HADOC - A Computer Code for Calculation of External and Inhalation Doses From Acute Radionuclide Releases

**D. L. Streng
R. A. Peloquin**

April 1981

**Prepared for the U.S. Department of Energy
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**Pacific Northwest Laboratory
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ABSTRACT

The computer code HADOC (Hanford Acute Dose Calculations) is described and instructions for its use are presented. The code calculates external dose from air submersion and inhalation doses following acute radionuclide releases. Atmospheric dispersion is calculated using the Hanford model with options to determine maximum conditions. Building wake effects and terrain variation may also be considered. Doses are calculated using dose conversion factor supplied in a data library. Doses are reported for one and fifty year dose commitment periods for the maximum individual and the regional population (within 50 miles). The fractional contribution to dose by radionuclide and exposure mode are also printed if requested.

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HADOC - A COMPUTER CODE FOR CALCULATION OF EXTERNAL AND INHALATION DOSES FROM ACUTE RADIONUCLIDE RELEASES

1.0 INTRODUCTION

The computer code HADOC (Hanford Acute Dose Calculations) was prepared for calculation of external and inhalation doses resulting from postulated accidental radionuclide releases on the Hanford site. The code generates doses to an individual at a specified location (referred to as the maximum individual) and to the population in the region near the Hanford site.

Atmospheric dispersion is calculated using the Hanford dispersion model (Fuquay et al. 1964) with building wake effects and terrain elevation considered as options. For elevated releases, the code will also determine (as an option) the worst case dispersion conditions by considering Pasquill dispersion categories A-F. The maximally exposed individual dispersion factor is calculated using the bivariate Gaussian dispersion equation (defined in Section 2.0). The population dispersion factors are based on a cross-wind sector averaged dispersion equation. The population dose is calculated for the sector having the highest population exposure factor as determined by the dispersion factors and the specified population distribution.

The decay of the released radionuclide activities is considered during transit from the release point to the location of the maximally exposed individual, MI, and to the center of each population ring. Decay times are based on user supplied average wind speeds. A chain decay processor with multiple branching is used to calculate decayed activities.

The doses from external and inhalation exposure are calculated at each location for specified organs. Doses reported include the MI dose (by organ and exposure mode) and the total population dose (by organ and exposure mode) in the sector having the highest population exposure factor. The first year and fifty-year dose commitments are reported.

Optional reports may be printed giving the fractional contribution to total dose by radionuclide for each organ and dose commitment period for the MI and the population.

2.0 MATHEMATICAL MODELS

The mathematical models employed by HADOC in estimation of potential radiation doses to individuals and the population are described in this section. The models were selected to be consistent with the current methodology used for accident consequence analysis for releases on the Hanford Site. This code implements models for dose calculations that are currently performed using hand calculations and other codes not designed for this type of calculation.

The doses to the maximally exposed individual are calculated at the location of nearest public access to the release site as specified by the user. The population doses are calculated for the maximum exposed sector as determined by the maximum value generated for the population-exposure factor. The population dose calculations are performed for the spatial grid system shown in Figure 2.0-1. The population-exposure factor is calculated for each sector by:

$$PM_j = \sum_{i=1}^{d_j} (E/Q)_{ij} P_{ij} \quad (2.0-1)$$

where

- PM_j • population-exposure factor for sector j, person-sec/m³,
- d_j • centerline distances of spatial intervals (see Figure 2.0-1),
- $(E/Q)_{ij}$ • time-integrated air concentration at center of spatial interval in sector j at distance i, sec/m³,
- P_{ij} • number of people living in the spatial interval in direction j and at distance i, persons.

Values are generated for PM_j for each sector and the maximum sector value is used for the population dose calculations.

Models are described in the following sections for atmospheric dispersion, terrain elevation, external exposure from submersion in the plume and inhalation exposure from inhalation during plume passage.

(FACILITY AT CENTER OF GRID)
FIGURE 2.0-1 Population Dose Grid System Definition

2.1 ATMOSPHERIC DISPERSION

The dispersion of released activity is estimated at the location of the MI and at the midpoint of each population distance interval. The atmospheric dispersion of activity is expressed as the time-integral of air concentration at each location of interest. For the MI's location, the atmospheric dispersion calculation is based on the following assumptions:

- the individual is located at the closest point of public access,
- the wind blows toward the individual at a continuous speed of one m/sec,
- the air concentration is described by a bivariate Gaussian plume model,
- atmospheric stability conditions are stable (Hanford model or Pasquill E-F) or unstable (Pasquill A-D) whichever is limiting,
- plume rise is not considered,
- building wake effects are considered for ground level releases, and
- terrain variation is considered.

With these assumptions the time-integrated normalized air concentration at the location of the MI is given by:

$$(E/Q)_m = \frac{\exp \left[-h_e^2 / (2\Sigma_z) \right]}{\pi u \Sigma_y \Sigma_z} \quad (2.1-1)$$

where:

- $(E/Q)_m$ • time-integrated air concentration at the location of the maximally exposed individual, sec/m^3 ,
- h_e • effective release height at the location of interest, m,
- u • average wind speed at the release elevation, m/sec,
- Σ_y • effective crosswind horizontal standard deviation of plume concentration at the location of interest, m, and
- Σ_z • effective crosswind vertical standard deviation of plume concentration at the location of interest, m.

The dispersion parameters (Σ_y and Σ_z) include building wake effects and are defined as:

$$\Sigma_y = (\sigma_y^2 + A/2)^{1/2} \quad (2.1-2)$$

$$\Sigma_z = (\sigma_z^2 + A/2)^{1/2} \quad (2.1-3)$$

where

A • minimum cross sectional area of the facility, m²,

σ_y • crosswind horizontal standard deviation of plume concentration at the location of interest, m, and

σ_z • crosswind vertical standard deviation of plume concentration at the location of interest, m.

This model for the effective dispersion parameters includes enhanced dispersion in the wake of the building through the cross sectional area parameter A (Slade 1968). For stack releases significantly above the height of the building, wake effects would not be important and A would be set to zero. The Nuclear Regulatory Commission (USNRC 1979) suggests that building wake effects be considered only when the release point is lower than two and one-half times the height of adjacent solid structures. Building wake effects are limited by the relation:

$$\Sigma_y \Sigma_z \leq 3 \sigma_y \sigma_z \quad (2.1-4)$$

When $\Sigma_y \Sigma_z > 3 \sigma_y \sigma_z$ the value used for Σ_z in the exponential of Equation 2.1-1 is calculated as:

$$\Sigma_z = \sigma_z \sqrt{3} \quad (2.1-5)$$

The effective release height is given by:

$$h_e = h_s - h_t \geq 0 \quad (2.1-6)$$

where

h_s • stack height, m, and

h_t • maximum terrain elevation above the base of the stack between the stack and the location of interest, m. (See Section 2.2).

The dispersion parameters (σ_y , σ_z) are calculated using the Hanford dispersion model for moderately stable conditions when ground-level releases are considered. For elevated releases, however, unstable conditions (Pasquill A-D) may result in higher values for $(E/Q)_m$ at locations near the release point. Values for $(E/Q)_m$ are calculated for each stability (Pasquill A-F and Hanford) and the maximum value is used in the dose calculations.

The crosswind standard deviations, σ_y and σ_z , for stable atmospheric conditions are calculated by the Hanford model as follows:

$$\sigma_y^2 = A \left[T - \alpha (1 - e^{-T/\alpha}) \right] \quad (2.1-7)$$

$$\sigma_z^2 = a(1 - e^{-k^2 T^2}) + bT \quad (2.1-8)$$

where:

T • transport time from point of release to point of interest, sec

$$\text{and: } A = c + d(\sigma_\theta u) \quad (2.2-9)$$

$$\alpha = A/2 (\sigma_\theta u)^2 \quad (2.1-10)$$

a , b , c , d , k and $(\sigma_\theta u)$ are parameters describing the atmospheric condition. Table 2.1-1 summarizes suggested parameter values to be used with Hanford moderately stable and Hanford very stable conditions.

Graphical representations of σ_y and σ_z for the six Pasquill stability categories (Slade, 1968) have been tabulated and incorporated in a subroutine for the computer code SUBDOSA (Streng et al. 1975). This subroutine has been modified for use by HADOC in estimating dispersion parameters for the six Pasquill stability categories (A-F). Tabulated values for σ_y and σ_z are presented in Tables 2.1-2 and 2.1-3 respectively.

Atmospheric dispersion for the population dose calculations is calculated with the following assumptions:

TABLE 2.1-1 Values of Meteorological Parameters for the Hanford Model

Parameter	Moderately Stable Conditions	Very Stable Conditions
a, m ²	97	34
b, m ² /sec	0.33	0.025
c, m ² /sec	13	13
d, m	230	230
k ² , sec ⁻²	2.5 x 10 ⁻⁴	8.8 x 10 ⁻⁴

MINIMUM VALUES OF ($\sigma_{\theta}\bar{u}$), radian · m/sec

Assumed Duration of Release, Min.	1	2.5	5	10
10	0.024	0.10	0.20	0.30
60	0.04	0.15	0.25	0.35
120	0.08	0.25	0.35	0.45
240	0.10	0.40	0.50	0.60
480	0.18	0.60	0.70	0.90

TABLE 2.1-2 Values of σ_y for Pasquill Stability Categories

Distance Meters	σ_y (m) for Pasquill Type					
	A	B	C	D	E	F
100	21	16	12	8.0	6.0	3.9
150	34	24	18	12	9.0	6.0
250	54	40	28	20	14	9.8
350	75	55	40	26	20	14
500	100	76	55	37	28	18
700	140	110	76	51	37	26
1,000	200	150	110	72	52	36
1,500	290	220	160	100	75	52
2,500	450	340	240	160	120	81
3,500	610	460	330	220	160	110
5,000	830	630	450	310	220	150
7,000	1,100	840	610	420	300	210
10,000	1,600	1,200	850	570	410	280
15,000	2,200	1,700	1,200	810	570	400
25,000	3,400	2,600	1,800	1,200	880	610
35,000	4,500	3,500	2,500	1,700	1,200	820
50,000	6,200	4,700	3,400	2,300	1,600	1,100
70,000	8,200	6,400	4,700	3,000	2,100	1,500
100,000	11,000	8,500	6,300	4,100	2,800	2,000

TABLE 2.1-3 Values of σ_z for Pasquill Stability Categories
 σ_z (m) for Pasquill Type

Distance Meters	A	B	C	D	E	F
100	15	10	7.8	4.7	3.0	1.4
150	22	15	11	6.8	4.3	2.2
250	43	26	18	10	7.1	4.0
350	70	37	24	14	9.4	5.3
500	140	57	34	19	13	7.6
700	270	86	46	25	17	10
1,000	670	140	64	33	22	14
1,500	2,000	240	90	43	29	18
2,500	2,000	580	140	62	41	25
3,500	2,000	1,200	190	76	50	30
5,000	2,000	2,000	260	95	61	35
7,000	2,000	2,000	340	120	72	41
10,000	2,000	2,000	440	140	84	47
15,000	2,000	2,000	600	170	99	55
25,000	2,000	2,000	880	220	120	64
35,000	2,000	2,000	1,100	260	130	72
50,000	2,000	2,000	1,400	320	140	79
70,000	2,000	2,000	1,800	370	160	86
100,000	2,000	2,000	2,000	450	170	94

- the plume spreads uniformly over a 22.5° sector,
- the wind blows in one direction continuously at one m/sec,
- the population is uniform within each sector and distance ring,
- the atmospheric conditions are stable,
- terrain variation is considered,
- plume rise is not considered,
- building wake effects are considered, and
- the release is transported through the sector with the highest value of PM_{10} as defined by Equation 2.0-1.

The time-integrated air concentration at the center of each spatial interval is calculated as:

$$(E/Q)_{ij} = \left(\frac{2}{\pi}\right)^{1/2} \frac{\exp\left[-h_e^2 / (2\sigma_z^2)\right]}{\sigma_z \bar{u} W_i} \quad (2.1-11)$$

where

$(E/Q)_{ij}$ • time-integrated air concentration for the spatial interval at distance i in sector j , sec/m^3 ,

W_i • sector width at distance i , m ,

W_i • $\pi x_i/81$

x_i • distance from release point to center of spatial interval i , m .

Other terms are as previously defined.

When building wake effects are to be considered, plume expansion in the wake is limited by:

$$\Sigma_z \leq \sigma_z \sqrt{3} \quad (2.1-12)$$

2.2 TERRAIN ELEVATION

The effects of terrain elevation variation are considered by defining an effective elevation h_t at the location of the maximum individual and at the midpoint of each spatial interval. The effective terrain elevation is used to determine the effective plume height in Equation 2.1-6. The recommended method for defining values of h_t is the horizontal plume model for terrain correction as described in Regulatory Guide 1.111 (USNRC, 1977). Using this method the value of h_t is defined as the maximum terrain height between the release point and the exposure point. The values of h_t are specified for each spatial interval.

2.3 EXTERNAL DOSE

Persons exposed to the plume will receive a radiation dose from gamma emitting radionuclides during plume passage. This external gamma dose is calculated assuming the plume to be semi-infinite in size (bounded by the ground) and of uniform concentration equal to the ground-level centerline air concentration. The dose to the maximally exposed individual is then given by:

$$D_{me} = \sum_{k=1}^K Q_k (E/Q)_m D_k^e \quad (2.3-1)$$

where

- D_{me} • external total body dose to an individual from submersion in the plume, rem,
- Q_k • activity of radionuclide k passing the location of interest, curies,
- D_k^e • external dose conversion factor for radionuclide k, rem per (Ci sec/m³)
- K • total number of radionuclides considered.

The external dose conversion factors supplied in the data library NUCDFL (see Appendix C) are calculated for penetration to a tissue depth of 5 cm.

The dose to the population from external exposure is given by:

$$D_{pe} = \sum_{i=1}^{d_i} \sum_{k=1}^K Q_k (E/Q)_{ij} D_k^e P_{ij} \quad (2.3-2)$$

where

- D_{pe} • population total body dose (in maximum sector j) from submersion in the plume, person-rem

and other terms are as previously defined.

The activity, Q_k , includes correction for radioactive decay in transit to the location of interest. Chain decay is considered with branching to and from isomeric states.

2.4 INHALATION DOSE

Persons in the passing plume will receive radiation dose via inhalation to the lungs and other internal organs. The dose to the maximally exposed individual is calculated as:

$$D_{mo} = \sum_{k=1}^K Q_k (E/Q)_m D_{ko}^i \quad (2.4-1)$$

where

D_{mo} • inhalation dose to organ o of the maximally exposed individual at the location of interest, rem,

D_{ko}^i • inhalation dose conversion factor for radionuclide k and organ o, rem per (Ci sec/m³),

and other terms are as previously defined.

The population dose is calculated as:

$$D_{po} = \sum_{i=1}^{d_i} \sum_{k=1}^K Q_k (E/Q)_{ij} D_{ko}^i P_{ij} \quad (2.4-2)$$

where

D_{po} • inhalation population dose (in maximum sector j) to organ o, person rem,

D_{ko}^i • inhalation dose conversion factor for radionuclide and organ o, rem per (Ci sec/m³).

and other terms are as previously defined.

The inhalation dose conversion factors supplied in the data library NUCDFL (see Appendix C) were calculated using the computer program DACRIN (Houston, Streng and Watson 1976; Streng 1975). The program DACRIN employs the respiratory tract model adopted by the ICRP Task Group on Lung Dynamics (ICRP 1966; ICRP 1972). Dose factors are provided for acute inhalation followed by dose commitment periods of 1 year and 50 years. The computer program HADOC presents reports for both of these dose commitment periods.

3.0 REFERENCES

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APPENDIX A
COMPUTER CODE DESIGN

APPENDIX A

COMPUTER CODE DESIGN

This appendix provides information on the computer code design useful to programmers desiring to make modifications to the program. The average user of the code will not need the information provided here. The following sections provide:

- code hierarchy diagrams
- module summary information
- module logic diagrams.

The computer program was developed for execution on the UNIVAC 1100/44 system operated by Boeing Computer Services for the Department of Energy at Richland, Washington. The programming language is ASCII FORTRAN as implemented by the UNIVAC FTN compiler. A listing of the FORTRAN source code is given in Appendix D.

A.1 CODE HIERARCHY

The computer code HADOC is composed of 29 modules including the main program. The calling sequence for the program is indicated in the hierarchy diagrams of Figures A.1-1 through A.1-3. These diagrams only indicate module calling sequences; module logic diagrams are given in Section A.3. A brief description of the function of each model is also indicated on the hierarchy diagrams.

FIGURE A.1-1. (Cont'd)

FIGURE A.1-1. Hierarchy Diagram of the MAIN Program

FIGURE A.1-1. (Cont'd)

FIGURE A.1-2. Hierarchy Diagram for Subroutine DISPRS (called by MAIN)

FIGURE A.1-3. Hierarchy Diagram for Subroutine ACHAIN (called by TRANSIT)

A.2 MODULE SPECIFICATIONS

The computer program HADOC has been designed as a structured program consisting of 29 well defined modules. Summary information on each module is provided in the following subsections. The main program (module MAIN) is described first followed by each subroutine (or function) in alphabetical order. The descriptions contain the following information:

- module name
- calling module(s)
- primary function
- common block usage
- argument list
- subordinate modules
- detailed specifications

A.2.1. Specifications for MAIN Program

Primary Function: This code calculates radiation doses from external and inhalation uptake from accidental releases on the Hanford site.

Common Blocks Used: ACTVTY, AIRCON, DAY, DECAY, DISPSN, DISTNC, DOSFAC, DOSMI, DOSPOP, ELEVAT, FLAGS, NAMES, ORGID, SOURCE, POPU

Argument List: None

Subordinate Routines: ASGH, RLIBIN, NLIBIN, IDNUC, ORGCHK, QAPAGE, DISPRS, MIDOSE, POPDOS, DOSRPT, FRDOSE, FRDRPT, ZEROR

This module controls data input, calculations and result output through calls to subroutines. Default parameter values are also specified. The subroutine ASGH is called to request that necessary data files be made available for the run. Conversion of the code to other computers would require rewriting of the subroutine ASGH or replacing it with appropriate control cards prior to program execution.

A.2.2. Specifications for Subroutine ACHAIN, Called by TRANSIT

Primary Function:

Calculate radioactive decay for a chain of radionuclides for a given time period.

Common Blocks Used:

None

Argument List:

NUC, T, DK, IFRM, AL, AM, AO, INTGRL

Subordinate Routines:

ZEROR, EXMO, ASUM, SUMPRD

This subroutine calculates radioactive decay for a time period (T) for a chain of NUC radionuclides. The argument list parameters have the following uses:

<u>Parameter</u>	<u>Description</u>
NUC	Number of radionuclides in the decay chain. $1 \leq \text{NUC} \leq 9$.
T	Time over which decay is to be considered. Units of T must be compatible with the units of the decay constants, AL.
DK(2,9)	Branching ratios: DK(1,i), fraction of first parent decays resulting in production of chain member i. DK(2,i), fraction of second parent (if any) decays resulting in production of chain member i.
IFRM(2,9)	Position in chain of parents for each chain member. IFRM(1,i), index of first parent for chain member i. IFRM(2,i), index of second parent for chain member i.
AL(9)	Radiological decay constants for each chain member in units compatible with T.
AM(9)	Initial quantity of each radionuclide in mass units (or Curie-seconds).

Parameter	Description
A0(9)	Quantity of each radionuclide after decay for a time period T in mass units (or Curie-seconds).
INTGRL	Control integer to select decay or the time integral of activity. INTGRL $\leq$ 0; decayed activity INTGRL > 0, calculate $\int_0^t A(T)dt$ where A(t) is mass of a radionuclide.

The data arrays IFRM and DK provide branching data and allow for complex decay schemes of up to 9 chain members. Additional chain members could be considered by increasing array dimensions for A and EXPO. The dimension for A is determined by $\sum_{n=1}^{NUC} n$ and the dimension for EXPO is the number of chain members (NUC).

Three subroutines are called by ACHAIN:

- EXMO - to calculate $(1 - e^{-\lambda t})/\lambda$ when INTGRL > 0
- ASUM - to generate the sum of terms for a chain member
- SUMPRD - to generate the sum of the product of members of two arrays.

A.2.3. Specifications for Subroutine ASGH, called by MAIN

Primary Function:

This subroutine makes necessary data files available to the run.

Common Blocks Used:

None

Argument List:

IEND

Subordinate Routines:

None

This subroutine accesses necessary data files for the run through calls to the system routine FACSF. The function of this subroutine could be replaced by appropriate system control cards. When the input argument IEND = 1 (first call), the necessary data files are assigned to the run. When IEND $\neq$ 0 (second call), the files are released for use elsewhere.

A.2.4. Specifications for Function ASUM, called by ACHAIN

Primary Function:

This function sums terms of an array.

Common Blocks Used:

None

Argument List:

J, A

Subordinate Routines:

None

This function calculates the sum of J terms of array A.

$$ASUM = \sum_{i=1}^J A(i)$$

A.2.5. Specifications for Subroutine DISPRS , called by MAIN

Primary Function:

Calculate atmospheric dispersion parameters for maximum individual and population locations.

Common Blocks Used:

DISTNC, DISPSN, ELEVAT, AIRCON

Argument List:

IQP, KKRPT

Subordinate Routines:

SIGMAY, SIGMAZ, POPEQ, MMAXEQ

This subroutine calculates the air concentration at the location of the maximum individual and then calls subroutine POPEQ which calculates the population dispersion parameters. The maximum individual air concentration is calculated using Equation 2.1-1 of the text.

The argument list parameters have the following use:

<u>Parameter</u>	<u>Use</u>
IQP	Control integer to cause printing of air concentration values (printed if IQP > 0).
KKRPT	Control air concentration calculation; KKRPT $\leq$ 0 for population and maximum individual dispersion parameters, KKRPT = 1 for maximum individual only, KKRPT $\geq$ 2 for population only.

A.2.6. Specifications for Subroutine DOSRPT, called by MAIN

Primary Function:

Write dose result reports.

Common Blocks Used:

DOSMI, DOSPOP, DAY, ORGID

Argument List:

KKRPT, TITLE1

Subordinate Routines:

None

This subroutine writes dose result reports as requested by the control parameter KKRPT. When $KKRPT \leq 0$, total doses to each organ are printed (maximum individual and population). When $KKRPT = 1$, only doses to the maximum individual are printed and when $KKRPT = 2$, only population doses are printed. The title array TITLE1 is printed in each page heading.

A.2.7. Specifications for Function EXMO, called by ACHAIN

Primary Function:

The function calculates a value for the expression $(1 - e^{-\lambda t})/\lambda$.

Common Blocks Used:

None

Argument List:

ARG, AL

Subordinate Routines:

None

This function calculates a value for the expression:

$$\frac{1 - e^{-\lambda t}}{\lambda}$$

The argument list is:

- ARG = λt
- AL = λ

The method used to evaluate the expression is determined by the value of ARG. When ARG is positive, an error message is printed and execution is stopped. When $-ARG > 0.001$, then the expression is evaluated as

$$EXMO = (1. - EXP(ARG))/AL$$

When $-ARG \leq 0.001$, the expression is evaluated as

$$EXMO = \sum_{n=1}^I \frac{(\lambda t)^n (-1)^{n-1}}{n! \lambda}$$

where $I = \text{integer value of } 8 - \text{Log}_{10}(-ARG) \text{ and } I \geq 2.$

A.2.8 Specifications for Subroutine FRDOSE, called by MAIN

Primary Function:

Calculate fractional contributions to doses.

Common Blocks Used:

DOSMI, DOSPOP, NAMES, ORGID, NFLAGS

Argument List:

KKRPT

Subordinate Routines:

None

This subroutine converts dose result tables to fractional dose contribution tables by dividing by total dose.

A.2.9 Specifications for Subroutine FRDRPT, called by MAIN

Primary Function:

Write reports of fractional contributions to dose.

Common Blocks Used:

DAY, FLAGS, NAMES, ORGID

Argument List:

FRAC, KKRPT, TITLE1

Subordinate Routines:

MIORPO

This subroutine prepares output reports of fractional dose contributions by radionuclide. The argument list parameters have the following use.

<u>Parameter</u>	<u>Use</u>
FRAC	Fractional contribution cutoff value. Any radionuclide contributing more than FRAC to the dose to an organ will be included in the fractional dose contribution table.
KKRPT	Control parameter for selection of population and maximum individual reports. KKRPT $\leq$ 0, print all reports KKRPT = 1, print only maximum individual reports KKRPT $\geq$ 1, print only population reports
TITLE1	Descriptive title array (20 words) for the current run

A maximum of eight output reports may be prepared depending on the value of KKRPT (as described above). The fractional contribution reports are:

- maximum individual one-year dose commitment contribution by intake mode (external and inhalation)
- maximum individual fifty-year dose commitment contribution by intake mode

- maximum individual total one-year dose commitment contribution
- maximum individual total fifty-year dose commitment contribution
- population one-year dose commitment contribution by intake mode
- population fifty-year dose commitment contribution by intake mode
- population total one-year dose commitment contribution
- population total fifty-year dose commitment contribution.

The subroutine MIOPRO is called to establish the fractional contribution values for maximum individual and population reports.

A.2.10 Specifications for Subroutine IDLINE, called by MAIN

Primary Function:

This subroutine writes a line to output giving identification information on the program being executed.

Common Blocks Used:

None

Argument List:

None

Subordinate Routines:

None

IDLINE is a nonessential subroutine called to print the name of the program being executed. The subroutine is written in assembly language. To eliminate the subroutine simply remove the call statement from subroutine QAPAGE.

A.2.11 Specifications for Subroutine IDNUC, called by MAIN

Primary Function:

This module attempts to identify input inventory radionuclides against the master library list.

Common Blocks Used:

ACTVTY, DECAY, FLAGS, NAMES, SOURCE

Argument List:

QI, FINV

Subordinate Routines:

ZEROI, ZEROR

This subroutine tests the input radionuclide names against the master list names. The input activity, QI, is converted to curie-sec (mass units for decay calculation) and stored in array Q. The names of any unidentified radionuclides are printed. (Execution stops if there are unidentified radionuclides). The arguments are:

QI(300) array of released activities.

FINV factor by which each release activity is multiplied.

A.2.12 Specifications for Subroutine LIBRPT, called by NLIBIN

Primary Function:

This subroutine prepares a report of data contained in the library NUCDFL.

Common Blocks Used:

DAY, NAMES

Argument List:

TITLN, NUC, LORG, INFLG, EXDF, ODF, ONAME

Subordinate Routines:

None

This subroutine writes a report of dose conversion factors supplied in the data library NUCDFL. The argument list parameters have the following uses:

<u>Parameter</u>	<u>Use</u>
TITLN(20)	Title array from the library NUCDFL
NUC	Number of radionuclides in master list from data library RMDLIB
LOG	Number of organs for which data is available in data library NUCDFL
INFLG(300)	Flag array to identify which nuclides have dose factors given in data library NUCDFL
EXDF(300)	External dose factor array
ODF(2,10, 300)	Inhalation dose factor array for 2 dose commitment periods, 10 organs and 300 radionuclides
ONAME(10)	Organ name titles (10 character words)

The subroutine prints dose factors for each radionuclide for which data is given in library NUCDFL.

A.2.13 Specifications for Subroutine MIDOSE, called by MAIN

Primary Function:

This subroutine calculates the maximum individual doses.

Common Blocks Used:

ACTVTY, AIRCON, DISPSN, DISTNC, DECAY, DOSFAC, DOSMI, FLAGS, ORGID

Argument List:

None

Subordinate Routines:

TRNSIT, ZEROR

This subroutine calculates the external and inhalation dose contributions using equations 2.3-1 and 2.4-1 of the text. A call to subroutine TRNSIT is made to generate the radionuclide inventory with decay to the location of the maximum individual. The travel time to the maximum individual location is calculated as:

$$T = DMI/UMI$$

Doses are calculated for the first year and fifty year commitment periods.

A.2.14 Specifications for Subroutine MIORPO, called by FRDRPT

Primary Function:

This subroutine fills temporary dose contribution arrays.

Common Blocks Used:
DOSMI, DOSPOP, NAMES, ORGID

Argument List:
DVET, DVE, DVOT, DVO, IRPRT

Subordinate Routines:
ZEROR

This subroutine fills temporary fractional dose contribution arrays with either maximum individual values or population values. The argument list parameters have the following use:

<u>Parameter</u>	<u>Use</u>
DVET	Total external total body dose
DVE(300)	Fractional contribution to external dose for each radionuclide
DVOT(2,5)	Total inhalation doses for two time periods and five organs
DVO(2,5,300)	Fractional contribution to inhalation dose for each radionuclide for two time periods and five organs
IRPRT	Control integer to select maximum individual data or population data
	IRPRT = 1 for maximum individual data,
	IRPRT = 2 for population data.

When maximum individual data is requested (IRPRT = 1) the data arrays DVET, DVE, DVOT and DVO are set equal to the maximum individual data arrays DMET, DME, DMOT and DMO respectively. When population data is requested (IRPRT = 2) the data arrays DVET, DVE, DVOT and DVO are set equal to the population data arrays DPET, DPE, DPOT and DPO respectively.

A.2.15 Specifications for Subroutine MMAXEQ, called by DISPRS

Primary Function:

This subroutine determines which atmospheric stability gives the highest value for the maximum individual air concentration.

Common Blocks Used:

None

Argument List:

EQMI, HE, UMI, IMP, AREA, IWAKE, DMI

Subordinate Routines:

PASSIG

This subroutine calculates the time-integrated air concentration at the location of the maximum individual for the six Pasquill dispersion categories (A-F) and returns the highest value EQMI and the condition index IMP.

<u>IMP</u>	<u>Condition</u>
1	Pasquill A
2	Pasquill B
3	Pasquill C
4	Pasquill D
5	Pasquill E
6	Pasquill F
7	Hanford

The other argument list parameters have the following use:

<u>Parameter</u>	<u>Use</u>
HE	Effective plume height at the location of the maximum individual, m
UMI	Average wind speed (m/sec) for the maximum individual dose calculation
IWAKE	Control parameter to indicate that building wake effects are to be considered (if IWAKE > 0)

<u>Parameter</u>	<u>Use</u>
AREA	Minimum building cross-sectional area for use with the building wake effects model, m ²
DMI	Distance from the release point to the maximum individual location, m.

The subroutine PASSIG is called to determine dispersion parameter values (σ_y and σ_z) for the Pasquill stability categories.

A.2.16 Specifications for Subroutine NLIBIN, called by MAIN

Primary Function:

This subroutine reads inhalation and external dose conversion factor data.

Common Blocks Used:

DECAY, FLAGS, DOSFAC, DAY, NAMES, ORGID

Argument List:

TITLN

Subordinate Routines:

LIBRPT, ZEROI, ZEROR

This subroutine reads inhalation and external dose conversion factors from the data library NUCDFL on input unit 12. The library title (TITLN) is returned as an argument for printing in subroutine QAPAGE. The first four cards of the data library give descriptive information on the data that follows. Each nuclide has data for external exposure and some have data for inhalation exposure also. The flag array (INFLG(i)) is set to 1 if data for external exposure only is supplied for radionuclide i. If inhalation dose factors are also supplied then INFLG(i) is set to 2. Each radionuclide read from NUCDFL is compared to those in the master radionuclide list. If a radionuclide cannot be identified then an error message is printed and execution is stopped.

Subroutine LIBRPT is called to prepare a report of dose conversion factors read from data library NUCDFL.

A.2.17 Specifications for Subroutine ORGCHK, called by MAIN

Primary Function:

This subroutine checks input organ index values against allowed values provided in data library NUCDFL.

Common Blocks Used:

ORGID

Argument List:

None

Subordinate Routines:

ZEROI

This subroutine checks the input organ index values (array KORG) against allowed values provide in data library NUCDFL (array IORG). The number of organs requested is also calculated.

A.2.18 Specifications for Subroutine PASSIG, called by MMAXEQ and PMAXEQ

Primary Function:

Calculate dispersion parameters for a given distance and Pasquill stability category.

Common Blocks Used:

None

Argument List:

XX, IP, SY, SZ

Subordinate Routines:

None

This subroutine interpolates stored data to determine dispersion parameters σ_y and σ_z for a Pasquill atmospheric stability category and a given distance. The argument list parameters have the following uses:

<u>Parameter</u>	<u>Use</u>
XX	Distance from the release point to the location at which dispersion parameters are to be determined, m
IP	Index to indicate which Pasquill stability category is to be used: IP = 1 for A, IP = 2 for B, IP = 3 for C, IP = 4 for D, IP = 5 for E and IP = 6 for F.
SY	Crosswind horizontal standard deviation of plume concentration at the location of interest, m
SZ	Crosswind vertical standard deviation of plume concentration at the location of interest, m

Tabulated values are interpolated for the distance XX between 1 and 10^5 meters. In practical applications the distance XX should not be less than 100 meters or greater than 10^5 meters. The vertical dispersion parameter σ_z is limited to 2000 meters.

Tabulated values are provided for distances given in array DIST(20). Horizontal dispersion parameters are given for 6 stabilities and 20 distances in the array SIGY(6,20) and vertical dispersion parameters are given in the array SIGZ(6,20).

