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L'ÉNERGIE ATOMIQUE DU CANADA LIMITÉE

NEPTUN: AN INTERACTIVE CODE FOR CALCULATING DOSES TO MAN DUE TO RADIONUCLIDES IN AQUATIC FOOD CHAINS

NEPTUN: CODE CONVERSATIONNEL DE CALCUL DES DOSES TRANSMISES A L'HOMME PAR LES RADIONUCLIDES DES CHAINES ALIMENTAIRES AQUATIQUES

Reto Zach

Whiteshell Nuclear Research Establishment

Etablissement de Recherches Nucléaires de Whiteshell

Pinawa, Manitoba R0E 1L0

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RESUME

On a rédigé un code souple et conversationnel, NEPTUN, en langage FORTRAN IV pour l'ordinateur PDP-10 pour évaluer les conséquences, pour l'homme, des radionuclides des chaînes alimentaires aquatiques. Le code NEPTUN est basé sur un modèle d'équilibre du type à chaîne linéaire et calcule les concentrations dans les aliments aquatiques et les doses transmises à l'homme. On y a prévu un terme de décomposition pour le temps de retenue des différents types d'aliments. On peut choisir sept types d'aliments au total, qui comprennent l'eau potable, les plantes d'eau douce et d'eau de mer, les invertébrés et les poissons. On peut appliquer trente régimes différents et choisir cinq dossiers de facteurs de doses différents. Ceux-ci comprennent les facteurs de conversion de doses pour les enfants en bas âge et adultes basés sur les méthodologies ICRP 2 et ICRP 26. Tous les facteurs de doses comportent une dose prévue de cinquante ans, soit un équivalent de cinquante ans d'exposition chronique. A ce jour, seuls les calculs de doses ICRP 26 (stochastiques) one été appliqués. Le dossier de base des facteurs de concentration comporte des données pour 211 radionuclides différents, les dossiers des facteurs de doses sont moins complets. Cependant, tous les dossiers peuvent être facilement étendus. La sortie comprend des tableaux de concentrations et de doses pour chaque radionuclide ainsi que des sommaires pour les groupes de radionuclides.

Les modèles existants de chaînes alimentaires aquatiques et les sources de facteurs de concentrations génériques actuellement utilisés sont brièvement examinés et les facteurs de doses basés sur les méthodologies ICRP 2 et ICRP 26 sont comparés.

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ABSTRACT

A flexible and interactive code, NEPTUN, has been written in FORTRAN IV for the PDP-10 computer to assess the impact on man of radionuclides in aquatic food chains. NEPTUN is based on an equilibrium model of the linear-chain type, and calculates aquatic food concentrations and doses to man. A decay term is included for the holdup time of the various food types. A total of seven food types can be selected, which include drinking water, freshwater and salt-water plants, invertebrates and fish. Thirty different diets can be implemented and five different dose factor files can be chosen. These include dose conversion factors for infants and adults based on ICRP 2 and ICRP 26 methodologies. All dose factors involve a dose commitment of 50 years, or equivalently, 50 years of chronic exposure. To date, only stochastic ICRP 26 dose calculations have been implemented. The basic concentration factor file contains data for 211 different radionuclides; the dose factor files are less comprehensive. However, all files can be readily expanded. The output includes tables of concentrations and doses for individual radionuclides, as well as summaries for groups of radionuclides.

Existing aquatic food chain models and the sources of currently-used generic concentration factors are briefly reviewed, and dose factors based on ICRP 2 and ICRP 26 methodologies are contrasted.

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CONTENTS

1. INTRODUCTION

Computer codes for the assessment of environmental impacts have become increasingly important in the planning and operation of nuclear installations. These codes usually accept environmental releases of radionuclides as input, and translate them into dose exposures to man. Thus, if implemented and kept up to date, these codes can be used to assess environmental contamination rapidly. However, to do so effectively, it is necessary to consider all of the major pathways of exposure.

We have previously implemented an interactive code FOOD II (Zach, 1978) of the terrestrial food chain model FOOD, developed at Battelle (Baker et al., 1976). Later, FOOD II was revised to FOOD III by adding variable dose factor files, including ICRP 26 (1977) infant and adult dose factors. We now introduce a new code, NEPTUN, which is concerned with aquatic food chains and which closely parallels FOOD III. NEPTUN is an interactive code in FORTRAN IV for the PDP-10 computer. Like FOOD III, it is based on an equilibrium model, which assumes that radionuclide concentrations in man and his food chains are in equilibrium with those in water. NEPTUN can assess numerous radionuclides and seven food types, which include drinking water, freshwater and saltwater fish, invertebrates and plants.

In order to place NEPTUN in perspective, it is necessary to consider existing codes. Further, since all food chain models depend heavily on the values of transfer coefficients or concentration factors (Zach and Iverson, 1980), it is helpful to establish the sources of these values currently used in various codes.

2. EXISTING CODES

Hoffman et al. (1977) have listed a large array of codes for the assessment of radionuclides released to the environment. Codes which deal with aquatic foods include AQUAMOD (Booth, 1975), ARRRG (Soldat et al., 1974), CARDOCC (Watts, 1976), HERMES (Fletcher and Dotson, 1971) and VADOSCA (Bramati et al., 1973). An aquatic food model has also been included in the USNRC 1.109 Regulatory Guide (1977), and Shaeffer and Ethier (1979) have recently published a new code called AQUAMAN.

Of these codes ARRRG and the USNRC 1.109 model have been most widely used. Both of these codes and AQUAMAN are rather similar in being designed to evaluate routine reactor releases, assuming equilibrium conditions. All three codes have been extensively documented. AQUAMOD is a sparsely documented code which can handle both accidental and routine releases. CARDOCC is a partially documented code designed to assess routine reactor releases. HERMES is a well-documented and comprehensive code for routine releases, but ARRRG represents a more flexible version of the aquatic food model of HERMES. VADOSCA is a sparsely documented but comprehensive code for routine reactor assessment.

Codes vary in the number and types of foods implemented. ARRRG considers fish, crustaceans, molluscs and plants for freshwater and salt-water, the USNRC 1.109 model includes freshwater and salt-water fish and invertebrates, but AQUAMAN considers only freshwater and salt-water fish. All three codes also consider drinking water. Thus, NEPTUN includes more food types than most of the existing codes.

Traditionally, codes dealing with aquatic foods have also included other pathways of exposure. For instance, ARRRG calculates doses due to shoreline recreation, swimming and boating, the USNRC 1.109 Regulatory guide considers shoreline recreation, and AQUAMAN includes swimming. These exposure pathways will be considered in separate codes but are not included in NEPTUN.

Since ARRRG and the USNRC 1.109 model are specifically designed to evaluate liquid reactor releases, they contain very simple dilution models. In these models, concentrated reactor effluent is diluted to levels encountered in the general environment. AQUAMAN has no such dilution model and accepts environmental water concentrations as input. The same is true for NEPTUN.

3. DEFINITION AND SOURCES OF CONCENTRATION FACTORS

The concentration factor for a given radionuclide and aquatic food type is given by the expression

$$T_{fi} = CA_{fi}/CW_{fi} \qquad (1)$$

where: T_{fi} = concentration factor for aquatic food type f and radionuclide i (L/kg)

CA_{fi} = concentration in edible portion of food type f of radionuclide i under equilibrium conditions (Bq/kg)

CW_{fi} = concentration in freshwater or salt-water surrounding food type f of radionuclide i (Bq/L).

Since concentration factors are generally thought to be element-specific, they can also be determined from elemental, rather than radionuclide concentrations (see Zach and Iverson, 1980).

The concentration factors used in ARRRG were taken from Thompson et al. (1972) and Freke (1967). The USNRC 1.109 values were taken almost exclusively from Thompson et al. However, the values for tellurium can be traced to Killough and McKay (1976) and a value for cesium to Vanderploeg et al. (1975). The concentration factors for AQUAMAN were taken exclusively from Killough and McKay.

The values listed by Killough and McKay seem to be of major importance. However, these numbers were not directly derived from the literature. Most of the concentration factors for freshwater food products were taken from Thompson et al., but values for tellurium were derived from the Farley Nuclear Power Station Environmental Report (1972). The salt-water concentration factors of Killough and McKay were taken largely from the values published by Freke, but the factors for uranium, neptunium, plutonium, americium and curium were taken from Thompson et al. Fresh and salt-water values for bismuth were derived from data provided by Ng et al. (1968). Thus, there seem to be three major source files of generally used or generic concentration factors: Freke (1967), Ng et al. (1968) and Thompson et al. (1972). The study of Vanderploeg et al. (1975) involves only six different elements.

Freke (1967) published concentration factors for 65 elements for salt-water fish, crustaceans, molluscs and plants. Most of the elements considered are important in terms of fission products and activated corrosion products. The concentration factors were derived from data published in the primary literature. However, for many elements which lacked data, values were decided on the basis of chemical similarity. On the whole, conservative values were chosen.

Ng et al. (1968) published comprehensive elemental concentrations of fresh and salt water, and of freshwater and salt-water fish, invertebrates and plants. Since concentration factors are simply ratios of concentrations in a given food product and water (equation 1), the data provided by Ng et al. can be readily converted to concentration factors. All of the concentrations were based directly or indirectly on values published in the primary literature, and the various methods employed have been carefully documented. Conservative values were chosen whenever possible.

Thompson et al. (1972) published comprehensive elemental concentration factors for freshwater and salt-water fish, invertebrates and plants. The data are based on an extensive literature review of elemental water and food product concentrations. For comparison, elemental concentration factors have been published together with experimentally determined values. The latter values are thought to be less reliable than elemental concentration factors, since experimental studies are usually not representative of natural conditions. Further, such studies are frequently terminated before equilibrium has been reached. A special effort was made to use concentrations of edible portions of organisms, and average estimates. Due to the complete lack of data, some or all of the concentration factors for indium, tellurium, thallium and bismuth could not be determined. All the sources and methods have been carefully documented.

The concentration factors for NEPTUN were mainly taken from the elemental values published by Thompson et al. (1972). This is consistent with the axiom that the most recent values are the best available generic estimates. However, it should be noted that the salt-water values of Freke (1967) are generally higher than those of Thompson et al. because they are conservative, rather than average. Whenever deemed necessary, values for NEPTUN were taken from other sources, as documented in Appendix A.

It is important to note that most aquatic food chain models for the assessment of radionuclides released from nuclear installations are rather similar in structure. This implies that uncertainties of model-predictions relate mainly to model parameters. This is especially true for concentration factors. Since the determination of these factors is a very active field, better values than those implemented in NEPTUN will undoubtedly become available in the future.

4. MODELS

Calculation of radiation doses to man due to aquatic food types are straightforward and of the linear chain type. In their simplest form, doses for drinking water ingestion can be calculated using

$$D_{lij} = C_i . I_l . V_{ij} \quad (2)$$

and for aquatic food ingestion

$$D_{fij} = C_i . I_f . T_{fi} . V_{ij} \quad (3)$$

where D_{lij} = dose from drinking water due to radionuclide i and dose path j (Sv/a)

C_i = concentration in water of radionuclide i (Bq/L)

I_l = ingestion rate of drinking water (L/a)

V_{ij} = dose conversion factor for radionuclide i and dose path j (Sv/Bq)

D_{fij} = dose due to aquatic food type f, radionuclide i and dose path j (Sv/a)

I_f = ingestion rate of aquatic food type f (kg/a).

In AQUAMAN equations 2 and 3 are u d. However, ARRRG and the USNRC 1.109 Regulatory Guide use modified equations, which include a hold-up time. This is a delay between the harvest and consumption of food types during which radioactive decay occurs. Without such a term, the impact of short-lived radionuclides could be greatly overestimated. For drinking water ingestion, doses can be calculated using

$$D_{lij} = C_i . I_l . V_{ij} . e^{-\lambda_i t_l} \quad (4)$$

and for aquatic food ingestion

$$D_{fij} = C_i . I_f . T_{fi} . V_{ij} . e^{-\lambda_i t_f} \quad (5)$$

where λ_i = radiological decay constant of radionuclide i (1/d)

t_1 = hold-up time for drinking water (d).

t_f = holdup time for food type f (d).

In NEPTUN, expressions (4) and (5) have been implemented. It should be noted that in NEPTUN, f={2,3,4,5,6,7} since food type 1 is assigned to drinking water. In addition, subscript j can be ignored for ICRP 26 (1977) stochastic dose calculations, since a single dose is calculated for each radionuclide. Further, equations (2) to (5) do not include subscripts for different age groups. NEPTUN contains dose factors for both infants and adults, which also involve age-specific ingestion rates.

The decay term in equations (4) and (5) can cause underflow during execution, if the absolute value of the exponent is very large. This can occur in very short-lived radionuclides in which the decay term becomes very small; this in turn leads to very low doses. To handle this problem, NEPTUN uses a criterion (CRIT) which has an absolute value of 80.0. If the absolute value of the exponent exceeds 80.0, food concentrations and doses are set to zero and an appropriate message is printed during execution. The value of CRIT can be changed, depending on the computer installation. However, with an absolute value of 80.0, the decay term ($e^{-80.0}$) has a value of 1.80^{-35}. In most cases, this low value fully justifies the setting to zero of food concentrations and doses.

5. DOSE FACTORS AND CALCULATION OF TOTAL DOSES

NEPTUN includes two types of dose conversion factors (V_{ij}) which are based on ICRP 2 (1959) and ICRP 26 (1977) methodologies, respectively.

ICRP 2 represents the traditional critical organ approach to dose calculations which involves separate doses to the whole body and various internal organs. Thus, separate organ doses must be evaluated for each radionuclide. Usually, at least seven such doses are considered. If several radionuclides are involved, these doses are additive over radionuclides. In NEPTUN, the total dose for radionuclide i and organ $j=\{1....7\}$ is given by

$$TD_{ij} = D_{1ij} + \sum_{f=2}^{7} D_{fij} \qquad (6)$$

where TD_{ij} = the total dose due to drinking water and the six food types f for radionuclide i and organ j (Sv/a).

The total dose from several radionuclides for organ j is given by

$$GTD_j = \sum_{i=1}^{N} TD_{ij} \qquad (7)$$

where GTD_j = the total dose for organ j and radionuclides $i=\{1,2,3....N\}$ (Sv/a)

N = number of radionuclides.

Note that the doses based on different organs cannot be added. Hence ICRP 2 involves separate limits of exposure to the whole body and each of the internal organs. In NEPTUN, the maximum value of N is 100.

ICRP 26 represents a new approach to dose calculations, and has been adopted for the environmental assessment of Canadian nuclear installations. In its recommendations, ICRP 26 includes two types of effects: stochastic and non-stochastic. Stochastic effects are those for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose, for which there is no threshold. Non-stochastic effects are those for which the severity of the effect varies with the dose, and for which a threshold may therefore occur (ICRP 26, 1977). Basically, stochastic and non-stochastic dose calculations involve the same dose factors for individual organs, although there are differences in computational procedures.

Stochastic dose factors are based on a series of dose factors for individual organs (up to 11 different organs may be involved). These organ dose factors are multiplied by weighting factors prior to addition (see Johnson et al., 1979). The advantage of ICRP 26 over ICRP 2 is that these procedures yield a single stochastic dose factor for each radionuclide. Further, stochastic doses can be readily summed over radionuclides. In NEPTUN the total stochastic dose for radionuclide i is given by

$$TD_i = D_{1i} + \sum_{f=2}^{7} D_{fi} \qquad (8)$$

where TD_i = the total stochastic dose due to drinking water and the six food types f for radionuclide i (Sv/a)

D_{1i} = stochastic dose due to drinking water from radionuclide i calculated by equation 4 (Sv/a)

D_{fi} = stochastic dose due to aquatic food type f from radionuclide i calculated by equation 5 (Sv/a).

The total stochastic dose for several radionuclides is given by

$$GTD = \sum_{i=1}^{N} TD_i \qquad (9)$$

where GTD = the total stochastic dose for radionuclides $i=\{1,2,3...N\}$ (Sv/a).

For the stochastic dose, ICRP 26 involves a single limit of exposure.

ICRP 26 non-stochastic doses resemble ICRP 2 doses and, for each radionuclide, an entire series of separate organ doses must be calculated. These doses are based on the separate organ dose factors used to calculate the stochastic dose factors. However, no weighing factors or additions are involved. As in the case of ICRP 2 doses, non-stochastic doses due to several radionuclides can be added for each organ, but addition of doses to different organs is meaningless. Thus, ICRP 26 non-stochastic doses involve separate limits of exposure for various organs.

The total non-stochastic doses for radionuclide i and organ j is given by equation (6), although more than seven individual organs may need to be considered. The total non-stochastic dose for organ j and several radionuclides i is given by equation (7).

Although the proper application of ICRP 26 recommendations implies the use of both stochastic and non-stochastic doses, only the former have been implemented in NEPTUN. Non-stochastic doses will be implemented in the future once detailed dose factor files become available.

6. DOSE CONSEQUENCE RATIOS

For ICRP 26 stochastic doses, NEPTUN also calculates dose consequence ratios. As outlined by Zach and Iverson (1979), these ratios can be very helpful in environmental assessments by reducing the number of computer runs. For aquatic food types, the dose consequence ratio is the dose due to a given water concentration divided by that water concentration. Since NEPTUN may involve different freshwater and saltwater concentrations, separate ratios must be calculated. Freshwater dose consequence ratios can be calculated using

$$SDR_{iFw} = \left(D_{1i} + \sum_{f=2}^{4} D_{fi} \right) / \; C_{iFw} \qquad (10)$$

where SDR_{iFw} = dose consequence ratio for radionuclide i due to drinking water and food types 2 to 4 ($Sv \cdot L \cdot a^{-1} \cdot Bq^{-1}$)

C_{iFw} = freshwater concentration of radionuclide i (Bq/L)

and for salt-water

$$SDR_{iSw} = \sum_{f=5}^{7} D_{fi} \, / \, C_{iSw} \tag{11}$$

where SDR_{iSw} = dose consequence ratio for radionuclide i due to food types 5 to 7 ($Sv \cdot L \cdot a^{-1} \cdot Bq^{-1}$)

C_{iSw} = salt-water concentration of radionuclide i (Bq/L).

It is important to note that dose consequence ratios are independent of water concentration (C_{iFw} and C_{iSw}) as long as the number of food types, ingestion rates (I_1 and I_f), dose factors (V_i) and all the other model variables remain unchanged.

7. ORGANIZATION OF NEPTUN

NEPTUN consists of a total of eleven interrelated files (Figure 1).

(1) NEP.F4 - program with the subroutine DOSE and DASE for calculating doses to the total body and six individual organs, or ICRP 26 stochastic doses, respectively.

(2) CFAC.DAT - radiological decay constant and concentration factors for the six aquatic food types for each radionuclide.

(3) THOLD.DAT hold-up times for drinking water and the six aquatic food types.

(4) DIET.DAT - diets of man for drinking water and the six aquatic food types.

(5) LABEL.DAT - labels for the output of model variables.

(6) NAME.DAT - labels for food and diet types and names for dose factor files.

(7) DOS.DAT - Battelle adult dose factors (Baker, 1977) for the total body and six individual organs.

(8) A2ICR.DAT - adult dose factors for the total body and six individual organs based on ICRP 2 methodologies.

(9) CUSNR.DAT - USNRC Regulatory Guide 1.109 (1977) dose factors for infants.

(10) A26IC.DAT - stochastic dose factors for adults (Johnson et al., 1979) based on ICRP 26 (1977).

(11) C26IC.DAT - stochastic dose factors for infants (Johnson et al., 1977) based on ICRP 26 (1977).

7.1 NEP.F4 FILE AND INTERACTIVE DIALOG (Appendices A-1 and A-2)

During execution, NEP.F4 (Appendix A-1) asks the user a series of questions which must be answered. Some of these questions have several possible responses, as summarized in Table 1.

