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LADTAP II - Technical Reference and User Guide

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ABSTRACT

This report describes the U.S. Nuclear Regulatory Commission computer program LADTAP II, which performs environmental dose analyses for releases of radioactive effluents from nuclear power plants into surface waters. The analyses estimate radiation dose to individuals, population groups, and biota from ingestion (aquatic foods, water, and terrestrial irrigated foods) and external exposure (shoreline, swimming, and boating) pathways. The calculated doses provide information for National Environmental Policy Act (NEPA) evaluations and for determining compliance with Appendix I of 10 CFR 50 (the "ALARA" philosophy).

The report also instructs the user in preparing input to the program, describes the mathematical models that are used, and supplies detailed information on program structure and parameters used to modify the program.

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EXECUTIVE SUMMARY

The LADTAP II computer program was developed by the U.S. Nuclear Regulatory Commission to estimate radiation doses to individuals, population groups, and biota from radionuclide releases as liquid effluents from light-water nuclear reactors during routine operation. This document was prepared by the Pacific Northwest Laboratory to serve as a technical reference and user guide for NRC's LADTAP II program. The document contains three main parts: 1) a user manual, 2) a description of mathematical models used in LADTAP II, and 3) technical information useful in installing or modifying the program.

USER INFORMATION

The user manual portion of this report (Section 2) presents information needed to prepare input for the LADTAP II program for the purpose of simulating a user-defined release and exposure scenario. Three sample problems are used to illustrate input preparation and the resulting output reports. The sample problems illustrate most of the options available with the program. Error messages generated by LADTAP II are described along with the cause and resulting program action (stop or continue) for each error message.

MATHEMATICAL MODELS

The mathematical models described in Section 3 include hydrologic models used to represent mixing in the effluent impoundment system and in surface waters, and exposure pathway models used to calculate radiation dose to selected groups at various water usage locations in the environment. Four options are available to describe the impoundment system:

1. Direct release to the receiving water
2. Plug-flow through the impoundment with release to the receiving water
3. Partial recirculation of cooling water through the reactor with no mixing in the impoundment
4. Complete mixing in the impoundment with no recirculation through the reactor.

DETAILED PROGRAM INFORMATION

Information on the installation of LADTAP II on a new system and on modification of the program is provided for use by experienced programmers. This program information includes details of program structure, data transfer, data files, and modules. The structure information includes the calling sequence hierachy, locations (modules) of data record input, and locations (modules) of output report preparation. Data transfers are performed through common blocks (10 in all) and argument lists. Parameters in each common block and argument list are fully described. A summary of each of the 32 LADTAP II modules is given, and a global dictionary that describes the usage of all major parameters throughout the program is provided. A summary of changes made to LADTAP II as a result of the current technical review and documentation effort is also included.

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1.0 INTRODUCTION

The LADTAP II computer program was developed by the U.S. Nuclear Regulatory Commission (NRC) and is designed to estimate radiation doses to individuals, population groups, and biota from radionuclides released as liquid effluents from light-water nuclear reactors during routine operation. This report contains a user's guide (Section 2), a description of the mathematical models used (Section 3), and detailed information on the program structure that is useful for modifying the program (Section 4).

The main features of the LADTAP II program are 1) the hydrologic model used to represent mixing in the effluent impoundment system and surface waters, and 2) the exposure pathway models used to estimate exposure of selected groups at various water usage locations in the environment. The hydrologic model represents the impoundment system as one of four models:

1. Direct release to the receiving water: no effect of the impoundment system on effluent concentration
2. Plug-flow model: linear flow with no mixing between the reactor and the receiving water body
3. Partially mixed model: linear flow through the impoundment with partial recirculation through the reactor
4. Completely mixed model: complete mixing in the impoundment with partial recirculation through the reactor.

The last three models account for radiological decay during transit through the impoundment system. Optional models are also available to estimate dilution in nontidal rivers and near-shore lake environments.

The consequence calculation portion of LADTAP II starts with the water concentration at a specific usage location in the environment. (The user must indicate if the reactor is at a saltwater or freshwater site.) The effluent concentration (from the impoundment system) is related to the water concentrations at the usage locations by two parameters: 1) a dilution factor, and 2) a transit time (for radiological decay in transport through the surface-water system). The water concentration at the usage location is applied to specific exposure pathway models to estimate the resulting exposure. Pathways included in LADTAP II are:

- ingestion of aquatic foods such as fish, invertebrates, and aquatic plants
- external exposure to shoreline
- external exposure to water through boating and swimming
- ingestion of drinking water (freshwater sites only)
- ingestion of irrigated terrestrial food crops.

Applied to specific usage locations, these pathways estimate a variety of exposures including doses to individuals, populations, and biota. Table 1.1 indicates the exposures considered in LADTAP II and the pathways included in each exposure. The exposed groups listed in Table 1.1 are organized according to the order in which reports are printed.

Two types of population doses are calculated in LADTAP II. An "ALARA" analysis is performed based on exposure of people within 50 miles of the site. In addition, a "NEPA" analysis is performed based on exposure of all people in the U.S. from effluents from the site. LADTAP II also performs a special population-dose analysis, which is printed as a "cost-benefit" table on the last page of output. The population dose values in this output table represent the sum of ALARA population doses at all locations for the following pathways:

- ingestion of sport and commercially harvested fish and invertebrates
- ingestion of drinking water
- ingestion of irrigated terrestrial foods: vegetables, leafy vegetables, milk, and meat
- external exposure from aquatic recreational activities: swimming, boating, and shoreline activities.

This special cost-benefit report presents the total-body and thyroid doses from each radionuclide released. Also printed are the population doses (total-body and thyroid) per curie of each radionuclide released.

