written to an Excel file allows a user to easily understand which members of a decay chain are dominant for the criterion of interest.

CONCLUSION

An application has been developed to streamline the assessment of performance objective criteria for groundwater using concentration results from groundwater transport analyses. The SRNL All-Pathways Application evaluates the groundwater portion of all-pathways analysis and also evaluates EPA groundwater protection criteria. The application can perform a calculation using a specified inventory to determine if that inventory meets performance objectives, or it can perform a sum of fractions calculation to provide results for each parent chain that are subsequently used to establish limits on the amount of parent radionuclides that can be placed in the waste disposal unit.