The user is first asked whether listings of the food types, diet types or dose factor file names are desired (see Appendix A-2). In each case, '0' will suppress the listing, '1' will print it, followed by continuation of execution, and '9' will print it, followed by termination of execution. These listings may be required by the user to gain information required for subsequent interactive input.

The user is then asked whether all model variables are to be listed. If responded to by '1', general model variables and radionuclide-specific variables, inclusive concentration factors and, if applicable, dose factors, will be listed in the course of execution (see Appendix A-2). '0' will suppress this option.

The user is then asked to specify food types. This involves a binary string of seven digits. The sequence of these numbers parallel the sequence of the food types implemented in NEPTUN (see Appendix A-7). Food types chosen are designated with '1' and those not chosen by '0'. An option is provided, which allows specification of a new set of food types, if a mistake has been made. Next the user must specify the diet. In DIET.DAT provisions have been made for 30 different diets, each of which can be requested by typing the appropriate diet number (see Appendix A-5).

Following this, the user must indicate whether dose calculations are to be made. Typing '0' will result in food concentrations of individual radionuclides only, and typing '1' will enable dose calculations to be made. If dose calculations are demanded, the name of the file of the dose factors to be used must be supplied. A total of five different sets of dose factors have been implemented in NEPTUN (Appendices A-8 to A-12). It is important to realize that DOS.DAT, A2ICR.DAT and A26IC.DAT contain adult dose factors while CUSNR.DAT and C26IC.DAT involve infant dose factors. Therefore, all these files at be used with appropriate diets.

Next the program asks for a radionuclide. Basically, only those in CFAC.DAT are allowed and the appropriate symbol used in that file must be supplied (Appendix A-3). If another radionuclide is selected or a typing error occurs, a different radionuclide will be automatically demanded. If a specified radionuclide is missing in a selected dose factor file, dose calculations will be skipped and an appropriate message will be printed during execution. The request for a radionuclide can also be responded to by '0', which will direct execution back to the start, or by '9', which will terminate execution. If dose calculations have not been requested, '1' will lead execution back to food type specification. If dose calculations have been specified, it will lead to printing of a dose summary for all the radionuclides entered during a given run.

If a proper radionuclide symbol has been entered, the user must next supply freshwater concentration in Bq/L, provided drinking water or any or all of the food types 2 to 4 have been specified. Otherwise, the user is asked to supply salt-water concentration in Bq/L only. After specification of freshwater and/or salt-water concentrations, execution returns to radionuclide specification.

Normally execution is terminated during radionuclide specification. However, if a dose summary for the combined radionuclides is demanded during radionuclide specification, the user is asked whether termination is desired. '0' will direct execution back to the start and '1' will cause termination of execution.

7.2 CFAC.DAT FILE - CONCENTRATION FACTORS (Appendix A-3)

CFAC.DAT contains data for 221 radionuclides. The exact radionuclide symbol given in this file must be used when specifying radionuclides during execution. Each radionuclide is accompanied by seven values. These are listed in the order

1. Radiological decay constant (λ_i in 1/h) which is converted in NEPTUN to 1/d (see equations (4) and (5))
2. Concentration factor for freshwater fish (T_{2i} in L/kg)
3. Concentration factor for freshwater invertebrates (T_{3i} in L/kg)
4. Concentration factor for freshwater plants (T_{4i} in L/kg)
5. Concentration factor for salt-water fish (T_{5i} in L/kg)
6. Concentration factor for salt-water invertebrates (T_{6i} in L/kg)
7. Concentration factor for salt-water plants (T_{7i} in L/kg).

The sources of these concentration factors are given in Appendix A-3. Additional radionuclides can be readily added to CFAC.DAT, provided the symbol used is unique and the radiological decay constant and all the concentration factors are known.

7.3 THOLD.DAT FILE - HOLD-UP TIMES (Appendix A-4)

THOLD.DAT contains the hold-up times (t_1 and t_f in d) for drinking water and the six food types. Depending on food type, the hold-up time may include delays due to commercial processing and storing, transportation, and storage at home prior to consumption. The values listed are exemplary only and they can be readily changed. Zero values can be used.

Hold-up times for aquatic food types appear to be highly variable. In HERMES (Fletcher and Dotson, 1971), no hold-up times were defined for most food types other than non-commercial river fish and drinking water, which were assumed to have hold-up times of 3 and 0 days, respectively. In ARRRG (Soldat et al., 1974), hold-up time is an input variable which must be assigned values by the user. In AQUAMAN (Schaeffer and Ethier, 1979), no hold-up times need to be specified because this code does not involve a decay term (see equations (2) and (3)). The USNRC 1.109 Regulatory Guide (1977) indicates that hold-up times can be at least one day for each food type. For population dose estimates, it recommends the use of 7, 10 and 1 day for sport fish, commercial fish and drinking water, respectively.

Hold-up times are only important for short-lived radionuclides; for long-lived radionuclides they have little or no effect on food concentrations and dose estimates.

7.4 DIET.DAT FILE - DIETS (Appendix A-5)

DIET.DAT contains diets 1 to 30 for drinking water and the six food types. The values listed are ingestion rates (L/d or kg/d) which, during execution of NEPTUN, are converted to annual ingestion rates (I_l in L/a and I_f in kg/a). The diet numbers of DIET.DAT correspond to the diet numbers and names in the NAME.DAT file. Thus changes in DIET.DAT may also necessitate changes in NAME.DAT.

Currently, only diet 30 has been implemented as a test diet. The values chosen are purely exemplary. Additional diets can be readily entered.

Little information is readily available on ingestion rates of aquatic food types. In ARRRG (Soldat et al., 1974), ingestion rate is an input variable to be assigned values by the user. However, in HERMES (Fletcher and Dotson, 1971), diets are evaluated comprehensively and ingestion rates are derived for processed ocean fish, shellfish, and fresh ocean fish and sports fish, for urban and rural farming, and for non-farming households, in the North Central U.S. Average and maximum values are given for children, teenagers and adults. The USNRC 1.109 Regulatory Guide (1977) recommends 6.9 kg/a, 1.0 kg/a and 370 L/a for the average adult consumption of fish, seafood and drinking water, respectively. The corresponding maximum values for adults are 21.0 kg/a, 5.0 kg/a and 730 L/a, respectively. Values are also recommended for infants, children and teenagers. In AQUAMAN (Shaeffer and Ethier, 1979), man is assumed to consume 20 g/d of fish and 1.2 L/d of water. However, these values can be readily changed.

7.5 LABEL.DAT FILE (Appendix A-6)

LABEL.DAT contains labels for the output of all model variables.

7.6 NAME.DAT FILE (Appendix A-7)

NAME.DAT contains numbers and labels of food and diet types as well as the names and labels of the five dose factor files. These data are used for output purposes. In order to keep the output of NEPTUN as complete as possible, diets added to DIET.DAT must be given labels in the NAME.DAT file under the appropriate diet number.

7.7 DOS.DAT FILE - FOOD DOSE FACTORS (Appendix A-8)

The dose factors listed in DOS.DAT are for adults. They were taken from FOOD II (Zach, 1978), and are essentially those listed by Baker (1977). They are for one year's chronic ingestion at a uniform rate involving a 50-year dose commitment. The factors were derived using ICRP 2 (1959) models (Baker et al., 1976). Each radionuclide is accompanied by seven dose factors (mrem/pCi), which are listed in the order of

1. Dose factor for whole body.
2. Dose factor for GI-LLI (gastrointestinal - lower large intestine).
3. Dose factor for thyroid.
4. Dose factor for bone.
5. Dose factor for liver.
6. Dose factor for lung.
7. Dose factor for kidney.

These dose factors are converted in NEPTUN to Sv/Bq (V_{ij}) by using a conversion factor of 0.00001 Sv/mrem per 0.037 Bq/pCi or 2.7×10^{-4} Sv·pCi·mrem^{-1}·Bq^{-1}.

7.8 A2ICR.DAT FILE - ICRP 2 ADULT DOSE FACTORS (Appendix A-9)

The dose factors listed in A2ICR.DAT were derived at WNRE using ICRP 2 (1959) methodologies. The values are for adults and for one year's chronic ingestion at a uniform rate involving a 50-year dose commitment. Thus, the dose factors in A2ICR.DAT are very similar to those in DOS.DAT, and the values are listed in the same order. However, the units of the two sets of dose factors differ. The values in A2ICR.DAT are in mrem/μCi, while those in DOS.DAT are in mrem/pCi. In NEPTUN the dose factors in A2ICR.DAT are converted to Sv/Bq (V_{ij}) by using a conversion factor of 0.00001 Sv/mrem per 37 000 Bq/μCi or 2.7×10^{-10} Sv·μCi·mrem^{-1}·Bq^{-1}.

7.9 CUSNR.DAT FILE - USNRC 1.109 INFANT DOSE FACTORS (Appendix A-10)

The dose factors listed in CUSNR.DAT are for infants, and were taken from the USNRC 1.109 Regulatory Guide (1977). These values can be traced to Hoenes and Soldat (1977), who used primarily ICRP 2 (1959) models in their calculations. The dose factors are based on continuous intake over a one-year environmental exposure period, and an associated dose commitment extending over a 50-year period from initiation of intake. The dose factors are in mrem/Ci and they are listed in the same order as those in DOS.DAT. In NEPTUN, the dose factors in CUSNR.DAT are converted to Sv/Bq (V_{ij}) by applying a conversion factor of 0.00001 Sv/mrem per 0.037 Bq/pCi or 2.7×10^{-4} Sv·pCi·mrem^{-1}·Bq^{-1}.

7.10 A26IC.DAT FILE - ICRP 26 ADULT DOSE FACTORS (Appendix A-11)

The values listed in A26IC.DAT are stochastic dose conversion factors for adults in rem/μCi based on ICRP 26 methodologies. All the values were taken from Johnson et al. (1979). Thus, they are for one year's chronic ingestion at a uniform rate, involving a 50-year dose commitment. In NEPTUN, the dose factors in A26IC.DAT are converted to Sv/Bq (V_i) by using a conversion factor of 0.01 Sv/rem per 37 000 Bq/μCi or 2.7 x 10^{-7} Sv·μCi·rem^{-1}.Bq^{-1}. A26IC.DAT also includes information on the daughters considered in the calculations of the dose factors (see also Johnson et al., 1979).

7.11 C26IC.DAT FILE - ICRP 26 INFANT DOSE FACTORS (Appendix A-12)

The values listed in C26IC.DAT are stochastic dose factors for infants (rem/μCi) and are otherwise analogous to the adult factors in A26IC.DAT. They were taken from Johnson et al. (1979) and are based on ICRP 26 models (1977), using one-year's chronic ingestion at a uniform rate and a 50-year dose commitment.

8. OUTPUT

Depending on the job control language (Appendix A-2), NEPTUN displays output on a local terminal or an auxiliary high-speed printer. The first option allows rapid feedback, but is slow when many runs are executed; the second option has slower feedback, but is fast when many runs are made.

Depending on the option selected (Table 1), the output may contain complete listings of food and diet types, dose factor file names and model variables. The latter option includes concentration and dose factors for the selected radionuclides.

The output for each radionuclide includes a listing of the variable values or options chosen by the user during execution. For each radionuclide, a table of concentrations is printed, which includes a series of four values for each of the food types specified (Appendix A-2). These are listed in the order

1. Concentration in edible portion of plant or animal product (Bq/L or Bq/kg). These values are based on equations (4) and (5) before multiplying by ingestion rates (I_l or I_f) and dose factors (V_{ij}).

2. Ingestion rates (L/d or kg/d) as listed in DIET.DAT for the specified diet. Essentially, these values are converted during execution to the yearly ingestion rates (I_l and I_f) used in equations (4) and (5).

3. Radionuclide ingestion rates (Bq/d). These rates are the product of the values listed in columns one and two.

4. Percentage contribution of each food type to the total daily or annual radionuclide ingestion rate.

The table of concentrations also includes total daily and yearly radionuclide ingestion rates.

Provided dose calculations have been specified, the output for each radionuclide includes a table of doses. The format of this table is dependent on the dose factor file chosen (Appendix A-2).

For DOS.DAT, A2ICR.DAT and CUSWR.DAT, the table of doses contains doses (Sv/a) to the whole body and six individual internal organs for each of the food types chosen (D_{lij} and D_{fij}). This is followed by dose totals (TD_{ij}), and percentage contribution of these total doses to the whole body and the six individual organs, to the grand total dose. Although this grand total dose has no meaning, since individual doses are not additive, the percentages allow rapid assessment of the relative magnitude of the doses to the whole body and the internal organs.

For A26IC.DAT and C26IC.DAT, the table of dose (Sv/a) contains stochastic doses for each of the specified food types (D_{li} and D_{fi}).

This is followed by the total stochastic dose (TD_i). No percentage dose contributions have been included for the food types, since these percentages correspond exactly to those listed in the table of concentrations.

In addition to the table of doses for individual radionuclides, NEPTUN can also produce summaries of doses (Table 1). These summaries include the doses of all the radionuclides chosen during a given run (Appendix A-2). A maximum of 100 radionuclides can be included in each run.

For DOS.DAT, A2ICR.DAT and CUSNR.DAT, the summary of doses (Sv/a) is essentially a list of the total doses to the whole body and individual internal organs (TD_{ij}) for each radionuclide. This is followed by the total doses due to all the radionuclides (GTD_j), and a list of percentage contributions. The percentages in this list give the contribution of each radionuclide to the total dose to the whole body and the internal organs.

For A26IC.DAT and C26IC.DAT, the summary of doses (Sv/a) is a list of the total stochastic doses (TD_i) for each radionuclide. This is followed by a total stochastic dose (GTD) for all the radionuclides. Percentage contributions to this dose by individual radionuclides have also been included.

For ICRP 26 adult and infant doses, the summary also includes a table of stochastic dose consequence ratios. To emphasize the dependence of these ratios on food and diet types and the dose factors, the number of freshwater and salt-water food types, the diet type and the dose factor file name are also printed out. The table is arranged in four columns. These are

1. Total dose (Sv/a) for radionuclide i due to drinking water and to freshwater food types 2 to 4 (see equation (10)).

2. Stochastic dose consequence ratio for radionuclide i due to drinking water, and to freshwater food types 2 to 4 (SDR_{ifw} in $Sv \cdot L \cdot a^{-1} \cdot Bq^{-1}$).

3. Total dose (Sv/a) for radionuclide i due to salt-water food types 5 to 7 (see equation (11)).

4. Stochastic dose consequence ratio for radionuclide i due to salt-water food types 5 to 7 (SDR_{iSw} in $Sv \cdot L \cdot a^{-1} \cdot Bq^{-1}$).

9. UPDATING AND EXPANSION

Without changing the actual model, NEPTUN's estimates of radionuclide concentrations in aquatic food products, and the resulting doses to man, can be improved by continuous updating of the values of all the model parameters as better data become available. This is particularly true for the concentration factors in the CFAC.DAT file.

NEPTUN can be readily expanded by adding more radionuclides to the CFAC.DAT file and/or to the dose factor files. The only requirement is that all the radionuclide symbols are unique and consistent among all files. In order to allow dose calculations, radionuclides must be included in the CFAC.DAT file.

The addition of new food types and dose factor files requires fairly extensive changes in NEP.F4. This is particularly true for ICRP 26 non-stochastic dose factors.

10. REFERENCES

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TABLE 1

SUMMARY OF INTERACTIVE DIALOG OF NEPTUN GIVING
QUESTIONS POSED AND USER SUPPLIED RESPONSES

1. LISTING OF FOOD TYPES?	0	Directly to question 2.
	1	List is typed and then to question 2.
	9	List is typed and then end of execution.
2. LISTING OF DIET TYPES?	0	Directly to question 3.
	1	List is typed and then to question 3.
	9	List is typed and then end of execution.
3. LISTING OF DOSE FACTOR FILE NAMES?	0	Directly to question 4.
	1	List is typed and then to question 4.
	9	List is typed and then end of execution.
4. LISTING OF ALL MODEL VARIABLES?	0	Variables will not be printed out.
	1	Variables will be printed out.
5. WHICH FOOD TYPES?	0	Food type not specified.
	1	Food type specified, e.g., '1111111' types 1 to 7 specified '0100100' types 2 and 5 specified
6. MISTAKES?	0	To question 7.
	1	Back to question 5.
7. WHICH DIET TYPE?		Specify diet number as implemented in DIET.DAT, e.g., '30' specifies test diet.
8. DOSE CALCULATIONS?	0	Directly to question 10.
	1	To question 9.
9. WHICH DOSE FACTOR FILE?		Specify dose factor file name as listed in NAME.DAT, e.g., 'DOS.DAT' specifies Battelle dose factors.
10. NUCLIDE?		Specify radionuclide symbol as listed in CFAC.DAT, e.g., 'SR90', and then to question 11. If symbol is not listed in CFAC.DAT question 10 is repeated.
	0	Back to question 1.
	1	If dose calculations have not been specified, back to question 1; if dose calculations have been specified, summaries will be first printed out and then to question 13.
	9	End of execution
11. FRESHWATER CONCENTRATION (Bq/L)?		Supply freshwater concentration and then to question 12, or, if no salt-water food types have been specified, back to question 10. Question 11 is only posed if drinking water or any or all of the food types 2-4 have been specified.
12. SALT-WATER CONCENTRATION (Bq/L)?		Supply salt-water concentration and then back to question 10.
13. TERMINATION?	0	Back to question 1.
	1	End of execution.

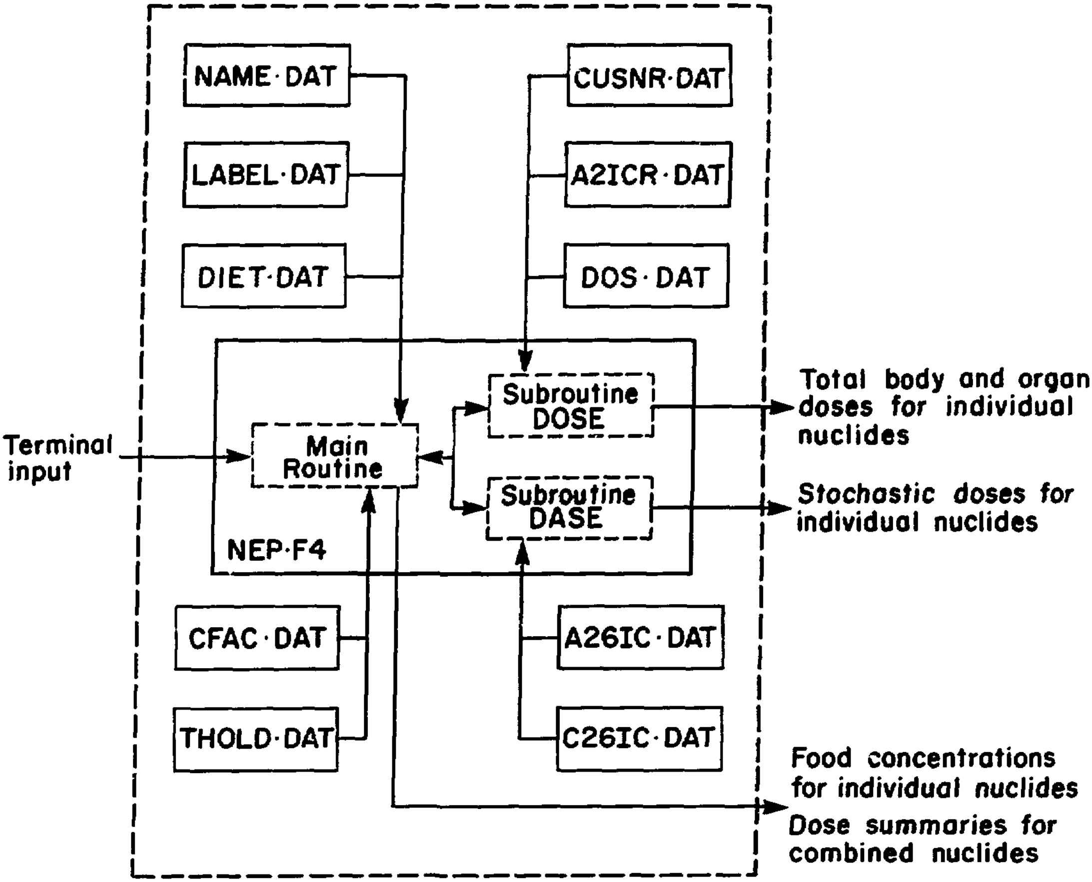

FIGURE 1: Organization of NEPTUN showing NEP.F4 with its main routine and the two dose subroutines DOSE and DASE. The main routine receives interactive input from the terminal and five associated disc files. DOSE and DASE receive input from three and two disc files, respectively. Information is interchanged between the main and subroutines. The latter produce dose output files for individual radionuclides, and the former produces food concentration output files for individual radionuclides and also dose summaries for the combined radionuclides.

