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ANDROS: A Code for Assessment of Nuclide Doses and Risks with Option Selection

C. L. Begovich
A. L. Sjoreen
S. Y. Oh
R. O. Chester

Contract No. DE-AC05-85OR21400

Health and Safety Research Division

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and Risks with Option Selection**

C. L. Begovich

A. L. Sjoreen

S. Y. Ohr

Computing and Telecommunications Division

R. O. Chester

Health and Safety Research Division

Date Published - November 1986

Research sponsored by the Office of Radiation Programs,
U.S. Environmental Protection Agency under Interagency Agreement
AD-89-F-2-A106 (formerly EPA-78-D-X0394)

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
Martin Marietta Energy Systems, Inc.
for the
DEPARTMENT OF ENERGY

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ACKNOWLEDGMENTS

We wish to express our very deepest gratitude to C. B. Nelson, Office of Radiation Programs, U.S. Environmental Protection Agency, for his ideas, support, discussion, and assistance in this work. C. J. Emerson, R. C. Ward, and K. F. Eckermann provided helpful reviews. We also thank S. R. Morris, U. F. Strong, B. R. Ferguson, R. J. Patton, and R. M. Watkins for their assistance in producing this document.

HIGHLIGHTS

ANDROS (Assessment of Nuclide Doses and Risks with Option Selection) is a computer code written to compute doses and health effects from atmospheric releases of radionuclides. ANDROS has been designed as an integral part of the CRRIS (Computerized Radiological Risk Investigation System). ANDROS reads air concentrations and environmental concentrations of radionuclides to produce tables of specified doses and health effects to selected organs via selected pathways (e.g., ingestion or air immersion). The calculations may be done for an individual at a specific location or for the population of the whole assessment grid. The user may request tables of specific effects for every assessment grid location. Along with the radionuclide concentrations, the code requires radionuclide decay data, dose and risk factors, and location-specific data, all of which are available within the CRRIS. This document is a user manual for ANDROS and presents the methodology used in this code.

1. INTRODUCTION

This research was funded by the U.S. Environmental Protection Agency (EPA), which, upon assuming regulatory authority for nuclear effluents covered by the Clean Air Act of 1977, launched an extensive review and revision of models that simulate transport of radionuclides through environmental pathways to man and calculate resulting health effects. The results of the first phase of this work, undertaken by the Health and Safety Research Division (HASRD) of the Oak Ridge National Laboratory (ORNL), are published in two reports: AIRDOS-EPA (Moore et al., 1979) and DARTAB (Begovich et al., 1981). While the AIRDOS-EPA and DARTAB computer codes have provided EPA with an interim methodology for performing nuclear assessments, work has continued at ORNL on an integrated set of computer codes and data bases that serves as a state-of-the-art radiological risk assessment methodology. This Computerized Radiological Risk Investigation System, or CRRIS (Baes and Miller, 1981; Baes et al., in press), is based on a review and evaluation of the AIRDOS-EPA/DARTAB system. This report documents one code of the CRRIS: ANDROS (Assessment of Nuclide Doses and Risks with Option Selection), a computer code for computing doses and health effects from environmental concentrations of radionuclides.

Figure 1 shows the relationship of ANDROS to the other CRRIS codes. PRIMUS (Hermann et al., 1984) is a preprocessing code that accesses a data base of decay data (Kocher, 1981a) and determines all radionuclides in all decay chains that must be considered in calculations by other codes of the CRRIS. RETADD-II (Murphy, Ohr, and Begovich, 1984) is a long-range trajectory atmospheric dispersion code that calculates radionuclide air concentrations and ground deposition rates on a square grid on a regional or continental scale. ANEMOS (Miller et al., in press) is a short-range (<100 km) Gaussian plume atmospheric dispersion code that calculates radionuclide air concentrations and deposition rates on a circular grid. Output from ANEMOS may be specified for successive downwind distances or averaged over the sector segments. Multiple runs of ANEMOS within a relatively small area can be summed on a

Figure 1. Codes that make up the CRRIS and possible pathways of information flow among them in performing nuclear risk assessments.

master grid by the SUMIT code (Begovich et al., 1984). TERRA (Baes et al., 1984a; 1984b) calculates concentrations of radionuclide chain members in four produce categories, four cattle feed categories, irrigated and nonirrigated soils, beef, and milk. MLSOIL and DFSOIL (Sjoreen et al., 1984) compute an effective soil concentration. Dose factors used by MLSOIL are computed in DFSOIL. MLSOIL contains a five-compartment model for leaching radionuclides through soil, rather than the single-compartment model used in TERRA. The output of MLSOIL can be merged with a TERRA output file. ANDROS receives the environmental radionuclide concentrations and combines them with population estimates, food and air consumption rates, and dose and health risk factors to calculate population or individual doses and health effects from the source term supplied to ANEMOS or RETADD-II.

As indicated by Fig. 1, various combinations of the CRRIS codes can be used to tailor the assessment to the user's needs. For example, if only inhalation and air immersion doses and risks are to be calculated, the user may wish to eliminate TERRA and MLSOIL from the assessment strategy. If ground surface deposition rates and air concentrations are known for a given location, the user may wish to make the assessment by using only PRIMUS, TERRA, MLSOIL, and ANDROS.

The ANDROS code was written as a final step in the estimation of radiological impact from airborne effluents. The code is analogous to DARTAB in that it combines concentrations of radionuclides in the environment with dosimetric and health effect factors to estimate the doses and health effects from the release. ANDROS requires as input radionuclide concentrations, a file of decay data, a dosimetric/health effects data base, data on food intakes and usage, and a data base describing population and food production for the assessment area. These files have been updated and reformatted from the DARTAB files. The ANDROS data files are described in Sects. 2.1.3 and 3.3.2 and in Appendix C.

The output of the ANDROS code is tables of doses and health effects. A table showing total risk, risk equivalent, dose equivalent, and lifetime lost is always printed, as are summary tables by organ/cancer, by pathway, and by nuclide. For each of

these summary categories, separate tables list somatic effects, genetic effects, special unit effects (e.g., working level), and total effects. Note that these tables are for the whole assessment grid for population assessments and for the single selected location for individual assessments. The user may request other tables of specific effects and tables of effects by location.

A variety of health effects can be computed and tabulated by ANDROS. These are low and high linear energy transfer (LET) dose, dose equivalent, low and high LET risk, total risk, risk equivalent, lifetime lost, and radon progeny effects. The doses for low and high LET are absorbed dose (rad); the value of the dose equivalent (rem) is the sum of the low LET dose plus the quality factor times the high LET dose. High LET radiation is caused by alpha particles and the resultant recoiling nuclei; low LET radiation is caused by other radiation (e.g., gamma, beta). Somatic risk is the fraction of radiogenic cancer deaths in a hypothetical cohort experiencing the exposure or intake rate throughout their lifetime. Risk equivalent is the constant annual low LET dose (rad) that produces the same health risk. The years of life lost are the average years of life lost per premature death.

The dose/health effects are summarized for organs or cancers (index i), for radionuclides (index j), and for pathways (index k) at a specified location (index x). ANDROS provides two options for summarizing doses and risks by radionuclide. The release of a radionuclide chain member can result in exposures and intakes of subsequent members of the chain. The released radionuclide option attributes doses and risks due to decay product exposures to the released parent radionuclide; the exposure radionuclide option attributes doses and risks to each radionuclide providing the exposures or intakes without regard to the radionuclide's origin. Throughout the environmental assessment, the concentrations of all exposure nuclides resulting from each released nuclide are calculated. Four types of pathways are considered: air immersion, ground surface exposure, inhalation, and ingestion. The ingestion pathway is further subdivided into ingestion of meat, milk leafy vegetables, protected produce, exposed produce, and grain. The

pathways can be summed as internal and external exposures. Also, the calculations can be performed for an individual (superscript I), a mean individual (superscript M), or the collective population (superscript P).

The notation used throughout the remainder of this report incorporates all parameters by identifying low or high LET by a subscript; individual, mean individual, or collective population is identified by a superscript. Therefore, $D_1^I(i, j, k, x)$ represents the low LET dose to an individual at location x for organ i , nuclide j , and pathway k . In addition, the doses and health effects will be designated with upper case letters, the dose and health effect factors from the RADRISK data base will be designated with lower case letters without the location index [e.g., $d_1^I(i, j, k)$], and concentrations of radionuclides from the assessment codes will be denoted $C(j, k, x)$ for nuclide j , pathway k , and location x . The notation is summarized in Table 1.

Table 1. Key to notation used in this report

Variable	Symbol	Definition
For X^a (i, j, k, x), which is computed in ANDROS		
X	- D_l	Low LET dose
	- D_h	High LET dose
	- H	Dose equivalent
	- R_l	Low LET fatal cancer risk
	- R_h	High LET fatal cancer risk
	- R	Fatal cancer risk
	- G_l	Low LET genetic dose
	- G_h	High LET genetic dose
	- G	Genetic dose equivalent
	- F_l	Low LET genetic risk
	- F_h	High LET genetic risk
	- F	Total genetic risk
	- E	Risk equivalent
	- FE_l	Low LET genetic risk equivalent
	- FE_h	High LET genetic risk equivalent
	- FE	Total genetic risk equivalent
	- W	Radon decay product exposure
	- L	Lifetime lost
a	- I	For individual
	- M	For mean individual
	- P	For collective population
i		For organ
j		For nuclide
k		For pathway
x		For location on the assessment grid

For Y (j, k, x), which is data for ANDROS

k	- 1	Pathway is air immersion, and Y is effective air concentration (Ci/m^3 or Bq/m^3)
	- 2	Pathway is ground surface exposure, and Y is ground concentration (Ci/m^2 or Bq/m^2)
	- 3	Pathway is inhalation, and Y is air concentration (Ci/m^3 or Bq/m^3)
	- 4-9	Pathway is ingestion, and Y is concentration in food pathway (Ci/kg or Bq/kg)

2. DISCUSSION OF METHODOLOGY

2.1 DATA REQUIREMENTS

The ANDROS code was written to calculate dose and health risk to man given the air concentration, ground surface concentration, and food concentrations of radionuclides. Therefore, ANDROS must calculate intake rates and exposures from these concentrations. The data required are (1) air, food, and ground surface concentrations; (2) population and food production parameters; and (3) nuclide decay chain information. To calculate doses and risks, the required data are dose and health risk factors for unit exposures. Each of these data sets is described in the following subsections.

2.1.1 Air, Food, and Ground Surface Concentrations

These radionuclide concentrations are computed in one of the other CRRIS codes. They can be computed for grid points or averaged over grid cells. They can be for a circular grid (up to 16 sectors and 20 distances) or for a rectangular grid (up to 20 by 20 locations or cells). In the CRRIS, the air concentration (Ci/m^3) is calculated in ANEMOS or RETADD-II. The ground surface concentration (Ci/m^2) and food pathway concentration (Ci/kg) are calculated in TERRA from the ANEMOS or RETADD-II output. The ground surface concentration computed by MISOIL may be substituted for that computed by TERRA.

2.1.2 Concentrations for Individual vs Population Calculations

Dose and health effects can be summarized for a selected individual, for a mean individual, or for the collective population. If the environmental concentrations have been read for a grid point and collective population summaries are to be made, an average grid cell concentration is calculated in ANDROS. For a rectangular grid, the grid cell average is the arithmetic mean of the four corner values. For a circular grid, an area-weighted average is

calculated. Given a concentration C_1 at distance x_1 and a concentration C_2 at distance x_2 for the same sector, the average concentration for the grid cell ranging from x_1 to x_2 is given by

$$C_{1,2} = \frac{\int_{x_1}^{x_2} ax^{b+1} dx}{\int_{x_1}^{x_2} x dx} \quad (1)$$

where a and b are the solutions to the equations

$$C_1 = ax_1^b \quad (2)$$

and

$$C_2 = ax_2^b \quad (3)$$

When an individual assessment is requested, the computations are done for the selected individual or for the mean individual, depending on whether point concentrations or cell-averaged concentrations have been read. If the environmental concentrations have been read as averages over the grid cells, collective population calculations are made and then divided by the grid cell population to give a mean individual assessment. If the concentrations are point values, a population of 1 is assumed for each grid point, and the selected individual computations are performed.

2.1.3 Dosimetric and Health Effects Data

Dosimetric and health effects data were developed using the RADRISK computer code (Dunning, Leggett, and Yalcintas, 1980) and external factors by Kocher (1981b). Modifications to these data for use in ANDROS are described in detail in Appendix C. The units were

changed to conform more closely with results of the environmental transport calculations. Genetic risk and risk equivalent factors were computed from the genetic dose factors. In addition, the risk factors are grouped under the corresponding dose to organs. The factors and units are listed in Table 2.

The factors are grouped by pathway and nuclide. The pathways are ingestion, inhalation, air immersion, and ground surface exposure. The ingestion factors are also subdivided by gastrointestinal (GI) absorption factor. The inhalation factors are subdivided by particle size and respiratory clearance class.

2.1.4 Population and Food Production Parameters

Food production parameters are needed to calculate ingestion rates. Ingestion is subdivided into the ingestion of meat, milk, leafy vegetables, protected produce, exposed produce, and grains. These subdivisions are used by and discussed in the TERRA document (Baes et al., 1983a). The data required by ANDROS are the production of each category inside the assessment area. The SITE data base (Baes et al., 1983b) is accessed to calculate these values as well as the populations that are used by ANDROS to estimate collection population and mean individual doses and health risks. The fractions of the population that are urban, rural farm, and rural nonfarm are also contained in the data base and are used by ANDROS to calculate intake rates (see Sect. 2.2.2.5).

2.1.5 Nuclide Decay Chain Information

ANDROS computes radionuclide decay and buildup during the storage of foods. The required radionuclide decay chain information is read from a file written by either PRIMUS or ANEMOS. The file contains all of the radionuclides released in the assessment, their daughters, and their decay matrices. This file is described in the PRIMUS documentation (Hermann et al., 1984).

Table 1. Factors in the Dosimetric and Health Effects Data Base

Factor	Pathway	Unit
Dose	Internal	Rad/Ci
	Air immersion	Rad/(Ci year/m ²)
	Ground surface	Rad/(Ci year/m ²)
Dose equivalent	Internal	Rem/Ci
	Air immersion	Rem/(Ci year/m ²)
	Ground surface	Rem/(Ci year/m ²)
Somatic risk	Internal	Risk/Ci
	Air immersion	Risk/(Ci year/m ²)
	Ground surface	Risk/(Ci year/m ²)
Risk equivalent	Internal	Rad/Ci
	Air immersion	Rad/(Ci year/m ²)
	Ground surface	Rad/(Ci year/m ²)
Genetic dose	Internal	Rad/Ci
	Air immersion	Rad/(Ci year/m ²)
	Ground surface	Rad/(Ci year/m ²)
Genetic risk	Internal	Risk/Ci
	Air immersion	Risk/(Ci year/m ²)
	Ground surface	Risk/(Ci year/m ²)
Genetic risk equivalent	Internal	Rad/Ci
	Air immersion	Rad/(Ci year/m ²)
	Ground surface	Rad/(Ci year/m ²)
Lifetime lost	All pathways	year

2.2 ANDROS CALCULATIONS

2.2.1 Introduction

The computations made in ANDROS are not complicated mathematically. In general, all ANDROS does is to multiply nuclide concentrations by the appropriate sets of scaling factors to compute health effects. These health effects are then added to produce the required health effect summaries. In detail, however, the organization of these computations is much more complicated because of the types of factors involved, including four pathway and nine health effect factors, which lead to individual vs population summaries, organ vs whole-body summaries, and somatic vs genetic summaries. Intake and exposure computations vary by pathway. Health effect calculations depend on the type of summary being computed.

2.2.2 Exposures and Intakes

Radionuclide exposures in ANDROS are the integral over time of the concentration to which an individual (or population) is exposed. For example, the immersion exposure to an individual over a period, t , can be formally calculated as

$$E = \int_0^t C(u) du, \quad (4)$$

where $C(u)$ is the concentration (Ci/m^3) to which the individual is exposed during time, u , between zero and t , and E is the resulting exposure ($\text{Ci s}/\text{m}^3$). Practically, such a calculation is performed by using the product of the concentration at a particular location (e.g., the concentration in outdoor air) and a dimensionless correction factor (e.g., the fraction of time spent outdoors) to estimate the average value of the time-varying concentration, $C(u)$, to which the individual is exposed. Note that the radionuclide exposure is different from a radiation exposure, which would be

specified in units of coulombs per kilogram (C/kg) or Roentgens (R).

Internal intakes are calculated by integrating, over a period of time, the product of a concentration and an intake rate, both of which may be time varying (but are not in ANDROS); that is,

$$I = \int_0^t i(u) C(u) du \quad , \quad (5)$$

where i and C are the corresponding intake rates and environmental concentrations, respectively, t is the period of time, and I is the resulting intake. The units of intake are those of activity (e.g., Ci). For example, the inhalation intake over a period of time, t , would be found by integrating the product of the inhalation rate, i (m^3/s), and the radionuclide air concentration, C (Ci/ m^3), to determine the inhalation intake, I (Ci).

2.2.2.1 Ground Surface Exposure

ANDROS reads the ground surface concentration (Ci/ m^2) to compute ground surface exposure. If input option EFFGS is set to true and the effective ground surface concentration from MLSOIL is available, this concentration will be used; otherwise, the ground surface concentration from TERRA will be used. The default condition uses the concentration from TERRA. The assumption that the terrain is not flat can be accommodated by a ground surface correction factor. The dose equivalent to an individual at location x for organ i and radionuclide j is thus

$$H^I(i, j, 2, x) = S Y(j, 2, x) h^I(i, j, 2) \quad , \quad (6)$$

where $0 \leq S \leq 1$ is the ground surface correction factor. The default value of S is 0.5 when ground surface concentrations from TERRA are used and 1.0 when ground surface concentrations from MLSOIL are used. Other doses and health risks for ground surface exposure are calculated similarly.

2.2.2.2 Indoor Air Concentration

The outdoor air concentration (C_i/m^3) of the exposure nuclides for each grid location is read by ANDROS for calculating doses and health effects resulting from air immersion. For an individual outdoors, the calculation of dose or health effects is the product of the air concentration, the breathing rate, and the appropriate dose or health effect factor. However, an individual is usually inside a building for a significant portion of the time. The indoor concentration is computed from the equation for the rate of change of the indoor air concentration at equilibrium, which is

$$\dot{Y}_i^{in} - A Y_i^{in} + \lambda^V F Y_i^{out} = 0, \quad (7)$$

where

Y_i^{in} - concentration inside the building for exposure radionuclide j ,

$A = -(\lambda_i + \lambda^V + \lambda_i^r)$ for a_{ii} and $\lambda_i b_{ij}$ for a_{ij} ,

λ_i - decay constant of radionuclide i (s^{-1}),

λ^V - rate that indoor air is replaced by outdoor air (s^{-1}),

λ_i^r - indoor removal rate (s^{-1}),

b_{ij} - branching fraction from radionuclide j to radionuclide i , and

F - fraction of radionuclide i remaining after filtering of air for f_{ii} and 0 otherwise.

Solving for Y^{in} ,

$$Y^{in} = -\lambda^v A^{-1} F Y^{out} . \quad (8)$$

2.2.2.3 Air Immersion

The air immersion dose equivalent to an individual is calculated by a weighted average of the indoor and outdoor concentrations:

$$H^I(i, j, l, x) = \left[f_{in} Y^{in}(j, l, x) + (1 - f_{in}) Y^{out}(j, l, x) \right] h(i, j, l) , \quad (9)$$

where f_{in} is the average fraction of time an individual spends indoors. The other doses and health risks are computed similarly.

For the case in which a finite plume exists and doses/health effects may be caused by gamma shine, additional air concentrations are read from ANEMOS. ANDROS reads an effective air concentration, which is the equivalent concentration in a semi-infinite cloud that would effect the same dosage to man as the finite plume. When this effective air concentration is available to ANDROS, the calculations for doses/health effects due to indoor and outdoor exposures are performed using either the actual or effective air concentrations, depending on the input option INOAIR. In the default case, the effective air concentration is used in both indoor and outdoor computations if it is present in the data file.

2.2.2.4 Inhalation

The dose/risk calculations for inhalation are based on air concentrations and the average breathing rate. As in the air immersion calculations, indoor air concentrations are used for the fraction of time spent indoors. Even if an effective air concentration is read (see the description in the previous section), it is never used for

inhalation calculations. As an example, the computation for dose equivalent is

$$H^I(i, j, 3, x) = \left[f_{in} Y^{in}(j, 3, x) + (1 - f_{in}) Y^{out}(j, 3, x) \right] U_{BR} h(i, k, 3) , \quad (10)$$

where U_{BR} is the breathing rate (m^3 /year). The dose and health effect factors are based on respiratory clearance class and particle size.

2.2.2.5 Ingestion

To compute doses and health effects due to ingestion, the intake rate at each location must be calculated. The user can select from two methods of computation. The first option is to assume that the individual within the grid cell receives a fraction f_1 of his or her food from inside the grid cell or at the particular grid location, a fraction f_2 of food from the assessment area, and the remainder f_3 (equal to $1 - f_1 - f_2$) from outside the assessment area. The fraction f_1 is assumed to be produced in home gardens and is not limited by the amount produced commercially at that location. The fraction f_2 is limited by the total amount produced in the assessment area. The intake rate is then f_1 times the utilization rate. The values of f_1 and f_2 are computed by combining input fractions for urban, rural-farm, and rural-nonfarm population weighted by the fraction of population in the cell in each category (from the SITE data base). The second option is to assume that all food produced in the assessment area is consumed. In this case, the intake rate is the amount produced annually. Therefore, the resulting dose and health effects from ingestion for the collective population would be in terms of the total dose and health effects to the collective population that would be required to consume all food produced in that cell. The user should exercise caution when this option is used because the other pathway calculations will be set to zero.

An option is available to account for radioactive decay and daughter ingrowth during the shelf life of the food. The DECAY package of subroutines described in Hermann et al. (1984) is used for the decay calculations.

2.2.2.6 Radon Progeny Exposure

Radionuclide concentrations may need to be summarized by using a quantity other than activity. An example is the assessment of the short-lived decay products of ^{222}Rn . A unit used to quantify the environmental concentration is the working level, where one working level is defined as any combination of the short-life progeny (^{218}Po , ^{214}Pb , ^{214}Bi , and ^{214}Po) in 1 L of air that will release 1.3×10^5 MeV of alpha particle energy. In ANDROS, working level or other special units can be used in radionuclide assessments.

The working level calculation is performed by defining the parent nuclide and its decay products that will be affected. A conversion factor is then required for each decay product to convert activity in the air to the special concentration units [e.g., working levels (WLs)]. Table 3 lists factors to convert air concentrations in Ci/m^3 to WLs. In ANDROS, WLs are converted to working level months (WLMs) by multiplying the concentrations by 31.4 (EPA, 1984). The factors needed to convert radon decay products exposures (WLMs) to health effects are included in the dose factor data base. If other special units calculations are needed, the user will have to modify the RADRISK data base to contain dose and risk factors based on the special unit.

2.2.3 Dose

Doses and dose equivalents are calculated from radionuclide exposures and intakes by multiplying them by an appropriate dose factor. For external exposures, the dose factors convert the exposure to the absorbed dose from photons. For example, the units of exposure due to immersion are $\text{Ci year}/\text{m}^3$, and the units of the corresponding dose factors are rad per $\text{Ci year}/\text{m}^3$. For a radionuclide intake (Ci), the somatic dose factor (rad/Ci) is the 70-year committed dose for a unit

Table 3. Factors to convert
an air concentration of
 1 Ci/m^3 to working levels
(USNC, 1982; Annex D, Table 3)

Nuclide	Factor
^{218}Po	1.029E6
^{214}Pb	5.069E6
^{214}Bi	3.737E6
^{214}Po	5.920E-1
^{212}Pb	1.228E8
^{212}Bi	1.166E7
^{212}Po	1.110E-3

intake. Both low and high LET doses can be calculated using the appropriate dose factors for each nuclide. Dose equivalents (with $Q = 20$ for alpha particles) can also be computed to provide an assessment combining the low and high LET doses from each nuclide. Genetic dose factors for intakes have the same units (rad/Ci) as their somatic gonadal dose counterparts but are the absorbed dose over a 30-year period for a uniform intake rate over that period.

An internal annual dose, $D(i, j, k, x)$, is given by

$$D(i, j, k, x) = Y(j, k, x) U(k) d(i, j, k) \quad , \quad (11)$$

where $U(k)$ is the utilization factor (for ingestion) or the breathing rate (for inhalation). The internal dose equivalent is computed as

$$H(i, j, k, x) = D_l(i, j, k, x) + Q D_h(i, j, k, x) \quad . \quad (12)$$

Since the annual exposure is numerically the same as the corresponding concentration, the external annual dose is

$$D(i, j, k, x) = Y(j, k, x) d(i, j, k) \quad , \quad (13)$$

or simply the product of the radionuclide concentration times the appropriate dose factor. Since external exposures produce only low LET doses, the external dose equivalent is the same as the low LET dose.

An effective whole-body dose is calculated in ANDROS by using a weighted sum of the organ doses. The weights are uniform for all nuclides and are input parameters. Default values are shown in Table 4. The code normalizes the weights to sum to 1.

Population doses are computed by multiplying the individual dose by the total population. The units of dose and dose equivalent become person-rad/year and person-rem/year, respectively.

Table 4. Organ names and organ dose weighting factors
used in ANDROS (Table 8.2-3; USEPA, 1984)

Organ	Weighting factor	Organ	Weighting factor
Red marrow	0.15	Thyroid	0.099
Endosteal tissue	0.009	Intestinal wall	0.039
Pulmonary tissue	0.21	Pancreas	0.058
Breast	0.13	Kidneys	0.025
Liver	0.085	Other	0.11
Stomach wall	0.084		

2.2.4 Risk

The methodology used in ANDROS for calculating fatal cancer risk is designed to be consistent with RADRISK (Dunning, Leggett, and Yalcintas, 1980) and DARTAB (Begovich et al., 1981). Before describing the calculations performed in ANDROS, a little background in the underlying risk modeling assumptions is necessary to provide a conceptual framework.

