ORNL/TM-11037

ornl

OAK RIDGE
NATIONAL
LABORATORY

MARTIN MARIETTA

ADGEN – ADjoint GENerator for Computer Models

B. A. Worley
F. G. Pin
J. E. Horwedel
E. M. Oblow

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL/TM-11037
Dist. Category: UC-70B (Waste)

Engineering Physics and Mathematics Division

ADGEN - ADJOINT GENERATOR FOR COMPUTER MODELS

B. A. Worley, F. G. Pin, J. E. Horwedel,* and E. M. Oblow

*Computing and Telecommunications Division
Martin Marietta Energy Systems, Inc.
P.O. Box 2008
Oak Ridge, Tennessee 37831-6357

Date Published - May 1989

Prepared for the
National Low-Level Waste Management Program
U.S. Department of Energy

Prepared by the
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This paper presents the development of a FORTRAN compiler and an associated supporting software library called ADGEN. ADGEN reads FORTRAN models as input and produces an enhanced version of the input model. The enhanced version reproduces the original model calculations but also has the capability to calculate derivatives of model results of interest with respect to any and all of the model data and input parameters. The method for calculating the derivatives and sensitivities is the adjoint method. Partial derivatives are calculated analytically using computer calculus and saved as elements of an adjoint matrix on direct assess storage. The total derivatives are calculated by solving an appropriate adjoint equation. ADGEN is applied to a major computer model of interest to the Low-Level Waste Community, the PRESTO-II model. PRESTO-II sample problem results reveal that ADGEN correctly calculates derivatives of a response of interest with respect to 3000 parameters. The execution time to create the adjoint matrix is a factor of 45 times the execution time of the reference sample problem. Once this matrix is determined, the derivatives with respect to 3000 parameters are calculated in a factor of 6.8 that of the reference model for each response of interest. For a single response, the total factor of 51.8 compares to a factor of 3000 for determining these derivatives by parameter perturbations. The automation of the implementation of the adjoint technique for calculating derivatives and sensitivities eliminates the costly and manpower-intensive task of direct hand-implementation by reprogramming and thus makes the powerful adjoint technique more amenable for use in sensitivity analysis of existing models.

I. INTRODUCTION

Sensitivity and uncertainty analysis are important components of any system performance assessment. The role of sensitivity analysis is to provide a quantitative measure of the effect of system parameters upon key performance indices. Sensitivity analysis also helps limit the scope of the more complicated problem of quantifying uncertainties. Uncertainty analyses is performed to support reliability studies, to produce a cost-benefit analysis in conjunction with cost estimates, to insure compliance with regulatory criteria, and to help identify important research and development needs.

Sensitivity analysis of computer-generated results consists of determining the effect of model data upon the calculated results of interest. Because computer model equations can be differentiated analytically, sensitivities can be precisely defined and calculated in a deterministic fashion using both direct and adjoint methods.[1-8] The deterministic approach is particularly suited to large-scale problems for which direct perturbation of the model data as performed using statistical analysis techniques becomes impractical from a cost standpoint. But despite this recognized advantage, these deterministic methods have been rarely employed because of the painstaking initial manpower investment need to add the computational capability for calculating the necessary derivatives into existing computer models.

To circumvent this costly manpower investment and thus provide the means for model users to take advantage of the strengths of deterministic sensitivity analysis, a software system was developed to automate the implementation of these methods into existing FORTRAN computer models. This system, named GRESS (Gradient-Enhanced Software System), was initially developed to solve the direct problem and has been thoroughly tested.[9-16] The purpose here is to report on the development and availability of the ADGEN (Adjoint Generator) system[17,18] within GRESS that provides the capability of automated implementation of the adjoint method into existing FORTRAN models.

Section II provides a review of the direct and adjoint sensitivity problem. Section III gives an overview of the ADGEN system. Section IV discusses the application of ADGEN to a full-scale sample problem. Section V summarizes the conclusions and recommendations as a result of this work. Sections VI and VII discuss the current ADGEN configuration and terminology respectively.

II. DETERMINISTIC SENSITIVITY ANALYSIS

A brief description of general sensitivity theory is given here as an aid to understanding the problem of applying this theory to computer models. The example to be discussed will be that of a general set of non-linear equations given by

$$\mathbf{y} = \mathbf{F}(\mathbf{y},\mathbf{c}) \quad , \tag{1}$$

where **y** represents the dependent variable being solved for, **c** represents the user-specified model data or parameter set, and **F** is a vector of the model equations. The particular form chosen in Eq. (1) is one that can be used generally to represent equations coded in the FORTRAN programming language. The left side of the equation can represent the stored value of the variable calculated from the functional formula on the right side.

Since the number of components of the vector **y** calculated in any typical large-scale modeling problem is large, it is useful to define a generic result for such a calculation that is of particular interest to the model user. Typically many results will be needed for analysis but in most cases they form a much smaller set than the actual set of **y** component values. A typical result will be defined as

$$R = h(\mathbf{y}) \quad , \tag{2}$$

where R is a single number that is a function of the solution to Eq. (1). For notational ease, the generic parameter α_i will be used to denote any individual parameter. The total number of parameters in the problem will be assumed to be M so that the index on α_i will run from 1 to M.

The basic problem in any sensitivity study is to find the rate of change in the result R arising from changes in any model parameters. For the generic parameter α_i, then, the quantity of interest is the numerical value of $dR/d\alpha_i$ given analytically by

$$\frac{dR}{d\alpha_i} = \frac{\partial h}{\partial \mathbf{y}} \frac{d\mathbf{y}}{d\alpha_i} \quad . \tag{3}$$

Since the functional dependence of R on **y** through h(**y**) is defined analytically by the model user, only $d\mathbf{y}/d\alpha_i$ needs to be generated in order to evaluate Eq. (3). The procedure needed to get $d\mathbf{y}/d\alpha_i$ is to differentiate Eq. (1) as follows:

$$\frac{d\mathbf{y}}{d\alpha_i} = \frac{\partial \mathbf{F}}{\partial \mathbf{y}} \frac{d\mathbf{y}}{d\alpha_i} + \frac{\partial \mathbf{F}}{\partial \mathbf{c}} \frac{d\mathbf{c}}{d\alpha_i} \quad . \tag{4}$$

Rearranging Eq. (4) yields the following set of coupled equations to solve for $dy/d\alpha_i$,

$$\left(I - \frac{\partial F}{\partial y}\right) \frac{dy}{d\alpha_i} = \frac{\partial F}{\partial c} \frac{dc}{d\alpha_i} \quad , \tag{5}$$

or in more compact form,

$$A y_i' = s_i \quad , \quad i = 1, \ldots, M \quad , \tag{6}$$

where I is the identity matrix and A, y_i', and s_i are given by

$$A = I - \frac{\partial F}{\partial y} \quad , \tag{7}$$

$$y_i' = \frac{dy}{d\alpha_i} \quad , \tag{8}$$

and

$$s_i = \frac{\partial F}{\partial c} \frac{dc}{d\alpha_i} \quad . \tag{9}$$

If Eq. (6) were solved directly for y_i', the result could be used in Eq. (3) to evaluate $dR/d\alpha_i$. This method of sensitivity analysis is called the "direct" approach and is a classical methodology that has received a great deal of attention in the literature.[1,5] Since Eq. (6) must be solved each time a new α_i is defined, the direct approach is most suitable for problems with relatively few input parameters of interest, for problems in which the solution of Eq. (6) is very inexpensive compared to the solution of the model itself. GRESS was the system developed to automate the implementation of the direct method into existing FORTRAN models.

For large-scale models with a large data base in which the ultimate objective is still the evaluation of $dR/d\alpha_i$ for many α_i, the intermediary step of solving for $dy/d\alpha_i$ and its inherent computational inefficiency can be avoided. For such problems the "adjoint" approach is far more applicable. In this methodology, use is made of the fact that Eq. (6) is linear in y_i', and appropriate adjoint equations can therefore be developed specifically to evaluate Eq. (3).

Defining the matrix adjoint of **A** as **A*** and using the usual definition of this adjoint give the identity,

$$\mathbf{u}^{tr}\mathbf{A}\mathbf{v} = \mathbf{v}^{tr}\mathbf{A}^*\mathbf{u} \quad , \tag{10}$$

where **u** and **v** are arbitrary vectors and **A*** is defined as

$$\mathbf{A}^* = \mathbf{A}^{tr} \quad . \tag{11}$$

Here the tr superscript represents the transpose of the vector or matrix.

If specific vectors for the problem at hand are chosen for **u** and **v**, the problem-specific adjoint equation can be set up as follows:

$$\mathbf{A}^*\mathbf{y}^* = \mathbf{s}^* \quad , \tag{12}$$

where

$$\mathbf{A}^* = \mathbf{A}^{tr} = \left(\mathbf{I} - \frac{\partial \mathbf{F}}{\partial \mathbf{y}}\right)^{tr} \quad . \tag{13}$$

Choosing s* as

$$\mathbf{s}^* = (\mathrm{d}\mathbf{h}/\mathrm{d}\mathbf{y})^{tr} \quad , \tag{14}$$

Eq. (3) can now be evaluated as follows:

$$\frac{\mathrm{dR}}{\mathrm{d}\alpha_i} = \mathbf{y}^{*tr} \frac{\partial \mathbf{F}}{\partial \mathbf{c}} \frac{\mathrm{d}\mathbf{c}}{\mathrm{d}\alpha_i} \quad , \quad i = 1,\ldots,M, \tag{15}$$

where **y*** is now the solution to

$$\left(\mathbf{I} - \frac{\partial \mathbf{F}}{\partial \mathbf{y}}\right)^{tr} \mathbf{y}^* = \frac{\mathrm{d}\mathbf{h}}{\mathrm{d}\mathbf{y}}^{tr} \quad . \tag{16}$$

The simplicity of the adjoint approach lies in the fact that Eq. (16) needs to be solved only once to get any and all sensitivities in the problem. This is a result of Eq. (16) being independent of the definition of α_i. The particular choice of α_i is only reflected in the evaluation of Eq. (15), which involves simple vector products.

In essence, the adjoint approach reduces the computational effort needed to evaluate $dR/d\alpha_i$ from solving many coupled linear equations to the evaluation of several vector products. For large-scale systems with many thousands or even millions of parameters, this represents orders of magnitude in computational efficiency.

It should be noted here that both the direct and adjoint equations (Eqs. (6) and (16)) are in any case far easier to solve than the original model (Eq. (1)). Both Eqs. (6) and (16) are linear while Eq. (1) is nonlinear. The direct and adjoint approaches, however, require the results of the original model equations to be available in order to set up Eqs. (6) and (16), since the $\mathbf{A}$ matrix and the vectors $\mathbf{s}$, and $\mathbf{s}^*$ depend on $\mathbf{y}$.

In order to carry out the adjoint sensitivity analysis, then, the model user must first generate the matrices $\partial \mathbf{F}/\partial \mathbf{y}$ and $\partial \mathbf{F}/\partial \mathbf{c}$ from the original nonlinear computer model. For large-scale problems this generally requires a great deal of painstaking human effort. First, the model equations must be extracted from the computer coding. They must then be differentiated with respect to all parameters of interest, and finally direct or adjoint sets of equations must be set up for computational solution. Successful automation of this procedure greatly reduces the human effort involved, potentially by orders of magnitude. The advantage of automation of sensitivity model development is therefore great indeed. The next section discusses an automated system that uses a calculus precompiler to add capability to existing FORTRAN computer models for solving the adjoint equations.

III. ADGEN

An Automated System for Solving the Adjoint Sensitivity Problem

The basic adjoint equation that ADGEN solves is a somewhat modified version of Eq. (16). ADGEN does not initially distinguish the c vector as data, but instead treats all real data declarations (READ statements, DATA blocks, data set by equations, etc.) as elements of **F** in which the data variable is considered as an element of the **y** vector. Thus, Eq. (1) becomes

$$\mathbf{y} = \mathbf{F}(\mathbf{y}) \quad , \tag{17}$$

and

$$\frac{d\mathbf{y}}{d\mathbf{y}} = \frac{\partial \mathbf{F}(\mathbf{y})}{\partial \mathbf{y}} \frac{d\mathbf{y}}{d\mathbf{y}} + I \quad , \tag{18}$$

or

$$\left(I - \frac{\partial \mathbf{F}(\mathbf{y})}{\partial \mathbf{y}}\right) \frac{d\mathbf{y}}{d\mathbf{y}} = I \quad . \tag{19}$$

Defining $u_j = \{0, 0, 0, \ldots, 1, \ldots, 0\}^{tr}$ where the unit element denotes the j^{th} element of **y**, the calculation of $dy_j/d\mathbf{y}$, a row of the $d\mathbf{y}/d\mathbf{y}$ matrix, is carried out by multiplying Eq. (19) by u_j to give

$$\left(I - \frac{\partial \mathbf{F}}{\partial \mathbf{y}}\right)^{tr} \frac{dy_j}{d\mathbf{y}} = u_j \quad . \tag{20}$$

ADGEN computes and stores the $(I - \partial\mathbf{F}/\partial\mathbf{y})^{tr}$ matrix and solves for the desired $dy_j/d\mathbf{y}$. Note the similarity of Eq. (20) and Eq. (16). The $dy_j/d\mathbf{y}$ vector contains the derivatives of the model result of interest, y_j, with respect to the entire **y** vector, which includes the data. It can be shown that the **y*** solution of Eq. (16) is a subset of $dy_j/d\mathbf{y}$ solved from Eq. (20). Equation (2) is thus directly generalized to $dR/d\mathbf{y} = (dh/d\mathbf{y})\ (d\mathbf{y}/d\mathbf{y})$ where $d\mathbf{y}/d\mathbf{y}$ is the general solution given by solving Eq. (20) for the y_j needed to define $h(\mathbf{y})$. Alternately, the equations defining $h(\mathbf{y})$ can be added to the model and the appropriate $dy_j/d\mathbf{y}$ calculated using Eq. (20).

A key component in the ADGEN system is an interpretor routine (INTPXX) that actually solves the real equations during execution of the computer model. INTPXX is a math processor, specifically developed to calculate derivatives of the mathematical operations at the same time the mathematical operations are being performed. In order to use INTPXX, the application model is precompiled with EXAP.[19] EXAP works like a FORTRAN compiler, in that it identifies all real number replacement operations and creates the sequence of instructions (i.e., P-code) necessary to perform those operations with INTPXX. Each equation is replaced by a call to INTPXX with the terms in the equation as arguments in the subroutine call. During program execution, when any mathematical operation is performed (e.g., data initialization, intrinsic function, arithmetic, etc.), the derivatives of the left-hand-side variable with respect to the variables on the right-hand-side of that equation are immediately calculated, and become available as a secondary output from the INTPXX. For adjoint matrix generation, the derivatives, $\partial F/\partial y$, are output for later processing by matrix solving routines (i.e., YSOLVE and TMAT).

ADGEN only calculates derivatives for real-variable replacement operations. That is, a variable being defined by some arithmetic or data initialization operation must be declared explicitly or implicitly to be of type real in the FORTRAN program. Both single and double precision real variables are supported.

There is a distinction between a FORTRAN variable name and the mathematical variable name. The FORTRAN name is associated with a single location in the memory space of the computer. The mathematical name is associated with the row or equation number in the solution sequence. If a given FORTRAN variable is redefined, mathematically, it is not the same variable. Each time a variable (i.e., memory location) is redefined, the left-hand side of the equation becomes a new element in y. For $x = x + 5.0$, the x on the left and the x on the right represent two different locations in the solution vector y.

ADGEN only recognizes real-variable store operations as valid equations (i.e., the left side variable in a FORTRAN equation must be real), since continuous derivatives are to be calculated. Also, the left hand side of an equation is treated as a separate component of **y** each time it is executed (including each execution in a DO LOOP).

The application of ADGEN to an existing FORTRAN model consists of a step in which the reference model is read as input to EXAP. This step consists primarily of a rearrangement of the program data structure and a substitution of calls to the interpretive software. The two output files of this step are thus the enhanced model and the binary P-code file. These two files and a set of ADGEN software subroutines supporting the enhanced model are compiled and run as a normal FORTRAN program to produce both the reference model results and the adjoint matrix. The adjoint equation, Eq. (20) is subsequently solved by the ADGEN solution module using the adjoint matrix and $\mathbf{u}_j$ as input. Although only the nonzero elements are saved, the storage of the matrix $(I - \partial F/\partial y)^{tr}$ may require a substantial amount of storage capability. The storage difficulties are counterbalanced by features of Eq. (20) that make the ADGEN calculation of y^* both practical and cost efficient. Note that the matrix $(I - \partial F/\partial y)^{tr}$ is upper triangular. Thus Eq. (20) is easily solved by back substitution and the elements of $\mathbf{y}^*$ can be successively stored in the space allocated for the $\mathbf{u}_j$. ADGEN circumvents the necessity to store the adjoint matrix in memory by using an efficient scheme for solving Eq. (20) based upon retrieval of portions of $(I - \partial F/\partial y)^{tr}$ from off-line storage and segmenting the calculation of derivatives.

IV. APPLICATION OF ADGEN TO PRESTO-II

The first large-scale test of ADGEN was performed on the PRESTO-II computer model.[20] PRESTO-II (Prediction of Radiation Effects from Shallow Trench Operations) is a computer code designed for the evaluation of possible health effects from shallow-land and waste-disposal trenches. The model is intended to serve as a non-site-specific screening model for assessing radionuclide transport, ensuing exposure, and health impacts to a static local population for a 1000-year period following the end of disposal operations. Human exposure scenarios considered include normal releases (including leaching and operational spillage), human intrusion, and limited site farming or reclamation. Pathways and processes of transit from the trench to an individual or population include groundwater transport, overland flow, erosion, surface water dilution, suspension, atmospheric transport, deposition, inhalation, external exposure, and ingestion of contaminated beef, milk, crops, and water. Both population doses and individual doses, as well as doses to the intruder and farmer, may be calculated. Cumulative health effects in terms of cancer deaths are calculated for the population over the 1000-year period using a life-table approach. Sample input data are available for three example sites: Barnwell, South Carolina; Beatty, Nevada; and West Valley, New York.

IV.A. Processing PRESTO-II with ADGEN

There are phases in using ADGEN in application to an existing FORTRAN 77 program, such as PRESTO-II.

1. Precompilation with EXAP.

2. Creation of the adjoint matrix.

3. Solving of the adjoint matrix for selected results.

During the precompilation phase, any FORTRAN syntax that is not ANSI-X3.9/1978 FORTRAN 77, or is not compatible with EXAP for any reason, must be identified and possibly re-coded into a more standard, EXAP compatible form. PRESTO-II was developed in FORTRAN IV, and therefore, was not fully compatible with EXAP. The modifications, however, only impacted CHARACTER variables, and did not affect the numerical calculations. For most codes developed on VAX/VMS systems, or IBM type personal computers, little or no modifications are required.

Once PRESTO-II is successfully enhanced with EXAP, and then compiled and linked with the ADGEN library routines, it is now ready for execution. During execution, the ADGEN interpretive software claculates the derivatives for each equation, and outputs these derivatives (the forward matrix) with addressing information necessary to create the adjoint matrix. The forward matrix is a temporary data set that may be deleted once it is finished being used to produce the adjoint matrix. The actual adjoint matrix is then created by running the TMAT utility program to replace the addresses with row numbers and create the direct access adjoint matrix data set necessary for the solution phase.

Parameter identification occurs during the enhancement and execution process. By default any real variable that is defined via a FORTRAN read statement is automatically added to the Parameter Dictionary. The Parameter Dictionary contains the row number, the parameter name, the parameter value, and the parameter's virtual address. This data set is output during the execution of the enhanced code, and becomes input to the YSOLVE program.

For PRESTO-II, well over 100,000 real variables were entered via read statements. To limit the actual number of declared parameters, the automatic parameter declaration option was "switched off" with an ADGEN utility subroutine (i.e., DECLARXX). For user selected read statements, DECLARXX was used to temporarily switch automatic declaration on, and cause selected input variables to be added to the Parameter Dictionary. This resulted in a parameter dictionary with approximately 2900 terms.

Similarly, results of interest are added to a Response Dictionary; however, there is no automatic option for response identification. For each response of interest, the user inserts a call to subroutine POTRXX, with the response's FORTRAN name and a descriptive string as arguments. The descriptive string is usually the name of the variable. For example, if R is a result of interest, then immediately after R is calculated, the following call to POTRXX would result in R being added to the Response Dictionary.

```
CALL POTRXX(R, 'R')
```

The Response Dictionary contains the row number, virtual address, descriptive string, and the value for each response indicated by the execution of a call to POTRXX.

Finally, the adjoint matrix is solved using the ADGEN utility, YSOLVE. YSOLVE will calculate and report the derivatives for a single result of interest selected from the Response Dictionary with respect to all the parameters in the Parameter Dictionary. YSOLVE can be re-executed to solve for additional results in the Response Dictionary, without the necessity of re-creating the adjoint matrix. However, if parameters or results not included in either dictionary are desired, then it will be necessary to insert the appropriate calls into the enhanced code and re-create both dictionaries.

A complete description of how to enhance a code, generate an adjoint matrix, and solve the adjoint matrix is included in the "GRESS Version 0.0 User's Manual." Also provided are descriptions of YSOLVE, TMAT, and limitations of the present version of EXAP.

IV.B. Sample Problem Description

The sample problem chosen for the demonstration and testing of the application of ADGEN to PRESTO-II is the Barnwell sample problem described in Ref. 20. This problem calculates a time-dependent radiation dose to man from transport of 40 radionuclides. The variables considered well known include TDEPTH (trendy depth), OVER (overburden), DWELL (distance to nearest well), the atmospheric data, BDENS (soil bulk density), STFLOW (stream flow), PD (site boundary to nearest stream), SAREA (area of contaminated surface soil, and the radiological decay data. Less well known are WATL (fraction of irrigation water taken from the well, PORA, PORT, PORS (porosity of aquifer, trench, and surface region), PERMU (permeability of the trench bottom), DENCON (density of the trench contents), RELFAC (annual release fraction for activity leading from the trench), GWV (ground water velocity), AQTHK (aquifer plume), ADEPTH (active depth of the soil), and RUNOFF (fraction of annual precipitation that runs off). The radionuclide specific parameters that are poorly known are TRAM (initial inventory of each radionuclide), KD (distribution coefficient), SOAM (initial amount of spillage onto the surface, SOL (solubility of the stored radionuclides), BR and BV (plant uptake factors for grain and fruits), FMC and FMG (forage-to-milk transfer factors for cows and goats), and FF (forage-to-beef transfer factors).

The sample problem input is listed in Appendix A, and the sample problem output at 1000 years in listed in Appendix B. The full sample problem input and output are given in Ref. 20.

IV.C. Verification of Derivatives and Sensitivities

The capability of the ADGEN enhanced version of PRESTO-II to correctly calculate analytic first derivatives using the computer calculus was tested by comparison of ADGEN derivatives to those estimated by direct parameter perturbation and by derivatives calculated by the direct method option within GRESS. ADGEN calculates the derivatives based upon the adjoint method.

First, derivatives of various responses after 5 years of burial to several parameters were verified by perturbing the parameters by one percent. The results are shown in Tables 1 and 2. The comparison shows the ADGEN derivatives are correctly calculated. The small differences were shown to be a result of higher order effects by further reduction of the difference between the perturbed and reference parameter values.

Table 1. Perturbation analysis results

Response	Parameter	ADGEN Derivative	Direct Derivative (1% Pert.)
TTC	BDENS	8.04 E-12	7.98 E-12
TTQ	BDENS	3.87 E-09	3.84 E-09
TTM	BDENS	8.08 E-14	8.03 E-14
TTC	PORS	-1.68 E-12	-1.69 E-12
TTQ	PORS	-8.10 E-10	-8.10 E-10
TTM	PORS	-1.69 E-14	-1.69 E-14

Table 2. Perturbation analysis for the response of TTC

Parameter	ADGEN Derivative	Direct Derivative (1% Pert.)
BDENS	8.04 E-12	7.98 E-12
PORS	-1.68 E-12	-1.69 E-12
CHIQ	1.30 E-02	1.30 E-02
RE3	4.27 E-03	4.10 E-03
PPN	-5.15 E-11	-5.09 E-11
ULEAFY	9.41 E-14	9.41 E-14
QCW	0.00 E+00	0.00 E+00
FI	0.00 E+00	0.00 E+00
QFC	3.56 E-13	3.56 E-13
UMEAT	5.25 E-14	5.25 E-14

Note however, that as the perturbation of a parameter value is decreased, the calculation of the first derivative may not be possible because of computational precision and thus the calculation of first derivatives by perturbation may not always be straightforward.

After preliminary verification of derivatives for the 5 year case showed that selected derivatives were properly calculated, derivatives of several responses to various data of interest were computed using the direct and adjoint methods. Comparisons of derivatives from these two methods are shown in Tables 3 and 4.

Table 3. Comparison of derivatives calculated with the ADGEN and CHAIN options for result TBEQ

Row Number	Parameter Name	CHAIN Option	Adjoint Option
47122	PCT1	0.000000E+00	0.000000E+00
47123	PCT2	0.000000E+00	0.000000E+00
47124	WWATL	-7.695277E-05	-7.69528E-05
47125	WWATA	6.019085E-05	6.01908E-05
47126	WWATH	1.676195E-05	1.67619E-05
47127	SWATL	3.706543E-05	3.70654E-05
47128	SWATA	5.189165E-07	5.18916E-07
47129	SWATH	2.100382E-06	2.10038E-06

Table 4. Comparison of derivatives calculated with the ADGEN and CHAIN options for result TTC

Row Number	Parameter Name	CHAIN Option	Adjoint Option
47122	PCT1	0.000000E+00	0.000000E+00
47123	PCT2	0.000000E+00	0.000000E+00
47124	WWATL	-3.70442E-02	-3.70442E-02
47125	WWATA	2.89753E-02	2.89753E-02
47126	WWATH	8.06887E-03	8.06887E-03
47127	SWATL	1.78430E-02	1.78430E-02
47128	SWATA	2.49803E-04	2.49803E-04
47129	SWATH	1.01110E-03	1.01110E-03

All the derivatives compare almost exactly to the number of significant figures shown. The reason for comparing the ADGEN results to the direct results calculated by the CHAIN option within GRESS is that the calculation of derivatives using the GRESS method has been thoroughly tested over the past several years.[11-16] Recall, however, that the derivatives of a response to all the parameters is determined in a single solution of the adjoint equation (Eq. (20)) (single execution of ADGEN) whereas the direct method used in GRESS requires the equivalent of solving the direct equation (Eq. (6)) for each parameter for which derivatives are desired. Thus verification of ADGEN derivatives with respect to many paramters by comparison with the GRESS CHAIN option was performed for testing purposes only. The bookkeeping of parameters and responses within ADGEN is performed by identifying which elements of y are parameters and which elements are potential responses. The parameters are identified by their row number of the adjoint matrix, variable name, parameter value, and the virtual memory location in a parameter dictionary. This information is used to assign the derivatives of a response with respect to the parameters in a format usable to the analyst. Appendix A is an example of this derivative identification format and lists a selection of the parameters identified for the PRESTO-II sample problem. Appendix C gives the derivatives of the response TBEQ with respect to the listed parameters. A comparison of computational times for solving the adjoint and direct sensitivity problems for the PRESTO-II sample problem is summarized in the next section.

IV.D. Comparison of ADGEN with the Direct Method

The adjoint matrix $(I - \partial F/\partial y)^{tr}$ in Eq. (20) is upper triangular by definition and the solution to Eq. (20) is obtained by back substitution. Although the solution is straightforward in principal, the fact that the adjoint matrix is upper triangular requires that the adjoint matrix is upper triangular requires that the entire matrix be saved to calculate derivative vector dy_i/dy. This is in contrast to the solution of the direct method of applying the chain rule, Eq. (6), for which dy/dx_i can be computed by forward substitution ((I- $\partial F/\partial y$) is lower triangular) and the element of (I- $\partial F/\partial y$) need only be stored for each row as $dy/d\alpha_i$ is solved. The solution of the adjoint equation, then, is storage intensive, but capable of determining the derivative of a single response with respect to all parameters. The direct chain method does not require the storage of (I- $\partial F/\partial y$) and solves for the derivatives of all responses with respect to a single parameter. The particular choice of the desired derivatives then dictates whether the use of the ADGEN or CHAIN option within GRESS is most appropriate for the particular problem of interest.