A.2.19 Specifications for Subroutine PMAEQ, called by POPEQ

Primary Function:

This subroutine determines which atmospheric stability condition gives the highest value for sector averaged air concentration.

Common Blocks Used:

None

Argument List:

E, H2, UP, X, AREA, IWAKE, IPL

Subordinate Routines:

PASSIG

This subroutine calculates sector averaged air concentrations at a given distance using six Pasquill stability categories A-F. The highest value is compared with the Hanford model air concentration, E. If the Pasquill value is higher then E is replaced by the Pasquill value and the stability index IPL is reset.

The argument list parameters have the following use:

<u>Parameter</u>	<u>Use</u>
E	maximum air concentration, sec/m^3
H2	effective height term = h_e^2, m^2
UP	windspeed for population dose calculation, m/sec
X	distance to location of interest, X
AREA	building cross sectional area, m^2 , for building wake effects calculation
IWAKE	control parameter to indicate that building wake effects are to be considered (if IWAKE > 0)
IPL	index of the stability giving the highest value for air concentration

IPL = 1 through 6 for Pasquill A through F respectively
and IPL = 7 for Hanford.

A.2.20 Specifications for Subroutine POPDOS, called by MAIN

Primary Function:

This subroutine calculates the population doses for selected organs.

Common Blocks Used:

ACTVTY, AIRCON, DECAY, DISPSN, DISTNC, DOSFAC, DOSPOP, FLAGS, ORGID, POPU

Argument List:

None

Subordinate Routines:

TRANSIT, ZEROR

This subroutine calculates population doses for the maximum exposed sector for selected organs. Doses are calculated for one year and fifty year dose commitment periods by radionuclide. The contribution for each spatial interval is summed with decay in transit from the release point to the spatial interval midpoint calculated by a call to TRANSIT.

A.2.21 Specifications for Subroutine POPEQ, called by DISPRS

Primary Function:

This subroutine calculates the population dispersion factor for the maximum sector.

Common Blocks Used:

DISPSN, DISTNC, POPU, ELEVAT

Argument List:

EQP, PM, MS, IP

Subordinate Routines:

SIGMAZ, PMAEQ, ZEROR

This routine calculates the maximum sector population dispersion factor, PM. The ground level air concentration is calculated as a function of distance for a ground level release. If terrain effects are included, the directional dependence of air concentration is also calculated (when an elevated release is requested: HSTACK > 0).

The argument list parameters have the following uses:

<u>Parameter</u>	<u>Use</u>
EQP(10)	air concentration at each spatial interval of the maximum sector, sec/m ³
PM	population dispersion factor for the maximum sector, person-sec/m ³
MS	index of the maximum sector, $1 \leq MS \leq 16$
IP(10)	index value for the maximum atmospheric stability condition at each distance in the maximum sector.

When LIMTST > 0 the maximum atmospheric conditions are determined with calls to subroutine PMAEQ.

A.2.22 Specifications for Subroutine QAPAGE, called by MAIN

Primary Function:

This subroutine writes a report giving all input information.

Common Blocks Used:

DAY, DISPSN, DISTNC, ELEVAT, ORGID, POPU, SOURCE

Argument List:

TITLE1, TITLR, TITLN, QI, FINV, IFRAC, KKRPT, FRAC

Subordinate Routines:

IDLINE

This subroutine prints a quality assurance report describing all input parameters and requested options. The argument list parameters have the following uses:

<u>Parameter</u>	<u>Use</u>
TITLE1(20)	descriptive title for the current case,
TITLR(20)	descriptive title for the master radionuclide data library
TITLN(20)	descriptive title for the dose conversion factor data library
QI(300)	input radionuclide activity inventory
FINV	inventory modification factor
IFRAC	control integer, positive when fractional contributions to dose by radionuclide are to be determined
KKRPT	control integer to select types of doses to calculate $KKRPT \leq 0$ for population and maximum individual $KKRPT = 1$ for maximum individual only $KKRPT > 1$ for population only
FRAC	fractional contribution dose cutoff value.

A.2.23 Specifications for Subroutine RLIBIN, called by MAIN

Primary Function:

This subroutine reads data from the master radionuclide data library.

Common Blocks Used:

DECAY, NAMES

Argument List:

TITLR

Subordinate Routines:

ZEROR

This subroutine reads from the radionuclide master data library, RMDLIB. Data read include radionuclide identification parameter arrays ELT and AW and radiological half-life and chain decay data. The argument list parameter is a descriptive title read from RMDLIB and printed on the input summary report in QAPAGE.

In reading the data library this subroutine does several functions:

- the number of nuclides are counted, NUC
- decay constants are calculated, AL
- chain branching parameters are set, IFR, DKF
- chain lengths are set, NOFNUC

A.2.24 Specifications for Function SIGMAY, called by DISPRS

Primary Function:

This function calculates σ_y at a given location using the Hanford model.

Common Blocks Used:

None

Argument List:

TT, STUB

Subordinate Routines:

None

The value of σ_y is evaluated at a location TT seconds travel distance away from the release point.

The equations for σ_y are:

$$\sigma_y^2 = A[TT - \alpha(1 - e^{-TT/\alpha})]$$

$$A = 13 + 230(\sigma_\theta \bar{u})$$

$$\alpha = A/[2(\sigma_\theta \bar{u})^2]$$

where $\sigma_\theta \bar{u} = \text{STUB}$.

A.2.25 Specifications for Function SIGMAZ, called by DISPRS, POPEQ

Primary Function:

This function calculates σ_z at a given location using the Hanford model.

Common Blocks Used:

None

Argument List:

KS, TT

Subordinate Routines:

None

The value of σ_z (m) is evaluated at the travel time distance, TT (seconds). When $KS \leq 0$, moderately stable conditions are used and when $KS > 0$ very stable conditions are used. The equation is

$$\sigma_z^2 = a[1 - \exp(-k^2 T^2)] + bT$$

where $T = TT$, travel time, sec and values for a , b and k^2 are as follows:

<u>Parameter</u>	<u>Moderately Stable</u>	<u>Very Stable</u>
$a \text{ (m}^2\text{)}$	97	34
$b \text{ (m}^2\text{/sec)}$	.33	.025
$k^2 \text{ (sec}^2\text{)}$	2.5×10^{-4}	8.8×10^{-4}

A.2.26 Specifications for Function SUMPRD, called by ACHAIN

Primary Function:

This function sums the term by term products of two arrays.

Common Blocks Used:

None

Argument List:

J, A, B

Subordinate Routines:

None

The function evaluates the expression:

$$\text{SUMPRD} = \sum_{i=1}^J A(i) * B(i)$$

A.2.27 Specifications for Subroutine TRNSIT, called by MIDOSE and POPDOS

Primary Function:

This subroutine controls the radiological decay calculations.

Common Blocks Used:

ACTVTY, DECAY, FLAGS

Argument List:

T

Subordinate Routines:

ACHAIN

This subroutine controls the calculation of inventory radiological decay in transit during a period of T, seconds. The chain decay calculation is performed in subroutine ACHAIN for one chain at a time. The flag array NFLAGC is used to determine which chains to consider. $NFLAGC(i) > 0$ indicates the chain contains radionuclides with nonzero activities.

A.2.28 Specifications for Subroutine ZEROI, called by IDNUC and ORGCHK

Primary Function:

This subroutine initializes an integer array to zero.

Common Blocks Used:

None

Argument List:

N,K

Subordinate Routines:

None

This subroutine sets the first N members of integer array K to zero.

A.2.29 Specifications for Subroutine ZEROR

Primary Function:

This subroutine initializes a real valued array to zero.

Common Blocks Used:

None

Argument List:

N,A

Subordinate Routines:

None

This subroutine sets the first N values of real array A to zero.
ZEROR is called by ACHAIN, IDNUC, MAIN, MIDOSE, MIORPO, NLIBIN, POPDOS AND POPEQ.

A.3 MODULE LOGIC DIAGRAMS

This section provides logic diagrams for each module. The logic diagrams use flow charting techniques described by Chapin (1974)* and are referred to as Chapin charts. The basic logic constructs used in the diagrams are indicated in Figure A.3-1.

Logic diagrams are provided for each module (except IDLINE) in Figures A.3-2 through A.3-29 as follows.

<u>Figure</u>	<u>Module</u>	<u>Figure</u>	<u>Module</u>	<u>Figure</u>	<u>Module</u>
A.3-2	MAIN	A.3-12	LIBRPT	A.3-22	QAPAGE
A.3-3	ACHAIN	A.3-13	MIDOSE	A.3-23	RLIBIN
A.3-4	ASGH	A.3-14	MIORPO	A.3-24	SIGMAY
A.3-5	ASUM	A.3-15	MMAEQ	A.3-25	SIGMAZ
A.3-6	DISPRS	A.3-16	NLIBIN	A.3-26	SUMPRD
A.3-7	DOSRPT	A.3-17	ORGCHK	A.3-27	TRNSIT
A.3-8	EXMO	A.3-18	PASSIG	A.3-28	ZEROI
A.3-9	FRDOSE	A.3-19	PMAEQ	A.3-29	ZEROR
A.3-10	FRDRPT	A.3-20	POPDOS		
A.3-11	IDNUC	A.3-21	POPEQ		

*Chapin, N. 1974. "New Format for Flowcharts," Software - Practice and Experience, Vol. 4, pp. 341-357, John Wiley and Sons Ltd, London.

Sequential Block of Code

Conditional

Do While Loop

Do Until Loop

Abnormal Transfer

Abnormal Termination

FIGURE A.3-1. Chapin Chart Logic Constructs

FIGURE A.3-2. Logic Diagram for Module MAIN

FIGURE A.3-3. Logic Diagram for Module ACHAIN

FIGURE A.3-4. Logic Diagram for Module ASGH

FIGURE A.3-5. Logic Diagram for Module ASUM

FIGURE A.3-6. Logic Diagram for Module DISPRS

Then	If KKRPT ≤ 1	Else
	Print TITLE1 and DAIT on new page	Null
	Print "Maximum Individual Dose Commitments (REM)"	
	Print column headings	
	Print "air submersion" heading and dose DMET, DMET	
	Print "inhalation" heading and dose: DMOT(1,i), DMOT(2,i), i=1, NORG	
	Do for IO = 1, NORG (organs)	
	TOT(1,IO) = DMOT(1,IO) + DMET TOT(2,IO) = DMOT(2,IO) + DMET	
	Print total dose heading	
	Do for IO = 1, NORG (organs)	
	Print ORGT(IO), TOT(1,IO), TOT(2,IO)	
Then	If KKRPT ≠ 1	Else
	Print TITLE1 and DAIT on new page	Null
	Print "Population Dose Commitments (MAN-REM)"	
	Print column headings	
	Print "air submersion" heading and DPET, DPET	
	Print "Inhalation" heading and dose DPOT(1,i), DPOT(2,i), i=1, NORG	
	Do for IO = 1,NORG (organs)	
	TOT(1,IO) = DPOT(1,IO) + DPET TOT(2,IO) = DPOT(2,IO) + DPET	
	Print total dose heading	
	Do for IO = 1,NORG (organs)	
	Print ORGT(IO), TOT(1,IO), TOT(2,IO)	
Return		

FIGURE A.3-7. Logic Diagram for Module DOSRPT

FIGURE A.3-8. Logic Diagram for Module EXMO

FIGURE A.3-9. Logic Diagram for Module FRDOSE

FIGURE A.3-10. Logic Diagram for Module FRDRPT

FIGURE A.3-10. (Cont'd)

FIGURE A.3-11. Logic Diagram for Module IDNUC

FIGURE A.3-12. Logic Diagram for Module LIBRPT

FIGURE A.3-13. Logic Diagram for Module MIDOSE

FIGURE A.3-14. Logic Diagram for Module MIORPO

FIGURE A.3-15. Logic Diagram for Module MMAXEQ

FIGURE A.3-16. Logic Diagram for Module NLIBIN

FIGURE A.3-17. Logic Diagram for Module ORGCHK

FIGURE A.3-18. Logic Diagram for Module PASSIG

FIGURE A.3-19. Logic Diagram for Module PMAEQ

FIGURE A.3-20. Logic Diagram for Module POPDOS

FIGURE A.3-21. Logic Diagram for Module POPEQ

FIGURE A.3-21. (Cont'd)

Print page heading and date; TITLE1, DAIT			
Call IDLINE; write program identification line			
Print data library titles, TITLR, TITLN			
Print headings for stability and windspeed			
CMI = "very"; CP = "very"			
If KKSMI ≤ 0			
Then			Else
CMI = "MOD."			Null
If KKSP ≤ 0			
Then			Else
CP = "MOD."			Null
Print "dispersion model", CMI,CP			
Print "windspeed", UMI,UP			
Print stack height; HSTACK			
Print names of selected organs, ORGT(i), i = 1,NORG			
Print option on maximum atmospheric condition calculation			
If IFRAC > 0			
Then			Else
Print "Fractional dose reports are requested"		Print "Fractional dose reports are not requested"	
If KKRPT ≤ 0			
Then			Else
Print "All dose reports are requested"	If KKRPT = 1		
	Then	Else	
	Print "Only maximum individual dose reports"	Print "Only population dose reports"	
If KKRPT ≤ 1			
Then			Else
Print σ _{θu} , STUB			Null
Print "Distance to maximum individual", DMI			
If KKRPT ≠ 1			
Then			Else
Print "Population distances; NPD: PD(i), i = 1,NPD Print Population distribution data headings			Null

FIGURE A.3-22. Logic Diagram for Module QAPAGE

FIGURE A.3-22. (Cont'd)

FIGURE A.3-23. Logic Diagram for Module RLIBIN

FIGURE A.3-24. Logic Diagram for Module SIGMAY

FIGURE A.3-25. Logic Diagram for Module SIGMAZ

FIGURE A.3-26. Logic Diagram for Module SUMPRD

FIGURE A.3-27. Logic Diagram for Module TRANSIT

FIGURE A.3-28. Logic Diagram for Module ZEROI

FIGURE A.3-29. Logic Diagram for Module ZEROR

APPENDIX B
COMMON BLOCK DESCRIPTIONS

APPENDIX B

COMMON BLOCK DESCRIPTIONS

The computer code HADOC uses labeled common blocks for the majority of data transfers between modules. Table B.0-1 gives a summary of each common block and indicates the modules that use each block. A detailed description of the parameters in each common block is given in Tables B.0-2 through B.0-16.

All common blocks are included in the main program module MAIN even though some are not referenced. This was done to facilitate variable checking during code conversion and testing.

TABLE B.O-1. HADOC Common Block Usage Summary

ACTVTY

Description: Released radionuclide activities
Used by: IDNUC, MAIN, MIDOSE, POPDOS, TRNSIT

AIRCON

Description: Time-integrated air concentration
Used by: DISPRS, MAIN, MIDOSE, POPDOS

DAY

Description: Day-of-year symbol
Used by: DOSRPT, FRDRPT, LIBRPT, MAIN, NLIBIN, QAPAGE

DECAY

Description: Decay parameters
Used by: IDNUC, MAIN, MIDOSE, NLIBIN, POPDOS, RLIBIN, TRNSIT

DISPSN

Description: Atmospheric dispersion model parameters
Used by: DISPRS, MAIN, MIDOSE, POPDOS, POPEQ, QAPAGE

DISTNC

Description: Exposure point locations
Used by: DISPRS, MAIN, MIDOSE, POPDOS, POPEQ, QAPAGE

DOSFAC

Description: Dose conversion factors
Used by: MAIN, MIDOSE, NLIBIN, POPDOS

DOSMI

Description: Maximum individual doses
Used by: DOSRPT, FRDOSE, MAIN, MIDOSE, MIORPO

DOSPOP

Description: Population doses
Used by: DOSRPT, FRDOSE, MAIN, MIORPO, POPDOS

ELEVAT

Description: Terrain elevations
Used by: DISPRS, MAIN, POPEQ, QAPAGE

TABLE B.0-1. (Cont'd)

FLAGS

Description Radionuclide usage flags
Used by FRDOSE, FRDRPT, IDNUC, MAIN, MIDOSE, NLIBIN, POPDOS

NAMES

Description: Master list radionuclide identification
Used by: FRDOSE, FRDRPT, IDNUC, LIBRPT, MAIN, MIORPO, NLIBIN, RLIBIN

ORGID

Description: Organ identification parameters
Used by: DOSRPT, FRDOSE, FRDRPT, MAIN, MIDOSE, MIORPO, NLIBIN,
ORGCHK, POPDOS, QAPAGE

POPU

Description: Population distribution data
Used by: MAIN, POPDOS, POPEQ, QAPAGE

SOURCE

Description: Input radionuclide identification symbols
Used by: IDNUC, MAIN, QAPAGE

TABLE B.0-2. Common Block ACTVTY

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
Q(300)	Real	Activity in release inventory for each radionuclide in the master radionuclide list, curies.
QD(300)	Real	Release activities corrected for decay in transit, Q_k , curies.

TABLE B.0-3. Common Block AIRCON

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
EQMI	Real	Time integrated air concentration for the maximum individual location $(E/Q)_m$, sec/m^3 .
PM	Real	Time integrated air concentration times population, PM_j , $\text{man-sec}/\text{m}^3$.
EQP(10)	Real	Time integrated air concentration at each population distance in the direction of the maximum exposure sector $(E/Q)_{sj}$, sec/m^3 .
MS	Int.	Index of the maximum population dose sector.

TABLE B.0-4. Common Block DAY

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
DAIT	Char.	Eight character name for day of year, MMDDYY: MM - month DD - day YY - year

TABLE B.0-5. Common Block DECAY

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
NUC	Int.	Number of radionuclides in the master library, RMDLIB. $1 \leq \text{NUC} \leq 300$.
NCH	Int.	Number of decay chains in the master library, RMDLIB. $1 \leq \text{NCH} \leq 200$.
NOFNUC(200)	Int.	Number of radionuclides in each decay chain. $1 \leq \text{NOFNUC}(i) \leq 9$. When $\text{NOFNUC}(i) = 1$, the radionuclide has no daughters.
NCHST(200)	Int.	Location in the master radionuclide list of the first member of a radionuclide chain. $1 \leq \text{NCHST}(i) \leq 300$.
IFR(2,300)	Int.	IFR(1,i) gives the chain member that is the first precursor to radionuclide i. IFR(2,i) gives the location of the second precursor. $\text{IFR}(1,i) < \text{IFR}(2,i) < \text{IMEM}(i)$.
DKF(2,300)	Int.	Fraction of first and second precursor that decay to this radionuclide.
AL(300)	Int.	Radiological decay constant for each radionuclide, sec^{-1} .
NCHN(300)	Int.	Chain number that each radionuclide is a member of.

TABLE B.0-6. Common Block DISPSN

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
UMI	Real	Wind speed to be used for the maximum individual dose calculation, $\bar{u}$, m/sec.
UP	Real	Wind speed to be used for the population dose calculation, $\bar{u}$, m/sec.
AREA	Real	Minimum building cross sectional area for the building wake model, A , m^2 .
KKSMI	Int.	Indicator for the dispersion model to be used for the maximum individual air concentration calculation. $KKSMI \leq 0$ for Hanford moderately stable $KKSMI \geq 1$ for Hanford very stable
KKSP	Int.	Indicator for the dispersion model to be used for the population air concentration calculation $KKSP \leq 0$ for Hanford moderately stable $KKSP \geq 1$ for Hanford very stable
STUB	Real	Value for $\sigma_{\theta} \bar{u}$ to be used for the maximum individual dispersion calculation.
ITERN	Int.	Control integer to indicate if terrain effects are to be considered. $ITERN > 0$ to include terrain effects.
IWAKE	Int.	Control integer to indicate if building wake is to be considered. $IWAKE > 0$ to include wake effects.

TABLE B.0-7. Common Block DISTNC

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
NPD	Int.	Number of distances considered for the population dose calculation. $1 \leq \text{NPD} \leq 10$.
DP(10)	Real	Distances from the release point to the center of each population ring, x_i , m. NPD values must be given in increasing order.
DMI	Real	Distance from the release point to the location of the maximum individual, m.

TABLE B.0-8. Common Block DOSFAC

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
EXDF(300)	Real	External dose conversion factors for air submersion for each radionuclide, D_k^e , rem per Ci·sec/m ³ .
ODF(2,10,300)	Real	Inhalation dose conversion factors for two time periods, ten organs and 300 radionuclides, D_{ko}^i , rem per Ci·sec/m ³ .

TABLE B.0-9. Common Block DOSMI

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
DME(300)	Real	External dose to maximum individual for each radionuclide. Also used for fractional dose storage, rem.
DMET	Real	Total dose from external radiation for the maximum individual, D_{me} , rem.
DMO(2,5,300)	Real	Inhalation dose for two times, 5 organs and 300 radionuclides for the maximum individual, rem. Also used for fractional dose storage.
DMOT(2,5)	Real	Total dose to each organ (2 times) for maximum individual, D_{mo} , rem

TABLE B.0-10. Common Block DOSPOP

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
DPE(300)	Real	External dose to the population for each radionuclide, person-rem. Also used for fractional dose contribution storage.
DPET	Real	Total dose to the population from external exposure, D_{pe} , person-rem.
DPO(2,5,300)	Real	Population dose from inhalation for two time periods, 5 organs and 300 radionuclides, person-rem. Also used for fractional dose contribution storage.
DPOT(2,5)	Real	Total population dose from inhalation for two time periods and 5 organs, D_{po} , person-rem.

TABLE B.0-11. Common Block ELEVAT

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
HMI	Real	Terrain elevation (above the base of the stack) at the location of the maximum individual, h_t , m.
HT(10,16)	Real	Terrain elevation at each location (10 distances and 16 directions) above the base of the stack, h_t , m.
HSTACK	Real	Elevation of the release point (above the base of the stack), h_s , m.

TABLE B.0-12. Common Block FLAGS

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
NFLAGC(200)	Int.	Control integer to indicate if any radionuclides in each chain are supplied on input. $NFLAGC(i) \leq 0$ radionuclide not given $NFLAGC(i) > 0$ radionuclide given
NFLAG(300)	Int.	Control integer to indicate if data is given in input inventory for each radionuclide. $IFLAG(i) \leq 0$ data not given $IFLAG(i) > 0$ data given
INFLG(300)	Int.	Control integer to indicate which master list radionuclides have dose factors supplied in library NUCDFL. $INFLG(i) \leq 0$ no NUCDFL data $INFLG(i) > 0$ NUCDFL data given
NPRT	Int.	Control integer to cause printing of data in library NUCDFL. Data is printed if $NPRT > 0$.

TABLE B.0-13. Common Block NAMES

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
ELT(300)	Char.	Two character element name for each radionuclide in the master radionuclide data library.
AW(300)	Char.	Six character atomic weight symbol for each radionuclide in the master radionuclide data library. Isomeric states are indicated by the letter M after the atomic weight. Daughter contributions are indicated by "+D" after the atomic weight and "M" if present.
NUCS	Int.	Number of radionuclides in the master library. (Same as NUC of common block DECAY.)

TABLE B.0-14. Common Block ORGID

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
LORG	Int.	Number of organs for which data is supplied in the dose conversion factor library NUCDFL. $1 \leq \text{LORG} \leq 10$.
IORG(10)	Int.	Organ index values for which data is supplied in the dose conversion factor library, NUCDFL. $1 \leq \text{IORG}(i) \leq 23$.
NORG	Int.	Number of organs for which doses are to be calculated. $1 \leq \text{NORG} \leq 5$.
KORG(5)	Int.	Organ index values for which doses are to be calculated. The index values must be taken from values in index array IORG from the dose conversion factor library, NUCDFL.
MORG(5)	Int.	Position in IORG corresponding to selected organs. This array is set in subroutine ORGCHK.
ORGT(5)	Char.	Ten character organ names for output.
ONAME(10)	Char.	Ten character organ names for data in library NUCDFL.

TABLE B.O-15. Common Block POPU

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
POP(10,16)	Real	Population within each spatial interval for 10 distances and 16 direction sectors, P_{ij} , persons.

TABLE B.O-16. Common Block SOURCE

Symbol & Dimension	Type	Problem Symbol/Definition/Values/Units
NIN	Int.	Number of radionuclides in the input inventory, $1 \leq NIN \leq NUC$.
ELTI(300)	Char.	Character names for input radionuclides. The names must be spelled identically to the spelling in the master radionuclide list.
AWI(300)	Char.	Six character atomic weight symbol for each input radionuclide. The spelling must correspond to the master list spelling (see variable AW in common block NAMES).

APPENDIX C
DATA LIBRARIES

APPENDIX C

DATA LIBRARIES

Two data libraries are required to run HADOC: a radionuclide master data library and a dose conversion factor data library. The libraries have been designed such that additional data or changes to existing data may be entered with little difficulty. Listings of the libraries are given in Appendix D.

C.1 RADIONUCLIDE MASTER DATA LIBRARY - RMDLIB

The radionuclide master data library (RMDLIB) contains all radiological decay data used by HADOC. The library is organized into two sections. The first section contains radionuclides which are not members of decay chains, and also radionuclides singled out from chains with the "+D" (plus daughters) designation. Radionuclides in the first section are arranged by increasing atomic number. The second section of the library contains radionuclides organized into decay chains ordered under the radionuclides highest in the chain. RMDLIB contains about 280 entries.

The first card of the library contains 80 characters of descriptive information used as identification in the input data report printed by subroutine QAPAGE. The remainder of the data cards have the following information:

Column 1	Alphabetic element symbol
Column 2	Atomic weight, also metastable and/or "+D" designation
Column 3	Radiological half-life, days
Column 4	Relative position in decay chain
Column 5	Precursor in decay chain
Column 6	Branching ratio from primary precursor
Column 7	Alternate precursor in decay chain
Column 8	Branching ratio from alternate precursor

The RMDLIB FORTRAN format is (A2, A6, E10.2, 2I2, F7.4, I2, F7.4). The parameter in Column 4 is used to signal the end of the data library (≤ 0).

C.2 DOSE CONVERSION FACTOR DATA LIBRARY - NUCDFL

The radionuclide dose conversion factor data library provides master organ identification parameters and dose conversion factor data for external exposure and inhalation uptake. The first card contains the following data:

<u>Parameter</u>	<u>Columns</u>	<u>Format</u>	<u>Description</u>
NU	1-5	I5	Number of radionuclides for which data will be supplied, $1 \leq \text{NU} \leq 300$.
LORG	6-10	I5	Number of organs for which data is supplied in this library, $1 \leq \text{LORG} \leq 10$.
--	11-20	--	Not used (read as NT, NR, 2I5)
IORG(10)	21-23 24-26 - 48-50	10I3	Organ index values for each organ that data will be provided for, $1 \leq \text{IORG}(i) \leq 23$. (See organ title information on the third card).

The second card contains an 80 character descriptive title to be printed in the input data report prepared by subroutine QAPAGE.

The third (and fourth card if necessary) contain descriptive titles (ONAME) for organs data is supplied for in this library. The format is 8A10 with 10 characters allowed for each organ name. If more than eight organs are specified (LORG) then an additional card is read. The card following the last organ name card gives the dose commitment periods data is supplied for (2I5). For the current library the times are 1 and 50 years. The remainder of the library contains dose conversion factor data for the NU radionuclides. The first card for each radionuclide contains the following data:

<u>Parameter</u>	<u>Columns</u>	<u>Format</u>	<u>Description</u>
ELT(i)	1-2	A2	Element symbol for radionuclide i.
AW(i)	3-8	A6	Atomic weight symbol for radionuclide i including metastable "M" and/or "+D" designation.
EXDF(i)	9-14 15-22	6X E8.1	External total body dose conversion factor in rem per (Ci sec per m ³).
L0	23-38 39-40	16X I2	The number of organs for which inhalation dose conversion factor data will be given. $1 \leq \text{L0} \leq \text{LORG}$.

When no inhalation data is provided for a radionuclide, L0 is zero and no additional cards are read for the radionuclide. Inhalation data is supplied for each organ as needed with data for one organ on one card as follows:

<u>Parameter</u>	<u>Columns</u>	<u>Format</u>	<u>Description</u>
MO	1-2	I2	Index of the organ for which data is supplied on this card. MO must correspond to a value in the array IORG.
ODF(1,i,j)	3-6 7-14	4X E8.1	Inhalation dose conversion factor for the first year dose commitment from acute uptake for organ i and radionuclide j, rem per (Ci sec/m ³).
ODF(2,i,j)	15-22	E8.1	Inhalation dose conversion factor for the fifty year dose commitment from acute uptake for organ i and radionuclide j, rem per (Ci sec/m ³).

Additional data is contained on each inhalation factor card, but this data is not required by HADOC and is therefore ignored. The library listing in Appendix D shows the additional data.

The current organs available in library NUCDFL are indicated in Table C.2-1.