APPENDIX A

A-1. LISTING OF NEP.F4 FILE

```
C        NEPTUN WAS CONCEIVED AND WRITTEN BY PETO ZACH OF
C        ATOMIC ENERGY OF CANADA LIMITED AT THE WHITESHELL
C        NUCLEAR RESEARCH ESTABLISHMENT IN PINAWA MANITOBA
C        IN DECEMBER 1979.
C
C        NEPTUN CALCULATES RADIONUCLIDE CONCENTRATIONS
C        IN DRINKING WATER AND SIX AQUATIC FOOD TYPES
C        AND THE RESULTING DOSES TO MAN. NEPTUN CONSISTS
C        OF A MAIN ROUTINE AND THE SUBROUTINES DOSE AND
C        DASE. IT ALSO INVOLVES TEN DATA FILES: DIET.DAT,
C        NAME.DAT, LABEL.DAT, THOLD.DAT, CFAC.DAT, DOS.DAT,
C        A2ICR.DAT, CUSNR.DAT, C26IC.DAT AND A26IC.DAT.
C        THE LAST FIVE FILES ARE DOSE FACTOR FILES WHICH
C        ARE SHARED WITH THE TERRESTRIAL FOOD CHAIN MODEL
C        FOODIII (SEE REPORT AECL-6305).
C        NEPTUN HAS BEEN FULLY DOCUMENTED IN REPORT AECL-6450
C
C
         COMMON /MT1/ FILN,CONC,YN,NUC1,NUC2,NSDO,NCOUNT,SDO
         COMMON /MT2/ FILNA,FILNB,FILNC,FILND,FILNE,ILV
         COMMON /MT3/ NAME1,NAME3,LAUB,CWIFW,CWISW,DCR,WTDOS
         DIMENSION TH(7),YN(7),NAME1(7,4),NAME2(30,4),NAME3(5,15)
         DIMENSION FILN(2),LAUB(22,8),DUP(8),ISR(7),TCOFF(7),CONC(7,4)
         DIMENSION NSDO(100,2),SDO(100,7),TSDO(7),PSDO(100,7),TPSDO(7)
         DIMENSION ULA(9),ULB(23),ULC(23),ULD(11),DIETT(7,30),DCR(100,2)
         DIMENSION WTDOS(100,2)
         INTEGER YN
         DATA FILNA/'DOS.D'/,FILNB/'CUSNR'/,FILNC/'A2ICR'/
         DATA FILND/'C26IC'/,FILNE/'A26IC'/
         DATA ULA/9*'*'/,ULB/23*'-'/,ULC/23*'*'/,ULD/11*'-'/
         OPEN (UNIT=10,DEVICE='DSK',ACCESS='SEQIN',FILE='DIET')
         OPEN (UNIT=11,DEVICE='DSK',ACCESS='SEQIN',FILE='NAME')
         OPEN (UNIT=12,DEVICE='DSK',ACCESS='SEQIN',FILE='LABEL')
         OPEN (UNIT=13,DEVICE='DSK',ACCESS='SEQIN',FILE='THOLD')
         OPEN (UNIT=14,DEVICE='DSK',ACCESS='SEQIN',FILE='CFAC')
C        CRIT IS CRITERION FOR PREVENTING UNDERFLOW IN EXPONENTS
         CRIT=80.0
C        READING DIET.DAT FILE - DIETS
         LL=1
         LT=10
  115    READ(10,100)
  100    FORMAT(//)
         DO 101 I=1,7
         READ(10,102) (DIETT(I,J),J=LL,LT)
  102    FORMAT(10X,10F7.0)
  101    CONTINUE
         LL=LL+10
         LT=LT+10
         IF(LT.LE.30) GO TO 115
C        READING NAME.DAT FILE - LABEL
```

```
C       NAMES OF FOOD TYPES
        DO 110 I=1,7
        READ(11,111)  (NAME1(I,J),J=1,4)
 111    FORMAT(3A5,A2)
 110    CONTINUE
C       NAMES OF DIET TYPES
        DO 112 I=1,30
        READ(11,111)  (NAME2(I,J),J=1,4)
 112    CONTINUE
C       NAMES OF DOSE FACTOR FILES
        DO 113 I=1,5
        READ(11,114)  (NAME3(I,J),J=1,15)
 114    FORMAT(15A5)
 113    CONTINUE
C       READING LABEL.DAT FILE - LABELS FOR OUTPUT OF MODEL VARIABLES
        DO 120 I=1,22
        READ(12,123)  (LAUB(I,J),J=1,8)
 123    FORMAT(8A5)
 120    CONTINUE
C       READING THOLD.DAT FILE - HOLDUP TIMES
        READ(13,132)
 132    FORMAT(/)
        DO 130 I=1,7
        READ(13,131)  TH(I)
 131    FORMAT(20X,F5.0)
 130    CONTINUE
C       TYPING NAMES OF FOOD TYPES
 232    TYPE 140
 140    FORMAT(' ','LISTING OF FOOD TYPE NAMES (1,9 OR 0) ? '$)
C       1 - LIST IS TYPED AND EXECUTION CONTINUES
C       9 - LIST IS TYPED AND EXECUTION STOPS
C       0 - NO LIST IS TYPED AND EXECUTION CONTINUES
        ACCEPT 141,IFTL
 141    FORMAT(I1)
        IF(IFTL.EQ.0) GO TO 142
        TYPE 143
 143    FORMAT(' ')
        DO 144 I=1,7
        TYPE 145,(NAME1(I,J),J=1,4)
 145    FORMAT(' ',3A5,A2)
 144    CONTINUE
        IF(IFTL.EQ.9) STOP
        TYPE 462
 462    FORMAT('0')
C       TYPING NAMES OF DIET TYPES
 142    TYPE 150
 150    FORMAT(' ','LISTING OF DIET TYPE NAMES (1,9 OR 0) ? '$)
        ACCEPT 141,IDT
        IF(IDT.EQ.0) GO TO 151
        TYPE 143
        DO 152 I=1,30
        TYPE 145,(NAME2(I,J),J=1,4)
```

```
 152    CONTINUE
        IF(IDT.EQ.9) STOP
        TYPE 462
C       TYPING NAMES OF DOSE FACTOR FILES
 151    TYPE 160
 160    FORMAT(' ','LISTING OF DOSE FACTOR FILE NAMES (1,9 OR 0) ? '$)
        ACCEPT 141,IDO
        IF(IDO.EQ.0) GO TO 161
        TYPE 143
        DO 162 I=1,5
        TYPE 163,(NAME3(I,J),J=1,15)
 163    FORMAT(' ',15A5)
 162    CONTINUE
        IF(IDO.EQ.9) STOP
        TYPE 462
C       TYPING ALL VARIABLES
 161    TYPE 170
 170    FORMAT(' ','LISTING OF ALL VARIABLES (1,9 OR 0) ? '$)
        ACCEPT 141,ILV
        IF(ILV.EQ.0) GO TO 171
C       ASSIGNING VALUES TO OUTPUT FILE
        DO 172 I=1,7
        OUP(I)=TH(I)
 172    CONTINUE
        OUP(8)=CRIT
        WRITE(6,143)
        WRITE(6,173)
 173    FORMAT(' ','GENERAL MODEL VARIABLES')
        WRITE(6,143)
        DO 174 I=1,8
        WRITE(6,175) (LAUB(I,J),J=1,8),OUP(I)
 175    FORMAT(' ',8A5,F6.2)
 174    CONTINUE
        IF(ILV.EQ.9) STOP
        WRITE(6,462)
C       CHOOSING FOOD TYPES
 171    TYPE 200
 200    FORMAT(' ','WHICH FOOD TYPES (1 OR 0 IN A STRING) ? '$)
C       1 - FOOD TYPE CHOSEN ('1' STANDS FOR 'YES')
C       0 - FOOD TYPE NOT CHOSEN ('0' STANDS FOR 'NO')
        ACCEPT 201,(YN(I),I=1,7)
 201    FORMAT(7I1)
C       LISTING CHOSEN FOOD TYPES
        TYPE 202
 202    FORMAT(' ','THE FOLLOWING FOOD TYPES HAVE BEEN SPECIFIED :')
        K=0
        DO 203 I=1,7
        IF(YN(I).EQ.0) GO TO 203
        K=K+1
        ISR(K)=I
 203    CONTINUE
        NTOP=K
```

```
      TYPE 204,(ISR(I),I=1,NTOP)
204   FORMAT(7I3)
C     MISTAKE OPTION
      TYPE 205
205   FORMAT(' ','MISTAKES (0 OR 1) ?  $)
      ACCEPT 141,MIST
      IF(MIST.EQ.0) GO TO 206
      TYPE 207
207   FORMAT(' ','TRY AGAIN')
      GO TO 171
C     DETERMINING THE NUMBER OF FRESHWATER FOOD TYPES
206   ITFW=0
      DO 208 I=1,NTOP
      IF(ISR(I).LE.4) ITFW=ITFW+1
208   CONTINUE
C     CHOSING DIET TYPE
      TYPE 210
210   FORMAT(' ','WHICH DIET TYPE (1-30) ?  $)
      ACCEPT 211,IDIE
211   FORMAT (I2)
C     CHOOSING DOSE FACTORS
      TYPE 220
220   FORMAT(' ','DOSE CALCULATIONS (1 OR 0) ? '$)
      ACCEPT 141,IDOSC
      IF(IDOSC.EQ.0) GO TO 221
      TYPE 222
222   FORMAT(' ','WHICH DOSE FACTORS (FILE NAME) ? '$)
      ACCEPT 223,FILN(1),FILN(2)
223   FORMAT(2A5)
C     INITIALIZING DOSE SUMMARY VARIABLES
      NCOUNT=0
      DO 224 I=1,7
      TSDO(I)=0.0
      TPSDO(I)=0.0
224   CONTINUE
C     SETTING DIET VALUES
221   DO 225 I=1,7
      IF(YN(I).EQ.0) GO TO 225
      CONC(I,2)=DIETT(I,IDIE)
225   CONTINUE
      GO TO 231
252   TYPE 251
251   FORMAT(' ','NO DOSE SUMMARY POSSIBLE WITH ZERO NUCLIDES')
C     CHOSING NUCLIDE
231   TYPE 230
230   FORMAT(' ','WHICH NUCLIDE ? '$)
239   ACCEPT 250,NUC1,NUC2
250   FORMAT (A5,A3)
      IF(NUC1.EQ.5H1     .AND.NCOUNT.EQ.0) GO TO 252
      IF(NUC1.EQ.5H0     ) GO TO 232
      IF(NUC1.EQ.5H1     .AND.IDOSC.EQ.0) GO TO 232
      IF(NUC1.EQ.5H1     .AND.IDOSC.EQ.1) GO TO 233
```

```
      IF(NUC1.EQ.5H9     ) STOP
C     READING CFAC.DAT AND SEARCHING FOR NUCLIDE
      READ(14,190)
 235  READ(14,234,END=237) NUK1,NUK2,DC,(TCOFF(I),I=2,7)
 234  FORMAT(A5,A3,E8.0,6(E9.0))
      IF(NUC1.NE.NUK1.OR.NUC2.NE.NUK2) GO TO 235
      REWIND 14
C     COUNTING THE NUMBER OF NUCLIDES
      NCOUNT=NCOUNT+1
C     FOR DRINKING WATER THE CONCENTRATION FACTOR IS SET TO  1.0
      TCOFF(1)=1.0
      GO TO 236
 237  REWIND 14
C     SPECIFICATION OF A WRONG OR AN UNLISTED NUCLIDE SYMBOL
      TYPE 238
 238  FORMAT(' ', NUCLIDE NOT IN CFAC.DAT FILE - TRY AGAIN')
      GO TO 231
C     SETTING WATER CONTAMINATION LEVELS
C     FRESHWATER
 236  IFRESH=0
      DO 240 I=1,4
      IF(YN(I).EQ.1) IFRESH=1
 240  CONTINUE
C     SALTWATER
      ISALT=0
      DO 241 I=5,7
      IF(YN(I).EQ.1) ISALT=1
 241  CONTINUE
      CWIFW=0.0
      CWISW=0.0
      IF(IFRESH.EQ.0) GO TO 242
      TYPE 243
 243  FORMAT('  ','FRESHWATER CONCENTRATION (BQ/L) ? '$)
      ACCEPT 244,CWIFW
 244  FORMAT(F10.0)
 242  IF(ISALT.EQ.0) GO TO 248
      TYPE 246
 246  FORMAT(' ','SALTWATER CONCENTRATION (BQ/L) ? '$)
      ACCEPT 244,CWISW
 248  IF(CWIFW.GT.0.0.OR.CWISW.GT.0.0) GO TO 245
C     NO CONTAMINATION SPECIFIED
      TYPE 249
 249  FORMAT(' ','NO CONTAMINATION SPECIFIED - TRY AGAIN')
      GO TO 231
C     CONVERTING DECAY CONSTANT FROM 1/H TO 1/D
 245  DDC=DC
      DC=DC*24.0
C     INITIALIZING NUCLIDE SPECIFIC VARIABLES
      TCON=0.0
      TPCON=0.0
      LDEC=0
C     CALCULATING FOOD CONCENTRATIONS
```

```
      DO 300 I=1,7
      IF(YN(I).EQ.0) GO TO 300
C     SETTING WATER CONCENTRATION
      CWI=CWIFW
      IF(I.GT.4) CWI=CWISW
C     TESTING FOR UNDERFLOW OF EXPONENT
      UFLOW=DC*TH(I)
      IF(UFLOW.GT.CRIT) GO TO 301
      CONC(I,1)=CWI*TCOFF(I)*(EXP(-UFLOW))
      GO TO 300
C     FOR VERY SHORT-LIVED NUCLIDES DECAY DURING HOLDUP IS
C     ASSUMED TO BE COMPLETE
 301  LDEC=1
      CONC(I,1)=0.0
 300  CONTINUE
C     CALCULATING DAILY INGESTION RATES AND TOTAL
      DO 302 I=1,7
      IF(YN(I).EQ.0) GO TO 302
      CONC(I,3)=CONC(I,1)*CONC(I,2)
      TCON=TCON+CONC(I,3)
 302  CONTINUE
C     CALCULATING INTAKE PERCENTAGES AND TOTAL
      DO 303 I=1,7
      IF(YN(I).EQ.0) GO TO 303
      IF(TCON.EQ.0.0) CONC(I,4)=0.0
      IF(TCON.GT.0.0) CONC(I,4)=(100.0/TCON)*CONC(I,3)
      TPCON=TPCON+CONC(I,4)
 303  CONTINUE
      YTCON=TCON*365.25
C     WRITING INPUT DATA, FOOD CONCENTRATIONS AND CONSUMPTION RATES
      WRITE(6,143)
      WRITE(6,400) NUK1,NUK2
 400  FORMAT('-','NUCLIDE :  ',A5,A3)
      WRITE(6,401) ULA
 401  FORMAT (' ',9A1)
      WRITE(6,143)
      IF(LDEC.EQ.0) GO TO 423
      WRITE(6,418)
 418  FORMAT(' ','FOR SOME OR ALL FOOD TYPES DECAY DURING HOLDUP IS ')
      WRITE(6,419)
 419  FORMAT(' ','ASSUMED TO BE COMPLETE DUE TO THE VERY SHORT HALF ')
      WRITE(6,425)
 425  FORMAT(' ','LIFE AND THE LENGTH OF THE HOLDUP TIME')
      WRITE(6,143)
 423  IF(IFRESH.EQ.1) WRITE(6,402) CWIFW
 402  FORMAT(' ','CONCENTRATION IN FRESHWATER =',E11.5,'  (BQ/L)')
      IF(ISALT.EQ.1) WRITE(6,403) CWISW
 403  FORMAT(' ','CONCENTRATION IN SALTWATER  =',E11.5,'  (BQ/L)')
      WRITE(6,143)
      WRITE(6,404)
 404  FORMAT(' ',' TABLE OF CONCENTRATION')
      WRITE(6,405) ULB
```

```
  405     FORMAT('      ',23A1)
          WRITE(6,406) (NAME2(IDIE,J),J=1,4)
  406     FORMAT('   , DIET TYPE :   ',3A5,A2)
          WRITE(6,407)
  407     FORMAT('0',40X,'CONSUMPTION RATE')
          WRITE(6,408)
  408     FORMAT(' ',22X,'(BQ/KG,BQ/L)',3X,'(KG/D,L/D)',6X,'(BQ/D)',3X,'P
         1ECENTAGES')
          WRITE(6,143)
          DO 410 I=1,7
          IF(YN(I).EQ.0) GO TO 410
          WRITE(6,411) (NAME1(I,J),J=1,4),(CONC(I,K),K=1,4)
  411     FORMAT(' ',3A5,A2,1X,3(4X,E10.4),4X,F6.2)
  410     CONTINUE
          WRITE(6,412) TCON,TPCON
  412     FORMAT('0',2X,'TOTAL INTAKE (BQ/D)',29X,E10.4,4X,F6.2)
          WRITE(6,417) YTCON
  417     FORMAT(' ',2X,'TOTAL INTAKE (BQ/Y)',29X,E10.4)
C         WRITING NUCLIDE SPECIFIC VARIABLES
          IF(ILV.EQ.0) GO TO 413
          WRITE(6,414)
  414     FORMAT('0','NUCLIDE SPECIFIC VARIABLES')
          WRITE(6,143)
          WRITE(6,416) (LAUB(9,J),J=1,8),DDC
  416     FORMAT(' ',8A5,E10.4)
          DO 415 I=10,15
          K=I-8
          IF(YN(K).EQ.1) WRITE(6,416) (LAUB(I,J),J=1,8),TCOFF(K)
  415     CONTINUE
  413     IF(IDOSC.EQ.1) GO TO 422
          WRITE(6,462)
          GO TO 231
C         SWITCHING TO DOSE SUBROUTINES
  422     IF(FILN(1).EQ.FILND.OR.FILN(1).EQ.FILNE) GO TO 420
C         SUBROUTINE DOSE IS FOR DOS.DAT, A2ICR.DAT AND CUSNR.DAT
          CALL DOSE
          GO TO 231
C         SUBROUTINE DASE IS FOR C26ICR.DAT AND A26ICR.DAT
  420     CALL DASE
          GO TO 231
  233     IF(FILN(1).EQ.FILND.OR.FILN(1).EQ.FILNE) GO TO 421
C         WRITING DOSE SUMMARY FOR DC_.DAT, A2ICR.DAT AND CUSNR.DAT
          WRITE(6,430)
  430     FORMAT('-','SUMMARY OF DOSES (SV/Y)')
          WRITE(6,405) ULC
          M=1
          IF(FILN(1).EQ.FILNB) M=2
          IF(FILN(1).EQ.FILNC) M=3
          WRITE(6,163) (NAME3(M,J),J=1,15)
          WRITE(6,431)
  431     FORMAT('0',20X,'BODY',4X,'GI-LLI',3X,'THYROID',3X,'BONE',4X,'L
         1VER',5X,'LUNG',4X,'KIDNEY')
```

```
      WRITE(6,143)
      DO 432 I=1,NCOUNT
      WRITE(6,433) NSDO(I,1),NSDO(I,2),(SDO(I,J),J=1,7)
 433  FORMAT('  ',A5,A3,9X,7E9.3)
 432  CONTINUE
C     CALCULATING AND WRITING DOSE TOTALS
      DO 434 I=1,NCOUNT
      DO 435 J=1,7
      TSDO(J)=TSDO(J)+SDO(I,J)
 435  CONTINUE
 434  CONTINUE
      WRITE(6,436) (TSDO(J),J=1,7)
 436  FORMAT('0','TOTAL DOSES',6X,7E9.3)
C     CALCULATING AND WRITING PERCENTAGES
      DO 440 I=1,NCOUNT
      DO 441 J=1,7
      IF(TSDO(J).EQ.0.0) GO TO 470
      PSDO(I,J)=(100.0/TSDO(J))*SDO(I,J)
      GO TO 471
 470  PSDO(I,J)=0.0
 471  TPSDO(J)=TPSDO(J)+PSDO(I,J)
 441  CONTINUE
 440  CONTINUE
      WRITE(6,442)
 442  FORMAT('0','PERCENTAGES')
      WRITE(6,461) ULD
 461  FORMAT(' ',11A1)
      WRITE(6,431)
      WRITE(6,143)
      DO 443 I=1,NCOUNT
      WRITE(6,444) NSDO(I,1),NSDO(I,2),(PSDO(I,J),J=1,7)
 444  FORMAT(' ',A5,A3,7X,7F9.2)
 443  CONTINUE
      WRITE(6,445) (TPSDO(J),J=1,7)
 445  FORMAT('0','TOTAL',10X,7F9.2)
      GO TO 446
C     WRITING DOSE SUMMARY FOR C26IC.DAT AND A26IC.DAT
 421  WRITE(6,430)
      WRITE(6,405) ULC
      M=4
      IF(FILN(1).EQ.FILNE) M=5
      WRITE(6,163) (NAME3(M,J),J=1,15)
      WRITE(6,447)
 447  FORMAT('0',17X,'STOCHASTIC',3X,'PERCENTAGES')
C     CALCULATING TOTAL
      DO 450 I=1,NCOUNT
      TSDO(1)=TSDO(1)+SDO(I,1)
 450  CONTINUE
C     CALCULATING PERCENTAGES
      DO 451 I=1,NCOUNT
      PSDO(I,1)=(100.0/TSDO(1))*SDO(I,1)
      TPSDO(1)=TPSDO(1)+PSDO(I,1)
```

```
 451    CONTINUE
C       WRITING DOSES, PERCENTAGES AND TOTAL
        WRITE(6,143)
        DO 452 I=1,NCOUNT
        WRITE(6,453) NSDO(I,1),NSDO(I,2),SDO(I,1),PSDO(I,1)
 453    FORMAT('  ',A5,A3,9X,E9.3,6X,F6.2)
 452    CONTINUE
        WRITE(6,454) TSDO(1),TPSDO(1)
 454    FORMAT('0', TOTAL DOSE',7X,E9.3,6X,F6.2)
C       WRITING DOSE CONSEQUENCE RATIOS
        WRITE(6,480)
 480    FORMAT('-', DOSE CONSEQUENCE RATIOS (DOSE (SV/Y) / WATER CONCEN
       1TRATION (BQ/L))')
        WRITE(6,405) ULC
        IBSW=ITFW+1
        IF(IFRESH.EQ.1) WRITE(6,481) (ISR(I),I=1,ITFW)
 481    FORMAT('  ','FRESHWATER FOOD TYPES : ',4I2)
        IF(ISALT.EQ.1) WRITE(6,482) (ISR(I),I=IBSW,NTOP)
 482    FORMAT(' ','SALTWATER FOOD TYPES  : ',3I2)
        WRITE(6,406) (NAME2(IDIE,J),J=1,4)
        WRITE(6,163) (NAME3(M,J),J=1,15)
        WRITE(6,483)
 483    FORMAT('0',23X,'FRESHWATER',21X,'SALTWATER')
        WRITE(6,486)
 486    FORMAT('  ',15X,'INTAKE (SV/Y)',4X,'RATIO',8X,'INTAKE (SV/Y)',4X,
       1' RATIO')
        WRITE(6,143)
        DO 484 I=1,NCOUNT
        WRITE(6,485) NSDO(I,1),NSDO(I,2),WTDOS(I,1),DCR(I,1),WTDOS(I,2)
       1,DCR(I,2)
 485    FORMAT(' ',A5,A3,9X,E9.3,4X,E9.3,8X,E9.3,4X,E9.3)
 484    CONTINUE
C       TERMINATING EXECUTION
 446    TYPE 460
 460    FORMAT('-', TERMINATION OF EXECUTION (1 OR 0) ? '$)
        ACCEPT 141,ITERM
        IF(ITERM.EQ.0) GO TO 232
        STOP
        END
C
C
C
C
C       CALCULATING DOSES FOR DOS.DAT, A2ICR.DAT AND  CUSNR.DAT
        SUBROUTINE DOSE
        COMMON /MT1/ FILN,CONC,YN,NUC1,NUC2,NSDO,NCOUNT,SDO
        COMMON /MT2/ FILNA,FILNB,FILNC,FILND,FILNE,ILV
        COMMON /MT3/ NAME1,NAME3,LAUB,CWIFW,CWISW,DCR,WTDOS
        DIMENSION DOSFA(7),DOS(7,7),TDOS(7),DDOSF(7),PER(7)
        DIMENSION FILN(2),CONC(7,4),YN(7),NSDO(100,2),SDO(100,7)
        DIMENSION NAME1(7,4),NAME3(5,15),LAUB(22,8),ULB(21),DCR(100,2)
        DIMENSION WTDOS(100,2)
        INTEGER YN
        DATA ULB/21* - /
```

```
      OPEN (UNIT=15,DEVICE='DSK',ACCESS='SEQIN',DIALOG=FILN)
C     INITIALIZING
      DO 106 I=1,7
      TDOS(I)=0.0
 106  CONTINUE
      TTDOS=0.0
C     CONVERTING INTAKE BY MAN FROM 1/D TO 1/Y
      DO 100 I=1,7
      IF(YN(I).EQ.0) GO TO 100
      CONC(I,3)=CONC(I,3)*365.25
 100  CONTINUE
C     READING DOSE FACTOR FILE AND SEARCHING FOR NUCLIDE
      READ(15,101)
 101  FORMAT(/)
 103  READ(15,102,END=104) NUK1,NUK2,(DOSFA(J),J=1,7)
 102  FORMAT(A5,A3,E8.0,6E9.0)
      IF(NUC1.NE.NUK1.OR.NUC2.NE.NUK2) GO TO 103
      REWIND 15
      GO TO 110
 104  REWIND 15
C     SPECIFICATION OF AN UNLISTED NUCLIDE
      TYPE 105,FILN(1),FILN(2)
 105  FORMAT('0','NUCLIDE NOT IN ',2A5,' FILE - NO DOSE CALCULATIONS')
      CLOSE (UNIT=15,DEVICE='DSK',ACCESS='SEQIN',DIALOG=FILN)
      NCOUNT=NCOUNT-1
      RETURN
 110  IF(FILN(1).EQ.FILNC) GO TO 112
C     CONVERTING DOSE FACTORS OF DOS.DAT AND CUINR.DAT
C     FROM MREM/P CI TO SV/BQ
      DO 111 I=1,7
      ODOSF(I)=DOSFA(I)
      DOSFA(I)=DOSFA(I)*0.00001/0.037
 111  CONTINUE
      GO TO 130
C     CONVERTING DOSE FACTORS OF A2ICR.DAT
C     FROM MREM/MICRO CI TO SV/BQ
 112  DO 113 I=1,7
      ODOSF(I)=DOSFA(I)
      DOSFA(I)=DOSFA(I)*0.00001/37000.0
 113  CONTINUE
C     CALCULATING DOSES AND TOTALS
 130  DO 140 I=1,7
      IF(YN(I).EQ.0) GO TO 140
      DO 141 J=1,7
      DOS(I,J)=CONC(I,3)*DOSFA(J)
      TDOS(J)=TDOS(J)+DOS(I,J)
 141  CONTINUE
 140  CONTINUE
C     SAVING VALUES FOR DOSE SUMMARY
      NSDO(NCOUNT,1)=NUC1
      NSDO(NCOUNT,2)=NUC2
      DO 150 I=1,7
```

```
      SDO(NCOUNT,I)=TDOS(I)
 150  CONTINUE
C     CALCULATING PERCENTAGES
      DO 151 I=1,7
      TTDOS=TTDOS+TDOS(I)
 151  CONTINUE
      DO 152 I=1,7
      IF(TTDOS.GT.0.0) GO TO 153
      PER(I)=0.0
      GO TO 152
 153  PER(I)=(100.0/TTDOS)*TDOS(I)
 152  CONTINUE
C     WRITING TABLE OF DOSES FOR INDIVIDUAL NUCLIDES
      WRITE(6,160)
 160  FORMAT('0','TABLE OF DOSES (SV/Y)')
      WRITE(6,161) ULB
 161  FORMAT(' ',21A1)
      M=1
      IF(FILN(1).EQ.FILNB) M=2
      IF(FILN(1).EQ.FILNC) M=3
      WRITE(6,162) (NAME3(M,J),J=1,15)
 162  FORMAT(' ',15A5)
      WRITE(6,163)
 163  FORMAT('0',20X,'BODY',4X,'GI-LLI',3X,'THYROID',3X,'BONE',4X,'LI
     1VER',5X,'LUNG',4X,'KIDNEY')
      WRITE(6,164)
 164  FORMAT(' ')
      DO 165 I=1,7
      IF(YN(I).EQ.0) GO TO 165
      WRITE(6,166) (NAME1(I,J),J=1,4),(DOS(I,K),K=1,7)
 166  FORMAT(' ',3A5,A2,7E9.3)
 165  CONTINUE
      WRITE(6,167) (TDOS(J),J=1,7)
 167  FORMAT('0',2X,'TOTAL DOSES',4X,7E9.3)
      WRITE(6,168) (PER(I),I=1,7)
 168  FORMAT('0',2X,'PERCENTAGES',3X,7F9.2)
      IF(ILV.EQ.1) GO TO 180
      WRITE(6,181)
 181  FORMAT('-')
      CLOSE (UNIT=15,DEVICE='DSK',ACCESS='SEQIN',DIALOG=FILN)
      RETURN
C     WRITING NUCLIDE SPECIFIC DOSE VARIABLES
 180  WRITE(6,170)
 170  FORMAT('0','NUCLIDE SPECIFIC VARIABLES')
      IF(M.EQ.1.OR.M.EQ.2) WRITE(6,173)
 173  FORMAT('0',38X,'(MREM/PICO CI)',9X,'(SV/BQ)')
      IF(M.EQ.3) WRITE(6,174)
 174  FORMAT('0',38X,'(MREM/MICRO CI)',10X,'(SV/BQ)')
      WRITE(6,164)
      DO 171 I=16,22
      K=I-15
      WRITE(6,172) (LAUB(I,J),J=1,8),DDOSF(K),DOSFA(K)
```

```
 172    FORMAT(    ,3A5,E10.4,10X,E10.4)
 171    CONTINUE
        WRITE(6,181)
        CLOSE (UNIT=15,DEVICE='DSK',ACCESS='SEQIN',DIALOG=FILN)
        RETURN
        END
C
C       CALCULATING DOSES FOR A26IC.DAT AND C26IC.DAT
        SUBROUTINE DASE
        COMMON /MT1/ FILN,CONC,YN,NUC1,NUC2,NSDO,NCOUNT,SDO
        COMMON /MT2/ FILNA,FILNB,FILNC,FILND,FILNE,ILV
        COMMON /MT3/ NAME1,NAME3,LAUB,CWIFW,CWISW,DCR,WTDOS
        DIMENSION DOS(7)
        DIMENSION FILN(2),CONC(7,4),YN(7),NSDO(100,2),SDO(100,7)
        DIMENSION NAME1(7,4),NAME3(5,15),LAUB(22,8),ULB(21),DCR(100,2)
        DIMENSION WTDOS(100,2)
        INTEGER YN
        DATA ULB/21*'-'/
        OPEN (UNIT=15,DEVICE='DSK',ACCESS='SEQIN',DIALOG=FILN)
C       INITIALIZING
        TDOS=0.0
C       CONVERTING INTAKE BY MAN FROM 1/D TO 1/Y
        DO 100 I=1,7
        IF(YN(I).EQ.0) GO TO 100
        CONC(I,3)=CONC(I,3)*365.25
 100    CONTINUE
C       READING DOSE FACTOR FILE AND SEARCHING FOR NUCLIDE
        READ(15,101)
 101    FORMAT(/)
 103    READ(15,102,END=104) NUK1,NUK2,DOSFA
 102    FORMAT(A5,A3,2X,E10.0)
        IF(NUC1.NE.NUK1.OR.NUC2.NE.NUK2) GO TO 103
        REWIND 15
        GO TO 106
 104    REWIND 15
C       SPECIFICATION OF AN UNLISTED NUCLIDE
        TYPE 105,FILN(1),FILN(2)
 105    FORMAT('0','NUCLIDE NOT IN ',2A5,'FILE - NO DOSE CALCULATIONS')
        CLOSE (UNIT=15,DEVICE='DSK',ACCESS='SEQIN',DIALOG=FILN)
        NCOUNT=NCOUNT-1
        RETURN
C       CONVERTING DOSE FACTORS OF A26IC.DAT AND C26IC.DAT
C       FROM REM/MICRO CI TO SV/BQ
 106    ODOSF=DOSFA
        DOSFA=DOSFA*(0.01/37000.0)
C       CALCULATING DOSES AND TOTALS
        WTDOS(NCOUNT,1)=0.0
        WTDOS(NCOUNT,2)=0.0
        DO 110 I=1,7
        IF(YN(I).EQ.0) GO TO 110
C       STOCHASTIC DOSE
        DOS(I)=CONC(I,3)*DOSFA
```

```
      IF(I.LE.4) WTDOS(NCOUNT,1)=WTDOS(NCOUNT,1)+DOS(I)
      IF(I.GT.4) WTDOS(NCOUNT,2)=WTDOS(NCOUNT,2)+DOS(I)
 110  CONTINUE
      TDOS=WTDOS(NCOUNT,1)+WTDOS(NCOUNT,2)
C     SAVING VALUES FOR DOSE SUMMARY
      NSDO(NCOUNT,1)=NUC1
      NSDO(NCOUNT,2)=NUC2
      SDO(NCOUNT,1)=TDOS
C     CALCULATING DOSE CONSEQUENCE RATIOS
      DCR(NCOUNT,1)=0.0
      IF(CWIFW.GT.0.0) DCR(NCOUNT,1)=WTDOS(NCOUNT,1)/CWIFW
      DCR(NCOUNT,2)=0.0
      IF(CWISW.GT.0.0) DCR(NCOUNT,2)=WTDOS(NCOUNT,2)/CWISW
C     WRITING TABLE OF DOSES FOR INDIVIDUAL NUCLIDES
      WRITE(6,120)
 120  FORMAT('0','TABLE OF DOSES (SV/Y)')
      WRITE(6,121) ULB
 121  FORMAT(' ',21A1)
      M=4
      IF(FILN(1).EQ.FILNE) M=5
      WRITE(6,122) (NAME3(M,J),J=1,15)
 122  FORMAT(' ',15A5)
      WRITE(6,123)
 123  FORMAT('0',17X,'STOCHASTIC')
      WRITE(6,124)
 124  FORMAT(' ')
      DO 125 I=1,7
      IF(YN(I).EQ.0) GO TO 125
      WRITE(6,126) (NAME1(I,J),J=1,4),DOS(I)
 126  FORMAT(' ',3A5,A2,E9.3)
 125  CONTINUE
      WRITE(6,127) TDOS
 127  FORMAT('0',2X,'TOTAL DOSE',5X,E9.3)
      IF(ILV.EQ.1) GO TO 140
      WRITE(6,141)
 141  FORMAT('-')
      CLOSE (UNIT=15,DEVICE='DSK',ACCESS='SEQIN',DIALOG=FILN)
      RETURN
C     WRITING NUCLIDE SPECIFIC DOSE VARIABLES
 140  WRITE(6,130)
 130  FORMAT('0','NUCLIDE SPECIFIC VARIABLES')
      WRITE(6,131) DDOSF
 131  FORMAT('0','STOCHASTIC DOSE FACTOR =',E9.3,' (REM/MICRO CI)')
      WRITE(6,132) DOSFA
 132  FORMAT(' ',23X,'=',E9.3,' (SV/BQ)')
      WRITE(6,141)
      CLOSE (UNIT=15,DEVICE='DSK',ACCESS='SEQIN',DIALOG=FILN)
      RETURN
      END
```