Both the ADGEN and CHAIN options were applied to the PRESTO-II sample problem. The adjoint matrix for this problem is 8,054,068 rows in size. ADGEN stores only the non-zero elements of the adjoint matrix with each element identified by its row and comumn number. Figure 1 is a plot of the matrix for the PRESTO-II sample problem with each marker representing a submatrix 2,000 x 2,000 in size with at least one non-zero element. The back substitution computation of dy_j/dy in Eq. (20) is performed by segmenting the solution of dy_j/dy to take advantage of the sparse nature of the adjoint matrix, and bringing into memory only a portion of the adjoint matrix at a time. This segmentation makes possible the calculation of dy_j/dy given system memory availability, although the cost of input and output of the adjoint matrix can become a sizable proportion of the overall solution cost as the available memory decreases. A comparison of computation times for the ADGEN and CHAIN options for the PRESTO-II sample problem are summarized in Table 5. The number of parameters (data) and responses for this problem both number in the thousands. Calculation of derivatives of all responses (thousands) with respect to two data values using the CHAIN option requires an increase in execution time from 44 seconds (Reference PRESTO-II) to 1,560 seconds (GRESS-enhanced PRESTO-II), a factor of 35.5. Conversely, calculation of derivatives of a single response with respect to all the data (thousands of parameters) requires 2,279 seconds (using ADGEN) for the first response. This time is that required to create the adjoint matrix (1,980 seconds) and to calculate derivatives (299 seconds). For each additional response of interest, 299 seconds are required to calculate derivatives of the response to all the data. The 2,279 seconds and 299 seconds represent factors of 51.8 and 6.8, respectively, over the referrence model run time. These factors clearly indicate that the adjoint approach using ADGEN is very cost effective compared to estimating derivatives by parameter perturbations. For evaluating the sensitivities of a large subset of the data base, ADGEN is orders of magnitude more cost effective than direct parameter perturbations.

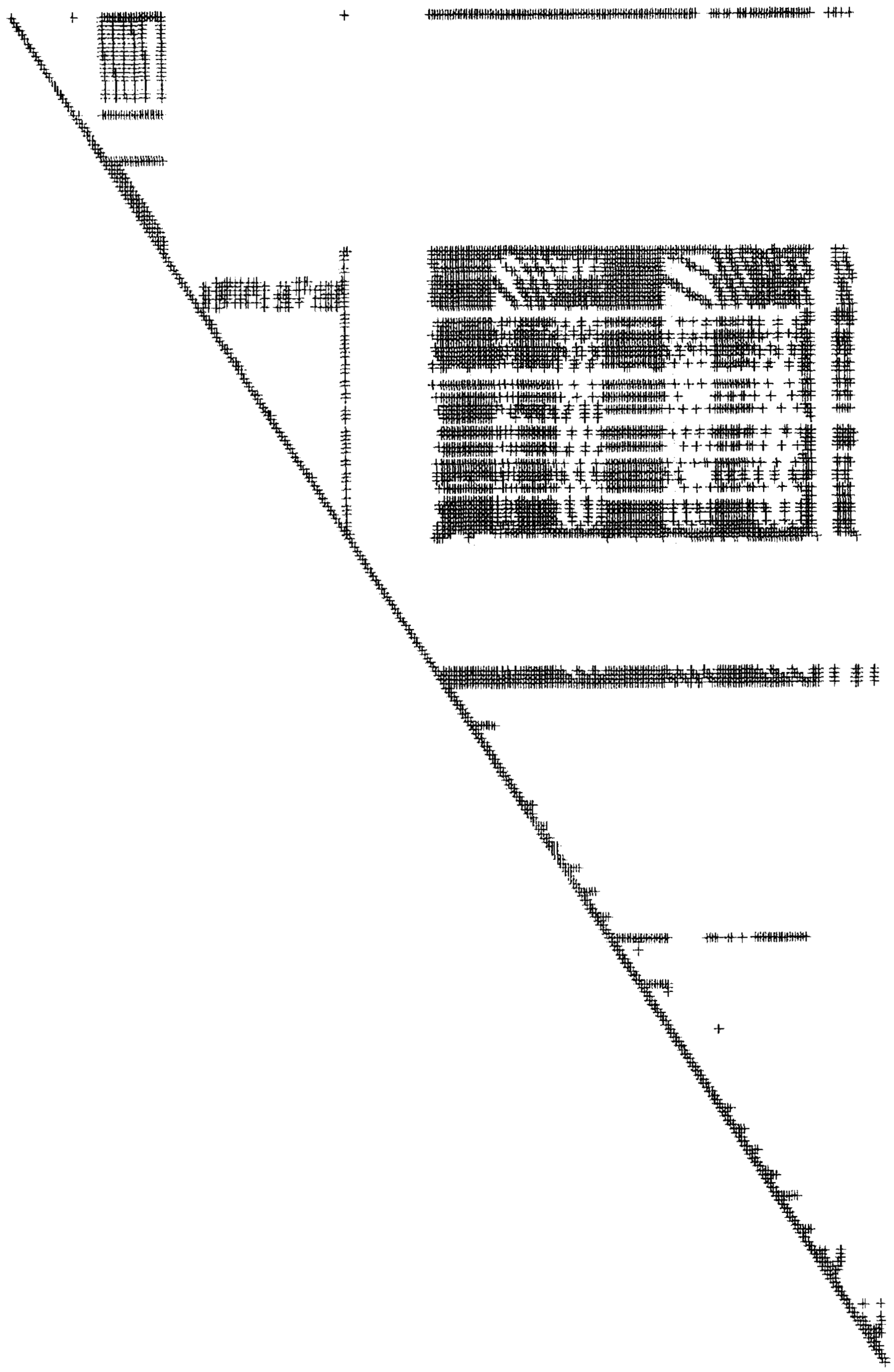

Fig. 1. Adjoint matrix structure for the PRESTO-II sample problem. Each cross denotes a 2,000 × 2,000 submatrix with at least one non-zero element.

Table 5. Comparison of execution times and storage requirements for derivative-enhancement of the PRESTO-II computer model by the GRESS direct approach and the ADGEN adjoint approach

PRESTO-II Reference Model		PRESTO-II, Derivative Enhancement	
Compilation Time, s	48	Precompilation Time, s	29
Link Time, s	3	Compilation Time, s	49
Run Time, s	44	Link Time, s	4

	Run Time (s)	Ratio to Reference
ADGEN		
Create Adjoint Matrix $(I - \partial f/dy)^{tr}$ [a]	1,980	45.0
Calculate Derivative of Response With Respect to 3000 Parameters	299	6.8
CHAIN		
Calculate Derivative of 8000 Responses With Respect to 2 Parameters	1,560	35.5
Calculate Derivative of 8000 Responses With Respect to 8 Parameters	1,816	41.3

[a]This matrix is created only once and can be used for calculating derivatives of one or more responses with respect to all the data or any subset thereof using the adjoint approach.

Note however, that the direct access storage requirements using the ADGEN system is quite large, evidenced by the 143.5 megabytes needed to store the adjoint matrix for the PRESTO-II sample problem.

The availability of both the ADGEN and CHAIN options allow the analyst to compute model derivatives and sensitivities for a wide range of applications. The CHAIN option is more suited for calculation of derivatives of many responses with respect to a limited number of input parameters. ADGEN is more suited for calculating derivatives of a few responses with respect to a large number of parameters. In either case, the first derivative and sensitivities are analytically exact and can be printed and/or saved by simple user instructions in addition to normal model results.

V. CONCLUSIONS AND RECOMMENDATIONS

Automated implementation of the adjoint method for calculating model derivatives and sensitivities into existing FORTRAN models using ADGEN has been tested and verified on a major model of interest to the low-level waste community. The potential for significant computational and manpower savings using ADGEN for problems with a large data base has been quantitatively demonstrated from the PRESTO-II sample problem results. The use of ADGEN is shown to produce the derivatives of a response of interest with respect to 3000 parameters in 2,279 seconds, a factor of 51.8 that of the reference run. This factor is to be compared with a factor of 3000 if the derivatives are obtained by direct perturbation. Moreover, once the adjoint matrix is created, the time required to calculate 3000 derivatives with respect to other responses of interest is 299 seconds, a factor of 6.8.

Major improvements are planned for subsequent versions of ADGEN. In particular, the storage requirements for the adjoint matrix can be significantly reduced if the elements of dy/dy that are not needed for subsequent calculation of the derivatives of interest are eliminated. Secondly, the vectors dy_j/dy for $j = 1, N$ can be solved in a fraction of the time required to solve for a single vector dy_j/dy N times by making maximum use of information each time segments of the adjoint matrix are brought into memory. Preliminary testing of these ideas has produced encouraging results.

VI. CURRENT ADGEN CONFIGURATION

The development of the ADGEN system involved three major efforts leading to the following products: (1) a new GRESS precompiler named EXAP, that includes the option to calculate derivatives using the original GRESS direct method or the option to calculate and store the forward matrix, (2) the TMAT and YSOLVE routines for solving the large, sparse linear system of equations defined by Eq. (20), and (3) an efficient "dictionary" for identification of the model data and results within the y vector and for identification of the corresponding derivatives dy_j/dy. Originally developed as a stand-alone system, ADGEN is now included within the GRESS Code Package. The GRESS system and the EXAP precompiler have been extensively tested on approximately 10 major models over the past several years. The ADGEN solution modules have undergone relatively much less testing and are not as user friendly at this point.

Computer manual documentation of ADGEN is included in the "GRESS Version 0.0 User's Manual." The GRESS 0.0 code package is available from the Radiation Shielding Information Center at Oak Ridge National Laboratory. A request form is included at the end of the report.

VII. TERMINOLOGY

ADGEN. ADjoint GENerator. That part of GRESS that automates calculation of derivatives using the adjoint method.

ADJOINT. Option flag in the EXAP precompiler for producing the adjoint matrix.

Adjoint Matrix. A direct access output data set containing partial derivatives identified by row and column number information. The data set is created by restructuring the forward matrix for reading sequentially from the last record to the first reconrd, and by replacing the virtual addresses with column and row number information.

CHAIN. Option flag in the EXAP precompiler for calculating derivatives by the direct sensitivity method using the chain rule.

Dependent Variable. Any program calculated real number variable whose value is at least partially determined by one or more independent variables.

Enhanced Model. The reference model enhanced for gradient calculation.

EXAP. EXtended Arithmatic Processor. The FORTRAN precompiler in GRESS that enhances a FORTRAN computer with (1) the capability to calculate derivatives by the direct method of chain rate application or (2) the capability to produce the adjoint matrix for subsequent calculation of derivatives by the adjoint method.

Forward Matrix. An output data set from an adjoint application containing partial derivatives identified by virtual address.

Forward Solution. The results that are obtained by running the code prior to precompilation.

GRESS. GRadient Enhanced Software System. The overall software system consisting of the EXAP precompiler, run-time library routines, and the TMAT and YSOLVE routines required by ADGEN.

Parameter. Any real number variable, input or calculated, that is explicitly declared to be a parameter.

Precompilation. A line-by-line translation of a FORTRAN program into an enhanced FORTRAN program.

Pseudo-code (P-code). A sequence of integers that specifies the mathematical relationship between the term on the LHS and the terms on the RHS for each equation.

Reference Model. The user's source code prior to enhancement with EXAP.

Response. Any program calculated real number selected by the user for gradient calculation.

REFERENCES

1. Tomovic, R. and Vukobratovic, M., **General Sensitivity Theory**, Elsevier North-Holland, Inc., New York (1972).

2. Stacey, W. M., **Variational Methods in Nuclear Reactor Physics**, Academic Press, New York (1974).

3. Greenspan, E., "Developments in Perturbation Theory," **Advances in Nuclear Science and Technology**, Vol. 9, Academic Press, New York (1976).

4. Oblow, E. M., "Sensitivity Theory for Reactor Thermal-Hydraulics Problems," **Nucl. Sci. Eng.**, **68**, 322 (1978).

5. Frank, P. M., **Introduction to System Sensitivity Theory**, Academic Press, New York (1978).

6. Cacuci, D. G., **J. Math. Phys.** (NY), **22**, 2794 (1981).

7. Cacuci, D. G., **J. Math. Phys.** (NY), **22**, 2803 (1981).

8. Weisbin, C. R. et al, "Sensitivity and Uncertainty Analysis of Reactor Performance Parameters," **Advances in Nuclear Science and Technology**, Vol. 14, Plenum Press, New York (1982).

9. Oblow, E. M., "An Automated Procedure for Sensitivity Analysis Using Computer Calculus," ORNL/TM-8776, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1983.

10. Oblow, E. M., "GRESS, Gradient-Enhanced Software System," ORNL/TM-9658, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1985.

11. Oblow, E. M., F. G. Pin, R. Q. Wright, "Sensitivity Analysis Using Computer Calculus: A Nuclear Waste Isolation Application," **Nucl. Sci.**,**94**, 46 (1986).

12. Worley, B. A., R. Q. Wright, F. G. Pin, W. V. Harper, "Application of an Automated Procedure for Adding a Comprehensive Sensitivity Calculation Capability to the ORIGEN2 Point Depletion and Radioactivity Decoy Code," **Nucl. Sci. Eng.**, **94**, 180 (1986).

13. Pin, F. G., B. A. Worley, E. M. Oblow, R. Q. Wright, W. V. Harper, "An Automated Sensitivity Analysis Procedure for the Performance Assessment of Nuclear Waste Isolation Systems," **Nucl. and Chem. Waste Man.**, **6**, 255 (1986).

14. Worley, B. A., R. Q. Wright, F. G. Pin, "A Finite-Line Heat Transfer Code with Automated Sensitivity-Calculation Capability," ORNL/TM-9975, Oak Ridge, Tennessee (1986).

15. Worley, B. A. and J. E. Horwedel, "A Waste Package Performance Assessment Code with Automated Sensitivity-Calculation Capability," ORNL/TM-9976, Oak Ridge, Tennessee (1986).

16. Horwedel, J. E., Worley, B. A., Oblow, E. M., Pin, F. G., and Wright, R. Q., "GRESS Version 0.0 User's Manual," ORNL/TM-10835, Oak Ridge National Laboratory (1988).

17. Pin, F. G. and E. M. Oblow, "Sensitivity Analysis of Predictive Models with an Automated Adjoint Generator," Proceedings of Ninth Annual DOE Low-Level Waste Management Conference, Denver, CO, August 25-27, 1987.

18. Pin, F. G., E. M. Oblow, J. E. Horwedel, and J. L. Lucius, "ADGEN: An Automated Adjoint Code Generator for Large-Scale Sensitivity Analysis," paper to be presented at Am. Nuc. Soc. Winter Mtg., Los Angeles, California, Nov. 1987.

19. Horwedel, J. E., F. G. Pin, B. A. Worley, and E. M. Oblow, "EXAP-Precompiler for the GRESS and ADGEN Automated Sensitivity Calculation Systems." To be published in the Proceedings of the Annual Meeting of the American Nuclear Society, San Diego, California, June 12-16, 1988.

20. Fields, D. E., et al., "PRESTO-II: A Low-Level Waste Environmental Transport and Risk Assessment Code," ORNL-5970, Oak Ridge National Laboratory, Oak Ridge, TN (1986).

APPENDIX A

PRESTO-II SAMPLE PROBLEM INPUT

** INPUT DATA AS READ IN **

```
BARNWELL -- 40 NUCLIDES
BARNWELL SC
 1000   40    1  100  200    1    1    0 1000  100    0    0    1    1 1000
    4  000    0
      .01        .1       1.0       1.0       1.0       0.0       0.0       0.0
    1.130    1002.3         0      33.2
      .56       .60       .64       .70       .68       .65       .65       .65
      .61       .66       .64       .69
      8.0       9.3      12.9      18.0      22.3      25.9      27.1      26.7
     23.7      18.2      12.4       8.4
      3.1       3.3       5.8      10.3      15.5      19.2      21.2      21.2
     18.5      12.5       6.7       2.6
    9150.       6.7       1.5       0.4        2.         0       1.0       .09
     43.3
      2.4      914.      2.15        25       0.3       0.4       0.4      43.3
       1.       .01        .4       .01     8000.      300.       .01
      .49    7.7E-9    1.0E-6     -.15   1.0E-11       0.0       0.0
    1    2
     250.       .23      0.27       .30       .30       1.0
       .4       1.6      5300     305.0      0.01
     914.       .05
      .19       .53      240.     .0021      720.     1440.
        0     2160.       24.     1440.      336.      336.       .77       .94
      50.        6.       48.       96.      480.       9.9        1.
      .73      .015       60.        8.       50.
     190.      190.      110.        0.       95.      370.     8000.     7033.
H-3          34499.    3.4E-4         0         0   5.64E-2
H-3            0.01      0.01      0.01      0.01
H-3            0.20      0.25    4.8E-0    4.8E-0    1.0E-2    1.7E-1    1.2E-2
C-14            9.5    9.5E-8                       1.21E-4
C-14           0.01      0.01      0.01      0.01
C-14           0.20      0.25    5.5E-0    5.5E-0    1.2E-2    1.0E-1    3.1E-2
MN-54         9737.    9.7E-5         0         0   8.09E-1    1.5E+2
MN-54           150       150       150       150
MN-54          0.20      0.25    2.5E-1    5.0E-2    2.5E-4    2.5E-4    8.0E-4
FE-55        65672.    6.6E-4                       2.57E-1
```

FE-55	55.	55.	55.	55.			
FE-55	0.20	0.25	4.0E-3	1.0E-3	1.2E-3	1.3E-4	4.0E-2
NI-59	0.0				8.66E-6		
NI-59	150	150	150	150			
NI-59	0.20	0.25	6.0E-2	6.0E-2	6.7E-3	6.7E-3	5.3E-2
CO-60	432755.	4.3E-3	0.	0.	1.32E-1	100.	
CO-60	55.	55.	55.	55.			
CO-60	0.20	0.25	9.4E-3	9.4E-3	1.0E-3	1.0E-3	1.3E-2
NI-63	11029.	1.1E-4			6.29E-3		
NI-63	150.	150.	150.	150.			
NI-63	0.20	0.25	6.0E-2	6.0E-2	6.7E-3	6.7E-3	5.3E-2
ZN-65	7613.	7.6E-5			1.04E-0		
ZN-65	16.	16.	16.	16.			
ZN-65	0.20	0.25	1.5E+0	9.0E-1	3.9E-2	3.9E-2	3.0E-2
KR-85	1682.	1.7E-5			6.47E-2		
KR-85	0.	0.	0.	0.			
KR-85	.20	0.25	0.	0.	2.0E-2	2.0E-2	2.0E-2
SR-90	2617.	2.6E-5			2.42E-2		
SR-90	27.	27.	27.	27.			
SR-90	.20	.25	2.5E+0	2.5E-1	8.0E-4	1.4E-2	6.0E-4
Y-90	2617.	2.6E-5			2.42E-2		
Y-90	27.	27.	27.	27.			
Y-90	.20	.25	2.5E+0	2.5E-1	8.0E-4	1.4E-2	6.0E-4
NB-94	0.0				3.47E-5		
NB-94	350.	350.	350.	350.			
NB-94	0.20	0.25	2.0E-2	5.0E-3	2.5E-3	2.5E-3	2.5E-3
TC-99	61.	6.1E-7			3.25E-6		
TC-99	0.033	0.033	0.033	0.033			
TC-99	0.20	0.25	9.5E-0	1.5E+0	2.5E-2	2.5E-2	4.0E-1
RU-106	0.0				6.89E-1		
RU-106	220.	220.	220.	220.			
RU-106	0.20	0.25	7.5E-2	2.0E-2	1.0E-6	1.0E-6	1.0E-6
CD-109	16.	1.6E-7			5.45E-1		
CD-109	6.7	6.7	6.7	6.7			
CD-109	0.20	0.25	5.5E-1	1.5E-1	1.3E-4	1.3E-4	5.3E-4
SB-125	2.7	2.7E-8			2.50E-1		
SB-125	45.	45.	45.	45.			
SB-125	0.20	0.25	2.0E-1	3.0E-2	1.5E-3	1.5E-3	4.0E-3

I-125	0.0				4.22E-0		
I-125	0.01	0.01	0.01	0.01			
I-125	0.20	0.25	1.0E+0	1.0E+0	6.0E-3	6.0E-2	6.0E-2
I-129	0.0				4.08E-8		
I-129	0.01	0.01	0.01	0.01			
I-129	0.20	0.25	1.0E+0	1.0E+0	6.0E-3	6.0E-2	6.0E-2
CS-134	37069.	3.7E-4	0.	0.	3.36E-1	300.	
CS-134	1100.	1100.	1100.	1100.			
CS-134	0.20	0.25	1.0E-2	1.0E-2	1.2E-2	3.0E-1	4.0E-3
CS-137	289403.	2.9E-3	0.	0.	2.31E-2	300.	
CS-137	1100.	1100.	1100.	1100.			
CS-137	0.20	0.25	1.0E-2	1.0E-2	1.2E-2	3.0E-1	4.0E-3
BA-137M	289403.	2.9E-3	0.	0.	2.31E-2	300.	
BA-137M	1100.	1100.	1100.	1100.			
BA-137M	0.20	0.25	1.0E-2	1.0E-2	1.2E-2	3.0E-1	4.0E-3
CE-141	547.	5.5E-6			7.78E-0		
CE-141	1100.	1100.	1100.	1100.			
CE-141	0.20	0.25	1.0E-2	4.0E-3	1.0E-4	1.0E-4	1.2E-3
CE-144	2160.	2.2E-5			8.90E-1		
CE-144	1100.	1100.	1100.	1100.			
CE-144	0.20	0.25	1.0E-2	4.0E-3	1.0E-4	1.0E-4	1.2E-3
PM-147	179.	1.8E-6			2.64E-1		
PM-147	61.	61.	61.	61.			
PM-147	0.20	0.25	1.0E-2	4.0E-3	5.0E-6	5.0E-6	4.8E-3
RE-187	1.5	1.5E-8			1.47E-11		
RE-187	7.5	7.5	7.5	7.5			
RE-187	0.20	0.25	1.5E+0	3.5E-1	2.5E-2	2.5E-2	8.0E-3
PB-210	22.	2.2E-7			3.11E-2		
PB-210	540.	540.	540.	540.			
PB-210	0.20	0.25	1.0E-5	1.0E-5	1.0E-5	1.0E-5	1.0E-5
RA-226	0.6	6.0E-9			4.34E-4		
RA-226	220.	220.	220.	220.			
RA-226	0.20	0.25	1.5E-2	1.5E-3	1.5E-2	1.5E-2	3.4E-2
TH-232	1.3	1.3E-8			4.93E-11		
TH-232	6.0E4	6.0E4	6.0E4	6.0E4			
TH-232	0.20	0.25	1.0E-5	1.0E-5	1.0E-5	1.0E-5	1.0E-5
U-233	0.0				4.28E-6		
U-233	45.	45.	45.	45.			

U-233	0.20	0.25	1.0E-5	1.0E-5	1.0E-5	1.0E-5	1.0E-5
U-234	3.0	3.0E-8			2.83E-6		
U-234	45.	45.	45.	45.			
U-234	0.20	0.25	1.0E-5	1.0E-5	1.0E-5	1.0E-5	1.0E-5
U-235	3.5	3.5E-8			9.85E-10		
U-235	45.	45.	45.	45.			
U-235	0.20	0.25	1.0E-5	1.0E-5	1.0E-5	1.0E-5	1.0E-5
U-236	0.5	5.0E-9			2.96E-8		
U-236	45.	45.	45.	45.			
U-236	0.20	0.25	1.0E-5	1.0E-5	1.0E-5	1.0E-5	1.0E-5
U-238	3063.	3.1E-5			1.55E-10		
U-238	45.	45.	45.	45.			
U-238	0.20	0.25	1.0E-5	1.0E-5	1.0E-5	1.0E-5	1.0E-5
PU-238	0.2	2.0E-9			7.90E-3		
PU-238	1800.	1800.	1800.	1800.			
PU-238	0.20	0.25	4.5E-4	4.5E-5	1.5E-6	1.5E-6	8.0E-3
PU-239	0.1	1.0E-9			2.87E-5		
PU-239	1800.	1800.	1800.	1800.			
PU-239	0.20	0.25	4.5E-4	4.5E-5	1.5E-6	1.5E-6	8.0E-3
PU-241	0.0				5.25E-2		
PU-241	1800.	1800.	1800.	1800.			
PU-241	0.20	0.25	4.5E-4	4.5E-5	1.5E-6	1.5E-6	8.0E-3
AM-241	0.0				1.51E-3		
AM-241	810.	810.	810.	810.			
AM-241	0.20	0.25	5.5E-3	2.5E-4	0.	0.	
PU-242	0.0				1.83E-6		
PU-242	1800.	1800.	1800.	1800.			
PU-242	0.20	0.25	4.5E-4	4.5E-5	1.5E-6	1.5E-6	8.0E-3
AM-243	0.0				8.72E-5		
AM-243	810.	810.	810.	810.			
AM-243	0.20	0.25	5.5E-3	2.5E-4	0.	0.	
CM-243	0.0				2.7E-2		
CM-243	3300.	3300.	3300.	3300.			
CM-243	0.20	0.25	8.5E-4	1.5E-5			

1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	6	0	0	0	0	0	0	0	10	2	0	0	2	12	0	0	0	0	0	0	0	0	0	0	0
1	7	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	20	30	35	60	27	0	0	0	0

1	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	35	35	73	27	43	45
1	13	22	12	2	0	17	5	17	48	27	2	12	35	10	48	53	5	0	0	0	0	0	0	0	0
1	17	0	0	0	2	0	0	0	0	2	68	38	12	0	0	0	0	0	0	0	0	0	0	0	0
1	19	0	0	0	0	0	0	0	5	124	124	129	124	43	5	5	5	2	5	10	10	22	22	30	5
1	20	2	12	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	17	12	12	22
1	25	20	30	43	60	60	48	165	68	5	5	20	5	17	17	17	17	99	99	2	30	114	20	0	5
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	5	20	12
2	2	20	12	5	10	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	9	0	5	5	5	10	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	13	0	0	0	0	0	0	0	0	10	30	43	0	0	0	0	0	0	0	0	0	0	0	0	0
2	16	0	0	0	0	0	0	0	0	0	0	5	5	2	12	5	10	2	0	0	0	0	0	0	0
2	18	0	0	5	43	17	48	0	0	0	5	12	2	2	5	2	2	2	0	0	0	0	0	0	0
2	28	0	0	0	0	0	0	0	10	2	5	5	2	2	0	2	5	10	10	2	2	2	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3	0	22	60	43	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12	10	10	2	2
3	8	2	0	0	0	2	2	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	9	0	0	0	0	0	0	0	0	0	0	0	0	2	2	43	63	111	71	38	10	5	5	0	0
3	10	0	2	2	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	12	0	0	0	0	0	0	0	0	17	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	14	0	0	0	0	0	0	0	0	27	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	25	0	0	48	2	12	71	2	0	10	2	0	0	0	0	2	5	12	162	175	81	20	0	0	0
3	26	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43	27	0	2	2	5
4	12	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	13	2	0	0	0	106	200	165	78	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	18	0	0	0	0	0	0	0	0	0	0	0	0	12	2	0	0	0	0	0	0	0	0	0	0
4	19	0	0	0	12	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	25	0	0	0	0	0	0	10	12	20	10	104	38	2	0	0	0	43	5	27	2	0	0	0	0
4	26	0	0	0	0	0	0	0	0	0	0	0	2	5	5	53	2	2	0	0	0	0	0	0	0
4	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	162	35	0
5	1	0	0	0	0	0	0	0	0	0	2	86	73	2	0	0	0	0	0	0	0	0	0	0	0
5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	27	10	55	27	20
5	4	0	0	0	0	0	0	0	0	0	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0
5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	22	20	2	2	0	0	0	0

