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## Automated Inadvertent Intruder Application

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### INTRODUCTION

The Environmental Analysis and Performance Modeling group of Savannah River National Laboratory (SRNL) conducts performance assessments of the Savannah River Site (SRS) low-level waste facilities to meet the requirements of DOE Order 435.1. These performance assessments, which result in limits on the amounts of radiological substances that can be placed in the waste disposal facilities, consider numerous potential exposure pathways that could occur in the future. One set of exposure scenarios, known as inadvertent intruder analysis, considers the impact on hypothetical individuals who are assumed to inadvertently intrude onto the waste disposal site. Inadvertent intruder analysis considers three distinct scenarios for exposure referred to as the agriculture scenario, the resident scenario, and the post-drilling scenario. Each of these scenarios has specific exposure pathways that contribute to the overall dose for the scenario.

For the inadvertent intruder analysis, the calculation of dose for the exposure pathways is a relatively straightforward algebraic calculation that utilizes dose conversion factors. Prior to 2004, these calculations were performed using an Excel spreadsheet. However, design checks of the spreadsheet calculations revealed that errors could be introduced inadvertently when copying spreadsheet formulas cell by cell and finding these errors was tedious and time consuming. This weakness led to the specification of functional requirements to create a software application that would automate the calculations for inadvertent intruder analysis using a controlled source of input parameters. This software application, named the Automated Inadvertent Intruder Application, has undergone rigorous testing of the internal calculations and meets software QA requirements.

The Automated Inadvertent Intruder Application was intended to replace the previous spreadsheet analyses with an automated application that was verified to produce the same calculations and results. The application was extended to calculate full decay chains for a given parent so that an intruder calculation could be performed without any input from transport calculations, i.e. the intruder analysis was decoupled from groundwater analysis. Once this full decay chain capability was in place, the application was extended to perform a transient calculation of the dose to an intruder over a specified time

range, from which the maximum dose in time was determined. Use of the transient calculation to find the maximum dose in time was a significant step forward in automating and simplifying the inadvertent intruder analysis.

### DESCRIPTION OF THE AUTOMATED INADVERTENT INTRUDER APPLICATION

In addition to recovering the calculations previously done with spreadsheet analysis, the functional requirements for the Automated Inadvertent Intruder Application specified that the application have a graphical user interface (GUI) that makes the application easy to use, that standard input values be specified only one time and kept under configuration control, that output results be written to Excel, and that final tables be written directly to Word for inclusion in reports. 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 products Excel and Word. Visual Basic also produces compiled program code that executes quickly.

A key software design concept is to keep all input in external Excel files with given formats and not have any embedded input in the Visual Basic executable. The generalized VB program reads the input Excel files and does not restrict the input to a specific set of radionuclides. That is, the goal is to permit radionuclides to be added in the future through input without altering the VB program.

There are three required input files. The input file *IntruderInput.xls* contains standard radionuclide input and parameters used for inadvertent intruder dose calculations. This input file has a list of parent radionuclides available for analysis and worksheets with dose conversion factors (DCF) and with decay chain information for the parents and their daughter radionuclides. The dose conversion factor worksheet includes ingestion, inhalation, soil uptake rates, and external exposure from surface soil with contamination in depths of 15 cm and of infinite depth. These DCF values are taken from the EPA Federal Guidance Reports 11 and 12. The decay chain information, which includes half life and daughters with branching fractions, is taken from Brookhaven National Laboratory's 2005 Wallet Cards.

The resident scenario requires DCF values for external exposure with shielding from soil of various thicknesses. The strategy for accounting for the shielding came from Dave Kocher of Oak Ridge National Laboratory, who used a table that has shielding DCF values for 496 radionuclides at discrete soil shielding thicknesses of 0, 1, 5, 15, 30, 45, and 100 cm. For intermediate thicknesses, Kocher interpolated values from this table. This strategy has been implemented in the Automated Inadvertent Intruder Application and the table of DCF values is contained in the input file *KocherShielding.xls*.