TABLE C.2-1 Organs Available in NUCDFL

<u>Organ Number</u>	<u>Organ Index</u>	<u>Organ Name</u>
i	IORG (i)	ONAME(i)
1	1	Total Body
2	3	Kidney
3	4	Liver
4	6	Bone
5	8	Lungs
6	16	Thyroid
7	23	LLI

APPENDIX D

CODE AND DATA LIBRARY LISTINGS

APPENDIX D

CODE AND DATA LIBRARY LISTINGS

This appendix contains listings of each module for the computer code HADOC plus listings of the two data libraries RMDLIB and NUCDFL. The code listing (Figure D.0-1) starts with the main program (MAIN) followed by the remaining modules in alphabetical order and common blocks in alphabetical order. The listing of RMDLIB is next (Figure D.0-2) with the NUCDFL listing last (Figure D.0-3).

```

C*****
C
C   HADOC CALCULATES RADIATION DOSES FROM EXTERNAL AND INHALATION
C   UPTAKE FROM ACCIDENTAL RELEASES ON THE HANFORD SITE.
C*****
C
C   SUBORDINATE ROUTINES--  RLIBIN, NLIBIN, ZEROR, IDNUC, ORGCHK,
C                           QAPAGE, DISPRS, MIDOSE, POPDOS, DOSRPT,
C                           FRDOSE, FRDRPT
C   INPUTS--  NAMELIST PARAMETERS, RELEASE INVENTORY, POPULATION
C              AND TERRAIN DATA
C   INPUT COMMONS-- NONE
C   OUTPUTS-- NONE
C   OUTPUT COMMONS-- SOURCE, POPU, ELEVAT
C-----
C
C   INCLUDE NEPA*HADOC.ACTVTY,LIST
C   INCLUDE NEPA*HADOC.AIRCON,LIST
C   INCLUDE NEPA*HADOC.DAY,LIST
C   INCLUDE NEPA*HADOC.DECAY,LIST
C   INCLUDE NEPA*HADOC.DISPSN,LIST
C   INCLUDE NEPA*HADOC.DISTNC,LIST
C   INCLUDE NEPA*HADOC.DOSFAC,LIST
C   INCLUDE NEPA*HADOC.DOSMI,LIST
C   INCLUDE NEPA*HADOC.DOSPOP,LIST
C   INCLUDE NEPA*HADOC.ELEVAT,LIST
C   INCLUDE NEPA*HADOC.FLAGS,LIST
C   INCLUDE NEPA*HADOC.NAMES,LIST
C   INCLUDE NEPA*HADOC.ORGID,LIST
C   INCLUDE NEPA*HADOC.SOURCE,LIST
C   INCLUDE NEPA*HADOC.POPU,LIST
C
C   DIMENSION TITLR(20),TITLE1(20),TITLN(20),QI(300)
C
C   NAMELIST INPUT LIST--
C
C   NAMELIST /INPUT/ UP, UMI, AREA, KKSMI, KKSP, STUB, ITERN, IWAKE,
C   .NPD, DP, DMI, HMI, HSTACK, NORG, KORG, IQP, IFRAC, KKRPT,
C   .KKPOP, NEXT, FRAC, LIMTST, NPRT
C
C   CONTROL PARAMETERS DEFAULT VALUES--
C
C   DATA FRAC / 0.0001/
C   DATA LIMTST / 0/
C   DATA IFRAC / 0 /
C   DATA IQP / 1 /
C   DATA ITERN / 0 /
C   DATA IWAKE / 0 /
C   DATA KKPOP / 1 /
C   DATA KKRPT / 0 /
C   DATA KKSMI / 0 /
C   DATA KKSP / 0 /
C   DATA NEXT / 1 /
C   DATA NPRT / 0 /
C
C   DISPERSION PARAMETERS DEFAULT VALUES--
C
C   DATA AREA / 0. /
C   DATA HMI / 0. /
C   DATA HSTACK / 0. /
C   DATA UMI / 1. /
C   DATA UP / 1. /
C   DATA NPD / 9 /
C   DATA DP / 2414., 4022., 5632., 7240., 12070., 24140., 40220.,
C   + 56320., 72400. /
C   DATA STUB / .024 /
C
C   ORGAN SELECTION DEFAULT VALUES--
C
C   DATA NORG / 4 /
C   DATA KORG / 1, 6, 8, 16 /

```

FIGURE D.0-1. Program Listing


```

C      ASSIGN PERTINENT DATA FILES--
C
C      CALL ASGH (1)
C
C      READ DATA LIBRARY FOR MASTER NUCLIDE INDEX & RADIOLOGICAL HALF LIFE--
C
3  CONTINUE
  CALL RLIBIN(TITLR)
C
C      READ DOSE FACTOR DATA LIBRARY--
C      CALL NLIBIN(TITLN)
C
C      FINISHED WITH DATA FILES, SO FREE--
C      CALL ASGH(2)
C
C      START OF CALCULATION FOR NEXT CASE--
C
C      READ INPUT CARD DATA--
1  READ(5,100,END=99) TITLE1
C
C      READ NAMELIST DATA--
C      READ(5,INPUT,ERR=97)
C      IF(NEXT.GE.4.) GO TO 95
C      IF(NEXT.EQ.3) GO TO 2
C
C      READ NEW RELEASE INVENTORY--
C      CALL ZEROR(300,QI)
C      READ(5,200,END=99)  NIN,FINV
C
C      IF NUMBER OF NUCLIDES IS OUT OF RANGE PRINT ERROR MESSAGE, STOP--
C
C      IF(NIN.GT.300.OR.NIN.LT.1)  GO TO 98
C      READ(5,300,END=99) (ELTI(I),AWI(I),QI(I),I=1,NIN)
C
C      READ POPULATION DATA--
C
2  IF (KKRPT .NE. 1 .AND. KKPOP .GE. 1)  THEN
    DO 10 IS = 1, 16
      READ (5,700,END=99) (POP(I,IS), I=1,NPD)
10  CONTINUE
    ENDIF
C
C      READ TERRAIN DATA--
C
C      IF (KKRPT .NE. 1 .AND. ITERN .GE. 2)  THEN
    DO 20 IS = 1, 16
      READ (5,700,END=99) (HT(I,IS), I=1,NPD)
20  CONTINUE
    ENDIF
C
C      IDENTIFY INPUT RADIONUCLIDES--
C      CALL IDNUC(QI, FINV)
C
C      COUNT ORGANS--
C      CALL ORGCHK
C
C      WRITE QUALITY ASSURANCE PAGE--
C      CALL QAPAGE(TITLE1,TITLR,TITLN,QI,FINV,IFRAC,KKRPT,FRAC)
C
C      CALCULATE DISPERSION PARAMETERS--
C      CALL DISPRS (IQP, KKRPT)
C
C      CALCULATE DOSES AND WRITE REPORTS--
C
C      IF (KKRPT .LE. 1)  CALL MIDOSE
C      IF (KKRPT .NE. 1)  CALL POPDOS
C      CALL DOSRPT (KKRPT, TITLE1)
C      IF (IFRAC .GT. 0) THEN
        CALL FRDOSE (KKRPT)
        CALL FRDRPT (FRAC, KKRPT, TITLE1)
C      ENDIF
C

```

FIGURE D.0-1. Program Listing

```

C      RETURN TO START FOR NEXT CASE--
C
C      GO TO 1
C
C      NORMAL EXIT 95
C
C      95 PRINT 400
C      STOP
C
C      INVENTORY INPUT ERROR IN SPECIFICATION OF NUMBER OF NUCLIDES--
C      98 PRINT 500, NIN
C      STOP
C
C      END OF INPUT CARD FILE--
C      99 PRINT 600
C      STOP
C
C      97 PRINT 1009
C      1009 FORMAT(' ERROR ON NAMELIST INPUT')
C      STOP
C
C      FORMAT STATEMENTS--
C
C      100 FORMAT(20A4)
C      200 FORMAT(I3,E10.2)
C      300 FORMAT(A2,A6,4X,E8.2)
C      400 FORMAT(1H1,'END OF INPUT FOR THIS RUN')
C      500 FORMAT(1H1,'ERROR IN NUMBER OF NUCLIDES INPUT, NONUC =',I5,' MAXI
C      .MUM ALLOWED IS 300 ')
C      600 FORMAT(1H1,'END OF FILE ON INPUT, STOP')
C      700 FORMAT (10E8.0)
C      END

```

FIGURE D.0-1. Program Listing

```

C      SUBROUTINE ACHAIN (NUC, T, DK, IFRM, AL, AM, AO, INTGRL)
C      C*****
C      ACHAIN CALCULATES DECAY FOR ONE CHAIN
C      C*****
C      CALLED BY-- TRANSIT
C      SUBORDINATE ROUTINES-- ASUM, SUMPRD, ZEROR, EXMO
C      INPUTS-- NUC, T, DK, IFRM, AL, AM, INTGRL
C      INPUT COMMONS-- NONE
C      OUTPUTS-- AO
C      OUTPUT COMMONS-- NONE
C      -----
C      DIMENSION DK(2,9), IFRM(2,9), AL(9), AM(9), AO(9), A(45), EXPO(9)
C      INITIALIZE COEFFICIENT ARRAY TO ZERO--
C      N2N = NUC * (NUC-1) / 2 + NUC
C      CALL ZEROR (N2N, A)
C      DO LOOP ON CHAIN MEMBERS, MAX = NUC--
C      DO 5 J = 1, NUC
C      CALCULATE EXPONENTIAL FOR CURRENT NUCLIDE--
C      ARG=-AL(J) * T
C      IF (INTGRL .GT. 0) THEN
C      FORM IS: (1 - EXP (ARG) ) / AL FOR INTGRL > 0
C      EXPO(J) = EXMO (ARG, AL(J) )
C      ELSE
C      FORM IS EXP(ARG) FOR INTGRL = 0
C      EXPO(J) = EXP (ARG)
C      ENDIF
C      SET STARTING INDEX FOR TERM ARRAY A--
C      JJ = J * (J-1) / 2
C      SET CHAIN POSITION MINUS ONE--
C      J1 = J - 1
C      IF(J1 .GT. 0) THEN
C      IMAX = MIN0 (J1, 2)
C      DO 3 M = 1, J1
C      DO 2 L = M, J1
C      DO 1 I = 1, IMAX
C      IF (IFRM(I,J) .EQ. L) THEN
C      A(M+JJ) = A(M+JJ) + DK(I,J) * AL(L) * A(M+L * (L-1)/2)
C      ENDIF
C      1 CONTINUE
C      2 CONTINUE
C      A(M+JJ) = A(M+JJ) / (AL(J) - AL(M))
C      3 CONTINUE
C      ENDIF
C      A(J + JJ) = AM(J) - ASUM (J1, A(JJ+1) )
C      AO(J)= SUMPRD (J, EXPO, A(JJ + 1) )
C      5 CONTINUE
C      RETURN
C      END

```

FIGURE D.0-1. Module ACHAIN

```

      FUNCTION ASUM(J,A)
C *****
C
C      THIS FUNCTION SUMS J ELEMENTS OF THE ARRAY A.
C *****
C
C      CALLED BY-- ACFAIN
C      SUBORDINATE ROUTINES-- NONE
C      INPUTS-- J, A
C      INPUT COMMONS-- NONE
C      OUTPUTS-- ASUM
C      OUTPUT COMMONS--
C
C-----
C
C      DIMENSION A(1)
C
C      ASUM=0.
C      IF(J.LE.0) GO TO 2
C
C      DO 1 I=1,J
C          ASUM=ASUM+A(I)
C 1 CONTINUE
C
C 2 RETURN
C
C      END

```

FIGURE D.0-1. Module ASUM

```

                                MODULE DISPRS

SUBROUTINE DISPRS (IQP, KKRPT)                                $$$START
C
C*****
C
C    DISPRS CALCULATE ATMOSPHERIC DISPERSION PARAMETERS FOR MAXIMUM
C    INDIVUAL AND POPULATION LOCATIONS.
C*****
C
C    CALLED BY-- MAIN
C    SUBORDINATE ROUTINES-- SIGMAY, SIGMAZ, POPEQ, MAXEQ
C    INPUTS-- IQP, KKRPT
C    INPUT COMMONS-- DISPSN, ELEVAT, DISTNC
C    OUTPUTS-- NONE
C    OUTPUT COMMONS-- AIRCON
C-----
C
C    INCLUDE NEPA#HADOC.DISPSN,LIST
C    INCLUDE NEPA#HADOC.ELEVAT,LIST
C    INCLUDE NEPA#HADOC.AIRCON,LIST
C    INCLUDE NEPA#HADOC.DISTNC,LIST
C
C    DIMENSION STAB(7), IP(10)
C    CHARACTER*10 STAB
C
C    DATA STAB / 'PASQUILL A', 'PASQUILL B', 'PASQUILL C',
+               'PASQUILL D', 'PASQUILL E', 'PASQUILL F', 'HANFORD' /
C
C    IF (KKRPT .LE. 1) THEN
C
C        TT = DMI / UMI
C
C        SY = SIGMAY(TT,STAB)
C        SZ = SIGMAZ(KKSMI,TT)
C        SYZ = SY * SZ
C
C        IF BUILDING WAKE IS CONSIDERED--
C        IF (IWAKE .GT. 0) THEN
C
C            EY = SORT (SY * SY + .5 * AREA )
C            EZ = SORT (SZ * SZ + .5 * AREA )
C            EYZ = EY * EZ
C            SS = EZ
C
C            IF (EYZ .GT. 3. * SYZ) THEN
C                SYZ = 3. * SYZ
C                SS = SORT(3) * EZ
C            ELSE
C                SYZ = EYZ
C            ENDIF
C
C        ELSE
C
C            SS = SZ
C
C        ENDIF
C
C        IF TERRAIN EFFECTS ARE CONSIDERED--
C        IF (ITERN .GT. 0) THEN
C
C            HE = HSTACK - HMI
C            IF (HE .LT. 0) HE = 0.
C
C        ELSE
C
C            HE = HSTACK
C
C        ENDIF
C
C        EXPO = EXP ( - HE * HE * .5 / (SS * SS))
C        EQMI = EXPO / (3.14159 * UMI * SYZ)
C
C        IF (LIMTST .GT. 0) THEN

```

FIGURE D.0-1. Module DISPRS


```

SUBROUTINE DOSRPT (KKRPT, TITLE1)                                $$$START
C
C *****
C
C   DOSRPT WRITES DOSE RESULTS REPORTS.
C *****
C
C   CALLED BY-- MAIN
C   SUBORDINATE ROUTINES-- NONE
C   INPUTS-- KKRPT, TITLE1
C   INPUT COMMONS-- DOSMI, DOSPOP, DAY, ORGID
C   OUTPUTS-- PRINTED REPORTS
C   OUTPUT COMMONS-- NONE
C
C -----
C
C   INCLUDE NEPA#HADOCDOSMI,LIST
C   INCLUDE NEPA#HADOCDOSPOP,LIST
C   INCLUDE NEPA#HADOCDAY,LIST
C   INCLUDE NEPA#HADOCDORGID,LIST
C
C   DIMENSION TITLE1(20), TOT(2,5)
C
C   TEST PRINT FLAG--
C   IF (KKRPT .LE. 1) THEN
C
C     PRINT HEADINGS--
C     WRITE (6,100) TITLE1, DAIT
C     WRITE (6,200)
C     WRITE (6,400)
C
C     PRINT AIR SUBMERSION DATA--
C     WRITE (6,500) DMET, DMET
C
C     PRINT INHALATION INFORMATION--
C     WRITE (6,600) (ORGT(IO), DMOT(1,IO), DMOT(2,IO), IO = 1, NORG)
C
C     FOR EACH ORGAN, CALCULATE TOTALS--
C     DO 10 IO = 1, NORG
C       TOT(1,IO) = DMOT(1,IO) + DMET
C       TOT(2,IO) = DMOT(2,IO) + DMET
10    CONTINUE
C
C     PRINT TOTALS--
C     WRITE (6,900) (ORGT(IO), TOT(1,IO), TOT(2,IO), IO = 1,NORG)
C
C   ENDIF
C
C   IF (KKRPT .NE. 1) THEN
C
C     PRINT HEADINGS--
C     WRITE (6,100) TITLE1, DAIT
C     WRITE (6,300)
C     WRITE (6,400)
C
C     PRINT AIR SUBMERSION DATA--
C     WRITE (6,500) DPET, DPET
C
C     PRINT INHALATION DATA--
C     WRITE (6,600) (ORGT(IO), DPOT(1,IO), DPOT(2,IO), IO = 1, NORG)
C
C     CALCULATE TOTAL DOSE--
C     DO 20 IO = 1, NORG
C       TOT(1,IO) = DPOT(1,IO) + DPET
C       TOT(2,IO) = DPOT(2,IO) + DPET
20    CONTINUE
C
C     PRINT TOTAL DOSE DATA--
C     WRITE (6,900) (ORGT(IO), TOT(1,IO), TOT(2,IO), IO = 1, NORG)
C
C   ENDIF

```

FIGURE D.0-1. Module DOSRPT

```

C      RETURN
C
C      FORMATS--
C
C      100 FORMAT (1H1, 20A4 / 37X, A8)
C
C      200 FORMAT (1H0, 20X, 'MAXIMUM INDIVIDUAL DOSE COMMITMENTS (REM)')
C
C      300 FORMAT (1H0, 22X, 'POPULATION DOSE COMMITMENTS (MAN-REM)')
C
C      400 FORMAT (1H0, 32X, 'DOSE COMMITMENT PERIOD' / 8X, 'PATHWAY/ORGAN',
C      + 12X, '1 YEAR      50 YEARS' / )
C
C      500 FORMAT (1H , 6X, 'AIR SUBMERSION' // 10X, 'TOTAL BODY', 8X,
C      + 2 ( 2X, 1PE10.1E2) / )
C
C      600 FORMAT (1H , 6X, 'INHALATION' // 5 (10X, A10, 8X,
C      + 2 ( 2X, 1PE10.1E2) / ))
C
C      900 FORMAT (1H , 6X, 'TOTAL DOSES' // 5 (10X,A10, 8X,
C      + 2 (2X, 1PE10.1E2) / ))
C
C      END

```

FIGURE D.0-1. Module DOSRPT


```

      FUNCTION EXMO(ARG,AL)
C
C *****
C
C      THIS FUNCTION CALCULATES (1-EXP(ARG))/AL FOR NEGATIVE ARG
C
C *****
C
C      CALLED BY-- ACHAIN
C      SUBORDINATE ROUTINES-- NONE
C      INPUTS-- ARG, AL
C      INPUT COMMONS-- NONE
C      OUTPUTS-- EXMO
C      OUTPUT COMMONS-- NONE
C
C -----
C
C      IF(ARG.GT.0.0)GO TO 99
C
C      IF (-ARG .GT. 0.001)   THEN
C
C          EXMO=(1.0-EXP(ARG))/AL
C
C      ELSE
C
C          I=-IFIX(ALOG10(-ARG))
C          I=8-I
C          IF(I.LT.2)I=2
C          TERM=-ARG
C          EXMO=-ARG/AL
C
C          DO 1 IT=2,I
C              TERM=(TERM*ARG)/FLOAT(IT)
C              EXMO=EXMO+TERM/AL
C
C          1 CONTINUE
C
C      ENDIF
C
C      RETURN
C
C
C 99  PRINT 100,ARG
C 100 FORMAT(' ERROR IN FUNCTION EXMO, POSITIVE ARG=',1PE10.3)
C      STOP
C      END

```

FIGURE D.0-1. Module EXMO

```

SUBROUTINE FRDOSE (KKRPT)                                $$$START
C
C*****
C
C   FRDOSE CALCULATES FRACTIONAL CONTRIBUTIONS TO DOSES.
C*****
C
C   CALLED BY-- MAIN
C   SUBORDINATE ROUTINES-- NONE
C   INPUTS-- KKRPT
C   INPUT COMMONS-- NAMES, ORGID, FLAGS
C   OUTPUTS-- NONE
C   OUTPUT COMMONS-- DOSMI, DOSPOP
C
C-----
C
C   INCLUDE NEPA#HADOC.NAMES,LIST
C   INCLUDE NEPA#HADOC.ORGID,LIST
C   INCLUDE NEPA#HADOC.FLAGS,LIST
C   INCLUDE NEPA#HADOC.DOSMI,LIST
C   INCLUDE NEPA#HADOC.DOSPOP,LIST
C
C   IF (KKRPT .LE. 1) THEN
C
C       IF (DMET .GT. 0.) THEN
C           DM = 1. / DMET
C       FOR EACH RADIONUCLIDE--
C           DO 100 IN = 1, NUCS
C               DME(IN) = DME(IN) * DM
C   100   CONTINUE
C       ENDIF
C
C       FOR EACH ORGAN--
C           DO 200 IO = 1, NORG
C
C               IF (DMOT(1,IO) .GT. 0.) THEN
C                   DM1 = 1. / DMOT(1,IO)
C                   DM2 = 1. / DMOT(2,IO)
C
C                   FOR EACH RADIONUCLIDE--
C                       DO 300 IN = 1, NUCS
C
C                           IF (INFLG(IN) .GT. 0) THEN
C                               DMO(1,IO,IN) = DMO(1,IO,IN) * DM1
C                               DMO(2,IO,IN) = DMO(2,IO,IN) * DM2
C                           ENDIF
C
C   300   CONTINUE
C               ENDIF
C           200 CONTINUE
C       ENDIF
C
C   IF (KKRPT .NE. 1) THEN
C
C       IF (DPET .GT. 0.) THEN
C           DP = 1. / DPET
C       FOR EACH RADIONUCLIDE--
C           DO 400 IN = 1, NUCS
C               DPE(IN) = DPE(IN) * DP
C   400   CONTINUE
C       ENDIF
C
C       FOR EACH ORGAN--
C           DO 500 IO = 1, NORG
C
C               IF (DPOT(1,IO) .GT. 0.) THEN
C                   DP1 = 1. / DPOT(1,IO)
C                   DP2 = 1. / DPOT(2,IO)
C
C               FOR EACH RADIONUCLIDE--

```

FIGURE D.0-1. Module FRDOSE

```

C          SUBROUTINE FRDRPT (FRAC, KKRPT, TITLE1)                      $$$START
C
C *****
C
C          FRDRPT WRITES REPORTS FOR FRACTIONAL CONTRIBUTIONS TO DOSES.
C
C *****
C
C          CALLED BY-- MAIN
C          SUBORDINATE ROUTINES-- MIORPO
C          INPUTS-- FRAC, KKRPT, TITLE1
C          INPUT COMMONS-- ORGID, FLAGS, NAMES, DAY
C          OUTPUTS-- REPORT OF FRACTIONAL DOSE CONTRIBUTIONS
C          OUTPUT COMMONS-- NONE
C
C -----
C
C          INCLUDE NEPA#HADOC.DAY,LIST
C          INCLUDE NEPA#HADOC.NAMES,LIST
C          INCLUDE NEPA#HADOC.ORGID,LIST
C          INCLUDE NEPA#HADOC.FLAGS,LIST
C
C          DIMENSION FRTOT(2,5,300)
C          DIMENSION DVE(300), DVOT(2,5), DVO(2,5,300)
C          DIMENSION IYEAR(2)
C          CHARACTER SUBHD#18(2), TOT#5(2), TITLE1#4(20)
C
C          DATA SUBHD /'MAXIMUM INDIVIDUAL', 'POPULATION'/
C          DATA IYEAR /1, 50/
C          DATA TOT /' ', 'TOTAL'/
C
C          LOOP TO WRITE BOTH TYPES OF REPORTS--
C          DO 100 I = 1, 2
C
C              SET PRINT FLAG FOR MAXIMUM INDIVIDUAL OR POPULATION REPORT--
C              KKRPT <= 0  -- ALL DOSE REPORTS REQUESTED
C              KKRPT = 1   -- ONLY MAXIMUM DOSE REPORTS REQUESTED
C              KKRPT >= 2   -- ONLY POPULATION DOSE REPORTS ARE REQUESTED
C
C              IF (I .EQ. 1) THEN
C                  IF (KKRPT .LE. 1) THEN
C                      IRPT = 1
C                  ELSE
C                      IRPT = 2
C                  ENDIF
C              ELSE
C                  IF (KKRPT .LT. 1) THEN
C                      IRPT = 2
C                  ELSE
C                      RETURN
C                  ENDIF
C              ENDIF
C
C          CALL MIORPO (DVET, DVE, DVOT, DVO, IRPT)
C          TO TRANSFER DOSE VALUES INTO PRINTING ARRAYS.
C
C          PRINT FIRST REPORT--
C
C              WRITE (6,1000) TITLE1, DAIT
C              WRITE (6,1100) SUBHD(IRPT), TOT(1), IYEAR(1)
C              WRITE (6,1200) (ORGT(IO), IO = 1, NORG)
C
C          FOR EACH RADIONUCLIDE--
C          DO 200 IN = 1, NUCS
C
C              CHECK IF THERE IS DATA FOR THIS NUCLIDE IN NUCDFL LIBRARY--
C              IF (INFLG(IN) .GT. 0) THEN
C
C                  IPR = 0
C                  IO = 1
C                  IF (DVE(IN) .GT. FRAC) IPR = 1

```

FIGURE D.0-1. Module FRDRPT

```

C
C 300      CONTINUE
C
C          FRTOT(1,IO,IN) = (DVE(IN) * DVET + DVO(1,IO,IN) *
C          +              DVOT(1,IO)) / (DVET + DVOT(1,IO))
C
C          IF (DVO(1,IO,IN) .GT. FRAC)   IPR = 1
C
C          IO = IO + 1
C          IF (IO .LE. NORG)      GOTO 300
C
C          IF (IPR .GT. 0)   THEN
C
C              PRINT DATA FOR THIS NUCLIDE--
C              WRITE (6,2000) ELT(IN), AW(IN), DVE(IN), (DVO(1,IO,IN),
C          +              IO = 1, NORG)
C
C              ENDIF
C          ENDIF
C 200      CONTINUE
C
C          PRINT SECOND REPORT--
C
C          WRITE (6,1000) TITLE1, DAIT
C          WRITE (6,1100) SUBHD(IRPT), TOT(1), IYEAR(2)
C          WRITE (6,1200) (ORGT(IO), IO = 1, NORG)
C
C          FOR EACH RADIONUCLIDE--
C          DO 400 IN = 1, NUCS
C
C              CHECK IF THERE IS DATA FOR THIS NUCLIDE IN NUCDFL LIBRARY--
C              IF (INFLG(IN) .GT. 0)   THEN
C
C                  IPR = 0
C                  IO = 1
C                  IF (DVE(IN) .GT. FRAC)   IPR = 1
C
C          C 500      CONTINUE
C
C          C          FRTOT(2,IO,IN) = (DVE(IN) * DVET + DVO(2,IO,IN) *
C          C          +              DVOT(2,IO)) / (DVET + DVOT(2,IO))
C
C          C          IF (DVO(2,IO,IN) .GT. FRAC)   IPR = 1
C
C          C          IO = IO + 1
C          C          IF (IO .LE. NORG)      GOTO 500
C
C          C          IF (IPR .GT. 0)   THEN
C
C              C          PRINT DATA FOR THIS NUCLIDE--
C              C          WRITE(6,2000) ELT(IN), AW(IN), DVE(IN), (DVO(2,IO,IN),
C          C          +              IO = 1, NORG)
C
C              C          ENDIF
C          C          ENDIF
C          C 400      CONTINUE
C
C          PRINT THIRD REPORT--
C
C          WRITE (6,1000) TITLE1, DAIT
C          WRITE (6,1100) SUBHD(IRPT), TOT(2), IYEAR(1)
C          WRITE (6,1300) (ORGT(IO), IO = 1, NORG)
C
C          FOR EACH RADIONUCLIDE--
C          DO 600 IN = 1, NUCS
C
C              CHECK IF THIS RADIONUCLIDE IS IN INVENTORY--
C              IF (INFLG(IN) .GT. 0)   THEN

```

FIGURE D.0-1. Module FRDRPT

```

C          IO = 1
700      CONTINUE
          IF (FRTOT(1,IO,IN) .GT. FRAC) THEN
              IPR = 1
          ELSE
              IPR = 0
          ENDIF
          IO = IO + 1
          IF (IPR .LE. 0 .AND. IO .LE. NORG) GO TO 700
C
          IF (IPR .GT. 0) THEN
              WRITE (6,2100) ELT(IN), AW(IN), (FRTOT(1,IO,IN),
+               IO = 1, NORG)
          ENDIF
C
          ENDIF
600      CONTINUE
C
C
C
C      PRINT FOURTH REPORT--
C
          WRITE (6,1000) TITLE1, DAIT
          WRITE (6,1100) SUBHD(IPRT), TOT(2), IYEAR(2)
          WRITE (6,1300) ORGT(IO), IO = 1, NORG)
C
          FOR EACH RADIONUCLIDE--
          DO 800 IN = 1, NUCS
C
          CHECK IF THIS RADIONUCLIDE IS IN INVENTORY--
          IF (INFLG(IN) .GT. 0) THEN
C
          IO = 1
          CONTINUE
          900      IF (FRTOT(2,IO,IN) .GT. FRAC) THEN
              IPR = 1
          ELSE
              IPR = 0
          ENDIF
              IO = IO + 1
              IF (IPR .LE. 0 .AND. IO .LE. NORG) GO TO 900
C
              IF (IPR .GT. 0) THEN
                  WRITE (6,2100) ELT(IN), AW(IN), (FRTOT(2,IO,IN),
+                   IO = 1, NORG)
              ENDIF
C
          ENDIF
800      CONTINUE
C
100 CONTINUE
C
          RETURN
C
          FORMAT STATEMENTS--
1000 FORMAT (1H1, 20A4 / 37X, A8)
C
1100 FORMAT (1H0, 'FRACTIONAL DOSE BY RADIONUCLIDE FOR ', A18 /
+ 10X, 'FOR ', A5, 1X, I2, ' YEAR DOSE COMMITMENT')
C
1200 FORMAT (1H0, 20X, 'EXTERNAL', 8X, 'INHALATION' /
+ 8X, 'NUCLIDE' TOTAL BODY', 4X, 5 (2X,A10) )
C
1300 FORMAT (1H0, 7X, 'NUCLIDE', 9X, 5 (2X, A10) )
C
2000 FORMAT (1H , 7X, A2,A6, 4X, 1PE10.2, 2X, 5 (2X, 1PE10.2) )
C
2100 FORMAT (1H , 7X, A2,A6, 4X, 5 (2X, 1PE10.2) )
C
END

```

FIGURE D.0-1. Module FRDRPT

```

      SUBROUTINE IDNUC (QI, FINV)
C
C*****
C
C      IDNUC IDENTIFIES NUCLIDES IN INPUT INVENTORY
C*****
C
C      CALLED BY-- MAIN
C      SUBORDINATE ROUTINES-- ZEROI, ZEROR
C      INPUTS-- QI, FINV
C      INPUT COMMONS-- SOURCE, NAMES, DECAY
C      OUTPUTS-- NONE
C      OUTPUT COMMONS-- FLAGS, ACTVTY
C
C-----
C
C      INCLUDE NEPA#HADOC.ACTVTY,LIST
C      INCLUDE NEPA#HADOC.DECAY,LIST
C      INCLUDE NEPA#HADOC.FLAGS,LIST
C      INCLUDE NEPA#HADOC.NAMES,LIST
C      INCLUDE NEPA#HADOC.SOURCE,LIST
C
C      DIMENSION QI(300)
C
C      INITIALIZE COUNT INDEX ON UNIDENTIFIED NUCLIDES
C
C      ISTOP=0
C
C      CALL ZEROI(200,NFLAGC)
C      CALL ZEROI(300,NFLAG)
C      CALL ZEROR(300,Q)
C
C      SET ACTIVITY FACTOR--
C
C      AF = 1.
C      IF (FINV .GT. 0.) AF = FINV
C
C      LOOP ON NUCLIDES INPUT.  TEST AGAINST MASTER LIST.
C
C      DO 3 IN=1,NIN
C      DO 1 IL=1,NUCS
C      ILN=IL
C      IF(ELT(IL).NE.ELTI(IN)) GO TO 1
C      IF(AW(IL).EQ.AWI(IN)) GO TO 2
C      1 CONTINUE
C
C      NO MATCH IN LIBRARY FOR INPUT NUCLIDE.  PRINT NAME OF UNKNOWN NUCLIDE
C
C      ISTOP=ISTOP+1
C      PRINT 100, ELTI(IN),AWI(IN)
C      GO TO 3
C      2 NFLAG(ILN)=IN
C      NFLAGC(NCHN(ILN))=1
C      Q(ILN) = QI(IN) * AF / AL(ILN)
C      3 CONTINUE
C      IF(ISTOP.LT.1) RETURN
C
C      PRINT TOTAL NUMBER OF UNKNOWN NUCLIDES AND STOP.
C
C      PRINT 200, ISTOP
100 FORMAT(1H0,'UNIDENTIFIED NUCLIDE ',A2,A6)
200 FORMAT(1H0,'THERE WERE UNIDENTIFIED NUCLIDES, ISTOP =',I4)
      STOP
      END

```

FIGURE D.0-1. Module IDNUC

```

      SURROUTINE LIBRPT(TITLN,NUC,LORG,INFLG,EXDF,ODF,ONAME)
C *****
C
C      LIBRPT PRINTS A REPORT OF LIBRARY DATA.
C *****
C
C      CALLED BY-- NLIBIN
C      SUBORDINATE ROUTINES-- NONE
C      INPUTS-- TITLN, NUC, INFLG, ONAME, EXDF
C      INPUT COMMONS-- DAY, NAMES
C      OUTPUTS-- PRINTED REPORT OF LIBRARY DATA
C      OUTPUT COMMONS-- NONE
C
C-----
C
C      INCLUDE NEPA#HADOC.NAMES,LIST
C      INCLUDE NEPA#HADOC.DAY,LIST
C
C      DIMENSION TITLN(20),EXDF(300),ODF(2,10,300),
C      .ONAME(10), INFLG(300)
C      CHARACTER ONAME#10, TITLN#4
C
C      PRINT PAGE HEADING
C      PRINT 100
C      PRINT 200,TITLN,DAIT
C      IN=1
C      1 IF(IN.GT.NUC) GO TO 20
C      IF(IN.GT.1) PRINT 100
C      PRINT 300
C      IC=0
C
C      TEST FOR DOSE FACTOR INCLUSION FOR THIS NUCLIDE
C      2 IF (INFLG(IN) .GT. 0) THEN
C
C      PRINT DATA FOR A NUCLIDE
C      PRINT 400, ELT(IN),AW(IN),EXDF(IN),ONAME(1),
C      . (ODF(1,1,IN),I=1,2)
C
C      TEST IF ORGAN DATA INCLUDED FOR THIS NUCLIDE--
C      IF (INFLG(IN) .GT. 1) THEN
C      PRINT REMAINING ORGAN DATA
C      DO 3 IO=2,LORG
C      PRINT 500, ONAME(IO),(ODF(1,IO,IN),I=1,2)
C      3 CONTINUE
C      IC = IC + 9
C      ENDIF
C
C      IC=IC+2
C      ENDIF
C
C      IN=IN+1
C      IF(IC.GT.43)GO TO 1
C      IF(IN.LE.NUC) GO TO 2
C
C      20 RETURN
C
C      100 FORMAT(1H1)
C
C      200 FORMAT(16X,'LIBRARY DATA FOR ',20A4,6X,A10)
C
C      300 FORMAT(1H0,13X,'EXTERNAL DOSE FACTOR      INHALATION DOSE FACTORS
C      .'/45X,'ACUTE UPTAKE'/
C      . ' NUCLIDE', 15X, 'TOTAL BODY ORGAN',8X,'1 YR      50 YRS')
C
C      400 FORMAT (1H0, A2, A6, 15X, 1PE9.2, 1X, A10, 1X, 2 (1PE9.1, 2X ))
C
C      500 FORMAT(34X,A10,1X,2(1PE9.1,2X))
C
C      END

```

FIGURE D.0-1. Module LIBRPT

```

SUBROUTINE MIDOSE                                     $$$START
C
C*****
C
C      MIDOSE CALCULATES THE MAXIMUM INDIVIDUAL DOSES.
C*****
C
C      CALLED BY-- MAIN
C      SUBORDINATE ROUTINES--  TRNSIT, ZEROR
C      INPUTS--  NONE
C      INPUT COMMONS--  ACTVTY, AIRCON, DECAY, DISPSN, DISTNC, DOSFAC,
C                      FLAGS, ORGID
C      OUTPUTS--  NONE
C      OUTPUT COMMONS--  DOSMI
C
C-----
C
C      INCLUDE NEPA#HADOC.ACTVTY,LIST
C      INCLUDE NEPA#HADOC.AIRCON,LIST
C      INCLUDE NEPA#HADOC.DECAY,LIST
C      INCLUDE NEPA#HADOC.DISPSN,LIST
C      INCLUDE NEPA#HADOC.DISTNC,LIST
C      INCLUDE NEPA#HADOC.DOSFAC,LIST
C      INCLUDE NEPA#HADOC.DOSMI,LIST
C      INCLUDE NEPA#HADOC.FLAGS,LIST
C      INCLUDE NEPA#HADOC.ORGID,LIST
C
C
C      INITIALIZE ARRAYS--
C      CALL ZEROR (300, DME)
C      CALL ZEROR (3000, DMO)
C      CALL ZEROR (10, DMOT)
C      DMET = 0.
C
C      T = DMI / UMI
C
C      TRNSIT CONTROLS RADIOLOGICAL DECAY CALCULATIONS--
C      CALL TRNSIT (T)
C
C      INUC = 0
C
C      FOR EACH DECAY CHAIN--
C      DO 100 IC = 1, NCH
C
C          J = NOFNUC(IC)
C
C          TEST FOR INCLUSION OF CHAIN IN INVENTORY--
C          IF (NFLAGC(IC) .GT. 0) THEN
C
C              SET ARRAY INDEX LIMITS FOR THIS CHAIN--
C              IST = INUC + 1
C              K = IST + J - 1
C
C              FOR EACH NUCLIDE IN CHAIN--
C              DO 200 IN = IST, K
C
C                  TEST FOR DOSE FACTOR DATA FOR NUCLIDE--
C                  IF (INFLG(IN) .GT. 0) THEN
C
C                      CALCULATE DOSE FOR EXTERNAL EXPOSURE--
C                      DME(IN) = EQMI * QD(IN) * EXDF(IN)
C                      DMET = DMET + DME(IN)
C
C                      FOR EACH ORGAN--
C                      DO 300 IO = 1, NORG
C
C                          SET ORGAN INDEX FOR DOSE FACTOR ARRAYS--
C                          IL = MORG(IO)
C
C                          FIRST YEAR DOSES FOR THIS ORGAN AND RADIONUCLIDE--
C                          DMO(1,IO,IN) = EQMI * QD(IN) * ODF(1,IL,IN)
C                          DMOT(1,IO) = DMOT(1,IO) + DMO(1,IO,IN)