5	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12	10	0	0
5	9	0	0	0	0	0	0	0	53	167	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	18	0	0	0	0	0	0	0	0	0	0	0	0	71	10	0	0	0	0	0	0	0	0	0	0
5	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	5	0	0	0	0	0	0	0	0
6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	3	0	0	0	0	0	0	0	0	0	0	0	0	5	10	5	0	0	0	0	0	0	0	231	5
6	5	0	0	0	0	0	0	0	12	0	0	0	0	0	27	10	0	0	0	0	0	0	0	0	0
6	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	71	0	0	17	121	0	0	0	10	2	0
6	26	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
6	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0
7	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53	0	0	0	0	0
7	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	5	0	0
7	15	0	0	0	0	0	0	0	0	0	0	0	0	0	99	17	180	91	2	0	0	0	0	0	0
7	16	2	0	0	0	2	10	10	2	5	0	0	0	0	5	10	0	0	0	0	0	0	0	0	0
7	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0
7	27	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0
8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
8	3	0	0	0	0	0	17	0	0	0	0	0	0	0	0	10	12	0	0	0	0	0	0	0	0
8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88	2	0	2	0	0	0	0	0	0
8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55	0	0	0	0	0	0	0	0	0
8	6	0	0	0	0	0	0	0	0	2	5	0	0	0	20	0	0	0	0	0	0	0	0	0	0
8	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	5	0	0	0	0	0	0	0
8	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	10	0	0
8	14	0	0	0	0	0	0	0	0	0	0	0	10	2	0	0	0	0	0	0	0	0	0	0	0
8	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	180	5	0	0	0	0	0	0
8	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0
8	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	2	0	0	0	0	0	0	0
8	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	142	167	0	0	0	0	0	0	0
8	31	0	0	0	0	0	0	0	0	0	0	0	0	0	431	35	0	45	2	0	309	114	0	0	0
9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
9	3	0	35	45	71	276	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	23	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
9	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2

```
 9 30   0  0  0 10 10  2  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
10  1   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
10 13   0  0  0  0  0  0  0  0  0  0  0  0  0  0330 43  2  0 12  0  0  0  0  5
10 14   0  0  2  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
11  1   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
11  7   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 10 45  2  5 10  5 10
11  8   2  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
11 17   0  0  0  0  0  0  0  0  0  0  0  0  0  5  0  0  0  0  0  0  0  0  0  0
11 27   0  0  0  0  0  0  0 12 53 45 20  2  0  0  0 10 20  0  0  2  2 10  2  2
11 28   0  0  2  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
11 29   0  0  2  0  0  0  0  0  2  5 45 78 86 60 30  5 55 43 38 38 10 17 10  2
11 30   0  0  0  2  0  0  0  0  0  0  0  0  0  0  0  2 12  0 10  0  2  0  2  0
12  1   2  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
12  4   0  0  0  0  0  0  0  0  2  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
12  5   0  0  2  5  0  5  0  0  0  2  0  0  0  0  0  0  0  0  0  0  0  0  0  0
12  9   0  0  0  0  0  0  0  0  0  0  0 20 12  0  0  0  0  0  0  0  0  0  0  0
12 16   0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 17
12 21   0  0  0  0  0 30  2  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
12 24   0  0  0  0  0  0 63 88 73 22 20 17 27  5  0  2  0  0  0  0  0  0  0  0
99
BARNWELL SIMULATION, WELL AT 914 M, XG=8000 M, SOAM=E-8
 &INPUT ILOC=1,JLOC=1,ILET=1,1,DTABLE=0,0,0,0,0,3,3,
 RTABLE=0,0,0,0,0,3,3,OUTPUT=.FALSE.,&END
 &ORGAN NORGN=18,ORGN='R MAR   ','ENDOST  ','*PUL*    ',
 'MUSCLE  ','LIVER    ','S WALL  ','PANCREAS','LLI WALL',
 'KIDNEYS ','BL WALL ','ULI WALL','SI WALL ','OVARIES ',
 'TESTES  ','SPLEEN  ','UTERUS  ','THYMUS  ','THYROID ',
 TIME=70,70,70,70,70,70,70,70,70,70,70,70,70,70,70,70,70,70,&END
 &QFACTR HLET=20,20,20,20,20,20,20,20,20,20,20,20,20,20,20,20,20,20,
 LLET=1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,&END
 &CANCER NCANC=18,CANC='R MARROW','ENDOST  ','PULMNARY','BREAST  ',
                       'ST WALL ','PANCREAS','LLI WALL','KIDNEYS ',
                       'BL WALL ','ULI WALL','SI WALL ','OVARIES ',
                       'TESTES  ','SPLEEN  ','UTERUS  ',
                       'THYMUS  ','THYROID ','LIVER   ',
 RELABS=1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,&END
 &GENTIC GENEFF=.TRUE.,GEN='TESTES  ','OVARIES ','AVERAGE ',
 NGEN=3,GRFAC=200,20000,REPPER=.014133,GLLET=1,1,1,
```

```
GHLET=20,20,20,&END
&RNUCLD NONCLD=40,
NUCLID='H-3','C-14','MN-54','FE-55','NI-59','CO-60','NI-63',
  'ZN-65','KR-85','SR-90','Y-90','NB-94','TC-99','RU-106',
  'CD-109','SB-125','I-125','I-129','CS-134','CS-137','BA-137M',
  'CE-141','CE-144','PM-147','RE-187','PB-210','RA-226',
  'TH-232','U-233','U-234','U-235','U-236','U-238','PU-238',
  'PU-239','PU-241','AM-241','PU-242','AM-243','CM-243',
PSIZE=  0,  0,1.0,1.0,1.0,1.0,1.0,1.0, 0 ,1.0,1.0,1.0,1.0 ,1.0,
       1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,
       1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,
RESP=' ',' ','W','W','W','Y','W','Y','*',
  'Y','Y','Y','W','Y',
  ' ','W','D','D','D','D','D',
  'Y','Y','Y',' ','W','W','W',
  'Y','Y','Y','Y','Y','Y','Y','Y',
  'Y','Y','Y','Y',
GIABS=
        0.0, 9.5E-1,0.0,0.0,
        0.0, 9.5E-1,0.0,0.0,
        0.0, 1.0E-1,0.0,0.0,
        0.0, 1.0E-1,0.0,0.0,
        0.0, 5.0E-2,0.0,0.0,
        0.0, 5.0E-2,0.0,0.0,
        0.0, 5.0E-2,0.0,0.0,
        0.0, 5.0E-1,0.0,0.0,
        0.0,  0.0  ,0.0,0.0,
        0.0, 1.0E-2,0.0,0.0,
        0.0, 1.0E-2,0.0,0.0,
        0.0, 1.0E-2,0.0,0.0,
        0.0, 8.0E-1,0.0,0.0,
        0.0, 5.0E-2,0.0,0.0,
        0.0,  0.0  ,0.0,0.0,
        0.0, 2.0E-1,0.0,0.0,
        0.0, 9.5E-1,0.0,0.0,
        0.0, 9.5E-1,0.0,0.0,
        0.0, 9.5E-1,0.0,0.0,
        0.0, 9.5E-1,0.0,0.0,
```

```
        0.0, 9.5E-1,0.0,0.0,
        0.0, 3.0E-4,0.0,0.0,
        0.0, 3.0E-4,0.0,0.0,
        0.0, 3.0E-4,0.0,0.0,
        0.0,  0.0  ,0.0,0.0,
        0.0, 2.0E-1,0.0,0.0,
        0.0, 1.0E-1,0.0,0.0,
        0.0, 2.0E-1,0.0,0.0,
        0.0, 2.0E-1,0.0,0.0,
        0.0, 2.0E-3,0.0,0.0,
        0.0, 2.0E-3,0.0,0.0,
        0.0, 2.0E-3,0.0,0.0,
        0.0, 2.0E-3,0.0,0.0,
        0.0, 2.0E-3,0.0,0.0,
        0.0, 1.0E-3,0.0,0.0,
        0.0, 1.0E-4,0.0,0.0,
        0.0, 1.0E-3,0.0,0.0,
        0.0, 1.0E-3,0.0,0.0,
        0.0, 1.0E-3,0.0,0.0,
        0.0, 1.0E-3,0.0,0.0,
 &END
 &LOCTBL NTLOC=0,RNLOC='SUM     ',
 OGLOC='SUM     ',
 PTLOC=7,FALOC=1,HLLOC=1,LTABLE=3,&END
 &ORGANF NORGB=18,ORGB='R MAR   ','ENDOST  ','*PUL*   ',
 'MUSCLE  ','LIVER   ','S WALL  ','PANCREAS','LLI WALL',
 'KIDNEYS ','BL WALL ','ULI WALL','SI WALL ','OVARIES ',
 'TESTES  ','SPLEEN  ','UTERUS  ','THYMUS  ','THYROID ',
 IPATH=5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,
 ORGDAT=.1559,.0147,.2908,.1908,.0746,.0415,.0581,.0332,.0166,.0166,
 .0166,.0083,.0083,.0083,.0083,.0083,.0083,.0405,&END

DECLARING VARIABLE   32462 AS PARAMETER     1

DECLARING VARIABLE   32463 AS PARAMETER     2

DECLARING VARIABLE   32477 AS PARAMETER     3
```

PRESTO-II: A MODEL FOR PREDICTING THE MIGRATION OF RADIOACTIVE WASTES
FROM SHALLOW TRENCH BURIAL SITES
RSIC PACKAGE CCC-504, 1987 RELEASE

BARNWELL -- 40 NUCLIDES

*** CONTROL INFORMATION ***

THE BURIAL SITE IS LOCATED AT BARNWELL SC
THE SIMULATION WILL RUN FOR 1000 YEARS AND WILL INCLUDE 40 NUCLIDES
LEACHING OPTION NUMBER 1 WILL BE USED
IN YEAR 100 ,0.01 OF THE CAP WILL BE ASSUMED TO FAIL
    THIS WILL CONTINUE UNTIL 0.10 HAS FAILED IN YEAR 200
CAP MAY ALSO FAIL BY SURFACE EROSION
VERTICAL WATER VELOCITY WILL BE CALCULATED USING INFILTRATION AND POROSITY
LENGTH OF VERTICAL SATURATED ZONE WILL BE CALCULATED USING INFILTRATION AND POROSITY
POPULATION INDICATOR IS 1
    GENERAL POPULATION EXPOSURE WILL BE USED TO CALCULATE HEALTH EFFECTS
1.000 OF IRRIGATION WATER WILL BE GOTTEN FROM WELL
1.000 OF DRINKING WATER FOR ANIMALS WILL BE GOTTEN FROM WELL
1.000 OF DRINKING WATER FOR HUMANS WILL BE GOTTEN FROM WELL
0.000 OF IRRIGATION WATER WILL BE GOTTEN FROM STREAM
0.000 OF DRINKING WATER FOR ANIMALS WILL BE GOTTEN FROM STREAM
0.000 OF DRINKING WATER FOR HUMANS WILL BE GOTTEN FROM STREAM
TRENCH CAP INFILTRATION WILL BE CALCULATED FROM HOURLY PRECIPITATION

*** CLIMATIC INFORMATION ***

THE AVERAGE ANNUAL PRECIPITATION IS 1.130 METERS
THE AVERAGE ATMOSPHERIC PRESSURE IS 1002.30 MBAR
THE LATITUDE OF THE SITE IS 33.20

MONTH	FRACTION OF SUNSHINE	AVERAGE TEMP C	AVG DEW POINT TEMP C
JAN	.56	8.00	3.10
FEB	.60	9.30	3.30
MAR	.64	12.90	5.80
APR	.70	18.00	10.30
MAY	.68	22.30	15.50
JUN	.65	25.90	19.20
JUL	.65	27.10	21.20
AUG	.65	26.70	21.20
SEP	.61	23.70	18.50
OCT	.66	18.20	12.50
NOV	.64	12.40	6.70
DEC	.69	8.40	2.60

*** TRENCH INFORMATION ***

THE TRENCH HAS AN AREA OF 0.9150E+04 SQUARE METERS AND A DEPTH OF 0.6700E+01 METERS
TRENCH POROSITY IS 0.40
TRENCH CAP PERMEABILITY IS 43.300 METERS PER YEAR

*** AQUIFER INFORMATION ***

THE GROUND WATER HAS A VELOCITY OF 2.150 METERS PER YEAR
TRENCH TO AQUIFER DISTANCE IS 2.4 METERS
TRENCH TO WELL DISTANCE IS 914.00 METERS
THE AQUIFER THICKNESS IS 25.00 METERS
THE AQUIFER DISPERSION ANGLE IS 0.3000 RADIANS
POROSITY OF THE AQUIFER REGION IS 0.40000
POROSITY BENEATH THE TRENCH IS 0.40000
PERMEABILITY BENEATH THE TRENCH IS 43.300 METERS/YEAR

*** ATMOSPHERIC INFORMATION ***

SOURCE HEIGHT IS 1.0 METERS
VELOCITY OF GRAVITATION FALL IS 0.01 METERS/SECOND
WIND VELOCITY IS 0.40 METERS/SECOND
DEPOSITION VELOCITY IS 0.01 METERS/SECOND
GAUGE DISTANCE FROM SOURCE IS 8000.00 METERS
LID HEIGHT IS 300.00 METERS
HOSKER ROUGHNESS FACTOR IS 0.01
TYPE OF STABILITY FORMULATION IS 1
STABILITY CLASS IS 2
FRACTION OF TIME WIND BLOWS TOWARD POPULATION IS 0.490000
NORMALIZED DOWN WIND ATMOSPHERIC EXPOSURE IS 7.7000E-09 CI/M**3 PER CI/SEC
RESUSPENSION FACTOR PARAMETERS 0.1000E-05 -0.1500E+00 0.1000E-10
FROM YEAR 0 TO YEAR 0 THE RESUSPENSION RATE DUE TO MECHANICAL DISTURBANCES WILL BE 0.0000
THIS WILL OCCUR DURING 0.00 OF EACH YEAR

*** SURFACE INFORMATION ***

PARAMETERS FOR UNIVERSAL LOSS EQUATION

RAINFALL	250.00
ERODIBILITY	0.23
STEEPNESS-SLOPE	0.27
COVER	0.30
EROSION CONTROL	0.30
DELIVERY RATIO	1.00

SOIL POROSITY IS 0.40000
SOIL BULK DENSITY IS 1.60000 G/CC
RUNOFF FRACTION IS 0.05000

STREAM FLOW RATE IS 5.3000E+03 CUBIC METERS PER YEAR
CROSS SLOPE EXTENT OF SPILLAGE IS 305.00 METERS
ACTIVE SOIL DEPTH IS 0.01 METERS
AVERAGE DOWN SLOPE DISTANCE TO STREAM IS 914.00 METERS

*** AIR-FOODCHAIN INFORMATION ***

AGRICULTURAL PRODUCTIVITY FOR GRASS 0.19 KG/M**2
AGRICULTURAL PRODUCTIVITY FOR VEGETATION 0.53 KG/M**2
SURFACE DENSITY FOR SOIL 240.00 KG/M**2
WEATHER DECAY CONSTANT 0.00 1/HOURS
PERIOD PASTURE GRASS EXPOSURE GROWING SEASON 720.00 HOURS
PERIOD CROP/VEGETATION EXPOSURE GROWING SEASON 1440.00 HOURS
PERIOD BETWEEN HARVEST PASTURE GRASS AND INGESTION BY ANIMAL 0.00 HOURS
PERIOD BETWEEN STORED FEED AND INGESTION BY ANIMAL 2160.00 HOURS
PERIOD BETWEEN HARVEST LEAFY VEGETABLES AND INGESTION BY MAN(M.I.E.) 24.00 HOURS
PERIOD BETWEEN HARVEST PRODUCE AND INGESTION BY MAN(M.I.E.) 1440.00 HOURS
PERIOD BETWEEN HARVEST LEAFY VEG AND INGESTION BY MAN(G.P.E.) 336.00 HOURS
PERIOD BETWEEN HARVEST PRODUCE AND INGESTION BY MAN(G.P.E.) 336.00 HOURS
FRACTION OF YEAR ANIMALS GRAZE ON PASTURE 0.77
FRACTION OF DAILY FEED THAT IS FRESH GRASS 0.94
AMOUNT OF FEED CONSUMED BY CATTLE 50.00 KG
AMOUNT OF FEED CONSUMED BY GOATS 6.00 KG
TRANSPORT TIME FEED-MILL-RECEPTOR FOR M.I.E. 48.00 HOURS
TRANSPORT TIME FEED-MILL-RECEPTOR FOR G.P.E. 96.00 HOURS
TIME FROM SLAUGHTER OF MEAT TO CONSUMPTION 480.00 HOURS
ABSOLUTE HUMIDITY OF THE ATMOSPHERE 9.90 G/M**3
FRACTIONAL EQUILIBRIUM RATIO FOR C-14 1.00

*** WATER-FOODCHAIN INFORMATION ***

FRACTION OF YEAR CROPS ARE IRRIGATED 0.73
IRRIGATION RATE 0.01 L/(M**2-H)
AMOUNT OF WATER CONSUMED BY COWS 60.00 L/D
AMOUNT OF WATER CONSUMED BY GOATS 8.00 L/D
AMOUNT OF WATER CONSUMED BY BEEF CATTLE 50.00 L/D

*** HUMAN INGESTION AND INHALATION RATE INFORMATION ***

ANNUAL INTAKE OF LEAFY VEG 190.00 KILOGRAMS PER YEAR
ANNUAL INTAKE OF PRODUCE 190.00 KILOGRAMS PER YEAR
ANNUAL INTAKE OF COW'S MILK 110.00 LITERS PER YEAR
ANNUAL INTAKE OF GOAT'S MILK 0.00 LITERS PER YEAR
ANNUAL INTAKE OF MEAT 95.00 KILOGRAMS PER YEAR
ANNUAL INTAKE OF DRINKING WATER 370.00 LITERS PER YEAR
ANNUAL INHALATION RATE OF AIR 8000.00 CUBIC METERS PER YEAR
A POPULATION OF 7033. WILL BE CONSIDERED

*** NUCLIDE INFORMATION ***

INFORMATION ON INDIVIDUAL NUCLIDES

NUCLIDE	AMT IN TRENCH CI	SPILLAGE CI	STREAM AMT CI	AMT IN AIR CI	DECAY CONST 1/Y	SOLUBILITY CONST G/ML
H-3	3.4499E+04	3.4000E-04	0.0000E+00	0.0000E+00	5.6400E-02	0.0000E+00
C-14	9.5000E+00	9.5000E-08	0.0000E+00	0.0000E+00	1.2100E-04	0.0000E+00
MN-54	9.7370E+03	9.7000E-05	0.0000E+00	0.0000E+00	8.0900E-01	1.5000E+02
FE-55	6.5672E+04	6.6000E-04	0.0000E+00	0.0000E+00	2.5700E-01	0.0000E+00
NI-59	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	8.6600E-06	0.0000E+00
CO-60	4.3276E+05	4.3000E-03	0.0000E+00	0.0000E+00	1.3200E-01	1.0000E+02
NI-63	1.1029E+04	1.1000E-04	0.0000E+00	0.0000E+00	6.2900E-03	0.0000E+00
ZN-65	7.6130E+03	7.6000E-05	0.0000E+00	0.0000E+00	1.0400E+00	0.0000E+00
KR-85	1.6820E+03	1.7000E-05	0.0000E+00	0.0000E+00	6.4700E-02	0.0000E+00
SR-90	2.6170E+03	2.6000E-05	0.0000E+00	0.0000E+00	2.4200E-02	0.0000E+00
Y-90	2.6170E+03	2.6000E-05	0.0000E+00	0.0000E+00	2.4200E-02	0.0000E+00
NB-94	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	3.4700E-05	0.0000E+00
TC-99	6.1000E+01	6.1000E-07	0.0000E+00	0.0000E+00	3.2500E-06	0.0000E+00
RU-106	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	6.8900E-01	0.0000E+00
CD-109	1.6000E+01	1.6000E-07	0.0000E+00	0.0000E+00	5.4500E-01	0.0000E+00
SB-125	2.7000E+00	2.7000E-08	0.0000E+00	0.0000E+00	2.5000E-01	0.0000E+00
I-125	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	4.2200E+00	0.0000E+00
I-129	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	4.0800E-08	0.0000E+00
CS-134	3.7069E+04	3.7000E-04	0.0000E+00	0.0000E+00	3.3600E-01	3.0000E+02
CS-137	2.8940E+05	2.9000E-03	0.0000E+00	0.0000E+00	2.3100E-02	3.0000E+02
BA-137M	2.8940E+05	2.9000E-03	0.0000E+00	0.0000E+00	2.3100E-02	3.0000E+02
CE-141	5.4700E+02	5.5000E-06	0.0000E+00	0.0000E+00	7.7800E+00	0.0000E+00
CE-144	2.1600E+03	2.2000E-05	0.0000E+00	0.0000E+00	8.9000E+00	1.0000E+09
PM-147	1.7900E+02	1.8000E-06	0.0000E+00	0.0000E+00	2.6400E-01	0.0000E+00
RE-187	1.5000E+00	1.5000E-08	0.0000E+00	0.0000E+00	1.4700E-11	0.0000E+00
PB-210	2.2000E+01	2.2000E-07	0.0000E+00	0.0000E+00	3.1100E-02	0.0000E+00
RA-226	6.0000E-01	6.0000E-09	0.0000E+00	0.0000E+00	4.3400E-04	0.0000E+00
TH-232	1.3000E+00	1.3000E-08	0.0000E+00	0.0000E+00	4.9300E-11	0.0000E+00
U-233	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	4.2800E-06	0.0000E+00
U-234	3.0000E+00	3.0000E-08	0.0000E+00	0.0000E+00	2.8300E-06	0.0000E+00
U-235	3.5000E+00	3.5000E-08	0.0000E+00	0.0000E+00	9.8500E-10	0.0000E+00
U-236	5.0000E-01	5.0000E-09	0.0000E+00	0.0000E+00	2.9600E-08	0.0000E+00
U-238	3.0630E+03	3.1000E-05	0.0000E+00	0.0000E+00	1.5500E-10	0.0000E+00

PU-238	2.0000E-01	2.0000E-09	0.0000E+00	0.0000E+00	7.9000E-03	0.0000E+00
PU-239	1.0000E-01	1.0000E-09	0.0000E+00	0.0000E+00	2.8700E-05	0.0000E+00
PU-241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	5.2500E-02	0.0000E+00
AM-241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.5100E-03	0.0000E+00
PU-242	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.8300E-06	0.0000E+00
AM-243	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	8.7200E-05	0.0000E+00
CM-243	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	2.7000E-02	0.0000E+00

DISTRIBUTION COEFFICIENTS ML/G

NUCLIDE	SURFACE	TRENCH	VERTICAL	AQUIFER
H-3	1.00E-02	1.00E-02	1.00E-02	1.00E-02
C-14	1.00E-02	1.00E-02	1.00E-02	1.00E-02
MN-54	1.50E+02	1.50E+02	1.50E+02	1.50E+02
FE-55	5.50E+01	5.50E+01	5.50E+01	5.50E+01
NI-59	1.50E+02	1.50E+02	1.50E+02	1.50E+02
CO-60	5.50E+01	5.50E+01	5.50E+01	5.50E+01
NI-63	1.50E+02	1.50E+02	1.50E+02	1.50E+02
ZN-65	1.60E+01	1.60E+01	1.60E+01	1.60E+01
KR-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR-90	2.70E+01	2.70E+01	2.70E+01	2.70E+01
Y-90	2.70E+01	2.70E+01	2.70E+01	2.70E+01
NB-94	3.50E+02	3.50E+02	3.50E+02	3.50E+02
TC-99	3.30E-02	3.30E-02	3.30E-02	3.30E-02
RU-106	2.20E+02	2.20E+02	2.20E+02	2.20E+02
CD-109	6.70E+00	6.70E+00	6.70E+00	6.70E+00
SB-125	4.50E+01	4.50E+01	4.50E+01	4.50E+01
I-125	1.00E-02	1.00E-02	1.00E-02	1.00E-02
I-129	1.00E-02	1.00E-02	1.00E-02	1.00E-02
CS-134	1.10E+03	1.10E+03	1.10E+03	1.10E+03
CS-137	1.10E+03	1.10E+03	1.10E+03	1.10E+03
BA-137M	1.10E+03	1.10E+03	1.10E+03	1.10E+03
CE-141	1.10E+03	1.10E+03	1.10E+03	1.10E+03
CE-144	1.10E+03	1.10E+03	1.10E+03	1.10E+03
PM-147	6.10E+01	6.10E+01	6.10E+01	6.10E+01

RE-187	7.50E+00	7.50E+00	7.50E+00	7.50E+00
PB-210	5.40E+02	5.40E+02	5.40E+02	5.40E+02
RA-226	2.20E+02	2.20E+02	2.20E+02	2.20E+02
TH-232	6.00E+04	6.00E+04	6.00E+04	6.00E+04
U-233	4.50E+01	4.50E+01	4.50E+01	4.50E+01
U-234	4.50E+01	4.50E+01	4.50E+01	4.50E+01
U-235	4.50E+01	4.50E+01	4.50E+01	4.50E+01
U-236	4.50E+01	4.50E+01	4.50E+01	4.50E+01
U-238	4.50E+01	4.50E+01	4.50E+01	4.50E+01
PU-238	1.80E+03	1.80E+03	1.80E+03	1.80E+03
PU-239	1.80E+03	1.80E+03	1.80E+03	1.80E+03
PU-241	1.80E+03	1.80E+03	1.80E+03	1.80E+03
AM-241	8.10E+02	8.10E+02	8.10E+02	8.10E+02
PU-242	1.80E+03	1.80E+03	1.80E+03	1.80E+03
AM-243	8.10E+02	8.10E+02	8.10E+02	8.10E+02
CM-243	3.30E+03	3.30E+03	3.30E+03	3.30E+03

NUCLIDE	RETENTION IN AIR	RETENTION IN WATER	TRANS COEFF SOIL-V CROP D/KG	TRANS COEFF SOIL-R CROP D/KG	TRANS COEFF VEG-COW MILK D/KG	TRANS COEFF VEG-GOAT MILK D/KG	TRANS COEFF VEG-MEAT D/KG
H-3	2.00E-01	2.50E-01	4.80E+00	4.80E+00	1.00E-02	1.70E-01	1.20E-02
C-14	2.00E-01	2.50E-01	5.50E+00	5.50E+00	1.20E-02	1.00E-01	3.10E-02
MN-54	2.00E-01	2.50E-01	2.50E-01	5.00E-02	2.50E-04	2.50E-04	8.00E-04
FE-55	2.00E-01	2.50E-01	4.00E-03	1.00E-03	1.20E-03	1.30E-04	4.00E-02
NI-59	2.00E-01	2.50E-01	6.00E-02	6.00E-02	6.70E-03	6.70E-03	5.30E-02
CO-60	2.00E-01	2.50E-01	9.40E-03	9.40E-03	1.00E-03	1.00E-03	1.30E-02
NI-63	2.00E-01	2.50E-01	6.00E-02	6.00E-02	6.70E-03	6.70E-03	5.30E-02
ZN-65	2.00E-01	2.50E-01	1.50E+00	9.00E-01	3.90E-02	3.90E-02	3.00E-02
KR-85	2.00E-01	2.50E-01	0.00E+00	0.00E+00	2.00E-02	2.00E-02	2.00E-02
SR-90	2.00E-01	2.50E-01	2.50E+00	2.50E-01	8.00E-04	1.40E-02	6.00E-04
Y-90	2.00E-01	2.50E-01	2.50E+00	2.50E-01	8.00E-04	1.40E-02	6.00E-04
NB-94	2.00E-01	2.50E-01	2.00E-02	5.00E-03	2.50E-03	2.50E-03	2.50E-03
TC-99	2.00E-01	2.50E-01	9.50E+00	1.50E+00	2.50E-02	2.50E-02	4.00E-01
RU-106	2.00E-01	2.50E-01	7.50E-02	2.00E-02	1.00E-06	1.00E-06	1.00E-06
CD-109	2.00E-01	2.50E-01	5.50E-01	1.50E-01	1.30E-04	1.30E-04	5.30E-04
SB-125	2.00E-01	2.50E-01	2.00E-01	3.00E-02	1.50E-03	1.50E-03	4.00E-03
I-125	2.00E-01	2.50E-01	1.00E+00	1.00E+00	6.00E-03	6.00E-02	6.00E-02

I-129	2.00E-01	2.50E-01	1.00E+00	1.00E+00	6.00E-03	6.00E-02	6.00E-02
CS-134	2.00E-01	2.50E-01	1.00E-02	1.00E-02	1.20E-02	3.00E-01	4.00E-03
CS-137	2.00E-01	2.50E-01	1.00E-02	1.00E-02	1.20E-02	3.00E-01	4.00E-03
BA-137M	2.00E-01	2.50E-01	1.00E-02	1.00E-02	1.20E-02	3.00E-01	4.00E-03
CE-141	2.00E-01	2.50E-01	1.00E-02	4.00E-03	1.00E-04	1.00E-04	1.20E-03
CE-144	2.00E-01	2.50E-01	1.00E-02	4.00E-03	1.00E-04	1.00E-04	1.20E-03
PM-147	2.00E-01	2.50E-01	1.00E-02	4.00E-03	5.00E-06	5.00E-06	4.80E-03
RE-187	2.00E-01	2.50E-01	1.50E+00	3.50E-01	2.50E-02	2.50E-02	8.00E-03
PB-210	2.00E-01	2.50E-01	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05
RA-226	2.00E-01	2.50E-01	1.50E-02	1.50E-03	1.50E-02	1.50E-02	3.40E-02
TH-232	2.00E-01	2.50E-01	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05
U-233	2.00E-01	2.50E-01	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05
U-234	2.00E-01	2.50E-01	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05
U-235	2.00E-01	2.50E-01	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05
U-236	2.00E-01	2.50E-01	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05
U-238	2.00E-01	2.50E-01	1.00E-05	1.00E-05	1.00E-05	1.00E-05	1.00E-05
PU-238	2.00E-01	2.50E-01	4.50E-04	4.50E-05	1.50E-06	1.50E-06	8.00E-03
PU-239	2.00E-01	2.50E-01	4.50E-04	4.50E-05	1.50E-06	1.50E-06	8.00E-03
PU-241	2.00E-01	2.50E-01	4.50E-04	4.50E-05	1.50E-06	1.50E-06	8.00E-03
AM-241	2.00E-01	2.50E-01	5.50E-03	2.50E-04	0.00E+00	0.00E+00	0.00E+00
PU-242	2.00E-01	2.50E-01	4.50E-04	4.50E-05	1.50E-06	1.50E-06	8.00E-03
AM-243	2.00E-01	2.50E-01	5.50E-03	2.50E-04	0.00E+00	0.00E+00	0.00E+00
CM-243	2.00E-01	2.50E-01	8.50E-04	1.50E-05	0.00E+00	0.00E+00	0.00E+00

INITIAL CALCULATIONS

NUCLIDE	MASS
H-3	3.
C-14	14.
MN-54	54.
FE-55	55.
NI-59	59.
CO-60	60.
NI-63	63.
ZN-65	65.
KR-85	85.
SR-90	90.
Y-90	90.
NB-94	94.
TC-99	99.
RU-106	106.
CD-109	109.
SB-125	125.
I-125	125.
I-129	129.
CS-134	134.
CS-137	137.
BA-137M	137.
CE-141	141.
CE-144	144.
PM-147	147.
RE-187	187.
PB-210	210.
RA-226	226.
TH-232	232.
U-233	233.
U-234	234.
U-235	235.
U-236	236.
U-238	238.
PU-238	238.