A-2. SAMPLE RUNS OF NEPTUN

```
.SET TTY WIDTH 80

*.ASS TTY 6
TTY101 ASSIGNED

.EX NEP.F4
LINK:    LOADING
[LNKXCT NEP EXECUTION]
LISTING OF FOOD TYPE NAMES (1,9 OR 0) ? 1

1 DRINKING WATER
2 FW FISH
3 FW INVERTS
4 FW PLANTS
5 SW FISH
6 SW INVERTS
7 SW PLANTS


LISTING OF DIET TYPE NAMES (1,9 OR 0) ? 1

 1
 2
 3
 4
 5
 6
 7
 8
 9
10
11
12
13
14
15
16
17
```

*Deletion of this statement directs output to auxiliary high-speed printer. The same can be achieved by typing 'DEASS TTY 6'.

```
13
19
20
21
22
23
24
25
26
27
28
29
30 TEST DIET

LISTING OF DOSE FACTOR FILE NAMES (1,9 OR 0) ? 1

DOS.DAT - EXPANDED BATTELLE DOSE FACTOR FILE
CUSNR.DAT - INFANT DOSE FACTORS USNRC REG GUIDE 1:109-10 CTR-50 APP. I
A2ICR.DAT - ICRP 2 ADULT DOSE FACTORS
C26IC.DAT - ICRP 26 INFANT DOSE FACTORS
A26IC.DAT - ICRP 26 ADULT DOSE FACTORS


LISTING OF ALL VARIABLES (1,9 OR 0) ? 1

GENERAL MODEL VARIABLES

1 HOLDUP TIME FOR DRINKING WATER (D)       1.00
2 HOLDUP TIME FOR FW FISH (D)             10.00
3 HOLDUP TIME FOR FW INVERTS (D)           2.00
4 HOLDUP TIME FOR FW PLANTS (D)           40.00
5 HOLDUP TIME FOR SW FISH (D)             30.00
6 HOLDUP TIME FOR SW INVERTS (D)          50.00
7 HOLDUP TIME FOR SW PLANTS (D)          100.00
CRITERION FOR PREVENTING UNDERFLOW        30.00
```

```
WHICH FOOD TYPES (1 OR 0 IN A STRING) ? 1111111
THE FOLLOWING FOOD TYPES HAVE BEEN SPECIFIED :
 1   2   3   4   5   6   7
MISTAKES (0 OR 1) ? 0
WHICH DIET TYPE (1-30) ? 30
DOSE CALCULATIONS (1 OR 0) ? 1
* WHICH DOSE FACTORS (FILE NAME) ? DOS.DAT
WHICH NUCLIDE ? CS137
FRESHWATER CONCENTRATION (BQ/L) ? 2.0
SALTWATER CONCENTRATION (BQ/L) ? 4.0


NUCLIDE : CS137
*********

CONCENTRATION IN FRESHWATER = .20000E+01 (BQ/L)
CONCENTRATION IN SALTWATER  = .40000E+01 (BQ/L)

TABLE OF CONCENTRATIONS
-----------------------
DIET TYPE : 30 TEST DIET

                                         CONSUMPTION RATE
                        (BQ/KG,BQ/L)   (KG/D,L/D)      (BQ/D)   PECENTAGES

 1 DRINKING WATER        .2000E+01      .1013E+01      .2026E+01     13.09
 2 FW FISH               .7995E+03      .1370E-01      .1095E+02     70.76
 3 FW INVERTS            .2000E+03      .2000E-03      .3999E-01      0.26
 4 FW PLANTS             .1596E+03      .1000E-03      .1596E-01      0.10
 5 SW FISH               .1194E+03      .1640E-01      .1958E+01     12.65
 6 SW INVERTS            .7975E+02      .5500E-02      .4386E+00      2.83
 7 SW PLANTS             .7950E+02      .6000E-03      .4770E-01      0.31

   TOTAL INTAKE (BQ/D)                                 .1548E+02    100.00
   TOTAL INTAKE (BQ/Y)                                 .5654E+04
```

* DOS.DAT, CUSNR.DAT and A2ICR.DAT involve subroutine DOSF and separate doses to the whole body and six internal organs.