```

FIGURE D.0-1. Module MIDOSE


```

C
C      FIFTY YEAR DOSES FOR THIS ORGAN AND RADIONUCLIDE--
      DMO(2,IO,IN) = EQMI * QD(IN) * QDF(2,IL,IN)
      DMOT(2,IO) = DMOT(2,IO) + DMO(2,IO,IN)
C
C
300      CONTINUE
      ENDIF
200      CONTINUE
      ENDIF
C
      INUC = INUC + J
C
100 CONTINUE
C
C      RETURN
      END

```

FIGURE D.0-1. Module MIDOSE

```

MODULE MMAXEQ

SUBROUTINE MMAXEQ (EQMI, HE, UMI, IMP, AREA, IWAKE, DMI)      $$$$START
C
C*****
C
C   NMAXEQ DETERMINES WHICH ATMOSPHERIC STABILITY GIVES THE HIGHEST
C   VALUE FOR THE MAXIMUM INDIVIDUAL AIR CONCENTRATION.
C*****
C
C   CALLED BY-- DISPRS
C   SUBORDINATE ROUTINES-- PASSIG
C   INPUTS-- EQMI, HE, UMI, IWAKE, AREA, DMI
C   INPUT COMMONS-- NONE
C   OUTPUTS-- EQMI, IMP
C   OUTPUT COMMONS-- NONE
C
C-----
C
C   DATA PI /3.14159/
C
C   SET CONDITION INDEX FOR HANFORD MODEL--
C   IMP = 7
C
C   TEST FOR ELEVATED RELEASE--
C   IF (HE .GT. .1) THEN
C
C   FOR EACH UNSTABLE PASQUILL DISPERSION CATEGORY--
C   DO 100 IP = 1, 5
C
C       CALL PASSIG (DMI, IP, SY, SZ)
C       TO CALCULATE VALES OF SIGMA Y AND SIGMA Z AT DISTANCE DMI.
C
C       SYZ = SY * SZ
C
C       IF BUILDING WAKE IS CONSIDERED--
C       IF (IWAKE .GT. 0) THEN
C
C           EY = SORT (SY * SY + .5 * AREA)
C           EZ = SORT (SZ * SZ + .5 * AREA)
C           EYZ = EY * EZ
C           SS = EZ
C
C           IF (EYZ .GT. 3. * SYZ) THEN
C
C               SYZ = 3. * SYZ
C               SS = SORT (3.) * EZ
C
C           ELSE
C
C               SYZ = EYZ
C
C           ENDIF
C
C       ELSE
C
C           IF BUILDING WAKE NOT CONSIDERED--
C
C               SS = SZ
C
C           ENDIF
C
C       E = EXP ( -(HE**HE**5) / (SS * SS) ) / ( PI * UMI * SYZ)
C
C       IF (E .GT. EQMI) THEN
C           IMP = IP
C           EQMI = E
C       ENDIF
C
C 100 CONTINUE
C   ENDIF
C
C   RETURN
C   END

```

FIGURE D.0-1. Module MMAXEQ

```

SUBROUTINE MIORPO (DVET, DVE, DVOT, DVO, IRPRT)                $$$START
C
C *****
C
C   MIORPOP TRANSFERS EITHER MAXIMUM INDIVIDUAL OR POPULATION DOSE
C   VALUES INTO PRINTING ARRAYS.
C *****
C
C   CALLED BY--  FRDRPT
C   SUBORDINATE ROUTINES--  ZEROR
C   INPUTS--  IRPRT
C   INPUT COMMONS--  DOSMI, DOSPOP, NAMES, ORGID
C   OUTPUTS--  DVET, DVE, DVOT, DVO
C   OUTPUT COMMONS--  NONE
C
C -----
C
C   INCLUDE NEPA#HADOC.DOSMI,LIST
C   INCLUDE NEPA#HADOC.DOSPOP,LIST
C   INCLUDE NEPA#HADOC.NAMES,LIST
C   INCLUDE NEPA#HADOC.ORGID,LIST
C
C   DIMENSION DVE(300), DVOT(2,5), DVO(2,5,300)
C
C   INITIALIZE ARRAYS--
C   CALL ZEROR (300, DVE)
C   CALL ZEROR (10, DVOT)
C   CALL ZEROR (3000, DVO)
C
C   IF (IRPRT .EQ. 1) THEN
C
C     TRANSFER MAXIMUM INDIVIDUAL DOSE ARRAYS--
C
C     DVET = DMET
C     DO 100 I = 1,2
C       DO 200 IO = 1, NORG
C         DVOT(I,IO) = DMOT(I,IO)
C         DO 300 IN = 1, NUCS
C           DVO(I,IO,IN) = DMO(I,IO,IN)
C         300 CONTINUE
C       200 CONTINUE
C     DO 400 IN = 1, NUCS
C       DVE(IN) = DME(IN)
C     400 CONTINUE
C
C   ELSE
C
C     TRANSFER POPULATION DOSE ARRAYS--
C
C     DVET = DPET
C     DO 500 I = 1,2
C       DO 600 IO = 1, NORG
C         DVOT(I,IO) = DPOT(I,IO)
C         DO 700 IN = 1, NUCS
C           DVO(I,IO,IN) = DPO(I,IO,IN)
C         700 CONTINUE
C       600 CONTINUE
C     DO 800 IN = 1, NUCS
C       DVE(IN) = DPE(IN)
C     800 CONTINUE
C
C   ENDIF
C
C   RETURN
C   END

```

FIGURE D.0-1. Module MIORPO

```

      SUPROUTINE NLIBIN (TITLN)
C
C *****
C
C      NLIBIN READS DOSE CONVERSION FACTOR DATA.
C
C *****
C
C      CALLED BY-- MAIN
C      SUPERORDINATE ROUTINES-- ADATE, LIBRPT, ZEROI, ZEROP
C      INPUTS-- NUCLID LIBRARY
C      INPUT COMMONS-- NAMES
C      OUTPUTS-- TITLN
C      OUTPUT COMMONS-- DOSEFAC
C
C -----
C
C      INCLUDE NEPAHADOC.DECAY,LIST
C      INCLUDE NEPAHADOC.FLAGS,LIST
C      INCLUDE NEPAHADOC.DOSFAC,LIST
C      INCLUDE NEPAHADOC.DAY,LIST
C      INCLUDE NEPAHADOC.NAMES,LIST
C      INCLUDE NEPAHADOC.ORGID,LIST
C
C      DIMENSION OD(2), TITLN(20)
C      CHARACTER W*6, TITLN*4
C
C      CALL ADATE (DAIT, XY)
C      IEND=0
C
C      READ FIRST CARD FROM DATA LIBRARY--
C      READ (12,100,END=98) NU, LONG, NT, NR, IOPG, TITLN,
C      .              (ONAME(I), I = 1, LONG)
C
C      READ OVER DOSE COMMITMENT PERIOD CARD--
C      READ (12,800) IDUM
C
C      INITIALIZE ARRAYS TO ZERO--
C      CALL ZEROR (6000, ODF)
C      CALL ZEROR (300, EXDF)
C      CALL ZEROI (300, INFLG)
C
C      READ DATA FOR EACH NUCLIDE--
C      DO 10 I = 1, NU
C
C          READ(12,200,END=96) E,W, EX,LO
C
C          IDENTIFY RADIONUCLIDE (AGAINST MASTER LIST FROM RMDLIB)--
C          DO 4 IM = 1, NUCS
C
C              IF (E .NE. ELT(IM)) GO TO 4
C              IF (W .NE. AW(IM)) GO TO 4
C              II = IM
C
C              SET FLAG -- INTERNAL DOSE FACTORS ARE GIVEN FOR THIS NUCLIDE--
C              INFLG(II) = 1
C
C              EXDF(II) = EX
C              GO TO 5
C
C          4  CONTINUE
C              PRINT 700, IM, E, W
C              PRINT 800, NU, NUCS
C              GO TO 94
C
C          5  IF (LO.LE.0) GO TO 10
C
C              SET FLAG TO INDICATE THAT DOSE FACTORS ARE GIVEN FOR THIS NUCLIDE--
C              INFLG(II) = 2
C
C              READ INHALATION DOSE FACTORS--
C              DO 7 IO=1,LO

```

FIGURE D.0-1. Module NLIBIN

```

      READ(12,300,END=95) MO,(OD(J),J=1,2)
      MX=0
C
      DO 6 NO=1,LORG
      IF(IORG(NO).EQ.MO) MX=NO
6      CONTINUE
C
      IF(MX.LE.0) GO TO 97
      ODF(1,MX,11)=OD(1)
      ODF(2,MX,11)=OD(2)
7      CONTINUE
C
C      END OF NUCLIDE LOOP--
10     CONTINUE
C
C      PRINT LIBRARY DATA--
      IF (NPRT .GT. 0) THEN
      CALL LIBRPT(TITLN,NUCS,LOPG,INFLG,EXDF,ODF,ONAME)
      ENDIF
C
      RETURN
C
C      ERROR CONDITIONS--
C
94     IEND = 3
      GO TO 99
C
95     IEND=2
      GO TO 99
C
96     IEND=1
      GO TO 99
C
97     PRINT 400, MO,E, W,LORG,IORG
      IEND=2
      GO TO 99
C
98     PRINT 500
      IEND=1
C
99     PRINT 600,IEND
C
      STOP
C
100    FORMAT(4I5,10I3 / 20A4 / (8A10) )
200    FORMAT(A2,A6,6X,E8.1,16X,12)
300    FORMAT(I2,4X,5E8.1)
400    FORMAT(' IORGAN INDEX',I4,' FOR NUCLIDE ',A2,A6,' IS NOT IN ',
      ' IORGAN INDEX LIST OF ',I3,' VALUES = '10I3)
500    FORMAT('IEND OF INPUT ON NUCDEL AT FIRST CARD READ')
600    FORMAT('3ERROR IN NLIBIN, IEND = ',I2)
700    FORMAT('3',16,2A6)
800    FORMAT(4I5)
      END

```

FIGURE D.0-1. Module NLIBIN

```

      SUBROUTINE ORGCHK
C
C *****
C
C      ORGCHK COUNTS AND CHECKS ORGAN DATA
C
C *****
C
C      CALLED BY-- MAIN
C      SUBORDINATE ROUTINES-- ZEROI
C      INPUTS-- NONE
C      INPUT COMMONS-- ORGID
C      OUTPUTS-- NONE
C      OUTPUT COMMONS-- ORGID
C
C -----
C
C      INCLUDE NEPA#HADOC.ORGID,LIST
C
C      CALL ZEROI (5, MORG)
C      NORG=0
C
C      DO 10 I=1,5
C         IF(KORG(I).LE.0) GO TO 10
C         NORG = NORG + 1
C
C         DO 5 IO = 1, LORG
C            II = IO
C            IF (KORG(I) .EQ. IORG(IO)) GOTO 9
C      5  CONTINUE
C
C      UNIDENTIFIED ORGAN INDEX--
C      PRINT 200, I, KORG(I)
C      STOP
C
C      9 MORG(I) = II
C      ORGT(I) = ONAME(II)
C
C      10 CONTINUE
C
C      PRINT ERROR MESSAGES IF NO ORGANS SPECIFIED
C
C      IF(NORG.GT.0) GO TO 12
C      PRINT 100, NORG
C      STOP
C      12 CONTINUE
C
C      FORMAT STATEMENTS
C
C      100 FORMAT(1H1,' NO ORGANS SPECIFIED, NORG = ',I4)
C      200 FORMAT (1H1, ' UNIDENTIFIED ORGAN INDEX FOR INPUT ORGAN ', I3,
C      +          ' INPUT VALUE IS ', I4)
C      END

```

FIGURE D.0-1. Module ORGCHK

```

C      SUBROUTINE PASSIG(XX,IP,SY,SZ)
C*****
C
C      PASSIG INTERPOLATES STORED PASQUILL CURVES FOR SY AND SZ FOR TYPE
C      IP AND DISTANCE XX.
C*****
C
C      CALLED BY-- PMAEO, MMAXEO
C      SUBORDINATE ROUTINES-- NONE
C      INPUTS-- XX, IP
C      INPUT COMMONS-- NONE
C      OUTPUTS-- SY, SZ
C      OUTPUT COMMONS-- NONE
C-----
C
C      DIMENSION SIGY(6,20),SIGZ(6,20),DIST(20)
C
C      DISTANCES TO WHICH SY AND SZ DATA CORRESPOND--
C      DATA DIST/0.0,1.E4,1.5E4,2.5E4,3.5E4,5.E4,7.E4,1.E5,1.5E5,2.5E5,
1      3.5E5,5.E5,7.E5,1.E6,1.5E6,2.5E6,3.5E6,5.E6,7.E6,1.E7/
C
C      SIGMA Y DATA - 1 FOR TYPE A, 2 FOR TYPE B, ETC--
C
C      DATA (SIGY(1,I),I=1,20)/100.,2.1E3,3.2E3,5.4E3,7.5E3,1.05E4,1.42E4
1      ,2.E4,2.9E4,4.5E4,6.1E4,8.3E4,1.12E5,1.55E5,2.2E5,3.4E5,4.5E5,
2      6.2E5,8.2E5,1.1E6/
C
C      DATA (SIGY(2,I),I=1,20)/100.,1.6E3,2.4E3,4.E3,5.5E3,7.6E3,1.06E4,
1      1.48E4,2.15E4,3.4E4,4.6E4,6.3E4,8.4E4,1.2E5,1.68E5,2.6E5,3.5E5,
2      4.7E5,6.4E5,8.5E5/
C
C      DATA (SIGY(3,I),I=1,20)/100.,1.2E3,1.75E3,2.85E3,4.E3,5.5E3,7.6E3,
1      1.06E4,1.55E4,2.4E4,3.3E4,4.5E4,6.1E4,8.5E4,1.2E5,1.85E5,2.5E5,
2      3.4E5,4.7E5,6.3E5/
C
C      DATA (SIGY(4,I),I=1,20)/100.,800.,1.2E3,1.95E3,2.65E3,3.7E3,5.1E3,
1      7.2E3,1.04E4,1.6E4,2.25E4,3.1E4,4.2E4,5.7E4,7.1E4,1.25E5,1.7E5,
2      2.3E5,3.E5,4.1E5/
C
C      DATA (SIGY(5,I),I=1,20)/100.,600.,900.,1450.,2.E3,2.8E3,3.7E3,
1      5.2E3,7.5E3,1.20E4,1.65E4,2.2E4,3.E4,4.1E4,5.7E4,8.8E4,1.18E5,
2      1.6E5,2.1E5,2.8E5/
C
C      DATA (SIGY(6,I),I=1,20)/100.,390.,600.,980.,1350.,1850.,2550.,
1      13600.,5200.,8100.,1.1E4,1.53E4,2.1E4,2.8E4,4.E4,6.1E4,8.2E4,1.12E5
2      ,1.48E5,2.E5/
C
C      SIGMA Z DATA - 1 FOR TYPE A, 2 FOR TYPE B, ETC.
C
C      DATA (SIGZ(1,I),I=1,20)/100.,1500.,2250.,4300.,7.E3,1.35E4,2.7E4,
1      6.7E4,2.E5,1.1E5/
C
C      DATA (SIGZ(2,I),I=1,20)/100.,1.E3,1500.,2550.,3700.,5700.,8500.,
1      1.35E4,2.4E4,5.8E4,1.2E5,2.E5,8E5/
C
C      DATA (SIGZ(3,I),I=1,20)/100.,780.,1100.,1750.,2400.,3400.,4600.,
1      16400.,9000.,1.4E4,1.9E4,2.6E4,3.4E4,4.4E4,6.E4,8.8E4,1.12E5,1.44E5
2      ,1.78E5,2.E5/
C
C      DATA (SIGZ(4,I),I=1,20)/100.,470.,680.,1050.,1400.,1900.,2500.,
1      13300.,4300.,6200.,7600.,9500.,1.15E4,1.4E4,1.7E4,2.2E4,2.65E4,
2      3.2E4,3.7E4,4.5E4/
C
C      DATA (SIGZ(5,I),I=1,20)/100.,300.,430.,710.,940.,1300.,1700.,2200.
1      ,2900.,4100.,5000.,6100.,7200.,8400.,9900.,1.17E4,1.3E4,1.4E4,
2      1.55E4,1.7E4/
C
C      DATA (SIGZ(6,I),I=1,20)/100.,140.,220.,400.,530.,760.,1000.,1350.,
1      11770.,2500.,3000.,3500.,4100.,4700.,5500.,6400.,7200.,7900.,8600.,
2      9400./

```

FIGURE D.0-1. Module PASSIG

```

C      X=XX*100.
C
C      CALCULATE SY AND SZ FOR EACH X POSITION DESIRED--
      IDATA = 1
      1 IF(IDATA,GT,20) GO TO 7
C
C      201 IF(X-DIST(IDATA)) 4,3,2
C
C      IF X IS GREATER THAN DISTANCE--
      2 IDATA=IDATA+1
      GO TO 1
C
C      IF X IS EQUAL TO DISTANCE--
      3 SY=SIGY(IP,IDATA)
      SZ=SIGZ(IP,IDATA)
      GO TO 8
C
C      IF X IS LESS THAN DISTANCE--
      4 IF(IDATA,EQ,1) GO TO 3
      SY1=SIGY(IP,IDATA-1)
      SY2=SIGY(IP,IDATA)
      SZ1=SIGZ(IP,IDATA-1)
      SZ2=SIGZ(IP,IDATA)
      D1=DIST(IDATA-1)
      D2=DIST(IDATA)
      SY=SY1+(X-D1)*(SY2-SY1)/(D2-D1)
      SZ=SZ1+(X-D1)*(SZ2-SZ1)/(D2-D1)
      GO TO 8
C
C      IDATA IS GREATER THAN 20--
      7 SY=SIGY(IP,20)
      SZ=SIGZ(IP,20)
C
C      8 SY=SY*.01
      SZ=SZ*.01
C
C      RETURN
      END
>

```

FIGURE D.0-1. Module PASSIG


```

C          SUBROUTINE POPDOS                                $$$START
C
C*****
C
C          POPDOS CALCULATES THE POPULATION DOSES
C*****
C
C          CALLED BY-- MAIN
C          SUBORDINATE ROUTINES-- TRANSIT, ZEROR
C          INPUTS-- NONE
C          INPUT COMMONS-- DOSFAC, FLAGS, ORGID, POPU, ACTVTY, AIRCON, DECAY,
C                        DISPSN, DISTNC
C          OUTPUTS-- NONE
C          OUTPUT COMMONS-- DOSPOP
C
C-----
C
C          INCLUDE NEPA#HADOCACTVTY,LIST
C          INCLUDE NEPA#HADOCAIRCON,LIST
C          INCLUDE NEPA#HADOCADECAY,LIST
C          INCLUDE NEPA#HADOCADISPSN,LIST
C          INCLUDE NEPA#HADOCADISTNC,LIST
C          INCLUDE NEPA#HADOCADOSFAC,LIST
C          INCLUDE NEPA#HADOCADOSPOP,LIST
C          INCLUDE NEPA#HADOCAFLAGS,LIST
C          INCLUDE NEPA#HADOCAORGID,LIST
C          INCLUDE NEPA#HADOCAPOPU,LIST
C
C          INITIALIZE DOSE ARRAYS--
C
C          CALL ZEROR (300, DPE)
C          CALL ZEROR (3000, DPO)
C          CALL ZEROR (10, DPOT)
C          DPET = 0.
C
C          FOR EACH POPULATION DISTANCE--
C          DO 100 IX = 1, NPD
C
C              T = DP(IX) / UP
C              PEQ = EQP(IX) * POP(IX,MS)
C
C              CALL TRANSIT (T)
C              INUC = 0.
C
C              FOR EACH DECAY CHAIN--
C              DO 200 IC = 1, NCH
C
C                  J = NOFNUC(IC)
C
C                  TEST FOR INCLUSION OF CHAIN IN INVENTORY--
C                  IF (NFLAGC(IC) .GT. 0) THEN
C
C                      IST = INUC + 1
C                      K = IST + J - 1
C
C                      FOR EACH RADIONUCLIDE IN CHAIN--
C                      DO 300 IN = IST, K
C
C                          TEST FOR DOSE FACTOR DATA FOR NUCLIDE--
C                          IF (INFLG(IN) .GT. 0) THEN
C
C                              D = PEQ * QD(IN) * EXDF(IN)
C                              DPE(IN) = D + DPE(IN)
C                              DPET = DPET + D
C
C                              FOR EACH ORGAN--
C                              DO 400 IO = 1, NORG
C
C                                  IL = MORG(IO)
C
C                                  D = PEQ * QD(IN) * ODF(1,IL,IN)
C                                  DPO(1,IO,IN) = DPO(1,IO,IN) + D

```

FIGURE D.0-1. Module POPDOS

```

C          DPOT(1,IO) = DPOT(1,IO) + D
C          D = PEQ * QD(IN) * ODF(2,IL,IN)
C          DPO(2,IO,IN) = DPO(2,IO,IN) + D
C          DPOT(2,IO) = DPOT(2,IO) + D
C 400      CONTINUE
C          ENDIF
C 300      CONTINUE
C          ENDIF
C          INUC = INUC + J
C
C 200 CONTINUE
C 100 CONTINUE
C
C      RETURN
C      END

```

FIGURE D.0-1. Module POPDOS

```

                                MODULE POPEQ

SUBROUTINE POPEQ (EQP, PM, MS, IP)                                $$$START
C
C*****
C
C   POPEQ CALCULATES THE POPULATION DISPERSION FACTOR FOR THE MAX-
C   IMUM SECTOR.
C*****
C
C   CALLED BY-- DISPPS
C   SUBORDINATE ROUTINES-- SIGMAZ, ZEROR, PMAEQ
C   INPUTS-- NONE
C   INPUT COMMONS-- DISPSN, DISTNC, POPU, ELEVAT
C   OUTPUTS-- EQP, PM, MS, IP
C   OUTPUT COMMONS-- NONE
C
C-----
C
C   INCLUDE NEPA#HADOC.DISPSN,LIST
C   INCLUDE NEPA#HADOC.DISTNC,LIST
C   INCLUDE NEPA#HADOC.POPU,LIST
C   INCLUDE NEPA#HADOC.ELEVAT,LIST
C
C   DIMENSION EQ(10), SS(10), POPM(16), EOS(10,16), EQP(10)
C   DIMENSION IP(10), IPP(10,16)
C
C   CALL ZEROR (16,POPM)
C
C   FOR EACH DISTANCE CONSIDERED--
C   DO 100 ID = 1, NPD
C
C       TT = DP(ID) / UP
C       SZ = SIGMAZ (KKSP,TT)
C       SS(ID) = SZ
C
C       IF BUILDING WAKE CONSIDERED--
C       IF (IWAKE .GT. 0) THEN
C
C           EZ = SQRT (SZ**SZ + .5 * AREA)
C
C           IF (EZ .GT. SQRT (3.) * SZ) THEN
C               SS(ID) = SZ * SQRT(3)
C           ELSE
C               SS(ID) = EZ
C           ENDIF
C       ENDIF
C
C       EQ(ID) = 2.032 / (SS(ID) * UP * DP(ID))
C
C   100 CONTINUE
C
C   IF ELEVATION OF RELEASE POINT IS GREATER THAN ONE--
C   IF (HSTACK .GT. 1.) THEN
C
C       IF TERRAIN EFFECTS ARE CONSIDERED--
C       IF (ITERN .GT. 0) THEN
C
C           FOR EACH DISTANCE--
C           DO 200 ID = 1, NPD
C
C               FOR EACH DIRECTION--
C               DO 300 IS = 1, 16
C
C                   H = HSTACK - HT(ID,IS)
C
C                   IF (H .LT. 0.) H = 0.
C
C                   SET TO HANFORD STABILITY CONDITIONS---
C                   IPL = 7
C
C                   H2 = H * H
C                   EXP0 = H2 * .5 / SS(ID)**2.
C                   EXPT = EXP (-EXP0)

```

FIGURE D.0-1. Module POPEQ

```

MODULE POPEQ

      E = EQ(ID) * EXPT
C
C      IF MAX. ATMOS. DISPERSION CONDITIONS ARE TO BE DETERMINED--
      IF (LIMITST .GT. 0) THEN
        CALL PMAEQ (E, H2, UP, DP(ID), AREA, IWAKE, IPL)
      ENDIF
C
      IPP(ID,IS) = IPL
C
      POPM(IS) = POPM(IS) + E * POP(ID,IS)
C
      EQS(ID,IS) = E
C
300      CONTINUE
200      CONTINUE
C
C      ELSE
C
C      FOR EACH DISTANCE--
      DO 400 ID = 1, NPD
C
      H2 = HSTACK * HSTACK
      EXPT = EXP (- H2 * .5 / SS(ID)**2)
C
      E = EQ(ID) * EXPT
C
C      FOR EACH DIRECTION--
      DO 500 IS = 1, 16
C
      SET TO HANFORD STABILITY CONDITIONS--
      IPL = 7
C
      IF MAX. ATMOS. DISPERSION CONDITIONS ARE TO BE DETERMINED--
      IF (LIMITST .GT. 0) THEN
        CALL PMAEQ (E, H2, UP, DP(ID), AREA, IWAKE, IPL)
      ENDIF
C
      TO DETERMINE WHICH ATMOSPHERIC STABILITY CONDITION GIVES
      THE HIGHEST VALUE FOR SECTOR AVERAGED AIR CONCENTRATION.
C
      IPP(ID,IS) = IPL
C
      POPM(IS) = POPM(IS) + E * POP(ID,IS)
      EQS(ID,IS) = E
C
500      CONTINUE
400      CONTINUE
C
      ENDIF
C
C      ELSE
C
C      FOR EACH DIRECTION--
      DO 500 IS = 1,16
C
      FOR EACH DISTANCE--
      DO 700 ID = 1, NPD
C
      IPP(ID,IS) = 7
C
      POPM(IS) = EQ(ID) * POP(ID,IS) + POPM(IS)
      EOS(ID,IS) = EQ(ID)
C
700      CONTINUE
500      CONTINUE
C
      ENDIF
C
      FIND DIRECTION WITH MAXIMUM (POPULATION) * (E/Q) SUM--
C
      MS = 1

```

FIGURE D.0-1. Module POPEQ

```

                                MODULE POPEQ

      PM = 0.
C
C   FOR EACH DIRECTION--
DO 800 IS = 1, 16
C
      IF (POPM(IS) .GT. PM) THEN
C
        PM = POPM(IS)
        MS = IS
C
C   FOR EACH DIRECTION--
DO 900 ID = 1, NPD
C
        EQP(ID) = EQS(ID,IS)
        IPP(ID) = IPP(ID,IS)
C
900    CONTINUE
      ENDIF
800 CONTINUE
C
      RETURN
      END

```

FIGURE D.0-1. Module POPEQ

```

                                MODULE PMAEQ

SUBROUTINE PMAEQ (E, H2, UP, X, AREA, IWAKE, IPL)                                $$$START
C
C *****
C
C   PMAEQ DETERMINES WHICH ATMOSPHERIC STABILITY CONDITION GIVES
C   THE HIGHEST VALUE FOR SECTOR AVERAGED AIR CONCENTRATION.
C *****
C
C   CALLED BY-- POPEQ
C   SUBORDINATE ROUTINES-- PASSIG
C   INPUTS-- H2, UP, X, AREA, IWAKE
C   INPUT COMMONS-- NONE
C   OUTPUTS-- E, IPL
C   OUTPUT COMMONS-- NONE
C
C -----
C
C   SET CONDITION INDEX FOR HANFORD--
C   IPL = 7
C
C   TEST FOR ELEVATED RELEASE--
C   IF (H2 .GT. .1) THEN
C
C     FOR EACH PASQUILL CONDITION--
C     DO 100 IP = 1, 5
C
C       CALL PASSIG (X, IP, SY, SZ)
C       TO CALCULATE SIGMA Y AND SIGMA Z FOR PASQUILL DISPERSION
C       CATEGORIES.
C
C       IF BUILDING WAKE CONSIDERED--
C       IF (IWAKE .GT. 0) THEN
C
C         EZ = SQRT (SZ * SZ + .5 * AREA)
C         IF (EZ .LT. SQRT (3.) * SZ) THEN
C           SS = SZ * SQRT (3.)
C         ELSE
C           SS = EZ
C         ENDIF
C
C       ELSE
C
C         SS = SZ
C
C       ENDIF
C
C       EE = 2.032 / (SS * UP * X) * EXP (-H2 * .5 / (SS*SS))
C
C       IF (EE .GT. E) THEN
C         IPL = IP
C         E = EE
C       ENDIF
C
C 100 CONTINUE
C   ENDIF
C
C   RETURN
C   END

```

FIGURE D.0-1. Module PMAEQ

```

      SUBROUTINE QAPAGE (TITLE1,TITLR,TITLN,QI,FINV,IFRAC,KKRPT,FRAC)  $$$START
C
C*****
C
C      QAPAGE PRINTS THE QUALITY ASSURANCE REPORT.
C
C*****
C
C      CALLED BY-- MAIN
C      SUBORDINATE ROUTINES-- IDLINE
C      INPUTS-- TITLE1, TITLR, TITLN, QI, FINV, IFRAC, KKRPT, FRAC
C      INPUT COMMONS-- DAY, DISPSN, DISTNC, ELEVAT, ORGID, POPU, SOURCE
C      OUTPUTS-- QUALITY ASSURANCE REPORT
C      OUTPUT COMMONS-- NONE
C
C-----
C
C      INCLUDE NEPA$HADOC.DAY,LIST
C      INCLUDE NEPA$HADOC.DISPSN,LIST
C      INCLUDE NEPA$HADOC.DISTNC,LIST
C      INCLUDE NEPA$HADOC.ELEVAT,LIST
C      INCLUDE NEPA$HADOC.ORGID,LIST
C      INCLUDE NEPA$HADOC.POPU,LIST
C      INCLUDE NEPA$HADOC.SOURCE,LIST
C
C      DIMENSION QI(300), TITLE1(20), TITLR(20), TITLN(20)
C
C      DIMENSION CLIM (2)
C      DATA CLIM /'NOT', '  '/
C
C      PRINT HEADINGS--
C      WRITE (6,100) TITLE1, DAIT
C
C      CALL IDLINE
C      TO PRINT ID LINE.
C
C      PRINT DATA LIBRARY TITLES--
C      WRITE (6,200) TITLR, TITLN
C
C      PRINT SUMMARY OF INPUT DATA--
C      WRITE (6,300)
C
C      CMI = 'VERY'
C      CP = 'VERY'
C      IF (KKSMI .LE. 0) CMI = 'MOD.'
C      IF (KKSP .LE. 0) CP = 'MOD.'
C
C      WRITE (6,400) CMI, CP
C      WRITE (6,500) UMI,UP
C      WRITE (6,600) HSTACK
C      WRITE (6,700) (ORGT(I), I = 1, NORG)
C
C      MAXIMUM ATMOSPHERIC CONDITIONS INFO--
C      WRITE (6,1600) CLIM(LIMITST+1)
C
C      FRACTIONAL INFORMATION--
C      IF (IFRAC .GT. 0) THEN
C        WRITE (6,800) FRAC
C      ELSE
C        WRITE (6,801)
C      ENDIF
C
C      REQUESTED REPORTS INFORMATION--
C      IF (KKRPT .LE. 0) THEN
C        WRITE (6,1500)
C      ELSE
C        IF (KKRPT .EQ. 1) THEN
C          WRITE (6,1501)
C        ELSE
C          WRITE (6,1502)
C        ENDIF
C      ENDIF
C