PU-239	239.
PU-241	241.
AM-241	241.
PU-242	242.
AM-243	243.
CM-243	243.

INITIAL CALCULATIONS

NUCLIDE	VERTICAL RETARDATION	VERTICAL TIME Y	HORIZONTAL RETARDATION	HORIZONTAL TIME Y	BREAK THRU TIME Y
H-3	1.0400E+00	1.4009E+00	1.0400E+00	4.4212E+02	4.4352E+02
C-14	1.0400E+00	1.4009E+00	1.0400E+00	4.4212E+02	4.4352E+02
MN-54	6.0100E+02	8.0959E+02	6.0100E+02	2.5549E+05	2.5630E+05
FE-55	2.2100E+02	2.9770E+02	2.2100E+02	9.3951E+04	9.4248E+04
NI-59	6.0100E+02	8.0959E+02	6.0100E+02	2.5549E+05	2.5630E+05
CO-60	2.2100E+02	2.9770E+02	2.2100E+02	9.3951E+04	9.4248E+04
NI-63	6.0100E+02	8.0959E+02	6.0100E+02	2.5549E+05	2.5630E+05
ZN-65	6.5000E+01	8.7559E+01	6.5000E+01	2.7633E+04	2.7720E+04
KR-85	1.0000E+00	1.3471E+00	1.0000E+00	4.2512E+02	4.2646E+02
SR-90	1.0900E+02	1.4683E+02	1.0900E+02	4.6338E+04	4.6485E+04
Y-90	1.0900E+02	1.4683E+02	1.0900E+02	4.6338E+04	4.6485E+04
NB-94	1.4010E+03	1.8872E+03	1.4010E+03	5.9559E+05	5.9748E+05
TC-99	1.1320E+00	1.5249E+00	1.1320E+00	4.8123E+02	4.8276E+02
RU-106	8.8100E+02	1.1868E+03	8.8100E+02	3.7453E+05	3.7571E+05
CD-109	2.7800E+01	3.7448E+01	2.7800E+01	1.1818E+04	1.1856E+04
SB-125	1.8100E+02	2.4382E+02	1.8100E+02	7.6946E+04	7.7190E+04
I-125	1.0400E+00	1.4009E+00	1.0400E+00	4.4212E+02	4.4352E+02
I-129	1.0400E+00	1.4009E+00	1.0400E+00	4.4212E+02	4.4352E+02
CS-134	4.4010E+03	5.9284E+03	4.4010E+03	1.8709E+06	1.8769E+06
CS-137	4.4010E+03	5.9284E+03	4.4010E+03	1.8709E+06	1.8769E+06
BA-137M	4.4010E+03	5.9284E+03	4.4010E+03	1.8709E+06	1.8769E+06
CE-141	4.4010E+03	5.9284E+03	4.4010E+03	1.8709E+06	1.8769E+06
CE-144	4.4010E+03	5.9284E+03	4.4010E+03	1.8709E+06	1.8769E+06
PM-147	2.4500E+02	3.3003E+02	2.4500E+02	1.0415E+05	1.0448E+05
RE-187	3.1000E+01	4.1759E+01	3.1000E+01	1.3179E+04	1.3220E+04
PB-210	2.1610E+03	2.9110E+03	2.1610E+03	9.1868E+05	9.2159E+05
RA-226	8.8100E+02	1.1868E+03	8.8100E+02	3.7453E+05	3.7571E+05
TH-232	2.4000E+05	3.2330E+05	2.4000E+05	1.0203E+08	1.0235E+08
U-233	1.8100E+02	2.4382E+02	1.8100E+02	7.6946E+04	7.7190E+04
U-234	1.8100E+02	2.4382E+02	1.8100E+02	7.6946E+04	7.7190E+04
U-235	1.8100E+02	2.4382E+02	1.8100E+02	7.6946E+04	7.7190E+04
U-236	1.8100E+02	2.4382E+02	1.8100E+02	7.6946E+04	7.7190E+04
U-238	1.8100E+02	2.4382E+02	1.8100E+02	7.6946E+04	7.7190E+04
PU-238	7.2010E+03	9.7002E+03	7.2010E+03	3.0613E+06	3.0710E+06

PU-239	7.2010E+03	9.7002E+03	7.2010E+03	3.0613E+06	3.0710E+06
PU-241	7.2010E+03	9.7002E+03	7.2010E+03	3.0613E+06	3.0710E+06
AM-241	3.2410E+03	4.3658E+03	3.2410E+03	1.3778E+06	1.3822E+06
PU-242	7.2010E+03	9.7002E+03	7.2010E+03	3.0613E+06	3.0710E+06
AM-243	3.2410E+03	4.3658E+03	3.2410E+03	1.3778E+06	1.3822E+06
CM-243	1.3201E+04	1.7783E+04	1.3201E+04	5.6120E+06	5.6297E+06

ANNUAL SOIL LOSS IS 3.1315E-01 KILOGRAMS PER SQUARE METER
OR 1.9572E-04 METERS IS REMOVED FROM THE SURFACE
ANNUAL INFILTRATION INTO TRENCH IS 0.7127 METERS
VERTICAL WATER VELOCITY IS 1.7816 METERS PER YEAR
NORMALIZED DOWN WIND ATMOSPHERIC EXPOSURE PER UNIT SOURCE RELEASE IS 0.7700E-08 CI/M**3 PER CI/SEC

WATER OUTFLOW FROM TRENCH BOTTOM IS APPROACHING DILUTION VOLUME IN AQUIFER FOR YEAR 1

APPENDIX B

PRESTO-II SAMPLE PROBLEM OUTPUT

ANNUAL SUMMARY FOR YEAR 1000 OF THE SIMULATION

THE TRENCH CAP HAS HAD 10.00 PER CENT FAILURE
THE MAXIMUM CALCULATED WATER DEPTH IN TRENCH DURING THE YEAR IS 0.00 METERS
6.0440E+03 CUBIC METERS OF WATER LEFT BOTTOM OF TRENCH
0.0000E+00 CUBIC METERS OF WATER OVERFLOWED TRENCH

NUCLIDE TRANSPORT INFORMATION

NUCLIDE	AMOUNT IN TRENCH CI	TRENCH OVERFLOW CI	TRENCH DRAINAGE CI	AMOUNT AT WELL CI
H-3	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
C-14	7.9067E-36	0.0000E+00	0.0000E+00	0.0000E+00
MN-54	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
FE-55	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
NI-59	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CO-60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
NI-63	1.4673E+01	0.0000E+00	4.8218E-03	0.0000E+00
ZN-65	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
KR-85	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
SR-90	1.2788E-08	0.0000E+00	2.3343E-11	0.0000E+00
Y-90	1.2788E-08	0.0000E+00	2.3343E-11	0.0000E+00
NB-94	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
TC-99	1.2467E-35	0.0000E+00	0.0000E+00	0.0000E+00
RU-106	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CD-109	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
SB-125	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
I-125	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
I-129	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CS-134	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CS-137	2.5681E-05	0.0000E+00	1.1508E-09	0.0000E+00

BA-137M	2.5681E-05	0.0000E+00	1.1508E-09	0.0000E+00
CE-141	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CE-144	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
PM-147	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
RE-187	1.9950E-03	0.0000E+00	1.3106E-05	0.0000E+00
PB-210	6.2485E-13	0.0000E+00	5.7040E-17	0.0000E+00
RA-226	3.0992E-01	0.0000E+00	6.9442E-05	0.0000E+00
TH-232	1.2989E+00	0.0000E+00	1.0672E-06	0.0000E+00
U-233	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
U-234	9.8866E-01	0.0000E+00	1.0829E-03	0.0000E+00
U-235	1.1567E+00	0.0000E+00	1.2669E-03	0.0000E+00
U-236	1.6524E-01	0.0000E+00	1.8099E-04	0.0000E+00
U-238	1.0122E+03	0.0000E+00	1.1088E+00	0.0000E+00
PU-238	7.2122E-05	0.0000E+00	1.9751E-09	0.0000E+00
PU-239	9.4519E-02	0.0000E+00	2.5885E-06	0.0000E+00
PU-241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
AM-241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
PU-242	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
AM-243	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CM-243	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

NUCLIDE	SURFACE SOIL CONC CI/M**3	SURFACE WATER CONC CI/M**3	SOLUBLE TO STREAM CI	SOLUBLE TO TRENCH CI	ATMOSPHERE AT SPILLAGE CI/M**3	ATMOSPHERE DOWN WIND CI/M**3	WELL WATER CONC CI/M**3
H-3	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
C-14	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
MN-54	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
FE-55	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
NI-59	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CO-60	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
NI-63	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
ZN-65	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
KR-85	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
SR-90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Y-90	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
NB-94	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

TC-99	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
RU-106	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CD-109	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
SB-125	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
I-125	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
I-129	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CS-134	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CS-137	4.0328E-26	0.0000E+00	5.7744E-22	1.9572E-21	1.3627E-33	0.0000E+00	0.0000E+00
BA-137M	4.0328E-26	0.0000E+00	5.7744E-22	1.9572E-21	1.3627E-33	0.0000E+00	0.0000E+00
CE-141	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CE-144	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
PM-147	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
RE-187	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
PB-210	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
RA-226	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
TH-232	2.2365E-15	0.0000E+00	5.8710E-13	1.9899E-12	7.5574E-23	2.8514E-31	0.0000E+00
U-233	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
U-234	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
U-235	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
U-236	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
U-238	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
PU-238	2.7301E-23	0.0000E+00	2.3889E-19	8.0969E-19	9.2253E-31	3.4807E-39	0.0000E+00
PU-239	3.5779E-20	0.0000E+00	3.1307E-16	1.0611E-15	1.2090E-27	4.5616E-36	0.0000E+00
PU-241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
AM-241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
PU-242	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
AM-243	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CM-243	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

AVERAGE CONCENTRATIONS OVER THE YEARS 1 TO 1000 OF THE SIMULATION
MAXIMUM ANNUAL CONCENTRATIONS

NUCLIDE	ATMOSPHERE DOWNWIND			IN WELL			IN STREAM		
	AVERAGE CI/M**3	MAXIMUM CI/M**3	YEAR	AVERAGE CI/M**3	MAXIMUM CI/M**3	YEAR	AVERAGE CI/M**3	MAXIMUM CI/M**3	YEAR
H-3	3.3199E-29	3.3193E-26	1	1.4494E-16	1.2326E-13	444	1.3594E-11	1.3586E-08	1
C-14	9.8134E-33	9.8115E-30	1	2.8685E-09	2.4146E-06	444	4.0183E-15	4.0158E-12	1
MN-54	7.3018E-27	6.3634E-24	1	0.0000E+00	0.0000E+00	0	2.9065E-13	1.7363E-10	1
FE-55	8.0465E-26	6.4594E-23	1	0.0000E+00	0.0000E+00	0	1.2041E-11	4.8068E-09	1
NI-59	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0
CO-60	6.1648E-25	4.7687E-22	1	0.0000E+00	0.0000E+00	0	1.1120E-10	3.5487E-08	1
NI-63	2.3424E-26	1.6104E-23	1	0.0000E+00	0.0000E+00	0	4.3558E-12	4.3940E-10	1
ZN-65	2.3327E-27	2.2037E-24	1	0.0000E+00	0.0000E+00	0	6.8570E-13	5.6371E-10	1
KR-85	0.0000E+00	0.0000E+00	0	5.3814E-19	5.3814E-16	427	6.7410E-13	6.7410E-10	1
SR-90	3.2728E-27	2.6092E-24	1	0.0000E+00	0.0000E+00	0	1.0302E-12	3.9553E-10	1
Y-90	3.2728E-27	2.6092E-24	1	0.0000E+00	0.0000E+00	0	1.0302E-12	3.9553E-10	1
NB-94	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0
TC-99	2.0776E-31	2.0762E-28	1	1.9406E-08	1.1975E-05	483	2.5805E-14	2.5751E-11	1
RU-106	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0
CD-109	4.7630E-30	4.5072E-27	1	0.0000E+00	0.0000E+00	0	3.3287E-15	2.7534E-12	1
SB-125	3.1248E-30	2.5356E-27	1	0.0000E+00	0.0000E+00	0	5.4453E-16	2.3062E-13	1
I-125	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0
I-129	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0
CS-134	5.5483E-26	4.2435E-23	1	0.0000E+00	0.0000E+00	0	5.3372E-13	1.5789E-10	1
CS-137	6.9042E-25	4.5479E-22	1	0.0000E+00	0.0000E+00	0	4.6106E-11	1.6922E-09	1
BA-137M	6.9042E-25	4.5479E-22	1	0.0000E+00	0.0000E+00	0	4.6106E-11	1.6922E-09	1
CE-141	3.6902E-31	3.6898E-28	1	0.0000E+00	0.0000E+00	0	1.3735E-18	1.3729E-15	1
CE-144	4.8158E-31	4.8156E-28	1	0.0000E+00	0.0000E+00	0	1.7920E-18	1.7918E-15	1
PM-147	2.2372E-28	1.7885E-25	1	0.0000E+00	0.0000E+00	0	3.0768E-14	1.2000E-11	1
RE-187	8.7700E-31	7.8768E-28	1	0.0000E+00	0.0000E+00	0	6.3424E-16	4.2985E-13	1
PB-210	5.0436E-29	3.3733E-26	1	0.0000E+00	0.0000E+00	0	4.3927E-15	2.5568E-13	1
RA-226	1.3539E-30	9.1108E-28	1	0.0000E+00	0.0000E+00	0	2.5170E-16	1.6950E-14	1
TH-232	3.6087E-30	2.1157E-27	1	0.0000E+00	0.0000E+00	0	1.2667E-16	1.4432E-16	1
U-233	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0

U-234	4.8161E-30	3.6175E-27	1	0.0000E+00	0.0000E+00	0	1.2674E-15	3.2902E-13	1
U-235	5.6188E-30	4.2204E-27	1	0.0000E+00	0.0000E+00	0	1.4786E-15	3.8386E-13	1
U-236	8.0269E-31	6.0292E-28	1	0.0000E+00	0.0000E+00	0	2.1123E-16	5.4837E-14	1
U-238	4.9767E-27	3.7381E-24	1	0.0000E+00	0.0000E+00	0	1.3096E-12	3.3999E-10	1
PU-238	4.9465E-31	3.2021E-28	1	0.0000E+00	0.0000E+00	0	4.4104E-17	7.2811E-16	1
PU-239	2.5215E-31	1.6137E-28	1	0.0000E+00	0.0000E+00	0	4.2068E-17	3.6693E-16	1
PU-241	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0
AM-241	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0
PU-242	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0
AM-243	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0
CM-243	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0	0.0000E+00	0.0000E+00	0

RADIONUCLIDE CONCENTRATION IN FOODS DUE TO ATMOSPHERIC DEPOSITION
PICO CURIES PER KILOGRAM

NUCLIDE	LEAFY VEG M.I.E.	PRODUCE M.I.E.	LEAFY VEG G.P.E.	PRODUCE G.P.E.	COW'S MILK M.I.E.	COW'S MILK G.P.E.	GOAT'S MILK M.I.E.	GOAT'S MILK G.P.E.	BEEF MEAT
H-3	1.2576E-15	1.2576E-15	1.2576E-15	1.2576E-15	6.2878E-16	6.2878E-16	1.2827E-15	1.2827E-15	7.5453E-16
C-14	6.7467E-18	6.7467E-18	6.7467E-18	6.7467E-18	4.0480E-18	4.0480E-18	4.0480E-18	4.0480E-18	1.0457E-17
MN-54	4.3703E-11	3.8010E-11	4.2462E-11	4.2090E-11	1.1901E-12	1.1848E-12	1.4281E-13	1.4218E-13	3.6593E-12
FE-55	4.8944E-10	4.6927E-10	4.8498E-10	4.8472E-10	6.6158E-11	6.6065E-11	8.6005E-13	8.5884E-13	2.1775E-09
NI-59	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CO-60	3.7828E-09	3.7030E-09	3.7651E-09	3.7651E-09	4.2833E-10	4.2802E-10	5.1400E-11	5.1362E-11	5.5322E-09
NI-63	1.9875E-10	1.9854E-10	1.9870E-10	1.9870E-10	1.2860E-10	1.2860E-10	1.5432E-11	1.5431E-11	1.0170E-09
ZN-65	1.4266E-11	1.1853E-11	1.3748E-11	1.3513E-11	5.8872E-11	5.8537E-11	7.0646E-12	7.0245E-12	4.3022E-11
KR-85	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
SR-90	9.3620E-11	2.7362E-11	9.3539E-11	2.7445E-11	4.7719E-12	4.7712E-12	1.0021E-11	1.0020E-11	3.5746E-12
Y-90	9.3620E-11	2.7362E-11	9.3539E-11	2.7445E-11	4.7719E-12	4.7712E-12	1.0021E-11	1.0020E-11	3.5746E-12
NB-94	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
TC-99	1.5890E-15	1.3277E-15	1.5890E-15	1.3277E-15	4.0410E-15	4.0410E-15	4.8492E-16	4.8492E-16	6.4656E-14
RU-106	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CD-109	2.9619E-14	2.6411E-14	2.9050E-14	2.8289E-14	4.1879E-16	4.1754E-16	5.0254E-17	5.0105E-17	1.6621E-15
SB-125	1.9700E-14	1.8348E-14	1.9525E-14	1.8935E-14	3.2643E-15	3.2599E-15	3.9172E-16	3.9118E-16	8.5982E-15
I-125	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
I-129	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CS-134	3.3641E-10	3.1863E-10	3.3241E-10	3.3241E-10	4.5268E-10	4.5184E-10	1.3580E-09	1.3555E-09	1.4841E-10
CS-137	4.3403E-09	4.3241E-09	4.3367E-09	4.3367E-09	5.8705E-09	5.8697E-09	1.7611E-08	1.7609E-08	1.9546E-09
BA-137M	4.3403E-09	4.3241E-09	4.3367E-09	4.3367E-09	5.8705E-09	5.8697E-09	1.7611E-08	1.7609E-08	1.9546E-09
CE-141	1.6201E-15	4.6065E-16	1.2280E-15	1.2280E-15	1.5146E-17	1.4513E-17	1.8175E-18	1.7416E-18	1.2383E-16
CE-144	2.0259E-15	4.8066E-16	1.4756E-15	1.4756E-15	1.8812E-17	1.7917E-17	2.2575E-18	2.1500E-18	1.4555E-16
PM-147	1.3617E-12	1.3035E-12	1.3490E-12	1.3476E-12	7.6621E-16	7.6510E-16	9.1945E-17	9.1812E-17	7.2605E-13
RE-187	1.5676E-14	7.7959E-15	1.5676E-14	7.7959E-15	2.8269E-14	2.8269E-14	3.3923E-15	3.3923E-15	9.0461E-15
PB-210	3.0995E-13	3.0839E-13	3.0960E-13	3.0960E-13	3.5359E-16	3.5353E-16	4.2430E-17	4.2423E-17	3.5304E-16
RA-226	1.1333E-14	8.6320E-15	1.1333E-14	8.6324E-15	1.6533E-14	1.6533E-14	1.9840E-15	1.9840E-15	3.7475E-14
TH-232	2.2221E-14	2.2221E-14	2.2221E-14	2.2221E-14	2.5387E-17	2.5387E-17	3.0464E-18	3.0464E-18	2.5387E-17
U-233	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
U-234	2.9643E-14	2.9643E-14	2.9643E-14	2.9643E-14	3.3875E-17	3.3875E-17	4.0650E-18	4.0650E-18	3.3875E-17
U-235	3.4584E-14	3.4584E-14	3.4584E-14	3.4584E-14	3.9521E-17	3.9521E-17	4.7425E-18	4.7425E-18	3.9521E-17
U-236	4.9406E-15	4.9406E-15	4.9406E-15	4.9406E-15	5.6458E-18	5.6458E-18	6.7750E-19	6.7750E-19	5.6458E-18
U-238	3.0632E-11	3.0632E-11	3.0632E-11	3.0632E-11	3.5004E-14	3.5004E-14	4.2005E-15	4.2005E-15	3.5004E-14

PU-238	3.0522E-15	3.0402E-15	3.0513E-15	3.0432E-15	5.2210E-19	5.2208E-19	6.2652E-20	6.2649E-20	2.7834E-15
PU-239	1.5855E-15	1.5552E-15	1.5855E-15	1.5552E-15	2.6854E-19	2.6854E-19	3.2224E-20	3.2224E-20	1.4322E-15
PU-241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
AM-241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
PU-242	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
AM-243	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CM-243	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

RADIONUCLIDE CONCENTRATION IN FOODS DUE TO IRRIGATION
PICO CURIES PER KILOGRAM

NUCLIDE	LEAFY VEG M.I.E.	PRODUCE M.I.E.	LEAFY VEG G.P.E.	PRODUCE G.P.E.	COW'S MILK M.I.E.	COW'S MILK G.P.E.	GOAT'S MILK M.I.E.	GOAT'S MILK G.P.E.	BEEF MEAT
H-3	1.4494E-07	1.4494E-07	1.4494E-07	1.4494E-07	1.5944E-07	1.5944E-07	3.4497E-07	3.4497E-07	1.9133E-07
C-14	6.7124E+00	6.7123E+00	6.7124E+00	6.7124E+00	1.1270E+01	1.1270E+01	1.1500E+01	1.1500E+01	2.8226E+01
MN-54	4.7850E-13	8.3969E-14	4.6491E-13	9.2982E-14	5.6699E-15	5.6449E-15	6.8039E-16	6.7738E-16	1.7434E-14
FE-55	3.5156E-13	8.4313E-14	3.4836E-13	8.7089E-14	2.0721E-14	2.0692E-14	2.6938E-15	2.6900E-15	6.8201E-13
NI-59	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CO-60	1.2882E-11	1.2610E-11	1.2822E-11	1.2822E-11	6.3818E-13	6.3772E-13	7.6582E-14	7.6527E-14	8.2426E-12
NI-63	5.4626E-11	5.4570E-11	5.4614E-11	5.4614E-11	1.8291E-11	1.8291E-11	2.1950E-12	2.1949E-12	1.4465E-10
ZN-65	6.0793E-13	3.0832E-13	5.8583E-13	3.5150E-13	1.1082E-12	1.1019E-12	1.3299E-13	1.3223E-13	8.0987E-13
KR-85	1.2553E-09	1.2422E-09	1.2524E-09	1.2524E-09	3.5043E-09	3.5031E-09	4.2912E-10	4.2897E-10	3.3859E-09
SR-90	7.3501E-11	7.3214E-12	7.3438E-11	7.3438E-12	2.9350E-12	2.9346E-12	6.1635E-12	6.1627E-12	2.1986E-12
Y-90	7.3501E-11	7.3214E-12	7.3438E-11	7.3438E-12	2.9350E-12	2.9346E-12	6.1635E-12	6.1627E-12	2.1986E-12
NB-94	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
TC-99	4.5409E+01	4.5409E+01	4.5409E+01	4.5409E+01	1.5884E+02	1.5884E+02	1.9449E+01	1.9449E+01	2.4638E+03
RU-106	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CD-109	1.0666E-15	2.6635E-16	1.0460E-15	2.6529E-16	6.6818E-18	6.6619E-18	8.0182E-19	7.9943E-19	2.6519E-17
SB-125	6.9992E-16	1.0083E-16	6.9372E-16	1.0406E-16	5.1592E-17	5.1521E-17	6.1910E-18	6.1826E-18	1.3589E-16
I-125	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
I-129	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CS-134	4.5552E-13	4.3144E-13	4.5010E-13	4.5010E-13	2.6707E-13	2.6657E-13	8.0120E-13	7.9972E-13	8.7559E-14
CS-137	9.5829E-11	9.5472E-11	9.5750E-11	9.5750E-11	5.7404E-11	5.7396E-11	1.7221E-10	1.7219E-10	1.9113E-11
BA-137M	9.5829E-11	9.5472E-11	9.5750E-11	9.5750E-11	5.7404E-11	5.7396E-11	1.7221E-10	1.7219E-10	1.9113E-11
CE-141	4.9611E-22	5.6425E-23	3.7604E-22	1.5042E-22	1.8560E-24	1.7786E-24	2.2272E-25	2.1343E-25	1.5175E-23

CE-144	2.1054E-22	1.9980E-23	1.5334E-22	6.1337E-23	7.7519E-25	7.3829E-25	9.3023E-26	8.8595E-26	5.9976E-24
PM-147	2.3772E-15	9.1114E-16	2.3549E-15	9.4196E-16	5.8352E-19	5.8268E-19	7.0023E-20	6.9921E-20	5.5293E-16
RE-187	1.0279E-14	2.3984E-15	1.0279E-14	2.3984E-15	1.2848E-14	1.2848E-14	1.5418E-15	1.5418E-15	4.1115E-15
PB-210	5.1452E-18	5.1194E-18	5.1395E-18	5.1395E-18	2.5670E-21	2.5665E-21	3.0804E-22	3.0798E-22	2.5630E-21
RA-226	3.0003E-15	3.0001E-16	3.0003E-15	3.0003E-16	2.2502E-15	2.2502E-15	2.7002E-16	2.7002E-16	5.1003E-15
TH-232	1.1306E-17	1.1306E-17	1.1306E-17	1.1306E-17	5.6529E-21	5.6529E-21	6.7835E-22	6.7835E-22	5.6529E-21
U-233	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
U-234	2.2323E-18	2.2323E-18	2.2323E-18	2.2323E-18	1.1161E-21	1.1161E-21	1.3394E-22	1.3394E-22	1.1161E-21
U-235	2.6054E-18	2.6054E-18	2.6054E-18	2.6054E-18	1.3027E-21	1.3027E-21	1.5632E-22	1.5632E-22	1.3027E-21
U-236	3.7220E-19	3.7220E-19	3.7220E-19	3.7220E-19	1.8610E-22	1.8610E-22	2.2332E-23	2.2332E-23	1.8610E-22
U-238	2.3076E-15	2.3076E-15	2.3076E-15	2.3076E-15	1.1538E-18	1.1538E-18	1.3846E-19	1.3846E-19	1.1538E-18
PU-238	9.0131E-18	9.0016E-19	9.0106E-18	9.0106E-19	6.7561E-22	6.7558E-22	8.1073E-23	8.1069E-23	3.6018E-18
PU-239	3.3615E-17	3.3615E-18	3.3615E-17	3.3615E-18	2.5211E-21	2.5211E-21	3.0254E-22	3.0254E-22	1.3446E-17
PU-241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
AM-241	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
PU-242	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
AM-243	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
CM-243	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