Let us assume for the population being considered that the probability of a liveborn individual surviving to age t is $s(t)$ where $s(0) = 1$ and decreases monotonically with increasing age. The expected time increment to be lived for such an individual between t and $t + dt$ is $s(t)dt$; hence, the expected lifetime for an individual is given by

$$T_L = \int_0^{\infty} s(t) dt \quad , \quad (14)$$

where the lifetime T_L and t are in the same units (e.g., years). Let $r(t)$ be the incremental increase in risk to an individual at age t caused by a unit exposure or intake at that time. The lifetime risk to an individual for a constant intake rate is

$$R = \int_0^{\infty} i r(t) s(t) dt \quad , \quad (15)$$

where R is the lifetime risk to an individual, $r(t)$ is the risk to an individual over the remainder of the individual's life from a unit intake at age t , and i is the intake in an interval t to $t + dt$. Assuming that the incremental risk is too small to change substantially, the total expected lifetime intake for an individual is given by

$$I = \int_0^{\infty} i s(t) dt = iT_L \quad , \quad (16)$$

where I is the lifetime intake in Ci. RADRISK customarily calculates

risks for an intake rate of 10^{-12} Ci/year, which ensures that $s(t)$ is essentially unchanged by the resulting $r(t)$. For use in ANDROS, the risk factor r^I is calculated where

$$r^I = R/I \quad (17)$$

is the lifetime risk per unit activity intake (Ci^{-1}), assuming that the intake rate is uniform over the individual's lifetime. To calculate individual lifetime risk for an intake, ANDROS uses the expression

$$R^I = r^I iT_L, \quad (18)$$

where iT_L is the lifetime intake (Ci) and r^I is the average risk factor as defined above. Similarly, for external exposure, the risk factor is based on lifetime exposure; hence,

$$r^I = R^I/E, \quad (19)$$

where $E = eT_L$ is the lifetime exposure at exposure rate e . The lifetime risk from exposure is calculated as

$$R^I = r^I eT_L. \quad (20)$$

A total risk for an individual is computed by summing the risks from each of the cancers associated with the organs included in the effective whole-body dose.

Collective (population) risk calculations are made for the stationary population corresponding to the expected survival of an individual. That population obtains, for a constant birthrate n_0 (live births per year), the same age-dependent survival $s(t)$ as for the individual and no external migration. In such a population, the number of individuals in the age increment t to $t + dt$ is $n(t)dt = n_0 s(t)dt$, and the total number of individuals of all ages is

$$N = \int_0^{\infty} u(t) dt = \int_0^{\infty} n_0 s(t) dt = n_0 T_L. \quad (21)$$

In other words, the stationary population is equal to the product of the birth rate and the expected lifespan for an individual.

For the population, an appropriate characterization of risk caused by chronic radionuclide exposures and intakes is the expected death rate at equilibrium caused by radiogenic cancer. This value is obtained by integrating the product of the risk to an individual at each age and the number of individuals at that age over all ages; that is,

$$M = \int_0^{\infty} i r(t) n_0 s(t) dt = n_0 R^I = N i r^I. \quad (22)$$

The corresponding intake rate for the population is

$$I = \int_0^{\infty} n_0 i s(t) dt = N i. \quad (23)$$

Hence, the equilibrium death rate for radiogenic cancer is equal to the product of the collective intake rate, Ni , and the individual risk factor, r^I . For groups other than a stationary population, no simple relationship exists between the lifetime risk to an individual and the population death rate. Any such calculation must account for both the age dependence of the risk and the age distribution of the population. ANDROS is not designed to perform calculations for groups other than a stationary population.

Note that, for the case of an individual, the exposure or intake must extend over a lifetime. For a population, all ages are present at any given time, and the deaths per unit population intake are numerically the same as the equilibrium death rate per unit population intake (or exposure) i. e. For example, if the environmental concentrations read by ANDROS were calculated for the annual release from a facility, the population risk values could be interpreted as the deaths per year of operation of the facility resulting from exposures and intakes taking place over a period equal to the environmental

accumulation time following the release.

The internal risk is

$$R(i, j, k, x) = Y(j, k, x) U(k) T_L r(i, j, k) , \quad (24)$$

where the exposure period, T_L , is the expected lifetime. The default value of T_L is 70.7565 years. The external risk is computed as

$$R(i, j, k, x) = Y(j, k, x) T_L r(i, j, k) . \quad (25)$$

Total risk is the sum of the low and high LET risks. The whole-body risk is computed as the sum of the risks for the cancers associated with the organs considered in the weighted sum dose.

In contrast to somatic risk, genetic risk is expressed in the generations following those exposed to the ionizing radiation rather than in the exposed individuals themselves. Hence, the risk coefficient indicates the likelihood of a liveborn individual manifesting a serious genetic effect as the result of the gonadal dose to his or her parents and other preceding generations. In ANDROS, the individual genetic risk for radionuclide intake is given by

$$R_g = i t_g r_g , \quad (26)$$

where R_g is the risk that a liveborn infant will manifest a serious genetic effect during his or her lifetime, i is the radionuclide intake rate (Ci/year) for members of the preceding generation, t_g is the mean age of the parents at conception (considered to be 30 years in RADRISK and ANDROS), and r_g is the genetic risk coefficient (Ci^{-1}). For external exposure, the intake rate, i , is replaced by the concentration, Y (Ci/m^3 or Ci/m^2), and the units of r_g change accordingly.

In analogy to the somatic risk calculation, the genetic risk for the population is the number of live births per year in that population that, at equilibrium, will manifest serious genetic effects. This value is simply the product of the birth rate and the individual genetic risk; that is,

$$G = n_o i t_g r_g = (N/I_L) i t_g r_g , \quad (27)$$

where G is the genetically affected birth rate and the other quantities are as previously defined. Again, the number of genetic effects committed per unit release is numerically the same as the equilibrium genetic effect rate per unit release rate.

The genetic risk is

$$G(i, j, k, x) = Y(j, k, x) U(k) T_G g(i, j, k) , \quad (28)$$

where T_G is the generation time (30 years). The intake per generation is assumed to be the average for the infant's parents.

2.2.5 Risk Equivalent

Risk equivalent is the low LET dose that would produce the same total risk as the radionuclide intakes and exposures. Risk equivalent is computed analogously to dose.

2.2.6 Lifetime Lost

The expected lifetime lost from a particular cancer, nuclide, and pathway is equal to the appropriate life lost factor (years) from the dose and risk factor data base. The expected lifetime lost for individuals who die from all radiogenic cancers is

$$L(j, k, x) = \frac{\sum_i R(i, j, k, x) L(i, j, k, x)}{\sum_i R(i, j, k, x)} \quad (29)$$

where the life lost for each cancer, i , is weighted by the corresponding risk. Other summaries are computed analogously. In a population assessment, the lifetime lost is computed for the mean individual.

3. CODE DESCRIPTION

The ANDROS computer code contains three types of subroutines: data input routines, calculational routines, and table-writing routines. The first set, the data input routines, reads the user input. Separate routines are used to read in parameters used in the calculation and options to define output tables. The second set of subroutines calculates doses and health risks for the individual or population for all locations, pathways, organs/cancers, and nuclides. An array of doses (low and high LET), health risks (low and high LET), risk equivalents, and lifetime lost is written to a random-access file keyed by pathway and location. All calculations, including intake rates, indoor air corrections, and radioactive decay during shelf life, are performed in this set of routines. The third set of routines selects the proper data from the file and writes the summary tables, the detail tables, and the location tables.

3.1 GENERAL OUTLINE OF THE CODE

3.1.1 Data Input Routines

The input required for ANDROS is presented in detail in Sect. 3.3. All user input data are read in INPUTP or TABINP. General parameters, such as the organs to be considered, are read in INPUTP. Parameters describing the tables to be written are read in TABINP. Both routines use the NAMELIST form of input and write a listing describing the options selected. Both routines perform consistency checks on the input.

3.1.2 Dose and Health Risk Calculation Routines

The environmental radionuclide concentrations are read in MULTI. MULTI calls FINDFC to select the dose and health effect factors from the RADRISK data base. Then, in subroutine MULTI, the appropriate environmental concentrations and factors are multiplied. The results are stored on a temporary file, keyed by pathway and location. MULTI

calls WTSUM to compute effective whole-body dose and to sum the effects by nuclide. MULTI calls routine SETFIL to read the SITE parameters and calculate intake rates. The final arrays of dose and health effects for each location and pathway are then computed in SETFIL and written back to the temporary file. SETFIL calls ADDLL to compute the lifetime lost summaries from the organ-specific lifetime losses and the risks. Note that dose equivalent and total risk are not computed in these routines because they are composites of other effects. Dose equivalent and total risk are computed in the table-writing routines only when these effects are required.

3.1.3 Table Writing Routines

Once all doses and health risks are stored in the temporary file, the tables are formed. Subroutine TSUM writes the first table, which is a total summary table that summarizes dose equivalent, risk, risk equivalent, and lifetime lost for each death. The second set of tables, written by subroutine SUMRY, summarizes dose equivalents, risks, and risk equivalents, first by organs, then by pathways, and finally by nuclides. These tables are always written.

Additional tables can be written as the user requests. DTABLE is called to write a detailed table for any combination of nuclides, organs, pathways, and doses and health risks. The user indicates what column and row headings are desired for a subset of the data and for up to three effects, for example, a detailed table of doses for the ingestion pathways and subsets of the nuclides and organs. DTABLE can write up to 10 location tables that present a dose or health risk for a particular nuclide, organ, and pathway for all locations. Possible row and column combinations for the detailed tables and table types for the location tables are numerous (see Appendix B).

3.2 SUBROUTINE DESCRIPTIONS

Figure 2 is a flowchart for ANDROS. A short description of each routine follows.

Figure 2. A flowchart of the ANDROS computer code.

MAIN MAIN defines the temporary storage files, calls subroutine INPUTP to read the parameters, calls MULTI to calculate doses and health risks, and calls TSUM, SUMRY, DTABLE, and LTABLE to write the tables.

BLOCK DATA This block initializes some default parameters, arrays, and headings, which are stored in named COMMON blocks.

ADDL This subroutine computes summaries of lifetime lost from the organ-specific lifetime losses and the computed risks.

COLLP Given the nuclides, organs/cancers, pathways, and effects to be written, subroutine COLLP returns the appropriate collective population doses and health risks. Dose equivalent and total risk are computed in this routine.

DATABC This routine estimates population and food production parameters from the SITE data base for a circular grid cell, given the reference point plus the distance and angular boundaries of the grid cell.

DATABR This routine estimates population and food production parameters from the SITE data base for a rectangular grid cell, given the boundaries of the cell.

DTABLE This routine calls the proper routines to select values for the detailed tables and writes the tables.

FIND This routine determines whether the columns and rows of a detailed table are organs, nuclides, or pathways and also determines the number of items in the column or row.

FINDFC This routine accesses the RADRISK data base and selects the proper dose and health risk factors.

HEADIN This subroutine prints page headings.

INDIV Given the nuclides, organ/cancers, pathways, and effects to be written, subroutine INDIV returns selected individual doses and health risks. Dose equivalent and total risk are computed in this routine.

INPUTP All general parameters are read through NAMELIST statements in this routine. Options selected are written to the output listing.

INTEQA This routine finds an integral average described in Sect. 2.1.2.

INVER'' This subroutine inverts a triangular matrix.

IOCORR This subroutine makes final calculations to determine the indoor correction of air concentration.

LOCATE This routine locates appropriate dose and health risk factors in the storage array for the ingestion, air immersion, and ground surface pathways.

LOCAT2 This routine locates appropriate dose and health risk factors in the storage array for the inhalation pathway. Both particle size and clearance class are matched; if they are not matched exactly, the factor with the closest particle size is selected.

LTABLE This routine calls the proper routines to select appropriate values for the location tables and then writes the tables.

MATCH This subroutine determines the ordering of an input array of organs/cancers or nuclides in the appropriate storage arrays.

MATCHF This subroutine selects indices of the storage array required for computing a certain dose or health risk.

MULTI This subroutine reads the PRIMUS and radionuclide concentration files. The computation of all effects for each nuclide, organ/cancer, and pathway for the individual or population is controlled by this subroutine. Actual multiplications of concentrations and dose/health risk factors are performed in MULTI. Other functions required to complete individual and population dose and health risk computations are performed by calls to other routines.

SETCG This routine calls the SITE data base routines if the radionuclide concentrations are for point values on a circular grid.

SETFIL This subroutine completes computations for individual or population dose and health risks. Ingestion intake rates are calculated. In addition, sums over pathways are calculated and written to the temporary file.

SETHD This routine sets up the row and column headings for location tables.

SETIOC This routine makes preliminary calculations to determine the necessary arrays for the indoor correction of air concentration.

SETRG This routine calls the SITE data base routines if the radionuclide concentrations are for a point on a rectangular grid.

SETUPE This routine makes necessary summations of values for the detailed tables and then orders the array to be written by DTABLE.

SETVAL This routine is called if the radionuclide concentrations are cell average values. It accesses the SITE data base routines.

SORTR1 This routine sorts a list of array pointers without changing the storage of the array.

STDCY This routine makes appropriate preliminary calculations and calls DECAYI to allow for radionuclide decay during storage for the ingestion pathways.

SUMRC This routine calculates row and column sums for the detailed tables.

SUMRY This subroutine writes summary tables with separate tables for organs/cancers, nuclides, and pathways.

TABINP Input parameters for the summary, detailed, and location tables are read by NAMELIST input.

TSUM The total summary table is set up and written by this routine.

WTSUM This subroutine calculates an effective whole-body dose using a weighted sum. A total risk is also summed over organs, and dose and health risks are summed over all nuclides.

XTRCT This routine is used to unpack the decay constant array supplied by PRIMUS output.

3.3 INPUT DATA

3.3.1 Namelist Input

The user options available in ANDROS are read from unit 5 using NAMELIST statements. This allows extensive use of default parameters. Each set of NAMELIST variables is described below, and the default values are listed in parentheses. Dimensions of input variables that are arrays are given in square brackets. Note that, when entering NAMELIST data in a multidimensional array and not needing the full array size, the storage locations not used must be filled with dummy data. For example, if two types of location tables are to be printed (i.e., two values of FACL are entered in NAMELIST LTAB), the list of nuclide names for the first table must have exactly 50 entries (many of which may be blanks) so that the list for the second table will be entered into the proper array locations.

The default data produce collective population effects summarized by released nuclides. The two default inputs for organs are effective whole body (EFF WBOD) and the average of the genetic organs (AVERAGE). The ANDROS defaults assume that intake rates are calculated from the F1 and F2 fractions, the food produced, and the population; no special unit calculations are made; dose and health effect factors are not printed; intake rates are printed; only summary tables are printed; and no detailed or location tables are printed. See Appendix A for an example of an input data set.

NAMELIST/NRP/IFREL,INDMI,NUCG,GIING,NUCC,CLCLAS,NUCV,RRIND,FRVENT,
TPERD,FRACIN,GSCFAC,AGEX,TIMERQ,IFOUT,EFFGS,INOAIR

IFREL is the option to select whether the tables will be for released radionuclides, IFREL = TRUE, or exposure nuclides, IFREL = FALSE (TRUE).*

INDMI is the option to select whether the tables will be for an

* All options shown in parentheses are default options.

individual, INDMI = TRUE, or for the collective population, INDMI = FALSE (TRUE).

NUCG[50] are the radionuclide names of nuclides for which GI factors are entered in GIING.

GIING[50] are the GI absorption factors to use for the corresponding nuclide in NUCP (defaults are to select the smallest GI factor in the RADRISK data base).

NUCC[50] are the radionuclide names of nuclides for which clearance classes are entered in CLCLAS.

CLCLAS[4,50] are the clearance class fractions that will override those included on the concentration data file. Enter four fractions for each nuclide name entered in NUCC. The four fractions correspond to classes D, W, Y, and *, respectively. (The default uses the values entered in ANEMOS or RETADD-II.)

NUCV[50] are the radionuclide names of nuclides for which the ventilation fractions and removal rates are entered in FRVENT and RRIND.

RRIND[50] are the indoor removal rates in sec^{-1} (0.0).

FRVENT[50] are the fractions ventilated by building systems for indoor air concentration for each corresponding nuclide in NUCP (1.0).

TPERD is the ventilation rate in sec^{-1} ($2.778\text{E-}4$).

FRACIN is the fraction of time each individual is indoors (0.75).

GSCFAC is the ground surface correction factor (0.5 for TERRA and 1.0 for MLSOIL).

AGEX is the expected lifetime in years (70.7565).

TIMERQ is the time in years for which the internal dose factors are selected (70).

IFOUT is the option to list factors from the RADRISK data base, IFOUT = TRUE, or not list them, IFOUT = FALSE (FALSE).

EFFGS is the option to select the effective ground surface concentration from MLSOIL, EFFGS = TRUE, or select the TERRA ground surface concentration, EFFGS = FALSE (FALSE).

INOAIR is the option to select actual or effective air concentrations for external dose computations. If INOAIR = 1, the actual concentration is used. If INOAIR = 2, the actual concentration is used for the indoor calculation and the effective is used for the outdoor calculation. If INOAIR = 3, the effective concentration is used. If the effective air concentration is not included in the data file, the actual will be used in its place, if necessary (3).

NAMelist/ORP/NORGAN,ORGANS,Q,NGEN,ORGEN

NORGAN is the number of organs/cancers to be included in this run of ANDROS, a maximum of 24 (1).

ORGANS[24] are the organ names. Note that only organ names are entered here. Corresponding cancer names are listed in Table 5 (EFF WBOD).

Q is the quality factor (20).

NGEN is the number of genetic organs to be considered (1).

ORGEN[3] are the genetic organ names (AVERAGE).

Table 5. Correspondence
between doses to organs
and risks of cancers

Organ	Cancer
ADREN	
BL WALL	
BONE	
BREAST	Breast
ENDOST	Bone
INT WALL	Bowel
KIDNEYS	Urinary
LIVER	Liver
LLI WALL	
LUNGS	
MARROW	
OTHER	Other
OVARIES	
PANCREAS	Pancreas
R MAR	Leukemia
RES LYM	
S WALL	Stomach
SI WALL	
SKIN	
SPLEEN	
T BODY	
TESTES	
THYMUS	
THYROID	Thyroid
UTERUS	
ULI WALL	
Y MAR	
N-P	
PUL	Lung
T-B	

NAMELIST/WPR/NWTS,ORWT,WTSFAC

NWTS is the number of organs used in the weighted sum for the total body. The defaults for ORWT and WTSFAC are listed in Table 4.

ORWT[20] are the names of organs included in the weighted sum.

WTSFAC[24] are the weights associated with the ORWT organs.

NAMELIST/IRP/U,UBR,FRACTN,IFUP,SITIM,PRDMIL,HERDSL,WTCOW,DRLWT,IPRINT,IFAST

U[6] are the utilization factors for each food group in kg/year (see Sect. 2.2.2.5):

- U(1) meat (65),
- U(2) milk (112),
- U(3) leafy vegetables (14),
- U(4) protected produce (56),
- U(5) exposed produce (30), and
- U(6) grain (75).

UBR is the breathing rate in m^3 /year (8035).

FRACTN[2,3,6] are values of the intake fractions, F1 and F2, for each of the 6 food groups above, where I = 1 to 6 below (see Sect 2.2.2.5):

- FRACTN (1,1,I) is F1 for rural farm (0.5),
- (2,1,I) is F2 for rural farm (0.5),
- (1,2,I) is F1 for rural nonfarm (0.25),
- (2,2,I) is F2 for rural nonfarm (0.75),

(1,3,I) is F1 for urban (0.1), and

(2,3,I) is F2 for urban (0.9).

IFUP is the option for ingestion calculations; if IFUP = 1, intake rates will be calculated from F1, F2, production, and population; otherwise, all food produced is assumed to be eaten (1).

SITIM[6] are the average storage times of each food grouping in days (0, 3, 7, 90, 7, 365).

PRDMIL is the annual production of milk per cow in kg (4672).

HERDSL is the fraction of herd slaughtered annually for meat (.35).

WTCOW is the average weight (kg) per head in a herd of beef cattle (470).

DRLWT is the ratio of dressed weight to live weight for meat (0.56).

IPRINT is the option to print intake rate tables; if IPRINT = FALSE, intake rate tables are not written (TRUE).

IFAST is the option to read the SITE file saved by TERRA, IFAST = TRUE, or to read the SITE data base itself, IFAST = FALSE (FALSE).

NAMelist/SPCONS, SPNAME, PNUC, NSPNUC, SPNUC, NSPORG, SPORG, SPEXP, ISPRES

SPNAME[3] are the alphanumeric names for the special unit calculation (e.g., working level) (see Sect. 2.2.2.6). There can be three different calculations. These names must be unique for each calculation (e.i., for each parent). To request a detail or location table of the special unit results, the user must enter the appropriate SPNAME as a nuclide name in the DTAB or LTAB input.

PNUC[3] are the parent nuclides for the special unit calculation, one for each special unit calculation.

NSPNUC[3] are the numbers of daughter nuclides for each special unit.

SPNUC[5,3] are the daughter nuclides for the special unit calculation, ≤ 5 for each special unit.

NSPORG[3] are the numbers of organs affected.

SPORG[5,3] are the organs affected by the special unit calculation, ≤ 5 for each special unit.

SPEXP[5,3] are the conversion factors to convert air concentration in Ci/m^3 to the special unit, one for each SPNUC entered.

ISPRES[3] are the affected pathways for each special unit calculation. If ISPRES(1) = 0, no special unit calculations are done (0, 0, 0).

NAMELIST/IRL/ILOC

ILOC is the location for which summary tables are written for an individual assessment. These location numbers correspond to the order in which the locations were read. If ILOC = 0, the location of the individual having highest total risk will be selected (0).

NAMELIST/STAB/PERORG,PERNUC,PERPTH

PERORG is an option to summarize separately only the top percentage (based on total risk) of organs in the organ summary table (100).

PERNUC is an option to summarize separately only the top percentage of nuclides in the nuclide summary table (100).

PERPTH is an option to summarize separately only the top percentage of pathways in the pathway summary table (100).

NAMelist/DTAB/XT,YT,ZT,FACD

Note that XT, YT, and ZT must each be of one category. For example, XT - 'U-235', 'LUNGS' is illegal.

XT[50,25] are column headings for the detail tables, a maximum of 50 entries for each of 25 tables; they may be any nuclide in the assessment, any pathway in Table 6, or any organ entered in NAMelist ORP.

YT[50,25] are row headings for the detail tables, a maximum of 50 entries for each of 25 tables; they may be any nuclide in the assessment, any pathway in Table 6, or any organ entered in NAMelist ORP.

ZT[50,25] are the table headings, a maximum of 50 entries for each of 25 tables; they may be any nuclide in the assessment, any pathway in Table 6, or any organ entered in NAMelist ORP.

FACD[3,25] are doses and health risks that will appear in each table, a maximum of 3 per table; they may be any effect in Table 6.

NAMelist/LTAB/SPNUC,SPORG,SPPTH,FACL

SPNUC[50,10] are nuclides requested for the location tables, a maximum of 50 for each of 10 tables (TOT NUC).

SPORG[24,10] are organs requested for the location tables, a maximum of 24 for each of 10 tables.

SPPTH[13,10] are pathways requested for the location tables, a maximum of 13 for each of 10 tables; they may be any pathway in Table 6. (TOT PTHY)

Table 6. Pathways, doses, and health effects available in ANDROS

Pathway		Effect	
Name	Pathway or factor	Name	Pathway or factor
AIR-IMM	Air immersion	DL	Dose, low LET
GRND-SUR	Ground surface	RL	Risk, low LET
INHALTN	Inhalation	RE	Risk equivalent
ING-MEAT	Ingestion of meat	DE	Dose equivalent
ING-MILK	Ingestion of milk	DH	Dose, high LET
ING-LVEG	Ingestion of leafy vegetables	RH	Risk, high LET
ING-PVEG	Ingestion of protected produce	LL	Lifetime lost ^a
ING-NVEG	Ingestion of exposed produce	R	Risk
ING-GRN	Ingestion of grain	P	Population
ING-TVEG	Ingestion of produce		
ING-TOT	Total ingestion		
INTERNAL	Internal		
EXTERNAL	External		
TOT-PTHY	Total		

^aDetail tables of lifetime lost may be requested only for pre-computed organ, pathway, or nuclide summaries (i.e., for ING-TOT but not for ING-MEAT and ING-MILK combined).

FACL[10] are effects printed in the location tables, 1 per table for up to 10 tables; they may be any effect in Table 6.

3.3.2 Data Files

ANDROS reads four data files. The environmental concentrations are read from unit 25. The SITE data base or the SITE file produced by TERRA is read from unit 12. The PRIMUS decay chain file (Hermann et al., 1984) is read from unit 26. The ANDROS/RADRISK data base is read from unit 24. Understanding the formats of these files is necessary only if ANDROS is used to read data that have not been created within the CRRIS. The environmental concentration file format is discussed in the ANEMOS (Miller et al., in press) and MLSOIL (Sjoreen et al., 1984) documents. The ANDROS/RADRISK data base is a modification of the DARTAB/RADRISK data base and is described in Appendix C. All data in the ANDROS/RADRISK data base are from or are computed from data in the DARTAB/RADRISK data base.

4. DISCUSSION

ANDROS is the final code in the CRRIS. It is very flexible because it must process data from any combination of codes in the CRRIS and because it can produce a wide variety of tables. This flexibility may make the user data for ANDROS seem unduely complicated. In running ANDROS, as in running all the CRRIS codes, the default input values provided should be acceptable most of the time, and the user should be concerned only about parameters that must be changed for the specific assessment. The ultimate purpose of the CRRIS is to estimate health effects. ANDROS allows the computation of a wide variety of effects, which may be presented in tabular form according to the user's needs.

5. REFERENCES

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APPENDIX A

ANDROS JCL, INCLUDING INPUT

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APPENDIX B

OUTPUT FROM DATA IN APPENDIX A

ANDROS - DOSE AND HEALTH RISK COMPUTATIONS FOR THE CRRIS

12-17-85

THE GROUND SURFACE CORRECTION FACTOR IS 0.50
THE AVERAGE LIFE EXPECTANCY IS 70.7565 YEARS.
THE DOSE COMMITMENT TIME IS 70.

THE FRACTION OF TIME SPENT INDOORS IS 0.750
THE VENTILATION RATE (1/SEC) IS $2.78E-04$ ($1.00E+00$ /HR)
THE FOLLOWING PARAMETERS WILL BE USED TO CORRECT AIR CONCENTRATION FOR INSIDE BUILDINGS.