```

FIGURE D.0-1. Module QAPAGE

MODULE QAPAGE

```

C
C  DISTANCE INFORMATION--
C  IF (KKRPT .LE. 1) THEN
C    WRITE (6,900) STUB
C    WRITE (6,1000) DM1
C  ENDIF
C  IF (KKRPT .NE. 1) THEN
C    WRITE (6,901) NPD, (DP(I), I=1,NPD)
C    WRITE (6,902) (I, I = 1, NPD)
C    DO 10 IS = 1, 16
C      WRITE (6,1001) IS, (POP(J,IS), J=1,NPD)
10  CONTINUE
C  ENDIF
C
C  BUILDING WAKE OPTION--
C  IF (IWAKE .GT. 0) THEN
C    WRITE (6,1100) AREA
C  ELSE
C    WRITE (6,1101)
C  ENDIF
C
C  TERRAIN EFFECTS OPTION--
C  IF (ITERN .GT. 0) THEN
C    WRITE (6,1200)
C    IF (KKRPT .LE. 1) THEN
C      WRITE (6,1201) HMI
C    ENDIF
C    IF (KKRPT .NE. 1) THEN
C      WRITE (6,1202) (I, I=1,NPD)
C      DO 20 IS = 1, 16
C        WRITE (6,1203) IS, (HT(J,IS), J= 1,NPD)
20  CONTINUE
C    ENDIF
C
C  ELSE
C    WRITE (6,1204)
C  ENDIF
C
C
C  PRINT RADIONUCLIDE INVENTORY--
C  WRITE (6,1300)
C  WRITE (6,1301) (ELTI(I), AWI(I), QI(I), I=1,NIN)
C  WRITE (6,1302) FINV
C
C  WRITE (6,1400)
C
C  RETURN
C  FORMAT STATEMENTS--
C
100 FORMAT (1H1, 20A4 // 37X, A8/)
C
200 FORMAT (1H0, 'DATA LIBRARY TITLES:' /
+ '   ***MASTER RADIONUCLIDE DATA LIBRARY***' /
+ 5X, 20A4 /
+ '   ***DOSE FACTOR LIBRARY***' /
+ 5X, 20A4)
C
300 FORMAT (1H0, 'SUMMARY OF INPUT DATA:' /
+ 31X, 'MAXIMUM INDIVIDUAL      POPULATION')
C
400 FORMAT (1H , 3X, '***DISPERSION MODEL', 12X, A4, ' STABLE', 10X,
+ A4, ' STABLE')
C
500 FORMAT (1H , 3X, '***WIND SPEED (M/SEC)', 10X, F3.1, 18X, F3.1)
C
600 FORMAT (1H0, 3X, '***STACK HEIGHT IS ', F5.0, ' METERS')
C
700 FORMAT (1H0, 3X, '***ORGANS SELECTED ARE:  ', 5 (A10, 2X) )
C
800 FORMAT (1H0, 3X, '***FRACTIONAL DOSE REPORTS ARE REQUESTED' /
+ 11X, 'MINIMUM FRACTION REPORTED IS ', 1PE10.1)
C
801 FORMAT (1H0, 3X, '***FRACTIONAL DOSE REPORTS ARE NOT REQUESTED')

```

FIGURE D.0-1. Module QAPAGE


```

C
900 FORMAT (1H , 3X, '***DISPERSION PARAMETER SIGMA THETA U BAR = ',
+ F6.4)
C
901 FORMAT (1H , 3X, '***POPULATION DISTANCES: ', I2, ' ', METERS' /
+ 10X, 10F11.0 /)
902 FORMAT (1H0, 3X, '***POPULATION DISTRIBUTION DATA' /
+ 43X, 'DISTANCE INTERVAL' /
+ 7X, 'SECTOR', 6X, 10 (I2, 9X) )
C
1000 FORMAT (1H , 3X, '***DISTANCE TO MAXIMUM INDIVIDUAL', 3X, F6.0,
+ ' METERS')
C
1001 FORMAT (1H , 7X, I2, 10 (4X, F7.0) )
C
1100 FORMAT (1H0, 3X, '***BUILDING WAKE EFFECTS ARE CONSIDERED' /
+ 11X, 'AREA = ', F5.0, ' METERS**2' )
C
1101 FORMAT (1H0, 3X, '***BUILDING WAKE EFFECTS ARE NOT CONSIDERED' )
C
1200 FORMAT (1H0, 3X, '***TERRAIN EFFECTS ARE CONSIDERED')
C
1201 FORMAT (1H , 10X, 'ELEVATION OF MAXIMUM INDIVIDUAL IS ', F4.0,
+ ' METERS')
C
1202 FORMAT (1H0, 3X, '***TERRAIN DATA*** DISTANCE INTERVAL' /
+ 7X, 'SECTOR ', 10 (6X, I2) )
C
1203 FORMAT (1H , 8X, I2, 4X, 10 ( 3X, F5.0) )
C
1204 FORMAT (1H0, 3X, '***TERRAIN EFFECTS ARE NOT CONSIDERED' )
C
1300 FORMAT (1H0, 3X, '***RADIONUCLIDE INPUT INVENTORY' /
+ 10X, 3 (11X, 'NUCLIDE RELEASE ' ) /
+ 10X, 3 (10X, 'ELT. WT. (CI) ' ) )
C
1301 FORMAT ((10X, 3 (10X, A2, 1X, A6, 2X, 1PE8.2E2)))
C
1302 FORMAT (1H0, 3X, '***THE ABOVE ACTIVITIES ARE MULTIPLIED BY ',
+ 1PE10.2, ' TO GET THE RELEASE ACTIVITY' )
C
1400 FORMAT (1H0, / 4X, '*** INPUT PREPARED BY:', 16X, 'DATE' /
+ 27X, '*****' )
+ 4X, '*** INPUT CHECKED BY:', 17X, 'DATE' /
+ 26X, '*****' )
C
1500 FORMAT (1H0, 3X, '***ALL DOSE REPORTS ARE REQUESTED' /)
C
1501 FORMAT (1H0, 3X, '***ONLY MAXIMUM INDIVIDUAL DOSE REPORTS ',
+ ' ARE REQUESTED' )
C
1502 FORMAT (1H0, 3X, '***ONLY POPULATION DOSE REPORTS ARE REQUESTED' )
C
1600 FORMAT (1H0, 3X, '***MAXIMUM ATMOSPHERIC DISPERSION CONDITIONS '
+ ' WILL ', A3, ' BE DETERMINED')
C
END

```

FIGURE D.0-1. Module QAPAGE

```

      SUBROUTINE RLIBIN (TITLR)
C
C *****
C
C   THIS SUBROUTINE READS A MASTER NUCLIDE DATA LIBRARY WITH CHAIN
C   DECAY DATA.
C *****
C
C   INCLUDE NEPA*HADOC.DECAY,LIST
C   INCLUDE NEPA*HADOC.NAMES,LIST
C
C   DIMENSION TITLR(20),IT(2),FR(2)
C
C   CHARACTER A*6, TITLR*4
C
C   INITIALIZE INDICES
C   CALL ZEROR (300, AL)
C
C   AL2 = ALOG (2.)
C   IMO=0
C   NCH=0
C   NUC=1
C
C   READ TITLE CARD
C
C   READ(10,200,END=99) TITLR
C
C   READ AND COUNT NUCLIDE ID AND DECAY DATA.
C
C   1 READ(10,100,END=99) E,A,T,IM,IT(1),FR(1),IT(2),FR(2)
C
C   TEST FOR END OF LIBRARY
C
C   IF(IM.GT.0) GO TO 2
C   NUC=NUC+1
C   IF(NUC.GT.300) GO TO 98
C   IF(NUC.LT.1) GO TO 98
C   NUCS = NUC
C   RETURN
C
C   TEST FOR NEW CHAIN, IM = 1
C
C   2 IF(IM.GT.1) GO TO 3
C
C   FIRST MEMBER, NEW CHAIN
C
C   NCH=NCH+1
C   NOFNUC(NCH)=1
C   IMO=1
C   NCHST(NCH)=NUC
C   GO TO 4
C
C   DAUGHTER NUCLIDES
C   TEST ORDER
C
C   3 IF(IM-IMO.NE.1) GO TO 97
C   IMO=IM
C   NOFNUC(NCH)=NOFNUC(NCH)+1
C   IFR(1,NUC)=IT(1)
C   IFR(2,NUC)=IT(2)
C   DKF(1,NUC)=FR(1)
C   DKF(2,NUC)=FR(2)
C
C   SET DATA FOR CURRENT NUCLIDE.
C
C   4 ELT(NUC)=E
C   AW(NUC)=A
C   AL(NUC) = AL2 / (T * 86400.)
C   IMEM(NUC)=IM
C   NCHN(NUC)=NCH

```

FIGURE D.0-1. Module RLIBIN

```

      NUC=NUC+1
      GO TO 1
C
C  PRINT ERROR MESSAGES AND STOP
C
      97 PRINT 500, NCH, IM
      500 FORMAT(1H1, ' DIAGNOSTIC 1: DECAY CHAIN', I4, ' HAS IMPROPER ORDER. C
        .URRENT MEMBER INDEX IS', I4)
      STOP
      98 PRINT 300, NUC
      300 FORMAT(1H1, ' DIAGNOSTIC 2: IMPROPER NUMBER OF NUCLIDES IN MASTER L
        .IBRARY, NUC=', I8)
      STOP
      99 PRINT 400
      400 FORMAT(1H1, ' DIAGNOSTIC 3: END OF FILE ON MASTER LIBRARY UNIT 10')
      STOP
C
C  INPUT DATA FORMATS
C
      100 FORMAT(A2, A6, E10.2, I2, 2(I2, F7.4))
      200 FORMAT(20A4)
      END

```

FIGURE D.O-1. Module RLIBIN

```

C      FUNCTION SIGMAY (TT, STUB)                                     $$$START
C      C*****
C      SIGMAY CALCULATES SIGMA Y AT A GIVEN LOCATION.
C      C*****
C      CALLED BY-- DISPRS
C      SUBORDINATE ROUTINES-- NONE
C      INPUTS-- TT, STUB
C      INPUT COMMONS-- NONE
C      OUTPUTS-- SIGMAY
C      OUTPUT COMMONS-- NONE
C      -----
C
C      A = 13. + 230. * STUB
C      ALPHA = 0.5 * A / (STUB * STUB)
C      EXPO = TT / ALPHA
C      SY2 = A * (TT - ALPHA * (1. - EXP(-EXPO)) )
C      SIGMAY = SQRT (SY2)
C      RETURN
C      END

```

FIGURE D.0-1. Module SIGMAY

```

C      FUNCTION SIGMAZ (KS, TT)                                     $$$START
C      C*****
C      SIGMAZ CALCULATES SIGMA Z AT A GIVEN LOCATION.
C      C*****
C      CALLED BY-- DISPRS, POPEQ
C      SUBORDINATE ROUTINES-- NONE
C      INPUTS-- KS, TT
C      INPUT COMMONS-- NONE
C      OUTPUTS-- SIGMAZ
C      OUTPUT COMMONS-- NONE
C      -----
C      IF (KS .GT. 0) THEN
C          EXPO = 8.8E-4 * TT * TT
C          SZ2 = 34. * (1. - EXP (-EXPO)) + .025 * TT
C      ELSE
C          EXPO = 2.54E-4 * TT * TT
C          SZ2 = 97. * (1. - EXP (-EXPO)) + .33 * TT
C      ENDIF
C      SIGMAZ = SQRT (SZ2)
C      RETURN
C      END

```

FIGURE D.0-1. Module SIGMAZ

```

                                MODULE  TRNSIT

                                SUBROUTINE TRNSIT (T)                                $$$START
C
C *****
C
C   TRNSIT CONTROLS RADIOLOGICAL DECAY CALCULATIONS.
C
C *****
C
C   CALLED BY-- POPDOS, MIDOSE
C   SUBORDINATE ROUTINES-- ACHAIN
C   INPUTS-- T
C   INPUT COMMONS-- ACTVTY, DECAY, FLAGS
C   OUTPUTS-- NONE
C   OUTPUT COMMONS-- ACTVTY
C
C -----
C
C   INCLUDE NEPA#HADO.C.ACTVTY,LIST
C   INCLUDE NEPA#HADO.C.DECAY,LIST
C   INCLUDE NEPA#HADO.C.FLAGS,LIST
C
C   INUC = 0
C
C
C   FOR EACH CHAIN--
C   DO 100 IC = 1, NCH
C
C       IF DATA SUPPLIED FOR ANY RADIONUCLIDES IN THIS CHAIN--
C       IF (NFLAGC (IC) .GT. 0) THEN
C
C           J = NOFNUC(IC)
C           IST = INUC + 1
C           K = IST + J - 1
C
C           CALL ACHAIN (J, T, DKF(1,IST), IFR(1,IST), AL(IST), Q(IST),
C           +           QD(IST), 0)
C
C           DO 200 IN = IST, K
C               QD(IN) = QD(IN) + AL(IN)
C           200 CONTINUE
C
C       ENDIF
C
C       INUC = INUC + NOFNUC(IC)
C
C   100 CONTINUE
C
C   RETURN
C   END

```

FIGURE D.0-1. Module TRNSIT

```

      SUBROUTINE ZEROI(N,K)
C
C*****
C
C      THIS MODULE SETS N VALUES OF ARRAY K TO INTEGER ZERO.
C*****
C
C      CALLED BY-- NLIBIN, IDNUC, ORGCHK
C      SUBORDINATE ROUTINES-- NONE
C      INPUTS-- N
C      INPUT COMMONS-- NONE
C      OUTPUTS-- K
C      OUTPUT COMMONS-- NONE
C
C-----
C
C      DIMENSION K(1)
C
C      DO 1 J=1,N
C        K(J)=0
C 1 CONTINUE
C
C      RETURN
C      END

```

FIGURE D.0-1. Module ZEROI

```

      SUBROUTINE ZEROR(N,A)
C
C *****
C
C   THIS MODULE SETS N VALUES OF ARRAY A TO REAL ZERO.
C
C *****
C
C   CALLED BY-- POPDOS, MIDOSE, FRDRPT, RLIBIN, NLIBIN, IDNUC
C   SUBORDINATE ROUTINES-- NONE
C   INPUTS-- N
C   INPUT COMMONS-- NONE
C   OUTPUTS-- A
C   OUTPUT COMMONS-- NONE
C
C -----
C
C   DIMENSION A(1)
C
C   DO 1 J=1,N
C     A(J)=0.
C 1 CONTINUE
C
C   RETURN
C   END

```

FIGURE D.0-1. Module ZEROR


```

ACTVTY PROC                                     $$$START
C
C-----
C   ACTVTY                                CODED BY RAP                06-05-80
C-----
C
COMMON /ACTVTY/  Q(300),  QD(300)
C
C   Q(300)      - ACTIVITY IN RELEASE INVENTORY FOR EACH RADIONU-
C                CLIDE IN THE MASTER RADIONUCLIDE LIST,  Curies.
C   QD(300)     - RELEASE ACTIVITES CORRECTED FOR DECAY IN TRANSIT.
C
END

```

```

AIRCON PROC                                     $$$START
C
C-----
C   AIRCON                                CODED BY RAP                06-05-80
C-----
C
COMMON / AIRCON /  EQMI, PM, EQP(10), MS
C
C   EQMI        - TIME INTEGRATED AIR CONCENTRATION FOR THE MAXIMUM
C                INDIVIDUAL LOCATION, SEC/M**3.
C   PM          - TIME INTEGRATED AIR CONCENTRATION TIMES POPULA-
C                TION, MAN-SEC/M**3.
C   EQP(10)     - TIME INTEGRATED AIR CONCENTRATION AT EACH POPULA-
C                TION DISTANCE IN THE DIRECTION OF THE MAXIMUM
C                EXPOSURE SECTOR, SEC/M**3.
C   MS          - INDEX OF THE MAXIMUM POPULATION DOSE SECTOR.
C
END

```

```

DAY   PROC                                     $$$START
C
C-----
C   DAY                                CODED BY RAP                06-09-80
C-----
C
COMMON /DAY/  DAIT
C
C   CHARACTER**8 DAIT
C
C   DAIT        - EIGHT CHARACTER NAME FOR DAY OF YEAR, MMDDYY:
C                MM - MONTH, DD - DAY, YY - YEAR.
C
END

```

```

DECAY PROC                                     $$$START
C
C-----
C   DECAY                                CODED BY RAP                06-05-80
C-----
C
COMMON /DECAY/  NUC, NCH, NOFNUC(200), NCHST(200), IFR(2,300),
+ DKF(2,300), AL(300), NCHN(300)
C
C   NUC          - NO. OF RADIONUCLIDES IN THE MASTER LIBRARY RMDLIB
C                1 <= NUC => 300.
C   NCH          - NO. OF DECAY CHAINS IN THE MASTER LIBRARY RMDLIB
C                1 <= NCH => 200.
C   NOFNUC(200) - NO. OF RADIONUCLIDES IN EACH DECAY CHAIN. 1 <=
C                NOFNUC(I) => 9. WHEN NOFNUC(I) = 1, NO DAUGHTERS.
C   NCHST(200)  - LOCATION IN THE MASTER RADIONUCLIDE LIST OF THE
C                1ST MEMBER OF EACH CHAIN. 1 <= NCHST(I) => 300.
C   IFR(2,300)  - IFR(1,I) GIVES THE CHAIN MEMBER THAT IS THE 1ST
C                PRECURSOR TO RADIONUCLIDE I. IFR(2,I) IS LOCATION
C                OF 2ND PRECURSOR. IFR(1,I) < IFR(2,I) < IMEM(I)
C   DKF(2,300)  - FRACTION OF 1ST AND 2ND PRECURSOR THAT DECAYS TO
C                THIS RADIONUCLIDE.
C   AL(300)     - RADIOLOGICAL DECAY CONSTANT FOR EACH RADIONUCLIDE
C                SEC ** -1.
C   NCHN(300)   - CHAIN NUMBER FOR EACH RADIONUCLIDE.
C
END

```

FIGURE D.0-1. Common Blocks

```

DISPSN PROC                                     $$$START
C
C-----
C   DISPSN                                CODED BY RAP                06-05-80
C-----
C
C   COMMON /DISPSN/  UMI, UP, AREA, KKSMI, KKSP, STUB, ITERN, IWAKE,
+   LIMTST
C
C   UMI          - WIND SPEED TO BE USED FOR THE MAXIMUM INDIVIDUAL
C                 DOSE CALCULATION, M/SEC.
C   UP           - WIND SPEED TO BE USED FOR THE POPULATION DOSE
C                 CALCULATION, M/SEC.
C   AREA        - MINIMUM BUILDING CROSS SECTIONAL AREA FOR THE
C                 BUILDING WAKE MODEL.
C   KKSMI       - INDICATOR FOR THE DISPERSION MODEL TO BE USED FOR
C                 THE MAX. INDIVIDUAL AIR CONCENTRATION CALCULATION.
C   KKSP        - INDICATOR FOR THE DISPERSION MODEL TO BE USED FOR
C                 POPULATION AIR CONCENTRATION CALCULATION.
C   STUB        - VALUE FOR SIGMA THETA U BAR TO BE USED FOR THE
C                 MAXIMUM INDIVIDUAL DISPERSION CALCULATION.
C   ITERN       - CONTROL INTEGER TO INDICATE IF TERRAIN EFFECTS
C                 ARE TO BE CONSIDERED. TRUE IF > 0.
C   IWAKE       - CONTROL INTEGER TO INDICATE IF BUILDING WAKE IS
C                 TO BE CONSIDERED. TRUE IF > 0.
C   LIMTST      - CONTROL INTEGER TO INDICATE IF CONDITION WHICH
C                 GAVE MAXIMUM CONCENTRATION VALUES IS TO BE
C                 DETERMINED.
C
C   NOTE: FOR KKSMI AND KKSP; <= 0 FOR HANFORD MODERATELY STABLE
C           => 1 FOR HANFORD VERY STABLE
C
END

```

```

DISTNC PROC                                     $$$START
C
C-----
C   DISTNC                                CODED BY RAP                06-05-80
C-----
C
C   COMMON /DISTNC/  NPD, DP(10), DMI
C
C   NPD          - NO. OF DISTANCES CONSIDERED FOR THE POPULATION
C                 DOSE CALCULATION. 1<= NPD => 10.
C   DP(10)       - DISTANCES FROM THE RELEASE POINT TO THE CENTER OF
C                 EACH POPULATION RING, M. NPD VALUES MUST BE
C                 GIVEN IN INCREASING ORDER.
C   DMI          - DISTANCE FROM THE RELEASE POINT TO THE LOCATION
C                 OF THE MAXIMUM INDIVIDUAL.
C
END

```

```

DOSFAC PROC                                     $$$START
C
C-----
C   DOSFAC                                CODED BY RAP                06-05-80
C-----
C
C   COMMON /DOSFAC/  EXDF(300), ODF(2,10,300)
C
C   EXDF(300)    - EXTERNAL DOSE CONVERSION FACTORS FOR AIR SUBMER-
C                 SION FOR EACH RADIONUCLIDE, REM PER CI SEC/M**3.
C   ODF(2,10,300)- INHALATION DOSE CONVERSION FACTORS FOR TWO TIME
C                 PERIODS, 10 ORGANS AND 300 RADIONUCLIDES, REM
C                 PER CI SEC / M**3.
C
END

```

FIGURE D.0-1. Common Blocks

```

DOSMI  PROC                                     $$$START
C
C-----
C      DOSMI                                CODED BY RAP                05-06-80
C-----
C
C      COMMON /DOSMI/ DME(300), DMET, DMO(2,5,300), DMOT(2,5)
C
C      DME(300)      - EXTERNAL DOSE TO MAXIMUM INDIVIDUAL FOR EACH
C                    RADIONUCLIDE. ALSO USED FOR FRACTIONAL DOSE
C                    STORAGE.
C      DMET          - TOTAL DOSE FROM EXTERNAL RADIATION FOR THE MAX-
C                    IMUM INDIVIDUAL.
C      DMO(2,5,300)  - INHALATION DOSE FOR TWO TIMES, 5 ORGANS AND 300
C                    RADIONUCLIDES FOR THE MAXIMUM INDIVIDUAL. ALSO
C                    USED FOR FRACTIONAL DOSE STORAGE.
C      DMOT          - TOTAL DOSE FROM INHALATION FOR TWO TIMES AND
C                    FIVE ORGANS.
C
C      END

```

```

DOSPOP PROC                                     $$$START
C
C-----
C      DOSPOP                                CODED BY RAP                05-06-80
C-----
C
C      COMMON /DOSPOP/ DPE(300), DPET, DPO(2,5,300), DPOT(2,5)
C
C      DPE(300)      - EXTERNAL DOSE TO THE POPULATION FOR EACH RADIO-
C                    NUCLIDE. ALSO USED FOR FRACTIONAL DOSE CONTRIBU-
C                    TION STORAGE.
C      DPET          - TOTAL DOSE TO THE POPULATION FROM EXTERNAL
C                    EXPOSURE.
C      DPO(2,5,300)  - POPULATION DOSE FROM INHALATION FOR TWO TIME PER-
C                    IODS, 5 ORGANS AND 300 RADIONUCLIDES. ALSO USED
C                    FOR FRACTIONAL DOSE CONTRIBUTION STORAGE.
C      DPOT(2,5)     - TOTAL POPULATION DOSE FROM INHALATION FOR TWO
C                    PERIODS AND FIVE ORGANS.
C
C      END

```

```

ELEVAT PROC                                     $$$START
C
C-----
C      ELEVAT                                CODED BY RAP                06-05-80
C-----
C
C      COMMON /ELEVAT/ HMI, HT(10,15), HSTACK
C
C      HMI           - TERRAIN ELEVATION (ABOVE THE BASE OF THE STACK)
C                    AT THE LOCATION OF THE MAXIMUM INDIVIDUAL, M.
C      HT(10,15)     - TERRAIN ELEVATION AT EACH LOCATION (10 DISTANCES
C                    & 16 DIRECTIONS) ABOVE THE BASE OF THE STACK, M.
C      HSTACK        - ELEVATION OF THE RELEASE POINT, M.
C
C      END

```

FIGURE D.0-1. Common Blocks

```

FLAGS  PROC                                     $$$$START
C
C-----
C      FLAGS                                CODED BY RAP                06-05-80
C-----
C
C      COMMON /FLAGS/  NFLAGC(200), NFLAG(300), INFLG(300), NPRT
C
C      NFLAGC(200) - CONTROL INTEGER TO INDICATE IF ANY RADIONUCLIDES
C                   IN EACH CHAIN ARE SUPPLIED ON INPUT.
C      NFLAG(300)  - CONTROL INTEGER TO INDICATE IF A RADIONUCLIDE IS
C                   GIVEN IN THE INPUT INVENTORY FOR EACH RADIO-
C                   NUCLIDE IN THE MASTER LIST.
C      INFLG(300)  - CONTROL INTEGER TO INDICATE WHICH MASTER LIST
C                   RADIONUCLIDE HAVE DOSE FACTORS SUPPLIED IN INPUT
C
C      NOTE:
C          <= 0 -- NO DATA GIVEN
C          > 0  -- DATA GIVEN
C
C      NPRT        - CONTROL INTEGER TO CAUSE PRINTING OF THE DATA
C                   LIBRARY NUCDFL. PRINT IF NPRT > 0.
C
C      END

```

```

NAMES  PROC                                     $$$$START
C
C-----
C      NAMES                                CODED BY RAP                06-05-80
C-----
C
C      COMMON /NAMES/  ELT(300), AW(300), NUCS
C
C      CHARACTER*6 AW
C
C      ELT(300)    - TWO CHARACTER ELEMENT NAME FOR EACH RADIONUCLIDE
C                   IN THE MASTER RADIONUCLIDE DATA LIBRARY.
C      AW(300)     - SIX CHARACTER ATOMIC WEIGHT SYMBOL FOR EACH RADI-
C                   ONUCLIDE IN THE MASTER RADIONUCLIDE DATA LIBRARY.
C                   ISOMERIC STATES ARE INDICATED BY THE LETTER M AF-
C                   TER THE ATOMIC WEIGHT. DAUGHTER CONTRIBUTIONS ARE
C                   INDICATED BY "+D" AFTER THE ATOMIC WEIGHT AND "M"
C                   IF PRESENT.
C      NUCS        - NO. OF RADIONUCLIDES IN THE MASTER LIBRARY. (SAME
C                   AS NUC OF COMMON BLOCK DECAY.)
C
C      END

```

```

ORGID  PROC                                     $$$$START
C
C-----
C      ORGID                                CODED BY RAP                06-05-80
C-----
C
C      COMMON /ORGID/  LORG, IORG(10), NORG, KORG(5), MORG(5), ORGT(5),
C      +              ONAME(10)
C
C      CHARACTER*10 ORGT, ONAME
C
C      LORG        - NO. OF ORGANS FOR WHICH DATA IS SUPPLIED IN LIB-
C                   RARY NUCDFL. 1 <= LORG => 10.
C      IORG(10)    - ORGAN INDEX FOR EACH ORGAN DATA IS SUPPLIED FOR
C                   IN LIBRARY NUCDFL. 1 <= IORG(I) => 23.
C      NORG        - NO. OF ORGANS FOR WHICH DOSES ARE TO BE
C                   CALCULATED. 1 <= NORG => 5.
C      KORG(5)     - ORGAN INDEX FOR EACH ORGAN DOSES ARE TO BE CALCU-
C                   LATED FOR. THESE VALUES MUST BE SELECTED FROM VAL-
C                   LUES GIVEN IN THE ARRAY IORG FROM LIBRARY NUCDFL.
C      MORG(5)     - POSITION IN IORG ARRAY FOR EACH SELECTED ORGAN.
C                   THIS PARAMETER IS SET IN ORGCHK.
C      ORGT(5)     - TEN CHARACTER ORGAN NAMES FOR OUTPUT.
C      ONAME(10)   - TEN CHARACTER ORGAN NAMES FOR DATE IN LIBRARY
C                   NUCDFL.
C
C      END

```

FIGURE D.0-1. Common Blocks

```

POPU  PROC                                     $$$START
C
C-----
C      POPU                                CODED BY RAP          06-05-80
C-----
C
C      COMMON /POPU/  POP(10,16)
C
C      POP(10,16)  - POPULATION WITHIN EACH SPATIAL INTERVAL FOR 10
C                  DISTANCES AND 16 DIRECTION SECTORS.
C
C      END

SOURCE PROC                                     $$$START
C
C-----
C      SOURCE                                CODED BY RAP          06-05-80
C-----
C
C      COMMON /SOURCE/  NIN,  ELTI(300),  AWI(300)
C
C      CHARACTER#5 AWI
C
C      NIN          - NO. OF RADIONUCLIDES IN THE INPUT INVENTORY,
C                    1 <= NIN => NUC.
C      ELTI(300)    - CHARACTER NAMES FOR INPUT RADIONUCLIDES. SPELLING
C                    MUST BE IDENTICAL TO MASTER RADIONUCLIDE LIST.
C      AWI(300)     - SIX CHARACTER ATOMIC WEIGHT SYMBOL FOR EACH INPUT
C                    RADIONUCLIDE. SPELLING MUST CORRESPOND TO THE
C                    MASTER LIST SPELLING.
C
C      END

```

FIGURE D.0-1. Common Blocks

RADIONUCLIDE MASTER DATA LIBRARY, 15 MARCH 78, BA NAPIER

H 3	4.51E+3	1 0	0
BE10	5.84E+8	1 0	0
C 14	2.091E+6	1 0	0
N 13	6.92E-3	1 0	0
F 18	7.62E-2	1 0	0
NA22	9.50E+2	1 0	0
NA24	6.25E-1	1 0	0
P 32	1.43E+1	1 0	0
P 33	2.44E+1	1 0	0
AR39	9.83E+4	1 0	0
AR41	7.61E-2	1 0	0
CA41	5.11E+7	1 0	0
SC46	8.38E+1	1 0	0
CR51	2.77E+1	1 0	0
MN54	3.12E+2	1 0	0
MN56	1.07E-1	1 0	0
FE55	9.86E+2	1 0	0
FE59	4.46E+1	1 0	0
CO57	2.71E+2	1 0	0
CO58	7.08E+1	1 0	0
CO60	1.92E+3	1 0	0
NI59	2.74E+7	1 0	0
NI63	3.51E+4	1 0	0
NI65	1.05E-1	1 0	0
CU64	5.29E-1	1 0	0
ZN65	2.44E+2	1 0	0
AS76	1.10E+0	1 0	0
SE79	2.37E+7	1 0	0
BR82	1.47E+0	1 0	0
BR83+D	9.96E-2	1 0	0
BR84	2.21E-2	1 0	0
KR90	3.74E-4	1 0	0
KR91	1.13E-4	1 0	0
RB86	1.87E+1	1 0	0
RB89+D	1.06E-2	1 0	0
SR89+D	5.06E+1	1 0	0
SR90+D	1.04E+4	1 0	0
SR91+D	3.96E-1	1 0	0
SR92+D	1.13E-1	1 0	0
Y 91M+D	3.45E-2	1 0	0
ZR93+D	5.59E+8	1 0	0
ZR95+D	6.40E+1	1 0	0
ZR97+D	7.04E-1	1 0	0
MO93	3.65E+4	1 0	0
MO99+D	2.75E+0	1 0	0
TC101	9.86E-3	1 0	0
RU103+D	3.94E+1	1 0	0
RU105+D	1.85E-1	1 0	0
RU106+D	3.68E+2	1 0	0
PD107	2.37E+9	1 0	0
AG110M+D	2.52E+2	1 0	0
AG111	7.45E+0	1 0	0
CD113M	4.97E+3	1 0	0
SN117M	1.40E+1	1 0	0
SN119M	2.50E+2	1 0	0
SN121M	2.78E+4	1 0	0
SN123	1.29E+2	1 0	0
SN125+D	9.64E+0	1 0	0
SN126+D	3.65E+7	1 0	0
SB124	6.02E+1	1 0	0
SB125+D	1.01E+3	1 0	0
TE123M	1.17E+2	1 0	0
TE127M+D	1.09E+2	1 0	0
TE129M+D	3.36E+1	1 0	0
TE131M+D	1.25E+0	1 0	0
TE131+D	1.74E-2	1 0	0
TE132+D	3.26E+0	1 0	0
TE133M+D	3.85E-2	1 0	0
I 130	5.15E-1	1 0	0
I 131+D	8.04E+0	1 0	0
I 135+D	2.75E-1	1 0	0
CS136	1.31E+1	1 0	0