TABLE 1.1. Pathways and Exposed Groups Considered by LADTAP II

	Aquatic Foods				External Exposure			Irrigated Farm Products			
	Fish	Invertebrates	Aquatic Plants	Drinking Water	Shoreline	Swimming	Boating	Vegetables	Leafy Vegetables	Milk	Meat
ALARA[a] Analysis for Individuals											
Adult	●	●	●	●	●	●	●				
Teen	●	●	●	●	●	●	●				
Child	●	●	●	●	●	●	●				
Infant	●	●	●	●	●	●	●				
Population Doses from Sport and Commercial Harvests											
Adult	●	●									
Teen	●	●									
Child	●	●									
Population Doses from Potable Water Supply Systems											
Adult				●							
Teen				●							
Child				●							
Population Dose from Hydrosphere Tritium											
Adult				●							
Population Doses from Aquatic Recreation											
Adult					●	●	●				
Individual Dose from Irrigated Farm Products											
Adult								●	●	●	●
Teen								●	●	●	●
Child								●	●	●	●
Population Dose from Irrigated Farm Products NEPA[b]											
Adult								●	●	●	●
Teen								●	●	●	●
Child								●	●	●	●
ALARA[a]											
Adult								●	●	●	●
Teen								●	●	●	●
Child								●	●	●	●
Population Dose for Cost-Benefit Analysis											
Adult	●	●		●	●	●	●	●	●	●	●
Dose to Individual Biota											
Fish				●	●	●					
Invertebrate				●	●	●					
Algae				●		●					
Muskrat			●		●	●					
Raccoon		●			●						
Heron	●				●	●					
Duck			●		●	●					

(a) ALARA (as low as reasonably achievable) for compliance with 10 CFR 50, Appendix I (maximally exposed individual and 50-mi population).

(b) NEPA (National Environmental Policy Act) U.S. Population.

2.0 USER INFORMATION

This section describes the use of the computer program LADTAP II in performing environmental dose analyses. Instructions for preparing input to the program are given in Section 2.1, and output reports generated by the program are described in Section 2.2. Three sample problems presented in Section 2.3 will help users understand the program. A summary of program generated error messages is given in Section 2.4.

2.1 INPUT INSTRUCTIONS

This section provides information needed to prepare case input for the LADTAP II program for the purpose of simulating a user-defined release scenario. The information presented assumes the user has no familiarity with the internal workings of the LADTAP II program and little experience with computers. However, the instructions only cover preparation of the record images for the input file; the LADTAP II program is assumed to be installed and available on a mainframe computer, and job control information is assumed to be provided by the user or by the computer support group at the user's installation.

All input to LADTAP II is provided as formatted records. These records are of two main types: case-specific parameters and BLOCK DATA parameters. The case-specific parameters include those parameters that may differ for each application and those for which it is difficult to assign default values. A few of the case-specific parameters have default values that may either be retained or changed by the user. The BLOCK DATA parameters include radionuclide constants and data for the various exposure pathways that are not likely to be site or case specific. Default values are supplied for all of these parameters. Most default parameters are derived from Regulatory Guide 1.109. The source of default values in the Regulatory Guide is indicated for each value (i.e., RG-TA1 refers to Table A-1 of the guide).

The order of all formatted input records is defined in Figure 2.1. The record types indicated in the figure refer to case-specific input records as

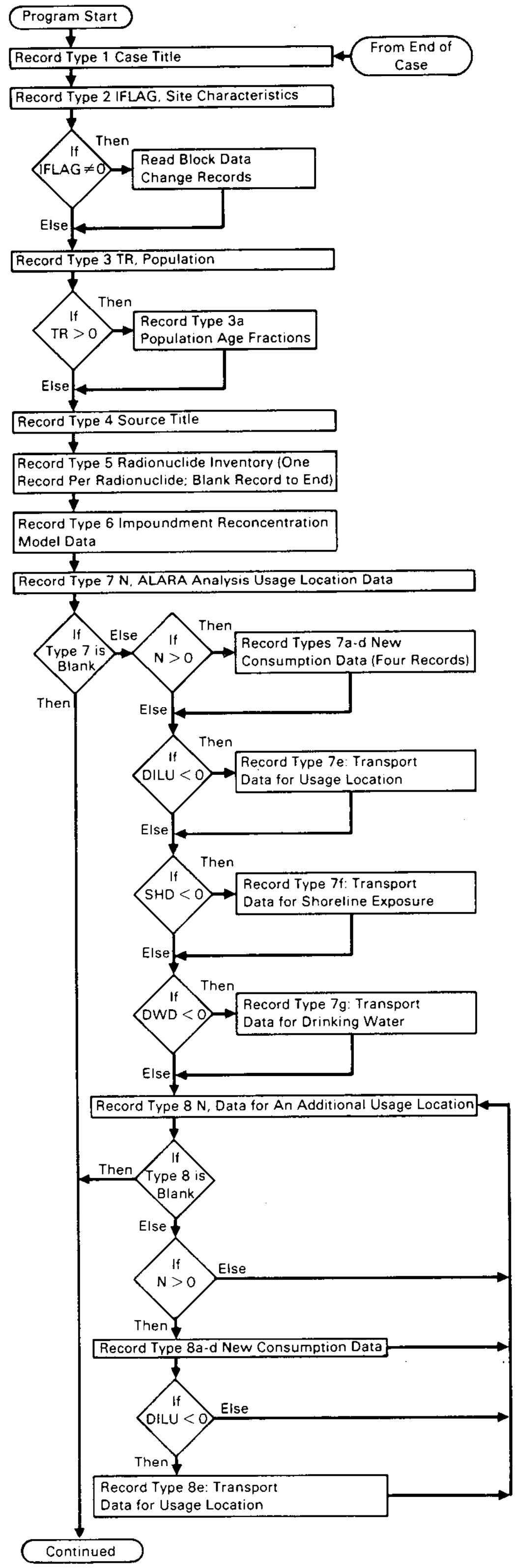


FIGURE 2.1. Logic Diagram for Input Records

Figure 2.1 (Contd)