NUCLIDE	REMOVAL RATE 1/SEC	FILTERED FRACTION IN AIR
ALL	$0.00E+00$	1.000

THE QUALITY FACTOR (Q) IS 20.00

THE ORGANS SELECTED ARE:
R MAR ENDOST *PUL* BREAST OVARIES THYROID EFF WBOO OVARIESG AVERAGE

ORGANS AND WEIGHTS FOR EFFECTIVE WHOLE BODY:

ORGAN	WEIGHT
R MAR	0.150
ENDOST	0.009
THYROID	0.099
BREAST	0.130
PUL	0.210
S WALL	0.084
INT WALL	0.039
LIVER	0.085
PANCREAS	0.058
KIDNEYS	0.025
OTHER	0.110

THE FRACTION OF FOOD INGESTED WILL DEPEND ON THE POPULATION AND AMOUNT CONSUMED:

PATHWAY	FARM		NONFARM		URBAN	
	F1	F2	F1	F2	F1	F2
ING-MEAT	0.300	0.500	0.250	0.750	0.100	0.900
ING-MILK	0.300	0.500	0.250	0.750	0.100	0.900
ING-LVEG	0.300	0.500	0.250	0.750	0.100	0.900
ING-PVEG	0.300	0.500	0.250	0.750	0.100	0.900
ING-NVEG	0.300	0.500	0.250	0.750	0.100	0.900
ING-GRN	0.300	0.500	0.250	0.750	0.100	0.900

THE BREATHING RATE (M³/YR) IS 8035.00 (15.7 L/MIN)

THE UTILIZATION RATE AND STORAGE TIME FOR EACH INGESTION PATHWAY IS

PATHWAY	UTILIZATION (KG/YR)	STORAGE TIME (DAYS)
ING-MEAT	65.00	0.00
ING-MILK	112.00	3.00
ING-LVEG	14.00	7.00
ING-PVEG	56.00	90.00
ING-NVEG	30.00	7.00
ING-GRN	75.00	365.00

MILK PRODUCTION (KG/Y) PER COW IS $4.67E+03$
FRACTION OF HERD (1/Y) SLAUGHTERED FOR MEAT IS 0.350
AVERAGE WEIGHT (KG) AT SLAUGHTER IS $4.70E+02$
RATIO OF DRESSED WEIGHT TO LIVE WEIGHT IS 0.560

COMPUTATIONS ARE DONE FOR AN INDIVIDUAL
THE TABLES WILL BE IN TERMS OF EXPOSURE RADIONUCLIDES.
THE FACTORS FROM THE RADRISK DATA BASE WILL BE PRINTED
THE GROUND SURFACE CONCENTRATION FROM TERRA WILL BE USED FOR GROUND EXPOSURE
THE EFFECTIVE AIR CONCENTRATION FROM ANEMOS WILL NOT BE USED FOR IMMERSION EXPOSURE
INTAKE RATES WILL NOT BE PRINTED
READ THE SITE DATA BASE DIRECTLY

THE FOLLOWING SPECIAL EXPOSURE UNITS WILL BE CALCULATED:

SPECIAL UNIT NAME = WLM-222 PARENT NUCLIDE = RN-222 PATHWAY = INHALTN
THE DAUGHTER NUCLIDES AFFECTED ARE : PO-210 PB-214 SI-214 PO-214
CONVERSION FACTORS (WL/(CI/M³)) ARE : $1.029E+06$ $5.069E+06$ $3.737E+06$ $5.920E-01$
THERE WILL BE 2 ORGANS AFFECTED: *PUL* EFF WBOO

FACTORS FROM JOSE/RISK FILE.

NUCLIDES: 91-210

	R MAX INT WALL	ENDOST LIVER	*PUL* PANCREAS	BREAST KIDNEYS	OVARIES OTHER	THYROID	EFF WBOD	OVARIESG	AVERAGE	9 WALL
PATHWAY: INGESTION										
DOSE LOW LET	1.24E+01	5.27E+00	8.40E+00	8.40E+00	8.40E+00	8.40E+00	1.43E+03	8.40E+00	8.40E+00	1.65E+03
RAD/CI	3.24E+01	8.20E+00	8.40E+00	8.40E+00	8.40E+00	8.40E+00				
DOSE HIGH LET	7.82E+01	4.71E+00	4.63E+00	4.63E+00	4.63E+00	4.60E+01	2.90E+02	4.57E+01	4.57E+01	4.58E+01
RAD/CI	2.13E+02	1.13E+01	4.63E+00	4.63E+00	4.63E+00	4.60E+01				
RISK LOW LET	5.23E+01	2.25E+00	4.89E+00	4.89E+00	4.89E+00	2.33E-04	4.02E-01	2.18E-03	2.18E-03	3.89E-02
RISK/CI	1.19E+02	5.19E+00	1.19E+01	1.19E+01	1.19E+01	2.33E-04				
RISK HIGH LET	2.13E+02	9.16E+00	2.14E+01	2.14E+01	2.14E+01	1.02E-02	6.42E-01	2.38E-01	2.38E-01	8.63E-03
RISK/CI	6.13E+02	2.16E+01	6.06E+00	6.06E+00	6.06E+00	1.02E-02				
RISK EQUIVALENT	5.56E+02	3.78E+01	1.76E+01	1.76E+01	1.76E+01	3.76E+02	3.76E+03	9.23E+02	9.23E+02	2.02E+03
RAD/CI	1.19E+02	1.12E+01	1.76E+01	1.76E+01	1.76E+01	3.76E+02				
LIFE LOSS	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.73E+01	2.19E+01	0.00E+00	0.00E+00	2.15E+01
YEARS	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.73E+01	2.19E+01	0.00E+00	0.00E+00	2.15E+01

PATHWAY: INHALATION

PARTICLE SIZE = 3.00E-01 MICROMETERS										
DOSE LOW LET	1.12E+01	8.78E+00	7.77E+00	7.77E+00	7.77E+00	8.77E+01	8.77E+01	8.77E+01	8.77E+01	1.22E+02
RAD/CI	3.12E+01	2.48E+01	2.17E+01	2.17E+01	2.17E+01	2.48E+02	2.48E+02	2.48E+02	2.48E+02	5.82E+02
DOSE HIGH LET	5.75E+01	6.00E+00	1.08E+01	1.08E+01	1.08E+01	5.84E+02	3.36E+03	5.81E+02	5.81E+02	5.82E+02
RAD/CI	1.63E+02	1.72E+01	3.84E+01	3.84E+01	3.84E+01	5.84E+02				
RISK LOW LET	1.12E+01	2.25E+00	1.72E+01	1.72E+01	1.72E+01	2.43E-03	7.90E-01	2.28E-02	2.28E-02	2.84E-03
RISK/CI	3.12E+01	6.05E+00	4.55E+01	4.55E+01	4.55E+01	2.43E-03				
RISK HIGH LET	2.98E+01	1.17E+01	3.03E+01	3.03E+01	3.03E+01	1.29E-01	7.41E+00	3.02E+00	3.02E+00	1.10E-01
RISK/CI	8.11E+01	3.30E+01	7.75E+01	7.75E+01	7.75E+01	1.29E-01				
RISK EQUIVALENT	7.12E+01	4.81E+04	1.86E+04	1.86E+04	1.86E+04	4.76E+03	2.97E+04	1.17E+04	1.17E+04	4.77E+03
RAD/CI	6.20E+01	1.39E+04	4.78E+03	4.78E+03	4.78E+03	4.76E+03				
LIFE LOSS	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.82E+01	2.23E+01	0.00E+00	0.00E+00	2.15E+01
YEARS	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.82E+01	2.23E+01	0.00E+00	0.00E+00	2.15E+01

PATHWAY: INHALATION

PARTICLE SIZE = 1.00E-01 MICROMETERS										
DOSE LOW LET	1.12E+01	8.78E+00	7.77E+00	7.77E+00	7.77E+00	7.95E+01	7.95E+01	7.95E+01	7.95E+01	3.01E+02
RAD/CI	3.12E+01	2.48E+01	2.17E+01	2.17E+01	2.17E+01	2.48E+02	2.48E+02	2.48E+02	2.48E+02	5.82E+02
DOSE HIGH LET	5.75E+01	6.00E+00	1.08E+01	1.08E+01	1.08E+01	4.47E+02	2.83E+03	4.45E+02	4.45E+02	4.45E+02
RAD/CI	1.63E+02	1.72E+01	3.84E+01	3.84E+01	3.84E+01	4.47E+02				
RISK LOW LET	1.12E+01	2.25E+00	1.72E+01	1.72E+01	1.72E+01	2.20E-03	5.70E-01	2.07E-02	2.07E-02	7.10E-03
RISK/CI	3.12E+01	6.05E+00	4.55E+01	4.55E+01	4.55E+01	2.20E-03				
RISK HIGH LET	2.98E+01	1.17E+01	3.03E+01	3.03E+01	3.03E+01	9.90E-02	6.24E+00	2.31E+00	2.31E+00	8.38E-02
RISK/CI	8.11E+01	3.30E+01	7.75E+01	7.75E+01	7.75E+01	9.90E-02				
RISK EQUIVALENT	5.45E+01	3.67E+04	1.17E+04	1.17E+04	1.17E+04	3.65E+03	2.47E+04	8.97E+03	8.97E+03	3.86E+03
RAD/CI	8.22E+01	1.39E+04	4.78E+03	4.78E+03	4.78E+03	3.65E+03				
LIFE LOSS	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.82E+01	2.22E+01	0.00E+00	0.00E+00	2.15E+01
YEARS	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.82E+01	2.22E+01	0.00E+00	0.00E+00	2.15E+01

PATHWAY: INHALATION

PARTICLE SIZE = 3.00E-01 MICROMETERS										
DOSE LOW LET	1.31E+01	9.74E+00	8.83E+00	8.83E+00	8.83E+00	8.83E+01	8.83E+01	8.83E+01	8.83E+01	5.56E+02
RAD/CI	3.31E+01	2.74E+01	2.49E+01	2.49E+01	2.49E+01	2.74E+02	2.74E+02	2.74E+02	2.74E+02	1.31E+02
DOSE HIGH LET	6.13E+01	4.14E+00	5.96E+02	5.96E+02	5.96E+02	4.10E+02	2.91E+03	4.08E+02	4.08E+02	4.08E+02
RAD/CI	1.83E+02	8.03E+01	4.10E+02	4.10E+02	4.10E+02	4.10E+02				
RISK LOW LET	1.31E+01	2.37E+00	1.75E+01	1.75E+01	1.75E+01	2.44E-03	4.85E-01	2.29E-02	2.29E-02	1.31E-02
RISK/CI	3.31E+01	6.05E+00	4.55E+01	4.55E+01	4.55E+01	2.44E-03				
RISK HIGH LET	2.98E+01	1.15E+01	3.03E+01	3.03E+01	3.03E+01	9.07E-02	6.42E+00	2.12E+00	2.12E+00	7.68E-02
RISK/CI	8.11E+01	3.54E+01	7.75E+01	7.75E+01	7.75E+01	9.07E-02				
RISK EQUIVALENT	5.45E+01	3.54E+04	1.17E+04	1.17E+04	1.17E+04	3.36E+03	2.50E+04	8.24E+03	8.24E+03	3.82E+03
RAD/CI	8.22E+01	1.39E+04	4.78E+03	4.78E+03	4.78E+03	3.36E+03				
LIFE LOSS	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.82E+01	2.21E+01	0.00E+00	0.00E+00	2.15E+01
YEARS	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.82E+01	2.21E+01	0.00E+00	0.00E+00	2.15E+01

PATHWAY: INHALATION		PARTICLE SIZE = 3.00E-01 MICROMETERS		CLEARANCE CLASS						
DOSE LOW LET	1.17E+01	1.45E+04	1.17E+01	1.17E+01	4.43E+02					
DOSE HIGH LET	3.77E+02	3.28E+04	3.73E+02	3.73E+02	3.77E+02					
RISK LOW LET	3.23E-04	4.02E+00	3.04E-03	3.04E-03	1.04E-02					
RISK HIGH LET	8.30E-02	7.26E+01	1.94E+00	1.94E+00	7.04E-02					
RISK EQUIVALENT	3.01E+03	2.77E+05	7.48E+03	7.48E+03	3.43E+03					
LIFE LOSS YEARS	2.81E+01	2.30E+01	0.00E+00	0.00E+00	2.14E+01					

PATHWAY: INHALATION		PARTICLE SIZE = 1.00E+00 MICROMETERS		CLEARANCE CLASS						
DOSE LOW LET	1.61E+01	8.74E+03	1.61E+01	1.61E+01	6.44E+02					
DOSE HIGH LET	2.75E+02	1.92E+04	2.73E+02	2.73E+02	2.75E+02					
RISK LOW LET	4.45E-04	2.42E+00	4.18E-03	4.18E-03	1.52E-02					
RISK HIGH LET	6.08E-02	4.26E+01	1.42E+00	1.42E+00	5.15E-02					
RISK EQUIVALENT	2.21E+03	1.63E+05	5.48E+03	5.48E+03	2.83E+03					
LIFE LOSS YEARS	2.81E+01	2.30E+01	0.00E+00	0.00E+00	2.14E+01					

PATHWAY: INHALATION		PARTICLE SIZE = 3.00E+00 MICROMETERS		CLEARANCE CLASS						
DOSE LOW LET	2.28E+01	5.14E+03	2.28E+01	2.28E+01	9.93E+02					
DOSE HIGH LET	2.35E+02	1.04E+04	2.34E+02	2.34E+02	2.35E+02					
RISK LOW LET	6.31E-04	1.43E+00	5.92E-03	5.92E-03	2.34E-02					
RISK HIGH LET	5.20E-02	2.30E+01	1.22E+00	1.22E+00	4.41E-02					
RISK EQUIVALENT	1.90E+03	8.82E+04	4.70E+03	4.70E+03	2.86E+03					
LIFE LOSS YEARS	2.81E+01	2.29E+01	0.00E+00	0.00E+00	2.15E+01					

PATHWAY: INHALATION		PARTICLE SIZE = 3.00E-01 MICROMETERS		CLEARANCE CLASS						
DOSE LOW LET	2.82E+00	1.56E+04	2.82E+00	2.82E+00	4.91E+02					
DOSE HIGH LET	1.25E+02	9.99E+04	1.24E+02	1.24E+02	1.26E+02					
RISK LOW LET	7.81E-05	4.32E+00	7.33E-04	7.33E-04	1.16E-02					
RISK HIGH LET	2.76E-02	2.24E+02	6.44E-01	6.44E-01	2.35E-02					
RISK EQUIVALENT	3.98E+02	8.10E+05	2.48E+03	2.48E+03	1.49E+03					
LIFE LOSS YEARS	2.75E+01	2.30E+01	0.00E+00	0.00E+00	2.14E+01					

PATHWAY: INHALATION		PARTICLE SIZE = 1.00E+00 MICROMETERS		CLEARANCE CLASS						
DOSE LOW LET	4.40E+00	9.37E+03	4.40E+00	4.40E+00	7.30E+02					
DOSE HIGH LET	9.89E+01	5.77E+04	9.80E+01	9.80E+01	9.93E+01					
RISK LOW LET	1.22E-04	2.60E+00	1.14E-03	1.14E-03	1.72E-02					
RISK HIGH LET	2.18E-02	1.27E+02	5.09E-01	5.09E-01	1.86E-02					
RISK EQUIVALENT	7.91E+02	4.68E+05	1.96E+03	1.96E+03	1.52E+03					
LIFE LOSS YEARS	2.78E+01	2.30E+01	0.00E+00	0.00E+00	2.14E+01					

RISK IN LET	7.34E-03	9.98E+00	1.72E-01	1.72E-01	1.09E-02
RISK EQUIVALENT	2.76E+02	1.82E+04	6.78E+02	6.75E+02	7.32E+02
RISK LOSS	2.73E+01	2.29E+01	0.00E+00	0.00E+00	2.12E+01
LIFE LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PATHWAY: INHALATION	1.37E+01	1.90E+02	2.64E+01	1.85E+01	5.23E+02
PARTICLE SIZE = 3.00E-05	5.21E+01	1.32E+03	5.21E+01	5.21E+01	1.01E+02
DOSE LOW/CI	3.81E+04	5.21E+02	6.87E-03	9.81E-03	1.23E-02
DOSE HIGH/CI	1.15E-02	2.93E+00	2.71E-01	2.71E-01	1.99E-02
RISK IN/CI	9.30E+02	1.08E+04	1.07E+03	1.06E+03	1.33E+03
RISK EQUIVALENT	2.74E+01	2.28E+01	0.00E+00	0.00E+00	2.12E+01
RISK LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LIFE LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PATHWAY: INHALATION	9.02E+00	3.78E+02	3.56E+00	2.58E+00	4.66E+01
PARTICLE SIZE = 3.00E-05	6.45E+00	3.89E+03	6.45E+00	6.45E+00	9.50E+00
DOSE LOW/CI	2.50E-04	1.04E-01	9.26E-04	6.71E-04	1.10E-03
DOSE HIGH/CI	1.43E-03	8.63E+00	3.35E-02	3.35E-02	1.79E-03
RISK IN/CI	6.06E+01	3.16E+04	1.33E+02	1.32E+02	1.23E+02
RISK EQUIVALENT	2.36E+01	2.30E+01	0.00E+00	0.00E+00	2.11E+01
RISK LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LIFE LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PATHWAY: INHALATION	9.71E+00	2.30E+02	5.40E+00	3.85E+00	8.51E+01
PARTICLE SIZE = 1.00E-05	9.40E+00	2.27E+03	9.39E+00	9.39E+00	1.61E+01
DOSE LOW/CI	2.69E-04	6.36E-02	1.40E-03	1.00E-03	2.00E-03
DOSE HIGH/CI	2.08E-03	5.03E+00	4.89E-02	4.89E-02	3.03E-03
RISK IN/CI	8.48E+01	1.84E+04	1.93E+02	1.92E+02	2.12E+02
RISK EQUIVALENT	2.71E+01	2.30E+01	0.00E+00	0.00E+00	2.12E+01
RISK LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LIFE LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PATHWAY: INHALATION	1.28E+01	1.39E+02	8.25E+00	5.80E+00	1.42E+02
PARTICLE SIZE = 3.00E-05	1.34E+01	1.21E+03	1.34E+01	1.34E+01	2.51E+01
DOSE LOW/CI	3.46E-04	3.82E-02	2.14E-03	1.51E-03	3.32E-03
DOSE HIGH/CI	2.97E-03	2.67E+10	6.98E-02	6.98E-02	4.74E-03
RISK IN/CI	1.20E+02	9.79E+03	2.77E+02	2.74E+02	3.43E+02
RISK EQUIVALENT	2.70E+01	2.30E+01	0.00E+00	0.00E+00	2.12E+01
RISK LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LIFE LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PATHWAY: AIR IMMERSION	1.06E+06	8.54E+05	7.62E+05	9.42E+05	7.84E+05
PARTICLE SIZE = 3.00E-05	2.93E+01	2.82E+02	1.98E+02	2.45E+02	1.85E+01
DOSE LOW/CI	1.06E+06	8.54E+05	7.62E+05	9.42E+05	7.84E+05
DOSE HIGH/CI	2.82E+01	2.44E+01	0.00E+00	0.00E+00	2.12E+01
RISK IN/CI	1.98E+04	1.50E+04	1.41E+04	1.75E+04	1.49E+04
RISK EQUIVALENT	1.98E+04	1.50E+04	1.41E+04	1.75E+04	1.49E+04
RISK LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LIFE LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PATHWAY: GROUND SURFACE	1.98E+04	1.50E+04	1.41E+04	1.75E+04	1.49E+04
PARTICLE SIZE = 3.00E-05	1.98E+04	1.50E+04	1.41E+04	1.75E+04	1.49E+04
DOSE LOW/CI	1.98E+04	1.50E+04	1.41E+04	1.75E+04	1.49E+04
DOSE HIGH/CI	1.98E+04	1.50E+04	1.41E+04	1.75E+04	1.49E+04
RISK IN/CI	1.98E+04	1.50E+04	1.41E+04	1.75E+04	1.49E+04
RISK EQUIVALENT	1.98E+04	1.50E+04	1.41E+04	1.75E+04	1.49E+04
RISK LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LIFE LOSS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

RISK LOW LET	6.69E-01	4.20E-02	9.14E-01	6.90E-01	0.00E+00	5.43E-01	4.24E+00	3.67E+00	4.84E+00	3.42E-01
RISK/CT Y/M+2)	1.50E-01	3.34E-01	1.48E-01	1.30E-01	0.00E+00	1.26E+04	1.88E+04	1.41E+04	1.75E+04	1.45E+04
RISK EQUIVALENT	1.50E-04	1.30E-04	1.48E-04	1.30E-04	0.00E+00	2.42E+01	2.43E+01	0.00E+00	0.00E+00	2.15E+01
RAD/CT Y/M+2)	1.50E-04	1.30E-04	1.48E-04	1.30E-04	0.00E+00					
LIFE LOSS	1.50E-01	1.30E-01	1.48E-01	1.30E-01	0.00E+00					
YEARS	2.15E+01	2.15E+01	2.15E+01	2.15E+01	2.15E+01					

SPECIAL FACTORS FOR PARENT NUCLIDE: RN-222
 PATHWAY: INHALATION DAUGHTERS AFFECTED: PO-210 PB-210 BI-210 PO-210
 CONVERSION TO SPECIAL UNITS FROM CURIES/M+3: 1.029E+06 5.069E+06 3.737E+06 5.920E-01

CONVERSION FACTORS
 ORGANS: *PUL* EFF WBOD
 RISK (PER ULM) 7.40E-04 7.40E-04
 RISK EQ. (RAD/ULM) 1.20E+01 2.50E+00
 LIFE LOSS (Y) 1.40E+01 1.40E+01

SPECIAL FACTORS FOR PARENT NUCLIDE: RN-220
 PATHWAY: INHALATION DAUGHTERS AFFECTED: PB-212 BI-212 PO-212
 CONVERSION TO SPECIAL UNITS FROM CURIES/M+3: 1.228E+08 1.166E+07 1.110E-03

CONVERSION FACTORS
 ORGANS: *PUL* EFF WBOD
 RISK (PER ULM) 2.51E-04 2.51E-04
 RISK EQ. (RAD/ULM) 4.01E+00 8.51E-01
 LIFE LOSS (Y) 1.40E+01 1.40E+01

CLEARANCE CLASS FRACTIONS AND PARTICLE SIZES
 USED TO SELECT INHALATION DOSE FACTORS

	D	M	Y	* SIZE (MICROMETERS)
U-238	0.00	0.00	1.00	0.00
TH-230	0.00	0.00	1.00	0.00
RA-226	0.00	1.00	0.00	0.00
RN-222	0.00	0.00	0.00	1.00
PO-210	0.00	1.00	0.00	0.00
PB-214	1.00	0.00	0.00	0.00
BI-214	0.00	1.00	0.00	0.00
PO-214	0.00	1.00	0.00	0.00
PB-210	1.00	0.00	0.00	0.00
BI-210	0.00	1.00	0.00	0.00
PO-210	0.00	1.00	0.00	0.00
RN-220	0.00	0.00	0.00	1.00
PO-216	0.00	1.00	0.00	0.00
PB-212	1.00	0.00	0.00	0.00
BI-212	0.00	1.00	0.00	0.00
PO-212	0.00	1.00	0.00	0.00
TL-208	1.00	0.00	0.00	0.00

LOCATION CHOSEN FOR SELECTED INDIVIDUAL IS 200.00 M NNE

THE TOTAL POPULATION IS 3.

SAMPLE RUN TO TEST ANEMOS

12-17-85

MEAN INDIVIDUAL LOCATION 200.00 M NNE

ANEMOS AVERAGE RUV FOR EXPOSURE NUCLIDES, OPTIONS: HTMAX \$40004

	LIFE TIME FATAL CANCER RISK & ASSOC. DOSES	RISK FROM RADON DECAY PRODUCT EXPOSURE (Y)	TOTAL FATAL CANCER RISK FROM ALL EXPOSURES	GENETIC RISK & ASSOC. DOSES
AVG. LIFE LOSS	40.2 Y	1.40 Y	40.2 Y	
RISK (PER BIRTH)	2.23E-07 (LIFETIME)	7.31E-05 (LIFETIME)	1.22E-07 (LIFETIME)	1.51E-07 (PER BIRTH)
RISK EQUIVALENT	1.66E-03 (RAD/Y)	2.60E-01 (RAD/Y)	1.66E-03 (RAD/Y)	9.88E-04 (RAD/Y)
DOSE EQUIVALENT	1.51E-03 (REM/Y)			9.88E-04 (REM/Y)

* ZEROS IN THE SPECIAL UNITS COLUMN INDICATE SPECIAL UNIT CALCULATION IS NOT REQUESTED.

MEAN INDIVIDUAL
LOCATION 200.00 M NNE

SAMPLE RUN TO TEST ANEMOS

12-17-85

ANEMOS AVERAGE RUN
FOR EXPOSURE NUCLIDES. OPTIONS:
HYMAX SNOUG

• ORGAN/CANCER SUMMARY •

LIFETIME FATAL CANCER RISK & ASSOC ORBAN DOSES							
	TOTAL EFF WBOD	LONG PUL	BREAST BREAST	LEUKEMIA R MAR	THYROID THYROID	BONE ENDOST	OVARIES OVARIES
RISK(LIFETIME)	7.253E-07	1.113E-07	2.415E-08	2.276E-08	1.800E-08	1.515E-09	0.000E+00
RISK EQ.(RAD/Y)	1.643E-03	1.912E-03	6.631E-04	5.408E-04	6.498E-04	6.233E-04	0.000E+00
DOSE EQ.(REM/Y)	1.643E-03	4.172E-03	6.631E-04	5.408E-04	6.498E-04	6.233E-04	4.595E-04

CANCER RISK FROM RADON DECAY PRODUCT EXPOSURE		
	LONG	TOTAL
RISK(LIFETIME)	7.306E-05	7.306E-05
RISK EQ.(RAD/Y)	1.257E+00	2.603E+01
EXPOSURE (WLM/Y)	3.132E-01	3.132E-01

TOTAL FATAL CANCER RISK FROM ALL EXPOSURES							
	TOTAL	LONG	BREAST	LEUKEMIA	THYROID	BONE	OVARIES
RISK(LIFETIME)	7.329E-05	7.318E-05	2.415E-08	2.276E-08	1.800E-08	1.515E-09	0.000E+00
RISK EQ.(RAD/Y)	2.620E-01	1.259E+00	6.631E-04	5.408E-04	6.498E-04	6.233E-04	0.000E+00

TOTAL GENETIC DOSE AND RISK		
	OVARIESG	AVERAGE
RISK(LIFETIME)	1.195E-07	1.515E-07
RISK EQ.(RAD/Y)	4.595E-04	5.818E-04
DOSE EQ.(REM/Y)	4.595E-04	5.818E-04

NOTE THAT THE DOSE IS CALCULATED FOR THE CORRESPONDING TISSUE.

*** PATHWAY SUMMARY ***

LIFETIME FATAL CANCER RISK & ASSOC WHOLE BODY DOSES					
	GRND SUR	INHALATION	WTR INH	ING TOT	TOTAL
RISK(LIFETIME)	1.381E-07	8.027E-08	6.633E-09	3.599E-10	2.255E-07
RISK EQ.(RAD/Y)	1.031E-03	5.799E-04	4.945E-05	2.614E-06	1.663E-03
DOSE EQ.(REM/Y)	3.155E-04	7.654E-04	2.47E-05	3.100E-06	1.309E-03

CANCER RISK FROM RADON DECAY PRODUCT EXPOSURE		
	INHALTN	
RISK(LIFETIME)	7.306E-05	
RISK EQ.(RAD/Y)	2.603E-01	
EXPOSURE (WL/Y)	3.132E-01	

TOTAL FATAL CANCER RISK FROM ALL EXPOSURES					
	BRND SUR	INHALTN	ATR INH	ING TOT	TOTAL
RISK(LIFETIME)	1.381E-07	8.027E-08	6.635E-09	3.599E-10	2.255E-07
RISK EQ.(RAD/Y)	1.031E-03	5.799E-04	4.943E-05	2.614E-06	1.663E-03

TOTAL GENETIC DOSE AND RISK					
	BRND SUR	INHALTN	ATR INH	ING TOT	TOTAL
RISK(LIFETIME)	1.442E-07	1.061E-11	6.915E-09	1.738E-10	1.513E-07
RISK EQ.(RAD/Y)	5.545E-04	4.079E-08	2.660E-05	6.683E-07	5.818E-04
DOSE EQ.(REM/Y)	5.545E-04	4.079E-08	2.660E-05	6.683E-07	5.818E-04

NOTE THAT THE DOSE IS CALCULATED FOR THE CORRESPONDING TISSUE.