NUCLIDE SPECIFIC VARIABLES

RADIOLOGICAL DECAY CONSTANT (1/H)	.2630E-05
2 CONC FACTOR FOR FW FISH (L/KG)	.4000E+03
3 CONC FACTOR FOR FW INVERTS (L/KG)	.1000E+03
4 CONC FACTOR FOR FW PLANT (L/KG)	.8000E+02
5 CONC FACTOR FOR SW FISH (L/KG)	.3000E+02
6 CONC FACTOR FOR SW INVERTS (L/KG)	.2000E+02
7 CONC FACTOR FOR SW PLANTS (L/KG)	.2000E+02

TABLE OF DOSES (SV/Y)

DOS.DAT - EXPANDED BATTELLE DOSE FACTOR FILE

	BODY	GI-LLI	THYROID	BONE	LIVER	LUNG	KIDNEY
1 DRINKING WATER	.854E-05	.422E-06	.000E+00	.862E-05	.145E-04	.133E-05	.618E-05
2 FW FISH	.462E-04	.228E-05	.000E+00	.466E-04	.784E-04	.717E-05	.334E-04
3 FW INVERTS	.169E-06	.833E-08	.000E+00	.170E-06	.286E-06	.262E-07	.122E-06
4 FW PLANTS	.673E-07	.332E-08	.000E+00	.679E-07	.114E-06	.104E-07	.487E-07
5 SW FISH	.825E-05	.408E-06	.000E+00	.833E-05	.140E-04	.128E-05	.597E-05
6 SW INVERTS	.185E-05	.914E-07	.000E+00	.187E-05	.314E-05	.287E-06	.134E-05
7 SW PLANTS	.201E-06	.994E-08	.000E+00	.203E-06	.341E-06	.312E-07	.145E-06
TOTAL DOSES	.652E-04	.322E-05	.000E+00	.659E-04	.111E-03	.101E-04	.472E-04
PERCENTAGES	21.57	1.07	0.00	21.77	36.63	3.35	15.61

NUCLIDE SPECIFIC VARIABLES

	(MREM/PICO CI)	(SV/BQ)
DOSE FACTOR FOR BODY	.4270E-04	.1154E-07
DOSE FACTOR FOR GI-LLI	.2110E-05	.5703E-09
DOSE FACTOR FOR THYROID	.0000E+00	.0000E+00
DOSE FACTOR FOR BONE	.4310E-04	.1165E-07
DOSE FACTOR FOR LIVER	.7250E-04	.1959E-07
DOSE FACTOR FOR LUNG	.6630E-05	.1792E-08
DOSE FACTOR FOR KIDNEY	.3090E-04	.8351E-08

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WHICH NUCLIDE ? SR90
FRESHWATER CONCENTRATION (BQ/L) ? 3.0
SALTWATER CONCENTRATION (BQ/L) ? 6.0


NUCLIDE : SR90
*********

CONCENTRATION IN FRESHWATER = .30000E+01 (BQ/L)
CONCENTRATION IN SALTWATER  = .60000E+01 (BQ/L)

TABLE OF CONCENTRATIONS
-----------------------
DIET TYPE : 30 TEST DIET
```

Etc.

WHICH NUCLIDE ? 1

SUMMARY OF DOSES (SV/Y)
****
DOS.DAT - EXPANDED BATTELLE DOSE FACTOR FILE

	BODY	GI-LLI	THYROID	BONE	LIVER	LUNG	KIDNEY
CS137	.652E-04	.322E-05	.000E+00	.659E-04	.111E-03	.101E-04	.472E-04
SR90	.166E-04	.378E-04	.000E+00	.622E-04	.000E+00	.000E+00	.000E+00
I131	.335E-06	.159E-06	.191E-03	.412E-06	.593E-06	.000E+00	.102E-05
U235	.233E-04	.589E-04	.000E+00	.196E-03	.000E+00	.000E+00	.133E-03
PU239	.559E-07	.181E-04	.000E+00	.224E-05	.345E-06	.000E+00	.266E-06
TOTAL DOSES	.106E-03	.118E-03	.191E-03	.327E-03	.112E-03	.101E-04	.181E-03

PERCENTAGES

	BODY	GI-LLI	THYROID	BONE	LIVER	LUNG	KIDNEY
CS137	61.79	2.73	0.00	20.14	99.16	100.00	26.04
SR90	15.75	31.97	0.00	19.04	0.00	0.00	0.00
I131	0.32	0.13	100.00	0.13	0.53	0.00	0.56
U235	22.08	49.87	0.00	60.01	0.00	0.00	73.25
PU239	0.05	15.30	0.00	0.69	0.31	0.00	0.15
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TERMINATION OF EXECUTION (1 OR 0) ? 0

```
LISTING OF FOOD TYPE NAMES (1,9 OR 0) ? 0
LISTING OF DIET TYPE NAMES (1,9 OR 0) ? 0
LISTING OF DOSE FACTOR FILE NAMES (1,9 OR 0) ? 0
LISTING OF ALL VARIABLES (1,9 OR 0) ? 0
WHICH FOOD TYPES (1 OR 0 IN A STRING) ? 11001
THE FOLLOWING FOOD TYPES HAVE BEEN SPECIFIED :
 1  2  5
MISTAKES (0 OR 1) ? 0
WHICH DIET TYPE (1-30) ? 30
DOSE CALCULATIONS (1 OR 0) ? 1
* WHICH DOSE FACTORS (FILE NAME) ? A26IC.DAT
WHICH NUCLIDE ? CS137
FRESHWATER CONCENTRATION (BQ/L) ? 6.0
SALTWATER CONCENTRATION (BQ/L) ? 5.0


NUCLIDE : CS137
*********

CONCENTRATION IN FRESHWATER = .60000E+01 (BQ/L)
CONCENTRATION IN SALTWATER  = .50000E+01 (BQ/L)

TABLE OF CONCENTRATIONS
-----------------------
DIET TYPE : 30 TEST DIET

                                        CONSUMPTION RATE
                      (BQ/KG,BQ/L)    (KG/D,L/D)      (BQ/D)    PECENTAGE

1 DRINKING WATER       .6000E+01      .1013E+01     .6078E+01     14.69
2 FW FISH              .2398E+04      .1370E-01     .3286E+02     79.40
3 SW FISH              .1490E+03      .1640E-01     .2443E+01      5.91

  TOTAL INTAKE (BQ/D)                               .4138E+02    100.00
  TOTAL INTAKE (BQ/Y)                               .1512E+05
```

* A26IC.DAT and C26IC.DAT involve subroutine DASE and a single stochastic dose.

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TABLE OF DOSES (SV/Y)
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A26IC.DAT - ICRP 26 ADULT DOSE FACTORS

                    STOCHASTIC

1 DRINKING WATER   .275E-04
2 FW FISH          .149E-03
5 SW FISH          .111E-04

  TOTAL DOSE       .188E-03


WHICH NUCLIDE ? SR90
FRESHWATER CONCENTRATION (BQ/L) ? 2.0
SALTWATER CONCENTRATION (BQ/L) ? 3.0


NUCLIDE : SR90
*********

CONCENTRATION IN FRESHWATER = .20000E+01 (BQ/L)
CONCENTRATION IN SALTWATER  = .30000E+01 (BQ/L)
```

Etc.

WHICH NUCLIDE ? 1

SUMMARY OF DOSES (SV/Y)
****
A26IC.DAT - ICRP 26 ADULT DOSE FACTORS

	STOCHASTIC	PERCENTAGES
CS137	.188E-03	43.89
SR90	.319E-04	7.46
I131	.379E-04	8.88
U235	.105E-03	24.67
PU239	.645E-04	15.10
TOTAL DOSE	.427E-03	100.00

DOSE CONSEQUENCE RATIOS (DOSE (SV/Y) / WATER CONCENTRATION (BQ/L))
****
FRESHWATER FOOD TYPES : 1 2
SALTWATER FOOD TYPES : 5
DIET TYPE : 30 TEST DIET
A26IC.DAT - ICRP 26 ADULT DOSE FACTORS

	FRESHWATER		SALTWATER	
	INTAKE (SV/Y)	RATIO	INTAKE (SV/Y)	RATIO
CS137	.176E-03	.294E-04	.111E-04	.222E-05
SR90	.310E-04	.155E-04	.334E-06	.117E-06
I131	.379E-04	.542E-05	.177E-08	.887E-09
U235	.335E-04	.295E-04	.168E-04	.421E-05
PU239	.450E-04	.450E-04	.135E-04	.244E-05

TERMINATION OF EXECUTION (1 OR 0) ? 1
STOP

A-3. LISTING OF CFAC.DAT FILE

	R.D.C. I·H	FW FISH	FW INVERT	FW PLANT	FISH	[illegible]	[illegible]
H3	6.41E-06	9.01E-01	9.01E-01	9.01E-01	[illegible]	[illegible]	[illegible]
BE10	4.94E-11	2.00E+00	1.00E+01	2.00E+01	2.00E+02	2.00E+02	1.00E+0[illegible]
C14	1.39E-08	4.55E+03	9.09E+03	4.55E+03	1.79E+03	1.43E+03	1.79E+0[illegible]
N13	4.17E+00	1.50E+05	1.50E+05	1.25E+04	6.00E+04	1.70E+04	1.00E+04
F18	3.78E-01	1.00E+01	1.00E+02	2.00E+00	3.57E+00	3.57E+00	1.4[illegible]
NA22	3.04E-05	2.00E+01	1.70E+01	1.00E+02	6.67E-02	1.90E-01	9.52E-01
NA24	4.62E-02	2.00E+01	1.70E+01	1.00E+02	6.67E-02	1.90E-01	9.52E-01
P32	2.02E-03	1.00E+05	1.00E+05	1.00E+04	2.86E+04	2.86E+04	2.86E+0[illegible]
P33	1.14E-03	1.00E+05	1.00E+05	1.00E+04	2.86E+04	2.86E+04	2.86E+0[illegible]
AR39	2.94E-07	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	[illegible]
AR41	3.79E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	[illegible]
CA41	6.08E-10	4.00E+01	3.33E+02	1.33E+02	5.00E-01	1.25E+01	5.0[illegible]E+00
SC45	3.45E-04	1.00E+02	1.00E+03	1.00E+04	2.00E+00	1.00E+04	1.0[illegible]E+05
CR51	1.04E-03	4.00E+01	2.00E+01	4.00E+01	4.00E+02	2.00E+03	2.0[illegible]
MN54	9.24E-05	1.00E+02	4.00E+04	1.00E+04	6.00E+02	1.00E+04	2.0[illegible]E+04
MN56	2.69E-01	1.00E+02	4.00E+04	1.00E+04	6.00E+02	1.00E+04	2.0[illegible]E+04
FE55	2.93E-05	1.00E+02	3.20E+03	1.00E+03	3.00E+03	3.00E+04	5.[illegible]E+04
FE59	6.48E-04	1.00E+02	3.20E+03	1.00E+03	3.00E+03	3.00E+04	5.[illegible]E+04
CO57	1.07E-04	2.00E+01	2.00E+02	2.00E+02	1.00E+02	1.00E+03	[illegible]
CO58	4.05E-04	2.00E+01	2.00E+02	2.00E+02	1.00E+02	1.00E+03	[illegible]
CO60	1.50E-05	2.00E+01	2.00E+02	2.00E+02	1.00E+02	1.00E+03	[illegible]
NI59	9.88E-10	1.00E+02	1.00E+02	5.00E+01	1.00E+02	2.50E+02	2.5[illegible]
NI63	7.91E-07	1.00E+02	1.00E+02	5.00E+01	1.00E+02	2.50E+02	2.5[illegible]
NI65	2.75E-01	1.00E+02	1.00E+02	5.00E+01	1.00E+02	2.50E+02	2.5[illegible]
CU64	5.46E-02	2.00E+02	1.00E+03	1.00E+03	6.67E+02	1.67E+03	[illegible]
ZN65	1.19E-04	1.00E+03	1.00E+04	1.00E+03	2.00E+03	1.00E+05	[illegible]
ZN69M	4.99E-02	1.00E+03	1.00E+04	1.00E+03	2.00E+03	1.00E+05	[illegible]
ZN69	7.30E-01	1.00E+03	1.00E+04	1.00E+03	2.00E+03	1.00E+05	[illegible]
SE79	1.22E-09	1.67E+02	1.67E+02	1.00E+03	4.00E+03	1.00E+03	[illegible]
BR82	1.96E-02	4.17E+02	3.33E+02	5.00E+01	1.54E-02	3.08E+00	1.54[illegible]
BR83	2.89E-01	4.17E+02	3.33E+02	5.00E+01	1.54E-02	3.08E+00	1.54[illegible]
BR84	1.31E+00	4.17E+02	3.33E+02	5.00E+01	1.54E-02	3.08E+00	1.54[illegible]
BR85	1.45E+01	4.17E+02	3.33E+02	5.00E+01	1.54E-02	3.08E+00	1.54[illegible]
KR83M	3.73E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	[illegible]
KR85M	1.55E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	[illegible]
KR85	7.37E-06	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	[illegible]
KR87	5.47E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	[illegible]
KR88	2.48E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	[illegible]
KR89	1.31E+01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	[illegible]
RB86	1.55E-03	2.00E+03	1.00E+03	1.00E+03	8.33E+00	1.67E+01	1.67[illegible]
RB87	1.68E-15	2.00E+03	1.00E+03	1.00E+03	8.33E+00	1.67E+01	1.67[illegible]
RB88	2.35E+00	2.00E+03	1.00E+03	1.00E+03	8.33E+00	1.67E+01	1.67[illegible]
RB89	2.74E+00	2.00E+03	1.00E+03	1.00E+03	8.33E+00	1.67E+01	1.67[illegible]
SR89	5.72E-04	5.00E+00	1.00E+02	5.00E+02	5.00E-01	[illegible]	[illegible]
SR90	2.73E-06	5.00E+00	1.00E+02	5.00E+02	5.00E-01	[illegible]	[illegible]
SR91	7.31E-02	5.00E+00	1.00E+02	5.00E+02	[illegible]	[illegible]	[illegible]
SR92	2.56E-01	5.00E+00	1.00E+02	[illegible]	[illegible]	[illegible]	[illegible]

Y90	1.08E-02	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
Y91M	9.37E-01	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
Y91	4.93E-04	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
Y92	1.96E-01	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
Y93	6.79E-02	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
ZR93	8.32E-11	3.33E+00	6.67E+00	1.00E+03	2.00E+02	2.00E+01	2.00E+03
ZR95	4.41E-04	3.33E+00	6.67E+00	1.00E+03	2.00E+02	2.00E+01	2.00E+03
ZR97	4.12E-02	3.33E+00	6.67E+00	1.00E+03	2.00E+02	2.00E+01	2.00E+03
NB93M	6.59E-06	3.00E+04	1.00E+02	8.00E+02	3.00E+04	1.00E+02	1.00E+03
NB94	3.95E-09	3.00E+04	1.00E+02	8.00E+02	3.00E+04	1.00E+02	1.00E+03
NB95	8.23E-04	3.00E+04	1.00E+02	8.00E+02	3.00E+04	1.00E+02	1.00E+03
NB97	5.65E-01	3.00E+04	1.00E+02	8.00E+02	3.00E+04	1.00E+02	1.00E+03
MO93	2.63E-08	1.00E+01	1.00E+01	1.00E+03	1.00E+01	1.00E+01	1.00E+01
MO99	1.05E-02	1.00E+01	1.00E+01	1.00E+03	1.00E+01	1.00E+01	1.00E+01
TC99M	1.15E-01	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03
TC99	3.73E-10	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03
TC101	2.93E+00	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03
RU103	7.29E-04	1.00E+01	3.00E+02	2.00E+02	1.00E+01	2.00E+03	2.00E+03
RU105	1.56E-01	1.00E+01	3.00E+02	2.00E+02	1.00E+01	2.00E+03	2.00E+03
RU106	7.83E-05	1.00E+01	3.00E+02	2.00E+02	1.00E+01	2.00E+03	2.00E+03
RH105	1.95E-02	1.00E+01	3.00E+02	2.00E+02	1.00E+01	2.00E+03	2.00E+03
RH106	3.20E-01	1.00E+01	3.00E+02	2.00E+02	1.00E+01	2.00E+03	2.00E+03
PD107	1.13E-11	1.00E+01	3.00E+02	2.00E+02	1.00E+01	2.00E+03	2.00E+03
PD109	5.13E-02	1.00E+01	3.00E+02	2.00E+02	1.00E+01	2.00E+03	2.00E+03
AG110M	1.15E-04	2.31E+00	7.69E+02	2.00E+02	3.33E+03	3.33E+03	2.00E+02
AG111	3.87E-03	2.31E+00	7.69E+02	2.00E+02	3.33E+03	3.33E+03	2.00E+02
CD113M	5.42E-06	2.00E+02	2.00E+03	1.00E+03	3.00E+03	2.50E+05	1.00E+03
CD115M	3.73E-01	2.00E+02	2.00E+03	1.00E+03	3.00E+03	2.50E+05	1.00E+03
SN119M	1.16E-04	3.00E+03	1.00E+03	1.00E+02	3.00E+03	1.00E+03	1.00E+02
SN121M	1.04E-06	3.00E+03	1.00E+03	1.00E+02	3.00E+03	1.00E+03	1.00E+02
SN123	2.24E-04	3.00E+03	1.00E+03	1.00E+02	3.00E+03	1.00E+03	1.00E+02
SN125	2.99E-03	3.00E+03	1.00E+03	1.00E+02	3.00E+03	1.00E+03	1.00E+02
SN126	7.91E-10	3.00E+03	1.00E+03	1.00E+02	3.00E+03	1.00E+03	1.00E+02
SB124	4.80E-04	1.00E+00	1.00E+01	1.50E+03	4.00E+01	5.00E+00	1.45E+03
SB125	2.90E-05	1.00E+00	1.00E+01	1.50E+03	4.00E+01	5.00E+00	1.45E+03
SB126	2.33E-03	1.00E+00	1.00E+01	1.50E+03	4.00E+01	5.00E+00	1.45E+03
SB127	7.60E-03	1.00E+00	1.00E+01	1.50E+03	4.00E+01	5.00E+00	1.45E+03
TE125M	4.98E-04	4.00E+02*	6.10E+05	1.00E+03*	1.00E+01*	1.00E+05	1.00E+03*
TE127M	2.65E-04	4.00E+02*	6.10E+05	1.00E+03*	1.00E+01*	1.00E+05	1.00E+03*
TE127	7.37E-02	4.00E+02*	6.10E+05	1.00E+03*	1.00E+01*	1.00E+05	1.00E+03*
TE129M	8.65E-04	4.00E+02*	6.10E+05	1.00E+03*	1.00E+01*	1.00E+05	1.00E+03*
TE129	5.94E-01	4.00E+02*	6.10E+05	1.00E+03*	1.00E+01*	1.00E+05	1.00E+03*
TE131M	2.31E-02	4.00E+02*	6.10E+05	1.00E+03*	1.00E+01*	1.00E+05	1.00E+03*
TE131	1.66E+00	4.00E+02*	6.10E+05	1.00E+03*	1.00E+01*	1.00E+05	1.00E+03*
TE132	8.89E-03	4.00E+02*	6.10E+05	1.00E+03*	1.00E+01*	1.00E+05	1.00E+03*
TE133M	7.51E-01	4.00E+02*	6.10E+05	1.00E+03*	1.00E+01*	1.00E+05	1.00E+03*
TE134	9.90E-01	4.00E+02*	6.10E+05	1.00E+03*	1.00E+01*	1.00E+05	1.00E+03*
I129	4.65E-12	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03
I130	5.59E-02	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03
I131	3.59E-03	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03
I132	3.03E-01	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03
I133	3.33E-02	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03
I134	7.91E-01	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03