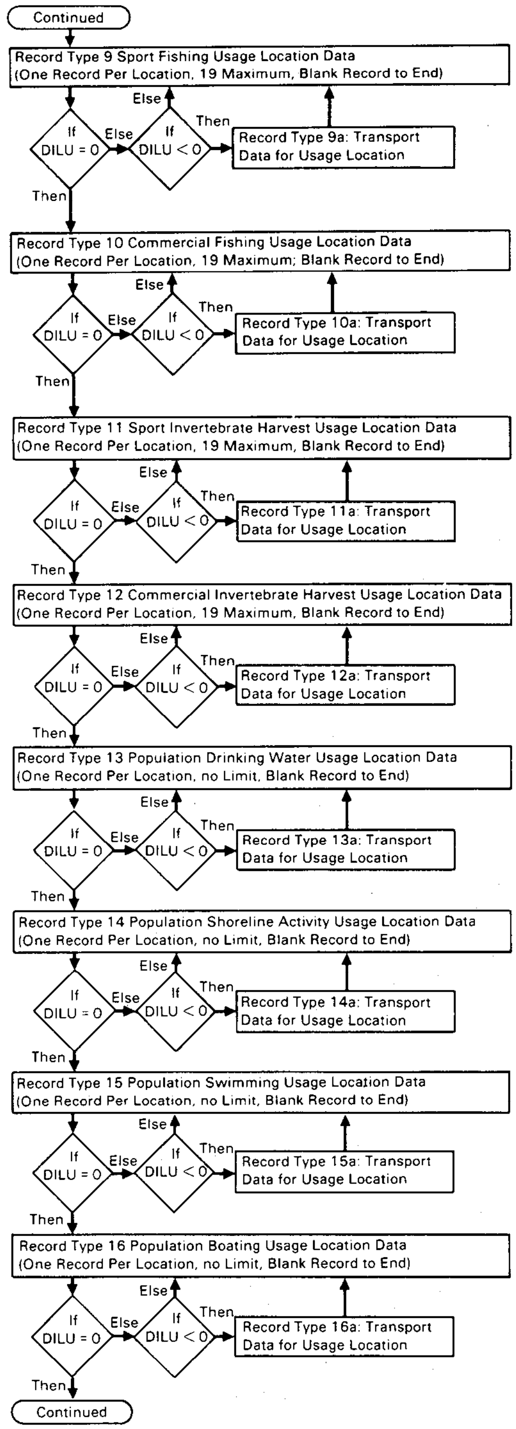
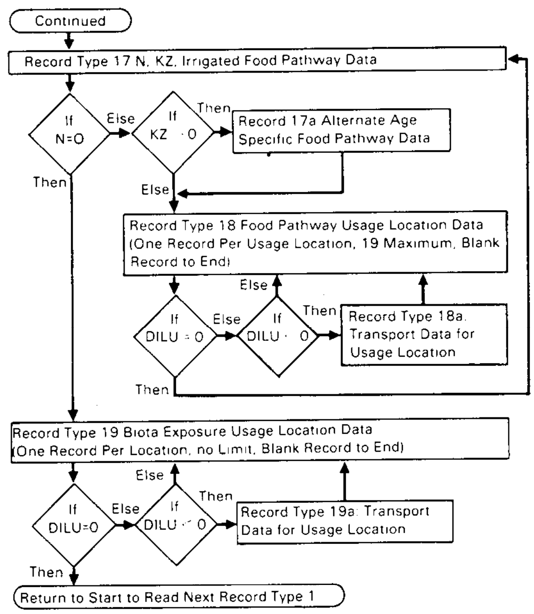


Figure 2.1 (Contd)



defined in Section 2.1.1. The optional input records identified as "read BLOCK DATA change records" are defined in Section 2.1.2. A properly prepared input record file is a sequential record file with record types ordered as defined in Figure 2.1. Each formatted record will consist of 80 or fewer data characters as required and defined for the specific record types. The user is urged to refer to Figure 2.1 when preparing the input record file to ensure that the read control information parameters (IFLAG, TR, N, and KZ) are used properly and that all necessary records are included. Because reading of several records involves repeated reads which are ended by blank cards, the user is urged to pay particular attention to including blank records at the required locations. When a pathway or calculation is to be skipped entirely, it is still necessary to enter one blank record to indicate the omission.

2.1.1 Case-Specific Input Records

The 19 record types used by LADTAP II are defined in this section. The descriptions provide record format, parameter definitions, parameter names, and default values (if any). The user may change some of the default values using optional input records. Other default values may be changed using BLOCK DATA change records (see Section 2.1.2). Figure 2.1 provides a logic diagram of the required order for specifying record types in the input file.

The parameters may be of three types: character, integer, or real. Character parameters are usually defined with an alphanumeric format (represented as "A"). Such parameters are generally used for descriptive titles and may contain any combination of letters, numbers, and special symbols (+, -, ;, $, %, etc.), but should not contain computer control characters such as end-of-file markers. The user should also be careful not to use any special system-restricted characters. Integer parameters are defined as whole numbers and are right justified in the format field, with no letters or special symbols other than "+" or "-." Real (or floating point) parameters are generally specified as numbers containing a floating decimal point ("F" format). They may also be defined in exponential ("E" format) notation. For example, to define a real value of 150, the following notations would be acceptable: 150, 150.0, 1.5E+2, 1.5+2, or 1.5E2. The first two notations are examples of "F" format; the last three are examples of "E" format. Note that for "E" formats the exponent (2 in the example) must be right justified in the parameter field. In the following description of record types, real parameters are defined by "E" formats. When "E" formats are specified, the parameter value may be provided using either "E" or "F" notations. This is a general rule and depends on the characteristics of the computer being used.

The following discussion presents detailed information on preparation of each input record type. A summary reference table containing information on all record types is presented at the end of this section (Table 2.22).

Record Type 1: Case Title

The first record of each case provides a descriptive title for the release scenario that follows. The first two characters of this record are not used by the program and may be left blank or used as desired (i.e., as a case index). The descriptive title is entered on the remaining 78 positions of the record and is stored in the character array ITITLE(78). The record format is 2X,78A1. This descriptive title is printed in the heading of output report 3 (see Section 2.2) and on the banner page.

The read statement for this record type tests for an end-of-file (i.e., no more input records in the input record file). When an end-of-file is encountered, the run is stopped. This is the normal mode used to terminate a run.

Record Type 2: Site Characteristics

This record type provides control integers and discharge parameters. The format and parameter definitions are provided in Table 2.1. When BLOCK DATA parameters are to be changed, a set of BLOCK DATA change records (described in Section 2.1.2) must follow record type 2. A BLOCK DATA change record report (report 1, see Section 2.2) is printed. BLOCK DATA values are printed as report type 2, and dose conversion factors are printed as report type 4.