*** NUCLIDE SUMMARY ***

LIFETIME FATAL CANCER RISK & ASSOC WHOLE BODY DOSES								
	TL-208	U-234	PR-212	BT-212	RN-220	PO-215	RN-222	PO-218
RISK(LIFETIME)	1.074E-07	8.053E-08	1.895E-08	1.731E-08	1.505E-09	3.777E-11	1.308E-12	9.470E-13
RISK EQ.(RAD/Y)	8.020E-04	5.803E-04	1.409E-04	1.293E-04	9.723E-06	2.810E-07	9.853E-09	6.844E-09
DOSE EQ.(REM/Y)	4.012E-04	7.659E-04	7.191E-05	6.465E-05	4.859E-06	1.408E-07	1.224E-08	8.497E-09
	PR-214	BT-214	TH-230	PO-210	PO-210	RA-226	BT-210	PO-214
RISK(LIFETIME)	3.209E-13	3.757E-14	3.518E-15	3.468E-16	2.279E-16	1.462E-16	1.099E-17	1.307E-18
RISK EQ.(RAD/Y)	2.324E-09	2.769E-10	2.559E-11	2.502E-12	1.674E-12	1.082E-12	7.916E-14	9.758E-15
DOSE EQ.(REM/Y)	2.821E-09	2.210E-10	2.871E-11	3.619E-12	2.091E-12	1.298E-12	7.631E-14	4.888E-15
	PO-212	TOTAL						
RISK(LIFETIME)	9.085E-22	2.255E-07						
RISK EQ.(RAD/Y)	5.483E-18	1.663E-03						
DOSE EQ.(REM/Y)	4.107E-18	1.309E-03						

CANCER RISK FROM RADON DECAY PRODUCT EXPOSURE			
	RN-222	RN-220	TOTAL
RISK(LIFETIME)	3.384E-11	7.306E-05	7.305E-05
RISK EQ.(RAD/Y)	1.144E-07	2.603E-01	2.603E-01
EXPOSURE (WL/Y)	4.580E-08	3.132E-01	3.132E-01

TOTAL FATAL CANCER RISK FROM ALL EXPOSURES								
	YL-208	U-234	PB-212	BT-212	RN-220	PO-216	RN-222	PO-218
RISK(LIFETIME)	1.074E-07	8.033E-08	1.895E-08	1.751E-08	7.307E-09	3.774E-11	3.520E-11	9.470E-13
RISK EQ.(RAD/Y)	9.028E-04	5.803E-04	1.409E-04	1.293E-04	2.603E-01	2.818E-07	1.242E-07	6.844E-09
	PB-214	BT-214	TH-230	PB-210	PO-210	KA-226	BT-210	PO-214
RISK(LIFETIME)	3.289E-13	3.757E-14	3.515E-15	3.468E-16	2.279E-16	1.462E-16	1.099E-17	1.407E-16
RISK EQ.(RAD/Y)	2.324E-09	2.769E-10	2.559E-11	2.502E-12	1.674E-12	1.082E-12	7.916E-14	9.758E-15
	PO-212	TOTAL						
RISK(LIFETIME)	9.085E-22	7.329E-05						
RISK EQ.(RAD/Y)	3.483E-18	2.620E-01						

TOTAL GENETIC DOSE AND RISK								
	YL-208	U-234	PB-212	BT-212	RN-220	PO-216	RN-222	PO-218
RISK(LYK/BIRTH)	1.119E-07	1.843E-11	1.936E-08	1.833E-08	1.400E-09	4.065E-11	2.980E-12	2.004E-14
RISK EQ.(RAD/Y)	4.305E-04	7.087E-08	7.443E-05	7.126E-05	9.386E-06	1.963E-07	1.115E-08	7.709E-11
DOSE EQ.(REM/Y)	4.305E-04	7.087E-08	7.443E-05	7.126E-05	9.386E-06	1.963E-07	1.115E-08	7.709E-11
	PB-214	BT-214	TH-230	PB-210	PO-210	KA-226	BT-210	PO-214
RISK(LYK/BIRTH)	3.571E-14	2.365E-14	1.635E-15	8.329E-17	2.647E-16	1.508E-16	2.433E-18	1.408E-16
RISK EQ.(RAD/Y)	1.374E-10	9.097E-11	9.000E-12	3.203E-13	1.038E-12	5.800E-13	9.733E-15	5.414E-13
DOSE EQ.(REM/Y)	1.374E-10	9.097E-11	9.000E-12	3.203E-13	1.038E-12	5.800E-13	9.733E-15	5.414E-13
	PO-212	TOTAL						
RISK(LYK/BIRTH)	8.748E-42	1.513E-07						
RISK EQ.(RAD/Y)	3.364E-38	5.818E-04						
DOSE EQ.(REM/Y)	3.364E-38	5.818E-04						

NOTE THAT THE DOSE IS CALCULATED FOR THE CORRESPONDING TISSUE.

SAMPLE RUN TO TEST ANEMOS

12-17-85

MEAN INDIVIDUAL
LOCATION 200.00 M NNE

ANEMOS AVERAGE RUN
FOR EXPOSURE NUCLIDES, OPTIONS:
HYMAX 34004

FOR RADIONUCLIDES		U-234	ADU	ONUC	LIDE	S	LEUKEMIA	
PATHWAYS		AIR	INH	GRND	SUR	INHALTN	ING-TOT	SUM
ORGANS/CANCERS		(+)						
B MAR LEUKEMIA								
RISK		2	3.60E-18	2.18E-13	1.20E-11	6.74E-12	1.90E-11	
DOSE EQ.(REM/Y)		2	1.33E-13	5.20E-09	1.07E-06	5.49E-07	1.62E-06	
BREAST BREAST								
RISK		3	3.60E-17	7.43E-12	4.60E-13	2.65E-13	8.15E-13	
DOSE EQ.(REM/Y)		3	9.88E-13	2.04E-07	3.88E-08	1.95E-08	2.62E-07	
LUNG LUNG								
RISK		1	1.15E-17	9.74E-13	8.02E-08	4.24E-13	8.02E-08	
DOSE EQ.(REM/Y)		1	1.98E-13	9.86E-09	3.64E-03	1.95E-08	3.64E-03	
SUM OF RISK			5.31E-17	8.22E-12	8.02E-08	7.45E-12		

*THIS INTEGER RANKS THE ROW SUMS OF EACH EFFECT BY ORGANS/CANCERS

MEAN INDIVIDUAL
LOCATION 200.00 M NNE

SAMPLE RUN TO TEST ANEMOS

12-17-85

ANEMOS AVERAGE RUN
FOR EXPOSURE NUCLIDES, OPTIONS:
HTMAX SA0004

FOR RADIONUCLIDES :U-234
RADI ONUC LIDE S AVERAGE
PATHWAYS AIR IMM GRND SUR INHALTN ING-TOT SUM
ORGANS/CANCERS (+)
AVERAGE AVERAGE
RISK
DOSE EQ.(REM/Y) 1 7.01E-17 6.06E-12 7.66E-12 4.70E-12 1.94E-11
2 2.70E-13 2.33E-08 2.95E-08 1.81E-08 7.09E-08

OVARIES OVARIES
RISK
DOSE EQ.(REM/Y) 2 3.81E-17 1.68E-12 7.66E-12 4.77E-12 1.41E-11
3 1.46E-13 6.46E-09 2.95E-08 1.83E-08 5.43E-08

BREAST BREAST
RISK
DOSE EQ.(REM/Y) 3 3.60E-17 7.43E-12 4.60E-13 2.65E-13 8.15E-12
1 9.88E-13 2.04E-07 3.84E-08 1.95E-08 2.62E-07

SUM OF RISK 1.44E-16 1.52E-11 1.58E-11 9.74E-12

*THIS INTEGER RANKS THE ROW SUMS OF EACH EFFECT BY ORGANS/CANCERS

MEAN INDIVIDUAL
LOCATION 200.00 M NNE

SAMPLE RUN TO TEST ANEMOS

12-17-85

ANEMOS AVERAGE RUN
FOR EXPOSURE NUCLIDES, OPTIONS:
HTMAX SA0004

RISK EQ.(RAD/Y)
FOR RADIONUCLIDES :PB-212
PATHWAYS TOT PTMY SUM
ORGANS/CANCERS (+)
LUNG 2 6.73E-05 6.73E-05
LEUKEMIA 3 6.54E-05 6.54E-05
BREAST 1 1.01E-04 1.01E-04
SUM OF RISK EQ.(RAD/Y) 2.34E-04

*THIS INTEGER RANKS THE ROW SUMS OF EACH EFFECT BY ORGANS/CANCERS

MEAN INDIVIDUAL
LOCATION 200.00 M NNE

SAMPLE RUN TO TEST ANEMOS

12-17-85

ANEMOS AVERAGE RUN
FOR EXPOSURE NUCLIDES, OPTIONS:
HTMAX SA0004

FOR FACTOR : DOSE EQ. (REM/YR)
FOR NUCLIDES:RN-220
FOR ORGANS:BREAST
FOR PATHWAYS:TOT PTMY
DIRECTIONS:

	S	NNE SSW	NE SW	ENE WSW	E W	ESE WNW	SE NW	SSE NNW	AVG
DISTANCE (M)									
40.- 200.	0.00E+00	2.38E-07	1.16E-07	1.28E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
200.- 460.	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-07
AVG	2.05E-06	5.94E-06	4.30E-06	3.58E-06	1.85E-07	0.00E+00	0.00E+00	0.00E+00	2.85E-06
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.91E-07	1.33E-06	1.80E-06	2.63E-06	2.87E-06
	2.05E-06	4.51E-06	3.25E-06	2.71E-06	1.85E-07	0.00E+00	0.00E+00	0.00E+00	
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.91E-07	1.33E-06	1.80E-06	2.63E-06	

SAMPLE RUN TO TEST ANEMOS

12-17-85

MEAN INDIVIDUAL
LOCATION 200.00 M NNE

ANEMOS AVERAGE RUN
FOR EXPOSURE NUCLIDES, OPTIONS:
HYMAX SROUG4

FOR FACTOR : DOSE EQ. (REM/YR)
FOR NUCLIDES:RN-220
FOR ORGANS:AVERAGE
FOR PATHWAYS:TOT PTMY
DIRECTIONS:

	N	S	NNE SSW	NE SSW	ENE SSW	E W	ESE NNW	SE NW	SSE NNW	AVG
DISTANCE (M)										
90.- 200.	0.00E+00	0.00E+00	2.16E-07	1.06E-07	1.16E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-07
200.- 460.	1.86E-06	0.00E+00	5.39E-06	3.90E-06	3.24E-06	1.68E-07	0.00E+00	0.00E+00	0.00E+00	2.59E-06
AVG	1.86E-06	0.00E+00	4.09E-06	2.95E-06	2.46E-06	1.68E-07	0.00E+00	0.00E+00	0.00E+00	2.61E-06

SAMPLE RUN TO TEST ANEMOS

12-17-85

MEAN INDIVIDUAL
LOCATION 200.00 M NNE

ANEMOS AVERAGE RUN
FOR EXPOSURE NUCLIDES, OPTIONS:
HYMAX SROUG4

FOR FACTOR : DOSE EQ. (REM/YR)
FOR NUCLIDES:RN-220
FOR ORGANS:PUL
FOR PATHWAYS:TOT PTMY
DIRECTIONS:

	N	S	NNE SSW	NE SSW	ENE SSW	E W	ESE NNW	SE NW	SSE NNW	AVG
DISTANCE (M)										
90.- 200.	0.00E+00	0.00E+00	1.93E-07	9.44E-08	1.03E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-07
200.- 460.	1.66E-06	0.00E+00	4.81E-06	3.49E-06	2.90E-06	1.50E-07	0.00E+00	0.00E+00	0.00E+00	2.31E-06
AVG	1.66E-06	0.00E+00	3.66E-06	2.64E-06	2.20E-06	1.50E-07	0.00E+00	0.00E+00	0.00E+00	2.33E-06

SAMPLE RUN TO TEST ANEMOS

12-17-85

MEAN INDIVIDUAL
LOCATION 200.00 M NNE

ANEMOS AVERAGE RUN
FOR EXPOSURE NUCLIDES, OPTIONS:
HYMAX SROUG4

FOR FACTOR : RISK EQ. (MRAJ/YR)
FOR NUCLIDES:JLM-222
FOR ORGANS:LUNG
FOR PATHWAYS:
DIRECTIONS:

	N	S	NNE SSW	NE SSW	ENE SSW	E W	ESE NNW	SE NW	SSE NNW	AVG
DISTANCE (M)										
90.- 200.	0.00E+00	0.00E+00	1.72E-08	8.32E-09	9.18E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.16E-08
200.- 460.	2.38E-07	0.00E+00	5.31E-07	2.96E-07	2.99E-07	5.00E-08	0.00E+00	0.00E+00	0.00E+00	2.63E-07
AVG	2.38E-07	0.00E+00	4.18E-07	2.24E-07	2.26E-07	5.00E-08	0.00E+00	0.00E+00	0.00E+00	2.65E-07

12-17-85

SAMPLE RUN TO TEST ANEMOS

TEAM INDIVIDUAL
LOCATION 200.00 M NNE

AVG 99.9 AVERAGE BUY
FOR EXPOSURE
HIMAX STROUG

POPULATION
DIRECTIONS:

	N	S	NNE	SSW	NE	SW	ESE	WSW	E	W	ESE	WNW	SW	WNW	SSE	NNW	SUN
DISTANCE (M)																	
90.-	0	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	3
200.-	3	0	3	0	3	0	3	0	2	1	0	0	0	0	2	0	21
SUM	3	0	5	0	4	0	4	0	2	1	0	0	0	0	2	0	24

APPENDIX C

ANDROS/KADRISK DATA BASE

The ANDROS/RADRISK data base is a modification of the DARTAB/RADRISK data base. All data in the ANDROS/RADRISK data base are from or are computed from data in the DARTAB/RADRISK data base. The modified data base currently contains health effect factors for 502 nuclides, with up to 31 types of factors for each nuclide. The nuclides are sorted alphabetically. Each type of factor is identified by an indicator number listed in Table C.1. The factors are sorted by indicator number. Up to 29 organs are included for each type of factor. The specific organs that might be available for each type of factor are listed in Table C.2. If no factor exists for a particular organ for a specific nuclide, then a value of -1.0 occurs in that place in the data base.

The factors used to convert the units of the DARTAB/RADRISK data to the units desired for the ANDROS/RADRISK data base are listed in Table C.3. Note that the units of some of the factors are incorrect in the DARTAB document (Begovich et al., 1981). The factors in Table C.3 reflect actual DARTAB units. The factor of 31 in the genetic dose factor conversion of Table C.3 refers to the 30 years of exposure per generation assumed in the genetic dose calculation. The 70.7565 factor in the somatic risk conversion is the expected lifetime in years. Genetic risk and genetic risk equivalent factors were not included in the DARTAB/RADRISK data base. Genetic risk factors were computed by multiplying the converted genetic dose factors by the factor listed in Table C.3. The genetic risk equivalent factor was computed using the converted genetic risk factor and the factor in the table. The lifetime lost factor was computed by dividing the DARTAB/RADRISK lifetime lost factor by the DARTAB/RADRISK somatic risk factor. The working level factor conversion was computed separately.

The ANDROS/RADRISK file was written in binary by a FORTRAN IV program and has the following format:

One header record containing:

NTFILE	the number of indicators in the data base
NNUC	the number of nuclides in the data base
NORG	the number of organs in the data base

Table C.1. Factors in the ANDROS/RADRIK data base

Index	Factor	Pathway
1	Dose	Ingestion
2	Dose	Inhalation
3	Dose	Air immersion
4	Dose	Surface exposure
5	Genetic dose	Ingestion
6	Genetic dose	Inhalation
7	Genetic dose	Air immersion
8	Genetic dose	Surface exposure
11	Somatic risk	Ingestion
12	Somatic risk	Inhalation
13	Somatic risk	Air immersion
14	Somatic risk	Surface exposure
15	Genetic risk	Ingestion
16	Genetic risk	Inhalation
17	Genetic risk	Air immersion
18	Genetic risk	Surface exposure
19	Working level, somatic risk	Inhalation
111	Risk equivalent	Ingestion
112	Risk equivalent	Inhalation
113	Risk equivalent	Air immersion
114	Risk equivalent	Surface exposure
115	Genetic risk equivalent	Ingestion
116	Genetic risk equivalent	Inhalation
117	Genetic risk equivalent	Air immersion
118	Genetic risk equivalent	Surface exposure
119	Working level, risk equivalent	Inhalation
1111	Lifetime lost	Ingestion
1112	Lifetime lost	Inhalation
1113	Lifetime lost	Air immersion
1114	Lifetime lost	Surface exposure
1119	Working level, years of lost life	Inhalation

Table C.2. Organ names used in the ANDROS/RAD RISK data base

Somatic ^a	Somatic ^b	Genetic ^c
BREAST	ADREN	AVERAGE
ENDOST	BL WALL	OVARIESG
INT WALL	BONE	TESTESG
KIDNEYS	LLI WALL	
LIVER	LUNGS	
OTHER	*N-P*	
PANCREAS	OVARIES	
PUL	RES LYM	
R MAR	SPLEEN	
S WALL	SI WALL	
THYROID	SKIN	
	T BODY	
	T-B	
	TESTES	
	THYMUS	
	ULI WALL	
	UTERUS	
	Y MAR	

^a All factors present.

^b Dose factors only.

^c Dose, risk, and risk equivalent factors only.

Table C.3. Factors used to convert the DARTAB/RADRIK data base to ANDROS/RADRIK units

Effect	Pathway	Factor
Dose	Internal	10^9
	Air immersion	10^{-3}
	Ground surface	10^{-1}
Somatic risk	Internal	$10^7/70.7565$
	Air immersion	$10^1/70.7565$
	Ground surface	$10^3/70.7565$
Risk equivalent	Internal	10^9
	Air immersion	10^3
	Ground surface	10^5
Genetic dose	Internal	$10^9/30$
	Air immersion	$10^{-3}/30$
	Ground surface	$10^{-1}/30$
Genetic risk ^a	Internal	2.6E-4 low LET 5.2E-3 high LET
	Air immersion	2.6E-4
	Ground surface	2.6E-4
Genetic risk equivalent ^b	Internal	(high+low)/2.6E-4
	Air immersion	low/2.6E-4
	Ground surface	low/2.6E-4
Lifetime lost	All pathways	risk ⁻¹

^aThese factors are applied to the converted genetic dose factor.

^bThese factors are applied to the converted genetic risk factor.

ORGAN the list of organ names

The following three types of records [labeled (1), (2), and (3)] are included for each nuclide; their contents are listed below. The (2) and (3) records will occur more than once per nuclide.

(1)

NAME the nuclide name
ZAS the nuclide ZAS number
NFILE the number of indicator records for this nuclide
NIND the number of indicators included for this nuclide
INDS a list of the indicator numbers for this nuclide
NGIREP the number of combinations of GI absorption fractions, clearance classes, and particle sizes used for internal factors for this nuclide
FACS a list of the triples of factors counted by NGIREP

(2)

IND the indicator number
ILET 1 for low LET only, 2 for both high and low LET
NTIME the number of years included for internal dose factors (may be 50 or 70)
NC the number of organs
GIABS the GI absorption fraction for this factor
RESP the clearance class (D, W, Y, or *) for this factor
SIZE the particle size in μ
ORGANS the list of organ names

(3)

TIME the time for external dose factors
FACTOR the factors appropriate to this indicator, time, GI fraction, particle size, and clearance class; listed for NC organs and, if ILET is 2, for both low and high LET

APPENDIX D

ANDROS CODE LISTING

[illegible]

```

10 CONTINUE
RETURN
END
SUBROUTINE COLLP(RNUC,MNUC,PORG,NORG,IFAC,NFAC,
1PTHY,NPTH,VALUE,IER)
C... THIS SUBROUTINE CALCULATES FACTORS IFAC FOR NUCLIDES RNUC.
C... ORGANS NORG AND PATHWAYS PTHY FOR THE PEAK INDIVIDUAL.
C... THE RESULTS ARE STORED IN THE ARRAY VALUE.
C... RNUC IS THE NUMBER OF NUCLIDES IN RNUC.
C... NORG IS THE NUMBER OF ORGANS IN NORG.
C... NFAC IS THE NUMBER OF FACTORS IN IFAC.
C... NPTH IS THE NUMBER OF PATHWAYS IN PTHY.
C... INDIVIDUAL TO AREA VALUES
COMMON/FA-ARRAY(50,24,6)
REAL*8 PORG,RNUC
INTEGER PTHY
LOGICAL LOCTAB,MNCL
DIMENSION VALUE(1),RNUC(1),NORG(1),
1IFAC(1),PTHY(1),IN(5),IO(4),IF(2,8),NF(8)
COMMON/NORG/MT(24,2)
C... NLOC ARE THE NUMBER OF LOCATIONS
COMMON/LOCAT/POP(405),X(40),Y(40),ZC(40),YC(40),FEREF(40),
1PEPRN(40),PERU(40),XREF,XREF,NLOC,POPT
COMMON/CF/NA,MNCL
COMMON/CFAC/AGFX
COMMON/LOCOP/LOCTAB,JLOC
C
IER=0
CALL MATCH(RNUC,MNUC,2,IN,IER)
IF(IER.NE.0) RETURN
CALL MATCH(NORG,NORG,1,IO,IER)
IF(IER.NE.0) RETURN
CALL MATCH(IFAC,NFAC,IF,IO,NF)
IF(IER.NE.0) RETURN
NA=NPTH*AFAC*NORG*MLUC
DO 10 IA=1,NA
10 VALUE(IA)=0.0
N1=JLOC
N2=JLOC
IF(LOCTAB) GO TO 20
N1=1
N2=NLOC
20 DO 60 ILCC=N1,N2
IA=0
DO 60 JPTH=1,NPTH
INRD=PTHY(JPTH)+(ILCC-1)*14
READ(33) INRD,PRAY
DO 60 JFAC=1,NFAC
FACTOR=1.0
NF2=NF(JFAC)
IF(MNCL) GO TO 30
IF(IFAC(JFAC).EQ.3.CR.(IFAC(JFAC).EQ.8) FACTOR=1/AGEX
30 DO 60 JORG=1,NORG
DO 60 JNUC=1,MNUC
IA=IA+1
DO 60 JFAC2=1,NF2
V=PRAY(IN(JNUC),IO(JORG),IF(JFAC2,JFAC))*FACTOR
IF(IFAC(JFAC).EQ.7) GO TO 4
IF(IFAC(JFAC).EQ.6) GO TO 80
VALUE(IA)=VALUE(IA)+V*POP(ILCC)
GO TO 6
40 VALUE(IA)=VALUE(IA)+V*MT(JORG,IF(JFAC2,JFAC))*POP(ILCC)
GO TO 60
50 P=0
IF(ILCC.EQ.IND.POP(ILCC).GT.1.E-30) P=1
IF(LOCTAB.AND. POPT.GT.1.E-30) P=POP(ILCC)/POPT
VALUE(IA)=VALUE(IA)+V*P
60 CONTINUE
IF(LOCTAB) RETURN
NA=IA
RETURN
END
SUBROUTINE DATREC(YEFF,XREF,XMIN,XMAX,TN1,TN2,POP,PROD,PENEF,
1PEPRN,PRU,PTORG,ILCC)
LOGICAL DEPRG
REAL NUMCC,NUMPC,LONG,LAT,ATN
COMMON/ILN1/FRNCL,NRDS,JTCOM,ORLNT
COMMON/ILP(14),NDV,NDV,NDV,NDV
COMMON/COB/IFAST
LOGICAL IFAST
DIMENSION DATA(34),LUM(100),INDEX(100),IND(100),
1RUMS(100),P4(100)
DATA DEPRG,FALCE,/,INC/12/,PADIAN/57.2958/
INDEX(YV)=INDEX(YV-24,5)/.5/
INDV(YV)=INDEX(YV-24,5)/.5/
C
R1=XMIN
R2=XMAX
C... IF SITE DATA PACC VALUES ARE LEVEL GO TO 1000
IF(FAST) GO TO 210
F1367.77 RADIUS OF EARTH IN MILES,MILC=1609.25 METERS.
CONVERSION FACTOR DEGREES TO NAUTICAL MILES(METERS)/60.1653.
AMPD=1./160.1653/ FACTOR TO CONVERT METERS TO DPG. IN LAT.
AMPD=1./11118.
AMPD=16.0/30.48.
INITIAL POSITION OF SITE PARAMETERS
1PTORG=100.2 GO TO 1
TREAT LOC AS THIN SPOT
P2=1
P1=R1-100.
IF(ORLNT.EQ.0) P1=0.0
P2=R2-100.
10 DELTME=40*(TN1-TN2)
IF(DELTIME.EQ.1.0) GO TO 20
DELTME=.256
TMS=-116.
TMS=0.
GO TO 4