The input file *DisposalUnitInput.xls* contains information required by the model for each of the disposal units. This file contains volume and geometry factors but the key information needed for the disposal unit is a description of the cover material above the waste that leads to the timing of when various scenarios occur. Past performance assessment documents have described the logic for determining when various scenarios occur and include two considerations for timing: (1) erosion of soil-like cover material at some constant erosion rate and (2) degradation of an impenetrable barrier (e.g. concrete, grout) to soil-like material. For the Automated Inadvertent Intruder Application, these elements are incorporated into a simple one-dimensional “transient layer model” so that the thickness of cover material and whether it is penetrable changes as a function of time and becomes part of the transient calculation for dose. Cover material above the waste is represented as distinct layers with specified thickness, erosion rate, and degradation time for each layer.

The graphical user interface for the Automated Inadvertent Intruder Application is shown in Figure 1. The top of the form has choices for the disposal unit and the upper right has buttons that show a review of the input described above. The list of parents from input file *IntruderInput.xls* is shown on the form and the user may choose the parents to be analyzed. There are three calculation types with the first two representing the approach in past analyses where times are specified for the scenarios and the third being the transient calculation where scenario times are determined from the transient layer model. With the transient calculation selected as in Figure 1, the user can select the scenarios of interest and specify the calculation times of interest. The user specifies an output directory where standard output results are written. At the bottom left of the form are choices for additional optional output.

When the user clicks the Calculate button, the application begins processing and calculates each scenario selected in succession. The application assumes that one curie of a parent is distributed over the waste unit volume at time zero. At each time step, the application calculates the decay chain of the parent, determines the relevant exposure pathways from the transient layer model,

calculates the dose for each pathway, and sums the pathway doses to get the total dose from the parent and its daughters. When the analysis end time is reached, the application determines the maximum total dose over the specified time range for each parent and writes the results to output Excel files. Note that the detailed output options make it easy for a user to understand the dominant pathways and contributors in the decay chain.

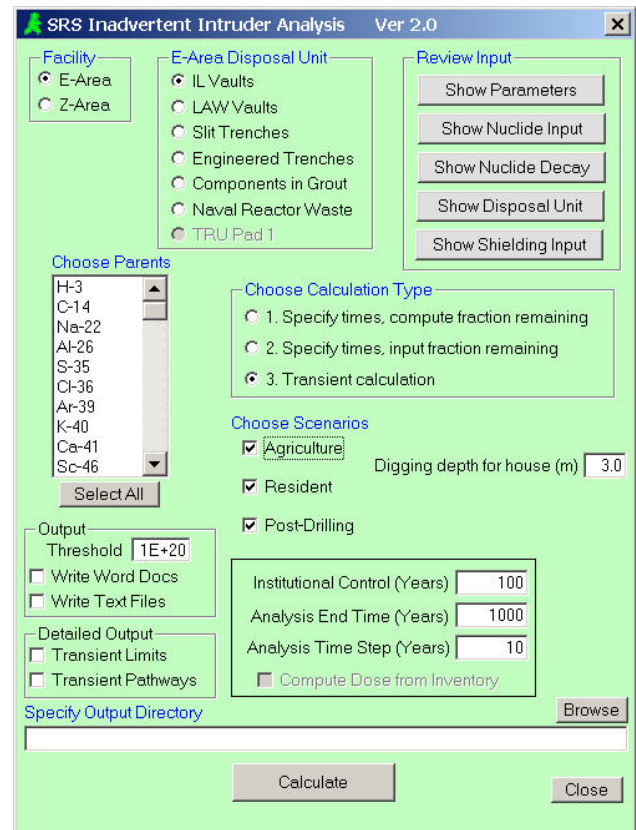


Fig. 1. User Interface for Intruder Application.

## CONCLUSION

An automated application has been developed to perform inadvertent intruder analysis for SRS low-level waste facilities. The application performs a transient analysis to find the maximum dose in time for each parent considered. Due to its ease of use and the standardization of input and methods, the Automated Inadvertent Intruder Application has been adopted as standard practice for inadvertent intruder analysis at SRS.