The user is cautioned that the parameter, CFS, always represents the discharge rate from the reactor to the impoundment system. This flow rate is only equal to the effluent rate to the receiving water body for the cases of no impoundment and the plug-flow impoundment model. (See Record Type 6 and Section 3.1.1). For the partially mixed and completely mixed impoundment models the two flow rates will probably be different.

Record Type 3 and 3a: Site Population Information

This record set consists of two records; the second record is optional. The first record gives both the total population within 50 miles of the site and a control parameter that initiates reading of the optional second record. The second record gives the population age-group fractions. Table 2.2 describes the record formats.

The three parameters on record type 3a are also in BLOCK DATA. Default population fractions are 0.71, 0.11, and 0.18 for adults, teenagers, and children, respectively. These values are based on ages of 0 to 11 for children, 11 to 17 for teenagers, and 17 and older for adults. The default values represent United States averages.

TABLE 2.1. Record Type 2 Description

Parameter Name	Format	Columns	Description
LT	I10	1-10	Site water type selection integer: LT=0, freshwater LT>0, saltwater LT<0, print error message and stop run
CFS	E10	11-20	Liquid effluent discharge rate from the reactor to the impoundment system (ft^3/sec): if CFS≤0., print error message and stop run
UML	E10	21-30	Source term multiplier - The radionuclide release inventory (parameter QQ on record Type 5) is multiplied by this factor: if UML=0. (or blank), set to 1.0 if UML<0., print error message and stop run
LCT	I10	31-40	Integer to control calculation and printing of % contribution to doses by radionuclide: LCT>0 calculate % contribution LCT≤0 do no calculation
IFLAG	I10	41-50	Integer to control changing and printing of BLOCK DATA parameters and printing of dose conversion factors.

IFLAG Value	Change Block Data	Print Block Data and Dose Factors
<-1	No	No
-1	No	Yes
0	No	No
1	Yes	Yes
>1	Yes	No

Record Type 4: Source Title

This record provides 78 characters of descriptive title for the radionuclide source term. The format is 2X,78A1. The title is printed in the heading of report 5 (see Section 2.2). Note that the first two spaces on the record are not read by the program.

TABLE 2.2. Record Type 3 and 3a Descriptions

Parameter Name	Format	Columns	Description
Record Type 3:			
POP	E10	1-10	Total population within 50 miles of the site
TR	E10	11-20	Control parameter for reading record Type 3a if TR≤0, do not read 3a if TR>0, read 3a
Record Type 3a:			
PERA	E10	1-10	Fraction of the population who are adults
PERT	E10	11-20	Fraction of the population who are teens
PERC	E10	21-30	Fraction of the population who are children

Record Type 5: Radionuclide Release Information

Information on records of this type defines the radionuclides being considered, their release rates, and reconcentration factors for the effluent impoundment system. The information for records of type 5 is described in Table 2.3. One record of type 5 must be provided for each radionuclide that is included in the inventory. The radionuclide name and mass number symbols should contain only capital letters. Records are read until a blank record is encountered (parameter QQ≤0).

Calculations can only be performed for radionuclides that are included in the dose conversion factor data library. If other radionuclides are entered, the program indicates that the radionuclide cannot be identified and the radionuclide is not included in the release inventory. A list of radionuclides in the current dose factor data library is given in Table 2.4. When special report 23 (see Section 2.2) is desired, all radionuclide release activities must be set to 1.0.

TABLE 2.3. Record Type 5 Description

Parameter Name	Format	Columns	Description
-	2X	1-2	Blank, not used
IA	A2	3-4	Radionuclide element symbol (left justified)
IM	5A1	5-9	Radionuclide mass number - Radinouclides in the meta stable state are indicated by an "M" following the numerical atomic mass number. For example, the IM value for ^{131m}Te may be expressed as 131M, 131 M, or 131-M; blanks and hyphens are ignored. The characters need not be left or right justified
-	1X	10	Blank, not used
QQ	E10	11-20	Radionuclide release rate (Ci/yr)
R	E10	21-30	Radionuclide reconcentration factor used when no reconcentration calculation is to be performed (see record Type 6): if R≤0., R is set to 1.0

Record Type 6: Impoundment Reconcentration Model Data

This record type selects the impoundment model and provides parameters needed by the impoundment models. If reconcentration factors are supplied through type 5 records, then no model should be selected (set M=0) on record type 6. If a model is selected, values given on type 5 records will be lost. The type of information found on record type 6 is given in Table 2.5.

When the plug-flow model is selected, a comparison is made between the blow-down rate (QSUBB) and the reactor effluent discharge rate (CFS, record type 2). If the blow-down rate is less than 99% of the effluent discharge rate, then an error message is printed. However, the run is not stopped and the values given are used.

Record Type 7: ALARA Analysis Usage Location Data

The ALARA analysis calculates doses to individuals from ingestion of aquatic foods, ingestion of drinking water, external exposure from shoreline