```



```

PPV=0.0
PGH=0.0
DO 150 NCELL=1,15000
WEIGHT=FLOAT(NUMS(NCELL))/FLOAT(N6000)
IND=INDS(NCELL)
IF (DEBUG) WRITE(6,1300) IND, WEIGHT
1300 FORMAT(' ', I5, '24', F6.4)
REAL(100) INDLONG, L17, DATA
IF (DEBUG) WRITE(5,1400) LOC, L17, D17:
DO 140 IC=1,33
IF (IC=18.OR.IC=23) GO TO 140
IF (IC=22) GO TO 140
DATA(IC)=DATA(IC)*WEIGHT
140 CONTINUE
IF (LONG.EQ.0.AND.LAT.EQ.0) GO TO 190
C
LATN=LAT+.5
C
TAPEAK = REVISED RECT. AREA OF THE CELL
C
USING FREDS DISTANCE FORMULA
BASEL=LAT
YCOMP=111.321+COS(BASEL/RADIAN)*-0.8549E-2+7.789E-3*BASEL
-5.884E-5*BASEL**2
YCOMP=XCOMP/COS(BASEL/RADIAN)-8.5697E-1+7.927E-3*BASEL
-5.888E-5*BASEL**2
DISTY=.5*YCOMP
DISTX=.5*XCOMP
TAPEAR=DISTX*DISTY*1.0E+6
RATIC=RATIC+DATA(18)/TAPEAR*WEIGHT
C
TOTAL WEIGHTED VALUES
AFEAT=AFEAT+DATA(18)
C
TOTAL WEIGHTED DENSITIES
AREAP=AREAP+DATA(19)/DATA(18)
NUMCC=NUMCC+DATA(10)/DATA(18)
NUMMC=NUMMC+DATA(12)/DATA(18)
NUMSH=NUMSH+DATA(13)/DATA(18)
POP=POP+DATA(14)/DATA(18)
POPNE=POPNE+DATA(15)/DATA(18)
POPFE=POPFE+DATA(19)/DATA(18)
POPURB=POPURB+DATA(19)/DATA(22)/DATA(18)
PLV=PLV+DATA(23)/DATA(18)
PEV=PEV+DATA(24)/DATA(18)
PPV=PPV+DATA(25)/DATA(18)
PGH=PGH+DATA(26)/DATA(18)
150 CONTINUE
C
:SEG IS THE AREA OF A CIRCULAR GRID SEGMENT.
ASG=(R2-R1)*R1*.5*14195*DELTH/6.283936
C
COMPUTE PERCENTAGES OF POPULATION GROUPS
AND OBTAIN THE AVERAGE DENSITY OF EACH VALUE.
C
CALCULATE PERCENTAGE OF POPULATION AND COMPUTE THE DENSITY.
IF (AREAT.EQ.0) GO TO 200
POPULATION OF SEG AREA ADJUSTED TO ACTUAL LAND
AREA OF GRIDS=DENSITY*ASG*TAPEAR/AREAT.
AREAT: ACTUAL LAND AREA OF GRIDS.
IF (RATIC.GT.1.000) RATIC=1.000
FAC=ASEG/RATIC
IF (DEBUG) WRITE(6,1600) RATIC
1600 FORMAT('0', 'RECTION OF THE SECTOR THAT IS LAND =', IPE15.7)
AREAP=AREAP*FAC
NUMCC=NUMCC*FAC
NUMMC=NUMMC*FAC
PERN=DATA(20)
PERFE=DATA(21)
PEU=DATA(22)
IF (POP.EQ.0) GO TO 161
PERN=POPNE/POP
PERFE=POPFE/POP
PEU=POPURB/POP
161 POP=POP*FAC
PLV=PLV*FAC
PEV=PEV*FAC
PPV=PPV*FAC
PGH=PGH*FAC
POPNE=POPNE*FAC
POPFE=POPFE*FAC
POPURB=POPURB*FAC
IPR=POP*F
POP=IPR
IF (PERN+PERFE+PEU.NE.0) GO TO 170
WRITE(6,1500) LOC
1500 FORMAT('0', 'WARNING, TOTAL POP. IS ZERO FOR LOC=', I4)
PERN=.51
PERFE=.53
PEU=.54
170 PRON(2)=PERN*NUMCC
PRON(1)=HERO5L*ATCON*ONLYT*NUMMC
PRON(3)=PLV
PRON(4)=PEV
PRON(5)=PPV
PRON(6)=PGH
IF (DEBUG) WRITE(6,1800) POP, PERN, PERFE, PEU, PRON
1800 FORMAT('1', I10, F10.3)
C
AREAT NOW EQUALS AREA OF THE SEGMENT THAT IS LAND
AREAT=FAC
RETURN
180 IF (DEBUG) WRITE(6,1900) IND
1900 FORMAT('1', I5, 'DATA INDEX NOT IN THE FILE, KEY=', I5)
GO TO 190
190 IF (DEBUG) WRITE(6,1900)
1900 FORMAT('1', 'DATA OBTAINED NOT VALID')
CALL E200
RETURN
210 NC1=(LOC-1)/NDY

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[illegible]

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[illegible]

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14HRSADI,4HHRUC,4HLOI,4HNS
24HORG,4HNS/C,4HANCE,4HRS
34HPATH,4HWAYS,4H
DATA FACT/4HDOSE,4HLOW,4HLET,4HCRAD,4H/Y,4H
14HDOSE,4HHIGH,4HLET,4HCRAC,4H/Y,4H
24HRISK,4HLOW,4HLET,4H
34HRISK,4HMI,4HLET,4H
44HRISK,4HEQ,4HCRAD,4H/Y,4H
54HVG,4HLIF,4HLE,4HSS,4H/Y,4H
64HDOSE,4HEQ,4HCRAD,4H/Y,4H
74HRISK,4H
C
ITAB=1
10 IF(NT(1,ITAB).EQ.BLANK) RETURN
IF(ITAB.GT.25) RETURN
IUL=0
ICF=0
INUC=0
IORG=0
IPTH=0
CALL FIND(NT(1,ITAB),RNUC,ORG,JPTH,
IINUC,IORG,IPTH,IN,IER)
IF(IER.NE.0) GO TO 160
IX=IU
IX=N
CALL FIND(NT(1,ITAB),RNUC,ORG,JPTH,
IINUC,IORG,IPTH,IN,IER)
IF(IER.NE.0) GO TO 160
IY=IU
IY=N
CALL FIND(NT(1,ITAB),RNUC,ORG,JPTH,
IINUC,IORG,IPTH,IN,IER)
IF(IER.NE.0) GO TO 160
IZ=IU
IZ=N
DO 20 J=1,3
IF(FACD(J,ITAB).EQ.0) GO TO 30
20 CONTINUE
J=0
30 NFAC=J-1
DOSE=.FALSE.
RISK=.FALSE.
DO 31 I=1,NFAC
IF(FACD(I,ITAB)
IF(LE,2,0,IF,50,7) DOSE=.TRUE.
IF(LE,2,0,IF,42,7) RISK=.TRUE.
31 CONTINUE
IF(.NOT.RISK) GO TO 34
DO 32 I=1,IORG
CANC(I)=FACD(I)
DO 32 J=1,11
IF(ORG(I).EQ.ORG(J)) CANC(I)=CANC(J)
32 CONTINUE
34 K=INC
GO TO (40,40,50),K
40 CALL INDI(RNUC,IINUC,IORG,IORG,FACD(1,ITAB),
INFC,JPTH,IPTH,VALUE,IER)
GO TO 41
50 CALL COLP(RNUC,IINUC,IORG,IORG,FACD(1,ITAB),
INFC,JPTH,IPTH,VALUE,IER)
60 CONTINUE
CALL SETUP(IY,IY,IZ,IINUC,IORG,IPTH,NFAC,VALUE,OUTPUT,
IROWS,COLS,ROWN,COLN,FACD(1,ITAB))
CALL HEADIN
IF(LE,3) WRITE(6,1005)
1000 FORMAT(' (PERSON UNITS)')
DO 110 IF=1,NFAC
CALL SORTI(ROWS(1,IF),N(1,IF),IY)
DO 70 I=1,IY
IC(I,IF)=I
70 CONTINUE
DO 80 I=1,IY
IR(I,IF)=IC(I)
80 CONTINUE
CALL SORTI(COLS(1,IF),IC(1,IF),IX)
DO 90 I=1,IX
IC(I,IF)=I
90 CONTINUE
DO 100 I=1,IX
IC(I,IF)=IC(I)
100 CONTINUE
110 CONTINUE
IF(NFAC.EQ.1) WRITE(6,1200) (FACD(IL,FACD(1,ITAB)),IL=1,4)
1200 FORMAT(' 6614')
IF(IZ.NE.2,0,1,NS) WRITE(6,1300) (WHICH(K,IZ),K=1,4),(ZT(1,ITAB),
-1,1,1)
IF(IZ.EQ.2,AND,RISK,AND,NOT,DOSE) WRITE(6,1300) (WHICH(K,IZ),
-1,1,1)
IF(IZ.EQ.2,AND,RISK,AND,DOSE) WRITE(6,1350) (WHICH(K,IZ),K=1,4),
-1,1,1)
1300 FORMAT(' 6614, 10( 8,2Y)/(24,1C(4P,2Y))')
1350 FORMAT(' 6614, 10( 8,2Y)/(24,1C(4P,2Y))')
IF(IZ.NE.2,0,1,NS) WRITE(6,1400) (WHICH(K,IY),K=1,4),
-1,1,1)
IF(IZ.EQ.2,AND,RISK,AND,NOT,DOSE) WRITE(6,1400) (WHICH(K,IY),
-1,1,1)
IF(IZ.EQ.2,AND,RISK,AND,DOSE) WRITE(6,1450) (WHICH(K,IY),K=1,4),
-1,1,1)
1400 FORMAT(' 6614, 12( 1C(2Y,4P)/(31Y,1C(2Y,4P))')
1450 FORMAT(' 6614, 12( 1C(2Y,4P)/(31Y,1C(2Y,4P))')
WRITE(6,1500) (WHICH(K,IY),K=1,4)
1500 FORMAT(' 6614, 10( 8,2Y)/(24,1C(4P,2Y))')
DO 160 I=1,IY
IF(IY.EQ.2,AND,DOSE) WRITE(6,1600) YT(1,ITAB)
IF(IY.EQ.2,AND,RISK,AND,DOSE) WRITE(6,1600) CANC(I)
IF(IY.EQ.2,AND,RISK,AND,DOSE) WRITE(6,1640) CANC(I)

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[illegible]

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N=1
IU=3
JPTH(1)=14
RETURN
END
SUBROUTINE FINDFC(ZASE,NR,XP,NUCLID)
DIMENSION ZASE(1),NUCLID(1),RORG(3),ICP(24),
1RORG(3),IORG(3),INDFC(12,36),GISEP(3,24),G(2,36),
2TITLE(4),DATE(2),FACNAM(4),PTH(4),INH(2,3),
3UNITA(2,4),UNITB(3,4)
LOGICAL IFOUT
REAL ITH,ISG
COMMON/HEAC/NUCV(50),NUCG(10),IT(50),RNTD(50),FRVINT(50),
1TPERD,TIPERG,IFCUT
COMMON/UTS/UTSFAC(24),TPT(24),UTSUMH,UTS
COMMON/SPRO/SPNAME(3),PNUC(3),SPNUC(5,3),SPORG(5,3),SPEYP(5,3),
1NSPNUC(3),NSPORG(3)
REAL*8 MUCC,81
COMMON/SPSU/MUCC(50),CLCLAT(4,53),ISPRE(3)
COMMON/O/OFANS(24),NORGAN,NGEN,NTORG
REAL*8 NUCLID,4NUC,5RGANS,3OPG,4CRG,NUCV,NUCG,EFW900,
1TITLE,DATE,IBODY,SPNAME,SPNUC,PNUC,SFORG
INTEGER ZASE,N
COMMON/DHFF/FACTOR(4,80,24,5),NONUC(500),PSIA(300,500),
1UTPTH(50)
COMMON/SDHFF/SPFACT(3,5,3)
REAL*8 CAN,ORG
COMMON/ORG/CAN/ORG(11),CAN(11)
DATA TBODY/8HT 500Y /, EFW900/9EFF W60D/98L/9 /
DATA UNITA/
14H 94HRAD/
24H 94NRISK/
34H 94H /
44H 94HARS /
DATA UNITB/
14H(1) 94NY/M,94H(3)
24H(1) 94NY/M,94H(2)
34H(1) 94H
44H 94H /
DATA FACNAM/4HOCSE,94H LCV,94H LET,94H
14HDOSE,94H HIG,94H LE,94H
24HNRISK,94H LOW,94H LET,94H
34HNRISK,94H HIG,94H LE,94H
44HNRISK,94H EQU,94H LVAL,94HENT
54HLIFE,94H LOS,94H
DATA PTH/4HATR,94HIME,94H IIO,94H
14HNGROU,94HND S,94HURF,94HCE
24HINHA,94HLAT1,94HON
34HINGE,94HSTIO,94H /
C
IF(TIMERQ.NE.50..AND.TIMER3.NE.70.) TIMERQ=76.
DO 10 I3=1,24
TOP(I3)=0
DO 10 I2=1,6
DO 10 I4=1,500
10 FACTOR(I4,I3,I2)=0.0E0
INUMR=0
READ(24) TITLE,DATE,HTFILE,NUC,NORG,(RORG(I),I=1,40RG),
1RORG(1RG,1),I=1,40RG)
WRITE(6,1000) (RORG(I),I=1,40RG)
WRITE(6,1100) (RORG(I),I=1,40RG)
1000 FORMAT(10H ORGANIS IN THE RADPISK FILE ARE : %)
1100 FORMAT(10H GENETIC ORGANS IN THE RADPISK FILE ARE : %)
11X,10(1X,2Y)
11X,10(1X,2Y)
WRITE(6,1150) (CAN(I),ORG(I),I=1,11)
1150 FORMAT(11H THE CANCERS AND CORRESPONDING DOSE ORGANS ARE : %)
11X,11(1X,48)
WRITE(6,1200)
1200 FORMAT(11H)
11X
12=NORGAN
DO 50 I=1,2
IF(I1,6Y,12) GO TO 50
DO 40 J=1,12
IF(ORGAN(I),EQ,EFW900) GO TO 40
DO 20 K=1,40RG
IF(ORGAN(I),EQ,RORG(K)) GO TO 20
20 CONTINUE
WRITE(6,1300) ORGAN(I)
1300 FORMAT(11H ORGAN?,1X,4R)
CALL FROOR
STOP
30 ICP(I)=K
40 CONTINUE
11=NORGAN*NGEN+1
50 I2=NTORG
1TBODY=C
DO 60 K=1,40RG
IF(R-ORG(K),EQ,1TBODY) ITRDY=K
60 CONTINUE
10P(10,ORGAN)=K
IF(NGEN,90,0) GO TO 100
DO 40 J=1,NGEN
DO 70 K=1,40RG
IF(ORGAN(I),EQ,RORG(K)) GO TO 80
70 CONTINUE
WRITE(6,1300) ORGAN(I),RORG(K)
CALL FROOR
STOP
80 ICP(I)=K
90 CONTINUE
100 ICP=0
WRITE(6,1400)
1400 FORMAT(11H SI ABSORPTION FACTORS FOR THE INGESTION FACTORS SELECTED
/ NUCLEID FILE AT 4800)

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```

116 READ(24,ERR=44) RMUC,IZAS,FILE,NIND,((INDRE(I,J),I=1,2),
1J=1,NIND),TSIP,P,((GIRP(I,J),I=1,3),J=1,NGIRP)
DO 126 J=1,NAEVP
IF(IZAS(J).EQ.IZAS) GO TO 140
120 CONTINUE
IF(INUMRR.EQ.AREXP) GO TO 440
DO 136 I=1,NFILE
130 READ(24)
GO TO 118
140 IN=J
INUMRR=INUMRR+1
NUCLID(J)=ZNUC
C
C*** NOW TRY TO FIND GI FACTOR
ING=8.8
IF(NUC(11).EQ.PL) GO TO 166
DO 158 L=1,58
IF(NUC(L).EQ.PL) GO TO 164
IF(NUC(L).EQ.RNUC .AND. GING(L).NE.8.8) ING=GING(L)
150 CONTINUE
160 SW=1.E20
DO 172 K=1,NGIRP
IF(GIRP(K).LT.SA) SW=GIRP(K)
IF(ING.EC.8.8) GO TO 176
DIV=1
IF(ING.NE.8.8) DIV=ING
IF(ABS(ING-GIRP(K))/DIV.LE.1.E-6) GO TO 188
170 CONTINUE
ING=SW
GO TO 190
180 INC=GINGP(K)
190 CONTINUE
WRITE(6,1500) ZASEN(J),NUCLID(J),ING
1500 FORMAT(' *I7.2X,A8,1PE8.2)
C
C BEGIN LOOP OVER ALL INICES AND RECORDS
DO 410 IJ=1,NIND
NREC=INREC(IJ)
DO 400 IF=1,NREC
F=1.0
READ(24) IND,ILET,NTIME,DUM,GIIN,RESPI,SIZEIN
IP=0
IFAC=MOD(IND,10)
IF(IFAC.EC.3 .OR. IFAC.EC.7) IF=1
IF(IFAC.EC.4 .OR. IFAC.EC.8) IF=2
IF(IFAC.EC.1 .OR. IFAC.EC.2) GO TO 200
IF(IFAC.EC.5 .OR. IFAC.EC.6) IF=3
GO TO 210
200 DIV=1
IF(ING.NE.8.8) DIV=ING
IF(ABS(ING-ING)/DIV.GT.1.E-6) GO TO 420
IP=4
210 IF=8
IF(IST.EC.0) GO TO 250
DO 228 IS=1,IST
IF(IJ.EC.NNUC(IST)) GO TO 237
220 CONTINUE
GO TO 249
230 DO 240 IS2=IS,IS
IS2=IS2
IF(IJ.NC.NNUC(IS2)) GO TO 250
IF(IP.EC.IUPTH(IS2).AND.IP.NC.3) GO TO 260
IF(IP.NC.3 .OR. IUPTH(IS2).N.3) GO TO 243
DIV=1
IF(SIZEIN.NE.6.0) DIV=SIZEIN
IF(ABS(SIZEIN-IS2)/DIV.GT.1.E-6) GO TO 240
IF(CLCL(IS2).EQ.FESPI4) GO TO 260
240 CONTINUE
250 IST=IST+1
IUPTH(IST)=IP
NNUC(IST)=IJ
PSIZ(IST)=SIZEIN
CLCL(IST)=RESPI4
IDO=IST
260 IF(IND.GT.10) IF=2
IF(IND.GT.100) IF=4
IF(IND.GT.1000) IF=8
C
C BELOW FOR SCHWYI FACTORS
IF(IFAC.GT.4) GO TO 310
DO 300 IT=1,NTIME
READ(24) TIME,((R(J,II),JJ=1,ILET),II=1,NORG)
IF(IT.EC.4) ILET=1
IF(TIME.NE.TIPRO .AND. NTIME.GT.1) GO TO 300
II=1
I2=NORGAN
IF(ORGAN(NORGAN).EQ.EF80) I2=I2-1
DO 290 I=1,I2
IF(I1.GT.I2) GO TO 290
DO 280 IC=I1,I2
IF(IOP(I1).EQ.0) GO TO 280
DO 280 IL=1,ILET
IF(PIL,ICP(IC).LT.0.3) R(IL,ICP(IC))=0.3E7
IF(I1P(IL).EQ.7) GO TO 270
FACTOR(ICO,IC,IF,IL)=R(IL,ICP(IC))
GO TO 280
270 CONTINUE
IF(FACTOR(ICO,IC,IF,IL).GT.0.0)
FACTOR(ICO,IC,6)=FACTOR(ICO,IC,6)+R(IL,ICP(IC))
FACTOR(ICO,IC,3)=FACTOR(ICO,IC,3)+R(IL,ICP(IC))
FACTOR(ICO,IC,4)=FACTOR(ICO,IC,4)
280 CONTINUE
I1=NORGAN+NGEN+1
I2=I1-1
290 IF(I1.EC.4) GO TO 310
FACTOR(ICO,NORGAN,5)
FACTOR(ICO,NORGAN,6)

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WRITE(6,2600) (SPFACT(I,II,IL),II=1,NSO)
WRITE(6,2700) (SPFACT(I,II,IL),II=1,NSO)
470 CONTINUE
1900 FORMAT(8PATHWAY: ',440)
2000 FORMAT(IX,440,X,10(IP,10,2))
2100 FORMAT(IX,440,X,10(IP,10,2))/(20X,10(IP,10,2))
2200 FORMAT('SPECIAL FACTORS FOR PARENT NUCLIDE: ',AB/
1' PATHWAY: ',440,' DAUGHTER AFFECTED: ',5(2X,AB))
2300 FORMAT('CONVERSION TO SPECIAL UNITS FROM CURIES/M--3: ',
15(IP,10,3))
2400 FORMAT('CONVERSION FACTORS: ',
1' ORGANS: ',13X,5(IX,10,1X))
2500 FORMAT('RISK (PER ULM) ',4',5(IP,10,2))
2600 FORMAT('RISK EQ. (RAD/ULM) ',5(IP,10,2))
2700 FORMAT('LIFE LOSS (Y) ',5X,5(IP,10,2))
RETURN
END
SUBROUTINE HEADIN
COMMON/IOE/INC,ICODE,OPTN(13)
COMMON/LOGCAT/POP(400),X(400),Y(400),XC(400),YC(400),PERRF(400),
IPERRN(400),PERU(400),XREF,YREF,NLOC,POPT
COMMON/D/DIR(16),IX,IY,GRDOPT
INTEGER GRDOPT
COMMON/SUMR/IFREL,IFFGS,INOATR,DEFGS
DOUBLE PRECISION OUTIO(13)
LOGICAL OPTNS,SLIOF,IFREL
COMMON/TITL/TITLE(20),SBTITL(6,3),IPTOGK
COMMON/LLOC/LLOC,SLIOF
DIMENSION CAT(2)
DATA OUTIO/ENTERMT ,BMLINEAR ,BMTNAY ,BMCVARE ,
1BNDVASH ,BNCLEADA ,BNSUTIT ,BNSFASDEP ,
2BNDVPCAL ,BNSROUGH ,BNCOSMT ,BNSAREA ,
3BNSRESUP ,
C
CALL TODAY(DATE)
WRITE(6,1500)TITLE,DATE
IF(INC.EQ.1) WRITE(6,1000)
IF(INC.EQ.2) WRITE(6,1200)
1000 FORMAT('SELECTED INDIVIDUAL')
1100 FORMAT('COLLECTIVE POPULATION')
1200 FORMAT('MEAN INDIVIDUAL')
IF(INC.NE.3.AND.(GRDOPT.EQ.2.OR.GRDOPT.EQ.4)) WRITE(6,1300)
1 X(ILOC),Y(ILOC)
IF(INC.NE.3.AND.(GRDOPT.EQ.1.OR.GRDOPT.EQ.3)) WRITE(6,1400)
1 X(ILOC),DIR(1+(ILOC-1)/IX)
1300 FORMAT('LOCATION',2(F11.2,' M'))
1400 FORMAT('LOCATION',F11.2,' M ',A4)
IF(INC.EQ.3) WRITE(6,1100)
IF(ICODE.EQ.1) GO TO 50
IF(IPTOGK.EQ.1) WRITE(6,1600)
IF(IPTOGK.EQ.2) WRITE(6,1700)
IF(IFREL) WRITE(6,1700)
IF(.NOT. IFREL) WRITE(6,1800)
ICNT=0
DO 40 IO=1,12
IF(.NOT. OPTNS(IO)) GO TO 40
ICNT=ICNT+1
IF(ICNT.GT.3) ICNT=1
GO TO (16,20,35),ICNT
10 WRITE(6,2000) OUTIO(IO)
GO TO 40
20 WRITE(6,2100) OUTIO(IO)
GO TO 40
30 WRITE(6,2200) OUTIO(IO)
GO TO 40
40 CONTINUE
IF(ICODE.EQ.3) WRITE(6,2300)
RETURN
50 WRITE(6,2400)
RETURN
1500 FORMAT('1/35X,2044,5X,244)
1600 FORMAT(10X,'ANEMOS POINT (UM)')
1700 FORMAT(10X,'FOR RELEASED NUCLIDES, OPTIONS:')
1800 FORMAT(10X,'FOR EXPOSURE NUCLIDES, OPTIONS:')
1900 FORMAT(10X,'ANEMOS AVERAGE (UM)')
2000 FORMAT(10X,A6)
2100 FORMAT('...',10X,A6)
2200 FORMAT('...',11X,A6)
2300 FORMAT(10X,'SUMIT WAS RUN FOLLOWING ANEMOS')
2400 FORMAT(10X,'READD RUN')
END
SUBROUTINE INDIV(NNUC,NRNG,NORG,IFAC,NFAC,
1PTM,NPTH,VALUE,IFR)
C*** THIS SUBROUTINE CALCULATES FACTORS IFAC FOR NUCLIDES NNUC.
C*** ORGANS NRNG, AND PATHWAYS PTH FOR AN INDIVIDUAL.
C*** THE RESULTS ARE STORED IN THE ARRAY VALUE.
C*** NNUC IS THE NUMBER OF NUCLIDES IN NRNG.
C*** NORG IS THE NUMBER OF ORGANS IN NRNG.
C*** NFAC IS THE NUMBER OF FACTORS IN IFAC.
C*** NPTH IS THE NUMBER OF PATHWAYS IN PTH.
C*** IF ANY OF THE VALUES ARE 0, THEN A SUM IS REQUESTED.
COMMON/ARRAY(50,20,6)
REAL NRNG,NNUC
INTEGER PTH
DIMENSION VALUE(1),NNUC(1),NRNG(1),
1IFAC(1),PTM(1),NPTH(1),IFR(1),IF(2,1),SF(1)
C*** WT IS WEIGHTED SUMS FOR IT SUM DOSE CALC
COMMON/TORG/UTR(2,2)
C*** ILOC IS THE LOCATION FOR THE SELECTED INDIVIDUAL.
COMMON/LLOC/LLOC,SLIOF
COMMON/LOGCAT/LOGCAT,JLOC
LOGICAL LOGTAB
CC
IFR=0
LOC=ILOC
IF (LOC=0) LOC=JLOC
CALL MATCH(NNUC,NNUC,2,14,IFR)

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REAL*8 SUCC
COMMON/SPSU/RUCC(50),CLCLAS(4,50),ISPRS(3)
COMMON/IFAC/IFUR,U(6),FACIN(2,3,6),IFUP,
ISITING,IFRAC,ISCF,AC,IPRINT
COMMON/SUCC/ISREL,FFG,INDOIN,DEFGSF
COMMON/IS/ISFAC(24),IPIN(24),WISMR,NUTS
COMMON/ILLOC/ILOC,SLIDE
REAL*8 BI
DATA AVERAGE/DAVERAGE /,ALL/ALL/
DATA EF1000/EF1000,AVETST/.FALSE./,BL//
DATA DUNIT/DR NER,ENDOST,INYSOID,FOREAST,POUL,
PS WALL,INY WALL,LIVER,PARENEAS,KIDNEYS,
OTHER,9//
CALL IOST(101,02)
WRITE(6,1000)DI,02
1000 FORMAT(' INDOIN - DOSE AND HEALTH RISK COMPUTATIONS FOR ')
1010 THE CRIS',10X,24X)
1020
1030
1040
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1070
1080
1090
1100
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2800
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2820
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2900
2910
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2950
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2970
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2990
3000
3010
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3070
3080
3090
3100
3110
3120
3130
 

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Figure 1

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3500 FORMAT(' COMPUTATIONS ARE DONE FOR AN INDIVIDUAL')
IF(I.FREL) WRITE(6,1400)
IF(.NOT. I.FREL) WRITE(6,1500)
IF(I.FOUT) WRITE(6,3600)
3600 FORMAT(' THE FACTORS FROM THE RADRISK DATA BASE WILL BE PRINTED')
IF(.NOT. I.FOUT) WRITE(6,3700)
3700 FORMAT(' THE FACTORS FROM THE RADRISK DATA BASE WILL NOT BE ')
1 *PRINTED*)
IF(I.EFFG) WRITE(6,3800)
3800 FORMAT(' THE EFFECTIVE GROUND SURFACE CONCENTRATION FROM HL SOIL ')
1 * WILL BE USED, IF AVAILABLE, FOR GROUND EXPOSURE')
IF(.NOT. I.EFFG) WRITE(6,3900)
3900 FORMAT(' THE GROUND SURFACE CONCENTRATION FROM TERRA ')
1 * WILL BE USED FOR GROUND EXPOSURE')
IF(I.INOAIR.EG.1) WRITE(6,4000)
4000 FORMAT(' THE EFFECTIVE AIR CONCENTRATION FROM ANEMOS WILL NOT BE ')
1 * USED FOR IMMERSION EXPOSURE')
IF(I.INOAIR.EG.2) WRITE(6,4100)
4100 FORMAT(' THE EFFECTIVE AIR CONCENTRATION, IF AVAILABLE, WILL BE ')
1 * USED FOR OUTDOOR IMMERSION EXPOSURE CALCULATIONS ONLY')
IF(I.INOAIR.EG.3) WRITE(6,4200)
4200 FORMAT(' THE EFFECTIVE AIR CONCENTRATION, IF AVAILABLE, WILL BE ')
1 * USED FOR ALL IMMERSION EXPOSURE CALCULATIONS')
IF(I.PRINT) WRITE(6,4300)
4300 FORMAT(' INTAKE RATES WILL BE PRINTED')
IF(.NOT. I.PRINT) WRITE(6,4400)
4400 FORMAT(' INTAKE RATES WILL NOT BE PRINTED')
IF(I.FAST) WRITE(6,4500)
4500 FORMAT(' READ SITE / ILE SAVED FROM TERRA')
IF(.NOT. I.FAST) WRITE(6,4600)
4600 FORMAT(' READ THE SITE DATA BASE DIRECTLY')
C... DEFAULTS
DO 210 I=1,3
ISPRES(I)=0
210 CONTINUE
READ(5,SPCONS)
DO 220 I=1,3
IF(ISPRES(I).EQ.0) GO TO 220
WRITE(6,4700) SPNUC(I),PNUC(I),PTHTIL(ISPRES(I))
NSP=NSPNUC(I)
WRITE(6,4800) (SPNUC(INS,I),INS=1,NSP)
NSP=NSPNUC(I)
WRITE(6,5000) (SPFXP(INS,I),INS=1,NSP)
NS=NSPORG(I)
WRITE(6,4900) NSP,(SPORG(INS,I),INS=1,NSP)
220 CONTINUE
4700 FORMAT(' THE FOLLOWING SPECIAL EXPOSURE UNITS WILL BE CALCULATED:')
2 / * SPECIAL UNIT NAME = 'A8,' PARENT NUCLEIDE = 'A8,
2 * PATHWAY = 'A8)
4800 FORMAT(' THERE WILL BE 'I2,' ORGANS AFFECTED:'5(2X,A8))
4900 FORMAT(' THE DAUGHTER NUCLEIDES AFFECTED ARE : '5(2X,A8))
5000 FORMAT(' CONVERSION FACTOR (UL/(CI/M*3)) ARE : '12X,IP5E10.3/
- * 1.0 UL = 31.4 ULM/Y')
C... DEFAULTS
ILOC=0
SLIDF=.TRUE.
READ(5,ILOC)
IF(ILOC.NE.0) SLIDF=.FALSE.
IF(I.NOMI.AND.SLIDF) WRITE(6,5100)
IF(I.NOMI.AND..NOT.SLIDF) WRITE(6,5200) ILOC
5100 FORMAT(' SELECTED INDIVIDUAL WILL BE FOR THE LOCATION',
1 * HAVING THE HIGHEST TOTAL RISK.')
5200 FORMAT(' SELECTED INDIVIDUAL WILL BE LOCATION AT GRID NO. ',I5)
RETURN
END
SUBROUTINE INTEGA(C1,C2,R1,R2,DIV,DELR,AVG)
IF(C1.LE.1.E-20 .OR. C2.LE.1.E-20) GO TO 30
B=ALOG(C2/C1)/DIV
IF(AE*(H).GT.15.0) GO TO 30
IF(AE*(3+2.*R2).GT.17.4) GO TO 30
A=C2/(EXP(B*R2))
IF(ABS(B*.2).LE.1.E-6) GO TO 10
AVG=2.*A*(EXP((3+2.*R2)-EXP((B+2.*R1)))/(B+2.))*DELR
GO TO 20
10 AVG=2.*A*(ALOG(R2)-ALOG(R1))*DELR
20 RETURN
30 AVG=.5*(C1+C2)
RETURN
END
SUBROUTINE INVERT(G,III)
DIMENSION A(50,50),B(50,50)
C
DO 41 I=1,III
DO 40 J=1,III
A(I,J)=B(I,J)
40 B(I,J)=0.
41 B(I,I)=1.
KK=III
KK=KK-1
DO 90 I=1,KK
S=0.
DO 10 J=KK
R=S*(A(I,J))
IF(R.LE.0) GO TO 10
S=R
L=J
CONTINUE
IF(L.EQ.I) GO TO 50
DO 20 J=I,KK
S=A(I,J)
A(I,J)=A(L,J)
20 A(L,J)=S
DO 30 J=1,KK
S=B(I,J)
B(I,J)=B(L,J)
30 B(L,J)=S
IF(A(I,I).EQ.0.) GO TO 90

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      IPO=1+1
      DO 80 J=IPO,KK
        IF (A(J,I).EQ.0.) GO TO 88
        S=A(J,I)/A(I,I)
        A(J,I)=0
        DO 60 K=IPO,KK
          A(J,K)=A(J,K)-A(I,K)*S
        DO 70 K=1,KK
          B(J,K)=B(J,K)-B(I,K)*S
        CONTINUE
      CONTINUE
      KMO = KK-1
      DO 120 K=1,KK
        R(K,K)=B(K,K)/A(K,K)
        DO 120 I=1,KMO
          R(K,I)=B(K,I)/A(K,K)
        DO 110 J=N,KMO
          B(N,K)=B(N,K)-A(N,J+1)*B(J+1,K)
          B(N,K)=B(N,K)/A(N,N)
        RETURN
      END
      SUBROUTINE IFCORREST,CPAK,NRNUCS,NREXP,XIO,CONCU,IC,JC,
      NPACK)
      DIMENSION ST(50,50),CPAK(1),XIO(1),CONCU(50,50),XN(50,50),
      IC(100),JC(100)
      DO 10 K=1,NRNUCS
        DO 10 J=1,NREXP
          CONCU(J,K)=0
          DO 20 I=1,NPACK
            CONCU(J,I)=CPAK(I)
          DO 30 I=1,NRNUCS
            DO 30 J=1,NREXP
              XN(I,J)=XIO(I)*CONCU(J,I)
            CONTINUE
          DO 40 I=1,NRNUCS
            DO 40 J=1,NREXP
              CONCU(J,I)=0
            DO 50 IADD=1,NREXP
              CONCU(J,I)=CONCU(J,I)+ST(IADD,J)*XN(IADD,I)
            CONTINUE
          CONCU(J,I)=CONCU(J,I)
        CONTINUE
      RETURN
      END
      SUBROUTINE LOCATE(INDX,IFAC,IC,NREXP)
      DIMENSION INDX(NREXP),IC(1)
      COMMON/DRHR/FACTOR(500,24,6),NONUC(500),PSIZ(500),CLCL(500),
      IUPTH(500)
      DO 60 IE=1,NREXP
        DO 10 I=1,500
          IF (NONUC(I).EQ.IE) GO TO 20
        CONTINUE
        INDX(IE)=0
        GO TO 60
      DO 30 J=1,500
        IF (IUPTH(J).EQ.IFAC) GO TO 51
        IF (NONUC(J).NE.IE) GO TO 40
      CONTINUE
      INDX(IE)=J
      GO TO 60
      INDX(IE)=J
    CONTINUE
    RETURN
  END
  SUBROUTINE LOCAT2(INDX,PSIZE,CLCLS,IC,NPACK)
  LOGICAL MATCH
  COMMON/DRHR/FACTOR(500,24,6),NONUC(500),PSIZ(500),CLCL(500),
  IUPTH(500)
  DIMENSION INDX(4,NPACK),CLCLS(4,1),PSIZE(1),ACL(4),
  IDIFF(20),MATCH(4,20),IC(1),NOP(20)
  DATA ACL/'0','0','0','0',/'Y','Y','Y','Y'/
  DO 10 I=1,NPACK
    DO 10 II=1,4
      INDX(II,I)=0
    CONTINUE
    DO 140 IN=1,NPACK
      IE=IC(IN)
      NOS=0
      DO 20 I=1,500
        IF (NONUC(I).EQ.IE) GO TO 40
      CONTINUE
      DO 30 K=1,4
        INDX(K,I)=0
      GO TO 140
    CONTINUE
    DO 60 J=1,500
      IF (NONUC(J).NE.IE) GO TO 91
      IF (IUPTH(J).NE.3) GO TO 60
      NOS=NOS+1
      DIFF(NOS)=ABS(PSIZ(J)-PSIZ(IN))
      NOP(NOS)=J
      DO 50 K=1,4
        FIT(K,I,NOS)=FIT(K,I)
      IF (CLCL(J,I).EQ.0.) GO TO 50
      IF (CLCL(J,I).EQ.ACL(K)) MATCH(K,NOS)=.TRUE.
    CONTINUE
    CONTINUE
    DO 80 K=1,4
      INDX(K,I)=0
    GO TO 140
  40 IF (NOS.EQ.0) GO TO 70