NOTE: G.P.E. - GENERAL POPULATION EXPOSURE
M.I.E. - MAXIMUM INDIVIDUAL EXPOSURE

G.P.E. WILL BE USED TO CALCULATE HEALTH EFFECTS

NUCLIDE	ANNUAL INTAKE BY INGESTION PCI/Y	ANNUAL INTAKE BY INHALATION PCI/Y
H-3	1.4442E-04	2.6560E-13
C-14	7.5332E+03	7.8508E-17
MN-54	1.6113E-08	5.8415E-11
FE-55	3.9644E-07	6.4372E-10
NI-59	0.0000E+00	0.0000E+00
CO-60	2.0007E-06	4.9319E-09
NI-63	2.2274E-07	1.8739E-10
ZN-65	1.5899E-08	1.8661E-11
KR-85	1.3808E-06	0.0000E+00
SR-90	3.9739E-08	2.6182E-11
Y-90	3.9739E-08	2.6182E-11
NB-94	0.0000E+00	0.0000E+00
TC-99	2.7597E+05	1.6620E-15
RU-106	0.0000E+00	0.0000E+00
CD-109	1.1106E-11	3.8104E-14
SB-125	8.5757E-12	2.4998E-14
I-125	0.0000E+00	0.0000E+00
I-129	0.0000E+00	0.0000E+00
CS-134	1.8856E-07	4.4386E-10
CS-137	2.5221E-06	5.5233E-09
BA-137M	2.5221E-06	5.5233E-09
CE-141	4.0877E-13	2.9522E-15
CE-144	4.9215E-13	3.8526E-15
PM-147	5.7613E-10	1.7897E-12
RE-187	1.2641E-11	7.0160E-15
PB-210	1.1756E-10	4.0349E-13
RA-226	1.0531E-11	1.0831E-14
TH-232	8.4536E-12	2.8870E-14
U-233	0.0000E+00	0.0000E+00
U-234	1.1272E-11	3.8529E-14
U-235	1.3151E-11	4.4951E-14
U-236	1.8787E-12	6.4215E-15
U-238	1.1648E-08	3.9813E-11
PU-238	1.4243E-12	3.9572E-15

PU-239	7.4112E-13	2.0172E-15
PU-241	0.0000E+00	0.0000E+00
AM-241	0.0000E+00	0.0000E+00
PU-242	0.0000E+00	0.0000E+00
AM-243	0.0000E+00	0.0000E+00
CM-243	0.0000E+00	0.0000E+00

FRACTION OF INGESTION DUE TO WATER

NUCLIDE	FRACTION
H-3	0.3713
C-14	0.1409
MN-54	0.0000
FE-55	0.0000
NI-59	0.0000
CO-60	0.0000
NI-63	0.0000
ZN-65	0.0000
KR-85	0.1442
SR-90	0.0000
Y-90	0.0000
NB-94	0.0000
TC-99	0.0260
RU-106	0.0000
CD-109	0.0000
SB-125	0.0000
I-125	0.0000
I-129	0.0000
CS-134	0.0000
CS-137	0.0000
BA-137M	0.0000
CE-141	0.0000
CE-144	0.0000
PM-147	0.0000
RE-187	0.0000
PB-210	0.0000
RA-226	0.0000
TH-232	0.0000
U-233	0.0000
U-234	0.0000
U-235	0.0000
U-236	0.0000
U-238	0.0000

PU-238	0.0000
PU-239	0.0000
PU-241	0.0000
AM-241	0.0000
PU-242	0.0000
AM-243	0.0000
CM-243	0.0000

MAXIMUM ANNUAL EXPOSURE

NUCLIDE	AIR CONCENTRATION CI/M**3	YEAR	SURFACE CONCENTRATION CI/M**2	YEAR	INGESTION RATE PERSON.PCI/Y	YEAR	INHALATION RATE PERSON.PCI/Y	YEAR
H-3	3.3193E-26	1	0.0000E+00	0	8.6378E+02	444	1.8676E-06	1
C-14	9.8115E-30	1	6.7856E-08	444	4.6219E+10	444	5.5204E-10	1
MN-54	6.3634E-24	1	8.9172E-19	1	9.7793E-02	1	3.5803E-04	1
FE-55	6.4594E-23	1	1.5663E-17	1	2.2367E+00	1	3.6343E-03	1
NI-59	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0
CO-60	4.7687E-22	1	1.4138E-16	2	1.0826E+01	1	2.6831E-02	1
NI-63	1.6104E-23	1	7.0092E-18	5	7.2549E-01	1	9.0605E-04	1
ZN-65	2.2037E-24	1	2.4086E-19	1	1.0230E-01	1	1.2399E-04	1
KR-85	0.0000E+00	0	1.3498E-17	427	9.7110E+00	427	0.0000E+00	0
SR-90	2.6092E-24	1	9.1972E-19	3	4.7792E-02	1	1.4681E-04	1
Y-90	2.6092E-24	1	9.1972E-19	3	4.7792E-02	1	1.4681E-04	1
NB-94	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0
TC-99	2.0762E-28	1	3.7188E-07	483	1.2562E+12	483	1.1682E-08	1
RU-106	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0
CD-109	4.5072E-27	1	7.8719E-22	1	7.1264E-05	1	2.5360E-07	1
SB-125	2.5356E-27	1	6.1837E-22	1	4.7213E-05	1	1.4266E-07	1
I-125	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0
I-129	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0
CS-134	4.2435E-23	1	9.5606E-18	1	1.0124E+00	1	2.3876E-03	1
CS-137	4.5479E-22	1	1.9260E-16	4	1.1277E+01	1	2.5588E-02	1
BA-137M	4.5479E-22	1	1.9260E-16	4	1.1277E+01	1	2.5588E-02	1
CE-141	3.6898E-28	1	4.8626E-26	1	2.8745E-06	1	2.0760E-08	1
CE-144	4.8156E-28	1	2.0707E-26	1	3.4611E-06	1	2.7094E-08	1
PM-147	1.7885E-25	1	4.3091E-20	1	3.2326E-03	1	1.0063E-05	1
RE-187	7.8768E-28	1	2.5220E-22	2	2.7706E-05	1	4.4318E-08	1
PB-210	3.3733E-26	1	1.3726E-20	4	5.5296E-04	1	1.8979E-06	1
RA-226	9.1108E-28	1	4.1928E-22	8	3.6991E-05	1	5.1261E-08	1
TH-232	2.1157E-27	1	1.1323E-21	1000	3.4821E-05	1	1.1904E-07	1
U-233	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0
U-234	3.6175E-27	1	1.4632E-21	4	5.9539E-05	1	2.0354E-07	1
U-235	4.2204E-27	1	1.7071E-21	4	6.9462E-05	1	2.3746E-07	1
U-236	6.0292E-28	1	2.4387E-22	4	9.9231E-06	1	3.3923E-08	1

U-238	3.7381E-24	1	1.5120E-18	4	6.1523E-02	1	2.1032E-04	1
PU-238	3.2021E-28	1	1.4639E-22	6	6.4643E-06	1	1.8016E-08	1
PU-239	1.6137E-28	1	7.8359E-23	15	3.2611E-06	1	9.0794E-09	1
PU-241	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0
AM-241	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0
PU-242	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0
AM-243	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0
CM-243	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0	0.0000E+00	0

BARNWELL SIMULATION, WELL AT 914 M, XG=8000 M, SOAM=E-8

ORGAN DOSE/EXPOSURE SUMMARY

*** SELECTED INDIVIDUAL ***

DOSE RATES:

ORGANS:	R MAR	ENDOST	*PUL*	MUSCLE	LIVER	S WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL
	ULI WALL	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	WT.SUM	
LOW LET (MRAD/Y)	0.114	0.133	6.735E-03	0.102	0.183	0.109	9.625E-02	0.894	0.134	5.066E-02
	0.304	5.728E-02	9.358E-02	9.348E-02	9.515E-02	9.520E-02	9.540E-02	3.90	0.265	
HIGH LET (MRAD/Y)	8.443E-15	1.265E-13	1.649E-12	8.401E-16	1.384E-14	2.123E-15	8.401E-16	9.287E-14	4.296E-14	4.355E-16
	3.090E-14	5.248E-15	8.790E-16	8.804E-16	8.490E-16	8.401E-16	8.401E-16	8.401E-16	4.885E-13	
DOSE EQUIVALENT (MREM/Y)	0.114	0.133	6.735E-03	0.102	0.183	0.109	9.625E-02	0.894	0.134	5.066E-02
	0.304	5.728E-02	9.358E-02	9.348E-02	9.515E-02	9.520E-02	9.540E-02	3.90	0.265	

GONADAL DOSES:

GONADS:	TESTES	OVARIES	AVERAGE
LOW LET (MRAD)	2.80	2.81	2.81
HIGH LET (MRAD)	1.878E-14	1.875E-14	1.877E-14
DOSE EQUIVALENT (MREM)	2.80	2.81	2.81

*** MEAN INDIVIDUAL ***

DOSE RATE:

ORGANS:	R MAR	ENDOST	*PUL*	MUSCLE	LIVER	S WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL
	ULI WALL	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	WT.SUM	
LOW LET (MRAD/Y)	0.114	0.133	6.735E-03	0.102	0.183	0.109	9.625E-02	0.894	0.134	5.066E-02
	0.304	5.728E-02	9.358E-02	9.348E-02	9.515E-02	9.520E-02	9.540E-02	3.90	0.265	

HIGH LET (MRAD/Y)	8.443E-15	1.265E-13	1.649E-12	8.401E-16	1.384E-14	2.123E-15	8.401E-16	9.287E-14	4.296E-14	4.355E-16
	3.090E-14	5.248E-15	8.790E-16	8.804E-16	8.490E-16	8.401E-16	8.401E-16	8.401E-16	4.885E-13	
DOSE EQUIVALENT (MREM/Y)	0.114	0.133	6.735E-03	0.102	0.183	0.109	9.625E-02	0.894	0.134	5.066E-02
	0.304	5.728E-02	9.358E-02	9.348E-02	9.515E-02	9.520E-02	9.540E-02	3.90	0.265	

GONADAL DOSES:

GONADS:	TESTES	OVARIES	AVERAGE
LOW LET (MRAD)	2.80	2.81	2.81
HIGH LET (MRAD)	1.878E-14	1.875E-14	1.877E-14
DOSE EQUIVALENT (MREM)	2.80	2.81	2.81

*** COLLECTIVE POPULATION ***

DOSE RATE:

ORGANS:	R MAR	ENDOST	*PUL*	MUSCLE	LIVER	S WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL
	ULI WALL	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	WT.SUM	
LOW LET (PERSON RAD/Y)	0.804	0.938	4.737E-02	0.721	1.29	0.765	0.677	6.29	0.945	0.356
	2.14	0.403	0.658	0.657	0.669	0.670	0.671	27.4	1.86	
HIGH LET (PERSON RAD/Y)	5.938E-14	8.899E-13	1.160E-11	5.908E-15	9.736E-14	1.493E-14	5.908E-15	6.532E-13	3.021E-13	3.063E-15
	2.173E-13	3.691E-14	6.182E-15	6.192E-15	5.971E-15	5.908E-15	5.909E-15	5.908E-15	3.435E-12	
DOSE EQ. (PERSON REM/Y)	0.804	0.938	4.737E-02	0.721	1.29	0.765	0.677	6.29	0.945	0.356
	2.14	0.403	0.658	0.657	0.669	0.670	0.671	27.4	1.86	

GONADAL DOSES:

GONADS:	TESTES	OVARIES	AVERAGE
LOW LET (PERSON RAD)	19.7	19.7	19.7
HIGH LET (PERSON RAD)	1.321E-13	1.319E-13	1.320E-13
DOSE EQ. (PERSON REM)	19.7	19.7	19.7

BARNWELL SIMULATION, WELL AT 914 M, XG=8000 M, SOAM=E-8

PATHWAY DOSE/EXPOSURE SUMMARY

*** SELECTED INDIVIDUAL ***

DOSE RATES:

WEIGHTED SUMS OF ORGAN DOSE RATES

PATHWAYS:	INGESTION	INHALATION	AIR IMMERSION	GROUND SURFACE	INTERNAL	EXTERNAL	TOTAL
LOW LET (MRAD/Y)	0.265	4.488E-12	1.093E-14	4.374E-10	0.265	4.374E-10	0.265
HIGH LET (MRAD/Y)	8.280E-15	4.802E-13	0.000E+00	0.000E+00	4.885E-13	0.000E+00	4.885E-13
DOSE EQUIVALENT (MREM/Y)	0.265	1.409E-11	1.093E-14	4.374E-10	0.265	4.374E-10	0.265

AVERAGE GONADAL DOSES:

PATHWAYS:	INGESTION	INHALATION	AIR IMMERSION	GROUND SURFACE	INTERNAL	EXTERNAL	TOTAL
LOW LET (MRAD)	2.81	8.812E-12	2.738E-13	1.069E-08	2.81	1.069E-08	2.81
HIGH LET (MRAD)	1.788E-14	8.848E-16	0.000E+00	0.000E+00	1.877E-14	0.000E+00	1.877E-14
DOSE EQUIVALENT (MREM)	2.81	8.829E-12	2.738E-13	1.069E-08	2.81	1.069E-08	2.81

*** MEAN INDIVIDUAL ***

DOSE RATES:

WEIGHTED SUMS OF ORGAN DOSE RATES

PATHWAYS:	INGESTION	INHALATION	AIR IMMERSION	GROUND SURFACE	INTERNAL	EXTERNAL	TOTAL
LOW LET (MRAD/Y)	0.265	4.488E-12	1.093E-14	4.374E-10	0.265	4.374E-10	0.265
HIGH LET (MRAD/Y)	8.280E-15	4.802E-13	0.000E+00	0.000E+00	4.885E-13	0.000E+00	4.885E-13
DOSE EQUIVALENT (MREM/Y)	0.265	1.409E-11	1.093E-14	4.374E-10	0.265	4.374E-10	0.265

AVERAGE GONADAL DOSES:

PATHWAYS:	INGESTION	INHALATION	AIR IMMERSION	GROUND SURFACE	INTERNAL	EXTERNAL	TOTAL
LOW LET (MRAD)	2.81	8.812E-12	2.738E-13	1.069E-08	2.81	1.069E-08	2.81
HIGH LET (MRAD)	1.788E-14	8.848E-16	0.000E+00	0.000E+00	1.877E-14	0.000E+00	1.877E-14
DOSE EQUIVALENT (MREM)	2.81	8.829E-12	2.738E-13	1.069E-08	2.81	1.069E-08	2.81

*** COLLECTIVE POPULATION ***

DOSE RATES:

WEIGHTED SUMS OF ORGAN DOSE RATES

PATHWAYS:	INGESTION	INHALATION	AIR IMMERSION	GROUND SURFACE	INTERNAL	EXTERNAL	TOTAL
LOW LET (PERSON RAD/Y)	1.86	3.156E-11	7.686E-14	3.076E-09	1.86	3.076E-09	1.86
HIGH LET (PERSON RAD/Y)	5.823E-14	3.377E-12	0.000E+00	0.000E+00	3.435E-12	0.000E+00	3.435E-12
DOSE EQ. (PERSON REM/Y)	1.86	9.910E-11	7.686E-14	3.076E-09	1.86	3.076E-09	1.86

AVERAGE GONADAL DOSES:

PATHWAYS:	INGESTION	INHALATION	AIR IMMERSION	GROUND SURFACE	INTERNAL	EXTERNAL	TOTAL
LOW LET (PERSON RAD)	19.7	6.197E-11	1.926E-12	7.520E-08	19.7	7.521E-08	19.7
HIGH LET (PERSON RAD)	1.258E-13	6.223E-15	0.000E+00	0.000E+00	1.320E-13	0.000E+00	1.320E-13
DOSE EQ. (PERSON REM)	19.7	6.210E-11	1.926E-12	7.520E-08	19.7	7.521E-08	19.7

BARNWELL SIMULATION, WELL AT 914 M, XG=8000 M, SOAM=E-8

NUCLIDE DOSE/EXPOSURE SUMMARY

*** SELECTED INDIVIDUAL ***

DOSE RATES:

WEIGHTED SUMS OF ORGAN DOSE RATES

```
          NUCLIDES:  H-3       C-14      MN-54     FE-55     NI-59     CO-60     NI-63     ZN-65     KR-85     SR-90
                      Y-90      NB-94     TC-99     RU-106    CD-109    SB-125    I-125     I-129     CS-134    CS-137
                      BA-137M   CE-141    CE-144    PM-147    RE-187    PB-210    RA-226    TH-232    U-233     U-234
                      U-235     U-236     U-238     PU-238    PU-239    PU-241    AM-241    PU-242    AM-243    CM-243
                      TOTAL
LOW LET (MRAD/Y)     1.244E-11 1.193E-02 1.022E-13 1.835E-13 0.000E+00 1.723E-10 7.142E-14 1.855E-13 2.159E-15 4.407E-13
                      4.841E-16 0.000E+00 0.253     0.000E+00 0.000E+00 9.257E-17 0.000E+00 0.000E+00 1.564E-11 1.106E-10
                      2.773E-10 6.408E-19 1.070E-17 4.729E-20 0.000E+00 1.823E-15 7.467E-17 1.520E-17 0.000E+00 6.855E-18
                      2.265E-15 8.804E-19 7.341E-13 4.461E-19 6.631E-19 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                      0.265
HIGH LET (MRAD/Y)    0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                      0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                      0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 2.179E-15 1.561E-17 4.167E-16 0.000E+00 5.335E-16
                      5.595E-16 8.387E-17 4.844E-13 9.564E-17 2.186E-16 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                      4.885E-13
DOSE EQUIVALENT (MREM/Y) 1.244E-11 1.193E-02 1.022E-13 1.835E-13 0.000E+00 1.723E-10 7.142E-14 1.855E-13 2.159E-15 4.407E-13
                      4.841E-16 0.000E+00 0.253     0.000E+00 0.000E+00 9.257E-17 0.000E+00 0.000E+00 1.564E-11 1.106E-10
                      2.773E-10 6.408E-19 1.070E-17 4.729E-20 0.000E+00 4.539E-14 3.869E-16 8.349E-15 0.000E+00 1.068E-14
                      1.345E-14 1.678E-15 1.042E-11 1.913E-15 4.372E-15 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                      0.265
```

AVERAGE GONADAL DOSES:

```
          NUCLIDES:  H-3       C-14      MN-54     FE-55     NI-59     CO-60     NI-63     ZN-65     KR-85     SR-90
                      Y-90      NB-94     TC-99     RU-106    CD-109    SB-125    I-125     I-129     CS-134    CS-137
                      BA-137M   CE-141    CE-144    PM-147    RE-187    PB-210    RA-226    TH-232    U-233     U-234
                      U-235     U-236     U-238     PU-238    PU-239    PU-241    AM-241    PU-242    AM-243    CM-243
                      TOTAL
LOW LET (MRAD)       3.595E-10 0.165     2.842E-12 6.976E-12 0.000E+00 4.450E-09 8.722E-13 6.805E-12 5.171E-14 3.440E-13
                      2.018E-17 0.000E+00 2.64      0.000E+00 0.000E+00 2.292E-15 0.000E+00 0.000E+00 5.066E-10 4.471E-09
                      6.631E-09 2.632E-18 2.528E-18 1.120E-18 0.000E+00 4.990E-15 2.119E-15 4.962E-16 0.000E+00 1.071E-16
                      6.190E-14 1.367E-17 7.773E-14 9.022E-18 1.744E-17 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
                          2.81
HIGH LET (MRAD)          0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                          0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                          0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 9.231E-15 9.279E-18 9.354E-17 0.000E+00 1.035E-17
                          1.038E-17 1.627E-18 8.988E-15 6.387E-17 3.586E-16 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                          1.877E-14
DOSE EQUIVALENT (MREM)   3.595E-10 0.165     2.842E-12 6.976E-12 0.000E+00 4.450E-09 8.722E-13 6.805E-12 5.171E-14 3.440E-13
                          2.018E-17 0.000E+00  2.64     0.000E+00 0.000E+00 2.292E-15 0.000E+00 0.000E+00 5.066E-10 4.471E-09
                          6.631E-09 2.632E-18 2.528E-18 1.120E-18 0.000E+00 1.896E-13 2.304E-15 2.367E-15 0.000E+00 3.140E-16
                          6.211E-14 4.621E-17 2.575E-13 1.286E-15 7.190E-15 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                          2.81


*** MEAN INDIVIDUAL ***

DOSE RATES:
WEIGHTED SUMS OF ORGAN DOSE RATES
               NUCLIDES:  H-3       C-14      MN-54     FE-55     NI-59     CO-60     NI-63     ZN-65     KR-85     SR-90
                          Y-90      NB-94     TC-99     RU-106    CD-109    SB-125    I-125     I-129     CS-134    CS-137
                          BA-137M   CE-141    CE-144    PM-147    RE-187    PB-210    RA-226    TH-232    U-233     U-234
                          U-235     U-236     U-238     PU-238    PU-239    PU-241    AM-241    PU-242    AM-243    CM-243
                          TOTAL
LOW LET (MRAD/Y)         1.244E-11 1.193E-02 1.022E-13 1.835E-13 0.000E+00 1.723E-10 7.142E-14 1.855E-13 2.159E-15 4.407E-13
                          4.841E-16 0.000E+00 0.253     0.000E+00 0.000E+00 9.257E-17 0.000E+00 0.000E+00 1.564E-11 1.106E-10
                          2.773E-10 6.408E-19 1.070E-17 4.729E-20 0.000E+00 1.823E-15 7.467E-17 1.520E-17 0.000E+00 6.855E-18
                          2.265E-15 8.804E-19 7.341E-13 4.461E-19 6.631E-19 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                          0.265
HIGH LET (MRAD/Y)        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                          0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                          0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 2.179E-15 1.561E-17 4.167E-16 0.000E+00 5.335E-16
                          5.595E-16 8.387E-17 4.844E-13 9.564E-17 2.186E-16 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                          4.885E-13
DOSE EQUIVALENT (MREM/Y) 1.244E-11 1.193E-02 1.022E-13 1.835E-13 0.000E+00 1.723E-10 7.142E-14 1.855E-13 2.159E-15 4.407E-13
                          4.841E-16 0.000E+00 0.253     0.000E+00 0.000E+00 9.257E-17 0.000E+00 0.000E+00 1.564E-11 1.106E-10
                          2.773E-10 6.408E-19 1.070E-17 4.729E-20 0.000E+00 4.539E-14 3.869E-16 8.349E-15 0.000E+00 1.068E-14
                          1.345E-14 1.678E-15 1.042E-11 1.913E-15 4.372E-15 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                          0.265
```

AVERAGE GONADAL DOSES:

NUCLIDES:	H-3	C-14	MN-54	FE-55	NI-59	CO-60	NI-63	ZN-65	KR-85	SR-90
	Y-90	NB-94	TC-99	RU-106	CD-109	SB-125	I-125	I-129	CS-134	CS-137
	BA-137M	CE-141	CE-144	PM-147	RE-187	PB-210	RA-226	TH-232	U-233	U-234
	U-235	U-236	U-238	PU-238	PU-239	PU-241	AM-241	PU-242	AM-243	CM-243
	TOTAL									
LOW LET (MRAD)	3.595E-10	0.165	2.842E-12	5.976E-12	0.000E+00	4.450E-09	8.722E-13	6.805E-12	5.171E-14	3.440E-13
	2.018E-17	0.000E+00	2.64	0.000E+00	0.000E+00	2.292E-15	0.000E+00	0.000E+00	5.066E-10	4.471E-09
	6.631E-09	2.632E-18	2.528E-18	1.120E-18	0.000E+00	4.990E-15	2.119E-15	4.962E-15	0.000E+00	1.071E-16
	6.190E-14	1.367E-17	7.773E-14	9.022E-18	1.744E-17	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	2.81									
HIGH LET (MRAD)	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.231E-15	9.279E-16	9.354E-17	0.000E+00	1.035E-17
	1.038E-17	1.627E-18	8.988E-15	6.387E-17	3.585E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	1.877E-14									
DOSE EQUIVALENT (MREM)	3.595E-10	0.165	2.842E-12	6.976E-12	0.000E+00	4.450E-09	8.722E-13	6.805E-12	5.171E-14	3.440E-13
	2.018E-17	0.000E+00	2.64	0.000E+00	0.000E+00	2.292E-15	0.000E+00	0.000E+00	5.066E-10	4.471E-09
	6.631E-09	2.632E-18	2.528E-18	1.120E-18	0.000E+00	1.896E-13	2.304E-15	2.367E-15	0.000E+00	3.140E-16
	6.211E-14	4.621E-17	2.575E-13	1.286E-15	7.190E-15	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	2.81									

*** COLLECTIVE POPULATION ***

DOSE RATES:

WEIGHTED SUMS OF ORGAN DOSE RATES

NUCLIDES:	H-3	C-14	MN-54	FE-55	NI-59	CO-60	NI-63	ZN-65	KR-85	SR-90
	Y-90	NB-94	TC-99	RU-106	CD-109	SB-125	I-125	I-129	CS-134	CS-137
	BA-137M	CE-141	CE-144	PM-147	RE-187	PB-210	RA-226	TH-232	U-233	U-234
	U-235	U-236	U-238	PU-238	PU-239	PU-241	AM-241	PU-242	AM-243	CM-243
	TOTAL									
LOW LET (PERSON RAD/Y)	8.749E-11	8.389E-02	7.190E-13	1.291E-12	0.000E+00	1.212E-09	5.023E-13	1.304E-12	1.518E-14	3.099E-12
	3.404E-15	0.000E+00	1.78	0.000E+00	0.000E+00	6.511E-16	0.000E+00	0.000E+00	1.100E-10	7.775E-10
	1.950E-09	4.507E-18	7.528E-17	3.326E-19	0.000E+00	1.282E-14	5.252E-16	1.069E-16	0.000E+00	4.821E-17
	1.593E-14	6.192E-18	5.163E-12	3.138E-18	4.664E-18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	1.85									

HIGH LET (PERSON RAD/Y)	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.532E-14	1.098E-16	2.931E-15	0.000E+00	3.752E-15
	3.935E-15	5.899E-16	3.406E-12	6.726E-16	1.537E-15	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	3.435E-12									
DOSE EQ. (PERSON REM/Y)	8.749E-11	6.389E-02	7.190E-13	1.291E-12	0.000E+00	1.212E-09	5.023E-13	1.304E-12	1.518E-14	3.099E-12
	3.404E-15	0.000E+00	1.78	0.000E+00	0.000E+00	6.511E-16	0.000E+00	0.000E+00	1.100E-10	7.775E-10
	1.950E-09	4.507E-18	7.528E-17	3.326E-19	0.000E+00	3.193E-13	2.721E-15	5.872E-14	0.000E+00	7.508E-14
	9.462E-14	1.180E-14	7.329E-11	1.346E-14	3.075E-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	1.86									

AVERAGE GONADAL DOSES:

NUCLIDES:	H-3	C-14	MN-54	FE-55	NI-59	CO-60	NI-63	ZN-65	KR-85	SR-90
	Y-90	NB-94	TC-99	RU-106	CD-109	SB-125	I-125	I-129	CS-134	CS-137
	BA-137M	CE-141	CE-144	PM-147	RE-187	PB-210	RA-226	TH-232	U-233	U-234
	U-235	U-236	U-238	PU-238	PU-239	PU-241	AM-241	PU-242	AM-243	CM-243
	TOTAL									
LOW LET (PERSON RAD)	2.528E-09	1.16	1.999E-11	4.906E-11	0.000E+00	3.130E-08	6.134E-12	4.786E-11	3.636E-13	2.419E-12
	1.419E-16	0.000E+00	18.6	0.000E+00	0.000E+00	1.612E-14	0.000E+00	0.000E+00	3.563E-09	3.144E-08
	4.664E-08	1.851E-17	1.778E-17	7.879E-18	0.000E+00	3.509E-14	1.490E-14	3.490E-15	0.000E+00	7.530E-16
	4.354E-13	9.613E-17	5.466E-13	6.345E-17	1.226E-16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	19.7									
HIGH LET (PERSON RAD)	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.492E-14	6.526E-17	6.578E-16	0.000E+00	7.278E-17
	7.297E-17	1.144E-17	6.321E-14	4.492E-16	2.522E-15	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	1.320E-13									
DOSE EQ. (PERSON REM)	2.528E-09	1.16	1.999E-11	4.906E-11	0.000E+00	3.130E-08	6.134E-12	4.786E-11	3.636E-13	2.419E-12
	1.419E-16	0.000E+00	18.6	0.000E+00	0.000E+00	1.612E-14	0.000E+00	0.000E+00	3.563E-09	3.144E-08
	4.664E-08	1.851E-17	1.778E-17	7.879E-18	0.000E+00	1.334E-12	1.621E-14	1.665E-14	0.000E+00	2.209E-15
	4.368E-13	3.250E-16	1.811E-12	9.047E-15	5.057E-14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	19.7									

BARNWELL SIMULATION, WELL AT 914 M, XG=8000 M, SOAM=E-8

RISK/RISK EQUIVALENT SUMMARY

*** SELECTED INDIVIDUAL ***

LIFETIME FATAL CANCER RISK:

CANCERS:	R MARROW	ENDOST	PULMNARY	BREAST	ST WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL	ULI WALL
	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	LIVER	TOTAL	
LOW LET	3.726E-07	4.104E-08	4.098E-08	4.082E-07	9.429E-08	1.170E-07	6.203E-07	4.665E-08	1.761E-08	1.050E-07
	9.956E-09	1.625E-08	1.623E-08	1.652E-08	1.653E-08	1.657E-08	3.317E-06	2.852E-07	5.558E-06	
HIGH LET	3.929E-19	2.637E-19	9.491E-17	2.651E-21	1.841E-20	8.070E-21	6.445E-19	1.311E-19	1.206E-21	1.072E-19
	9.104E-21	1.155E-21	1.157E-21	1.179E-21	1.153E-21	1.153E-21	5.974E-22	1.495E-19	9.684E-17	
TOTAL	3.726E-07	4.104E-08	4.098E-08	4.082E-07	9.429E-08	1.170E-07	6.203E-07	4.665E-08	1.761E-08	1.050E-07
	9.956E-09	1.625E-08	1.623E-08	1.652E-08	1.653E-08	1.657E-08	3.317E-06	2.852E-07	5.558E-06	

AVERAGE LIFE LOSS PER PREMATURE DEATH:

CANCERS:	R MARROW	ENDOST	PULMNARY	BREAST	ST WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL	ULI WALL
	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	LIVER	TOTAL	
LOW LET (YR)	31.5	29.3	23.0	21.6	21.5	21.4	21.5	21.4	21.4	21.5
	21.0	21.3	21.3	21.3	21.3	21.3	28.2	21.4	26.2	
HIGH LET (YR)	26.5	24.2	22.5	20.2	21.5	20.2	21.5	20.7	20.0	21.5
	21.5	20.0	20.0	20.1	20.0	20.0	26.1	19.7	22.5	
COMBINED (YR)	31.5	29.3	23.0	21.6	21.5	21.4	21.5	21.4	21.4	21.5
	21.0	21.3	21.3	21.3	21.3	21.3	28.2	21.4	26.2	

FATAL CANCER RISK EQUIVALENT:

CANCERS:	R MARROW	ENDOST	PULMNARY	BREAST	ST WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL	ULI WALL
	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	LIVER	TOTAL	
(MREM/YR)	0.114	0.133	6.742E-03	0.102	0.109	9.652E-02	0.894	0.134	5.066E-02	0.304
	5.728E-02	9.329E-02	9.319E-02	9.486E-02	9.490E-02	9.510E-02	3.90	0.183	0.266	

WHOLE BODY FATAL CANCER RISK EQ(MREM/YR) 0.266

GRADIENTS FOR VARIABLE 25949

0.00000E+00 0.00000E+00 -3.70442E-02 2.89753E-02 8.06887E-03 1.78430E-02 2.49803E-04 1.01110E-03

SENSITIVITIES FOR VARIABLE 25949

0.00000E+00	0.00000E+00	-1.39285E-01	1.08947E-01	3.03388E-02	0.00000E+00	0.00000E+00	0.00000E+00

GENETIC RISKS:
LOW LET (EFFECTS/BIRTH) 5.612E-07
HIGH LET (EFFECTS/BIRTH) 3.753E-19
COMBINED (EFFECTS/BIRTH) 5.612E-07

GENETIC RISK EQUIVALENT:
(MREM/YR) 9.353E-02

BARNWELL SIMULATION, WELL AT 914 M, XG=8000 M, SOAM=E-8

RISK/RISK EQUIVALENT SUMMARY

*** MEAN INDIVIDUAL ***

LIFETIME FATAL CANCER RISK:

CANCERS:	R MARROW	ENDOST	PULMNARY	BREAST	ST WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL	ULI WALL
	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	LIVER	TOTAL	
LOW LET	3.726E-07	4.104E-08	4.098E-08	4.082E-07	9.429E-08	1.170E-07	6.203E-07	4.665E-08	1.761E-08	1.050E-07
	9.956E-09	1.625E-08	1.623E-08	1.652E-08	1.653E-08	1.657E-08	3.317E-06	2.852E-07	5.558E-06	
HIGH LET	3.929E-19	2.637E-19	9.491E-17	2.651E-21	1.841E-20	8.070E-21	6.445E-19	1.311E-19	1.206E-21	1.072E-19
	9.104E-21	1.155E-21	1.157E-21	1.179E-21	1.153E-21	1.153E-21	5.974E-22	1.495E-19	9.664E-17	
TOTAL	3.726E-07	4.104E-08	4.098E-08	4.082E-07	9.429E-08	1.170E-07	6.203E-07	4.665E-08	1.761E-08	1.050E-07
	9.956E-09	1.625E-08	1.623E-08	1.652E-08	1.653E-08	1.657E-08	3.317E-06	2.852E-07	5.558E-06	

AVERAGE LIFE LOSS PER PREMATURE DEATH:

CANCERS:	R MARROW	ENDOST	PULMNARY	BREAST	ST WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL	ULI WALL
	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	LIVER	TOTAL	
LOW LET (YR)	31.5	29.3	23.0	21.6	21.5	21.4	21.5	21.4	21.4	21.5
	21.0	21.3	21.3	21.3	21.3	21.3	28.2	21.4	26.2	
HIGH LET (YR)	26.5	24.2	22.5	20.2	21.5	20.2	21.5	20.7	20.0	21.5
	21.5	20.0	20.0	20.1	20.0	20.0	26.1	19.7	22.5	
COMBINED (YR)	31.5	29.3	23.0	21.6	21.5	21.4	21.5	21.4	21.4	21.5
	21.0	21.3	21.3	21.3	21.3	21.3	28.2	21.4	26.2	

FATAL CANCER RISK EQUIVALENT:

CANCERS:	R MARROW	ENDOST	PULMNARY	BREAST	ST WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL	ULI WALL
	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	LIVER	TOTAL	
(MREM/YR)	0.114	0.133	6.742E-03	0.102	0.109	9.652E-02	0.894	0.134	5.066E-02	0.304
	5.728E-02	9.329E-02	9.319E-02	9.486E-02	9.490E-02	9.510E-02	3.90	0.183	0.266	

WHOLE BODY FATAL CANCER RISK EQ(MREM/YR) 0.266

GENETIC RISKS:

LOW LET (EFFECTS/BIRTH)	5.612E-07
HIGH LET (EFFECTS/BIRTH)	3.753E-19
COMBINED (EFFECTS/BIRTH)	5.612E-07

GENETIC RISK EQUIVALENT:

(MREM/YR)	9.353E-02

BARNWELL SIMULATION, WELL AT 914 M, XG=8000 M, SOAM=E-8

RISK/RISK EQUIVALENT SUMMARY

*** COLLECTIVE POPULATION ***

COLLECTIVE FATAL CANCER RISK:

CANCERS:	R MARROW	ENDOST	PULMNARY	BREAST	ST WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL	ULI WALL
	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	LIVER	TOTAL	
LOW LET(DEATHS/YR)	3.704E-05	4.079E-06	4.073E-06	4.057E-05	9.372E-06	1.163E-05	6.165E-05	4.637E-06	1.751E-06	1.044E-05
	9.896E-07	1.616E-06	1.613E-06	1.642E-06	1.643E-06	1.647E-06	3.297E-04	2.635E-05	5.525E-04	
HIGH LET(DEATHS/YR)	3.906E-17	2.621E-17	9.434E-15	2.635E-19	1.830E-18	8.021E-19	6.406E-17	1.303E-17	1.199E-19	1.066E-17
	9.049E-19	1.148E-19	1.150E-19	1.172E-19	1.146E-19	1.146E-19	5.938E-20	1.486E-17	9.606E-15	
TOTAL (DEATHS/YR)	3.704E-05	4.079E-06	4.073E-06	4.057E-05	9.372E-06	1.163E-05	6.165E-05	4.637E-06	1.751E-06	1.044E-05
	9.896E-07	1.616E-06	1.613E-06	1.642E-06	1.643E-06	1.647E-06	3.297E-04	2.835E-05	5.525E-04	

GRADIENTS FOR VARIABLE 25991

0.00000E+00 0.00000E+00 -7.69528E-05 6.01908E-05 1.67619E-05 3.70654E-05 5.18916E-07 2.10038E-06

SENSITIVITIES FOR VARIABLE 25991

0.00000E+00 0.00000E+00 -1.39286E-01 1.08946E-01 3.03394E-02 0.00000E+00 0.00000E+00 0.00000E+00

FATAL CANCER RISK EQUIVALENT:

CANCERS:	R MARROW	ENDOST	PULMNARY	BREAST	ST WALL	PANCREAS	LLI WALL	KIDNEYS	BL WALL	ULI WALL
	SI WALL	OVARIES	TESTES	SPLEEN	UTERUS	THYMUS	THYROID	LIVER	TOTAL	
(PERSON REM/YR)	0.802	0.938	4.742E-02	0.721	0.765	0.679	6.29	0.945	0.356	2.14
	0.403	0.656	0.655	0.667	0.667	0.669	27.4	1.29	1.87	

WHOLE BODY FATAL CANCER RISK EQ(PERSON REM/YR) 1.87

GENETIC RISKS:

LOW LET(EFFECTS/YR)	5.578E-05
HIGH LET(EFFECTS/YR)	3.731E-17
COMBINED(EFFECTS/YR)	5.578E-05

GENETIC RISK EQUIVALENT:

(PERSON REM/YR) 0.658

APPENDIX C

DERIVATIVES OF RESPONSE TBEQ WITH RESPECT TO THE PARAMETERS LISTED

Adjoint Matrix Row Number	Variable Name	Derivative Value
47122	PCT1	0.000000E+00
47123	PCT2	0.000000E+00
47124	WWATL	-7.695277E-05
47125	WWATA	6.019085E-05
47126	WWATH	1.676195E-05
47127	SWATL	3.706543E-05
47128	SWATA	5.189165E-07
47129	SWATH	2.100382E-06
47130	PPN	3.540512E-12
47131	P	6.662348E-15
47132	XIRR	4.630923E-12
47133	PHID	6.670062E-14
47134	S	-2.771945E-13
47135	S	-2.810301E-13
47136	S	-3.678286E-13
47137	S	-6.466465E-13
47138	S	-7.554134E-13
47139	S	-7.525230E-13
47140	S	-7.419394E-13
47141	S	-6.551549E-13
47142	S	-4.901107E-13
47143	S	-3.720032E-13
47144	S	-2.884595E-13
47145	S	-2.433675E-13
47146	T	2.947578E-14
47147	T	2.619100E-14
47148	T	3.069102E-14
47149	T	4.281383E-14
47150	T	4.932199E-14
47151	T	5.120686E-14
47152	T	5.570648E-14
47153	T	5.636830E-14
47154	T	5.319615E-14
47155	T	3.709291E-14
47156	T	3.075907E-14
47157	T	2.798103E-14
47158	TD	-2.776721E-14
47159	TD	-2.416091E-14
47160	TD	-2.688286E-14
47161	TD	-4.452828E-14
47162	TD	-5.830017E-14
47163	TD	-6.569591E-14
47164	TD	-7.508982E-14
47165	TD	-7.577286E-14
47166	TD	-6.675433E-14
47167	TD	-2.937255E-14
47168	TD	-2.729522E-14
47169	TD	-2.631709E-14
47170	TAREA	5.421011E-20
47171	TDEPTH	-2.426589E-10
47172	OVER	0.000000E+00

47173	PORT	0.000000E+00
47174	DENCON	-8.129074E-10
47175	RELFAC	0.000000E+00
47176	FN	0.000000E+00
47177	XINFL	0.000000E+00
47178	PERMC	0.000000E+00
47179	DTRAQ	0.000000E+00
47180	DWELL	0.000000E+00
47181	GWV	0.000000E+00
47182	AQTHK	0.000000E+00
47183	AQDISP	0.000000E+00
47184	PORA	0.000000E+00
47185	PORV	0.000000E+00
47186	PERMV	0.000000E+00
47187	H	0.000000E+00
47188	VG	0.000000E+00
47189	U	3.016879E-12
47190	VD	1.189346E-10
47191	XG	0.000000E+00
47192	HLID	0.000000E+00
47193	ROUGH	0.000000E+00
47194	FTWIND	2.463955E-12
47195	CHIQ	1.567971E-04
47196	RE1	1.204041E-06
47197	RE2	2.739004E-11
47198	RE3	2.710933E-04
47199	RR	0.000000E+00
47200	FTMECH	0.000000E+00
47201	RAINF	0.000000E+00
47202	ERODF	0.000000E+00
47203	STPLNG	0.000000E+00
47204	COVER	0.000000E+00
47205	CONTRL	0.000000E+00
47206	SEDELR	0.000000E+00
47207	PORS	-2.269513E-13
47208	BDENS	9.520531E-14
47209	STFLOW	0.000000E+00
47210	EXTENT	-1.978287E-15
47211	ADEPTH	6.154688E-12
47212	PD	-6.601485E-16
47213	RUNOFF	-2.464328E-11
47214	Y1	-2.184820E-03
47215	Y2	-7.808321E-05
47216	PP	-3.650531E-17
47217	XAMBWE	-1.298055E-01
47218	TE1	2.465481E-07
47219	TE2	4.440017E-09
47220	TH1	-2.161541E-13
47221	TH2	-8.248250E-14
47222	TH3	-6.405688E-14
47223	TH4	-6.405572E-14
47224	TH5	0.000000E+00
47225	TH6	0.000000E+00
47226	FP	6.091297E-10

47227	FS	4.989679E-10
47228	QFC	8.302318E-06
47229	QFG	0.000000E+00
47230	TF1	-6.871313E-14
47231	TF2	0.000000E+00
47232	TS	-2.878601E-13
47233	ABSH	-1.118966E-23
47234	P14	1.316326E-23
47235	FI	-1.054148E-04
47236	WIRATE	-5.130187E-03
47237	QCW	1.144962E-07
47238	QGW	0.000000E+00
47239	QBW	1.437836E-06
47240	ULEAFY	1.089057E-07
47241	UPROD	1.089053E-07
47242	UCMILK	3.407968E-07
47243	UGMILK	7.500994E-08
47244	UMEAT	4.804103E-06
47245	UWAT	4.530257E-08
47246	UAIR	2.246143E-18
47247	POP	-7.105427E-15
47250	TRAM(I)	7.495306E-19
47251	SOAM(I)	9.012530E-19
47252	STAM(I)	0.000000E+00
47253	ATAM(I)	1.258948E-05
47254	DECAY(I)	-1.148553E-11
47255	SOL(I)	0.000000E+00
47256	XKD(K,I)	1.107206E-20
47257	XKD(K,I)	-2.639084E-14
47258	XKD(K,I)	0.000000E+00
47259	XKD(K,I)	0.000000E+00
47260	RA(I)	0.000000E+00
47261	RW(I)	0.000000E+00
47262	BV(I)	0.000000E+00
47263	BR(I)	0.000000E+00
47264	FMC(I)	3.140129E-13
47265	FMG(I)	0.000000E+00
47266	FF(I)	2.711930E-13
48090	HP(MO,IDA,IH	0.000000E+00
48091	HP(MO,IDA,IH	0.000000E+00
48092	HP(MO,IDA,IH	0.000000E+00
48093	HP(MO,IDA,IH	0.000000E+00
48094	HP(MO,IDA,IH	0.000000E+00
48095	HP(MO,IDA,IH	0.000000E+00
48096	HP(MO,IDA,IH	0.000000E+00
48097	HP(MO,IDA,IH	0.000000E+00
48098	HP(MO,IDA,IH	0.000000E+00
48099	HP(MO,IDA,IH	0.000000E+00
48100	HP(MO,IDA,IH	0.000000E+00
48101	HP(MO,IDA,IH	0.000000E+00
48102	HP(MO,IDA,IH	0.000000E+00
48103	HP(MO,IDA,IH	0.000000E+00
48104	HP(MO,IDA,IH	0.000000E+00
48105	HP(MO,IDA,IH	0.000000E+00

48106	HP(MO,IDA,IH	0.000000E+00
48107	HP(MO,IDA,IH	0.000000E+00
48108	HP(MO,IDA,IH	0.000000E+00
48109	HP(MO,IDA,IH	0.000000E+00
48110	HP(MO,IDA,IH	0.000000E+00
48111	HP(MO,IDA,IH	0.000000E+00
48112	HP(MO,IDA,IH	0.000000E+00
48113	HP(MO,IDA,IH	0.000000E+00
48114	HP(MO,IDA,IH	0.000000E+00
48115	HP(MO,IDA,IH	0.000000E+00
48116	HP(MO,IDA,IH	0.000000E+00
48117	HP(MO,IDA,IH	0.000000E+00
48118	HP(MO,IDA,IH	0.000000E+00
48119	HP(MO,IDA,IH	0.000000E+00
48120	HP(MO,IDA,IH	0.000000E+00
48121	HP(MO,IDA,IH	0.000000E+00
48122	HP(MO,IDA,IH	0.000000E+00
48123	HP(MO,IDA,IH	0.000000E+00
48124	HP(MO,IDA,IH	0.000000E+00
48125	HP(MO,IDA,IH	0.000000E+00
48126	HP(MO,IDA,IH	0.000000E+00
48127	HP(MO,IDA,IH	0.000000E+00
48128	HP(MO,IDA,IH	0.000000E+00
48129	HP(MO,IDA,IH	0.000000E+00
48130	HP(MO,IDA,IH	0.000000E+00
48131	HP(MO,IDA,IH	0.000000E+00
48132	HP(MO,IDA,IH	0.000000E+00
48133	HP(MO,IDA,IH	0.000000E+00
48134	HP(MO,IDA,IH	0.000000E+00
48135	HP(MO,IDA,IH	0.000000E+00
48136	HP(MO,IDA,IH	0.000000E+00
48137	HP(MO,IDA,IH	0.000000E+00
48138	HP(MO,IDA,IH	0.000000E+00
48139	HP(MO,IDA,IH	0.000000E+00
48140	HP(MO,IDA,IH	0.000000E+00
48141	HP(MO,IDA,IH	0.000000E+00
48142	HP(MO,IDA,IH	0.000000E+00
48143	HP(MO,IDA,IH	0.000000E+00
48144	HP(MO,IDA,IH	0.000000E+00
48145	HP(MO,IDA,IH	0.000000E+00
48146	HP(MO,IDA,IH	0.000000E+00
48147	HP(MO,IDA,IH	0.000000E+00
48148	HP(MO,IDA,IH	0.000000E+00
48149	HP(MO,IDA,IH	0.000000E+00
48150	HP(MO,IDA,IH	0.000000E+00
48151	HP(MO,IDA,IH	0.000000E+00
48152	HP(MO,IDA,IH	0.000000E+00
48153	HP(MO,IDA,IH	0.000000E+00
48154	HP(MO,IDA,IH	0.000000E+00
48155	HP(MO,IDA,IH	0.000000E+00
48156	HP(MO,IDA,IH	0.000000E+00
48157	HP(MO,IDA,IH	0.000000E+00
48158	HP(MO,IDA,IH	0.000000E+00
48159	HP(MO,IDA,IH	0.000000E+00

48214	HP(MO,IDA,IH	0.000000E+00
48215	HP(MO,IDA,IH	0.000000E+00
48216	HP(MO,IDA,IH	0.000000E+00
48217	HP(MO,IDA,IH	0.000000E+00
48218	HP(MO,IDA,IH	0.000000E+00
48219	HP(MO,IDA,IH	0.000000E+00
48220	HP(MO,IDA,IH	0.000000E+00
48221	HP(MO,IDA,IH	0.000000E+00
48222	HP(MO,IDA,IH	0.000000E+00
48223	HP(MO,IDA,IH	0.000000E+00
48224	HP(MO,IDA,IH	0.000000E+00
48225	HP(MO,IDA,IH	0.000000E+00
48226	HP(MO,IDA,IH	0.000000E+00
48227	HP(MO,IDA,IH	0.000000E+00
48228	HP(MO,IDA,IH	0.000000E+00
48229	HP(MO,IDA,IH	0.000000E+00
48230	HP(MO,IDA,IH	0.000000E+00
48231	HP(MO,IDA,IH	0.000000E+00
48232	HP(MO,IDA,IH	0.000000E+00
48233	HP(MO,IDA,IH	0.000000E+00
48234	HP(MO,IDA,IH	0.000000E+00
48235	HP(MO,IDA,IH	0.000000E+00
48236	HP(MO,IDA,IH	0.000000E+00
48237	HP(MO,IDA,IH	0.000000E+00
48238	HP(MO,IDA,IH	0.000000E+00
48239	HP(MO,IDA,IH	0.000000E+00
48240	HP(MO,IDA,IH	0.000000E+00
48241	HP(MO,IDA,IH	0.000000E+00
48242	HP(MO,IDA,IH	0.000000E+00
48243	HP(MO,IDA,IH	0.000000E+00
48244	HP(MO,IDA,IH	0.000000E+00
48245	HP(MO,IDA,IH	0.000000E+00
48246	HP(MO,IDA,IH	0.000000E+00
48247	HP(MO,IDA,IH	0.000000E+00
48248	HP(MO,IDA,IH	0.000000E+00
48249	HP(MO,IDA,IH	0.000000E+00
48250	HP(MO,IDA,IH	0.000000E+00
48251	HP(MO,IDA,IH	0.000000E+00
48252	HP(MO,IDA,IH	0.000000E+00
48253	HP(MO,IDA,IH	0.000000E+00
48254	HP(MO,IDA,IH	0.000000E+00
48255	HP(MO,IDA,IH	0.000000E+00
48256	HP(MO,IDA,IH	0.000000E+00
48257	HP(MO,IDA,IH	0.000000E+00
48258	HP(MO,IDA,IH	0.000000E+00
48259	HP(MO,IDA,IH	0.000000E+00
48260	HP(MO,IDA,IH	0.000000E+00
48261	HP(MO,IDA,IH	0.000000E+00
48262	HP(MO,IDA,IH	0.000000E+00
48263	HP(MO,IDA,IH	0.000000E+00
48264	HP(MO,IDA,IH	0.000000E+00
48265	HP(MO,IDA,IH	0.000000E+00
48266	HP(MO,IDA,IH	0.000000E+00
48267	HP(MO,IDA,IH	0.000000E+00

48160	HP(MO,IDA,IH	0.000000E+00
48161	HP(MO,IDA,IH	0.000000E+00
48162	HP(MO,IDA,IH	0.000000E+00
48163	HP(MO,IDA,IH	0.000000E+00
48164	HP(MO,IDA,IH	0.000000E+00
48165	HP(MO,IDA,IH	0.000000E+00
48166	HP(MO,IDA,IH	0.000000E+00
48167	HP(MO,IDA,IH	0.000000E+00
48168	HP(MO,IDA,IH	0.000000E+00
48169	HP(MO,IDA,IH	0.000000E+00
48170	HP(MO,IDA,IH	0.000000E+00
48171	HP(MO,IDA,IH	0.000000E+00
48172	HP(MO,IDA,IH	0.000000E+00
48173	HP(MO,IDA,IH	0.000000E+00
48174	HP(MO,IDA,IH	0.000000E+00
48175	HP(MO,IDA,IH	0.000000E+00
48176	HP(MO,IDA,IH	4.460320E+08
48177	HP(MO,IDA,IH	4.880000E+03
48178	HP(MO,IDA,IH	1.462400E+04
48179	HP(MO,IDA,IH	2.787700E+06
48180	HP(MO,IDA,IH	6.075001E+00
48181	HP(MO,IDA,IH	5.589001E-03
48182	HP(MO,IDA,IH	2.020260E+08
48183	HP(MO,IDA,IH	1.290833E-04
48184	HP(MO,IDA,IH	0.000000E+00
48185	HP(MO,IDA,IH	0.000000E+00
48186	HP(MO,IDA,IH	0.000000E+00
48187	HP(MO,IDA,IH	0.000000E+00
48188	HP(MO,IDA,IH	0.000000E+00
48189	HP(MO,IDA,IH	0.000000E+00
48190	HP(MO,IDA,IH	0.000000E+00
48191	HP(MO,IDA,IH	0.000000E+00
48192	HP(MO,IDA,IH	0.000000E+00
48193	HP(MO,IDA,IH	0.000000E+00
48194	HP(MO,IDA,IH	0.000000E+00
48195	HP(MO,IDA,IH	0.000000E+00
48196	HP(MO,IDA,IH	0.000000E+00
48197	HP(MO,IDA,IH	0.000000E+00
48198	HP(MO,IDA,IH	0.000000E+00
48199	HP(MO,IDA,IH	0.000000E+00
48200	HP(MO,IDA,IH	0.000000E+00
48201	HP(MO,IDA,IH	0.000000E+00
48202	HP(MO,IDA,IH	0.000000E+00
48203	HP(MO,IDA,IH	0.000000E+00
48204	HP(MO,IDA,IH	0.000000E+00
48205	HP(MO,IDA,IH	0.000000E+00
48206	HP(MO,IDA,IH	0.000000E+00
48207	HP(MO,IDA,IH	0.000000E+00
48208	HP(MO,IDA,IH	0.000000E+00
48209	HP(MO,IDA,IH	0.000000E+00
48210	HP(MO,IDA,IH	0.000000E+00
48211	HP(MO,IDA,IH	0.000000E+00
48212	HP(MO,IDA,IH	0.000000E+00
48213	HP(MO,IDA,IH	0.000000E+00