I135	1.05E-01	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03
XE131M	2.41E-03	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
XE133M	1.30E-02	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
XE133	5.46E-03	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
XE135M	2.72E+00	1.00E+00	1.00E+00	1.00E+00	1.90E+00	1.00E+00	1.00E+04
XE135	7.56E-02	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
XE137	1.08E+01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
XE138	2.93E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
CS134M	2.39E-01	4.00E+02	1.00E+02	8.00E+01	3.00E+01	2.00E+01	2.00E+01
CS134	3.84E-05	4.00E+02	1.00E+02	8.00E+01	3.00E+01	2.00E+01	2.00E+01
CS135	2.64E-11	4.00E+02	1.00E+02	8.00E+01	3.00E+01	2.00E+01	2.00E+01
CS136	2.22E-03	4.00E+02	1.00E+02	8.00E+01	3.00E+01	2.00E+01	2.00E+01
CS137	2.63E-06	4.00E+02	1.00E+02	8.00E+01	3.00E+01	2.00E+01	2.00E+01
CS138	1.29E+00	4.00E+02	1.00E+02	8.00E+01	3.00E+01	2.00E+01	2.00E+01
CS139	4.47E+00	4.00E+02	1.00E+02	8.00E+01	3.00E+01	2.00E+01	2.00E+01
BA137M	1.63E+01	4.00E+00	2.00E+02	5.00E+02	1.00E+01	1.00E+02	5.00E+02
BA139	4.99E-01	4.00E+00	2.00E+02	5.00E+02	1.00E+01	1.00E+02	5.00E+02
BA140	2.26E-03	4.00E+00	2.00E+02	5.00E+02	1.00E+01	1.00E+02	5.00E+02
BA141	2.27E+00	4.00E+00	2.00E+02	5.00E+02	1.00E+01	1.00E+02	5.00E+02
BA142	3.89E+00	4.00E+00	2.00E+02	5.00E+02	1.00E+01	1.00E+02	5.00E+02
LA140	1.72E-02	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
LA141	1.79E-01	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
LA142	4.59E-01	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CE141	8.88E-04	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CE143	2.10E-02	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CE144	1.02E-04	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
PR143	2.13E-03	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
PR144	2.41E+00	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
ND144	1.58E-20	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
ND147	2.63E-03	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
PM147	3.01E-05	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
PM148M	6.99E-04	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
PM148	5.38E-03	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
PM149	1.31E-02	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
PM151	2.44E-02	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
SM147	7.46E-16	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
SM151	7.63E-07	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
SM153	1.49E-02	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
EU152	6.08E-06	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
EU154	9.19E-06	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.03E+03
EU155	1.65E-05	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.03E+03
EU156	1.90E-03	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
TB160	3.99E-04	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
HO166M	6.59E-08	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
W181	2.37E-04	1.20E+03	1.00E+01	1.20E+03	3.00E+01	3.00E+01	3.00E+01
W185	3.85E-04	1.20E+03	1.00E+01	1.20E+03	3.00E+01	3.00E+01	3.00E+01
W187	2.90E-02	1.20E+03	1.00E+01	1.20E+03	3.00E+01	3.00E+01	3.00E+01
TL207	3.70E+00	1.00E+04	1.50E+04	5.00E+03+	1.00E+04	1.50E+04	5.00E+03
TL208	1.34E+01	1.00E+04	1.50E+04	5.00E+03+	1.00E+04	1.50E+04	5.00E+03
TL209	1.39E+01	1.00E+04	1.50E+04	5.00E+03+	1.00E+04	1.50E+04	5.00E+03
PB209	2.10E-10	3.00E+02	1.00E+02	2.00E+02	3.00E+02	1.00E+03	1.00E+03
PB210	3.77E-06	3.00E+02	1.00E+02	2.00E+02	3.00E+02	1.00E+03	1.00E+03
PB211	1.15E+00	3.00E+02	1.00E+02	2.00E+02	3.00E+02	1.00E+03	1.00E+03

PB212	6.51E-02	3.00E+02	1.00E+02	2.00E+02	3.00E+02	1.00E+03	1.00E+03
PB214	1.95E+00	3.00E+02	1.00E+02	2.00E+02	3.00E+02	1.00E+03	1.00E+03
BI210	5.76E-03	1.50E+01	1.00E+05*	1.00E+05*	1.50E+01	1.00E+05*	1.00E+05*
BI211	1.93E+01	1.50E+01	1.00E+05*	1.00E+05*	1.50E+01	1.00E+05*	1.00E+05*
BI212	6.86E-01	1.50E+01	1.00E+05*	1.00E+05*	1.50E+01	1.00E+05*	1.00E+05*
BI213	3.85E-01	1.50E+01	1.00E+05*	1.00E+05*	1.50E+01	1.00E+05*	1.00E+05*
BI214	2.11E+00	1.50E+01	1.00E+05*	1.00E+05*	1.50E+01	1.00E+05*	1.00E+05*
PO210	2.09E-04	5.00E+01	2.00E+04	2.00E+03	2.00E+03	2.00E+04	2.00E+03
PO212	8.21E+09	5.00E+01	2.00E+04	2.00E+03	2.00E+03	2.00E+04	2.00E+03
PO213	5.94E+08	5.00E+01	2.00E+04	2.00E+03	2.00E+03	2.00E+04	2.00E+03
PO214	1.52E+07	5.00E+01	2.00E+04	2.00E+03	2.00E+03	2.00E+04	2.00E+03
PO215	1.40E+06	5.00E+01	2.00E+04	2.00E+03	2.00E+03	2.00E+04	2.00E+03
PO216	1.66E+04	5.00E+01	2.00E+04	2.00E+03	2.00E+03	2.00E+04	2.00E+03
PO218	1.36E+01	5.00E+01	2.00E+04	2.00E+03	2.00E+03	2.00E+04	2.00E+03
AT213	7.80E+04	1.50E+01	5.00E+00	4.00E+01	1.00E+01	5.00E+01	4.00E+03
RN219	6.24E+02	5.71E+01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
RN220	4.54E+01	5.71E+01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
RN222	7.55E-03	5.71E+01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
FR221	3.66E+00	4.00E+02	1.00E+02	3.00E+01	3.00E+01	2.00E+01	2.00E+01
RA223	2.53E-03	5.00E+01	2.50E+02	2.50E+03	5.00E+01	1.00E+02	1.00E+02
RA224	7.93E-03	5.00E+01	2.50E+02	2.50E+03	5.00E+01	1.00E+02	1.00E+02
RA225	1.95E-03	5.00E+01	2.50E+02	2.50E+03	5.00E+01	1.00E+02	1.00E+02
RA226	4.94E-08	5.00E+01	2.50E+02	2.50E+03	5.00E+01	1.00E+02	1.00E+02
RA228	1.37E-05	5.00E+01	2.50E+02	2.50E+03	5.00E+01	1.00E+02	1.00E+02
AC225	2.89E-03	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
AC227	3.66E-06	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
AC228	1.13E-01	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
TH227	1.56E-03	3.00E+01	5.00E+02	1.50E+03	1.00E+04	2.00E+03	3.00E+03
TH228	4.13E-05	3.00E+01	5.00E+02	1.50E+03	1.00E+04	2.00E+03	3.00E+03
TH229	1.08E-08	3.00E+01	5.00E+02	1.50E+03	1.00E+04	2.00E+03	3.00E+03
TH230	9.88E-10	3.00E+01	5.00E+02	1.50E+03	1.00E+04	2.00E+03	3.00E+03
TH231	2.72E-02	3.00E+01	5.00E+02	1.50E+03	1.00E+04	2.00E+03	3.00E+03
TH232	5.61E-15	3.00E+01	5.00E+02	1.50E+03	1.00E+04	2.00E+03	3.00E+03
TH234	1.20E-03	3.00E+01	5.00E+02	1.50E+03	1.00E+04	2.00E+03	3.00E+03
PA231	2.43E-09	1.13E+01	1.13E+02	1.13E+03	1.00E+01	1.00E+01	6.00E+00
PA233	1.07E-03	1.13E+01	1.13E+02	1.13E+03	1.00E+01	1.00E+01	6.00E+00
PA234M	3.55E+01	1.13E+01	1.13E+02	1.13E+03	1.00E+01	1.00E+01	6.00E+00
U232	1.10E-06	1.00E+01	1.00E+02	1.00E+03	1.00E+01	1.00E+01	6.67E+01
U233	4.88E-10	1.00E+01	1.00E+02	1.00E+03	1.00E+01	1.00E+01	6.67E+01
U234	3.20E-10	1.00E+01	1.00E+02	1.00E+03	1.00E+01	1.00E+01	6.67E+01
U235	1.11E-13	1.00E+01	1.00E+02	1.00E+03	1.00E+01	1.00E+01	6.67E+01
U236	3.31E-12	1.00E+01	1.00E+02	1.00E+03	1.00E+01	1.00E+01	6.67E+01
U237	4.28E-03	1.00E+01	1.00E+02	1.00E+03	1.00E+01	1.00E+01	6.67E+01
U238	1.75E-14	1.00E+01	1.00E+02	1.00E+03	1.00E+01	1.00E+01	6.67E+01
U240	4.92E-02	1.00E+01	1.00E+02	1.00E+03	1.00E+01	1.00E+01	6.67E+01
NP237	3.69E-11	1.00E+01	4.00E+02	1.00E+03	1.00E+01	1.00E+01	6.00E+00
NP238	1.36E-02	1.00E+01	4.00E+02	1.00E+03	1.00E+01	1.00E+01	6.00E+00
NP239	1.23E-02	1.00E+01	4.00E+02	1.00E+03	1.00E+01	1.00E+01	6.00E+00
NP240M	5.70E+00	1.00E+01	4.00E+02	1.00E+03	1.00E+01	1.00E+01	6.00E+00
PU238	9.01E-07	3.50E+00	1.00E+02	3.50E+02	3.50E+00	1.00E+02	3.50E+02
PU239	3.79E-09	3.50E+00	1.00E+02	3.50E+02	3.50E+00	1.00E+02	3.50E+02
PU240	1.20E-08	3.50E+00	1.00E+02	3.50E+02	3.50E+00	1.00E+02	3.50E+02
PU241	5.27E-06	3.50E+00	1.00E+02	3.50E+02	3.50E+00	1.00E+02	3.50E+02

PU242	2.04E-10	3.50E+00	1.00E+02	3.50E+02	3.50E+00	1.00E+02	3.50E+02
PU243	1.40E-01	3.50E+00	1.00E+02	3.50E+02	3.50E+00	1.00E+02	3.50E+02
PU244	3.33E-13	3.50E+00	1.00E+02	3.50E+02	3.50E+00	1.00E+02	3.50E+02
AM241	1.33E-07	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
AM242M	5.20E-07	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
AM242	4.33E-02	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
AM243	1.07E-08	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CM242	1.77E-04	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CM243	2.82E-06	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CM244	4.42E-06	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CM245	9.30E-09	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CM246	1.66E-08	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CM247	4.94E-12	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CM248	2.26E-10	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03
CF252	3.01E-05	2.50E+01	1.00E+03	5.00E+03	2.50E+01	1.00E+03	5.00E+03

All concentration factors were taken from Thompson, S.E., C.A. Burton, D.J. Quinn and Y.C. Ng. 1972. "Concentration Factors of Chemical Elements in Edible Aquatic Organisms". Report UCRL-50564 Lawrence Livermore Radiation Laboratory, University of California, Livermore, California, Rev. 1, except those followed by '*' which were taken from Killough, G.G. and L.R. McKay. 1976. "A Methodology for Calculating Radiation Doses from Radioactivity Released to the Environment". ESDP Report ORNL-4992, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Those followed by '+' are conservative estimates by the author based on chemical similarities. The format used in NEP.F4 is (A5, A3, E8.0, 6(E9.0)).

A-5. LISTING OF DIET.DAT FILE

```
HOLDUP TIMES             DAYS

1 DRINKING WATER          1.0
2 FW FISH                10.0
3 FW INVERTS              2.0
4 FW PLANTS              40.0
5 SW FISH                30.0
6 SW INVERTS             50.0
7 SW PLANTS             100.0
```

Values in this file are examplary only. They can be readily changed. The format used in NEP.F4 is (20X, F5.0).

continued....

A-5. LISTING OF DIET.DAT FILE (concluded)

	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										

	11	12	13	14	15	16	17	18	19	20
1										
2										
3										
4										
5										
6										
7										

	21	22	23	24	25	26	27	28	29	30
1										1.0130
2										0.0137
3										0.0002
4										0.0001
5										0.0164
6										0.0055
7										0.0006

The values of diet 30 are exemplary only. The numbers in the vertical columns refer to food types and those in the horizontal rows to diet types. The latter correspond to the numbers in the NAME.DAT file. Diets 1 to 29 can be readily implemented. The format used in NEP.F4 is (10X, 10F7.0).

A-6. LISTING OF LABEL.DAT FILE

```
1 HOLDUP TIME FOR DRINKING WATER (D)
2 HOLDUP TIME FOR FW FISH (D)
3 HOLDUP TIME FOR FW INVERTS (D)
4 HOLDUP TIME FOR FW PLANTS (D)
5 HOLDUP TIME FOR SW FISH (D)
6 HOLDUP TIME FOR SW INVERTS (D)
7 HOLDUP TIME FOR SW PLANTS (D)
CRITERION FOR PREVENTING UNDERFLOW
RADIOLOGICAL DECAY CONSTANT (1/H)
2 CONC FACTOR FOR FW FISH (L/KG)
3 CONC FACTOR FOR FW INVERTS (L/KG)
4 CONC FACTOR FOR FW PLANT (L/KG)
5 CONC FACTOR FOR SW FISH (L/KG)
6 CONC FACTOR FOR SW INVERTS (L/KG)
7 CONC FACTOR FOR SW PLANTS (L/KG)
DOSE FACTOR FOR BODY
DOSE FACTOR FOR GI-LLI
DOSE FACTOR FOR THYROID
DOSE FACTOR FOR BONE
DOSE FACTOR FOR LIVER
DOSE FACTOR FOR LUNG
DOSE FACTOR FOR KIDNEY
```

The format used in NEP.F4 is (8A5).

A-7. LISTING OF NAME.DAT FILE

```
 1 DRINKING WATER
 2 FW FISH
 3 FW INVERTS
 4 FW PLANTS
 5 SW FISH
 6 SW INVERTS
 7 SW PLANTS
* 1
  2
  3
  4
  5
  6
  7
  8
  9
 10
 11
 12
 13
 14
 15
 16
 17
 18
 19
 20
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30 TEST DIET
DOS.DAT - EXPANDED BATTELLE DOSE FACTOR FILE
CUSNR.DAT - INFANT DOSE FACTORS USNRC REG GUIDE 1:109-10 CTR-50 APP. I
A2ICR.DAT - ICRP 2 ADULT DOSE FACTORS
C26IC.DAT - ICRP 26 INFANT DOSE FACTORS
A26IC.DAT - ICRP 26 ADULT DOSE FACTORS
```

* Numbers 1-30 are reserved for diet names. The numbers correspond to those used in DIET.DAT (Appendix A-5). The format used in NEP.F4 is (15A5). The formats used in NEP.F4 for food types and diet names is (3A5,A2), and for dose factor file names (15A5).

A-8. LISTING OF DOS.DAT FILE

EXPANDED BATTELLE DOSE FACTOR FILE (MREM/P CI)

	BODY	GI-LLI	THYROID	BONE	LIVER	LUNG	KIDNEY
H3	1.07E-07	1.07E-07	1.07E-07	0.00E+00	1.07E-07	1.07E-07	1.07E-07
BE10	3.68E-08	2.68E-05	0.00E+00	7.47E-07	1.72E-07	0.00E+00	2.16E-07
C14	5.45E-07	5.45E-07	5.45E-07	2.39E-06	5.45E-07	5.45E-07	5.45E-07
N13	8.35E-09	8.35E-09	8.35E-09	8.35E-09	8.35E-09	8.35E-09	8.35E-09
F18	6.92E-08	1.85E-08	0.00E+00	6.23E-07	0.00E+00	0.00E+00	0.00E+00
NA22	1.66E-05	1.66E-05	1.66E-05	1.66E-05	1.66E-05	1.66E-05	1.66E-05
NA24	2.25E-06	2.25E-06	2.25E-06	2.25E-06	2.25E-06	2.25E-06	2.25E-06
P32	7.08E-06	2.17E-05	0.00E+00	1.82E-04	1.17E-05	0.00E+00	0.00E+00
P33	1.41E-06	2.69E-06	0.00E+00	3.77E-05	1.87E-06	0.00E+00	0.00E+00
AR39	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AR41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CA41	2.87E-07	1.84E-07	0.00E+00	2.58E-06	0.00E+00	0.00E+00	0.00E+00
SC45	2.84E-09	5.21E-05	0.00E+00	4.99E-09	9.67E-09	0.00E+00	8.42E-09
CR51	2.38E-09	6.69E-07	1.42E-09	0.00E+00	0.00E+00	3.16E-09	5.24E-10
MN54	8.16E-07	1.40E-05	0.00E+00	0.00E+00	4.15E-06	0.00E+00	1.32E-06
MN56	2.04E-08	3.67E-06	0.00E+00	0.00E+00	1.15E-07	0.00E+00	1.46E-07
FE55	1.06E-07	1.09E-06	0.00E+00	4.92E-08	5.43E-07	1.59E-07	0.00E+00
FE59	3.23E-06	3.40E-05	0.00E+00	3.59E-06	8.57E-06	2.36E-06	0.00E+00
CO57	2.80E-07	4.44E-06	0.00E+00	0.00E+00	1.68E-07	0.00E+00	0.00E+00
CO58	1.61E-06	1.51E-05	0.00E+00	0.00E+00	7.20E-07	0.00E+00	0.00E+00
CO60	4.54E-06	4.02E-05	0.00E+00	0.00E+00	2.06E-06	0.00E+00	0.00E+00
NI59	2.73E-07	6.90E-07	0.00E+00	1.39E-06	7.20E-07	0.00E+00	0.00E+00
NI63	7.42E-07	1.88E-06	0.00E+00	1.89E-05	1.96E-06	0.00E+00	0.00E+00
NI65	3.12E-08	1.74E-06	0.00E+00	5.28E-07	6.86E-08	0.00E+00	0.00E+00
CU64	3.90E-08	7.10E-06	0.00E+00	0.00E+00	8.30E-08	0.00E+00	2.10E-07
ZN65	3.08E-06	9.70E-06	0.00E+00	2.06E-06	1.15E-05	0.00E+00	6.77E-06
ZN69M	3.72E-08	2.49E-05	0.00E+00	1.69E-07	4.07E-07	0.00E+00	2.47E-07
ZN69	1.37E-09	2.96E-09	0.00E+00	1.03E-08	1.97E-08	0.00E+00	1.28E-08
SE79	4.20E-07	5.38E-07	0.00E+00	0.00E+00	2.38E-06	0.00E+00	4.35E-06
BR82	2.24E-06	2.59E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR83	4.01E-08	5.79E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR84	5.21E-08	4.09E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR85	2.13E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR83M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KR89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB86	9.31E-06	4.16E-06	0.00E+00	0.00E+00	1.99E-05	0.00E+00	0.00E+00
RB87	3.52E-06	5.76E-07	0.00E+00	0.00E+00	9.31E-06	0.00E+00	0.00E+00
RB88	3.21E-08	8.36E-19	0.00E+00	0.00E+00	6.08E-08	0.00E+00	0.00E+00
RB89	2.82E-08	2.33E-21	0.00E+00	0.00E+00	4.00E-08	0.00E+00	0.00E+00
SR89	7.09E-06	4.94E-05	0.00E+00	2.47E-04	0.00E+00	0.00E+00	0.00E+00
SR90	4.49E-05	1.02E-04	0.00E+00	1.68E-04	0.00E+00	0.00E+00	0.00E+00
SR91	2.55E-07	2.93E-05	0.00E+00	5.80E-06	0.00E+00	0.00E+00	0.00E+00
SR92	9.29E-08	4.26E-05	0.00E+00	2.15E-06	0.00E+00	0.00E+00	0.00E+00
Y90	2.55E-10	1.02E-04	0.00E+00	9.51E-09	0.00E+00	0.00E+00	0.00E+00