TABLE 2.4. Radionuclides in Dose Factor Data Library

^{3}H	^{89}SR	^{125}SB	^{141}CE	^{229}TH
^{10}BE	^{90}SR	^{126}SB	^{143}CE	^{230}TH
^{14}C	^{91}SR	^{127}SB	^{144}CE	^{232}TH
^{13}N	^{92}SR	^{125M}TE	^{143}PR	^{234}TH
^{18}F	^{90}Y	^{127M}TE	^{144}PR	^{231}PA
^{22}NA	^{91M}Y	^{127}TE	^{147}ND	^{233}PA
^{24}NA	^{91}Y	^{129M}TE	^{147}PM	^{232}U
^{32}P	^{92}Y	^{129}TE	^{148M}PM	^{233}U
^{41}CA	^{93}Y	^{131M}TE	^{148}PM	^{234}U
^{46}SC	^{93}ZR	^{131}TE	^{149}PM	^{235}U
^{51}CR	^{95}ZR	^{132}TE	^{151}PM	^{236}U
^{54}MN	^{97}ZR	^{133M}TE	^{151}SM	^{237}U
^{56}MN	^{93M}NB	^{134}TE	^{153}SM	^{238}U
^{55}FE	^{95}NB	^{129}I	^{152}EU	^{237}NP
^{59}FE	^{97}NB	^{130}I	^{154}EU	^{238}NP
^{57}CO	^{93}MO	^{131}I	^{155}EU	^{239}NP
^{58}CO	^{99}MO	^{132}I	^{156}EU	^{238}PU
^{60}CO	^{99M}TC	^{133}I	^{160}TB	^{239}PU
^{59}NI	^{99}TC	^{134}I	^{166M}HO	^{240}PU
^{63}NI	^{101}TC	^{135}I	^{181}W	^{241}PU
^{65}NI	^{103}RU	^{134M}CS	^{185}W	^{242}PU
^{64}CU	^{105}RU	^{134}CS	^{187}W	^{244}PU
^{65}ZN	^{106}RU	^{135}CS	^{210}PB	^{241}AM
^{65M}ZN	^{105}RH	^{136}CS	^{210}BI	^{242M}AM
^{69}ZN	^{107}PD	^{137}CS	^{210}PO	^{243}AM
^{79}SE	^{109}PD	^{138}CS	^{223}RA	^{242}CM
^{82}BR	^{110M}AG	^{139}CS	^{224}RA	^{243}CM
^{83}BR	^{111}AG	^{139}BA	^{225}RA	^{244}CM
^{84}BR	^{113M}CD	^{140}BA	^{226}RA	^{245}CM
^{85}BR	^{115M}CD	^{141}BA	^{226}RA	^{246}CM
^{86}RB	^{123}SN	^{142}BA	^{225}AC	^{247}CM
^{87}RB	^{125}SN	^{140}LA	^{227}AC	^{248}CM
^{88}RB	^{126}SN	^{141}LA	^{227}TH	^{252}CF
^{89}RB	^{124}SB	^{142}LA	^{228}TH	

TABLE 2.5. Record Type 6 Description

Parameter Name	Format	Columns	Description
M	I10	1-10	Index for selection of reconcentration model: M=0, no model M=1, completely mixed model M=2, plug-flow model M=3, partially mixed model Other, print error message and stop execution
QSUBB	E10	11-20	Effluent discharge rate (blowdown rate) from the impoundment systems to the receiving water body (ft^3/sec)
VSUBT	E10	21-30	Total volume of the impoundment (ft^3)

activities, and external exposure from swimming and boating. This hypothetical individual represents the maximally exposed individual within 50 miles. Type 7 records supply information on usage for each pathway. The control parameter N controls input of additional records (types 7a - 7d), allowing changes to default consumption rate parameters of BLOCK DATA. The information on record type 7 is described in Table 2.6. The shore-width factor represents a fraction of the dose from an infinite plane source that would be received from the shoreline geometry at the location of interest. Suggested values for shore-width factors (NRC 1977a) are given in Table 2.7 (RG-TA2).

The dilution factors represent the amount of dilution expected between the discharge point to the receiving water body and the usage location for the particular pathway. In applying the dilution factor, the discharge rate is divided by the dilution factor. Therefore a dilution factor of 100 represents a reduction in water concentration by a factor of 0.01. As an alternative to supplying dilution factors (DILU, SHD, and DWD), the user may provide data (see record types 7e, 7f, and 7g) on river or near-shore lake systems, and the dilution factor will be calculated. This calculation is requested by entering a negative value for the corresponding dilution factor on record 7. This

TABLE 2.6. Record Type 7 Description

Parameter Name	Format	Columns	Description
N	I10	1-10	Index for changing default usage and consumption parameter values: N=0, no change; N≠0, read new values on record types 7a - 7d
SWF	E10	11-20	Shore-width factor for shoreline exposure (dimensionless) (See Table 2.7)
DILU	E10	21-30	Dilution factor for aquatic food pathways and for external exposure while boating (dimensionless)
SHD	E10	31-40	Dilution factor for shoreline and swimming exposure (dimensionless)
DWD	E10	41-50	Dilution factor for drinking water pathway (dimensionless)
T	E10	51-60	Transit time from discharge (to the receiving water body) to exposure location - used for all pathways except drinking water (hr)
TD	E10	61-70	Transit time from discharge (to the receiving water body) to drinking water supply intake (hr)

TABLE 2.7. Suggested Shore-Width Factors (RG-TA2)

Exposure Situation	Shore-Width Factor
Discharge Canal Bank	0.1
River Shoreline	0.2
Lake Shore	0.3
Nominal Ocean Site	0.5
Tidal Basin	1.0

negative value is used only as an indicator to cause reading of an additional record (type 7e, 7f, or 7g). Application of these dilution models should be restricted to the portion of the river or lake removed from the influence of the discharge. Initial dilution near the discharge point is usually controlled by momentum effects.

Record Types 7a - 7d: Usage and Consumption Data for ALARA Location

Use of these record types is optional, based on the value supplied for parameter N of record type 7. When N is greater than zero, four additional records (types 7a - 7d) must be defined. Each record contains usage and consumption data for one age group: 7a for adults, 7b for teenagers, 7c for children, and 7d for infants. The information for the adult record type 7a is indicated in Table 2.8. Data are the same for the other age groups, but different parameter names are used to receive the data. The parameter names and default values for all age groups are given in Table 2.9 (RG-TE5). When special report 23 (see Section 2.2) is desired, parameters CRUS and ALUS must remain at zero for proper execution of the dose calculation.