48268	HP(MO,IDA,IH	0.000000E+00
48269	HP(MO,IDA,IH	0.000000E+00
48270	HP(MO,IDA,IH	0.000000E+00
48271	HP(MO,IDA,IH	0.000000E+00
48272	HP(MO,IDA,IH	0.000000E+00
48273	HP(MO,IDA,IH	0.000000E+00
48274	HP(MO,IDA,IH	0.000000E+00
48275	HP(MO,IDA,IH	0.000000E+00
48276	HP(MO,IDA,IH	4.460320E+08
48277	HP(MO,IDA,IH	4.880000E+03
48278	HP(MO,IDA,IH	1.462400E+04
48279	HP(MO,IDA,IH	2.787700E+06
48280	HP(MO,IDA,IH	6.075001E+00
48281	HP(MO,IDA,IH	5.589001E-03
48282	HP(MO,IDA,IH	2.020260E+08
48283	HP(MO,IDA,IH	1.290833E-04
48284	HP(MO,IDA,IH	0.000000E+00
48285	HP(MO,IDA,IH	0.000000E+00
48286	HP(MO,IDA,IH	0.000000E+00
48287	HP(MO,IDA,IH	0.000000E+00
48288	HP(MO,IDA,IH	0.000000E+00
48289	HP(MO,IDA,IH	0.000000E+00
48290	HP(MO,IDA,IH	0.000000E+00
48291	HP(MO,IDA,IH	0.000000E+00
48292	HP(MO,IDA,IH	0.000000E+00
48293	HP(MO,IDA,IH	0.000000E+00
48294	HP(MO,IDA,IH	0.000000E+00
48295	HP(MO,IDA,IH	0.000000E+00
48296	HP(MO,IDA,IH	0.000000E+00
48297	HP(MO,IDA,IH	0.000000E+00
48298	HP(MO,IDA,IH	0.000000E+00
48299	HP(MO,IDA,IH	0.000000E+00
48300	HP(MO,IDA,IH	0.000000E+00
48301	HP(MO,IDA,IH	0.000000E+00
48302	HP(MO,IDA,IH	0.000000E+00
48303	HP(MO,IDA,IH	0.000000E+00
48304	HP(MO,IDA,IH	0.000000E+00
48305	HP(MO,IDA,IH	0.000000E+00
48306	HP(MO,IDA,IH	0.000000E+00
48307	HP(MO,IDA,IH	0.000000E+00
48308	HP(MO,IDA,IH	0.000000E+00
48309	HP(MO,IDA,IH	0.000000E+00
48310	HP(MO,IDA,IH	0.000000E+00
48311	HP(MO,IDA,IH	0.000000E+00
48312	HP(MO,IDA,IH	0.000000E+00
48313	HP(MO,IDA,IH	0.000000E+00
48314	HP(MO,IDA,IH	0.000000E+00
48315	HP(MO,IDA,IH	0.000000E+00
48316	HP(MO,IDA,IH	0.000000E+00
48317	HP(MO,IDA,IH	0.000000E+00
48318	HP(MO,IDA,IH	0.000000E+00
48319	HP(MO,IDA,IH	0.000000E+00
48320	HP(MO,IDA,IH	0.000000E+00
48321	HP(MO,IDA,IH	0.000000E+00

48322	HP(MO,IDA,IH	0.000000E+00
48323	HP(MO,IDA,IH	0.000000E+00
48324	HP(MO,IDA,IH	0.000000E+00
48325	HP(MO,IDA,IH	0.000000E+00
48326	HP(MO,IDA,IH	0.000000E+00
48327	HP(MO,IDA,IH	0.000000E+00
48328	HP(MO,IDA,IH	0.000000E+00
48329	HP(MO,IDA,IH	0.000000E+00
48330	HP(MO,IDA,IH	0.000000E+00
48331	HP(MO,IDA,IH	0.000000E+00
48332	HP(MO,IDA,IH	0.000000E+00
48333	HP(MO,IDA,IH	0.000000E+00
48334	HP(MO,IDA,IH	0.000000E+00
48335	HP(MO,IDA,IH	0.000000E+00
48336	HP(MO,IDA,IH	0.000000E+00
48337	HP(MO,IDA,IH	0.000000E+00
48338	HP(MO,IDA,IH	0.000000E+00
48339	HP(MO,IDA,IH	0.000000E+00
48340	HP(MO,IDA,IH	0.000000E+00
48341	HP(MO,IDA,IH	0.000000E+00
48342	HP(MO,IDA,IH	0.000000E+00
48343	HP(MO,IDA,IH	0.000000E+00
48344	HP(MO,IDA,IH	0.000000E+00
48345	HP(MO,IDA,IH	0.000000E+00
48346	HP(MO,IDA,IH	0.000000E+00
48347	HP(MO,IDA,IH	0.000000E+00
48348	HP(MO,IDA,IH	0.000000E+00
48349	HP(MO,IDA,IH	0.000000E+00
48350	HP(MO,IDA,IH	0.000000E+00
48351	HP(MO,IDA,IH	0.000000E+00
48352	HP(MO,IDA,IH	0.000000E+00
48353	HP(MO,IDA,IH	0.000000E+00
48354	HP(MO,IDA,IH	0.000000E+00
48355	HP(MO,IDA,IH	0.000000E+00
48356	HP(MO,IDA,IH	0.000000E+00
48357	HP(MO,IDA,IH	0.000000E+00
48358	HP(MO,IDA,IH	0.000000E+00
48359	HP(MO,IDA,IH	0.000000E+00
48360	HP(MO,IDA,IH	0.000000E+00
48361	HP(MO,IDA,IH	0.000000E+00
48362	HP(MO,IDA,IH	0.000000E+00
48363	HP(MO,IDA,IH	0.000000E+00
48364	HP(MO,IDA,IH	0.000000E+00
48365	HP(MO,IDA,IH	0.000000E+00
48366	HP(MO,IDA,IH	0.000000E+00
48367	HP(MO,IDA,IH	0.000000E+00
48368	HP(MO,IDA,IH	0.000000E+00
48369	HP(MO,IDA,IH	0.000000E+00
48370	HP(MO,IDA,IH	0.000000E+00
48371	HP(MO,IDA,IH	0.000000E+00
48372	HP(MO,IDA,IH	0.000000E+00
48373	HP(MO,IDA,IH	0.000000E+00
48374	HP(MO,IDA,IH	0.000000E+00
48375	HP(MO,IDA,IH	0.000000E+00

48376	HP(MO,IDA,IH	4.460320E+08
48377	HP(MO,IDA,IH	4.880000E+03
48378	HP(MO,IDA,IH	1.462400E+04
48379	HP(MO,IDA,IH	2.787700E+06
48380	HP(MO,IDA,IH	6.075001E+00
48381	HP(MO,IDA,IH	5.589001E-03
48382	HP(MO,IDA,IH	2.020260E+08
48383	HP(MO,IDA,IH	1.290833E-04
48384	HP(MO,IDA,IH	0.000000E+00
48385	HP(MO,IDA,IH	0.000000E+00
48386	HP(MO,IDA,IH	0.000000E+00
48387	HP(MO,IDA,IH	0.000000E+00
48388	HP(MO,IDA,IH	0.000000E+00
48389	HP(MO,IDA,IH	0.000000E+00
48390	HP(MO,IDA,IH	0.000000E+00
48391	HP(MO,IDA,IH	0.000000E+00
48392	HP(MO,IDA,IH	0.000000E+00
48393	HP(MO,IDA,IH	0.000000E+00
48394	HP(MO,IDA,IH	0.000000E+00
48395	HP(MO,IDA,IH	0.000000E+00
48396	HP(MO,IDA,IH	0.000000E+00
48397	HP(MO,IDA,IH	0.000000E+00
48398	HP(MO,IDA,IH	0.000000E+00
48399	HP(MO,IDA,IH	0.000000E+00
48400	HP(MO,IDA,IH	0.000000E+00
48401	HP(MO,IDA,IH	0.000000E+00
48402	HP(MO,IDA,IH	0.000000E+00
48403	HP(MO,IDA,IH	0.000000E+00
48404	HP(MO,IDA,IH	0.000000E+00
48405	HP(MO,IDA,IH	0.000000E+00
48406	HP(MO,IDA,IH	0.000000E+00
48407	HP(MO,IDA,IH	0.000000E+00
48408	HP(MO,IDA,IH	0.000000E+00
48409	HP(MO,IDA,IH	0.000000E+00
48410	HP(MO,IDA,IH	0.000000E+00
48411	HP(MO,IDA,IH	0.000000E+00
48412	HP(MO,IDA,IH	0.000000E+00
48413	HP(MO,IDA,IH	0.000000E+00
48414	HP(MO,IDA,IH	0.000000E+00
48415	HP(MO,IDA,IH	0.000000E+00
48416	HP(MO,IDA,IH	0.000000E+00
48417	HP(MO,IDA,IH	0.000000E+00
48418	HP(MO,IDA,IH	0.000000E+00
48419	HP(MO,IDA,IH	0.000000E+00
48420	HP(MO,IDA,IH	0.000000E+00
48421	HP(MO,IDA,IH	0.000000E+00
48422	HP(MO,IDA,IH	0.000000E+00
48423	HP(MO,IDA,IH	0.000000E+00
48424	HP(MO,IDA,IH	0.000000E+00
48425	HP(MO,IDA,IH	0.000000E+00
48426	HP(MO,IDA,IH	0.000000E+00
48427	HP(MO,IDA,IH	0.000000E+00
48428	HP(MO,IDA,IH	0.000000E+00
48429	HP(MO,IDA,IH	0.000000E+00

49998	HP(MO,IDA,IH	0.000000E+00
49999	HP(MO,IDA,IH	0.000000E+00
50000	HP(MO,IDA,IH	0.000000E+00
50001	HP(MO,IDA,IH	0.000000E+00
50002	HP(MO,IDA,IH	0.000000E+00
50003	HP(MO,IDA,IH	0.000000E+00
50004	HP(MO,IDA,IH	0.000000E+00
50005	HP(MO,IDA,IH	0.000000E+00
50006	HP(MO,IDA,IH	0.000000E+00
50007	HP(MO,IDA,IH	0.000000E+00
50008	HP(MO,IDA,IH	0.000000E+00
50009	HP(MO,IDA,IH	0.000000E+00
50010	HP(MO,IDA,IH	0.000000E+00
50011	HP(MO,IDA,IH	0.000000E+00
50012	HP(MO,IDA,IH	0.000000E+00
50013	HP(MO,IDA,IH	0.000000E+00
50014	HP(MO,IDA,IH	0.000000E+00
50015	HP(MO,IDA,IH	0.000000E+00
50016	HP(MO,IDA,IH	0.000000E+00
50017	HP(MO,IDA,IH	0.000000E+00
50018	HP(MO,IDA,IH	0.000000E+00
50019	HP(MO,IDA,IH	0.000000E+00
50020	HP(MO,IDA,IH	0.000000E+00
50021	HP(MO,IDA,IH	0.000000E+00
50022	HP(MO,IDA,IH	0.000000E+00
50023	HP(MO,IDA,IH	0.000000E+00
50024	HP(MO,IDA,IH	0.000000E+00
50025	HP(MO,IDA,IH	0.000000E+00
50026	HP(MO,IDA,IH	0.000000E+00
50027	HP(MO,IDA,IH	0.000000E+00
50028	HP(MO,IDA,IH	0.000000E+00
50029	HP(MO,IDA,IH	0.000000E+00
50030	HP(MO,IDA,IH	0.000000E+00
50031	HP(MO,IDA,IH	0.000000E+00
50032	HP(MO,IDA,IH	0.000000E+00
50033	HP(MO,IDA,IH	0.000000E+00
50034	HP(MO,IDA,IH	0.000000E+00
50035	HP(MO,IDA,IH	0.000000E+00
50036	HP(MO,IDA,IH	0.000000E+00
50037	HP(MO,IDA,IH	0.000000E+00
50038	HP(MO,IDA,IH	0.000000E+00
50039	HP(MO,IDA,IH	0.000000E+00
50040	HP(MO,IDA,IH	0.000000E+00
50041	HP(MO,IDA,IH	0.000000E+00
50042	HP(MO,IDA,IH	0.000000E+00
50043	HP(MO,IDA,IH	0.000000E+00
50044	HP(MO,IDA,IH	0.000000E+00
50045	HP(MO,IDA,IH	0.000000E+00
50046	HP(MO,IDA,IH	0.000000E+00
50047	HP(MO,IDA,IH	0.000000E+00
50048	HP(MO,IDA,IH	0.000000E+00
50049	HP(MO,IDA,IH	0.000000E+00
50050	HP(MO,IDA,IH	0.000000E+00

50051	HP(MO,IDA,IH	0.000000E+00
50052	HP(MO,IDA,IH	0.000000E+00
50053	HP(MO,IDA,IH	0.000000E+00
50054	HP(MO,IDA,IH	0.000000E+00
50055	HP(MO,IDA,IH	0.000000E+00
50056	HP(MO,IDA,IH	0.000000E+00
50057	HP(MO,IDA,IH	0.000000E+00
50058	HP(MO,IDA,IH	0.000000E+00
50059	HP(MO,IDA,IH	0.000000E+00
50060	HP(MO,IDA,IH	0.000000E+00
50061	HP(MO,IDA,IH	0.000000E+00
50062	HP(MO,IDA,IH	0.000000E+00
50063	HP(MO,IDA,IH	0.000000E+00
50064	HP(MO,IDA,IH	0.000000E+00
50065	HP(MO,IDA,IH	0.000000E+00
50066	HP(MO,IDA,IH	0.000000E+00
50067	HP(MO,IDA,IH	0.000000E+00
50068	HP(MO,IDA,IH	0.000000E+00
50069	HP(MO,IDA,IH	0.000000E+00
50070	HP(MO,IDA,IH	0.000000E+00
50071	HP(MO,IDA,IH	0.000000E+00
50072	HP(MO,IDA,IH	0.000000E+00
50073	HP(MO,IDA,IH	0.000000E+00
50074	HP(MO,IDA,IH	0.000000E+00
50075	HP(MO,IDA,IH	0.000000E+00
50076	HP(MO,IDA,IH	4.460320E+08
50077	HP(MO,IDA,IH	4.880000E+03
50078	HP(MO,IDA,IH	1.462400E+04
50079	HP(MO,IDA,IH	2.787700E+06
50080	HP(MO,IDA,IH	6.075001E+00
50081	HP(MO,IDA,IH	5.589001E-03
50082	HP(MO,IDA,IH	2.020260E+08
50083	HP(MO,IDA,IH	1.290833E-04
50084	HP(MO,IDA,IH	0.000000E+00
50085	HP(MO,IDA,IH	0.000000E+00
50086	HP(MO,IDA,IH	0.000000E+00
50087	HP(MO,IDA,IH	0.000000E+00
50088	HP(MO,IDA,IH	0.000000E+00
50089	HP(MO,IDA,IH	0.000000E+00
50090	HP(MO,IDA,IH	0.000000E+00
50091	HP(MO,IDA,IH	0.000000E+00
50092	HP(MO,IDA,IH	0.000000E+00
50093	HP(MO,IDA,IH	0.000000E+00
50094	HP(MO,IDA,IH	0.000000E+00
50095	HP(MO,IDA,IH	0.000000E+00
50096	HP(MO,IDA,IH	0.000000E+00
50097	HP(MO,IDA,IH	0.000000E+00
50098	HP(MO,IDA,IH	0.000000E+00
50099	HP(MO,IDA,IH	0.000000E+00
50100	HP(MO,IDA,IH	0.000000E+00
50101	HP(MO,IDA,IH	0.000000E+00
50102	HP(MO,IDA,IH	0.000000E+00
50103	HP(MO,IDA,IH	0.000000E+00
50104	HP(MO,IDA,IH	0.000000E+00

50105	HP(MO,IDA,IH	0.000000E+00
50106	HP(MO,IDA,IH	0.000000E+00
50107	HP(MO,IDA,IH	0.000000E+00
50108	HP(MO,IDA,IH	0.000000E+00
50109	HP(MO,IDA,IH	0.000000E+00
50110	HP(MO,IDA,IH	0.000000E+00
50111	HP(MO,IDA,IH	0.000000E+00
50112	HP(MO,IDA,IH	0.000000E+00
50113	HP(MO,IDA,IH	0.000000E+00
50114	HP(MO,IDA,IH	0.000000E+00
50115	HP(MO,IDA,IH	0.000000E+00
50116	HP(MO,IDA,IH	0.000000E+00
50117	HP(MO,IDA,IH	0.000000E+00
50118	HP(MO,IDA,IH	0.000000E+00
50119	HP(MO,IDA,IH	0.000000E+00
50120	HP(MO,IDA,IH	0.000000E+00
50121	HP(MO,IDA,IH	0.000000E+00
50122	HP(MO,IDA,IH	0.000000E+00
50123	HP(MO,IDA,IH	0.000000E+00
50124	HP(MO,IDA,IH	0.000000E+00
50125	HP(MO,IDA,IH	0.000000E+00
50126	HP(MO,IDA,IH	0.000000E+00
50127	HP(MO,IDA,IH	0.000000E+00
50128	HP(MO,IDA,IH	0.000000E+00
50129	HP(MO,IDA,IH	0.000000E+00
50130	HP(MO,IDA,IH	0.000000E+00
50131	HP(MO,IDA,IH	0.000000E+00
50132	HP(MO,IDA,IH	0.000000E+00
50133	HP(MO,IDA,IH	0.000000E+00
50134	HP(MO,IDA,IH	0.000000E+00
50135	HP(MO,IDA,IH	0.000000E+00
50136	HP(MO,IDA,IH	0.000000E+00
50137	HP(MO,IDA,IH	0.000000E+00
50138	HP(MO,IDA,IH	0.000000E+00
50139	HP(MO,IDA,IH	0.000000E+00
50140	HP(MO,IDA,IH	0.000000E+00
50141	HP(MO,IDA,IH	0.000000E+00
50142	HP(MO,IDA,IH	0.000000E+00
50143	HP(MO,IDA,IH	0.000000E+00
50144	HP(MO,IDA,IH	0.000000E+00
50145	HP(MO,IDA,IH	0.000000E+00
50146	HP(MO,IDA,IH	0.000000E+00
50147	HP(MO,IDA,IH	0.000000E+00
50148	HP(MO,IDA,IH	0.000000E+00
50149	HP(MO,IDA,IH	0.000000E+00
50150	HP(MO,IDA,IH	0.000000E+00
50151	HP(MO,IDA,IH	0.000000E+00
50152	HP(MO,IDA,IH	0.000000E+00
50153	HP(MO,IDA,IH	0.000000E+00
50154	HP(MO,IDA,IH	0.000000E+00
50155	HP(MO,IDA,IH	0.000000E+00
50156	HP(MO,IDA,IH	0.000000E+00
50157	HP(MO,IDA,IH	0.000000E+00
50158	HP(MO,IDA,IH	0.000000E+00

50159	HP(MO,IDA,IH	0.000000E+00
50160	HP(MO,IDA,IH	0.000000E+00
50161	HP(MO,IDA,IH	0.000000E+00
50162	HP(MO,IDA,IH	0.000000E+00
50163	HP(MO,IDA,IH	0.000000E+00
50164	HP(MO,IDA,IH	0.000000E+00
50165	HP(MO,IDA,IH	0.000000E+00
50166	HP(MO,IDA,IH	0.000000E+00
50167	HP(MO,IDA,IH	0.000000E+00
50168	HP(MO,IDA,IH	0.000000E+00
50169	HP(MO,IDA,IH	0.000000E+00
50170	HP(MO,IDA,IH	0.000000E+00
50171	HP(MO,IDA,IH	0.000000E+00
50172	HP(MO,IDA,IH	0.000000E+00
50173	HP(MO,IDA,IH	0.000000E+00
50174	HP(MO,IDA,IH	0.000000E+00
50175	HP(MO,IDA,IH	0.000000E+00
50176	HP(MO,IDA,IH	4.460320E+08
50177	HP(MO,IDA,IH	4.880000E+03
50178	HP(MO,IDA,IH	1.462400E+04
50179	HP(MO,IDA,IH	2.787700E+06
50180	HP(MO,IDA,IH	6.075001E+00
50181	HP(MO,IDA,IH	5.589001E-03
50182	HP(MO,IDA,IH	2.020260E+08
50183	HP(MO,IDA,IH	1.290833E-04
50184	HP(MO,IDA,IH	0.000000E+00
50185	HP(MO,IDA,IH	0.000000E+00
50186	HP(MO,IDA,IH	0.000000E+00
50187	HP(MO,IDA,IH	0.000000E+00
50188	HP(MO,IDA,IH	0.000000E+00
50189	HP(MO,IDA,IH	0.000000E+00
50190	HP(MO,IDA,IH	0.000000E+00
50191	HP(MO,IDA,IH	0.000000E+00
50192	HP(MO,IDA,IH	0.000000E+00
50193	HP(MO,IDA,IH	0.000000E+00
50194	HP(MO,IDA,IH	0.000000E+00
50195	HP(MO,IDA,IH	0.000000E+00
50196	HP(MO,IDA,IH	0.000000E+00
50197	HP(MO,IDA,IH	0.000000E+00
50198	HP(MO,IDA,IH	0.000000E+00
50199	HP(MO,IDA,IH	0.000000E+00
50200	HP(MO,IDA,IH	0.000000E+00
50201	HP(MO,IDA,IH	0.000000E+00
50202	HP(MO,IDA,IH	0.000000E+00
50203	HP(MO,IDA,IH	0.000000E+00
50204	HP(MO,IDA,IH	0.000000E+00
50205	HP(MO,IDA,IH	0.000000E+00
50206	HP(MO,IDA,IH	0.000000E+00
50207	HP(MO,IDA,IH	0.000000E+00
50208	HP(MO,IDA,IH	0.000000E+00
50209	HP(MO,IDA,IH	0.000000E+00
50210	HP(MO,IDA,IH	0.000000E+00
50211	HP(MO,IDA,IH	0.000000E+00
50212	HP(MO,IDA,IH	0.000000E+00

50214	HP(MO,IDA,IH	0.000000E+00
50215	HP(MO,IDA,IH	0.000000E+00
50216	HP(MO,IDA,IH	0.000000E+00
50217	HP(MO,IDA,IH	0.000000E+00
50218	HP(MO,IDA,IH	0.000000E+00
50219	HP(MO,IDA,IH	0.000000E+00
50220	HP(MO,IDA,IH	0.000000E+00
50221	HP(MO,IDA,IH	0.000000E+00
50222	HP(MO,IDA,IH	0.000000E+00
50223	HP(MO,IDA,IH	0.000000E+00
50224	HP(MO,IDA,IH	0.000000E+00
50225	HP(MO,IDA,IH	0.000000E+00
50226	HP(MO,IDA,IH	0.000000E+00
50227	HP(MO,IDA,IH	0.000000E+00
50228	HP(MO,IDA,IH	0.000000E+00
50229	HP(MO,IDA,IH	0.000000E+00
50230	HP(MO,IDA,IH	0.000000E+00
50231	HP(MO,IDA,IH	0.000000E+00
50232	HP(MO,IDA,IH	0.000000E+00
50233	HP(MO,IDA,IH	0.000000E+00
50234	HP(MO,IDA,IH	0.000000E+00
50235	HP(MO,IDA,IH	0.000000E+00
50236	HP(MO,IDA,IH	0.000000E+00
50237	HP(MO,IDA,IH	0.000000E+00
50238	HP(MO,IDA,IH	0.000000E+00
50239	HP(MO,IDA,IH	0.000000E+00
50240	HP(MO,IDA,IH	0.000000E+00
50241	HP(MO,IDA,IH	0.000000E+00
50242	HP(MO,IDA,IH	0.000000E+00
50243	HP(MO,IDA,IH	0.000000E+00
50244	HP(MO,IDA,IH	0.000000E+00
50245	HP(MO,IDA,IH	0.000000E+00
50246	HP(MO,IDA,IH	0.000000E+00
50247	HP(MO,IDA,IH	0.000000E+00
50248	HP(MO,IDA,IH	0.000000E+00
50249	HP(MO,IDA,IH	0.000000E+00
50250	HP(MO,IDA,IH	0.000000E+00
50251	HP(MO,IDA,IH	0.000000E+00
50252	HP(MO,IDA,IH	0.000000E+00
50253	HP(MO,IDA,IH	0.000000E+00
50254	HP(MO,IDA,IH	0.000000E+00
50255	HP(MO,IDA,IH	0.000000E+00
50256	HP(MO,IDA,IH	0.000000E+00
50257	HP(MO,IDA,IH	0.000000E+00
50258	HP(MO,IDA,IH	0.000000E+00
50259	HP(MO,IDA,IH	0.000000E+00
50260	HP(MO,IDA,IH	0.000000E+00
50261	HP(MO,IDA,IH	0.000000E+00
50262	HP(MO,IDA,IH	0.000000E+00
50263	HP(MO,IDA,IH	0.000000E+00
50264	HP(MO,IDA,IH	0.000000E+00
50265	HP(MO,IDA,IH	0.000000E+00
50266	HP(MO,IDA,IH	0.000000E+00
50267	HP(MO,IDA,IH	0.000000E+00

50268	HP(MO,IDA,IH	0.000000E+00
50269	HP(MO,IDA,IH	0.000000E+00
50270	HP(MO,IDA,IH	0.000000E+00
50271	HP(MO,IDA,IH	0.000000E+00
50272	HP(MO,IDA,IH	0.000000E+00
50273	HP(MO,IDA,IH	0.000000E+00
50274	HP(MO,IDA,IH	0.000000E+00
50275	HP(MO,IDA,IH	0.000000E+00
50276	HP(MO,IDA,IH	4.460320E+08
50277	HP(MO,IDA,IH	4.880000E+03
50278	HP(MO,IDA,IH	1.462400E+04
50279	HP(MO,IDA,IH	2.787700E+06
50280	HP(MO,IDA,IH	6.075001E+00
50281	HP(MO,IDA,IH	5.589001E-03
50282	HP(MO,IDA,IH	2.020260E+08
50283	HP(MO,IDA,IH	1.290833E-04
50284	HP(MO,IDA,IH	0.000000E+00
50285	HP(MO,IDA,IH	0.000000E+00
50286	HP(MO,IDA,IH	0.000000E+00
50287	HP(MO,IDA,IH	0.000000E+00
50288	HP(MO,IDA,IH	0.000000E+00
50289	HP(MO,IDA,IH	0.000000E+00
50290	HP(MO,IDA,IH	0.000000E+00
50291	HP(MO,IDA,IH	0.000000E+00
50292	HP(MO,IDA,IH	0.000000E+00
50293	HP(MO,IDA,IH	0.000000E+00
50294	HP(MO,IDA,IH	0.000000E+00
50295	HP(MO,IDA,IH	0.000000E+00
50296	HP(MO,IDA,IH	0.000000E+00
50297	HP(MO,IDA,IH	0.000000E+00
50298	HP(MO,IDA,IH	0.000000E+00
50299	HP(MO,IDA,IH	0.000000E+00
50300	HP(MO,IDA,IH	0.000000E+00
50301	HP(MO,IDA,IH	0.000000E+00
50302	HP(MO,IDA,IH	0.000000E+00
50303	HP(MO,IDA,IH	0.000000E+00
50304	HP(MO,IDA,IH	0.000000E+00
50305	HP(MO,IDA,IH	0.000000E+00
50306	HP(MO,IDA,IH	0.000000E+00
50307	HP(MO,IDA,IH	0.000000E+00
50308	HP(MO,IDA,IH	0.000000E+00
50309	HP(MO,IDA,IH	0.000000E+00
50310	HP(MO,IDA,IH	0.000000E+00
50311	HP(MO,IDA,IH	0.000000E+00
50312	HP(MO,IDA,IH	0.000000E+00
50313	HP(MO,IDA,IH	0.000000E+00
50314	HP(MO,IDA,IH	0.000000E+00
50315	HP(MO,IDA,IH	0.000000E+00
50316	HP(MO,IDA,IH	0.000000E+00
50317	HP(MO,IDA,IH	0.000000E+00
50318	HP(MO,IDA,IH	0.000000E+00
50319	HP(MO,IDA,IH	0.000000E+00
50320	HP(MO,IDA,IH	0.000000E+00
50321	HP(MO,IDA,IH	0.000000E+00