```

C PRIMARY POPULATION SECTION.
200 CALL HISTORY
IF GROUND T. OF 1. AND GROUND T. OF 5. 500 TO 210
WHITE (6, 1000)

[illegible]

[illegible]

[illegible]

```

DC 2.3 ICRG=1.0, ICRG
DO 241 IFAC=1.5
ARRAY(1,1) ICRG, IFAC=1.5, ICRG, IFAC
IFAC=1.5, ICRG, IFAC=1.5, ICRG, IFAC
228 CONTINUE
295 DO 303 ICRG=1.0, ICRG
ICR=ICR(1,1)
NY=INDX(1,1)
IF(NY,1.0) GO TO 310
DO 300 ICRG=1.0, ICRG
DO 295 IFAC=1.5
295 ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
300 CONTINUE
ICR=1
GO TO 325
310 IF(IACR,1.0,0.0) GO TO 330
DO 320 ICRG=1.0, ICRG
ICR=ICR(1,1)
JN=JC(1,1)
NY=INDX(1,1)
IF(NY,1.0) GO TO 323
DO 320 ICRG=1.0, ICRG
DO 320 ICRG=1.0, ICRG
DO 320 ICRG=1.0, ICRG
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
IFAC=1.5, ICRG, IFAC=1.5, ICRG, IFAC
320 CONTINUE
330 DO 340 ICRG=1.0, ICRG
NY=INDX(1,1)
JN=JC(1,1)
IF(NY,1.0) GO TO 340
DO 340 ICRG=1.0, ICRG
DO 335 IFAC=1.5
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
340 CONTINUE
ICR=1
GO TO 370
350 CONTINUE
CALL LOCAT(INDX,2,ICR,IFAC)
C... THESE ARE GROUND SURFACE CONCENTRATIONS
IF(IFRPL) GO TO 370
DO 360 ICRG=1.0, ICRG
ICR=ICR(1,1)
NY=INDX(1,1)
IF(NY,1.0) GO TO 367
DO 360 ICRG=1.0, ICRG
DO 355 IFAC=1.5
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
360 CONTINUE
ICR=2
GO TO 370
370 DO 380 ICRG=1.0, ICRG
NY=INDX(1,1)
JN=JC(1,1)
IF(NY,1.0) GO TO 387
DO 380 ICRG=1.0, ICRG
DO 375 IFAC=1.5
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
380 CONTINUE
ICR=2
GO TO 370
390 ICR=99
DO 400 IF=1.5
DO 400 IF=1.5
DO 400 IF=1.5
400 ARRAY(1,1) IF=1.5, IF=1.5
CALL LOCAT(INDX,2,IF,ICR)
C... THESE ARE INHALATION CONCENTRATIONS
IF(IFRPL) GO TO 440
IF(IACR,1.0,0.0) GO TO 470
DO 410 ICRG=1.0, ICRG
ICR=ICR(1,1)
JN=JC(1,1)
DO 410 ICRG=1.0, ICRG
NY=INDX(1,1)
IF(NY,1.0) GO TO 411
DO 410 ICRG=1.0, ICRG
DO 405 IFAC=1.5
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
405 CONTINUE
DO 430 ICRG=1.0, ICRG
ICR=ICR(1,1)
DO 430 ICRG=1.0, ICRG
DO 430 ICRG=1.0, ICRG
DO 430 ICRG=1.0, ICRG
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
200 CONTINUE
ARRAY(1,1) ICRG, IFAC=ARRAY(1,1) ICRG, IFAC
430 CONTINUE
ICR=1
GO TO 470

```

```

448 IF (FRACIN.EQ.0.) GO TO 460
DO 450 IN=1,NPACK
JNUC=JC(IN)
DO 458 IP=1,4
N=INDEX(IP,IN)
IF (NY.EQ.0) GO TO 458
DO 458 IORG=1,NTORG
DO 445 IFAC=1,5
445 ARRAY(JNUC,IOIG,IFAC)=ARRAY(JNUC,IOIG,IFAC)+
IFRACIN*CONC(CIC(IN),JNUC)*FACTOR(NY,IOIG,IFAC)*UBR*CLCLS(IP, I)
ARRAY(JNUC,IOIG,6)=ARRAY(JNUC,IOIG,6)+
1*FACTOR(NY,IOIG,6)*CLCLS(IP,IN)
458 CONTINUE
DO 470 IP=1,NPACK
JN=JC(INUC)
DO 478 IP=1,4
NY=INDEX(IP,INUC)
IF (NY.EQ.0) GO TO 478
DO 478 IORG=1,NTORG
DO 478 IFAC=1,5
ARRAY(JN,IOIG,IFAC)=ARRAY(JN,IOIG,IFAC)+
1*1-IFRACIN*CONC(INUC)*FACTOR(NY,IOIG,IFAC)*UBR*CLCLS(IP,INUC)
478 CONTINUE
IPTH=3
GO TO 520
480 IF (IND.GE.10) GO TO 630
C
C... THESE ARE INGESTION CALCULATIONS
CALL LOCATE(INDX,4,IC,NREXP,
IF (SITIM(IND-3).GT.0.) CALL STOCY(SITIM(IND-3),JC,IC,NRNUCS,
INREXP,NPACK,CONC)
IF (IFREL) GO TO 580
DO 490 INUC=1,NPACK
NC=IC(INUC)
NX=INDEX(NC)
IF (NX.EQ.0) GO TO 493
DO 493 IORG=1,NTORG
DO 485 IFAC=1,5
485 ARRAY(NC,IOIG,IFAC)=ARRAY(NC,IOIG,IFAC)+
2*CONC(INUC)*FACTOR(NX,IOIG,IFAC)
ARRAY(NC,IOIG,6)=ARRAY(NC,IOIG,6)+FACTOR(NX,IOIG,6)
490 CONTINUE
IPTH=IND
GO TO 520
500 DO 510 INUC=1,NPACK
NX=INDEX(IC(INUC))
JN=JC(INUC)
IF (NX.EQ.0) GO TO 510
DO 510 IORG=1,NTORG
DO 505 IFAC=1,5
505 ARRAY(JN,IOIG,IFAC)=ARRAY(JN,IOIG,IFAC)+
2*CONC(INUC)*FACTOR(NX,IOIG,IFAC)
ARRAY(JN,IOIG,6)=ARRAY(JN,IOIG,6)+FACTOR(NX,IOIG,6)
510 CONTINUE
IPTH=IND
C
C SPECIAL UNIT COMPUTATIONS
520 DO 530 IP=1,5
IF (ISPRG(1),NE.IPTH) GO TO 590
NRSP=NSPNUC(1)
DO 530 IP=1,NRSP
DO 530 J=1,NPACK
IF (NUCLL(CIC(J)),NE.SPNUC(K,I)) GO TO 530
IF (NUCLL(JC(J)),EQ.PNUC(I)) GO TO 540
530 CONTINUE
GO TO 540
540 NOGSP=NSPORG(I)
DO 570 IOG=1,NOGSP
IF (SPORG(IOG,1).EQ.TCONV) SPORG(IOG,1)=E*UBOD
SORG=SPORG(IOG,1)
DO 550 IO=1,NTORG
IF (OR(ANS(10),EQ.IOIG,6) GO TO 560
550 CONTINUE
GO TO 570
560 NI=NUCLL(I)
ARRAY(NI,IO,1)=ARRAY(NI,IO,1)+CONC(J)*SPEXP(K,I)*31.4
RISK=CONC(J)*SPEXP(K,I)*SPFACT(1,IOG,1)*31.4
IF (RISK*ARRAY(NI,IO,3).NE.0.)
- ARRAY(NI,IO,6)=ARRAY(NI,IO,6)+ARRAY(NI,IO,3)*
- SPFACT(1,IOG,1)*RISK / (RISK+ARRAY(NI,IO,3))
- ARRAY(NI,IO,5)=ARRAY(NI,IO,5)+CONC(J)*SPEXP(K,I)*SPFACT(2,IOG,1)*
- 31.4
ARRAY(NI,IO,3)=ARRAY(NI,IO,3)+RISK
570 CONTINUE
580 CONTINUE
590 CONTINUE
C
CALL UTSUM(ARRAY)
IF (IPTH.NE.2) GO TO 610
DO 600 IP=1,5
DO 600 IC=1,NTORG
DO 600 IN=1,NNUCLY
ARRAY(IN,IO,IF)=GSCFAC*ARRAY(IN,IO,IF)
600 CONTINUE
610 CONTINUE
INRD=IPTH*(LOC-1)+1
C... SUM OVER PARTICLE SIZES
READ(30,INRD) ARRAH
DO 620 IP=1,6
DO 620 IO=1,NTORG
DO 620 N=1,NUCLTY
620 ARRAH(IN,IO,IF)=ARRAH(IN,IO,IF)+ARRAY(IN,IO,IF)
WRITE(30,INRD) ARRAH
IF (OR(UG.NUITE(AG,2500),LOC,IPTH,((ARRAY(IN,IO,IF),
IN=1,NUCLTY),IO=1,NTORG),IF=1,6)
2500 FORMAT( ' ARRAY FOR LOCATION ',I5,' PATHWAY ',I5/

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1110E12.5))
IF(IND.EG.1) GO TO 333
638 CONTINUE
648 CONTINUE
DEBUG=.FALSE.
CALL SETFIL(IPTOGR,INDM1)
RETURN
END
SUBROUTINE SETCG(IDELR,NR1,NR2,DIV,IOPY,INDM1)
DIMENSION IDELR(1),NR1(1),NR2(1),DIV(1)
LOGICAL INDR1
COMMON/LOCAT/POP(488),X(488),Y(488),XC(488),YC(488),
IPERRF(488),PERF(488),PERU(488),XREF,YREF,NLOC,POPT
COMMON/SHR3/ARR(58,24,6),ARRAP(58,24,6),FIUP(488),
IPROD(488),INRT(3,488),DUM1(488),DUM2(488),DUM3(488),
DUM4(488)
C
IOPY=2
POPT=0.
NR1=ALOG(X(1))
NLOC=0
CALL DATABC(XREF,YREF,X(1),XC(1),Y(1),YC(1),POP(1),
IPROD(1),IPERRF(1),PERF(1),PERU(1),IPTOGR,ILOC)
JLOC=1
IF(ILOC.EG.1) GO TO 48
DO 30 ILOC=2,NLOC
CALL DATABC(XREF,YREF,X(ILOC),XC(ILOC),Y(ILOC),YC(ILOC),
IPROD(ILOC),IPERRF(ILOC),PERF(ILOC),PERU(ILOC),IPTOGR,ILOC)
2IPTOGR,ILOC)
N2=ALOG(X(ILOC))
IDELR(ILOC)=0
IF(ABS(Y(ILOC)-Y(JLOC)).GT.1.E-6) GO TO 28
IF(ABS(X(ILOC)-X(JLOC)).GT.1.E-6) GO TO 28
DIV(ILOC)=1./(N2-N1)
IDELR(ILOC)=ILOC
NR1(ILOC)=NR1
NR2(ILOC)=NR2
IF(INDM1.EG.1) GO TO 23
POPT=POPT+POP(ILOC)
NLOC=NLOC+1
POP(INLOC)=POP(ILOC)
DO 10 J=1,6
10 PROD(J,NLOC)=PROD(J,ILOC)
PERF(INLOC)=PERF(ILOC)
PERRN(INLOC)=PERRN(ILOC)
PERU(INLOC)=PERU(ILOC)
28 JLOC=ILOC
N2=NR1
38 CONTINUE
48 IF(INDM1) RETURN
NLOC=NLOC
RETURN
END
SUBROUTINE SETFIL(IPTOGR,INDM1)
COMMON/SHR3/ARR(58,24,6),ARRAP(58,24,6),FIUP(488),
IPROD(488),INRT(3,488),IDELR(488),NR1(488),NR2(488),
2DIV(488)
COMMON/IONE/INL,ILOC,OPTM(12)
COMMON/D/DIR(16),IX,IY,GRDOPT
DIMENSION TA(488),FROUT(488),F2OUT(488)
FCUT=VAFACE(IDELR(1),ILOC(1,1))
NEA=INRT
COMMON/ALLLOC/JLOC,SLICF
COMMON/1/PRAY(58,24,6)
COMMON/2/GPGANS(24),CGORGAN,NGEN,NT
COMMON/4/NUCLIC(58),NNUCLY,NNUCLT,NUCXT
COMMON/5/PTHIL(9)
COMMON/UT/AC/UST,UI6,FRACTN(2,3,6),IFUP,
1SETTIN(6),FRACIN,G3CFAC,IPRINT
REAL*8 ORGANS,NUCLID,STHTIL
INTEGER GRDOPT
LOGICAL DEBUG,INDM1,SLICF,IPRINT
COMMON/LOCAT/POP(488),X(488),Y(488),XC(488),YC(488),IPERRF(488),
IPERRN(488),PERU(488),XREF,YREF,NLOC,POPT
DATA DEBUG/.FALSE./
C
NTORG=NGEN+NGEN
CALL SETHDX(Y,NLOC)
IF(IPTOGR.NE.2) GO TO 18
SETVAL IS THE ROUTINE TO CALL TO SIMPLY GET THE AVERAGE
VALUES OVER EACH CELL FOR ALL DATABASE PARAMETERS
CALL SETVAL(GRDOPT,IOPY,IPTOGR)
INC=3
IF(INDM1)INC=2
GO TO 21
C*** SETCG TAKES A CIRCULAR GRID AND USES AN INTEGRAL AVERAGE
C*** TO GET AVERAGE VALUES OVER A CELL
C*** SETCG TAKES A RECTANGULAR GRID AND USES THE FOUR CORNERS TO
C*** CALCULATE AN AVERAGE OVER THE CELL
18 IF(IGRDOPT.EQ.1,OP,GRDOPT.F1.3) CALL SETCG(IDELR,NR1,NR2,
I DIV,IOPY,INDM1)
IF(IGRDOPT.EQ.2,OR,GRDOPT.E1.4) CALL SETRGETA(IOPY,INDM1)
INC=1
IF(.NOT.INDM1)INC=3
IF(.NOT.INDM1,AND.I(,NE.1) IX=IX-1
C
INC=1 FOR SELECTED INDIVIDUAL, 2 FOR MEAN INDIVIDUAL, AND 3 FOR POPUL
C
21 DO 320 JP=1,9
30 30 IF=1,6
DO 30 IO=1,NTORG
DO 30 IY=1,NUCLYT
AP=API(IY,IO,IF)=0.0F C
30 CONTINUE
IYVL=0.0
IYED=0.0

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330 IF=1.5
 
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LT. 100-5160 TO 20

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IP=1
IA=IA+1
GO TO 88
22) CONTINUE
CALL SURRCIY,NHSUN,NHJRG,NFAC,NMPTH,VALUE,ROWS,ROWL,IFAC,NNUC,
      *NORG,NPTH)
CALL SURRCIX,NHSUN,NHJRG,NFAC,NMPTH,VALUE,COLS,COLU,IFAC,NNUC,
      *NORG,NPTH)
RETURN
END
SUBROUTINE SETVALIGRODT,IPDT,IPDOGR)
INTEGER GRODT
COMMON/LOCAT/POP(400),X(400),Y(400),XC(400),YC(400),
COMMON/LOCAT/POP(400),X(400),Y(400),XC(400),YC(400),
IPERR(400),PCARR(400),PERUT(400),XREF,YREF,NLOC,POPT,
COMMON/SHRD/ARRA(50,24,6),ARRAF(50,24,6),FIFUP(400),
IPROD(1,400),INRT(3,400),IDELR(400),R1(400),R2(400),
ZOUN(400)

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CC      TPUT=1
      POPT=0
      DO 10 I=1,NLOC
      IF (POPT.EQ.2.OR..POPT.EQ.4) CALL DATARC(XC(ILOC),Y(ILOC),
      1 XC(ILOC),YC(ILOC),P(ILOC),PRD(ILOC),PERR(ILOC),
      2 PERR(ILOC),PERU(ILOC),IPIDGR,ILOC,NLOC)
      IF (POPT.EQ.1.OR..POPT.EQ.3) CALL DATARC(KREF,YREF,
      1 XC(ILOC),XC(ILOC),P(ILOC),PRD(ILOC),PERR(ILOC),
      2 YC(ILOC),YC(ILOC),P(ILOC),PRD(ILOC),PERR(ILOC),
      3 PERR(ILOC),PERU(ILOC),IPIDGR,ILOC)
      POPT=POPT+POPI(ILOC)
10 CONTINUE
      RETURN
      END
      SUBROUTINE SORTIRF4,NCR,NM1
      ... WITH THE ELEMENTS OF NOX CONTAINING THE
      ... TO THE ORDER OF THE

```

```

RETURN
END
SUBROUTINE SORT1(R4,NDX,N)
  SORT1: RETURNS WITH THE ELEMENTS OF NDX CONTAINING THE ORDER.
  N SUBSCRIPTS OF R4 ORDERED ACCORDING TO THE DESCENDING SORT.
  I.E. R4(NDX(I)) IS THE I-TH STRING IN THE ORDER OF THE SORT.
  NDX IS INITIALISED PRIOR TO SORTING
  THE ELEMENT OF NDX AK, THEN PERMUTED USING A SHELL SORT
  ALGORITHM TO GENERATE A SORT INDEX FOR THE ARRAY R4.
  DIMENSION NDX(N),R4(N)
  DO I=1,N
  10 NDX(I)=1