Y91M	3.52E-12	2.67E-10	0.00E+00	9.03E-11	0.00E+00	0.00E+00	0.00E+00
Y91	2.91E-09	7.76E-05	0.00E+00	1.09E-07	0.00E+00	0.00E+00	0.00E+00
Y92	2.47E-11	1.48E-05	0.00E+00	8.44E-10	0.00E+00	0.00E+00	0.00E+00
Y93	7.38E-11	8.50E-05	0.00E+00	2.68E-09	0.00E+00	0.00E+00	0.00E+00
ZR93	2.57E-10	2.43E-06	0.00E+00	4.87E-09	7.22E-10	0.00E+00	1.14E-09
ZR95	5.12E-09	3.03E-05	0.00E+00	2.31E-08	7.67E-09	0.00E+00	1.17E-08
ZR97	1.55E-10	1.05E-04	0.00E+00	1.67E-09	3.38E-10	0.00E+00	5.10E-10
NB93M	3.53E-10	3.84E-06	0.00E+00	3.58E-09	1.32E-09	0.00E+00	1.65E-09
NB95	1.61E-09	2.10E-05	0.00E+00	5.33E-09	2.99E-09	0.00E+00	2.97E-09
NB97	4.82E-12	4.87E-08	0.00E+00	5.22E-11	1.32E-11	0.00E+00	1.54E-11
MO93	1.99E-07	1.22E-06	0.00E+00	0.00E+00	6.18E-06	0.00E+00	2.10E-06
MO99	8.14E-07	9.99E-06	0.00E+00	0.00E+00	4.26E-06	0.00E+00	9.70E-06
TC99M	8.88E-09	4.13E-07	0.00E+00	2.47E-10	6.97E-10	3.41E-10	1.06E-08
TC99	4.99E-08	6.08E-06	0.00E+00	1.13E-07	1.64E-07	1.55E-08	2.15E-06
TC101	3.59E-09	1.10E-21	0.00E+00	2.54E-10	3.66E-10	1.86E-10	6.59E-09
RU103	7.77E-08	2.16E-05	0.00E+00	1.76E-07	0.00E+00	0.00E+00	6.99E-07
RU105	6.07E-09	9.42E-06	0.00E+00	1.54E-08	0.00E+00	0.00E+00	1.98E-07
RU106	3.38E-07	1.78E-04	0.00E+00	2.58E-06	0.00E+00	0.00E+00	5.26E-06
RH105	5.79E-08	1.41E-05	0.00E+00	1.21E-07	8.30E-08	0.00E+00	3.74E-07
PD107	9.21E-09	9.11E-07	0.00E+00	0.00E+00	1.36E-07	0.00E+00	1.16E-06
PD109	3.98E-08	1.96E-05	0.00E+00	0.00E+00	1.77E-07	0.00E+00	1.01E-06
AG110M	8.61E-08	6.04E-05	0.00E+00	1.43E-07	1.40E-07	0.00E+00	2.80E-07
AG111	1.20E-08	4.46E-05	0.00E+00	5.67E-08	2.38E-08	0.00E+00	7.70E-08
CD113M	4.51E-08	2.56E-05	0.00E+00	0.00E+00	1.41E-06	0.00E+00	1.18E-06
CD115M	5.02E-08	7.74E-05	0.00E+00	0.00E+00	1.57E-06	0.00E+00	1.23E-06
SN123	6.76E-07	6.33E-05	3.59E-07	2.42E-05	4.23E-07	0.00E+00	0.00E+00
SN125	3.67E-07	1.04E-04	1.34E-07	8.06E-06	1.62E-07	0.00E+00	0.00E+00
SN126	2.07E-06	2.43E-05	3.59E-07	5.37E-05	1.22E-06	0.00E+00	0.00E+00
SB124	1.01E-06	7.95E-05	6.68E-09	2.39E-06	4.80E-08	1.85E-06	0.00E+00
SB125	3.83E-07	1.97E-05	1.94E-09	1.47E-06	2.05E-08	1.16E-06	0.00E+00
SB126	3.99E-07	9.40E-05	6.95E-09	1.10E-06	2.25E-08	6.73E-07	0.00E+00
SB127	9.76E-08	5.90E-05	3.08E-09	2.54E-07	5.57E-09	1.50E-07	0.00E+00
TE125M	3.42E-07	1.07E-05	7.81E-07	2.47E-06	8.95E-07	0.00E+00	1.01E-05
TE127M	7.82E-07	2.27E-05	1.67E-06	6.14E-06	2.14E-06	0.00E+00	2.49E-05
TE127	2.37E-08	8.68E-06	8.13E-08	1.10E-07	3.94E-08	0.00E+00	4.47E-07
TE129M	1.74E-06	5.79E-05	3.84E-06	1.07E-05	4.02E-06	0.00E+00	4.50E-05
TE129	7.64E-09	2.37E-08	2.41E-08	3.14E-08	1.18E-08	0.00E+00	1.32E-07
TE131M	7.02E-07	8.40E-05	1.33E-06	1.73E-06	8.41E-07	0.00E+00	8.52E-06
TE131	6.21E-09	2.95E-09	1.62E-08	1.97E-08	8.23E-09	0.00E+00	8.62E-08
TE132	1.51E-06	7.71E-05	1.78E-06	2.49E-06	1.61E-06	0.00E+00	1.56E-05
TE133M	4.45E-08	4.17E-09	3.91E-08	4.62E-08	2.79E-08	0.00E+00	2.67E-07
TE134	1.30E-08	4.46E-09	2.83E-08	3.23E-08	2.12E-08	0.00E+00	2.05E-07
I129	5.86E-06	4.44E-07	4.60E-03	3.09E-06	2.73E-06	0.00E+00	5.87E-06
I130	8.78E-07	1.92E-06	2.84E-04	7.54E-07	2.23E-06	0.00E+00	3.47E-06
I131	3.31E-06	1.57E-06	1.89E-03	4.07E-06	5.86E-06	0.00E+00	1.01E-05
I132	1.93E-07	1.02E-07	7.13E-05	2.02E-07	5.42E-07	0.00E+00	8.64E-07
I133	7.53E-07	2.18E-06	4.74E-04	1.42E-06	2.47E-06	0.00E+00	4.31E-06
I134	1.02E-07	2.51E-10	3.73E-05	1.06E-07	2.88E-07	0.00E+00	4.58E-07
I135	4.28E-07	1.31E-06	1.52E-04	4.42E-07	1.16E-06	0.00E+00	1.85E-06
XE131M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

XE135M	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS134M	2.29E-08	1.58E-08	0.00E+00	2.12E-08	4.48E-08	3.82E-09	2.43E-08
CS134	7.72E-05	2.59E-06	0.00E+00	3.65E-05	1.03E-04	9.32E-06	4.04E-05
CS135	4.76E-06	4.21E-07	0.00E+00	1.05E-05	1.20E-05	1.10E-06	5.68E-06
CS136	1.76E-05	2.92E-06	0.00E+00	6.20E-06	2.45E-05	1.86E-06	1.37E-05
CS137	4.27E-05	2.11E-06	0.00E+00	4.31E-05	7.25E-05	6.63E-06	3.09E-05
CS138	5.40E-08	4.65E-13	0.00E+00	5.51E-08	1.09E-07	7.91E-09	8.00E-08
CS139	1.85E-08	1.10E-30	0.00E+00	3.41E-08	5.08E-08	3.70E-09	4.07E-08
BA139	2.84E-09	1.72E-07	0.00E+00	9.69E-08	6.91E-11	3.91E-11	6.46E-11
BA140	3.31E-10	9.25E-05	0.00E+00	2.48E-09	1.25E-09	0.00E+00	0.00E+00
BA141	1.59E-09	2.22E-17	0.00E+00	6.73E-27	3.56E-11	2.02E-11	3.31E-11
BA142	1.34E-09	2.85E-26	0.00E+00	2.13E-08	2.19E-11	1.24E-11	1.85E-11
LA140	3.31E-10	9.25E-05	0.00E+00	2.48E-09	1.25E-09	0.00E+00	0.00E+00
LA141	1.62E-11	1.18E-05	0.00E+00	3.18E-10	9.89E-11	0.00E+00	0.00E+00
LA142	1.44E-11	4.25E-07	0.00E+00	1.28E-10	5.81E-11	0.00E+00	0.00E+00
CE141	6.30E-10	2.42E-05	0.00E+00	8.18E-09	5.60E-09	0.00E+00	2.58E-09
CE143	1.34E-10	4.56E-05	0.00E+00	1.64E-09	1.21E-06	0.00E+00	5.34E-10
CE144	1.[illegible]E-08	1.65E-04	0.00E+00	1.87E-07	1.08E-07	0.00E+00	5.41E-08
PR143	4.32E-10	4.03E-05	0.00E+00	8.70E-09	3.50E-09	0.00E+00	2.02E-09
PR144	1.53E-12	4.33E-18	0.00E+00	3.01E-11	1.25E-11	0.00E+00	7.05E-12
ND147	4.16E-10	3.49E-05	0.00E+00	6.02E-09	6.98E-09	0.00E+00	4.06E-09
PM147	7.59E-10	8.93E-06	0.00E+00	1.42E-08	1.88E-09	0.00E+00	3.54E-09
PM148M	5.14E-09	6.74E-05	0.00E+00	2.58E-08	6.72E-09	0.00E+00	1.02E-08
PM148	5.86E-10	9.35E-05	0.00E+00	7.02E-09	1.17E-09	0.00E+00	2.20E-09
PM149	8.70E-11	4.03E-05	0.00E+00	1.51E-09	2.13E-10	0.00E+00	4.03E-10
PM151	5.88E-11	3.22E-05	0.00E+00	6.93E-10	1.16E-10	0.00E+00	2.08E-10
SM151	4.94E-10	5.25E-06	0.00E+00	5.73E-09	5.39E-09	0.00E+00	2.30E-09
SM153	5.18E-11	2.55E-05	0.00E+00	8.50E-10	7.09E-10	0.00E+00	2.29E-10
EU152	7.62E-09	2.56E-05	0.00E+00	2.01E-08	2.55E-08	0.00E+00	2.87E-08
EU154	1.11E-08	5.48E-05	0.00E+00	7.07E-08	4.37E-08	0.00E+00	4.19E-08
EU155	1.80E-09	9.60E-06	0.00E+00	1.22E-08	7.18E-09	0.00E+00	3.01E-09
EU156	1.61E-09	7.26E-05	0.00E+00	1.29E-08	9.98E-09	0.00E+00	6.66E-09
TB160	4.38E-09	4.33E-05	0.00E+00	3.47E-08	0.00E+00	0.00E+00	1.45E-08
HO166M	9.69E-09	0.00E+00	0.00E+00	3.15E-08	1.11E-08	0.00E+00	1.80E-08
W181	3.44E-01	3.68E-07	0.00E+00	9.58E-09	3.18E-09	0.00E+00	0.00E+00
W185	1.41E-08	1.56E-05	0.00E+00	3.92E-07	1.33E-07	0.00E+00	0.00E+00
W187	3.01E-08	2.82E-05	0.00E+00	1.03E-07	8.58E-08	0.00E+00	0.00E+00
PB210	5.19E-05	5.42E-05	0.00E+00	7.49E-04	3.34E-04	0.00E+00	2.65E-03
BI210	3.92E-08	4.75E-05	0.00E+00	4.54E-07	3.14E-06	0.00E+00	3.79E-05
PO210	7.75E-05	6.36E-05	0.00E+00	3.27E-04	6.61E-04	0.00E+00	2.06E-03
RN222	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RA223	9.49E-04	3.21E-04	0.00E+00	4.75E-03	7.49E-06	0.00E+00	2.12E-04
RA224	3.18E-04	3.40E-04	0.00E+00	1.59E-03	3.86E-06	0.00E+00	1.09E-04
RA225	1.23E-03	3.06E-04	0.00E+00	6.17E-03	7.60E-06	0.00E+00	2.15E-04
RA226	4.36E-03	3.32E-04	0.00E+00	4.38E-03	5.51E-06	0.00E+00	1.56E-04
RA228	3.76E-03	5.64E-05	0.00E+00	7.28E-03	2.99E-06	0.00E+00	8.48E-05
AC225	2.84E-07	4.07E-04	0.00E+00	4.23E-06	5.82E-06	0.00E+00	6.62E-07
AC227	2.63E-06	7.94E-05	0.00E+00	3.96E-05	1.63E-05	0.00E+00	1.90E-06
TH227	3.66E-07	5.40E-04	0.00E+00	1.27E-05	2.30E-07	0.00E+00	1.30E-06

TH228	2.73E-06	5.63E-04	0.00E+00	8.05E-05	1.37E-06	0.00E+00	7.73E-06
TH229	4.40E-06	5.12E-04	0.00E+00	3.77E-05	1.34E-06	0.00E+00	7.60E-06
TH230	6.40E-07	6.02E-05	0.00E+00	2.26E-05	1.32E-06	0.00E+00	7.45E-06
TH231	3.56E-11	6.26E-05	0.00E+00	2.27E-09	2.44E-07	0.00E+00	0.00E+00
TH232	5.47E-07	1.28E-04	0.00E+00	1.96E-05	1.13E-06	0.00E+00	6.36E-06
TH234	2.09E-09	1.13E-04	0.00E+00	7.25E-08	4.26E-09	0.00E+00	2.41E-08
PA231	1.87E-06	6.27E-04	0.00E+00	4.50E-05	1.73E-06	0.00E+00	0.00E+00
PA233	8.14E-10	1.64E-05	0.00E+00	4.69E-09	9.43E-10	0.00E+00	3.56E-09
U232	1.88E-04	6.72E-05	0.00E+00	1.35E-03	0.00E+00	0.00E+00	4.20E-04
U233	3.36E-05	6.27E-05	0.00E+00	2.82E-04	0.00E+00	0.00E+00	1.91E-04
U234	3.29E-05	6.14E-05	0.00E+00	2.71E-04	0.00E+00	0.00E+00	1.87E-04
U235	3.09E-05	7.81E-05	0.00E+00	2.60E-04	0.00E+00	0.00E+00	1.76E-04
U236	3.16E-05	5.76E-05	0.00E+00	2.60E-04	0.00E+00	0.00E+00	1.80E-04
U237	1.43E-08	1.94E-05	0.00E+00	5.37E-08	0.00E+00	0.00E+00	2.23E-07
U238	2.89E-05	1.66E-04	0.00E+00	2.49E-04	0.00E+00	0.00E+00	1.64E-04
NP237	6.53E-07	7.94E-05	0.00E+00	1.50E-05	1.34E-06	0.00E+00	4.57E-06
NP238	2.11E-10	3.43E-05	0.00E+00	1.35E-08	3.65E-01	0.00E+00	1.24E-09
NP239	6.39E-11	2.40E-05	0.00E+00	1.18E-09	1.16E-10	0.00E+00	3.61E-10
PU238	2.19E-07	7.30E-05	0.00E+00	3.78E-06	1.35E-06	0.00E+00	1.02E-06
PU239	2.06E-07	6.66E-05	0.00E+00	3.26E-06	1.27E-06	0.00E+00	9.80E-07
PU240	2.06E-07	6.78E-05	0.00E+00	3.26E-06	1.27E-06	0.00E+00	9.62E-07
PU241	8.91E-09	1.40E-06	0.00E+00	4.17E-07	2.43E-09	0.00E+00	4.35E-09
PU242	1.96E-07	6.53E-05	0.00E+00	7.34E-06	1.21E-06	0.00E+00	9.13E-07
PU244	2.34E-07	9.73E-05	0.00E+00	4.35E-06	1.44E-06	0.00E+00	[illegible]
AM241	7.31E-07	7.42E-05	0.00E+00	3.14E-06	1.03E-05	0.00E+00	5.12E-06
AM242M	8.10E-07	9.34E-05	0.00E+00	1.01E-05	1.07E-05	0.00E+00	[illegible]
AM243	7.05E-07	9.73E-05	0.00E+00	3.32E-06	3.95E-06	0.00E+00	4.44E-06
CM242	5.15E-07	7.92E-05	0.00E+00	7.79E-06	3.13E-06	0.00E+00	[illegible]
CM243	7.92E-07	7.81E-05	0.00E+00	1.19E-05	1.27E-05	0.00E+00	2.69E-06
CM244	7.62E-07	4.55E-05	0.00E+00	1.15E-05	1.22E-05	0.00E+00	2.55E-06
CM245	7.45E-07	7.04E-05	0.00E+00	1.12E-05	1.20E-05	0.00E+00	3.43E-06
CM246	7.45E-07	6.31E-05	0.00E+00	[illegible]	[illegible]	0.00E+00	3.43E-06
CM247	7.32E-07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.41E-06
CM248	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.31E-05
CF252	7.71E-07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00E+00

The format used in NEP.F4 is (A5, A3, E8.0, 6E9.0).