TABLE 2.8. Record Type 7a Description

Parameter Name	Format	Columns	Description
FIUS	E10	1-10	Annual rate of fish consumption by adults (kg/yr)
CRUS	E10	11-20	Annual rate of invertebrate consumption by adults (kg/yr)
ALUS	E10	21-30	Annual rate of aquatic plant (i.e., algae) consumption by adults (kg/yr)
WUSE	E10	31-40	Annual rate of drinking water consumption by adults (kg/yr)
SHU	E10	41-50	Annual shoreline usage time for adults (hr/yr)
SWU	E10	51-60	Annual swimming exposure time for adults (hr/yr)
BUSE	E10	61-70	Annual boating usage time for adults (hr/yr)

TABLE 2.9. Parameter Names and Default Values for Usage and Consumption (RG-TE5)

Adults (Record 7a)	Teenagers (Record 7b)	Children (Record 7c)	Infants (Record 7d)
FIUS (21.)[a]	TAF (16.)	CHF (6.9)	TDF (0.)
CRUS (0.)[b]	TAC (0.)[b]	CHC (0.)[b]	TDC (0.)
ALUS (0.)	TAA (0.)	CHA (0.)	TDA (0.)
WUSE (730.)	TAW (510.)	CHW (510.)	TDW (330.)
SHU (12.)	TAS (67.)	CHS (14.)	TDS (0.)
SWU (0.)	TASW (0.)	CHSW (0.)	TDSW (0.)
BUSE (0.)	TAB (0.)	CHB (0.)	TDB (0.)

(a) Default values are in parentheses.
(b) Default values for invertebrate consumption for saltwater sites are: CRUS-5.0, TAC-3.8, and CHC-1.7.

Record Types 7e - 7g: ALARA Surface Water Data

These record types provide data used to calculate dilution factors to be used in place of DILU, SHD, and DWD (record type 7). The surface water dilution models for nontidal rivers or near-shore lakes may be used. To invoke the calculation of dilution factors, the corresponding dilution factor on record type 7 must be set negative. For each negative value, one record of type 7e, 7f, or 7g is read, as indicated in Figure 2.1. These records are defined in Table 2.10. All three records use the same format.

When the program calculates the dilution factor, the user has the option of allowing the program to calculate the transport time (T or TD). When a zero or negative value of T or TD is supplied, the program calculates the transit time from data on record types 7e, 7f, or 7g, as appropriate.

Record Type 8: Additional Selected Usage Location Data

This record type defines additional usage locations for analyses similar to ALARA analyses of record type 7. These locations represent individuals at selected locations other than the maximally exposed individual locations.

TABLE 2.10. Record Type 7e Description

Parameter Name	Format	Columns	Description
IFLAG	I10	1-10	Surface water model selection index: IFLAG=1, river IFLAG=2, lake
UR	E10	11-20	Average flow velocity of water body (ft/sec)
HR	E10	21-30	Average depth of water body (ft)
XR	E10	31-40	Downshore distance from discharge point to usage location (ft)
YR	E10	41-50	Offshore, distance to water usage location (ft)
BW	E10	51-60	Width of river (ft) or depth of discharge point in lake (ft)

Note that no records of type 8 are read if record type 7 is blank (see Figure 2.1). There is no limit to the number of additional usage locations that may be defined (one record type 8 per usage location analysis); reading of these records is ended by a blank card. Information on record type 8 is described in Table 2.11. For each record type 8 the user has the option of specifying new consumption and usage parameters. Input of this information is controlled through parameter N on record type 8 with new data being supplied on records of types 8a - 8d. Once values have been changed using record types 8a - 8d, the new values are used until purposely changed again. As for record type 7, a negative value for the dilution factor causes an additional record (type 8e), which contains data for calculating a dilution factor to be read.

Record Types 8a - 8d: Usage and Consumption Data for Selected Locations

Use of these records is optional, based on the value supplied for parameter N of record type 8. The format for these records is the same as for record types 7a - 7d, and the same parameters are referenced. If default

TABLE 2.11. Record Type 8 Description

Parameter Name	Format	Columns	Description
N	I10	1-10	Index for changing default usage and consumption parameter values: N=0, no change; N≠0, read new values on record types 8a - 8d
DILU	E10	11-20	Dilution factor for all pathways for current usage location (dimensionless)
T	E10	21-30	Transit time from discharge point (to receiving water body) to current usage locations for all pathways including drinking water (hr)
SWF	E10	31-40	Shore-width factor for shoreline exposure (dimensionless) - see record type 7 for suggested values
LOCA	5A4	41-52	A 20-character title for current usage location

values have been changed using record types 7a - 7d, the same values will be in effect for the calculations performed for selected usage locations (defined by record type 8).

Record Type 8e: Selected Location Surface Water Data

When the dilution factor (DILU) of record type 8 is set negative, the program will estimate the dilution factor based on data supplied on a type 8e record. The information on this record is as described for type 7e records in Table 2.10. The program may also be requested to calculate the transit time from data on record type 8e by setting the transit time to zero on record type 8.

Record Type 9: Sport Fishing Usage Location Data

This record type provides information on a usage location for population dose estimates from consumption of sport fishing harvest. Up to 19 usage locations may be defined with one record type 9 provided for each location. Reading of type 9 records is terminated by a blank record. Information provided on record type 9 is described in Table 2.12.

Record Type 9a: Sport Fishing Location Surface Water Data

The dilution factor for sport fishing will be calculated by LADTAP II when a negative value for DILU is supplied on record type 9. Information on this record is as described in Table 2.10 for record type 7e.

Record Types 10 and 10a: Commercial Fishing Usage Location Data

Information and usage of data on these record types is the same as for record types 9 and 9a as applied to locations involving commercial harvest of fish (see above).

Record Types 11 and 11a: Sport Invertebrate Harvest Location Data

Information and usage of data on these record types is the same as that on record types 9 and 9a as applied to locations involving sport harvest of invertebrates (see above).

Record Types 12 and 12a: Commercial Invertebrate Harvest Location Data

Information and usage of data on these record types is the same as that on record types 9 and 9a as applied to locations involving commercial harvest of invertebrates (see above).

TABLE 2.12. Record Type 9 Description

Parameter Name	Format	Columns	Description
CATH	E10	1-10	Annual harvest of sport fish for current location (kg/yr)
DILU	E10	11-20	Dilution factor for current sport fishing location (dimensionless)
T	E10	21-30	Transit time from discharge point (to receiving water body) to location of sport fishing harvest (hr)
LOC	5A4	31-50	A 20-character title for current location

Record Types 13 and 13a: Population Drinking Water Usage Location Data

These record types provide information for each drinking water usage location that contributes to population exposure. There is no limit to the number of usage locations that can be defined. Information provided in record type 13 is described in Table 2.13. One record of this type is provided for each drinking water usage location. Reading of type 13 records is terminated by a blank record. Record type 13a provides optional data for the dilution factor calculation, as described for record type 7e (see Table 2.10).