```

```

C
N=N
C... SORT IS COMPLETED WHEN N=1.
20 IF (N.EQ.1) GO TO 30
N=(N+1)/2
C... PERFORM L=N-M FORWARD COMPARES AT SPACING M.
L=N-M
DO 40 K=1,L
C... BUBBLE BACKWARDS THROUGH NDX M ENTRIES APART.
DO 30 J=1,K,N
I=NDX(K-J+1)
IM=NDX(K-J+1+M)
C... STOP ANY BUBBLING WHEN ENTRIES ARE ALREADY ORDERED.
IF(R4(IM).LE.R4(I)) GO TO 40
C... SWAP THE CURRENT PAIR OF NDX ENTRIES.
NDX(K-J+1)=I
NDX(K-J+1+M)=I
30 CONTINUE
C... BACKWARD BUBBLE COMPLETED.
40 CONTINUE
C... ENTRIES AT SPACING M ARE SORTED.
GO TO 20
C... SORT IS COMPLETED
50 RETURN
END
SUBROUTINE SYOCY(SITIM,JC,IC,NIR,NIE,NPACK,CPAK)
DIMENSION JC(1),IC(1),CPAK(1),REPLAN(500),CRATE(1),STORE(1)
LOGICAL DEBUC
COMMON/IMECM/SIT,ICTYP,ISTYP,IMULT,IDIAG,NP,IME,NCONC.
INPUT,NRCL,NEXP,KTYPE,IKEEP
DATA DEBUC/,FALSE/,ITIMES/0/
C
NREL=NIR
NEXP=NIE
DO 10 I=1,NEXP
10 REPLAN(I)=0.0
SIT=SITIM
CALL DECAI(NPACK,IND,CPAK,REPLAN,CRATE,STORE,
IIC,JC,CPAK)
IF(DEBUC.AND.ITIMES.LT.12)WRITE(6,1006)(CPAK(I),I=1,NPACK),SITIM
1000 FORMAT(1X,8F12.3)
ITIMES=ITIMES+1
RETURN
END
SUBROUTINE SUMRC(IN,NNUC,NORG,NFAC,NPTH,VALUE,ARRAY,WR,IFAC,NM,
- (3,NP)
LOGICAL WR
DIMENSION VALUE(NM,3,NFAC,NP),ARRAY(50,1)
WR(1),IFAC(1)
C
DO 1 IF=1,NFAC
WR(IF)=.TRUE.
DO 10 K=1,50
10 ARRAY(K,IF)=0.0
DO 20 IF=1,NFAC
IF(IFAC(IF).LE.2.OR.IFAC(IF).EQ.7.OR.IFAC(IF).EQ.6)WR(IF)=.FALSE.
DO 30 IP=1,NPTH
DO 30 IO=1,NORG
DO 30 IN=1,NNUC
ARRAY(IN,IF)=ARRAY(IN,IO,IF,IP)
30 CONTINUE
RETURN
40 DO 50 IF=1,NFAC
IF(IFAC(IF).EQ.6) WR(IF)=.FALSE.
DO 50 IP=1,NPTH
DO 50 IO=1,NORG
DO 50 IN=1,NNUC
ARRAY(IO,IF)=ARRAY(IO,IF)+VALUE(IN,IO,IF,IP)
50 CONTINUE
RETURN
60 DO 70 IF=1,NFAC
IF(IFAC(IF).LE.2.OR.IFAC(IF).EQ.7.OR.IFAC(IF).EQ.6)WR(IF)=.FALSE.
DO 70 IP=1,NPTH
DO 70 IO=1,NORG
DO 70 IN=1,NNUC
ARRAY(IP,IF)=ARRAY(IP,IF)+VALUE(IN,IO,IF,IP)
70 CONTINUE
RETURN
END
SUBROUTINE SUMRY
IZUTL=1: SUBTITLE IS SELECTED INDIVIDUAL
2: MEAN INDIVIDUAL
3: COLLECTIVE POPULATION
IHRND=1: HORIZONTAL HEADING IS ORGN
2: PATHWAY
3: NUCLIDES
REAL*8 SHMD(50),RPTH(5),SFNAME,PNUC,SPORG,SPNUC,
IORGANS,NUCLIO,TOTAL,SUMG,TOTNUC,OTHER,WLMD,PHTITL
INTEGER PTHY
COMMON/ITL/TITLE(20),SDTTL(6,5),IPTOGR
COMMON/P/PHTITL(15)
COMMON/TC/PERORG,PERPTH,PERNUC
COMMON/C/ORGANS(24),NORGAN,NGEN,NT
COMMON/N/NUCLIO(50),ANUCL1,ANUCL2,NUCEXT
COMMON/S/SFLL(24),OFLL(24)
COMMON/TON/IZUTL
COMMON/SPNC/SFNAME(3),PNUC(3),SFNUC(5,3),SPORG(5,3),
ISPI(5,3),NSPNUC(3),NSPORG(3)
REAL*8 NUCC,OPG,CAN,ORGWB(2),WB(2),SHMD(24),PUL,LUNG
COMMON/SPSW/NUCC(50),CLCL(4,50),ISPRE(3)
COMMON/ORGAN/ORG(11),CAN(11)
DIMENSION DOSOUT(100,3),WLUT(10,3),VALUE(300),PTHY(5),
IO(50),IFAC(5),SUM(3),WLMD(6)
LOGICAL EXTRA
INTEGER IAC
DATA PTHY/1,2,3,11,1/,RPTHY/PAIR IMM *,*GRND SUR*,

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[illegible]


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WRITE(6,1888) (DOSSOUT (NITEM+I,2), I=1,NGEN)
WRITE(6,1700)
WRITE(6,1900) (DOSSOUT (NITEM+I,3), I=1,NGEN)
WRITE(6,1710)
WRITE(6,2110) (PL,I=1,NGEN)
WRITE(6,1710)
250 WRITE(6,1720)
2999 FCFMATA*NOTE THAT THE DUST IS CALCULATED FOR THE CORRESPONDING*
144 TISSUE*)
240 CONTINUE
RETURN
250 NITEM
DO 260 NN=1,N,8
  NITEM=
  IF (NITEM.GT.1700) NITEM=NITEM+7
  WRITE(6,1200) (CBND(I,1), I=NN,NNN)
  WRITE(6,1300) (BL,I=NN,NNN)
  WRITE(6,1600) (DOSSOUT (I,1)+IADD,1), I=NN,NNN)
  WRITE(6,1700)
  WRITE(6,1800) (DOSSOUT (I,1)+IADD,2), I=NN,NNN)
  WRITE(6,1700)
  WRITE(6,1900) (DOSSOUT (I,1)+IADD,3), I=NN,NNN)
  WRITE(6,1700)
  WRITE(6,2100) (PL,I=NN,NNN)
  WRITE(6,1700)
260 CONTINUE
GO TO 230

*HORIZONTAL HEADING IS PATHWAY*
270 IF (THRD.NE.2) GO TO 440
IF (SUBTIL.NE.1) GO TO 360
WRITE(6,1030) (SBTIL(I,THRD), I=1,6)
CALL INIVIT (NCC,1,10M5,2,FAC,3,PTHY,NPTHY,VALUE,IER)
K=1
DO 280 IP=1,NPTHY
  DO 240 IF=1,3
    DO 290 JO=1,2
      DOSSOUT (IP+(JO-1)*NPTHY,IF)=VALUE(K)
      K=K+1
280 CONTINUE
  IADD=NPTHY
  EXTRA=FALSE
  DO 300 IL=1,3
    IF (ISPRES(IL).EQ.0) GO TO 300
    EXTRA=TRUE
    CALL INIVIT (NANC(IL),1,SUM0,1,FAC,3,ISPRES(IL),1,VALUE,IER)
    K=1
    DO 290 IF=1,3
      WOUT(1,IF)=VALUE(K)
      K=K+1
290 CONTINUE
300 CONTINUE
DO 320 I=1,NPTHY
  SBND(I)=NPTHY(I)
320 CONTINUE
  NITEM=NPTHY-1
  NITEM=NPTHY
  NGND=NPTHY-1
  NTS=NITEM+1
  CALL SORTR (DOSSOUT,10,NITEM)
  IF (PERPTH,6E-1,0) GO TO 30
  TPTH=0.0
  TPTH=DOSSOUT (NPTHY+1,1)
  SUM=0.0
  DO 330 II=1,NPTHY
    SUM=SUM+DOSSOUT (II,1)
  IF (SUM/TPTH,6E-1,PERPTH) GO TO 340
330 CONTINUE
GO TO 9
340 IF (NPTHY-II,LE,1) GO TO 90
  NSND=II
  NITEM=II+1
  IIS=II+1
  SBND (I,IISS)=OTHER
  IISS=IISS+1
  DO 350 IN=IISS,NITEM
    DOSSOUT (I,IISS),1)=DOSSOUT (I,IISS),1)+DOSSOUT (I,IN),1)
    DOSSOUT (I,IISS),2)=DOSSOUT (I,IISS),2)+DOSSOUT (I,IN),2)
    DOSSOUT (I,IISS),3)=DOSSOUT (I,IISS),3)+DOSSOUT (I,IN),3)
350 CONTINUE
  NYD=NITEM
  GO TO 9
360 IF (SUBTIL.NE.2) GO TO 400
*TABLE IS FOR MEAN INDIV. AND PATHWAY*
WRITE(6,1030) (SBTIL(I,THRD), I=1,6)
CALL INIVIT (NCC,1,10M5,2,FAC,3,PTHY,NPTHY,VALUE,IER)
K=1
DO 370 IP=1,NPTHY
  DO 370 IF=1,3
    DO 370 JO=1,2
      DOSSOUT (IP+(JO-1)*NPTHY,IF)=VALUE(K)
      K=K+1
370 CONTINUE
  IADD=NPTHY
  EXTRA=FALSE
  DO 390 IL=1,3
    IF (ISPRES(IL).EQ.0) GO TO 390
    EXTRA=TRUE
    CALL INIVIT (NANC(IL),1,SUM0(1),1,FAC,3,ISPRES(IL),1,VALUE,IER)
    DO 380 IF=1,3
      WOUT(1,IF)=VALUE(K)
380 CONTINUE
GO TO 310
400 WRITE(6,1030) (SBTIL(I,THRD), I=1,6)
*TABLE IS FOR COLLECTIVE POPULATION AND PATHWAY*
CALL COLLPIT (NCC,1,SUM0,2,FAC,3,PTHY,NPTHY,VALUE,IER)
K=1

```

```

DC 410 IF=1,3
GO 410 IF=1,3
DC 410 JO=1,2
DCSOUT(I*(JO-1)+4+1*Y,IF)=VALUE(IK)
K=K+1
510 CONTINUE
IADD=NPT*Y
EXTRA=FALSE
DO 430 IL=1,3
IF(I$PRES(IL),E0,0) GO TO 430
EXTRA=TRUE
CALL CALLPISPAPE(IL),1,SUMD(1),FAC,3,ISPRES(IL),1,VALUE,IER)
DO 450 IF=1,3
DCOUT(IL,IF)=VALUE(IF)
CONTINUE
END
GO TO 410
IF(I$SUTL,NE,1) GO TO 530

TABLE IS FOR SELECTED INDIV. AND NUCLIDE
WRITE(6,1000)$(SUTL(I),IHRND),I=1,6
CALL COLLENUCLID,NUCLT,SUMD,2,FAC,3,14,1,VALUE,IER)
K=1
DO 450 IF=1,3
DO 450 JO=1,2
DO 450 IN=1,NUCLT
DCSOUT(I*(JO-1)+NUCLT,IF)=VALUE(IK)
K=K+1
520 CONTINUE
IADD=NUCLT
EXTRA=FALSE
DO 470 IL=1,3
IF(I$PRES(IL),E0,0) GO TO 470
EXTRA=TRUE
CALL INDIVISPAPE(IL),1,SUMD(1),FAC,3,ISPRES(IL),1,VALUE,IER)
DO 490 IF=1,3
DCOUT(IL,IF)=VALUE(IF)
CONTINUE
CONTINUE
WRITE(NUCLT)
WRITE(NUCLT)
K=K+1
DO 470 IL=1,NUCLT
DCOUT(I*(NUCLT+1),NUCLT)
CALL COLLENUCLID,NUCLT,SUMD,2,FAC,3,14,1,VALUE,IER)
K=K+1
DO 500 I=1,NUCLT
SUM=SUM+DCOUT(I*(NUCLT+1),NUCLT)
IF(SUM/DCOUT(I*(NUCLT+1),NUCLT),GE,PERMUC) GO TO 510
500 CONTINUE
GO TO 50
510 IF(NUCLT-I,LE,1) GO TO 9
NITEN=I+1
NEND=I
IIS=I+1
SUMD(I(IIS))=OTHER
IIS=IIS+1
DO 520 I=1,IS,NUCLT
DCOUT(I*(IIS),1)=DCOUT(I*(IIS),1)+DCOUT(I*(IIS),1)
DCOUT(I*(IIS),2)=DCOUT(I*(IIS),2)+DCOUT(I*(IIS),2)
DCOUT(I*(IIS),3)=DCOUT(I*(IIS),3)+DCOUT(I*(IIS),3)
520 CONTINUE
NIT=N
GO TO 93
530 IF(I$SUTL,NE,2) GO TO 570

C
TABLE IS FOR MEAN INDIV. AND NUCLIDE
WRITE(6,1000)$(SUTL(I),IHRND),I=1,6
CALL INDIVNUCLID,NUCLT,SUMD,2,FAC,3,14,1,VALUE,IER)
K=1
DO 540 IF=1,3
DO 540 JO=1,2
DO 540 IN=1,NUCLT
DCSOUT(I*(JO-1)+NUCLT,IF)=VALUE(IK)
K=K+1
540 CONTINUE
IADD=NUCLT
EXTRA=FALSE
DO 560 IL=1,3
IF(I$PRES(IL),E0,0) GO TO 560
EXTRA=TRUE
CALL INDIVISPAPE(IL),1,SUMD(1),FAC,3,ISPRES(IL),1,VALUE,IER)
DO 580 IF=1,3
DCOUT(IL,IF)=VALUE(IF)
CONTINUE
CONTINUE
560 IF(I$SUTL,NE,2) GO TO 570

C
TABLE IS FOR COLLECTIVE POLLUTION AND NUCLIDE
WRITE(6,1000)$(SUTL(I),IHRND),I=1,6
CALL COLLENUCLID,NUCLT,SUMD,2,FAC,3,14,1,VALUE,IER)
K=1
DO 580 IF=1,3
DO 580 JO=1,2
DO 580 IN=1,NUCLT
DCSOUT(I*(JO-1)+NUCLT,IF)=VALUE(IK)
K=K+1
560 CONTINUE
IADD=NUCLT
EXTRA=FALSE
DO 600 IL=1,3
IF(I$PRES(IL),E0,0) GO TO 600
EXTRA=TRUE
CALL COLLEPISPAPE(IL),1,SUMD(1),FAC,3,ISPRES(IL),1,VALUE,IER)
DO 620 IF=1,3
DCOUT(IL,IF)=VALUE(IF)
CONTINUE
CONTINUE
600 IF(I$SUTL,NE,2) GO TO 570

```



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        LOGOYL IL=VALUE(IF)
597 CONTINUE
600 CONTINUE
    GO TO 430
610 IF(IISUBLINE,2) GO TO 650

TABLE IS FOR MEAN INDIV. AND ORGANS
WRITE(6,I50)(CUTITL(I),I=1,5)
CALL INITV(TITLE,1,ORGANS,NTORG,FAC,3,14,1,VALUE,IER)
K=1
DO 520 IF=1,3
DO 620 JO=1,NTORG
DO$OUT(JO,IF)=VALUE(K)
K=K+1
620 CONTINUE
EXTRA=.FALSE.
DO 640 IL=1,3
IF(IISPR$S(IL).EQ.0) GO TO 540
EXTRA=.TRUE.
CALL INDIVESPNAME(IL),1,SPORG(,IL),NSPORG(1)
IFAC,3,IISPR$(IL),1,VALUE,IER)
K=1
NSO=NSPORG(IL)
DO 630 IF=1,3
DO 640 JO=1,NSO
ULOUT(JO,IF)=VALUE(K)
K=K+1
630 CONTINUE
640 CONTINUE
GO TO 440

TABLE IS FOR COLLECTIVE SPIRATION AND ORGANS
WRITE(6,I50)(CUTITL(I),I=1,5)
CALL COLLECT TITLE,1,ORGANS,NTORG,FAC,3,24,1,VALUE,IER)
K=1
DO 660 IF=1,3
DO 660 JO=1,NTORG
DO$OUT(JO,IF)=VALUE(K)
K=K+1
660 CONTINUE
EXTRA=.FALSE.
DO 680 IL=1,3
IF(IISPR$(IL).EQ.0) GO TO -10
EXTRA=.TRUE.
CALL COLLECPNME(IL),1,SPORG(1,IL),NSPORG(IL)
IFAC,3,IISPR$(IL),1,VALUE,IER)
K=1
NSO=NSPORG(IL)
DO 670 IF=1,3
DO 670 JO=1,NSO
ULOUT(JO,IF)=VALUE(K)
K=K+1
670 CONTINUE
680 CONTINUE
GO TO 440

E30
$ROUTINE TAB=INFLUC,MM,PREL)
WHEELISTAB/PFORD,PFPY,PERNUC
WHEELISTAB/XAT,YT,ZT,FAC
WHEELISTAB/SPNUC,SPORG,PPTH,FACL
COMMON/OIC/PCORGE,PERPTH,PERNUC
COMMON/YIC/XT(56,25),YT(50,25),ZT(50,25),FACD(5,25)
COMMON/XIC/SPHUC(55,12),SPORG(24,12),SPPTH(13,12),FACL(1,12)
FACL=FLB,XT,YT,ZT,SPNUC,SPORG,PPTH,GLNORGE(3)
1 HUC(5,3),RTAV(5,2,5),DFAC(5)
INTERP FACD,FACL,RTAV
LOGICAL IF=EL,SORTAS,CFTAN
DATA NCM//PCL,PMY,PLR//,FN*,PRE*,PLL*,
1 TNY*,QY*,QPY*,QLS*,QY*,
2 C2HORQ/AVERAGE%,TESTES%,OVARISS%
DATA DEFALT//TOT WUP*,EFF JBOD*,TOT KTV*/

C...
DEFAULT
DO 5 I=1,10
SPNUC(I,1)=DEFUAL(1)
S.ORG(I,1)=DEFUAL(2)
3 SPPTH(I,1)=DEFUAL(3)
XT(1,1)=5LS
FACD(1,1)=0
FACL(1)=0
PERORG=100.
PERNUC=100.
PERPTH=100.
RFAD(5,5)=0
IF(PERORG.LE.99.99) WRITE(6,1000) PERORG
IF(PERNUC.LE.99.99) WRITE(6,1100) PERNUC
IF(PERTH.LE.99.99) WRITE(6,1200) PERTH
1000 FORMAT(' THE PERCENT TOTAL RISK TO INCLUDE IN MAJOR',
10 HEADINGS FOR CENTING IS ',95.3)
1100 FORMAT(' THE PERCENT TOTAL RISK TO INCLUDE IN MAJOR',
10 HEADINGS FOR NUCLIDIC IS ',95.3)
1200 FORMAT(' THE PERCENT TOTAL RISK TO INCLUDE IN MAJOR',
10 HEADINGS FOR PATHWAY IS ',95.3)

C
C READING LITAM)
C
C CONVERT LITERAL FACTOR VALUES TO INTEGERS
DO 20 I=1,10
DO 40 J=1,11
IF(FACL(I,J).EQ.'X') GO TO 20
1 CONTINUE
J=1
2 FACL(I,J)=J-1
DO 40 I=1,10
DO 40 J=1,11

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330 FACCL(I,1)=G
GO TO 340
331 DO 335 K=1,50
IF(RSAV(K,1,2).EQ.BLR) GO TO 340
DO 332 L=1,3
IF(RSAV(K,1,2).EQ.GENORG(L)) GO TO 333
332 CONTINUE
GO TO 335
333 DO 334 M=1,49
RSAV(K,1,2)=RSAV(K,1,1,2)
334 RSAV(K,1,2)=BLR
335 CONTINUE
336 I=I+1
GO TO 340
337 DO 338 J=1,50
DO 339 K=1,25
X(J,K)=RSAV(J,K,1)
Y(J,K)=RSAV(J,K,17)
339 Z(J,K)=RSAV(J,K,12)
338 CONTINUE
339 IF(ACCL(I,1).EQ.B) GO TO 340
IF(ACCL(I,1).EQ.B) GO TO 340
DO 340 J=1,50
IF(SPMUC(J,1).EQ.BLR) GO TO 340
DO 340 K=1,25
IF(SPMUC(J,1).EQ.GENORG(K)) GO TO 340
340 CONTINUE
341 IF(ACCL(I,1).EQ.B) WRITE(6,1000) SPMUC(J,1)
IF(ACCL(I,1).EQ.B) WRITE(6,1000) SPMUC(J,1)
342 STOP
343 CONTINUE
344 IF(ACCL(I,1).EQ.B) WRITE(6,1000) SPMUC(J,1)
345 SPLIT THE TABLE INTO TWO TABLES
346 GENTAB=FALSE
347 SORTAB=FALSE
DO 400 J=1,24
IF(SPORG(J,1).EQ.BLR) GO TO 470
DO 400 K=1,5
IF(SPORG(J,1).EQ.GENORG(K)) GO TO 450
400 CONTINUE
348 SORTAB=TRUE
GO TO 450
450 GENTAB=TRUE
451 CONTINUE
470 IF(ACCL(I,1).EQ.B) GO TO 370
IF(ACCL(I,1).EQ.B) GO TO 351
I=I+1
IF(I,LY,1) GO TO 370
DO 530 J=1,11
J1=10-J
IF(ACCL(J1,1).EQ.B) GO TO 500
DO 490 K=1,50
SPMUC(K,J1+1)=SPMUC(K,J1)
IF(K,LE,24) SPORG(K,J1+1)=SPORG(K,J1)
490 IF(K,LE,13) SPPTH(K,J1+1)=SPPTH(K,J1)
FACCL(J1+1)=FACCL(J1)
500 CONTINUE
DO 510 K=1,50
SPMUC(K,1+1)=SPMUC(K,1)
510 IF(K,LE,13) SPPTH(K,1+1)=SPPTH(K,1)
FACCL(1+1)=FACCL(1)
NG=0
NS=0
DO 540 J=1,24
IF(SPORG(J,1).EQ.BLR) GO TO 550
GO 520 K=1,5
IF(SPORG(J,1).EQ.GENORG(K)) GO TO 530
520 CONTINUE
NS=NS+1
SPORG(NS+1)=SPORG(J,1)
GO TO 540
530 NG=NG+1
SPORG(NG+1)=SPORG(J,1)
540 CONTINUE
541 SPORG(NS+1)=BLR
I=I+1
GO TO 370
551 DO 555 J1=1,24
J2=24-J1
IF(SPORG(J,1).EQ.BLR) GO TO 555
DO 552 L=1,3
IF(SPORG(J,1).EQ.GENORG(L)) GO TO 553
552 CONTINUE
GO TO 555
553 IF(J,LE,24) GO TO 556
DO 554 M=1,25
SPORG(M,1)=SPORG(M,1,1)
554 SPORG(M,1)=BLR
555 CONTINUE
GO TO 370
561 CONTINUE
RTURN
END
SUBROUTINE TSM
THIS ROUTINE PROVIDES THE TOTAL SUMMARY TABLE
REAL*4 TOTNUC,CPMNUC,PTNUC,SPNUC,SPORG,CPMNUC,CPMNUC
INTEGER IFAC
DIMENSION NSOUT(4),GENOUT(5),ULOUT(4,5),TCOUT(5),PFAC(4),
1VLT(1)
COMMON/CCCT/IFAC(40),IFAC(1),IFAC(2),IFAC(3),IFAC(4),IFAC(5),
1PERF(40),PERF(40),IFAC(1),IFAC(2),IFAC(3),IFAC(4),IFAC(5),
COMMON/IL/ITL(100),OUTITL(4,5),IPT(50)

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[illegible]

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DATA NUCNAM/HH-, 2HHE-, 2HHL-, 2HSE-, 2HSH-, 2HC-, 2HN-,
2HG-, 2HF-, 2HNF-, 2HKA-, 2HGA-, 2HAI-, 2HBI-, 2HPI-, 2HCR-,
2AS-, 2AC-, 2HAR-, 2HAR-, 2HCA-, 2HSC-, 2HTI-, 2HV-, 2HCR-,
2HAM-, 2HFE-, 2HCO-, 2HAI-, 2HCU-, 2HZN-, 2HGA-, 2HGE-, 2HAS-,
2HCE-, 2HBI-, 2HKE-, 2HKA-, 2HCR-, 2HY-, 2HTR-, 2HNR-, 2HNO-,
2HFC-, 2HBU-, 2HBL-, 2HPO-, 2HAG-, 2HCO-, 2HIN-, 2HSG-, 2HSE-,
2HTE-, 2HNI-, 2HNE-, 2HCS-, 2HCA-, 2HLA-, 2HCE-, 2HPR-, 2HND-,
2HPR-, 2HSH-, 2HEU-, 2HGO-, 2HTE-, 2HDT-, 2HNO-, 2HCR-, 2HCH-,
2HYB-, 2HLU-, 2HNF-, 2HTA-, 2HUV-, 2HRE-, 2HOS-, 2HIP-, 2HPT-,
2HAU-, 2HIG-, 2HTL-, 2HPR-, 2HBI-, 2HPO-, 2HAT-, 2HNR-, 2HFR-,
2HRA-, 2HAC-, 2HTH-, 2HPL-, 2HUB-, 2HXP-, 2HPU-, 2HAP-, 2HCR-,
2HSE-, 2HCF-, 2HES-, 2HFR-, 2HND-, 2HNO-, 2HNU-, 2HAP-, 2HCR-,
NAME=BLANK
Z=ZAS/10000
ITEPP=ZAS-Z*10000
A=ITEPP/10
EXCITE=ITEPP-A*10
IF(Z.GE.1.AND.Z.LE.103) GO TO 10
WRITE(6,10100) Z,ZAS
10100 FORMAT('Z NUMBER NOT IN LIST = ',I5,' ZAS = ',I10)
RETURN
10 ELEMENT=NUCNA(I)
I=1
J=1
IP=3
IF(LONAME(2).EQ.HYPHEN) GO TO 20
LONAME(IP)=HYPHEN
IP=IP+1
20 IF(A.LT.100) GO TO 30
I=A/100
LONAME(IP)=DIGIT(I+1)
IP=IP+1
30 IF(A.LT.10) GO TO 40
J=A-100*I
J=J/10
LONAME(IP)=DIGIT(J+1)
IP=IP+1
40 K=A-100*I-10*J
LONAME(IP)=DIGIT(K+1)
IP=IP+1
IF(EXCITE.NE.9) LONAME(IP)=X
IP=IP+1
IF(EXCITE.GT.1) LONAME(IP)=DIGIT(EXCITE+1)
UNPACK=NAME
RETURN
C
C THIS ENTRY PERFORMS THE REVERSE TRANSFORMATION.
C FROM THE ALPHANUMERIC NUCLIDE NAME TO THE ZAS NUMBER
C
ENTRY IO(NAMEIN)
NAME=NAMEIN
DO 100 I=1,103
IF(ELEMENT.EQ.NUCNA(I)) GO TO 110
CONTINUE
100 WRITE(6,10200) ELEMENT
10200 FORMAT('ELEMENT NAME: ',A2,' NOT FOUND')
ID=0
RETURN
110 IS=0
IA=0
IZ=1
IP=3
IF(LONAME(2).EQ.HYPHEN) IP=3
DO 140 I=1,10
IF(LONAME(IP).EQ.DIGIT(I)) GO TO 150
CONTINUE
140 I=I+10*I-1
IP=IP+1
IF(LONAME(IP).EQ.LBLANK) GO TO 210
IF(LONAME(IP).EQ.N) GO TO 180
GO TO 120
180 IS=1
IP=IP+1
IF(LONAME(IP).EQ.LBLANK) GO TO 210
DO 190 I=1,10
IF(LONAME(I+1).EQ.DIGIT(I)) GO TO 200
CONTINUE
190 IS=I+1
ID=IZ-10000*IA+10*IS
210 RETURN
END
SUBROUTINE WTSUM(ARRAY)
COMMON/WT/WTSPAC(24),IPTR(24),WTSM,WTST
COMMON/C/ORGANS(24),NORGAN,NGEN,NY
COMMON/N/NUCLID(50),ANUCLY,NUCLY,NUCEXY
PEAL=8 ORGANS,NUCLID
DIMENSION ARRAY(50,24,6)
C
C ZERO ORGAN AND NUCLIDE TOTALS
WTSPG=NORGAN*NGEN
DO 10 I=1,4
DO 10 J=1,ANUCLY
ARRAY(I,NORGAN,J)=0.0
10 CONTINUE
DO 20 I=1,ANUCLY
DO 20 J=1,NORGAN*6
ARRAY(I,NORGAN*6)=0.0
20 CONTINUE
DO 30 I=1,WTSPG
DO 30 J=1,10,IF=0.0
ARRAY(NUCLY+1,10,IF)=0.0
30 CONTINUE
C
C COMPUTE WEIGHTED SUMS (ORGAN TOTALS). IF=5 IS COMPUTED VIA WHOLE
C BODY FACTOR, IF=6 IS COMPUTED BELOW
DO 40 I=1,WTST
DO 40 J=1,ANUCLY
ARRAY(I,NORGAN*6)=ARRAY(I,NORGAN*6)+WTSPAC(I)
1ARRAY(I,IPTR(10),5)=WTSPAC(I)