A-9. LISTING OF A2ICR.DAT FILE

ICRP 2 ADULT DOSE FACTORS (MREM/MICRO CI)

	BODY	SI-LLI	THYROID	BONE	LIVER	LUNG	KIDNEY
H3	1.25E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
C14	6.23E-01	0.00E-01	0.00E-01	3.74E+00	0.00E-01	0.00E-01	0.00E-01
NA22	1.56E+01	6.25E+01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
AR41	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
SC46	3.11E-03	4.67E+01	0.00E-01	4.67E-03	0.00E-01	0.00E-01	0.00E-01
CR51	3.11E-02	9.35E-01	3.74E-02	0.00E-01	0.00E-01	4.67E-02	0.00E-01
MN54	7.78E-01	1.87E+01	0.00E-01	0.00E-01	4.67E+00	0.00E-01	0.00E-01
FE59	3.11E+00	3.73E+01	0.00E-01	3.74E+00	9.34E+00	2.67E+00	0.00E-01
CO58	1.56E+00	1.87E+01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
CO60	6.23E+00	3.73E+01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
ZN65	6.23E+00	9.35E+00	0.00E-01	3.74E+00	0.00E-01	0.00E-01	0.00E-01
AS76	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR83M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR85	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR85M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR87	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR88	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR89	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR90	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
SR89	8.90E+00	6.25E+01	0.00E-01	3.74E+02	0.00E-01	0.00E-01	0.00E-01
SR90	8.90E+02	4.67E+01	0.00E-01	9.34E+03	0.00E-01	0.00E-01	0.00E-01
Y90	2.08E-04	9.35E+01	0.00E-01	9.34E-03	0.00E-01	0.00E-01	0.00E-01
Y91	3.11E-03	6.25E+01	0.00E-01	1.25E-01	0.00E-01	0.00E-01	0.00E-01
ZR95	6.23E-03	3.12E+01	0.00E-01	1.87E-02	0.00E-01	0.00E-01	0.00E-01
NB95	1.56E-03	1.87E+01	0.00E-01	5.34E-03	0.00E-01	0.00E-01	0.00E-01
RU103	7.78E-02	2.33E+01	0.00E-01	1.87E-01	0.00E-01	0.00E-01	0.00E-01
RU106	3.11E-01	1.87E+02	0.00E-01	3.74E+00	0.00E-01	0.00E-01	0.00E-01
SN123	7.60E-01	3.17E+01	4.38E-01	3.11E+01	5.16E-01	0.00E-01	0.00E-01
SB125	3.11E-01	1.87E+01	1.87E-03	1.87E+00	0.00E-01	1.87E+00	0.00E-01
TE125M	6.23E-01	1.87E+01	7.47E-01	1.87E+00	1.87E+00	0.00E-01	9.34E+00
TE127	2.08E-02	9.35E+00	7.47E-02	1.25E-01	0.00E-01	0.00E-01	0.00E-01
TE127M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
TE129M	3.11E+00	9.35E+01	4.67E+00	1.25E+01	0.00E-01	0.00E-01	0.00E-01
TE132	1.25E+00	9.35E+01	1.87E+00	1.87E+00	0.00E-01	0.00E-01	0.00E-01
I125	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I129	1.25E+01	9.35E+00	9.10E+03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I131	3.11E+00	3.17E+01	1.80E+03	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I133	6.92E-01	4.67E+01	3.50E+02	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE131M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE133	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE133M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE135	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE135M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE137	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE138	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
CS134	6.92E+01	4.67E+01	0.00E-01	5.34E+01	0.00E-01	1.37E+01	0.00E-01
CS136	6.92E+00	3.12E+01	0.00E-01	3.74E+00	0.00E-01	9.34E-01	0.00E-01
CS137	3.11E+01	4.67E+01	0.00E-01	7.47E+01	0.00E-01	9.34E+00	0.00E-01

BA140	1.25E+00	9.35E+01	0.00E-01	1.37E+01	0.00E-01	[illegible]	0.00E-01
LA140	3.11E-04	9.35E+01	0.00E-01	1.37E-03	0.00E-01	0.00E-01	0.00E-01
CE141	6.23E-04	[illegible]	0.00E-01	7.47E-03	6.23E-03	0.00E-01	[illegible]
CE144	2.08E-02	1.87E+02	0.00E-01	4.67E-01	0.00E-01	0.00E-01	0.00E-01
ND147	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
EU154	7.78E-02	9.35E+01	0.00E-01	1.25E+00	0.00E-01	0.00E-01	0.00E-01
TH228	1.56E+01	1.87E+02	0.00E-01	5.34E+02	0.00E-01	0.00E-01	0.00E-01
TH232	6.92E+01	4.67E+01	0.00E-01	1.87E+02	0.00E-01	0.00E-01	0.00E-01
U232	3.11E+02	6.25E+01	0.00E-01	4.67E+03	0.00E-01	0.00E-01	0.00E-01
U233	6.23E+01	6.25E+01	0.00E-01	9.34E+02	0.00E-01	0.00E-01	0.00E-01
U234	6.23E+01	6.25E+01	0.00E-01	9.34E+02	0.00E-01	0.00E-01	0.00E-01
U235	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
U238	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
NP239	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
PU238	1.56E+01	6.25E+01	0.00E-01	7.47E+02	0.00E-01	0.00E-01	0.00E-01
PU239	2.08E+01	6.25E+01	0.00E-01	7.47E+02	0.00E-01	0.00E-01	0.00E-01
PU240	2.08E+01	6.25E+01	0.00E-01	7.47E+02	0.00E-01	0.00E-01	0.00E-01
PU241	3.11E-01	1.87E+00	0.00E-01	1.37E+01	0.00E-01	0.00E-01	0.00E-01
AM241	6.23E+01	6.25E+01	0.00E-01	7.47E+02	2.67E+02	0.00E-01	4.67E+02
CM242	1.25E+00	9.35E+01	0.00E-01	1.37E+01	2.08E+01	0.00E-01	6.23E+00
CM244	3.11E+01	6.25E+01	0.00E-01	5.34E+02	2.08E+02	0.00E-01	1.37E+02

The format used in NEP.F4 is (A5, A3, E8.0, 6E9.0).

A-10. LISTING OF CUSNR.DAT FILE

INFANT DOSE FACTORS USNRC REG GUIDE 1.109-10 CTR-50 (MREM/P CI)

	BODY	GI-LLI	THYROID	BONE	LIVER	LUNG	KIDNEY
H3	3.08E-07	3.08E-07	3.08E-07	0.00E-01	3.08E-07	3.08E-07	3.08E-07
C14	5.06E-06	5.06E-06	5.06E-06	2.37E-05	5.06E-06	5.06E-06	5.06E-06
NA22	9.83E-05	9.83E-05	9.83E-05	9.83E-05	9.83E-05	9.83E-05	9.83E-05
AR41	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
SC46	1.69E-08	3.53E-05	0.00E-01	3.75E-08	5.41E-08	0.00E-01	3.56E-08
CR51	1.41E-08	4.11E-07	9.20E-09	0.00E-01	0.00E-01	1.79E-08	2.01E-09
MN54	4.51E-06	7.31E-06	0.00E-01	0.00E-01	1.99E-05	0.00E-01	4.41E-06
FE59	2.12E-05	2.57E-05	0.00E-01	3.08E-05	5.38E-05	1.59E-05	0.00E-01
CO58	8.98E-06	8.97E-06	0.00E-01	0.00E-01	3.60E-06	0.00E-01	0.00E-01
CO60	2.55E-05	2.57E-05	0.00E-01	0.00E-01	1.08E-05	0.00E-01	0.00E-01
ZN65	2.91E-05	5.33E-05	0.00E-01	1.84E-05	6.31E-05	0.00E-01	3.06E-05
A[illegible]76	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR83M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR85	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR85M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR87	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR88	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR89	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
KR90	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
SR89	7.20E-05	5.16E-05	0.00E-01	2.51E-03	0.00E-01	0.00E-01	0.00E-01
SR90	4.71E-03	2.31E-04	0.00E-01	1.85E-02	0.00E-01	0.00E-01	0.00E-01
Y90	2.33E-09	1.20E-04	0.00E-01	8.69E-08	0.00E-01	0.00E-01	0.00E-01
Y91	3.01E-08	9.10E-05	0.00E-01	1.13E-06	0.00E-01	0.00E-01	0.00E-01
ZR95	3.56E-08	2.50E-05	0.00E-01	2.06E-07	5.02E-08	0.00E-01	5.41E-08
NB95	1.00E-08	1.46E-05	0.00E-01	4.20E-08	1.73E-08	0.00E-01	1.24E-08
RU103	4.95E-07	1.80E-05	0.00E-01	1.48E-06	0.00E-01	0.00E-01	3.08E-06
RU106	3.01E-06	1.83E-04	0.00E-01	2.41E-05	0.00E-01	0.00E-01	2.85E-05
SN123	6.50E-06	6.58E-05	3.91E-06	2.49E-04	3.89E-06	0.00E-01	0.00E-01
SB125	2.53E-06	1.64E-05	1.54E-08	1.23E-05	1.19E-07	7.72E-06	0.00E-01
TE125M	3.15E-06	1.11E-05	7.84E-06	2.33E-05	7.79E-06	0.00E-01	0.00E-01
TE127	2.15E-07	2.10E-05	8.14E-07	1.00E-06	3.35E-07	0.00E-01	2.44E-06
TE127M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
TE129M	1.54E-05	5.97E-05	3.84E-05	1.00E-04	3.43E-05	0.00E-01	2.50E-04
TE132	9.61E-06	3.81E-05	1.52E-05	2.08E-05	1.03E-05	0.00E-01	6.44E-05
I125	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I129	1.55E-05	4.24E-07	1.36E-02	2.86E-05	2.12E-05	0.00E-01	2.51E-05
I131	1.36E-05	1.51E-06	1.10E-02	3.59E-05	4.23E-05	0.00E-01	4.94E-05
I133	5.33E-06	3.08E-06	3.31E-03	1.25E-05	1.82E-05	0.00E-01	2.14E-05
XE131M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE133	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE133M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE135	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE135M	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE137	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
XE138	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
CS134	7.10E-05	1.91E-06	0.00E-01	3.77E-04	7.03E-04	7.42E-05	1.81E-04
CS136	5.04E-05	2.05E-06	0.00E-01	4.59E-05	1.35E-04	1.10E-05	5.38E-05
CS137	4.50E-05	1.91E-06	0.00E-01	5.22E-04	6.11E-04	6.64E-05	1.64E-04

BA140	3.31E-06	4.20E-05	0.00E-01	1.71E-04	1.71E-07	1.05E-07	4.06E-03
LA140	2.14E-09	9.77E-05	0.00E-01	2.11E-08	3.32E-09	0.00E-01	0.00E-01
CE141	5.65E-09	2.49E-05	0.00E-01	7.37E-08	4.30E-08	0.00E-01	1.48E-08
CE144	1.67E-07	1.71E-04	0.00E-01	2.98E-06	1.22E-06	0.00E-01	4.93E-07
ND147	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
EU154	2.20E-07	4.58E-05	0.00E-01	2.64E-06	3.67E-07	0.00E-01	9.95E-07
TH228	8.36E-05	5.84E-04	0.00E-01	2.47E-03	3.38E-05	0.00E-01	1.59E-04
TH232	1.65E-04	5.31E-05	0.00E-01	4.24E-03	1.63E-04	0.00E-01	[illegible].79E-04
U232	2.16E-03	7.04E-05	0.00E-01	2.42E-02	0.00E-01	0.00E-01	2.37E-03
U233	3.87E-04	6.51E-05	0.00E-01	5.08E-03	0.00E-01	0.00E-01	1.08E-03
U234	3.80E-04	6.37E-05	0.00E-01	4.89E-03	0.00E-01	0.00E-01	1.06E-03
U235	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
U238	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
NP239	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
PU238	3.40E-05	7.57E-05	0.00E-01	1.34E-03	1.69E-04	0.00E-01	1.21E-04
PU239	3.54E-05	6.91E-05	0.00E-01	1.45E-03	1.77E-04	0.00E-01	1.28E-04
PU240	3.54E-05	7.04E-05	0.00E-01	1.45E-03	1.77E-04	0.00E-01	1.28E-04
PU241	3.92E-07	1.45E-06	0.00E-01	4.38E-05	1.90E-06	0.00E-01	3.17E-06
AM241	1.09E-04	7.70E-05	0.00E-01	1.53E-03	7.18E-04	0.00E-01	6.55E-04
CM242	9.10E-06	3.23E-05	0.00E-01	1.37E-04	1.24E-04	0.00E-01	2.62E-05
CM244	7.59E-05	7.84E-05	0.00E-01	1.22E-03	6.16E-04	0.00E-01	2.71E-04

The format used in NEP.F4 is (A5, A3, E8.0, 6E9.0).

A-11. LISTING OF A26ICR.DAT FILE

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ICRP26 STOCHASTIC DOSE FACTORS (REM/MICRO CI)
FOR ADULT (AECL-6540) REV JAN 25 80
H3          0.100E-03
C14         0.191E-02
NA22        0.118E-01
NA24        0.900E-03
P32         0.331E-02
P33         0.645E-03
S35         0.731E-03
SC46        0.338E-02
CR51        0.975E-04
MN54        0.123E-02
FE55        0.499E-03
FE59        0.511E-02
CO58        0.352E-02
CO60        0.447E-01
NI63        0.447E-03
ZN65        0.108E-01
AS76        0.872E-02
SE75        0.430E-02
SE79        0.529E-02
SR85        0.531E-03
SR89        0.980E-02
SR90        0.145E+00   INCL DAUGHTER(S)
Y90         0.110E-01
Y91         0.963E-02
NB95        0.262E-02
MO99        0.675E-02   INCL DAUGHTER(S)
TC99        0.256E-02
RU103       0.153E-02
RU106       0.273E-01   INCL DAUGHTER(S)
PD107       0.180E-03
AG110M      0.918E-02
SN123       0.949E-02
SB122       0.104E-01
SB124       0.115E-01
SB125       0.387E-02
TE125M      0.168E-02
TE127       0.789E-03
TE127M      0.105E-01   INCL DAUGHTER(S)
TE129M      0.122E-01   INCL DAUGHTER(S)
TE132       0.844E-02   INCL DAUGHTER(S)
I123        0.510E-03
I124        0.339E-01
I125        0.399E-01
I126        0.711E-01
I128        0.274E-04
I129        0.275E+00
I130        0.468E-02
I131        0.540E-01
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I132	0.597E-03	
I133	0.104E-01	
I134	0.131E-03	
I135	0.234E-02	
CS134	0.638E-01	
CS135	0.721E-02	
CS136	0.979E-02	
CS137	0.459E-01	
BA133	0.600E-03	
BA140	0.195E-02	INCL DAUGHTER(S)
ND147	0.415E-02	
LA140	0.677E-02	
CE141	0.276E-02	
CE144	0.202E-01	INCL DAUGHTER(S)
PM147	0.101E-02	
EU152	0.640E-02	
EU154	0.588E-02	
EU155	0.112E-02	
YB169	0.241E-02	
W185	0.252E+01	
IR192	0.958E-02	
HG197	0.877E-03	
HG203	0.329E-02	
TL204	0.196E-02	
PB210	0.312E+01	INCL BI210, PO210
BI210	0.747E-02	INCL PO210
PO210	0.174E+01	
RA223	0.378E+00	INCL DAUGHTER(S)
RA224	0.131E+00	INCL DAUGHTER(S)
RA225	0.478E+00	INCL DAUGHTER(S)
RA226	0.109E+02	INCL DAUGHTER(S)
RA228	0.922E+01	INCL DAUGHTER(S)
TH227	0.159E+01	INCL RA223 AND DAUGHTER(S)
TH228	0.536E+02	INCL DAUGHTER(S)
TH229	0.134E+01	INCL RA225 AND DAUGHTER(S)
TH230	0.726E+02	
TH231	0.970E-03	INCL PA231
TH232	0.765E+02	INCL RA228, TH228 AND DAUGHTER(S)
TH234	0.361E-01	INCL PA234, U234
AC225	0.117E+01	INCL DAUGHTER(S)
AC227	0.197E+01	INCL DAUGHTER(S)
U232	0.120E+02	INCL TH228, RA224 AND DAUGHTER(S)
U233	0.277E+00	
U234	0.277E+00	
U235	0.260E+00	
U236	0.260E+00	
U238	0.241E+00	
PU238	0.391E+00	
PU239	0.430E+00	
PU240	0.430E+00	
PU241	0.723E-02	INCL AM241
PU242	0.413E+00	

PU244	0.387E+00	
PA231	0.167E+03	INCL AC227, TH227 AND DAUGHTER(S)
PA233	0.166E-02	INCL U233
AM241	0.200E+01	
AM243	0.192E+01	
NP237	0.383E+02	
NP239	0.128E-02	
CM242	0.573E-01	
CM244	0.112E+01	
CM247	0.319E+02	

The format used in NEP.F4 is (A5, A3, 2X, E10.0).

A-12. LISTING OF C26IC.DAT FILE

ICRP26 STOCHASTIC DOSE FACTORS (REM/MICRO CI)
FOR INFANTS (AECL-6540) REV JAN 25 80

H3	0.294E-03	
C14	0.573E-02	
NA22	0.265E-01	
NA24	0.433E-02	
P32	0.236E-01	
P33	0.310E-02	
S35	0.140E-02	
SC46	0.275E-02	
CR51	0.138E-03	
MN54	0.152E-02	
FE55	0.174E-02	
FE59	0.129E-01	
CO58	0.117E-01	
CO60	0.977E-01	
NI63	0.118E-02	
ZN65	0.277E-01	
AS76	0.189E-01	
SE75	0.988E-02	
SE79	0.139E-01	
SR85	0.163E-02	
SR89	0.204E-01	
SR90	0.555E+00	INCL DAUGHTER(S)
Y90	0.191E-01	
Y91	0.132E-01	
NB95	0.689E-02	
MO99	0.294E-01	INCL DAUGHTER(S)
TC99	0.564E-03	
RU103	0.174E-02	
RU106	0.464E-01	INCL DAUGHTER(S)
PD107	0.244E-03	
AG110M	0.926E-02	
SN123	0.134E-01	
SB122	0.464E-01	
SB124	0.165E-01	
SB125	0.506E-02	
TE125M	0.434E-02	
TE127	0.295E-02	
TE127M	0.622E-01	INCL DAUGHTER(S)
TE129M	0.602E-01	INCL DAUGHTER(S)
TE132	0.165E-01	INCL DAUGHTER(S)
I123	0.504E-02	
I124	0.318E+00	
I125	0.246E+00	
I126	0.597E+00	
I128	0.275E-03	
I129	0.987E+00	
I130	0.462E-01	
I131	0.480E+00	

I132	0.582E-02	
I133	0.102E+00	
I134	0.132E-02	
I135	0.236E-01	
CS134	0.562E-01	
CS135	0.924E-02	
CS136	0.265E-01	
CS137	0.473E-01	
BA133	0.143E-02	
BA140	0.591E-02	INCL DAUGHTER(S)
ND147	0.548E-02	
LA140	0.970E-02	
CE141	0.355E-02	
CE144	0.288E-01	INCL DAUGHTER(S)
PM147	0.140E-02	
EU152	0.639E-02	
EU154	0.597E-02	
EU155	0.134E-02	
YB169	0.172E-02	
W185	0.929E+01	
IR192	0.110E-01	
HG197	0.104E-02	
HG203	0.546E-02	
TL204	0.301E-02	
PB210	0.130E+02	INCL BI210, PO210
BI210	0.114E-01	INCL PO210
PO210	0.530E+01	
RA223	0.246E+01	INCL DAUGHTER(S)
RA224	0.933E+00	INCL DAUGHTER(S)
RA225	0.302E+01	INCL DAUGHTER(S)
RA226	0.447E+02	INCL DAUGHTER(S)
RA228	0.375E+02	INCL DAUGHTER(S)
TH227	0.428E+01	INCL RA223 AND DAUGHTER(S)
TH228	0.364E+03	INCL DAUGHTER(S)
TH229	0.110E+02	INCL RA225 AND DAUGHTER(S)
TH230	0.195E+03	
TH231	0.246E-02	INCL PA231
TH232	0.200E+03	INCL RA228, TH228 AND DAUGHTER(S)
TH234	0.239E-01	INCL PA234, U234
AC225	0.322E+01	INCL DAUGHTER(S)
AC227	0.481E+01	INCL DAUGHTER(S)
U232	0.177E+02	INCL TH228, RA224 AND DAUGHTER(S)
U233	0.467E+00	
U234	0.467E+00	
U235	0.439E+00	
U236	0.439E+00	
U238	0.406E+00	
PU238	0.342E+01	
PU239	0.377E+01	
PU240	0.377E+01	
PU241	0.670E-01	INCL AM241
PU242	0.362E+01	

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PU244     0.339E+01
PA231     0.154E+04   INCL AC227, TH227 AND DAUGHTERS
PA233     0.210E-02   INCL U233
AM241     0.136E+02
AM243     0.179E+02
NP237     0.347E+03
NP239     0.189E-02
CM242     0.379E+00
CM244     0.101E+02
CM247     0.318E+03
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