50322	HP(MO,IDA,IH	0.000000E+00
50323	HP(MO,IDA,IH	0.000000E+00
50324	HP(MO,IDA,IH	0.000000E+00
50325	HP(MO,IDA,IH	0.000000E+00
50326	HP(MO,IDA,IH	0.000000E+00
50327	HP(MO,IDA,IH	0.000000E+00
50328	HP(MO,IDA,IH	0.000000E+00
50329	HP(MO,IDA,IH	0.000000E+00
50330	HP(MO,IDA,IH	0.000000E+00
50331	HP(MO,IDA,IH	0.000000E+00
50332	HP(MO,IDA,IH	0.000000E+00
50333	HP(MO,IDA,IH	0.000000E+00
50334	HP(MO,IDA,IH	0.000000E+00
50335	HP(MO,IDA,IH	0.000000E+00
50336	HP(MO,IDA,IH	0.000000E+00
50337	HP(MO,IDA,IH	0.000000E+00
50338	HP(MO,IDA,IH	0.000000E+00
50339	HP(MO,IDA,IH	0.000000E+00
50340	HP(MO,IDA,IH	0.000000E+00
50341	HP(MO,IDA,IH	0.000000E+00
50342	HP(MO,IDA,IH	0.000000E+00
50343	HP(MO,IDA,IH	0.000000E+00
50344	HP(MO,IDA,IH	0.000000E+00
50345	HP(MO,IDA,IH	0.000000E+00
50346	HP(MO,IDA,IH	0.000000E+00
50347	HP(MO,IDA,IH	0.000000E+00
50348	HP(MO,IDA,IH	0.000000E+00
50349	HP(MO,IDA,IH	0.000000E+00
50350	HP(MO,IDA,IH	0.000000E+00
50351	HP(MO,IDA,IH	0.000000E+00
50352	HP(MO,IDA,IH	0.000000E+00
50353	HP(MO,IDA,IH	0.000000E+00
50354	HP(MO,IDA,IH	0.000000E+00
50355	HP(MO,IDA,IH	0.000000E+00
50356	HP(MO,IDA,IH	0.000000E+00
50357	HP(MO,IDA,IH	0.000000E+00
50358	HP(MO,IDA,IH	0.000000E+00
50359	HP(MO,IDA,IH	0.000000E+00
50360	HP(MO,IDA,IH	0.000000E+00
50361	HP(MO,IDA,IH	0.000000E+00
50362	HP(MO,IDA,IH	0.000000E+00
50363	HP(MO,IDA,IH	0.000000E+00
50364	HP(MO,IDA,IH	0.000000E+00
50365	HP(MO,IDA,IH	0.000000E+00
50366	HP(MO,IDA,IH	0.000000E+00
50367	HP(MO,IDA,IH	0.000000E+00
50368	HP(MO,IDA,IH	0.000000E+00
50369	HP(MO,IDA,IH	0.000000E+00
50370	HP(MO,IDA,IH	0.000000E+00
50371	HP(MO,IDA,IH	0.000000E+00
50372	HP(MO,IDA,IH	0.000000E+00
50373	HP(MO,IDA,IH	0.000000E+00
50374	HP(MO,IDA,IH	0.000000E+00
50375	HP(MO,IDA,IH	0.000000E+00

50376	HP(MO,IDA,IH	4.460320E+08
50377	HP(MO,IDA,IH	4.880000E+03
50378	HP(MO,IDA,IH	1.462400E+04
50379	HP(MO,IDA,IH	2.787700E+06
50380	HP(MO,IDA,IH	6.075001E+00
50381	HP(MO,IDA,IH	5.589001E-03
50382	HP(MO,IDA,IH	2.020260E+08
50383	HP(MO,IDA,IH	1.290833E-04
50384	HP(MO,IDA,IH	0.000000E+00
50385	HP(MO,IDA,IH	0.000000E+00
50386	HP(MO,IDA,IH	0.000000E+00
50387	HP(MO,IDA,IH	0.000000E+00
50388	HP(MO,IDA,IH	0.000000E+00
50389	HP(MO,IDA,IH	0.000000E+00
50390	HP(MO,IDA,IH	0.000000E+00
50391	HP(MO,IDA,IH	0.000000E+00
50392	HP(MO,IDA,IH	0.000000E+00
50393	HP(MO,IDA,IH	0.000000E+00
50394	HP(MO,IDA,IH	0.000000E+00
50395	HP(MO,IDA,IH	0.000000E+00
50396	HP(MO,IDA,IH	0.000000E+00
50397	HP(MO,IDA,IH	0.000000E+00
50398	HP(MO,IDA,IH	0.000000E+00
50399	HP(MO,IDA,IH	0.000000E+00
50400	HP(MO,IDA,IH	0.000000E+00
50401	HP(MO,IDA,IH	0.000000E+00
50402	HP(MO,IDA,IH	0.000000E+00
50403	HP(MO,IDA,IH	0.000000E+00
50404	HP(MO,IDA,IH	0.000000E+00
50405	HP(MO,IDA,IH	0.000000E+00
50406	HP(MO,IDA,IH	0.000000E+00
50407	HP(MO,IDA,IH	0.000000E+00
50408	HP(MO,IDA,IH	0.000000E+00
50409	HP(MO,IDA,IH	0.000000E+00
50410	HP(MO,IDA,IH	0.000000E+00
50411	HP(MO,IDA,IH	0.000000E+00
50412	HP(MO,IDA,IH	0.000000E+00
50413	HP(MO,IDA,IH	0.000000E+00
50414	HP(MO,IDA,IH	0.000000E+00
50415	HP(MO,IDA,IH	0.000000E+00
50416	HP(MO,IDA,IH	0.000000E+00
50417	HP(MO,IDA,IH	0.000000E+00
50418	HP(MO,IDA,IH	0.000000E+00
50419	HP(MO,IDA,IH	0.000000E+00
50420	HP(MO,IDA,IH	0.000000E+00
50421	HP(MO,IDA,IH	0.000000E+00
50422	HP(MO,IDA,IH	0.000000E+00
50423	HP(MO,IDA,IH	0.000000E+00
50424	HP(MO,IDA,IH	0.000000E+00
50425	HP(MO,IDA,IH	0.000000E+00
50426	HP(MO,IDA,IH	0.000000E+00
50427	HP(MO,IDA,IH	0.000000E+00
50428	HP(MO,IDA,IH	0.000000E+00
50429	HP(MO,IDA,IH	0.000000E+00

50430	HP(MO,IDA,IH	0.000000E+00
50431	HP(MO,IDA,IH	0.000000E+00
50432	HP(MO,IDA,IH	0.000000E+00
50433	HP(MO,IDA,IH	0.000000E+00
50434	HP(MO,IDA,IH	0.000000E+00
50435	HP(MO,IDA,IH	0.000000E+00
50436	HP(MO,IDA,IH	0.000000E+00
50437	HP(MO,IDA,IH	0.000000E+00
50438	HP(MO,IDA,IH	0.000000E+00
50439	HP(MO,IDA,IH	0.000000E+00
50440	HP(MO,IDA,IH	0.000000E+00
50441	HP(MO,IDA,IH	0.000000E+00
7515994	AGEX	-7.808209E-06
7515995	PLOC	0.000000E+00
7515996	GSCFAC	1.819037E-12
7515997	TIME(IJQH	0.000000E+00
7515998	TIME(IJQH	0.000000E+00
7515999	TIME(IJQH	0.000000E+00
7516000	TIME(IJQH	0.000000E+00
7516001	TIME(IJQH	0.000000E+00
7516002	TIME(IJQH	0.000000E+00
7516003	TIME(IJQH	0.000000E+00
7516004	TIME(IJQH	0.000000E+00
7516005	TIME(IJQH	0.000000E+00
7516006	TIME(IJQH	0.000000E+00
7516007	TIME(IJQH	0.000000E+00
7516008	TIME(IJQH	0.000000E+00
7516009	TIME(IJQH	0.000000E+00
7516010	TIME(IJQH	0.000000E+00
7516011	TIME(IJQH	0.000000E+00
7516012	TIME(IJQH	0.000000E+00
7516013	TIME(IJQH	0.000000E+00
7516014	TIME(IJQH	0.000000E+00
7516015	TIME(IJQH	0.000000E+00
7516016	TIME(IJQH	0.000000E+00
7516017	LLET(IJQH	0.000000E+00
7516018	HLET(IJQH	0.000000E+00
7516019	LLET(IJQH	0.000000E+00
7516020	HLET(IJQH	0.000000E+00
7516021	LLET(IJQH	0.000000E+00
7516022	HLET(IJQH	0.000000E+00
7516023	LLET(IJQH	0.000000E+00
7516024	HLET(IJQH	0.000000E+00
7516025	LLET(IJQH	0.000000E+00
7516026	HLET(IJQH	0.000000E+00
7516027	LLET(IJQH	0.000000E+00
7516028	HLET(IJQH	0.000000E+00
7516029	LLET(IJQH	0.000000E+00
7516030	HLET(IJQH	0.000000E+00
7516031	LLET(IJQH	0.000000E+00
7516032	HLET(IJQH	0.000000E+00
7516033	LLET(IJQH	0.000000E+00
7516034	HLET(IJQH	0.000000E+00
7516035	LLET(IJQH	0.000000E+00

7516036	HLET(IJQH	0.000000E+00
7516037	LLET(IJQH	0.000000E+00
7516038	HLET(IJQH	0.000000E+00
7516039	LLET(IJQH	0.000000E+00
7516040	HLET(IJQH	0.000000E+00
7516041	LLET(IJQH	0.000000E+00
7516042	HLET(IJQH	0.000000E+00
7516043	LLET(IJQH	0.000000E+00
7516044	HLET(IJQH	0.000000E+00
7516045	LLET(IJQH	0.000000E+00
7516046	HLET(IJQH	0.000000E+00
7516047	LLET(IJQH	0.000000E+00
7516048	HLET(IJQH	0.000000E+00
7516049	LLET(IJQH	0.000000E+00
7516050	HLET(IJQH	0.000000E+00
7516051	LLET(IJQH	0.000000E+00
7516052	HLET(IJQH	0.000000E+00
7516053	LLET(IJQH	0.000000E+00
7516054	HLET(IJQH	0.000000E+00
7516055	LLET(IJQH	0.000000E+00
7516056	HLET(IJQH	0.000000E+00
7516057	RELABS(IJQ	0.000000E+00
7516058	RELABS(IJQ	0.000000E+00
7516059	RELABS(IJQ	0.000000E+00
7516060	RELABS(IJQ	0.000000E+00
7516061	RELABS(IJQ	0.000000E+00
7516062	RELABS(IJQ	0.000000E+00
7516063	RELABS(IJQ	0.000000E+00
7516064	RELABS(IJQ	0.000000E+00
7516065	RELABS(IJQ	0.000000E+00
7516066	RELABS(IJQ	0.000000E+00
7516067	RELABS(IJQ	0.000000E+00
7516068	RELABS(IJQ	0.000000E+00
7516069	RELABS(IJQ	0.000000E+00
7516070	RELABS(IJQ	0.000000E+00
7516071	RELABS(IJQ	0.000000E+00
7516072	RELABS(IJQ	0.000000E+00
7516073	RELABS(IJQ	0.000000E+00
7516074	RELABS(IJQ	0.000000E+00
7516075	RELABS(IJQ	0.000000E+00
7516076	RELABS(IJQ	0.000000E+00
7516077	GLLET(IJQH	0.000000E+00
7516078	GHLET(IJQH	0.000000E+00
7516079	GLLET(IJQH	0.000000E+00
7516080	GHLET(IJQH	0.000000E+00
7516081	GLLET(IJQH	0.000000E+00
7516082	GHLET(IJQH	0.000000E+00
7516083	GRFAC(1)	0.000000E+00
7516084	GRFAC(2)	0.000000E+00
7516085	REPPER	0.000000E+00
7516088	GIABS(JJQH,	0.000000E+00
7516089	GIABS(JJQH,	0.000000E+00
7516090	GIABS(JJQH,	0.000000E+00
7516091	GIABS(JJQH,	0.000000E+00

7516092	PSIZE(IJQH	0.000000E+00
7516093	GIABS(JJQH,	0.000000E+00
7516094	GIABS(JJQH,	0.000000E+00
7516095	GIABS(JJQH,	0.000000E+00
7516096	GIABS(JJQH,	0.000000E+00
7516097	PSIZE(IJQH	0.000000E+00
7516098	GIABS(JJQH,	0.000000E+00
7516099	GIABS(JJQH,	0.000000E+00
7516100	GIABS(JJQH,	0.000000E+00
7516101	GIABS(JJQH,	0.000000E+00
7516102	PSIZE(IJQH	0.000000E+00
7516103	GIABS(JJQH,	0.000000E+00
7516104	GIABS(JJQH,	0.000000E+00
7516105	GIABS(JJQH,	0.000000E+00
7516106	GIABS(JJQH,	0.000000E+00
7516107	PSIZE(IJQH	0.000000E+00
7516108	GIABS(JJQH,	0.000000E+00
7516109	GIABS(JJQH,	0.000000E+00
7516110	GIABS(JJQH,	0.000000E+00
7516111	GIABS(JJQH,	0.000000E+00
7516112	PSIZE(IJQH	0.000000E+00
7516113	GIABS(JJQH,	0.000000E+00
7516114	GIABS(JJQH,	0.000000E+00
7516115	GIABS(JJQH,	0.000000E+00
7516116	GIABS(JJQH,	0.000000E+00
7516117	PSIZE(IJQH	0.000000E+00
7516118	GIABS(JJQH,	0.000000E+00
7516119	GIABS(JJQH,	0.000000E+00
7516120	GIABS(JJQH,	0.000000E+00
7516121	GIABS(JJQH,	0.000000E+00
7516122	PSIZE(IJQH	0.000000E+00
7516123	GIABS(JJQH,	0.000000E+00
7516124	GIABS(JJQH,	0.000000E+00
7516125	GIABS(JJQH,	0.000000E+00
7516126	GIABS(JJQH,	0.000000E+00
7516127	PSIZE(IJQH	0.000000E+00
7516128	GIABS(JJQH,	0.000000E+00
7516129	GIABS(JJQH,	0.000000E+00
7516130	GIABS(JJQH,	0.000000E+00
7516131	GIABS(JJQH,	0.000000E+00
7516132	PSIZE(IJQH	0.000000E+00
7516133	GIABS(JJQH,	0.000000E+00
7516134	GIABS(JJQH,	0.000000E+00
7516135	GIABS(JJQH,	0.000000E+00
7516136	GIABS(JJQH,	0.000000E+00
7516137	PSIZE(IJQH	0.000000E+00
7516138	GIABS(JJQH,	0.000000E+00
7516139	GIABS(JJQH,	0.000000E+00
7516140	GIABS(JJQH,	0.000000E+00
7516141	GIABS(JJQH,	0.000000E+00
7516142	PSIZE(IJQH	0.000000E+00
7516143	GIABS(JJQH,	0.000000E+00
7516144	GIABS(JJQH,	0.000000E+00
7516145	GIABS(JJQH,	0.000000E+00

7516146	GIABS(JJQH,	0.000000E+00
7516147	PSIZE(IJQH	0.000000E+00
7516148	GIABS(JJQH,	0.000000E+00
7516149	GIABS(JJQH,	0.000000E+00
7516150	GIABS(JJQH,	0.000000E+00
7516151	GIABS(JJQH,	0.000000E+00
7516152	PSIZE(IJQH	0.000000E+00
7516153	GIABS(JJQH,	0.000000E+00
7516154	GIABS(JJQH,	0.000000E+00
7516155	GIABS(JJQH,	0.000000E+00
7516156	GIABS(JJQH,	0.000000E+00
7516157	PSIZE(IJQH	0.000000E+00
7516158	GIABS(JJQH,	0.000000E+00
7516159	GIABS(JJQH,	0.000000E+00
7516160	GIABS(JJQH,	0.000000E+00
7516161	GIABS(JJQH,	0.000000E+00
7516162	PSIZE(IJQH	0.000000E+00
7516163	GIABS(JJQH,	0.000000E+00
7516164	GIABS(JJQH,	0.000000E+00
7516165	GIABS(JJQH,	0.000000E+00
7516166	GIABS(JJQH,	0.000000E+00
7516167	PSIZE(IJQH	0.000000E+00
7516168	GIABS(JJQH,	0.000000E+00
7516169	GIABS(JJQH,	0.000000E+00
7516170	GIABS(JJQH,	0.000000E+00
7516171	GIABS(JJQH,	0.000000E+00
7516172	PSIZE(IJQH	0.000000E+00
7516173	GIABS(JJQH,	0.000000E+00
7516174	GIABS(JJQH,	0.000000E+00
7516175	GIABS(JJQH,	0.000000E+00
7516176	GIABS(JJQH,	4.460320E+08
7516177	PSIZE(IJQH	4.880000E+03
7516178	GIABS(JJQH,	1.462400E+04
7516179	GIABS(JJQH,	2.787700E+06
7516180	GIABS(JJQH,	6.075001E+00
7516181	GIABS(JJQH,	5.589001E-03
7516182	PSIZE(IJQH	2.020260E+08
7516183	GIABS(JJQH,	1.290833E-04
7516184	GIABS(JJQH,	0.000000E+00
7516185	GIABS(JJQH,	0.000000E+00
7516186	GIABS(JJQH,	0.000000E+00
7516187	PSIZE(IJQH	0.000000E+00
7516188	GIABS(JJQH,	0.000000E+00
7516189	GIABS(JJQH,	0.000000E+00
7516190	GIABS(JJQH,	0.000000E+00
7516191	GIABS(JJQH,	0.000000E+00
7516192	PSIZE(IJQH	0.000000E+00
7516193	GIABS(JJQH,	0.000000E+00
7516194	GIABS(JJQH,	0.000000E+00
7516195	GIABS(JJQH,	0.000000E+00
7516196	GIABS(JJQH,	0.000000E+00
7516197	PSIZE(IJQH	0.000000E+00
7516198	GIABS(JJQH,	0.000000E+00
7516199	GIABS(JJQH,	0.000000E+00

7516200	GIABS(JJQH,	0.000000E+00
7516201	GIABS(JJQH,	0.000000E+00
7516202	PSIZE(IJQH	0.000000E+00
7516203	GIABS(JJQH,	0.000000E+00
7516204	GIABS(JJQH,	0.000000E+00
7516205	GIABS(JJQH,	0.000000E+00
7516206	GIABS(JJQH,	0.000000E+00
7516207	PSIZE(IJQH	0.000000E+00
7516208	GIABS(JJQH,	0.000000E+00
7516209	GIABS(JJQH,	0.000000E+00
7516210	GIABS(JJQH,	0.000000E+00
7516211	GIABS(JJQH,	0.000000E+00
7516212	PSIZE(IJQH	0.000000E+00
7516213	GIABS(JJQH,	0.000000E+00
7516214	GIABS(JJQH,	0.000000E+00
7516215	GIABS(JJQH,	0.000000E+00
7516216	GIABS(JJQH,	0.000000E+00
7516217	PSIZE(IJQH	0.000000E+00
7516218	GIABS(JJQH,	0.000000E+00
7516219	GIABS(JJQH,	0.000000E+00
7516220	GIABS(JJQH,	0.000000E+00
7516221	GIABS(JJQH,	0.000000E+00
7516222	PSIZE(IJQH	0.000000E+00
7516223	GIABS(JJQH,	0.000000E+00
7516224	GIABS(JJQH,	0.000000E+00
7516225	GIABS(JJQH,	0.000000E+00
7516226	GIABS(JJQH,	0.000000E+00
7516227	PSIZE(IJQH	0.000000E+00
7516228	GIABS(JJQH,	0.000000E+00
7516229	GIABS(JJQH,	0.000000E+00
7516230	GIABS(JJQH,	0.000000E+00
7516231	GIABS(JJQH,	0.000000E+00
7516232	PSIZE(IJQH	0.000000E+00
7516233	GIABS(JJQH,	0.000000E+00
7516234	GIABS(JJQH,	0.000000E+00
7516235	GIABS(JJQH,	0.000000E+00
7516236	GIABS(JJQH,	0.000000E+00
7516237	PSIZE(IJQH	0.000000E+00
7516238	GIABS(JJQH,	0.000000E+00
7516239	GIABS(JJQH,	0.000000E+00
7516240	GIABS(JJQH,	0.000000E+00
7516241	GIABS(JJQH,	0.000000E+00
7516242	PSIZE(IJQH	0.000000E+00
7516243	GIABS(JJQH,	0.000000E+00
7516244	GIABS(JJQH,	0.000000E+00
7516245	GIABS(JJQH,	0.000000E+00
7516246	GIABS(JJQH,	0.000000E+00
7516247	PSIZE(IJQH	0.000000E+00
7516248	GIABS(JJQH,	0.000000E+00
7516249	GIABS(JJQH,	0.000000E+00
7516250	GIABS(JJQH,	0.000000E+00
7516251	GIABS(JJQH,	0.000000E+00
7516252	PSIZE(IJQH	0.000000E+00
7516253	GIABS(JJQH,	0.000000E+00

7516254	GIABS(JJQH,	0.000000E+00
7516255	GIABS(JJQH,	0.000000E+00
7516256	GIABS(JJQH,	0.000000E+00
7516257	PSIZE(IJQH	0.000000E+00
7516258	GIABS(JJQH,	0.000000E+00
7516259	GIABS(JJQH,	0.000000E+00
7516260	GIABS(JJQH,	0.000000E+00
7516261	GIABS(JJQH,	0.000000E+00
7516262	PSIZE(IJQH	0.000000E+00
7516263	GIABS(JJQH,	0.000000E+00
7516264	GIABS(JJQH,	0.000000E+00
7516265	GIABS(JJQH,	0.000000E+00
7516266	GIABS(JJQH,	0.000000E+00
7516267	PSIZE(IJQH	0.000000E+00
7516268	GIABS(JJQH,	0.000000E+00
7516269	GIABS(JJQH,	0.000000E+00
7516270	GIABS(JJQH,	0.000000E+00
7516271	GIABS(JJQH,	0.000000E+00
7516272	PSIZE(IJQH	0.000000E+00
7516273	GIABS(JJQH,	0.000000E+00
7516274	GIABS(JJQH,	0.000000E+00
7516275	GIABS(JJQH,	0.000000E+00
7516276	GIABS(JJQH,	4.460320E+08
7516277	PSIZE(IJQH	4.880000E+03
7516278	GIABS(JJQH,	1.462400E+04
7516279	GIABS(JJQH,	2.787700E+06
7516280	GIABS(JJQH,	6.075001E+00
7516281	GIABS(JJQH,	5.589001E-03
7516282	PSIZE(IJQH	2.020260E+08
7516283	GIABS(JJQH,	1.290833E-04
7516284	GIABS(JJQH,	0.000000E+00
7516285	GIABS(JJQH,	0.000000E+00
7516286	GIABS(JJQH,	0.000000E+00
7516287	PSIZE(IJQH	0.000000E+00
7729642	ORGDAT(IJQ)	0.000000E+00
7729643	ORGDAT(IJQ)	0.000000E+00
7729644	ORGDAT(IJQ)	0.000000E+00
7729645	ORGDAT(IJQ)	0.000000E+00
7729646	ORGDAT(IJQ)	0.000000E+00
7729647	ORGDAT(IJQ)	0.000000E+00
7729648	ORGDAT(IJQ)	0.000000E+00
7729649	ORGDAT(IJQ)	0.000000E+00
7729650	ORGDAT(IJQ)	0.000000E+00
7729651	ORGDAT(IJQ)	0.000000E+00
7729652	ORGDAT(IJQ)	0.000000E+00
7729653	ORGDAT(IJQ)	0.000000E+00
7729654	ORGDAT(IJQ)	0.000000E+00
7729655	ORGDAT(IJQ)	0.000000E+00
7729656	ORGDAT(IJQ)	0.000000E+00
7729657	ORGDAT(IJQ)	0.000000E+00
7729658	ORGDAT(IJQ)	0.000000E+00
7729659	ORGDAT(IJQ)	0.000000E+00
7729660	ORGDAT(IJQ)	0.000000E+00
7729661	ORGDAT(IJQ)	0.000000E+00

ORNL/TM-11037
Dist. Category: UC-70B (Waste)

INTERNAL DISTRIBUTION

1. R. G. Alsmiller, Jr.
2. B. R. Appleton
3. D. L. Barnett
4. M. Beckerman
5. A. G. Croff
6. J. R. Einstein
7. C. W. Glover
8. W. R. Hamel
9-13. J. E. Horwedel
14. J. P. Jones
15. D. C. Kocher
16. R. E. Maerker
17-21. F. C. Maienschein
22. R. C. Mann
23. J. R. Merriman
24-28. E. M. Oblow
29. L. E. Parker
30. W. H. Pechin
31-35. F. G. Pin
36. R. W. Roussin
37. T. H. Row
38-42. C. R. Weisbin
43-47. B. A. Worley
48-52. R. Q. Wright
53-57. RSIC
58-59. Central Research Library
60-61. Laboratory Records, RC
62. ORNL Technical Library Document Reference Section
63. ORNL Patent Office
64-67. EP&MD Reports Office

EXTERNAL DISTRIBUTION

68. Office of Assistant Manager for Energy Research and Development, DOE-ORO, Oak Ridge, TN 37830

69. R. Coller, Research and Waste Management Division, U.S. DOE-ORO, Oak Ridge, TN 37830

70. M. R. Jugan, Research and Waste Management Division, U.S. DOE-ORO, Oak Ridge, TN 37830

Idaho National Engineering Laboratory, EG&G Idaho, Inc., P.O. Box 1625, Idaho Falls, ID 83415

71. M. J. Case
72. S. J. Maheras
73. M. D. Otis
74. M. McKenzie-Carter

Pacific Northwest Laboratory, P.O. Box 999, Richland, WA 99352

75. M. Apted
76. C. Cole
77. P. Doctor
78. R. Erikson
79. M. Foley
80. W. E. Kennedy
81. A. Liebetrau
82. B. Napier
83. M. Piepho
84. B. Sager
85. S. Sneider

Rockwell Hanford Co., P.O. Box 800, Richland, WA 99352

86. L. C. Brown
87. C. DeFigh-Price
88. C. J. Geier
89. C. McLane
90. J. Sonnicksen
91. R. Wild
92. D. Wood

Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM 87185

93. R. Cranwell
94. J. C. Helton
95. R. L. Iman
96. E. J. Bonano

Savannah River Laboratory, U.S. DOE, P.O. Box A, Aiken, SC 29801

97. E. L. Albenesius
98. H. W. Sturm
99. E. L. Wilhite

U.S. DOE-BWIPO, Richland, WA 99352

100. D. H. Dahlem
101. P. E. Lamont
102. M. K. Thompson

U.S. DOE - Idaho Operations Office, 785 DOE Place, Idaho Falls, ID 83402

103. M. W. Shupe

United States Geological Survey, Box 25046, Denver Federal Center, Denver, CO 80225

104. J. B. Czarnecki
105. D. T. Hoxie

106. Donald Alexander, U.S. DOE, Civilian Radioactive Waste Management Program, 1000 Independence Ave., SW, Washington, DC 20585

107. R. E. Allan, Ontario Hydro, 700 University Ave., H18D16, Toronto, Ontario, M5G1X6, CANADA

108. B. R. Erdal, INC-DO, MS J-519, Los Alamos National Laboratory, Los Alamos, NM 87545

109. C. Koplik, The Analytic Sciences Corporation, 1 Jacob Way, Reading, MA 10867

110. W. J. Kurzeka, Manager, Commercial Waste Tech. Unit, Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352

111. D. Langmuir, Department of Chemistry and Geochemistry, Colorado School of Mines, Golden, CO 80401

112. W. L. Lee, R. F. Weston, Inc., 2301 Research Blvd., Rockville, MD 20850

113. J. A. Lieberman, OTHA, Inc., P.O. Box 651, Glen Echo, MD 20812

114. J. O. Neff, U.S. Department of Energy, Richland Operations Office, 505 King Avenue, Columbus, OH 43201

115. T. H. Pigford, Department of Nuclear Engineering, University of California, Berkeley, CA 94720

116. J. Rhoderick, U.S. DOE/OCRWM, 1000 Independence Ave., SW, Washington, DC 20585

117. S. Simonson, Massachusetts Institute of Technology, Room 24-304, 77 Massachusetts Ave., Cambridge, MA 02139

118. J. Sykes, Dept. of Civil Engineering, University of Waterloo, Waterloo, Ontario, N2L3G1, CANADA

119. D. Veneziano, Massachusetts Institute of Technology, Room 1-382, 77 Massachusetts Ave., Cambridge, MA 02139

120-450. For distribution as shown in TID-4500, Distribution category UC-70B - Nuclear Waste Management

☆ U.S. GOVERNMENT PRINTING OFFICE: 1989 640-119/00017

REQUEST FOR GRESS VERSION 0.0 CODE PACKAGE

(Includes ADGEN system of routines for solving the adjoint problem.)

Radiation Shielding Information Center
Oak Ridge National Laboratory
P.O. Box 2008
MS-6362
Oak Ridge, TN 37831-6362

- -

Please send me the GRESS Version 0.0 Code Package, which includes the User's Manual, source code, and library routines. I am enclosing a standard density (2S DD) 5.25 inch floppy disk onto which the GRESS system will be copied.

Name: ____________________

Company: ____________________

Address: ____________________

____

Telephone: ____________________