TABLE 2.13. Record Type 13 Description

Parameter Name	Format	Columns	Description
P	E10	1-10	Total population supplied by the current drinking water location: if P=0, calculate population served using GAL and GUS (described below)
DILU	E10	11-20	Dilution factor for current usage location intake (dimensionless)
T	E10	21-30	Transit time from discharge point (to the receiving water body) to water supply intake (hr)
GAL	E10	31-40	Supply rate of drinking water for current water plant (gal/d) - used only when P=0
GUS	E10	41-50	Average rate of water usage by individuals for the current water-plant service area (gal/d) - used only when P=0. GUS must be greater than zero. If both GUS and P are set to zero, the calculation proceeds with P=0, and zero doses are calculated.
SUP	5A4	51-70	A 20-character descriptive title for current water usage location

When the parameter P (total population) is set to zero, the program attempts to calculate a "population served" using the supply rate and individual usage rate (P=GAL/GUS). Therefore, when P is zero both GAL and GUS must be specified. When P is specified, neither GAL nor GUS are used, and their fields on the input record may be left blank.

Record Types 14 and 14a: Population Shoreline Usage Data

These record types provide information for calculating external exposures to the population from shoreline activities. The information included in record type 14 is indicated in Table 2.14. One record of this type is required for each usage location included in the analysis. The number of locations that may be considered for this exposure pathway is not limited. Reading of type 14 records is terminated by a blank record. Record type 14a provides optional data for the dilution factor calculation, as described for record type 7e (see Table 2.10).

TABLE 2.14. Record Type 14 Description

Parameter Name	Format	Columns	Description
SHU	E10	1-10	Total shoreline usage time for current locations (person-hr/yr)
DILU	E10	11-20	Dilution factor for current shoreline exposure location (dimensionless)
T	E10	21-30	Transit time from release point to current usage location (hr)
SWF	E10	31-40	Shore-width factor for the current shoreline usage location (dimensionless) - see record type 7 and Table 2.7 for a description of shore-width factors
LOCA	5A4	41-60	A 20-character descriptive title for current usage location

Record Types 15 and 15a: Population Swimming Usage Data

These record types provide information on usage locations where external exposure of the population from swimming is calculated. One record of type 15 is required for each usage location included in the analysis. The reading of this record type is terminated by a blank record. There is no limit to the number of usage locations that can be specified. Information in record type 15 is described in Table 2.15. Record type 15a provides optional data for the dilution factor calculation, as described for record type 7e (see Table 2.10).

Record Types 16 and 16a: Population Boating Usage Data

These record types provide information for estimating population exposure from boating. One type 16 record is provided for each usage location. There is no limit to the number of usage locations that can be specified. Reading of type 16 records is terminated with a blank record. Information from type 16 records is described in Table 2.16. Record type 16a provides optional data for the dilution factor calculation, as described for record type 7e (see Table 2.10).

Record Type 17: Irrigated Food Pathway Data

Doses that result from ingesting farm products irrigated with contaminated water are estimated using data provided on record types 17, 17a (optional), and 18. Each food product is described by one record type 17 and one or more type 18 records. One record of type 17a may follow the type 17 record if the user desires to modify food consumption parameters. (The order of these records is indicated in Figure 2.1.)

The type 17 record provides information on water usage rates and food production for one food product. Information on this record is indicated in Table 2.17.

TABLE 2.15. Record Type 15 Description

Parameter Name	Format	Columns	Description
SWU	E10	1-10	Total exposure time for swimming for the current usage location (person-hr/yr)
DILU	E10	11-20	Dilution factor for the current swimming usage location (dimensionless)
T	E10	21-30	Transit time from the release point to the current usage location (hr)
LOCA	5A4	31-50	A 20-character descriptive title for current swimming usage location

TABLE 2.16. Record Type 16 Description

Parameter Name	Format	Columns	Description
BTUSE	E10	1-10	Total exposure time for boating activities for current location (person-hr/yr)
DILU	E10	11-20	Dilution factor for current boating usage location (dimensionless)
T	E10	21-30	Transit time from release point to current usage location (hr)
LOCA	5A4	31-50	A 20-character descriptive title for current boating usage location

Record Type 17a: Food Consumption Parameters

This record type allows the user to specify annual consumption rates of food by individuals and populations. Holdup times are also provided for delays between harvest and consumption. This record type is optional and is only read if the parameter KZ on record type 17 is set greater than zero. Information for this record type is described in Table 2.18. When this record type is supplied, the given parameter values are used in place of default values which are stored in BLOCK DATA. However, supplying values on this

TABLE 2.17. Record Type 17 Description

Parameter Name	Format	Columns	Description
N	I10	1-10	Control integers used to select food type: N=0, stop reading food type information N=1, vegetables (root crops, wheat, fruit) N=2, leafy vegetables N=3, milk N=4, meat Other, print error message and stop run
KZ	I10	11-20	Control integer to allow addition of new consumption data: if KZ>0, read record type 17a
IRRIG	E10	21-30	Irrigation rate for the current food product ($L/m^2/mo$)
FFED	E10	31-40	Fraction of animal feed not produced with contaminated irrigation water - used only when N=3 or N=4
FDH20	E10	41-50	Fraction of animal drinking water not obtained from contaminated irrigation water supply - used only when N=3 or N=4
TFMG	E10	51-60	Total production of the current food product within 50 miles of the site (kg/yr or L/yr)
TGRW	E10	61-70	Growing period for current food product (d) - If not specified, default values (RG-TE15) will be used as follows: vegetables 60 leafy vegetables 60 milk 30 meat 30
YLD	E10	71-80	Crop yield for current food product (kg/m^2) - If not specified, default values (RG-TE15) will be used as follows: vegetables 2.0 leafy vegetables 2.0 milk 0.7 meat 0.7