FIGURE D.0-2. Radionuclide Master Data Library-RMDLIB

CS137+D	1.10E+4	1	0	0
CS139+D	5.53E-3	1	0	0
BA140+D	1.28E+1	1	0	0
CE143+D	1.38E+0	1	0	0
CE144+D	2.84E+2	1	0	0
PM148M+D	4.13E+1	1	0	0
PM149	2.21E+0	1	0	0
SA153	1.95E+0	1	0	0
EU152	4.97E+3	1	0	0
EU153	1.94E+0	1	0	0
EU154	3.14E+3	1	0	0
EU155	1.81E+3	1	0	0
EU156	1.52E+1	1	0	0
GD153	2.42E+2	1	0	0
TB160	7.23E+1	1	0	0
HO166M	4.38E+5	1	0	0
W 181	1.40E+2	1	0	0
W 185	7.51E+1	1	0	0
HG203	4.66E+1	1	0	0
PB210+D	8.14E+3	1	0	0
BI210+D	5.01E+0	1	0	0
RN222+D	3.82E+0	1	0	0
RA223+D	1.14E+1	1	0	0
RA224+D	3.66E+0	1	0	0
RA225+D	1.48E+1	1	0	0
RA226+D	5.84E+5	1	0	0
RA228+D	2.10E+3	1	0	0
AC227+D	7.95E+3	1	0	0
TH227+D	1.87E+1	1	0	0
TH228+D	6.99E+2	1	0	0
TH230+D	2.81E+7	1	0	0
TH232+D	5.13E12	1	0	0
PA231+D	1.19E+7	1	0	0
U 232+D	2.62E+4	1	0	0
U 233+D	5.79E+7	1	0	0
U 234	8.91E+7	1	0	0
U 235+D	2.59E11	1	0	0
U 236	8.55E+9	1	0	0
U 238+D	1.65E12	1	0	0
NP237+D	7.82E+8	1	0	0
PU236	1.04E+3	1	0	0
PU237	4.56E+1	1	0	0
PU241+D	5.26E+3	1	0	0
CM246	1.73E+6	1	0	0
CM247+D	5.70E+9	1	0	0
CM248	1.24E+8	1	0	0
CF252	9.64E+2	1	0	0
ZN69M	5.73E-1	1	0	0
ZN69	3.96E-2	2	1	1.0
BR83	9.96E-2	1	0	0
KR83M	7.62E-2	2	1	1.0
BR85	1.99E-3	1	0	0
KR85M	1.87E-1	2	1	1.0
KR85	3.92E+3	3	2	0.211
KR87	5.30E-2	1	0	0
RB87	1.72E13	2	1	1.0
KR88	1.18E-1	1	0	0
RB88	1.24E-2	2	1	1.0
KR89	2.20E-3	1	0	0
RB89	1.06E-2	2	1	1.0
SR89	5.06E+1	3	2	1.0
Y 89M	1.86E-4	4	3	0.0002
SR90	1.04E+4	1	0	0
Y 90	2.67E+0	2	1	1.0
SR91	3.96E-1	1	0	0
Y 91M	3.45E-2	2	1	0.58
Y 91	5.85E+1	3	2	1.0
SR92	1.13E-1	1	0	0
Y 92	1.48E-1	2	1	1.0
Y 93	4.21E-1	1	0	0
ZR93	5.59E+8	2	1	1.0
NB93M	4.97E+3	3	2	0.25
ZR95	6.40E+1	1	0	0

FIGURE D.0-2. Radionuclide Master Data Library-RMDLIB

NB95M	3.61E+0	2	1	0.007	0
NB95	3.52E+1	3	2	1.0	1 0.993
ZR97	7.04E-1	1	0		0
NB97M	6.94E-4	2	1	0.946	
NB97	5.01E-2	3	2	1.0	1 0.054
MO99	2.75E+0	1	0		0
TC99M	2.51E-1	2	1	0.868	0
TC99	7.78E+7	3	2	1.0	1 0.132
RU103	3.94E+1	1	0		0
RH103M	3.90E-2	2	1	.0025	0
PD103	1.70E+1	3	2	1.0	1 0.9975
RU105	1.85E-1	1	0		0
RH105M	5.21E-4	2	1	0.28	0
RH105	1.47E+0	3	2	1.0	1 0.72
RU106	3.68E+2	1	0		0
RH106	3.46E-4	2	1	1.0	0
PD109M	5.43E-5	1	0		0
PD109	5.61E-1	2	1	1.0	0
AG109M	4.58E-4	3	2	1.0	0
AG110M	2.52E+2	1	0		0
AG110	2.85E-4	2	1	0.0113	0
IN114M	5.00E+1	1	0		0
IN114	8.33E-4	2	1	1.0	0
CD115M	4.46E+0	1	0		0
CD115	2.23E+0	2	0		0
IN115M	1.88E-1	3	2	1.0	0
IN115	2.19E17	4	3	0.963	1 1.0
SN125	9.64E+0	1	0		0
SB125	1.01E+3	2	1	1.0	0
TE125M	5.80E+1	3	2	0.23	0
SN126	3.65E+7	1	0		0
SB126M	1.32E-2	2	1	1.0	0
SB126	3.75E-1	3	2	0.14	0
SB127	3.85E+0	1	0		0
TE127M	1.09E+2	2	1	0.139	0
TE127	3.90E-1	3	2	0.976	1 0.861
TE129M	3.36E+1	1	0		0
TE129	4.83E-2	2	1	1.0	0
I 129	5.73E+9	3	2	1.0	0
TE131M	1.25E+0	1	0		0
TE131	1.74E-2	2	1	0.222	0
I 131	8.04E+0	3	2	1.0	1 0.778
XE131M	1.19E+1	4	3	0.0109	0
TE132	3.26E+0	1	0		0
I 132	9.58E-2	2	1	1.0	0
TE133M	3.85E-2	1	0		0
TE133	8.64E-3	2	1	0.13	0
I 133	8.67E-1	3	2	1.0	1 0.87
XE133M	2.19E+0	4	3	0.029	0
XE133	5.24E+0	5	4	1.0	3 0.971
TE134	2.90E-2	1	0		0
I 134	3.65E-2	2	1	1.0	0
CS134M	1.21E-1	1	0		0
CS134	7.53E+2	2	1	1.0	0
I 135	2.75E-1	1	0		0
XE135M	1.09E-2	2	1	0.166	0
XE135	3.78E-1	3	2	1.0	1 0.834
CS135	8.40E+8	4	3	1.0	0
XE137	2.66E-3	1	0		0
CS137	1.10E+4	2	1	1.0	0
BA137M	1.77E-3	3	2	0.946	0
XE138	9.84E-3	1	0		0
CS138	2.24E-2	2	1	1.0	0
XE139	4.98E-4	1	0		0
CS139	6.53E-3	2	1	1.0	0
BA139	5.74E-2	3	2	1.0	0
XE140	1.85E-4	1	0		0
CS140	7.64E-4	2	1	1.0	0
BA140	1.28E+1	3	2	1.0	0
LA140	1.68E+0	4	3	1.0	0
BA141	1.27E-2	1	0		0
LA141	1.64E-1	2	1	1.0	0
CE141	3.25E+1	3	2	1.0	0

FIGURE D.0-2. Radionuclide Master Data Library-RMDLIB

BA142	7.43E-3	1	0	0
LA142	6.44E-2	2	1 1.0	0
CE143	1.38E+0	1	0	0
PR143	1.36E+1	2	1 1.0	0
CE144	2.84E+2	1	0	0
PR144	1.20E-2	2	1 1.0	0
ND144	8.77E17	3	2 1.0	0
ND147	1.11E+1	1	0	0
PM147	9.58E+2	2	1 1.0	0
PM148M	4.13E+1	1	0	0
PM148	5.37E+0	2	1 1.0	0
PM151	1.18E+0	1	0	0
SM151	3.29E+4	2	1 1.0	0
W 187	9.95E-1	1	0	0
RE187	1.83E13	2	1 1.0	0
TH230	2.81E+7	1	0	0
RA226	5.84E+5	2	1 1.0	0
RN222	3.82E+0	3	2 1.0	0
PB210	8.14E+3	4	3 1.0	0
SI210	5.01E+0	5	4 1.0	0
PO210	1.38E+2	6	5 1.0	0
U 232	2.62E+4	1	0	0
TH232	4.16E13	2	0	0
RA228	2.10E+3	3	2 1.0	0
AC228	2.55E-1	4	3 1.0	0
TH228	6.99E+2	5	4 1.0	1 1.0
RA224	3.66E+0	6	5 1.0	0
PB212	4.43E-1	7	6 1.0	0
SI212	4.20E-2	8	7 1.0	0
U 235	2.59E11	1	0	0
TH231	1.06E+0	2	1 1.0	0
PA231	1.19E+7	3	2 1.0	0
AC227	7.95E+3	4	3 1.0	0
TH227	1.87E+1	5	4 0.9862	0
FR223	1.51E-2	6	4 0.0138	0
RA223	1.14E+1	7	5 1.0	6 1.0
U 237	6.75E+0	1	0	0
NP237	7.82E+8	2	1 1.0	0
PA233	2.70E+1	3	2 1.0	0
U 233	5.79E+7	4	3 1.0	0
TH229	2.68E+6	5	4 1.0	0
RA225	1.48E+1	6	5 1.0	0
AC225	1.00E+1	7	6 1.0	0
U 238	1.65E12	1	0 0.0	0
TH234	2.41E+1	2	1 1.0	0
PA234M	8.13E-4	3	2 1.0	0
PA234	2.81E-1	4	3 0.0013	0
AM242M	5.55E+4	1	0	0
AM242	6.68E-1	2	1 1.0	0
CM242	1.63E+2	3	2 0.827	0
PU242	1.41E+8	4	2 .173	0
NP238	2.18E+0	5	0	0
PU238	3.21E+4	6	5 1.0	3 1.0
CM244	6.61E+3	1	0	0
PU244	3.02E10	2	0	0
U 240	5.88E-1	3	2 0.999	0
PU240	2.39E+6	4	3 1.0	1 1.0
CM247	5.70E+9	1	0	0
CM243	1.04E+4	2	0	0
PU243	2.06E-1	3	1 1.0	0
AM243	2.70E+6	4	3 1.0	2 0.0024
NP239	2.36E+0	5	4 1.0	0
PU239	8.91E+6	6	5 1.0	2 0.9976
CM245	3.10E+6	1	0	0
PU241	5.26E+3	2	1 1.0	0
AM241	1.58E+5	3	2 1.0	0

0

FIGURE D.0-2. Radionuclide Master Data Library-RMDLIB

FILE 10 DATA LIBRARY

100	7	2	2	1	3	4	6	8	16	23
CWMS DATA LIBRARY, AUG 06, 1980 (DLS)										
TOTAL BODY			KIDNEY	LIVER	BONE			LUNGS	THYROID	LLI
1	50	70	30							
H 3			0.00+00	0.00+00	0.00+00	0.00+00	6			
1	2.50-02	2.60-02	2.60-02	1.60-02	1.70-02	1.70-02	1.70-02			
3	2.60-02	2.60-02	2.60-02	1.60-02	1.70-02	1.70-02	1.70-02			
4	2.60-02	2.60-02	2.60-02	1.60-02	1.70-02	1.70-02	1.70-02			
8	2.60-02	2.60-02	2.60-02	1.60-02	1.70-02	1.70-02	1.70-02			
16	2.60-02	2.60-02	2.60-02	1.60-02	1.70-02	1.70-02	1.70-02			
23	2.60-02	2.60-02	2.60-02	1.60-02	1.70-02	1.70-02	1.70-02			
RE10		0.0					6			
1	4.80+00	5.30+00	1.90+00	4.10+00	4.10+00					
3	2.50+01	2.80+01	1.10+01	1.90+01	1.90+01					
4	2.20+01	3.70+01	8.50+00	2.40+01	2.40+01					
6	1.10+02	2.50+02	3.90+01	1.70+02	1.70+02					
8	3.80+01	3.80+01	2.00+01	2.50+01	2.50+01					
23	5.00+00	5.00+00	3.20+00	3.30+00	3.30+00					
C 14		0.00+00	0.00+00	7.55-04	7					
1	1.20-01	1.20-01	7.60-02	7.88-02	7.88-02					
3	1.20-01	1.20-01	7.60-02	7.88-02	7.88-02					
4	1.20-01	1.20-01	7.60-02	7.88-02	7.88-02					
6	5.99-01	5.99-01	3.30-01	3.94-01	3.94-01					
8	1.20-01	1.20-01	7.20-02	7.90-02	7.90-02					
16	1.20-01	1.20-01	7.60-02	7.88-02	7.88-02					
23	3.30-01	3.30-01	2.10-01	2.10-01	2.10-01					
CA41		0.00+00	0.00+00	0.00+00	4					
1	1.81-01	6.36-00	6.00-02	4.21-00	4.41+00					
6	1.63+00	5.90+01	5.40-01	3.90+01	4.10+01					
8	6.58-01	6.62-01	3.50-01	4.40-01	4.40-01					
23	3.50-02	3.50-02	2.20-02	2.30-02	2.30-02					
CR51		6.55-3	7.17-3	7.20-3	5					
1	8.40-2	8.40-2	4.90-2	5.50-2	5.50-2					
3	1.90-2	1.90-2	1.10-2	1.20-2	1.20-2					
8	1.40+0	1.40+0	8.10-1	9.03-1	9.03-1					
16	5.00-2	5.00-2	2.90-2	3.30-2	3.30-2					
23	1.20-1	1.20-1	7.70-2	7.70-2	7.70-2					
MN54		1.99-01	2.08-01	2.09-01	4					
1	1.42+00	1.42+00	8.80-01	9.40-01	9.40-01					
4	8.50+00	8.50+00	5.10+00	5.60+00	5.60+00					
8	1.20+02	1.57+02	4.70+01	1.10+02	1.10+02					
23	2.60+00	2.70+00	1.70+00	1.80+00	1.80+00					
FE55		2.09-06	2.29-06	2.30-06	5					
1	3.20-01	7.30-01	1.10-01	4.80-01	4.80-01					
4	1.50+00	2.90+00	5.50-01	1.90+00	1.90+00					
6	1.50+00	4.50+00	5.30-01	3.00+00	3.00+00					
8	6.20+00	1.10+01	2.30+00	7.70+00	7.70+00					
23	2.10-01	2.20-01	1.30-01	1.50-01	1.50-01					
FE59		2.88-01	2.97-01	3.11-01	5					
1	6.00+00	6.10+00	3.30+00	4.00+00	4.00+00					
4	1.61+01	1.61+01	8.70+00	1.00+01	1.00+01					
6	7.00+00	7.10+00	3.80+00	4.60+00	4.60+00					
8	6.44+01	6.46+01	3.50+01	4.24+01	4.24+01					
23	6.10+00	6.14+00	4.00+00	4.00+00	4.00+00					
CO58		0.00+00	0.00+00	0.00+00	4					
1	9.60-01	9.60-01	6.10-01	6.30-01	6.30-01					
4	7.00-01	7.00-01	4.40-01	4.60-01	4.60-01					
8	6.50+01	6.60+01	3.30+01	4.30+01	4.30+01					
23	2.70+00	2.70+00	1.80+00	1.80+00	1.80+00					
CO60		6.06-01	6.25-01	6.34-01	4					
1	2.70+00	2.70+00	1.71+00	1.80+00	1.80+00					
4	2.00+00	2.00+00	1.30+00	1.30+00	1.30+00					
8	4.91+02	1.00+03	1.80+02	6.81+02	6.81+02					
23	7.70+00	8.30+00	4.90+00	5.50+00	5.50+00					
NI59		0.00+00	0.00+00	0.00+00	5					
1	2.98-01	9.40-01	1.00-01	6.21-01	6.21-01					
4	7.70-01	1.90-00	2.70-01	1.30+00	1.30+00					
6	1.54+00	5.67+00	5.30-01	3.72+00	3.72+00					
8	5.57+00	1.30+01	2.00+00	9.20+00	9.20+00					
23	1.30-01	1.50-01	8.40-02	9.70-02	9.70-02					
NI63		0.00+00	0.00+00	0.00+00	5					
1	8.10-01	2.52+00	2.80-01	1.65+00	1.65+00					
4	2.10+00	5.20+00	7.40-01	3.40+00	3.40+00					

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6	2.10+01	7.60+01	7.20+00	5.00+01	5.00+01
8	1.51+01	3.50+01	5.42+00	2.47+01	2.47+01
23	3.50+01	4.00+01	2.30+01	2.60+01	2.60+01
SE79		0.0	0.0	6.0-4	5
1	1.00-1	1.00-1	6.30-2	6.59-2	6.58-2
3	9.00-1	9.00-1	5.70-1	5.90-1	5.90-1
4	5.90-1	5.90-1	3.50-1	3.90-1	3.90-1
8	7.68+0	7.73+0	4.10+0	5.10+0	5.10+0
23	1.10-1	1.10-1	6.40-2	6.70-2	6.70-2
KR85		4.94-04	5.25-04	4.69-02	0
RR87		0.	0.	5.2E-3	4
1	9.0E-1	9.0E-1	4.9E-1	5.9E-1	5.9E-1
4	2.4E-0	2.4E-0	1.2E-0	1.6E-0	1.6E-0
8	2.7E-1	2.7E-1	1.8E-1	1.8E-1	1.8E-1
23	3.3E-2	3.3E-2	2.2E-2	2.2E-2	2.2E-2
SR90		5.12-09	5.30-09	4.20-02	4
1	5.10+01	6.00+02	1.70+01	3.90+02	3.90+02
6	7.60+02	8.90+03	2.50+02	5.80+03	5.90+03
8	9.40+02	2.10+03	3.30+02	1.50+03	1.50+03
23	1.30+01	1.50+01	8.50+00	9.70+00	9.70+00
Y 90		1.71-05	1.77-05	2.45-01	4
1	3.70-01	3.70-01	2.37-01	2.37-01	2.37-01
6	1.40+01	1.40+01	9.00+00	9.10+00	9.10+00
8	1.00+01	1.00+01	6.60+00	6.70+00	6.68+00
23	1.50+01	1.50+01	1.00+01	1.00+01	1.00+01
Y 91		8.78-04	9.06-04	1.58-01	4
1	5.90+00	5.90+00	3.00+00	3.90+00	3.90+00
6	2.20+02	2.20+02	1.10+02	1.50+02	1.50+02
8	1.10+02	1.10+02	6.00+01	7.50+01	7.52+01
23	1.40+01	1.40+01	9.10+00	9.20+00	9.20+00
ZR93		3.02-12	6.01-12	6.31-12	6
1	7.50-01	1.70-00	2.70-01	1.10+00	1.10+0
3	3.30+00	1.40+01	1.10+00	9.00+00	9.00+0
4	1.90+00	3.50+00	7.14-01	2.30+00	2.30+0
6	1.50+01	6.64+01	5.10+01	4.36+01	4.36+1
8	1.70+01	4.00+01	6.20+00	2.90+01	2.87+1
23	4.70-01	5.10-01	3.00-01	3.40-01	3.40-1
NB93M		2.03-05	4.04-05	4.25-05	6
1	1.10+00	3.30+00	3.70-01	2.29+00	2.20+00
3	4.80+00	1.50+01	1.70+00	9.80+00	9.80+00
4	3.80+00	1.30+01	1.30+00	8.40+00	8.40+00
6	1.10+01	4.10+01	3.70+00	2.70+01	2.70+01
8	2.70+1	5.90+1	9.70+0	4.10+1	4.10+1
23	7.40-01	8.00-01	4.70-01	5.30-01	5.30-01
MO93		3.00-03			5
1	5.10-02	5.10-02	3.30-02	3.30-02	3.30-02
3	5.50-01	5.50-01	3.60-01	3.60-01	3.60-01
4	1.80+00	1.80+00	9.60-01	1.20+00	1.20+00
8	3.50+01	7.90+01	1.20+01	5.70+01	5.70+01
23	2.30-01	2.60-01	1.50-01	1.70-01	1.70-01
ZR95		1.73-01	1.81-01	1.93-01	6
1	1.03+01	1.04+01	5.20+00	6.70+00	6.70+00
3	2.30+01	2.30+01	1.20+01	1.50+01	1.50+01
4	1.40+01	1.40+01	7.40+00	9.40+00	9.40+00
6	4.60+01	4.70+01	2.40+01	3.10+01	3.10+01
8	1.20+2	1.20+2	6.00+1	7.70+1	7.70+1
23	5.50+00	5.50+00	3.60+00	3.60+00	3.60+00
NR95M		1.44-02	1.65-02	1.67-02	0
NR95		1.81-01	1.89-01	1.89-01	6
1	2.90+00	2.90+00	1.70+00	1.90+00	1.90+00
3	5.19+00	5.19+00	3.00+00	3.41+00	3.41+00
4	5.10+00	5.10+00	2.90+00	3.40+00	3.40+00
6	9.80+00	9.80+00	5.60+00	6.40+00	6.40+00
8	3.15+01	3.15+01	1.80+01	2.07+01	2.07+01
23	3.70+00	3.70+00	2.40+00	2.50+00	2.50+00
TC99		0.00+00	0.00+00	6.00-03	6
1	1.90-02	1.90-02	1.20-02	1.20-02	1.20-2
3	8.40-01	8.40-01	5.10-01	5.50-01	5.50-1
4	6.50-02	6.50-02	3.70-02	4.30-02	4.30-2
6	4.60-02	4.60-02	2.70-02	3.00-02	3.00-2
8	6.80+01	1.60+02	2.41+01	1.10+02	1.10+2
23	1.20+00	1.30+00	7.40-01	8.60-01	8.60-1
RH106		2.2E-03	2.42-03	3.30-02	0

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RU106		2.08-02	2.20-02	3.00-01	5
1	1.90+00	1.90+00	1.20+00	1.20+00	1.20+00
3	2.70+01	2.70+01	1.80+01	1.80+01	1.80+01
6	1.50+01	1.50+01	9.10+00	9.60+00	9.60+00
8	7.60+2	1.10+3	3.00+2	7.10+2	7.10+2
23	3.40+01	3.40+01	2.20+01	2.30+01	2.30+01
PD107		0.00+00	0.00+00	0.00+00	5
1	7.94-03	7.94-03	5.10-03	5.20-03	5.20-3
3	8.60-01	8.60-01	5.00-01	5.70-01	5.70-1
4	1.10-01	1.10-01	6.40-02	6.90-02	6.90-2
8	6.40+00	1.50+01	2.30+00	1.10+01	1.10+1
23	1.80-01	1.90-01	1.10-01	1.30-01	1.30-1
AG110		3.94-04	4.10-04	1.46-02	0
AG110M		6.92-01	7.25-01	7.39-01	6
1	1.40+00	1.40+00	9.00-01	9.20-01	9.21-01
3	4.50+00	4.50+00	2.80+00	2.90+00	2.90+00
4	2.20+00	2.20+00	1.40+00	1.50+00	1.50+00
6	2.48+00	2.48+00	1.50+00	1.70+00	1.70+00
8	4.00+2	5.10+2	1.60+2	3.1+2	3.44+2
23	1.10+01	1.10+01	7.30+00	7.50+00	7.50+00
CD113M		2.10-03			5
1	4.70+00	6.50+00	1.90+00	4.20+00	4.20+00
3	1.30+02	2.10+02	4.80+01	1.40+02	1.40+02
4	1.40+02	1.90+02	5.50+01	1.20+02	1.20+02
8	1.30+02	2.90+02	4.70+01	2.00+02	2.00+02
23	4.90+00	5.30+00	3.10+00	3.50+00	3.50+00
SN123		5.22-03	5.30-03	1.07-01	6
1	2.40+00	2.40+00	1.40+00	1.60+00	1.60+00
4	1.60+00	1.60+00	8.40+01	1.00+00	1.00+00
6	7.40+01	7.50+01	3.80+01	4.90+01	4.90+01
8	1.80+02	2.00+02	8.10+01	1.30+02	1.30+02
16	1.40+00	1.40+00	7.60-01	9.30-01	9.30-01
23	1.20+01	1.20+01	7.60+00	7.70+00	7.70+00
SB125		9.92-02	1.00-01	1.14-01	6
1	1.01+01	1.70+01	3.90+00	1.10+01	1.10+01
4	4.80-01	8.00-01	1.80-01	5.30-01	5.30-01
6	2.10+01	5.30+01	7.40+00	3.50+01	3.50+01
8	1.70+2	3.10+2	6.20+1	2.10+2	2.10+2
16	9.70-03	9.70-03	6.30-03	6.40-03	6.40-03
23	3.80+00	4.00+00	2.40+00	2.60+00	2.60+00
TE125M		3.97-03	7.62-03	7.98-03	7
1	2.50-01	2.50-01	1.50-01	1.60-01	1.60-01
3	6.30+00	6.30+00	3.80+00	4.10+00	4.10+00
4	7.80-01	7.80-01	4.70-01	5.10-01	5.10-01
6	1.80+00	1.80+00	1.10+00	1.20+00	1.20+00
8	2.70+01	2.70+01	1.40+01	1.80+01	1.80+01
16	5.50-01	5.50-01	3.50-01	3.60-01	3.60-01
23	1.90+00	1.90+00	1.30+00	1.30+00	1.30+00
SN126		1.7-2	2.1-2	2.4-2	6
1	7.70+0	7.80+0	4.40+0	5.10+0	5.10+0
4	5.01+0	5.10+0	2.40+0	3.40+0	3.40+0
6	1.88+2	2.04+2	8.50+1	1.34+2	1.34+2
8	8.00+2	1.80+3	2.80+2	1.30+3	1.30+3
16	1.50+0	1.59+0	7.63-1	1.04+0	1.04+0
23	4.70+0	5.10+0	3.00+0	3.40+0	3.40+0
SB126M		3.1-2	3.3-2	3.5-2	0
SB126		4.12-01	4.39-01	5.93-01	6
1	5.90-02	5.90-02	3.90-02	3.90-02	3.90-2
4	3.10-03	3.10-03	2.10-03	2.10-03	2.10-3
6	1.40-01	1.40-01	9.20-02	9.20-02	9.20-02
8	1.90+00	1.90+00	1.30+00	1.30+00	1.30+0
16	2.90-03	2.90-03	1.90-03	1.90-03	1.90-3
23	3.00+00	3.00+00	2.00+00	2.00+00	2.00+0
TE127M		1.16-03	2.29-03	2.78-03	7
1	5.60-01	5.60-01	3.50-01	3.70-01	3.70-01
3	1.60+01	1.60+01	9.50+00	1.00+01	1.00+01
4	2.00+00	2.00+00	1.20+00	1.30+00	1.30+00
6	4.50+00	4.50+00	2.70+00	3.00+00	3.00+00
8	9.90+01	1.00+02	4.60+01	6.90+01	6.90+01
16	1.20+00	1.20+00	7.50-01	7.80-01	7.80-01
23	4.20+00	4.20+00	2.70+00	2.70+00	2.70+00
TE127		3.54-04	3.83-04	3.49-02	7
1	1.14-02	1.14-02	7.40-03	7.40-03	7.40-03

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3	1.80-01	1.80-01	1.20-01	1.20-01	1.20-01
4	2.20-02	2.20-02	1.50-02	1.50-02	1.50-02
6	5.10-02	5.10-02	3.41-02	3.41-02	3.42-02
8	5.00-01	5.00-01	3.30-01	3.30-01	3.29-01
16	3.90-02	3.90-02	2.50-02	2.50-02	2.50-02
23	7.30-01	7.30-01	4.80-01	4.80-01	4.80-01
1 129		3.04-03	5.71-03	5.47-03	7
1	1.80+00	1.50+00	8.10-01	1.30+00	1.30+00
3	1.20+00	1.20+00	7.90-01	8.10-01	8.10-01
4	5.60-01	5.60-01	3.60-01	3.70-01	3.70-01
6	6.90-01	6.90-01	4.30-01	4.50-01	4.50-01
8	1.50+01	1.51+01	8.00+00	9.91+00	9.91+00
16	1.40+03	1.50+03	6.40+02	1.00+03	1.00+03
23	8.40-02	8.40-02	5.30-02	5.50-02	5.50-02
CS134		3.69-01	3.89-01	4.13-01	6
1	2.40+01	2.60+01	1.10+01	1.70+01	1.70+01
3	9.70+00	9.80+00	5.40+00	6.40+00	6.40+00
4	2.81+01	2.90+01	1.30+01	1.90+01	1.90+01
6	1.20+01	1.30+01	5.00+00	8.60+00	8.60+00
8	4.50+00	4.90+00	2.30+00	3.20+00	3.20+00
23	1.50-01	1.50-01	9.80-02	9.80-02	9.80-02
CS135		0.00+00	0.00+00	2.18-03	6
1	1.50+00	1.70+00	5.60-01	1.10+00	1.10+0
3	1.40+00	1.40+00	7.60-01	9.10-01	9.10-1
4	3.40+00	3.60+00	1.60+00	2.40+00	2.40+0
6	3.40+00	4.11+00	1.40+00	2.70+00	2.70+0
8	5.60-01	6.30-01	2.80-01	4.10-01	4.10-01
23	2.40-02	2.40-02	1.60-02	1.60-02	1.60-2
CS137		5.62-04	5.99-04	2.81-02	6
1	1.30+01	1.50+01	5.90+00	9.90+00	9.90+00
3	7.50+00	7.50+00	4.10+00	5.00+00	5.00+00
4	2.00+01	2.20+01	9.50+00	1.40+01	1.40+01
6	1.40+01	1.70+01	6.00+00	1.10+01	1.10+01
8	3.50+00	3.90+00	1.80+00	2.60+00	2.60+00
23	1.20-01	1.20-01	8.00-02	8.00-02	8.00-02
BA137M		1.38-01	1.46-01	1.47-01	0
CE144		4.25-03	5.15-03	1.13-02	6
1	6.90+00	9.80+00	2.60+00	6.39+00	6.40+00
3	3.10+01	4.40+01	1.20+01	2.90+01	2.90+01
4	5.70+01	7.20+01	2.20+01	4.70+01	4.70+01
6	1.11+02	1.80+02	4.10+01	1.20+02	1.20+02
8	6.50+02	8.60+02	2.60+02	5.60+02	5.60+02
23	3.10+01	3.20+01	2.00+01	2.10+01	2.10+01
PR144		7.38-03	7.65-03	2.69-01	0
PM147		0.00+00	0.00+00	2.71-03	6
1	4.95-01	1.11+00	1.70-01	7.40-01	7.40-01
3	2.31+00	5.10+00	7.70-01	3.42+00	3.42+00
4	1.22+00	2.60+00	4.00-01	1.70+00	1.70+00
6	9.60+00	3.00+01	3.20+00	2.00+01	2.00+01
8	4.40+01	8.10+01	1.60+01	5.40+01	5.40+01
23	1.70+00	1.80+00	1.10+00	1.20+00	1.20+00
SM147		0.	0.	0.	6
1	1.9E+2	6.4E+2	1.7E+2	4.2E+2	4.2E+2
3	8.8E+2	3.0E+3	8.1E+2	2.0E+3	2.0E+3
4	1.8E+3	2.6E+3	1.4E+3	1.7E+3	1.7E+3
6	3.6E+3	2.6E+4	3.5E+3	1.7E+4	1.7E+4
8	1.7E+4	4.2E+4	1.4E+4	2.7E+4	2.7E+4
23	4.9E-0	5.4E+0	3.3E-0	3.6E-0	3.6E+0
SM151		1.09-05	2.17-05	2.28-05	6
1	3.42-01	1.15+00	1.10-01	7.57-01	7.57-1
3	1.50+00	5.20+00	5.10-01	3.40+00	3.40+0
4	3.20+00	4.50+00	1.20+00	3.00+00	3.00+0
6	4.10+00	2.80+01	1.30+00	1.80+01	1.80+1
8	3.00+01	6.90+01	1.10+01	4.90+01	4.90+1
23	1.00+00	1.10+00	6.40-01	7.40-01	7.40-1
EU152		0.0	0.0	0.0	6
1	5.2+00	1.6+01	1.70+0	1.0+01	1.0+01
3	2.0+01	1.1+02	6.3+00	7.1+01	7.1+01
4	1.40+01	1.70+01	5.50+00	1.10+01	1.10+01
6	1.40+01	7.90+01	4.50+00	5.20+01	5.20+01
8	2.3+02	5.1+02	8.4+01	3.6+02	3.6+02
23	4.90+0	5.3+00	3.1+00	3.5+00	3.5+00
EU154		2.97-01	3.09-01	3.46-01	6