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DO 35 IF=1,2
35 ARRAY(IN,NORGAN,IF)=ARRAY(IN,NORGAN,IF)+
  ARRAY(I1,IF(I10),IF)=ARRAY(I10,IF)
DO 40 IF=3,4
40 ARRAY(IN,NORGAN,IF)=ARRAY(IN,NORGAN,IF)+ARRAY(I1,IF(I10),IF)
C COMPUTE FOR IF=6, YEARS OF LOST LIFE
TSRY=0.
TSR=0.
DO 45 I1=1,NNUCL1
SRV=0.
SR=0.
DO 50 I2=1,NUTS
I=I1*10+I2
R=ARRAY(I1,I2)+ARRAY(I1,I2)
SRV=SRV+R*ARRAY(I1,I2)
50 SR=SR+R
IF(SR.NE.0.) ARRAY(N,NORGAN,6)=SRV/SR
TSRY=TSRY+SRV
60 TSR=TSR+SR
DO 70 IF=1,5
DO 70 I2=1,NTORG
DO 70 I1=1,NNUCL1
ARRAY(I1,I2,IF)=ARRAY(I1,I2,IF)+
  ARRAY(I1,I2,IF)
70 CONTINUE
C COMPUTE NUCLIDE TOTALS FOR YEARS OF LOST LIFE
DO 90 I1=1,NNUCL1
SRV=0.
TSR=0.
DO 95 I2=1,NTORG
R=ARRAY(I1,I2)+ARRAY(I1,I2)
SRV=SRV+R*ARRAY(I1,I2)
95 SR=SR+R
IF(SR.NE.0.) ARRAY(NNUCL1+1,I2,6)=SRV/SR
C COMPUTE NUCLIDE TOTAL FOR YEARS OF LOST LIFE (IF=6)
IF(TSR.NE.0.) ARRAY(NNUCL1+1,NORGAN,6)=TSRY/TSR
RETURN
END
SUBROUTINE EXTRACTS,JS,ST,C,NCREL,NCEXP,KSHORT,JSHORT,L)
DIMENSION ST(52,53),S(37,37)
JS1=JS+1
NS1=NS+1
NS=NS+NCREL
JS=JS+NCEXP
IF(NCEXP.EQ.L.OR.KSHORT.EQ.0) GO TO 50
IF(KSHORT.NE.L) GO TO 50
DO 20 J=1,NCREL
I=L+2
DO 10 I1=KSHORT,L
I=I-1
10 S(I1,J)=S(I-1,J)
20 CONTINUE
IF(JSHORT.EQ.0) GO TO 50
IF(JSHORT.NE.L+1) GO TO 50
DO 40 J=1,NCREL
I=L+3
DO 30 I1=JSHORT,L
I=I-1
30 S(I1,J)=S(I-1,J)
40 CONTINUE
50 CONTINUE
J=0
I=0
DO 70 J1=JS1,JS
J=J+1
DO 60 I1=J1,JS
I=I+1
60 ST(I1,J1)=S(I,J)
70 I=0
RETURN
END
SUBROUTINE BACK (K1, L, CONC)
C
C * CALLED FROM DECYC *
C
PUTS CHAIN RESULTS, SIN, BACK INTO CONC, AFTER ADDING
SHORT-LIVED NUCL.
COMMON /DECAY/ S(37,37), O(N(37,37), REM(37)
COMMON /DECONS/ NCEXP, NCREL, L, NS, NS1, JS, JS1,
1 JSHORT, KSHORT, OJOT
C
DIMENSION CONC(K1, 1)
C
IF (NCEXP.EQ. L) GO TO 50
IF (KSHORT.NE. L) GO TO 50
IF (KSHORT.NE. 0) CALL ERROR
DO 20 J = 1, NCREL
1 START MOVE FROM L TO L + 1.
I = L + 2
DO 10 I1 = KSHORT, L
I = I - 1
10 O(I1,J) = GIVE(I-1, J)
20 CONTINUE
IF (JSHORT.EQ. 0) GO TO 50
IF (JSHORT.NE. L + 1) GO TO 50
DO 40 J = 1, NCREL
I = L + 3
C
START MOVE AT L + 1 TO L + 2.
DO 30 I1 = JSHORT, L
I = I - 1
30 O(I1,J) = GIVE(I-1, J)
40 CONTINUE
50 CONTINUE

```

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C
C
C PUT BACK INTO CONC...
J = 0
I = 0
DO 70 J1 = JS1, JS
J = J + 1
DO 60 N1 = NS1, NS
I = I + 1
60 CONC(N1, J1) = QIN(I, J)
I = 0
RETURN
END
SUBROUTINE CONVRT (NPRIME)
C
C * CALLED FROM DECATC *
C
C PURPOSE IS TO SKIP PRIMUS TRUNCATED SOURCE RECORD, OR CONVERT CONC
C FROM IT TO FULL SIZE CONC, IF A RETACD CODE CASE...
C
C READ (NPRIME)
C RETURN
C END
SUBROUTINE DECATC (L, JINL, C, H, D, E, F, A)
C
C * CALLED FROM DECATC *
C
C PREPARES ARRAY, AND CALLS THE DECAT SUBRS. & APPLIES EITHER
C DECAT OR INTEGRAL MODEL.
C
C DOUBLE PRECISION C(L,L), H(L,L), D(L,L), E(L,L), F(L,L),
C A(L,L), FACT
C 1.000(37)
C REAL*8 DC1, DC2
C
C COMMON /TIMECH/ TIME, ICTYP, ISTYP, IMULT, IDIAG, NPRIME, NCONC,
C KOUT, IREF, NEXP, KTRUNC, MPICK
C COMMON /DECAT/ S(37,37), QIN(37,37), REY(37)
C COMMON /DECON/ NEXP, NREF, NS, NS1, JS, JS1,
C JSHORT, KSHORT, STOT
C
C INTEGER JINL(1)
C LOGICAL PASS2
C
C NCONC = 1
C PASS = .FALSE.
C 10 IF (PASS2) NCONC = 4
C DO 20 I = 1, L
C DO 20 J = 1, L
C C(I,J) = 0.000
C 20 H(I,J) = 0.000
C DO 30 I = 1, L
C DO 30 J = 1, L
C C(I,J) = S(I,J)
C IF (IDIAG .EQ. 1 .AND. J .EQ. 1) C(I,J) = C(I,J) - REY(I)
C 30 C(I,J) = C(I,J) + TIME
C CALL DECP (L, P, NP, KOUT, C, H, HNORM)
C SUBR. DECP COMPUTES WELL-BEHAVED H-MATRIX FROM C / 2*NP, AFTER
C DETERMINING NP SUCH THAT THE NORM. HNORM < 0.25
C
C 40 NTR = L - 2 * NP + 3
C ASSURES AT LEAST 5 TERMS IN EXPANSION...
C IF (INT(.LT. 5) NTR = 5
C AND AT LEAST 5 TERMS IN EXP EXPANSION
C
C CALL DECEX (L, NTR, D, E, H, A)
C
C SUBR. DECEX COMPUTES D-MATRIX = EXP(H-MATRIX)...
C
C CALL DECD (L, NP, D, E, F, H, A)
C
C SUBR. DECD COMPUTES D(C) FROM D(H) AND H, IN RECURSION RELATIONSHIP.
C
C IF (ICTYP .NE. 0) GO TO 18
C NEXT APPLY MODEL FOR REGULAR DECAT AND INGROWTH.
C DO 50 I = 1, L
C DO 50 J = 1, L
C A(I,J) = 1.0050
C IF (C(I,J) .EQ. 0.000) GO TO 50
C 50 F(I,J) = DASS(1.00-74 / D(I,J))
C DO 70 I = 1, L
C DO 70 J = 1, L
C DC1 = 0.003
C DC2 = 0.000
C DO 70 K = 1, I
C IF (DARS(C(K,I), I, LT, S(J,K)) GO TO 73
C IF (C(K,I) .EQ. 0.000) GO TO 70
C IF (J .EQ. 1) GO TO 60
C IF (K .EQ. 1) DC2 = C(K,I) + D(J,K)
C IF (K .EQ. 1) DC1 = C(K,I) + D(J,K) + DC1
C IF (K .EQ. 1) GO TO 60
C IF (DC1 .EQ. 0.300) GO TO 60
C IF (DC1 .EQ. 0.600) GO TO 70
C IF (1.070 + DC2 / DC1 .GT. 1.00-11) GO TO 61
C
C THERE ARE 2 PRODUCTS OF 0 * C NEARLY EQUAL, LESS OF TOO MUCH
C PRECISION IS AVOIDED BY USIN. 1/4 * TIME AND LOOP 4 TIMES THRU DO 44
C
C IF (.NOT. PASS2) GO TO 240
C IF (DARS(1.000 + DC1 / DC2) .GT. 3.00-16) GO TO 60
C F(I,J) =
C 3.00-16 + DC1
C GO TO 7
C 60 CONTINUE
C F(I,J) = F(I,J) + C(K,I) + D(J,K)
C 70 CONTINUE

```

```

DO 170 KJ = 1, NCREL
DO 160 VPASS = 1, NCPAS
DO 80 J = 1, L
80 QIN(J) = QIN(J,KJ)
J1 = J*4L(KJ)
DO 70 I = 1, L
E(I,2) = 0.000
A(I,1) = 1.0050
IF (QIN(I,KJ) .GT. 1.0) A(I,1) = 1.00-74
IF (QIN(I,KJ) .GT. 1.0) GO TO 90
IF (QIN(I,KJ) .EQ. 0.0) GO TO 90
A(I,1) = .85 (1.00-74 / QIN(I,KJ))
90 E(I,1) = 0.000
DO 110 I = J1, L
DO 110 J = J1, L
IF (DABS(I(J,I)) .LT. A(J,1)) GO TO 110
IF (QIN(J,KJ) .EQ. 0.0) GO TO 110
IF (I .NE. J) GO TO 100
IF (I(J,I) .LT. 0.000) CALL ERROR
IF (1.000 - E(J,I) .GT. 1.00-11) GO TO 100
E(J,2) = 1.000
GO TO 110
100 CONTINUE
E(I,1) = E(I,1) + F(J,I) * QIN(J)
110 CONTINUE
DO 130 J = 1, L
IF (E(J,2) .GT. 0.000) GO TO 130
IF (J .GE. J1) GO TO 120
IF (QIN(J,KJ) .EQ. 0.0) GO TO 140
CALL ERROR
NOTE, E(J,1) = DIFF. IN QIN. 300 QIN...
QIN(J) = E(J,1) + QIN(J)
GO TO 140
120 EXFON = DABS( C(J,J) )
EXFO = 0.0
IF (EXFON .LT. 172.0) EXPO = EXP(-EXFON)
X = 0.0
IF (EXFO .GT. 0.0) X = *LOG10(EXFO)
IF (QIN(J,KJ) .GT. 0.0) X = X + *LOG10(QIN(J,KJ))
IF (X .LT. -74.0) EXPO = 0.0
QIN(J) = E(J,1) + EXPO * QIN(J)
NEED Y AVOID DIFF. IN I. AND F THAT IS LESS THAN 10**(-11)
THEN, REPLACE F WITH SIMPL. THE SMALL ELEMENT = DEXP(CTJ,J)
THIS AVOIDS >100% ERRORS IN REMAINING FRACTIONS WHICH < 10**(-15).
140 CONTINUE
DO 150 J = 1, L
150 QIN(J,KJ) = QIN(J)
160 CONTINUE
170 CONTINUE
IF (PASS2) TIME = TSAVE
GO TO 250
180 CONTINUE
NEXT: APPLY MODEL FOR INTEGRATED OR ACCUMULATED QUANTITY FROM INPUT
RATE. IT IS TIME * D * EACH QIN VECTOR FOR J1 NUC.
DO 230 KJ = 1, NCREL
J1 = JIN(KJ)
DO 190 I = 1, L
A(I,1) = 1.0050
IF (QIN(I,KJ) .EQ. 0.0) GO TO 190
A(I,1) = .85 (1.00-74 / QIN(I,KJ))
190 E(I,1) = 0.000
DO 200 I = J1, L
DO 200 J = J1, L
IF (DABS(D(I,J)) .LT. A(J,1)) GO TO 200
E(I,1) = E(I,1) + D(I,J) * QIN(J,KJ)
200 CONTINUE
DO 220 J = 1, L
IF (J .GE. J1) GO TO 210
IF (QIN(J,KJ) .EQ. 0.0) GO TO 220
CALL ERROR
210 QIN(J,KJ) = E(J,1) * TIME
220 CONTINUE
230 CONTINUE
GO TO 250
240 PASS2 = .TRUE.
TSAVE = TIME
TIME = TIME / 4.0
GO TO 17
250 RETURN
END
SUBROUTINE DECAY (K1, IND, CONC, RFLAN, CRATE, VELD,
1 IC, JC, CPAC)

```

PERFORMS EITHER DECAY OR INTEGRAL MODEL OF NUCLIDE DECAY & GROWTH.

<<<CONSUMERS>>> RETURNED IN C(1)(1), I1, NEXP, J1, NREL-----

MODEL CONTROLLED FROM FLAGS BELOW...

ICTYPE=0 REGULAR DECAY & INCREMENTAL MODEL, CURIES INPUT,
ICTYPE=1 INTEGRAL OF DECAY MODEL, CURIES/SEC USUALLY INPUT.

ISTYPE=0 REAC SOURCE FROM DECAY, NOT MADE BY PRIMUS.
ISTYPE=1 REAC SOURCE FROM PRIMUS, MADE BY PRIMUS CODE.
ISTYPE=2 SOURCE SUPPLIED IN CON = ARRAY, WITH NO REAC.

IMULT=0 NO MULTIPLICATION OF CONC.


```

C INUL=1 MAKE CONC = CONC + VELD (CON EXTR), FOR SOURCE RATE.
C INUL=2 MAKE CONC = CONC + CRATE, SUPPLIED AS ARGUMENT.
C IDIAG=6 MATR IX DIAGONAL UNCHANGED.
C IDIAG=1 ADD 10 DECAY CONSTANTS OTHER REMOVAL CONS., FROM REMLAN.
C IKEEP=0 STARTING CONC NOT SAVED.
C IKEEP=1 STARTING CONC ARE SAVED IN CONAIR(NEXP,NREL).
C KTRUNC=6 CPK INCLUDES FULL-SIZE OF DECAY CHAINS.
C KTRUNC=1 CPK INCLUDES ONLY PART OF DECAY CHAIN.
C
C ....OTHER DEFINITIONS....
C NPKINE = UNIT NO. OF POKINS DATA SET.
C NRENE = UNIT NO. OF REMOS OR OTHER CODE DATA SET.
C
C .THESE ARGUMENTS SENT, IF OPTIONS REQUIRE THEM.
C
C CPK SHOULD ALWAYS BE SENT, IF ISTYP .NE. 2, FOR STORING PACKED INPUT
C READ FROM NPKINE OR NCONC. THE INPUT IS RETURNED IN CPK.
C ERNE SHOULD ALWAYS BE SENT, FOR STORING UNPACKED ANSWERS.
C NS SHOULD ALWAYS BE SENT AS NEXP FOR NREXP, NS, OF EXP. RUES.
C REMLAN(NEXP) > 0, ADDITIONAL REMOVAL RATE CONSTANTS.
C CRATE(NEXP) > 0, FACTORS TIMES CONC TO GET INPUT SOURCE RATES.
C
C .ARGUMENTS RETURNED, PER OPTION.
C IND = CONC-TYPE INDICATOR, = 1 FOR LIN CONC., = 5 FOR PPK CONC., ETC.
C VELD(NEXP) = DEPOSITION RATES READ FROM DATA SET (EITHER DATA SET).
C
C
C DIMENSION CONC(K1,1), REMLAN(1), CRATE(1), VELD(1), JINL(37)
C DIMENSION CPK( 1), JCI( 1), JCI( 1)
C
C DOUBLE PRECISION C(1370), H(1370), O(1370), E(1370), F(1370).
C 1 H(1370)
C
C COMMON /TIMECN/ TIME, ICTYP, ISTYP, INUL, IDIAG, NPKINE, NCONC,
C 1 KOUT, VELD, NEXP, KTRUNC, NPACK,
C COMMON /DETR/ CCS(37), DTR(37), REM(37)
C COMMON /OECON/ NEXP, NREXP, NS, NS1, JS, JS1,
C 1 JSHORT, KSHORT, QST
C
C IF ISTYP .LT. 0 .OR. ISTYP .GT. 2) CALL ERROR
C IF ICTYP .LT. 0 .OR. ICTYP .GT. 1) CALL ERROR
C IF INUL .LT. 0 .OR. INUL .GT. 2) CALL ERROR
C IF IDIAG .LT. 0 .OR. IDIAG .GT. 1) CALL ERROR
C IF KTRUNC .LT. 0 .OR. KTRUNC .GT. 1) CALL ERROR
C IF KOUT .EQ. 40)
C WRITE(KOUT,12) ICTYP, ISTYP, INUL, IDIAG, KTRUNC, IKEEP, TIME
C 1000 FORMAT(1X, 'ICTYP=11,7H, ISTYP=11,7H, INUL=11,7H, IDIAG=11,
C 11H, KTRUNC=11,7H, IKEEP=11,7H, TIME=1PE19.7)
C IF (ISTYP .EQ. 2) GO TO 73
C DO 60 J = 1, NREL
C DO 60 I = 1, NEXP
C 60 CONC(I,J) = 0.0
C 70 CONTINUE
C READ(NPKINE) NUNCH, KTRUNC, NPACK
C READ(NPKINE) (IC(I), I = 1, NPACK),
C 1 (JCI(I), I = 1, NPACK)
C IGN = ISTYP * 1
C GO TO (10, 90, 100), IGN
C
C READ SOURCE FROM NCONC, SINCE ISTYP=0.
C
C 80 IF (INUL .EQ. 1) READ(CO,C) IND, (CPK(I), I = 1, NPACK)
C 1, (VELD(K), K = 1, NEXP)
C IF (INUL .NE. 1) READ(NCONC) IND, (CPK(I), I = 1, NPACK)
C IF (KTRUNC .EQ. 1) CALL CONVY (NPKINE, CONC, VELD, IC, JC, NPACK)
C IF (KOUT .EQ. 40) WRITE(KOUT,20)
C 1100 FORMAT(1X, 24HREAD SOURCE FROM NCONC)
C GO TO 110
C
C READ SOURCE FROM NPKINE, SINCE ISTYP=1.
C
C 90 J = NREL + NEXP + 2
C IF (INUL .EQ. 1) READ(NPKINE) (CPK(I), I = 1, NPACK),
C 1 (VELD(K), K = 1, NEXP)
C IF (INUL .NE. 1) READ(NPKINE) (CPK(I), I = 1, NPACK)
C IF (KTRUNC .EQ. 1) READ(NPKINE)
C IF (KOUT .EQ. 40) WRITE(KOUT,30)
C 1200 FORMAT(1X, 24HREAD SOURCE FROM NPKINE)
C GO TO 110
C
C SOURCE SUPPLIED IN CONC, SINCE ISTYP=2.
C
C 100 READ(NPKINE)
C IF (KTRUNC .EQ. 1) READ(NPKINE)
C IF (KOUT .EQ. 40) WRITE(KOUT,40)
C 1300 FORMAT(1X, 24HREAD SOURCE SUPPLIED IN CONC)
C GO TO 110
C
C IF (KTRUNC .EQ. 1) GO TO 110
C DO 120 I = 1, NPACK
C 120 CONC(I,IND, JCI(I)) = CPK(I)
C 130 JGN = INUL * 1
C GO TO (140, 140, 140), JGN
C

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REAL*8 O(L,L), F(L,L), H(L,L), FAC, ONE, A(L,L)
ONE = 1.000
IF (INT( LT. 2) NTR = 2
FAC = NTR
DO 10 I=1,L
DO 10 J=1,L
AIR(I) = 1.005C
* IF (H(K,I) .EQ. 0.0000) GO TO 10
AIR(I) = DABS(1.00-74 / H(K,I) )
10 CONTINUE
DO 20 I=1,L
DO 20 J=1,L
F(I,J) = 0.000
20 D(I,J) = H(J,I) / FAC
DO 30 N=2,NTR
WRITE(6,22) N
WRITE(6,22) 0
22 FORMAT (5E20.7)
22 FORMAT ( 4E20.7)
DO 30 I=1,L
DO 30 J=1,L
D(I,J) = O(I,I) + 0.5E
IF (N .EQ. NTR) GO TO 60
FAC = FAC - ONE
DO 40 I=1,L
DO 40 J=1,L
DO 40 K = J, I
FF (DABS(D(J,K)) .LT. AIR(I) ) GO TO 40
F(I,J) = F(I,J) + H(K,I) + D(J,K)
40 CONTINUE
DO 50 I=1,L
DO 50 J=1,L
D(I,J) = F(I,J) / FAC
50 F(I,J) = 0.000
60 CONTINUE
RETURN
END
SUBROUTINE DECP (L, P, NP, KOUT, C, H, HNORM)
-----WRITTEN FOR ANEMOS CODE BY O. W. HERMANN, 8/1/88.
** CALLED FROM SUBR. DECAT **
** FINDS P IN REDUCTION EQ FOR N = 2*(-P) + C
REAL*8 C(L,L), H(L,L), SUM, HI, HJ, HIN, HJM, FACT
--NOTE LEFT-HAND INDEX OF MATRICES DENOTES THE COLUMN OF MATRIX...
SUM = 0.000
DO 10 I=1,L
DO 10 J=1,L
IF (C(J,I) .EQ. 0.0) GO TO 10
SUM = SUM + C(J,I) * C(J,I)
10 CONTINUE
--FOR CALC OF THE EUCLIDEAN NORM OF S (THEN SQRT. BELOW) 4/28/80
S = SUM
IF (S .LE. 0.0) GO TO 40
S = SQRT(S)
P = ALOS(S) / 0.693147 + 2.0
20 CONTINUE
NP = P + 1.
IF (P .LT. 0.0) NP = 0
FACT = 1.000
IF (NP .GT. 6) FACT = (2.070) ** NP
DO 30 I=1,L
DO 30 J=1,L
H(J,I) = C(J,I) / FACT
30 HIN = 0.000
40 HJM = 0.000
HNORM = 0.0
DO 60 I=1,L
HI = 0.000
HJ = 0.000
DO 60 J=1,L
IF (H(J,I) .NE. 0.0) HNORM = HNORM + H(J,I) * H(J,I)
60 HI = HI + DABS(H(J,I) )
HJ = HJ + DABS(H(I,J) )
HIN = MAX1 (HIN, HI)
HJM = MAX1 (HJM, HJ)
HNORM = MAX1 (HIN, HJM)
HNORM = SQRT (HNORM)
IF (KOUT .EQ. 40)
1 WRITE (KOUT,1000) NP, HNORM, HNORM
1000 FORMAT (4H NP = , I4, 10H, EUCLIDEAN-NORM = , E16.4,
1 17H, MIN-MAX-NORM = , E16.4)
HNORM = MAX1 (HNORM, HNORM)
NORM SATISFIES EITHER DEFINITION BY LEE OR LAPIDUS AND LUDS.
IF (S .GE. 0.0 .AND. HNORM .LT. 0.25) RETURN
N = HNORM / 0.25
P = NP + 4LOG2(N) / 0.693147
GO TO 20
END
SUBROUTINE EXTRAC (KI, LV, CONC, REMLAN)
* CALLED FROM DECAT *
EXTRACTS CHAIN SOURCE WITH FROM CONC AND DELETES SHORT-LIVED RUCS.
DOES THE SAME FOR REM...
COMMON /DECAR/ S(37,37), WIN(37,37), REM(37)
COMMON /DECON/ NCE/P, NCR/L, NC, R21, JS, JS1,
1 JSHORT, KSHORT, GYOT
C
DIMENSION CONC(KI,17), REML(NCI)

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C
NS1 = NS + 1
JS1 = JS + 1
NS = NS + NCEXP
JS = JS + NCREL
KREDUS = 0
JREDUS = 0
IF (KSHORT .GT. 0) KREDUS = KSHORT + 1
IF (JSHORT .GT. 0) JREDUS = JSHORT + 2
C NOW, EXTRACT THE PROPER WIN FROM CONC. AS NEEDED.
C
OTOT = 0.0
J = 0
I = 0
DO 20 J1 = JS1, JS
J = J + 1
DO 10 N1 = NS1, NS
I = I + 1
IF (J .EQ. 1) REM(I) = REMLAMIN1
OTOT = OTOT + CONC(N1, J1)
10 QIN(I,J) = CONC(N1, J1)
20 I = 0
C
C NOW, DELETE KREDUS AND JREDUS RUCS FROM 2IN.
C DO 2ND, JREDUS, FIRST.
C
IF (NCEXP .EQ. 1) GO TO 60
IF (JREDUS .EQ. 0) GO TO 40
NS2 = NCEXP - 1
IF (JREDUS .GT. NS2) GO TO 40
DO 30 J = 1, NCREL
DO 30 I = JREDUS, NS2
IF (J .EQ. 1) REM(I) = REM(I+1)
30 QIN(I,J) = QIN(I+1, J)
40 IF (KREDUS .EQ. 0) CALL ER400
IF (KREDUS .GT. 1) CALL FR40P
DO 50 J = 1, NCREL
DO 50 I = KREDUS, 1
IF (J .EQ. 1) REM(I) = REM(I+1)
50 QIN(I,J) = QIN(I+1, J)
C
60 RETURN
END

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