FIGURE D.0-3. Dose Conversion Factor Data Library-NUCDFL

1	7.50+00	2.20+01	2.50+00	1.40+01	1.40+01
3	2.90+01	1.40+02	9.10+00	9.20+01	9.20+01
4	2.40+01	2.90+01	9.50+00	1.90+01	1.90+01
6	5.00+01	2.50+02	1.60+01	1.60+02	1.60+02
8	4.00+02	2.50+02	1.40+02	5.90+02	5.90+02
23	1.10+01	1.10+01	6.70+00	7.50+00	7.50+00
EU155		1.21-02	1.50-02	1.64-02	6
1	1.20+00	3.20+00	4.10-01	2.10+00	2.10+00
3	5.40+00	2.20+01	1.70+00	1.50+01	1.50+01
4	3.90+00	4.60+00	1.60+00	3.00+00	3.00+00
6	8.50+00	3.50+01	2.70+00	2.30+01	2.30+01
8	6.50+01	1.30+02	2.40+01	8.90+01	8.90+01
23	1.80+00	2.00+00	1.20+00	1.30+00	1.30+00
HO166M		3.70-03			6
1	6.80+00	2.60+01	2.20+00	1.70+01	1.70+01
3	1.20+01	4.90+01	3.90+00	3.20+01	3.20+01
4	7.40+00	3.20+01	2.40+00	2.10+01	2.10+01
6	2.20+01	1.10+02	7.10+00	7.20+01	7.20+01
8	2.70+02	6.20+02	9.60+01	4.40+02	4.40+02
23	4.90+00	5.40+00	3.10+00	3.60+00	3.60+00
W 185		0.00+00	0.00+00	0.00+00	5
1	6.90-03	6.90-03	4.40-03	4.50-03	4.50-03
4	6.20-02	6.20-02	3.90-02	4.10-02	4.10-02
6	2.00-01	2.00-01	1.20-01	1.30-01	1.30-01
8	3.30+01	3.40+01	1.70+01	2.20+01	2.20+01
23	2.80+00	2.80+00	1.80+00	1.90+00	1.90+00
PE210		3.20-4	4.59-4	4.70-4	6
1	6.30+1	3.70+2	2.00+1	2.40+2	2.40+2
3	3.30+3	9.00+3	1.10+3	5.90+3	5.90+3
4	3.90+2	2.80+3	1.20+2	1.80+3	1.80+3
6	1.00+3	1.20+4	3.20+2	7.60+3	7.60+3
8	5.40+4	1.20+5	1.90+4	8.50+4	8.50+4
23	1.00+1	1.10+1	6.60+0	7.60+0	7.60+0
BI210		0.0	0.0	6.91-2	6
1	7.00-1	7.00-1	4.50-1	4.60-1	4.60-1
3	9.80+1	9.80+1	6.40+1	6.40+1	6.40+1
4	7.90+0	7.90+0	5.10+0	5.20+0	5.20+0
6	1.20+0	1.20+0	7.90-1	8.00-1	8.00-1
8	1.51+3	1.51+3	9.80+2	9.91+2	9.91+2
23	7.70+0	7.70+0	5.00+0	5.00+0	5.00+0
PO210		0.	0.	0.	6
1	6.4E+1	6.4E+1	3.6E+1	4.2E+1	4.2E+1
3	1.9E+3	1.9E+3	9.7E+2	1.3E+3	1.3E+3
4	5.4E+2	5.4E+2	3.0E+2	3.6E+2	3.6E+2
6	2.7E+2	2.7E+2	1.5E+2	1.8E+2	1.8E+2
8	3.4E+4	3.8E+4	1.5E+4	2.5E+4	2.5E+4
23	1.2E+1	1.2E+1	7.6E+0	7.7E+0	7.7E+0
RA223		1.4E-2	1.5E-2	1.5E-2	6
1	2.2E+2	2.2E+2	1.4E+2	1.5E+2	1.5E+2
3	4.7E+1	4.7E+1	3.0E+1	3.1E+1	3.1E+1
4	1.6E+0	1.6E+0	1.0E+0	1.1E+0	1.1E+0
6	1.1E+3	1.1E+3	7.0E+2	7.4E+2	7.4E+2
8	2.1E+4	2.1E+4	1.3E+4	1.4E+4	1.4E+4
23	5.5E+1	5.5E+1	3.6E+1	3.6E+1	3.6E+1
RA224		2.05-3	2.24-3	2.25-3	4
1	6.70+1	6.70+1	4.30+1	4.40+1	4.40+1
6	3.32+2	3.32+2	2.18+2	2.18+2	2.20+2
8	7.38+3	7.38+3	4.80+3	4.90+3	4.90+3
23	5.40+1	5.40+1	3.50+1	3.50+1	3.50+1
RA225					6
1	3.00+02	3.00+02	1.90+02	2.00+02	2.00+02
3	4.90+01	4.90+01	3.10+01	3.20+01	3.20+01
4	1.70+00	1.70+00	1.10+00	1.10+00	1.10+00
6	1.50+03	1.50+03	9.30+02	9.90+02	9.90+02
8	2.40+04	2.40+04	1.50+04	1.60+04	1.60+04
23	5.30+01	5.30+01	3.50+01	3.50+01	3.50+01
RA226		1.57-3	1.83-3	1.85-3	4
1	2.47+3	6.70+4	7.80+2	4.40+4	4.60+4
6	2.49+3	9.30+4	7.90+2	6.10+4	6.40+4
8	1.40+5	3.20+5	5.00+4	2.30+5	2.30+5
23	6.40+1	7.00+1	4.00+1	4.70+1	4.70+1
RA228		3.00-03			4
1	4.90+03	3.70+04	1.60+03	2.40+04	2.40+04

FIGURE D.0-3. Dose Conversion Factor Data Library-NUCDFL

5	4.10+03	3.40+04	1.30+03	2.20+04	2.20+04
2	1.70+05	3.50+05	6.10+04	2.40+05	2.40+05
23	1.10+01	1.20+01	6.90+00	7.70+00	7.70+00
AC225		0.00+00			6
1	7.70+01	7.70+01	4.90+01	5.10+01	5.10+01
3	1.70+02	1.70+02	1.10+02	1.10+02	1.10+02
4	1.50+03	1.50+03	9.40+02	9.90+02	9.90+02
6	1.20+03	1.20+03	7.30+02	7.60+02	7.60+02
8	1.80+04	1.80+04	1.10+04	1.20+04	1.20+04
23	6.90+01	6.90+01	4.50+01	4.60+01	4.60+01
AC227		1.00-04	1.81-04	1.89-04	6
1	1.91+3	4.49+4	5.92+2	2.90+4	3.01+4
3	1.30+3	3.10+4	4.10+2	2.10+4	2.10+4
4	1.10+4	9.40+4	3.50+3	6.20+4	6.20+4
6	2.90+4	7.10+5	8.90+3	4.70+5	4.80+5
8	4.01+5	9.00+5	1.40+5	6.31+5	6.31+5
23	1.60+1	1.70+1	1.00+1	1.10+1	1.10+1
TH227		1.4E-2	1.6E-2	1.6E-2	6
1	1.1E+2	1.1E+2	6.6E+1	7.2E+1	7.2E+1
3	3.8E+2	3.8E+2	2.3E+2	2.5E+2	2.5E+2
4	6.5E+1	6.5E+1	3.9E+1	4.3E+1	4.3E+1
6	3.8E+3	3.8E+3	2.3E+3	2.5E+3	2.5E+3
8	2.70+4	2.70+4	1.7E+4	1.8E+4	1.8E+4
23	9.4E+1	9.4E+1	6.2E+1	6.2E+1	6.2E+1
TH228		5.11-4	6.00-4	6.04-4	6
1	1.90+3	6.60+3	6.10+2	4.31+3	4.31+3
3	5.10+3	1.80+4	1.70+3	1.20+4	1.20+4
4	8.80+2	3.10+3	2.90+2	2.00+3	2.00+3
6	5.50+4	1.00+5	1.80+4	1.30+5	1.30+5
8	2.60+5	4.40+5	9.80+4	2.90+5	2.90+5
23	1.10+2	1.10+2	6.80+1	7.40+1	7.40+1
TH229		5.19-3	5.98-3	6.03-3	6
1	3.21+3	1.59+5	9.90+2	1.00+5	1.10+5
3	5.40+3	2.30+5	1.70+3	1.50+5	1.60+5
4	9.30+2	4.60+4	2.90+2	3.00+4	3.30+4
6	6.40+4	3.30+6	2.00+4	2.10+5	2.30+5
8	3.40+5	7.90+5	1.20+5	5.70+5	5.70+5
23	9.80+1	1.10+2	6.20+1	7.20+1	7.20+1
TH230		9.83-5	1.25-4	1.27-4	6
1	4.70+2	2.30+4	1.40+2	1.50+4	1.70+4
3	5.30+3	2.20+5	1.60+3	1.50+5	1.60+5
4	9.10+2	4.50+4	2.80+2	2.90+4	3.20+4
6	1.63+4	7.70+5	5.10+3	5.00+5	5.50+5
8	5.10+4	1.40+5	2.20+4	1.01+5	1.01+5
23	1.20+1	1.30+1	7.30+0	8.50+0	8.50+0
TH232		0.	0.	0.	6
1	6.00+2	3.00+4	1.90+2	1.99+4	2.10+4
3	4.50+3	1.90+5	1.40+3	1.20+5	1.30+5
4	7.80+2	3.90+4	2.40+2	2.50+4	2.70+4
6	1.80+4	8.60+5	5.70+3	5.60+5	6.10+5
8	7.20+4	1.70+5	2.60+4	1.20+5	1.20+5
23	9.80+0	1.10+1	6.20+0	7.20+0	7.20+0
PA231		4.2E-3	4.7E-3	4.8E-3	6
1	1.4E+3	6.5E+4	4.20+2	4.2E+4	4.6E+4
3	6.90+3	3.4E+5	2.1E+3	2.2E+5	2.4E+5
4	1.2E+3	5.9E+4	3.7E+2	3.8E+4	4.2E+4
6	3.3E+4	1.5E+5	1.0E+4	1.0E+6	1.1E+6
8	8.9E+4	2.1E+5	3.2E+4	1.5E+5	1.5E+5
23	1.4E+1	1.5E+1	8.7E+0	1.0E+1	1.0E+1
PA233		4.12-02	4.63-02	4.95-02	6
1	2.60-01	2.60-01	1.50-01	1.70-01	1.70-1
3	1.10+00	1.10+00	6.40-01	7.30-01	7.30-1
4	2.90-01	2.90-01	1.70-01	1.90-01	1.90-1
6	1.50+00	1.50+00	8.80-01	1.01+00	1.01+0
8	1.70+01	1.70+01	1.00+01	1.10+01	1.10+1
23	2.90+00	2.90+00	1.90+00	1.90+00	1.90+0
U 232		4.52-05	5.56-05	5.62-02	5
1	1.10+03	1.20+03	4.50+02	8.10+02	8.10+02
3	1.79+03	1.80+03	1.00+03	1.20+03	1.20+03
6	9.20+03	1.70+04	3.20+03	1.10+04	1.10+04
8	2.40+05	5.50+05	8.60+04	3.90+05	3.91+05
23	1.30+01	1.40+01	8.20+00	9.40+00	9.40+00
U 233		0.0	0.0	0.0	5

FIGURE D.0-3. Dose Conversion Factor Data Library-NUCDFL

1	2.00+2	2.20+2	8.10+1	1.50+2	1.50+2
3	8.20+2	8.30+2	4.60+2	5.40+2	5.40+2
6	1.90+3	3.70+3	6.70+2	2.40+3	2.40+3
8	5.40+4	1.50+5	2.30+4	1.00+5	1.00+5
23	1.20+1	1.30+1	7.60+0	8.70+0	8.70+0
U 234		2.00-05	2.61-05	2.65-05	5
1	1.90+02	2.20+02	8.00+01	1.40+02	1.40+02
3	8.10+02	8.10+02	4.50+02	5.30+02	5.30+02
6	1.90+03	3.50+03	6.50+02	2.30+03	2.30+03
8	6.20+04	1.40+05	2.20+04	1.00+05	1.00+05
23	1.20+01	1.30+01	7.40+00	8.60+00	8.60+00
U 235		2.7E-2	3.1E-2	3.1E-2	5
1	1.8E+2	2.0E+2	7.5E+1	1.3E+2	1.3E+2
3	7.6E+2	7.6E+2	4.2E+2	5.0E+2	5.0E+2
6	1.8E+3	3.4E+3	6.2E+2	2.2E+3	2.2E+3
8	5.8E+4	1.4E+5	2.1E+4	9.6E+4	9.6E+4
23	1.5E+1	1.5E+1	9.4E+0	1.1E+1	1.1E+1
U 236		0.00+00	0.00+00	0.00+00	5
1	1.80+02	2.10+02	7.60+01	1.40+02	1.40+02
3	7.80+02	7.90+02	4.40+02	5.20+02	5.20+02
6	1.80+03	3.40+03	6.20+02	2.20+03	2.20+03
8	6.00+04	1.40+05	2.10+04	9.80+04	9.80+04
23	1.10+01	1.20+01	6.90+00	8.00+00	8.00+00
U 237		1.74-02	2.00-02	2.01-02	0
U 238		0.00+00	0.00+00	8.31-03	5
1	1.70+02	1.90+02	7.00+01	1.30+02	1.30+02
3	7.10+02	7.10+02	4.00+02	4.70+02	4.70+02
6	1.70+03	3.20+03	5.90+02	2.10+03	2.10+03
8	5.50+04	1.30+05	2.00+04	9.01+04	9.01+04
23	1.00+01	1.20+01	6.60+00	7.70+00	7.70+00
U 240		7.50-03			0
NP237		3.25-03	4.33-03	4.42-03	6
1	4.80+02	2.30+04	1.50+02	1.50+04	1.60+4
3	3.20+03	1.60+05	1.00+03	1.10+05	1.20+5
4	8.40+03	4.40+05	2.60+03	2.90+05	3.20+5
6	1.10+04	5.10+05	3.40+03	3.30+05	3.60+5
8	6.20+04	1.40+05	2.20+04	1.00+05	1.00+5
23	1.50+01	1.70+01	9.70+00	1.10+01	1.10+1
NP238		0.00+00			0
NP239		2.22-02	2.46-02	2.47-02	6
1	1.60-02	1.60-02	1.00-02	1.00-02	1.00-2
3	8.70-02	8.70-02	5.70-02	5.70-02	5.70-2
4	2.50-01	2.50-01	1.60-01	1.60-01	1.60-1
6	2.90-01	2.90-01	1.90-01	1.90-01	1.90-1
8	1.60+00	1.60+00	1.10+00	1.10+00	1.14+0
23	3.60+00	3.60+00	2.30+00	2.30+00	2.30+0
PU239		3.73-04	2.39-04	7.77-04	6
1	5.50+02	2.30+04	1.70+02	1.50+04	1.60+04
3	2.50+03	9.60+04	7.70+02	6.30+04	6.70+04
4	9.50+03	3.10+05	3.00+03	2.00+05	2.10+05
6	1.20+04	4.80+05	3.80+03	3.10+05	3.30+05
8	7.20+04	1.70+05	2.60+04	1.20+05	1.20+05
23	1.40+01	1.50+01	8.90+00	1.00+01	1.00+01
PU239		3.73-04	3.39-04	7.77-04	6
1	5.20+02	2.60+04	1.60+02	1.70+04	1.90+04
3	2.30+03	1.10+05	7.20+02	6.90+04	7.50+04
4	9.00+03	3.30+05	2.80+03	2.20+05	2.30+05
6	1.20+04	5.50+05	3.60+03	3.60+05	3.90+05
8	6.70+04	1.60+05	2.40+04	1.10+05	1.10+05
23	1.30+01	1.40+01	8.10+00	9.40+00	9.40+00
PU240		3.22-04	6.38-04	6.71-04	6
1	5.20+02	2.60+04	1.60+02	1.70+04	1.80+04
3	2.30+03	1.10+05	7.20+02	6.90+04	7.50+04
4	9.00+03	3.30+05	2.80+03	2.20+05	2.30+05
6	1.20+04	5.50+05	3.60+03	3.60+05	3.90+05
8	5.70+04	1.60+05	2.40+04	1.10+05	1.10+05
23	1.30+01	1.40+01	8.30+00	9.60+00	9.60+00
PU241		0.00+00	0.00+00	0.00+00	6
1	2.10+01	4.30+02	6.70+00	2.80+02	2.90+02
3	1.00+02	1.90+03	3.20+01	1.30+03	1.30+03
4	1.60+02	2.80+03	5.10+01	1.80+03	1.80+03
6	5.00+02	1.20+04	1.90+02	7.60+03	7.60+03
8	1.30+02	2.80+02	4.60+01	2.00+02	2.00+02

FIGURE D.0-3. Dose Conversion Factor Data Library-NUCDFL

23	2.70-01	2.90-01	1.70-01	2.00-01	2.00-01
PU242		4.04-04	8.03-04	8.44-04	6
1	5.00+02	2.50+04	1.50+02	1.60+04	1.80+04
3	2.20+03	1.00+05	5.90+02	6.70+04	7.20+04
4	8.60+03	3.20+05	2.70+03	2.10+05	2.20+05
6	1.10+04	5.10+05	3.40+03	3.30+05	3.60+05
8	6.50+04	1.50+05	2.30+04	1.10+05	1.10+05
23	1.30+01	1.40+01	8.00+00	9.20+00	9.20+00
PU243		4.20-03			6
1	1.80-03	1.80-03	1.20-03	1.20-03	1.20-03
3	8.40-03	8.40-03	5.50-03	5.50-03	5.50-03
4	2.20-02	2.20-02	1.40-02	1.40-02	1.40-02
6	4.50-02	4.50-02	3.00-02	3.0 -02	3.0 -02
8	2.20-01	2.20-01	1.40-01	1.50-01	1.50-01
23	2.20-01	2.20-01	1.50-01	1.50-01	1.50-01
PU244		0.00+00			6
1	5.70+02	2.90+04	1.80+02	1.90+04	2.00+04
3	2.60+03	1.20+05	7.90+02	7.70+04	8.30+04
4	9.90+03	3.70+05	3.10+03	2.40+05	2.50+05
6	1.30+04	6.00+05	3.90+03	3.90+05	4.20+05
8	7.40+04	1.70+05	2.60+04	1.20+05	1.20+05
23	1.90+01	2.10+01	1.20+01	1.40+01	1.40+01
AM241		5.03-03	7.23-03	7.42-03	6
1	5.50+02	2.20+04	1.70+02	1.40+04	1.50+04
3	3.70+03	1.60+05	1.20+03	1.00+05	1.10+05
4	9.60+03	3.50+05	3.00+03	2.30+05	2.40+05
6	1.20+04	5.50+05	3.80+03	3.60+05	3.90+05
8	7.20+04	1.70+05	2.60+04	1.20+05	1.20+05
23	1.40+01	1.60+01	9.00+00	1.00+01	1.00+01
AM242		8.34-04	1.61-03	1.69-03	6
1	5.90+02	2.21+04	1.80+02	1.40+04	1.50+04
3	4.00+03	1.60+05	1.20+03	1.00+05	1.10+05
4	9.60+03	3.30+05	3.00+03	2.10+05	2.20+05
6	1.30+04	5.60+05	4.10+03	3.60+05	3.90+05
8	5.10+04	1.20+05	1.80+04	8.30+04	8.30+04
23	1.80+01	2.00+01	1.10+01	1.30+01	1.30+01
AM242		6.74-04	1.34-03	2.30-02	6
1	1.10+00	1.10+00	7.40-01	7.40-01	7.40-01
3	7.50+00	7.50+00	4.90+00	4.90+00	4.90+00
4	1.90+01	1.90+01	1.20+01	1.20+01	1.20+01
6	2.60+01	2.60+01	1.70+01	1.70+01	1.70+01
8	2.40+02	2.40+02	1.60+02	1.60+02	1.60+02
23	1.60+00	1.60+00	1.00+00	1.00+00	1.00+00
AM243		3.24-04	4.55-04	4.69-04	6
1	5.20+02	2.20+04	1.60+02	1.40+04	1.50+04
3	3.60+03	1.60+05	1.10+03	1.00+05	1.10+05
4	9.10+03	3.40+05	2.80+03	2.20+05	2.40+05
6	1.20+04	5.50+05	3.60+03	3.60+05	3.90+05
8	6.90+04	1.60+05	2.40+04	1.10+05	1.10+05
23	1.70+01	1.80+01	1.10+01	1.20+01	1.20+01
CM242		1.15-05	1.34-05	1.35-05	6
1	3.70+02	4.90+02	1.50+02	3.20+02	3.20+02
3	1.70+03	2.20+03	6.40+02	1.40+03	1.40+03
4	6.40+03	8.30+03	2.50+03	5.50+03	5.50+03
6	8.40+03	1.10+04	3.30+03	7.30+03	7.30+03
8	4.40+04	5.00+04	1.90+04	3.30+04	3.30+04
23	1.50+01	1.50+01	9.50+00	9.70+00	9.70+00
CM243		1.70-02			6
1	5.80+02	1.50+04	1.80+02	1.00+04	1.00+04
3	2.60+03	6.90+04	8.10+02	4.50+04	4.70+04
4	1.00+04	2.40+05	3.10+03	1.60+05	1.60+05
6	1.30+04	3.70+05	4.00+03	2.40+05	2.50+05
8	7.50+04	1.70+05	2.70+04	1.20+05	1.20+05
23	1.50+01	1.60+01	9.50+00	1.10+01	1.10+01
CM244		3.08-04	6.09-04	6.40-04	6
1	5.50+02	1.20+04	1.70+02	7.60+03	7.80+03
3	2.50+03	5.30+04	7.70+02	3.50+04	3.50+04
4	8.60+03	1.60+05	2.70+03	1.10+05	1.10+05
6	1.20+04	2.80+05	3.90+03	1.80+05	1.90+05
8	7.50+04	1.70+05	2.70+04	1.20+05	1.20+05
23	1.50+01	1.60+01	9.20+00	1.10+01	1.10+01
CM245		6.61-03	7.62-03	7.68-03	6
1	5.40+02	2.30+04	1.70+02	1.50+04	1.60+04

FIGURE D.0-3. Dose Conversion Factor Data Library-NUCDFL

3	2.50+03	1.10+05	7.60+02	6.90+04	7.40+04
4	9.50+03	3.60+05	2.90+03	2.30+05	2.50+05
6	1.20+04	5.70+05	3.80+03	3.70+05	4.10+05
8	7.00+04	1.60+05	2.50+04	1.20+05	1.20+05
23	1.40+01	1.50+01	8.60+00	9.90+00	9.90+00
CM246		0.00+00			6
1	5.40+02	2.30+04	1.70+02	1.50+04	1.60+04
3	2.50+03	1.10+05	7.60+02	6.90+04	7.40+04
4	9.50+03	3.60+05	2.90+03	2.30+05	2.50+05
6	8.10+03	3.80+05	2.50+03	2.50+05	2.70+05
8	7.10+04	1.60+05	2.50+04	1.20+05	1.20+05
23	1.30+01	1.50+01	8.70+00	9.70+00	9.70+00
CM247		0.00+00			6
1	5.30+02	2.30+04	1.60+02	1.50+04	1.60+04
3	2.40+03	1.00+05	7.40+02	6.80+04	7.30+04
4	9.30+03	3.50+05	2.90+03	2.30+05	2.40+05
6	1.20+04	5.50+05	3.60+03	3.60+05	3.90+05
8	7.00+04	1.60+05	2.50+04	1.20+05	1.20+05
23	1.70+01	1.90+01	1.10+01	1.30+01	1.30+01
CM248		0.00+00			6
1	4.40+03	1.90+05	1.40+03	1.20+05	1.30+05
3	2.00+04	8.60+05	6.10+03	5.60+05	6.00+05
4	7.70+04	2.90+06	2.40+04	1.90+06	2.00+06
6	9.80+04	4.60+06	3.00+04	3.00+06	3.30+06
8	5.80+05	1.30+06	2.10+05	9.50+05	9.50+05
23	2.80+02	3.10+02	1.80+02	2.10+02	2.10+02

FIGURE D.0-3. Dose Conversion Factor Data Library-NUCDFL

4	9.36+03	1.82+05	9.41+03	1.20+05	1.21+05
6	8.57+03	1.93+05	8.64+03	1.27+05	1.29+05
8	7.49+04	1.78+05	6.47+04	1.17+05	1.17+05
20	4.35-01	4.80-01	2.93-01	3.15-01	3.15-01
21	3.96-01	4.36-01	2.66-01	2.87-01	2.87-01
22	6.45+00	7.11+00	4.34+00	4.67+00	4.67-00
23	1.28+01	1.41+01	8.63+00	9.30+00	9.30+00
CM245		6.61-03	7.62-03	7.68-03	9
1	5.40+02	2.30+04	5.50+02	1.60+04	1.65+04
3	2.53+03	1.09+05	2.58+03	7.24+04	7.68+04
4	8.91+03	3.36+05	9.06+03	2.22+05	2.32+05
6	8.16+03	3.83+05	8.31+03	2.53+05	2.71+05
8	6.98+04	1.75+05	6.09+04	1.15+05	1.15+05
20	4.21-01	4.69-01	2.83-01	3.08-01	3.08-01
21	4.10-01	4.56-01	2.76-01	3.00-01	3.00-01
22	6.13+00	6.83+00	4.13+00	4.49+00	4.49-00
23	1.20+01	1.40+01	8.20+00	8.90+00	8.92-00
CM246					
CM247					
CM248					

FIGURE D.0-3. Dose Conversion Factor Data Library-NUCDFL

APPENDIX E

INPUT INSTRUCTIONS FOR HADOC

APPENDIX E

INPUT INSTRUCTIONS FOR HADOC

This section describes preparation of input card images for HADOC. There are five main sets used to supply the necessary input information:

- 1) title or run,
- 2) NAMELIST parameters,
- 3) radionuclide release inventory,
- 4) population data and
- 5) terrain elevation data.

The control logic for input of these data sets is indicated in Figure E.0-1. Parameters and data supplied in each set are described in the following sections.

E.1 TITLE OF RUN

The first card of each case contains 80 characters of alphanumeric data used as a descriptive title for all output reports. The format is 20A4 and the characters are read into the array TITLE1.

E.2 NAMELIST PARAMETERS

The NAMELIST set titled INPUT is used to supply control parameters, dispersion parameters, and organ selection parameters as follows:

<u>Parameter</u>	<u>Description</u>
Control Parameters:	
FRAC	Fractional contribution cutoff value. Any radionuclide contributing more than FRAC to the dose to an organ will be included in the fractional dose contribution tables.
IFRAC	Control for printing fractional dose reports. Reports are printed if IFRAC > 0.
IQP	Control for printing of calculated dispersion parameters. Parameters are printed if IQP > 0.

FIGURE E.0-1 HADOC Input Logic

<u>Parameter</u>	<u>Description</u>								
ITERN	Control for reading terrain data and calculating terrain effects. ITERN causes data to be read only if KKRPT $\neq$ 1 (i.e., only if population doses are requested). ITERN $\leq$ 0; no terrain effects ITERN $>$ 0; terrain effects considered ITERN $\geq$ 2; read terrain data for the population dose calculation.								
IWAKE	Control for building wake effect considerations. If IWAKE $>$ 0 then building wake effects are to be considered and the parameter AREA should be specified.								
KKPOP	Control of input of population data. Data may be read if KKPOP $>$ 0 (and if KKRPT $\neq$ 1).								
KKRPT	Controls selection of output reports; input of population and terrain data; and calculation of doses.								
	<table> <tr> <th><u>Value</u></th><th><u>Use</u></th></tr> <tr> <td>0</td><td>Read, calculate and print results for both the maximum individual and population doses.</td></tr> <tr> <td>1</td><td>Only calculate and print maximum individual doses. Population and terrain data are not read.</td></tr> <tr> <td>2</td><td>Only calculate and print population doses. Population and terrain data may be read.</td></tr> </table> <p>(See ITERN and KKPOP for input of data.)</p>	<u>Value</u>	<u>Use</u>	0	Read, calculate and print results for both the maximum individual and population doses.	1	Only calculate and print maximum individual doses. Population and terrain data are not read.	2	Only calculate and print population doses. Population and terrain data may be read.
<u>Value</u>	<u>Use</u>								
0	Read, calculate and print results for both the maximum individual and population doses.								
1	Only calculate and print maximum individual doses. Population and terrain data are not read.								
2	Only calculate and print population doses. Population and terrain data may be read.								
KKSMI	Control for selection of Hanford dispersion models for the maximum individual dispersion calculation: KKSMI $\leq$ 0 for Hanford moderately stable, KKSMI $>$ 0 for Hanford very stable.								
KKSP	Control for selection of Hanford dispersion models for the population dispersion calculation:								

<u>Parameter</u>	<u>Description</u>
	<p>KKSP $\leq$ 0 for Hanford moderately stable, KKSP $>$ 0 for Hanford very stable.</p>
LIMTST	<p>Controls calculation of maximum atmospheric dispersion conditions. LIMTST $\leq$ 0 causes use of specified Hanford model. LIMTST $>$ 0 causes use of maximum conditions by testing Pasquill A-D stabilities.</p>
NEXT	<p>Controls selection of input sets.</p> <p>NEXT = 1 allows input of all data sets (subject to other controls) and input of data libraries.</p> <p>NEXT = 2 allows input of all data sets (subject to other controls) but libraries are not read when NEXT $>$ 1.</p> <p>NEXT = 3 allows input of population and terrain sets.</p> <p>NEXT = 4 indicates run is to be terminated.</p>
NPRT	<p>Controls printing of library NUCDFL data; print if NPRT $>$ 0.</p> <p>Dispersion Parameters:</p>
AREA	<p>Minimum building cross-sectional area for the building wake effects model, m². AREA is only used if IWAKE $>$ 0.</p>
DMI	<p>Distance from the release point to the location of the maximum individual, m.</p>
DP(array)	<p>Distances from the release point to the center of each spatial interval for which population data is defined, m. NPD values are used. Up to 10 values may be specified.</p>
HMI	<p>Elevation of the maximum individual above the base of the release stack, m. HMI is used only if ITERN $>$ 0.</p>
HSTACK	<p>Height of the release point above ground level, m.</p>
NPD	<p>Number of distance locations to be used for the population dose calculations.</p>

Parameter	Description																																			
STUB	Dispersion parameter σ_u for calculation of σ_y for the maximum individual calculation. Recommended values are:																																			
	<table><tr><th>Release Time</th><th colspan="4">Windspeed, m/sec.</th></tr><tr><th></th><th>1</th><th>2.5</th><th>5</th><th>10</th></tr><tr><td>10 min.</td><td>0.024</td><td>0.10</td><td>0.20</td><td>0.30</td></tr><tr><td>1 hr.</td><td>0.04</td><td>0.15</td><td>0.25</td><td>0.35</td></tr><tr><td>2 hrs.</td><td>0.08</td><td>0.25</td><td>0.35</td><td>0.45</td></tr><tr><td>4 hrs.</td><td>0.10</td><td>0.40</td><td>0.50</td><td>0.60</td></tr><tr><td>8 hrs.</td><td>0.18</td><td>0.60</td><td>0.70</td><td>0.90</td></tr></table>	Release Time	Windspeed, m/sec.					1	2.5	5	10	10 min.	0.024	0.10	0.20	0.30	1 hr.	0.04	0.15	0.25	0.35	2 hrs.	0.08	0.25	0.35	0.45	4 hrs.	0.10	0.40	0.50	0.60	8 hrs.	0.18	0.60	0.70	0.90
Release Time	Windspeed, m/sec.																																			
	1	2.5	5	10																																
10 min.	0.024	0.10	0.20	0.30																																
1 hr.	0.04	0.15	0.25	0.35																																
2 hrs.	0.08	0.25	0.35	0.45																																
4 hrs.	0.10	0.40	0.50	0.60																																
8 hrs.	0.18	0.60	0.70	0.90																																
UMI	Average wind speed to use in the maximum individual dispersion calculation, m/sec.																																			
UP	Average wind speed to use in the population dispersion calculation, m/sec.																																			

Organ Selection:

NORG	Number of organs for which doses are requested. $1 \leq \text{NORG} \leq 5$.
KORG(array)	Organ index values for selected organs (maximum of 5). These values must correspond to organ index values supplied in the library NUCDFL parameter array IORG. (See Table C.2-1).

A NAMELIST set is read for each case.

E.3 RADIONUCLIDE RELEASE INVENTORY

This card set is read when $\text{NEXT} \leq 2$. The first card gives the number of radionuclides in the release inventory and a modifying factor FINV (format I3, E10). The modifying factor is to be multiplied by each activity to give the actual release activity value used in the calculations. FINV is set to 1.0 if the given value is not greater than zero. The release inventory is supplied with one radionuclide per card. The cards contain the radionuclide name as represented in the master library RMDLIB and the total activity, curies, released during the accident. The format is A2, A6, 4X, E8.2.

E.4 POPULATION DATA

This set is read when KKRPT#1 and KKPOP > 0. The population distribution near the release site is provided in this data set. One card is provided for each of sixteen compass directions with NPD values per card. Each value gives the number of people in the spatial interval. Data for the north sector is given first, then NNE, etc. The format is 10F8.0.

E.5 TERRAIN ELEVATION DATA

This card set is read when KKRPT#1 and ITERN $\geq$ 2. Each data card contains information for one of sixteen compass directions. NPD values are given on each card; one for each distance. The values represent the maximum terrain elevation (above the base of the stack) at any point between the release point and the given distance. The values for a given sector are monatomic increasing (or constant). The format is 10F8.0.

E.6 DEFAULT VALUES

Several NAMELIST parameters have default values to be used if a value is not supplied on input cards. The default values are given in Table E.6-1.

TABLE E.6-1 NAMELIST Parameter Default Values

<u>Parameter</u>	<u>Default Value</u>
Control Parameters:	
FRAC	0.0001
IFRAC	0
IQP	1
ITERN	0
IWAKE	0
KKPOP	1
KKRPT	0
KKSMI	0
KKSP	0
LIMTST	0
NEXT	1
NPRT	0

TABLE E.6-1 (contd)

<u>Parameter</u>	<u>Default Value</u>
Dispersion Parameters:	
AREA	0
HMI	0
HSTACK	0
UMI	1.0
UP	1.0
NPD	9
DP	2414, 4022, 5632, 7240, 12070, 24140, 40220, 56320, 72400
STUB	0.024
Organ Selection:	
NORG	4
KORG	1, 6, 8, 16

APPENDIX F
SAMPLE PROBLEM

APPENDIX F

SAMPLE PROBLEM

The sample problem presented here is designed to test the features of the code: the calculated results do not represent any real or hypothetical accidental release for the Hanford site. The sample problem is composed of three cases to be executed in one run. The first case tests all major options except the building wake model (IWAKE) and selection of maximum atmospheric stability conditions (LIMTST). Parameters for the first case are given in Table F.0-1. The radionuclide release inventory is presented in Table F.0-2. Population data and terrain data are also supplied as indicated in the sample problem input listing of Figure F.0-1.

The second case is the same as case 1 except that the maximum dispersion calculation is selected (LIMTST=1) and the fractional contribution reports are not printed (IFRAC=0). The parameter NEXT is set to 3 to skip input of release inventory since the case 1 inventory is to be retained. Also KKPOP is set to zero and ITERN to 1 to skip reading of population and terrain data respectively.

Case 3 is the same as case 1 except the release height is now ground level (HSTACK=0.0), fractional contribution reports are not printed (as for case 2) and building wake effects are selected (IWAKE=1). The building cross-section area (AREA) is set to 1000 m².

The last two cards of the input listing with NEXT=4 cause normal termination of the run. The output listing for the sample problem is given in Figure F.0-2.

TABLE F.0-1 Sample Problem Case 1 Input Parameters

<u>Parameter</u>	<u>Value</u>	<u>Description</u>
NEXT	1	Read all data needed
FRAC	0.001	Contribution cut off 0.1 percent
IFRAC	1	Print contribution reports
IQP	1	Print dispersion parameters
DMI	1000.	Maximum individual at 1000 m
DP(1)	100, 200, 300, 500, 800, 24140, 40220, 56320, 72400	Population distances
HMI	20	Elevation of maximum individual
HSTACK	60	Height of release
NPD	9	Number of population distances
ITERN	2	Read terrain data
STUB	0.024	Hanford dispersion parameter

Default Values: (Not given on NAMELIST cards)

IWAKE	0	Do not consider building wake
KKPOP	1	Read population distribution data
KKSMI	0	Hanford moderately stable
KKSP	0	Hanford moderately stable
LIMITST	0	No dispersion limit testing
NPRT	0	Do not print NUCDFL data
AREA	0.0	Area of building (not needed)
UMI	1.0	Wind speed for maximum individual
UP	1.0	Wind speed for populations
NORG	4	From organs
KORG(1)	1, 6, 8, 16	Selects total body, bone, lungs and thyroid

TABLE F.0-2 Sample Problem Radionuclide Inventory

<u>Radionuclide</u>	<u>Released Activity, Curies</u>
H3	1.0×10^3
MN56	1.0×10^0
BR83	1.0×10^0
RU103	1.0×10^0
I131	2.0×10^1
CS137	1.0×10^2
BA127M	9.6×10^1
PU239	1.0×10^0


```

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMTST.
$INPUT NEXT=1,IFRAC=.001,IFRAC=1,IQP=1,DMI=1000.,DP(1)=100.,200.,300.,
500.,800.,24140.,40220.,56320.,72400.,HMI=20.,HSTACK=60.,NPD=9,ITERN=2,
STUB=0.024 $END
8      1.0
H 3      1000.
I 131      20.
CS137      100.
BA137M      96.
PU239      1.
MN56      1.0
BR83      1.0
RU103      1.0
.0      .0      .0      .0      .0      20.      1039.      461.      2696.
.0      .0      .0      .0      .0      5.      733.      974.      15962.
.0      .0      .0      .0      .0      273.      5890.      2366.      628.
.0      .0      .0      .0      .0      257.      914.      2368.      903.
.0      .0      .0      .0      .0      128.      384.      558.      855.
.0      .0      .0      .0      .0      288.      1642.      140.      348.
.0      .0      .0      .0      .0      3.      34522.      46456.      948.
.0      .0      .0      .0      .0      1911.      1180.      309.      1935.
.0      .0      .0      .0      .0      1029.      1644.      51.      555.
.0      .0      .0      .0      .0      512.      9996.      788.      144.
.0      .0      .0      .0      .0      545.      17054.      1047.      447.
.0      .0      .0      .0      .0      961.      2914.      14588.      5072.
.0      .0      .0      .0      .0      388.      498.      3750.      78520.
.0      .0      .0      .0      .0      239.      752.      1015.      560.
.0      .0      .0      .0      .0      225.      228.      394.      1058.
.0      .0      .0      .0      .0      26.      440.      228.      4000.
0.      0.      0.      0.      0.      0.      0.      0.      0.
5.      5.      5.      5.      5.      5.      5.      5.      5.
10.      10.      10.      10.      10.      10.      10.      10.      10.
20.      20.      20.      20.      20.      20.      20.      20.      20.
40.      40.      40.      40.      40.      40.      40.      40.      40.
50.      50.      50.      50.      50.      50.      50.      50.      50.
0.      0.      0.      0.      5.      60.      60.      60.      60.
100.      100.      100.      100.      100.      100.      100.      100.      100.      100.
0.      0.      0.      0.      0.      5.      5.      5.      5.
0.      0.      0.      0.      0.      10.      10.      10.      10.      10.
0.      0.      0.      0.      0.      60.      60.      60.      60.      60.
0.      0.      0.      0.      0.      5.      10.      20.      40.
0.      0.      0.      0.      5.      10.      20.      40.      50.
0.      0.      0.      5.      10.      20.      40.      50.      60.
0.      0.      5.      10.      20.      40.      50.      60.      100.
0.      5.      10.      20.      40.      50.      60.      100.      100.
HADOC SAMPLE PROBLEM, CASE 2. SAME AS CASE 1 EXCEPT LIMTST ON AND IFRAC OFF.
$INPUT NEXT=3,LIMTST=1,KKPOP=0,ITERN=1,IFRAC=0 $END
HADOC SAMPLE PROBLEM, CASE 3. SAME AS CASE 1 EXCEPT IFRAC OFF, IWAKE ON AND H=0
$INPUT NEXT=3,LIMTST=0,HSTACK=0.,AREA=1000.,IWAKE=1 $END
END OF RUN
$INPUT NEXT = 4 $END

```

FIGURE F.0-1. HADOC Sample Problem Input

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMTST.

011681

EXECUTING NEPA#HADOC(1).ABS CREATED ON JANUARY 16, 1981 AT 09:31:48

DATA LIBRARY TITLES:

MASTER RADIONUCLIDE DATA LIBRARY

RADIONUCLIDE MASTER DATA LIBRARY, 15 JANUARY 81, BA NAPIER

DOSE FACTOR LIBRARY

CWMS DATA LIBRARY, AUG 06, 1980 (DLS)

SUMMARY OF INPUT DATA:

MAXIMUM INDIVIDUAL POPULATION
MOD. STABLE MOD. STABLE
***DISPERSION MODEL MOD. STABLE 1.0 1.0
***WIND SPEED (M/SEC) 1.0
***STACK HEIGHT IS 50. METERS
***ORGANS SELECTED ARE: TOTAL BODY BONE LUNGS THYROID
***MAXIMUM ATMOSPHERIC DISPERSION CONDITIONS WILL NOT BE DETERMINED
***FRACTIONAL DOSE REPORTS ARE REQUESTED
MINIMUM FRACTION REPORTED IS 1.0-003
***ALL DOSE REPORTS ARE REQUESTED

***DISPERSION PARAMETER SIGMA THETA U BAR = .0240

***DISTANCE TO MAXIMUM INDIVIDUAL 1000. METERS

***POPULATION DISTANCES: 9, METERS

100. 200. 300. 500. 800. 24140. 40220. 56320. 72400.
***POPULATION DISTRIBUTION DATA

SECTOR	1	2	3	4	5	6	7	8	9
1	0.	0.	0.	0.	0.	20.	1039.	461.	2696.
2	0.	0.	0.	0.	0.	5.	733.	974.	15962.
3	0.	0.	0.	0.	0.	273.	5890.	2366.	628.
4	0.	0.	0.	0.	0.	257.	914.	2368.	903.
5	0.	0.	0.	0.	0.	128.	384.	558.	855.
6	0.	0.	0.	0.	0.	288.	1642.	140.	348.
7	0.	0.	0.	0.	0.	3.	34522.	46455.	948.
8	0.	0.	0.	0.	0.	1911.	1180.	309.	1935.
9	0.	0.	0.	0.	0.	1029.	1644.	51.	555.
10	0.	0.	0.	0.	0.	512.	9996.	788.	144.
11	0.	0.	0.	0.	0.	545.	17054.	1047.	447.
12	0.	0.	0.	0.	0.	961.	2914.	14588.	5072.
13	0.	0.	0.	0.	0.	388.	498.	3750.	78520.
14	0.	0.	0.	0.	0.	239.	752.	1015.	560.
15	0.	0.	0.	0.	0.	225.	228.	394.	1058.
16	0.	0.	0.	0.	0.	26.	440.	228.	4000.

***BUILDING WAKE EFFECTS ARE NOT CONSIDERED

***TERRAIN EFFECTS ARE CONSIDERED

ELEVATION OF MAXIMUM INDIVIDUAL IS 20. METERS

FIGURE F.0-2. HADOC Sample Problem Output

```

**TERRAIN DATA**
DISTANCE INTERVAL
SECTOR 1 2 3 4 5 6 7 8 9
1 0. 0. 0. 0. 0. 0. 0. 0. 0.
2 5. 5. 5. 5. 5. 5. 5. 5. 5.
3 10. 10. 10. 10. 10. 10. 10. 10. 10.
4 20. 20. 20. 20. 20. 20. 20. 20. 20.
5 40. 40. 40. 40. 40. 40. 40. 40. 40.
6 50. 50. 50. 50. 50. 50. 50. 50. 50.
7 0. 0. 0. 0. 5. 60. 60. 60. 60.
8 100. 100. 100. 100. 100. 100. 100. 100. 100.
9 0. 0. 0. 0. 0. 5. 5. 5. 5.
10 0. 0. 0. 0. 0. 10. 10. 10. 10.
11 0. 0. 0. 0. 0. 60. 60. 60. 60.
12 0. 0. 0. 0. 0. 5. 10. 20. 40.
13 0. 0. 0. 0. 5. 10. 20. 40. 50.
14 0. 0. 0. 5. 10. 20. 40. 50. 60.
15 0. 0. 5. 10. 20. 40. 50. 60. 100.
16 0. 5. 10. 20. 40. 50. 60. 100. 100.

**RADIONUCLIDE INPUT INVENTORY
NUCLIDE RELEASE
ELT. WT. (CI)
H 3 1.00E+03
BA 137M 9.60E+01
BR 83 1.00E+00

NUCLIDE RELEASE
ELT. WT. (CI)
I 131 2.00E+01
PU 239 1.00E+00
RU 103 1.00E+00

NUCLIDE RELEASE
ELT. WT. (CI)
CS 137 1.00E+02
MN 56 1.00E+00

**THE ABOVE ACTIVITIES ARE MULTIPLIED BY 1.00+000 TO GET THE RELEASE ACTIVITY

*** INPUT PREPARED BY: DATE
*****

*** INPUT CHECKED BY: DATE
*****

```

FIGURE F.0-2. HADOC Sample Problem Output

TIME INTEGRATED AIR CONCENTRATION
 FOR THE MAXIMUM INDIVIDUAL LOCATION (EOMI) = 9.96-005 SEC/M³
 INDEX OF THE MAXIMUM POPULATION DOSE SECTOR (MS) = 7
 TIME INTEGRATED AIR CONCENTRATION
 TIMES POPULATION (PM) = 2.75-002 MAN-SEC/M³
 TIME INTEGRATED AIR CONCENTRATION
 AT EACH POPULATION DISTANCE IN THE DIRECTION OF THE MAXIMUM EXPOSURE SECTOR = EQP(IX) SEC/M³

DISTANCE -----	EQP ---	MAXIMUM STABILITY -----
1	7.50-010	HANFORD
2	1.27-008	HANFORD
3	4.97-008	HANFORD
4	2.61-007	HANFORD
5	2.03-006	HANFORD
6	9.37-007	HANFORD
7	4.37-007	HANFORD
8	2.64-007	HANFORD
9	1.81-007	HANFORD

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMITS.
 011681

PATHWAY/ORGAN	MAXIMUM INDIVIDUAL DOSE COMMITMENTS (REM)	
	DOSE COMMITMENT PERIOD	
	1 YEAR	50 YEARS
AIR SUBMERSION		
TOTAL BODY	1.3E-03	1.3E-03
INHALATION		
TOTAL BODY	1.8E-01	2.7E+00
BONE	1.3E+00	5.5E+01
LUNGS	6.7E+00	1.6E+01
THYROID	2.6E-03	2.6E-03
TOTAL DOSES		
TOTAL BODY	1.9E-01	2.7E+00
BONE	1.3E+00	5.5E+01
LUNGS	6.7E+00	1.6E+01
THYROID	3.9E-03	3.9E-03

FIGURE F.0-2. HADOC Sample Problem Output

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMITST.
011681

POPULATION DOSE COMMITMENTS (MAN-REM)
DOSE COMMITMENT PERIOD
PATHWAY/ORGAN 1 YEAR 50 YEARS

AIR SUBMERSION

PATHWAY/ORGAN	1 YEAR	50 YEARS
TOTAL BODY	3.6E-01	3.6E-01

INHALATION

TOTAL BODY	5.1E+01	7.6E+02
BONE	3.7E+02	1.5E+04
LUNGS	1.9E+03	4.4E+03
THYROID	7.2E-01	7.2E-01

TOTAL DOSES

TOTAL BODY	5.1E+01	7.6E+02
BONE	3.7E+02	1.5E+04
LUNGS	1.9E+03	4.4E+03
THYROID	1.1E+00	1.1E+00

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMITST.
011681

FRACTIONAL DOSE BY RADIONUCLIDE FOR MAXIMUM INDIVIDUAL

NUCLIDE	1 YEAR DOSE COMMITMENT		BONE	LUNGS	THYROID
	EXTERNAL	INHALATION			
H 3	.00	1.41-002	.00	3.86-004	1.00+000
CS137	4.29-003	7.04-001	1.04-001	5.19-003	.00
BA137M	9.96-001	.00	.00	.00	.00
PU239	2.84-005	2.82-001	8.96-001	9.94-001	.00

FIGURE F.0-2. HADOC Sample Problem Output

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMTST.
011681
FRACTIONAL DOSE BY RADIONUCLIDE FOR MAXIMUM INDIVIDUAL
FOR 50 YEAR DOSE COMMITMENT

NUCLIDE	EXTERNAL TOTAL BODY	INHALATION TOTAL BODY	BONE	LUNGS	THYROID
H 3	.00	9.45-004	.00	1.62-004	1.00+000
CS137	4.29-003	5.45-002	3.08-003	2.43-003	.00
BA137M	9.96-001	.00	.00	.00	.00
PU239	2.84-005	9.45-001	9.97-001	9.97-001	.00

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMTST.
011681
FRACTIONAL DOSE BY RADIONUCLIDE FOR MAXIMUM INDIVIDUAL
FOR TOTAL 1 YEAR DOSE COMMITMENT

NUCLIDE	TOTAL BODY	BONE	LUNGS	THYROID
H 3	1.40-002	.00	3.86-004	6.65-001
CS137	6.99-001	1.04-001	5.19-003	1.44-003
BA137M	7.02-003	9.73-004	1.94-004	3.34-001
PU239	2.80-001	8.95-001	9.94-001	9.54-006

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMTST.
011681
FRACTIONAL DOSE BY RADIONUCLIDE FOR MAXIMUM INDIVIDUAL
FOR TOTAL 50 YEAR DOSE COMMITMENT

NUCLIDE	TOTAL BODY	BONE	LUNGS	THYROID
H 3	9.44-004	.00	1.62-004	6.65-001
CS137	5.45-002	3.08-003	2.43-003	1.44-003
BA137M	4.74-004	2.37-005	8.14-005	3.34-001
PU239	9.44-001	9.97-001	9.97-001	9.54-006

FIGURE F.0-2. HADOC Sample Problem Output

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMTST.

011681

FRACTIONAL DOSE BY RADIONUCLIDE FOR POPULATION

FOR	1 YEAR DOSE COMMITMENT				
	EXTERNAL	INHALATION			
NUCLIDE	TOTAL BODY	TOTAL BODY	BONE	LUNGS	THYROID
H 3	.00	1.41-002	.00	3.86-004	1.00+000
CS137	4.29-003	7.04-001	1.04-001	5.19-003	.00
BA137M	9.96-001	.00	.00	.00	.00
PU239	2.84-005	2.82-001	8.95-001	9.94-001	.00

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMTST.

011681

FRACTIONAL DOSE BY RADIONUCLIDE FOR POPULATION

FOR	50 YEAR DOSE COMMITMENT				
	EXTERNAL	INHALATION			
NUCLIDE	TOTAL BODY	TOTAL BODY	BONE	LUNGS	THYROID
H 3	.00	9.44-004	.00	1.62-004	1.00+000
CS137	4.29-003	5.45-002	3.08-003	2.43-003	.00
BA137M	9.96-001	.00	.00	.00	.00
PU239	2.84-005	9.45-001	9.97-001	9.97-001	.00

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMTST.

011681

FRACTIONAL DOSE BY RADIONUCLIDE FOR POPULATION

FOR TOTAL	1 YEAR DOSE COMMITMENT			
NUCLIDE	TOTAL BODY	BONE	LUNGS	THYROID
H 3	1.40-002	.00	3.86-004	6.65-001
CS137	6.99-001	1.04-001	5.19-003	1.44-003
BA137M	7.02-003	9.73-004	1.94-004	3.34-001
PU239	2.80-001	8.95-001	9.94-001	9.54-006

HADOC SAMPLE PROBLEM, CASE 1. TEST OF ALL OPTIONS EXCEPT IWAKE AND LIMTST.

011681

FRACTIONAL DOSE BY RADIONUCLIDE FOR POPULATION

FOR TOTAL	50 YEAR DOSE COMMITMENT			
NUCLIDE	TOTAL BODY	BONE	LUNGS	THYROID
H 3	9.44-004	.00	1.62-004	6.65-001
CS137	5.45-002	3.08-003	2.43-003	1.44-003
BA137M	4.74-004	2.37-005	8.14-005	3.34-001
PU239	9.44-001	9.97-001	9.97-001	9.54-006

FIGURE F.0-2. HADOC Sample Problem Output

HADOC SAMPLE PROBLEM, CASE 2. SAME AS CASE 1 EXCEPT LIMITST ON AND IFRAC OFF.

011681

EXECUTING NEPA:HADOC(1).ABS CREATED ON JANUARY 16, 1981 AT 09:31:48

DATA LIBRARY TITLES:

MASTER RADIONUCLIDE DATA LIBRARY

RADIONUCLIDE MASTER DATA LIBRARY, 15 JANUARY 81, BA NAPIER

DOSE FACTOR LIBRARY

CWMS DATA LIBRARY, AUG 06, 1980 (DLS)

SUMMARY OF INPUT DATA:

***DISPERSION MODEL MAXIMUM INDIVIDUAL POPULATION
MOD. STABLE MOD. STABLE
***WIND SPEED (M/SEC) 1.0 1.0
***STACK HEIGHT IS 60. METERS
***ORGANS SELECTED ARE: TOTAL BODY BONE LUNGS THYROID
***MAXIMUM ATMOSPHERIC DISPERSION CONDITIONS WILL BE DETERMINED
***FRACTIONAL DOSE REPORTS ARE NOT REQUESTED
***ALL DOSE REPORTS ARE REQUESTED

***DISPERSION PARAMETER SIGMA THETA U BAR = .0240

***DISTANCE TO MAXIMUM INDIVIDUAL 1000. METERS

***POPULATION DISTANCES: 9, METERS

100. 200. 300. 500. 800. 24140. 40220. 56320. 72400.

***POPULATION DISTRIBUTION DATA

SECTOR	1	2	3	4	5	6	7	8	9
1	0.	0.	0.	0.	0.	20.	1039.	461.	2696.
2	0.	0.	0.	0.	0.	5.	733.	974.	15962.
3	0.	0.	0.	0.	0.	273.	5890.	2366.	628.
4	0.	0.	0.	0.	0.	257.	914.	2368.	903.
5	0.	0.	0.	0.	0.	128.	384.	558.	855.
6	0.	0.	0.	0.	0.	288.	1642.	140.	348.
7	0.	0.	0.	0.	0.	3.	34522.	46456.	948.
8	0.	0.	0.	0.	0.	1911.	1180.	309.	1935.
9	0.	0.	0.	0.	0.	1029.	1644.	51.	555.
10	0.	0.	0.	0.	0.	512.	9996.	788.	144.
11	0.	0.	0.	0.	0.	545.	17054.	1047.	447.
12	0.	0.	0.	0.	0.	961.	2914.	14588.	5072.
13	0.	0.	0.	0.	0.	388.	498.	3750.	78520.
14	0.	0.	0.	0.	0.	239.	752.	1015.	560.
15	0.	0.	0.	0.	0.	225.	228.	394.	1058.
16	0.	0.	0.	0.	0.	26.	440.	228.	4000.

***BUILDING WAKE EFFECTS ARE NOT CONSIDERED

***TERRAIN EFFECTS ARE CONSIDERED

ELEVATION OF MAXIMUM INDIVIDUAL IS 20. METERS

TERRAIN DATA

SECTOR 1 2 3 4 5 6 7 8 9

F.10

FIGURE F.0-2. HADOC Sample Problem Output

1	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	5.	5.	5.	5.	5.	5.	5.	5.	5.
3	10.	10.	10.	10.	10.	10.	10.	10.	10.
4	20.	20.	20.	20.	20.	20.	20.	20.	20.
5	40.	40.	40.	40.	40.	40.	40.	40.	40.
6	50.	50.	50.	50.	50.	50.	50.	50.	50.
7	0.	0.	0.	0.	5.	60.	50.	60.	60.
8	100.	100.	100.	100.	100.	100.	100.	100.	100.
9	0.	0.	0.	0.	0.	5.	5.	5.	5.
10	0.	0.	0.	0.	0.	10.	10.	10.	10.
11	0.	0.	0.	0.	0.	60.	60.	60.	60.
12	0.	0.	0.	0.	0.	5.	10.	20.	40.
13	0.	0.	0.	0.	5.	10.	20.	40.	50.
14	0.	0.	0.	5.	10.	20.	40.	50.	60.
15	0.	0.	5.	10.	20.	40.	50.	60.	100.
16	0.	5.	10.	20.	40.	50.	60.	100.	100.

***RADIONUCLIDE INPUT INVENTORY

NUCLIDE RELEASE		NUCLIDE RELEASE		NUCLIDE RELEASE	
ELT.	WT. (CI)	ELT.	WT. (CI)	ELT.	WT. (CI)
H 3	1.00E+03	I 131	2.00E+01	CS 137	1.00E+02
BA 137M	9.60E+01	PU 239	1.00E+00	MN 56	1.00E+00
BR 83	1.00E+00	RU 103	1.00E+00		

***THE ABOVE ACTIVITIES ARE MULTIPLIED BY 1.00+000 TO GET THE RELEASE ACTIVITY

*** INPUT PREPARED BY: DATE

*** INPUT CHECKED BY: DATE

TIME INTEGRATED AIR CONCENTRATION
 FOR THE MAXIMUM INDIVIDUAL LOCATION (EQM1) = 9.96-005 SEC/M**3
 MAXIMUM AIR CONCENTRATION AT LOCATION OF MAXIMUM INDIVIDUAL WAS FOR HANFORD CONDITIONS.
 INDEX OF THE MAXIMUM POPULATION DOSE SECTOR (MS) = 13
 TIME INTEGRATED AIR CONCENTRATION
 TIMES POPULATION (PM) = 2.76-002 MAN-SEC/M**3
 TIME INTEGRATED AIR CONCENTRATION
 AT EACH POPULATION DISTANCE IN THE DIRECTION OF THE MAXIMUM EXPOSURE SECTOR = EQP(IX) SEC/M**3

DISTANCE	EQP	MAXIMUM STABILITY
1	4.54-007	PASQUILL A
2	5.79-005	PASQUILL A
3	6.82-005	PASQUILL A
4	4.10-005	PASQUILL B
5	2.79-005	PASQUILL C
6	9.74-007	PASQUILL F
7	5.87-007	PASQUILL F
8	4.31-007	PASQUILL F
9	3.22-007	PASQUILL F

FIGURE F.0-2. HADOC Sample Problem Output

HADOC SAMPLE PROBLEM, CASE 2. SAME AS CASE 1 EXCEPT LIMITS ON AND IFRAC OFF.
011681

PATHWAY/ORGAN	MAXIMUM INDIVIDUAL DOSE COMMITMENTS (REM)	
	DOSE COMMITMENT PERIOD	
	1 YEAR	50 YEARS
AIR SUBMERSION		
TOTAL BODY	1.3E-03	1.3E-03
INHALATION		
TOTAL BODY	1.8E-01	2.7E+00
BONE	1.3E+00	5.5E+01
LUNGS	6.7E+00	1.6E+01
THYROID	2.6E-03	2.6E-03
TOTAL DOSES		
TOTAL BODY	1.9E-01	2.7E+00
BONE	1.3E+00	5.5E+01
LUNGS	6.7E+00	1.6E+01
THYROID	3.9E-03	3.9E-03

HADOC SAMPLE PROBLEM, CASE 2. SAME AS CASE 1 EXCEPT LIMITS ON AND IFRAC OFF.
011681

PATHWAY/ORGAN	POPULATION DOSE COMMITMENTS (MAN-REM)	
	DOSE COMMITMENT PERIOD	
	1 YEAR	50 YEARS
AIR SUBMERSION		
TOTAL BODY	3.6E-01	3.6E-01
INHALATION		
TOTAL BODY	5.1E+01	7.6E+02
BONE	3.7E+02	1.5E+04
LUNGS	1.9E+03	4.4E+03
THYROID	7.2E-01	7.2E-01
TOTAL DOSES		
TOTAL BODY	5.1E+01	7.6E+02
BONE	3.7E+02	1.5E+04
LUNGS	1.9E+03	4.4E+03
THYROID	1.1E+00	1.1E+00

FIGURE F.0-2. HADOC Sample Problem Output

HADOC SAMPLE PROBLEM, CASE 3. SAME AS CASE 1 EXCEPT IFRAC OFF, IWAKE ON AND H=0

011681

EXECUTING NEPA:HADOC(1).ABS CREATED ON JANUARY 16, 1981 AT 09:31:48

DATA LIBRARY TITLES:

MASTER RADIONUCLIDE DATA LIBRARY

RADIONUCLIDE MASTER DATA LIBRARY, 15 JANUARY 81, BA NAPIER

DOSE FACTOR LIBRARY

CWMS DATA LIBRARY, AUG 06, 1980 (DLS)

SUMMARY OF INPUT DATA:

***DISPERSION MODEL MAXIMUM INDIVIDUAL POPULATION
 ***WIND SPEED (M/SEC) MOD. STABLE MOD. STABLE
 ***STACK HEIGHT IS 1.0 1.0
 ***STACK HEIGHT IS 0. METERS
 ***ORGANS SELECTED ARE: TOTAL BODY BONE LUNGS THYROID
 ***MAXIMUM ATMOSPHERIC DISPERSION CONDITIONS WILL NOT BE DETERMINED
 ***FRACTIONAL DOSE REPORTS ARE NOT REQUESTED
 ***ALL DOSE REPORTS ARE REQUESTED

***DISPERSION PARAMETER SIGMA THETA U BAR = .0240

***DISTANCE TO MAXIMUM INDIVIDUAL 1000. METERS

***POPULATION DISTANCES: 9, METERS

100. 200. 300. 500. 800. 24140. 40220. 56320. 72400.

***POPULATION DISTRIBUTION DATA

SECTOR	DISTANCE INTERVAL								
	1	2	3	4	5	6	7	8	9
1	0.	0.	0.	0.	0.	20.	1039.	461.	2696.
2	0.	0.	0.	0.	0.	5.	733.	974.	15952.
3	0.	0.	0.	0.	0.	273.	5890.	2366.	628.
4	0.	0.	0.	0.	0.	257.	914.	2368.	903.
5	0.	0.	0.	0.	0.	128.	384.	558.	855.
6	0.	0.	0.	0.	0.	288.	1642.	140.	348.
7	0.	0.	0.	0.	0.	3.	34522.	46456.	948.
8	0.	0.	0.	0.	0.	1911.	1180.	309.	1935.
9	0.	0.	0.	0.	0.	1029.	1644.	51.	555.
10	0.	0.	0.	0.	0.	512.	9996.	788.	144.
11	0.	0.	0.	0.	0.	545.	17054.	1047.	447.
12	0.	0.	0.	0.	0.	961.	2914.	14588.	5072.
13	0.	0.	0.	0.	0.	388.	498.	3750.	78520.
14	0.	0.	0.	0.	0.	239.	752.	1015.	560.
15	0.	0.	0.	0.	0.	225.	228.	394.	1058.
16	0.	0.	0.	0.	0.	26.	440.	228.	4000.

***BUILDING WAKE EFFECTS ARE CONSIDERED

AREA = 1000. METERS**2

***TERRAIN EFFECTS ARE CONSIDERED

ELEVATION OF MAXIMUM INDIVIDUAL IS 20. METERS

F.13

FIGURE F.0-2. HADOC Sample Problem Output

```

**TERRAIN DATA**
DISTANCE INTERVAL
SECTOR 1 2 3 4 5 6 7 8 9
1 0. 0. 0. 0. 0. 0. 0. 0. 0.
2 5. 5. 5. 5. 5. 5. 5. 5. 5.
3 10. 10. 10. 10. 10. 10. 10. 10. 10.
4 20. 20. 20. 20. 20. 20. 20. 20. 20.
5 40. 40. 40. 40. 40. 40. 40. 40. 40.
6 50. 50. 50. 50. 50. 50. 50. 50. 50.
7 0. 0. 0. 0. 5. 60. 60. 60. 60.
8 100. 100. 100. 100. 100. 100. 100. 100. 100.
9 0. 0. 0. 0. 0. 5. 5. 5. 5.
10 0. 0. 0. 0. 0. 10. 10. 10. 10.
11 0. 0. 0. 0. 0. 60. 60. 60. 60.
12 0. 0. 0. 0. 0. 5. 10. 20. 40.
13 0. 0. 0. 0. 5. 10. 20. 40. 50.
14 0. 0. 0. 5. 10. 20. 40. 50. 60.
15 0. 0. 5. 10. 20. 40. 50. 60. 100.
16 0. 5. 10. 20. 40. 50. 60. 100. 100.

**RADIONUCLIDE INPUT INVENTORY
NUCLIDE RELEASE
ELT. WT. (CI)
H 3 1.00E+03
BA 137M 9.60E+01
BR 83 1.00E+00
NUCLIDE RELEASE
ELT. WT. (CI)
I 131 2.00E+01
PU 239 1.00E+00
RU 103 1.00E+00
NUCLIDE RELEASE
ELT. WT. (CI)
CS 137 1.00E+02
MN 56 1.00E+00

**THE ABOVE ACTIVITIES ARE MULTIPLIED BY 1.00+000 TO GET THE RELEASE ACTIVITY

*** INPUT PREPARED BY: DATE
*****

*** INPUT CHECKED BY: DATE
*****

TIME INTEGRATED AIR CONCENTRATION
FOR THE MAXIMUM INDIVIDUAL LOCATION (EQM1) = 3.20-004 SEC/M**3
INDEX OF THE MAXIMUM POPULATION DOSE SECTOR (MS) = 7
TIME INTEGRATED AIR CONCENTRATION
TIMES POPULATION (PM) = 2.71-002 MAN-SEC/M**3
TIME INTEGRATED AIR CONCENTRATION
AT EACH POPULATION DISTANCE IN THE DIRECTION OF THE MAXIMUM EXPOSURE SECTOR = EQP(IX) SEC/M**3
DISTANCE EQP MAXIMUM STABILITY
-----
1 1.06-003 HANFORD
2 4.59-004 HANFORD
3 2.79-004 HANFORD
4 1.47-004 HANFORD
5 8.66-005 HANFORD
6 9.10-007 HANFORD
7 4.29-007 HANFORD
8 2.60-007 HANFORD
9 1.79-007 HANFORD

```

FIGURE F.O-2. HADOC Sample Problem Output

HADOC SAMPLE PROBLEM, CASE 3. SAME AS CASE 1 EXCEPT IFRAC OFF, IWAKE ON AND H=0
011681

PATHWAY/ORGAN	MAXIMUM INDIVIDUAL DOSE COMMITMENTS (REM)	
	DOSE COMMITMENT PERIOD	
	1 YEAR	50 YEARS
AIR SUBMERSION		
TOTAL BODY	4.2E-03	4.2E-03
INHALATION		
TOTAL BODY	5.9E-01	8.8E+00
BONE	4.3E+00	1.8E+02
LUNGS	2.2E+01	5.1E+01
THYROID	8.3E-03	8.3E-03
TOTAL DOSES		
TOTAL BODY	6.0E-01	8.8E+00
BONE	4.3E+00	1.8E+02
LUNGS	2.2E+01	5.1E+01
THYROID	1.3E-02	1.3E-02

HADOC SAMPLE PROBLEM, CASE 3. SAME AS CASE 1 EXCEPT IFRAC OFF, IWAKE ON AND H=0
011681

PATHWAY/ORGAN	POPULATION DOSE COMMITMENTS (MAN-REM)	
	DOSE COMMITMENT PERIOD	
	1 YEAR	50 YEARS
AIR SUBMERSION		
TOTAL BODY	3.6E-01	3.6E-01
INHALATION		
TOTAL BODY	5.0E+01	7.5E+02
BONE	3.6E+02	1.5E+04
LUNGS	1.8E+03	4.3E+03
THYROID	7.0E-01	7.0E-01
TOTAL DOSES		
TOTAL BODY	5.0E+01	7.5E+02
BONE	3.6E+02	1.5E+04
LUNGS	1.8E+03	4.3E+03
THYROID	1.1E+00	1.1E+00

END OF INPUT FOR THIS RUN

FIGURE F.0-2. HADOC Sample Problem Output

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