TABLE 2.18. Record Type 17a Description

Parameter Name	Format	Columns	Description
ACON	E10	1-10	Rate of current food product consumption by a maximally exposed adult (kg/yr)
TCON	E10	11-20	Rate of current food product consumption by a maximally exposed teen (kg/yr)
CCON	E10	21-30	Rate of current food product consumption by a maximally exposed child (kg/yr)
AC	E10	31-40	Average rate of current food product consumption by an adult member of the local population (kg/yr)
TC	E10	41-50	Average rate of current food product consumption by a teen from the local population (kg/yr)
CC	E10	51-60	Average rate of current food product consumption by a child of the local population (kg/yr)
HOLD	E10	61-70	Holdup time between harvest and consumption of current food product by average members of the population (hr)
HLD1	E10	71-80	Holdup time between harvest and consumption of current food product by a maximally exposed individual (hr)

TABLE 2.19. Record Type 17a Parameter Default Values (RG-TD1, TE4, TE5, TE15)

Parameter	Unit	Vegetables	Leafy Vegetables	Milk	Meat
ACON	kg/yr	520	64	310	110
TCON	kg/yr	630	42	400	65
CCON	kg/yr	520	26	330	41
AC	kg/yr	190	30	110	95
TC	kg/yr	240	20	200	59
CC	kg/yr	200	10	170	37
HOLD	hr	1440	48	96	480
HLD1	hr	336	24	48	480

TABLE 2.20. Record Type 18 Description

Parameter Name	Format	Columns	Description
DILU	E10	1-10	Dilution factor for irrigation water usage location for the current food product (dimensionless)
PROD	E10	11-20	Production rate for the current food product using current irrigation water supply (kg/yr or L/yr)
T	E10	21-30	Transit time from effluent release point to the current usage location (hr)
LOC	5A4	31-50	A 20-character description title for current usage location

record type does not change default values. Default values will be used when subsequent food products defined with a type 17 record do not specify a type 17a record.

Parameters are provided for "maximum" and "average" consumption rates for adults, teens, and children. The maximum values are used for estimating doses to maximally exposed individuals, and the average values are used for population dose estimates. Default values for record type 17a parameters are given in Table 2.19. (These parameter values are stored in BLOCK DATA array FLOODP.)

Record Types 18 and 18a: Food Product Water Usage Location Data

These record types provide information on water usage locations and food production rates for the current food product as defined on record type 17. Sets of type 18 records are supplied with each type 17 record. Information provided on record type 18 is described in Table 2.20. A maximum of 19 type 18 records may be supplied with each type 17 record. Reading of type 18 records is terminated with a blank record. One type 18a record may be optionally provided with each type 18 record. Record type 18a provides dilution factor calculation data as described for record type 7e (see Table 2.10).

Records Type 19 and 19a: Biota Exposure Location Data

These record types provide information for calculating doses to biota: fish, invertebrates, algae, muskrats, raccoons, herons, and ducks. A report giving doses to each of these species is written for each exposure location specified. One record of type 19 is used for each usage location. There is no limit to the number of type 19 records that can be supplied. Input of type 19 records is terminated by a blank record. This blank record also indicates the end of input for the current case. If no further cases are to be considered, then no additional records are needed. Information provided on record type 19 is described in Table 2.21. Record type 19a provides optional data for the dilution factor calculation, as described for record type 7e (see Table 2.10). One record of type 19a is read immediately following each type 19 record for which DILU is negative.

For easy reference, a summary of record types 1-19 is provided in Table 2.22.

TABLE 2.21. Record Type 19 Description

Parameter Name	Format	Columns	Description
DILU	E10	1-10	Dilution factor for current exposure location for biota (dimensionless)
T	E10	11-20	Transit time from the effluent release location to current exposure location (hr)
LOC	5A4	21-40	A 20-character title for current exposure location

TABLE 2.22. Input Record Description Summary

Record Type and Description	Field	Format	Parameter Description
1 - Case title	3-80	78A1	ITITLE, descriptive case title
2 - Site characteristics	1-10	I10	LT, water type selection: LT=0, salt LT>0, fresh
	11-20	E10	CFS, reactor effluent discharge rate
	21-30	E10	UML, source term multiplier
	31-40	I10	LCT, % contribution control: if LCT>0, print
	41-50	I10	IFLAG, BLOCK DATA change/print control
3 - Site population	1-10	E10	POP, total population with 50 miles
	11-20	E10	TR, control parameter for reading record 3a
3a - Site population fractions	1-10	E10	PERA, fraction of adults in population
	11-20	E10	PERT, fraction of teens in population
	21-30	E10	PERC, fraction of children in population
4 - Source term title	3-80	78A1	ISOR, source term title
5 - Radionuclide release information	3-4	A2	IA, radionuclide element symbol
	5-9	5A1	IM, radionuclide mass symbol
	11-20	E10	QQ, radionuclide release rate (Ci/yr)
	21-30	E10	R, radionuclide reconcentration factor
6 - Impoundment reconcentration model data	1-10	I10	M, reconcentration model index
	11-20	E10	QSUBB, discharge rate to receiving water
	21-30	E10	VSUBT, total impoundment volume
7 - ALARA analysis usage usage location data	1-10	I10	N, index for reading record types 7a - 7d
	11-20	E10	SWF, shore-width factor
	21-30	E10	DILU, dilution factor - aquatic food and boating
	31-40	E10	SHD, dilution factor - shoreline and swimming

Table 2.22 (Contd)

Record Type and Description	Field	Format	Parameter Description
	41-50	E10	DWD, dilution factor - drinking water
	51-60	E10	T, transit time - all pathways except drinking water
	61-70	E10	TD, transit time - drinking water
7a - Adult usage and consumption data for ALARA analysis	1-10	E10	FIUS, rate of fish consumption by adults (kg/yr)
	11-20	E10	CRUS, rate of invertebrate consumption by adults (kg/yr)
	21-30	E10	ALUS, rate of aquatic-plant consumption by adults (kg/yr)
	31-40	E10	WUSE, rate of drinking-water consumption by adults (L/yr)
	41-50	E10	SHU, shoreline usage by adults (hr/yr)
	51-60	E10	SWU, swimming usage by adults (hr/yr)
	61-70	E10	BUSE, boating usage by adults (hr/yr)
7b - Teen usage and consumption data for ALARA analysis	(same as record type 7a for teens, for parameters TAF, TAC, TAA, TAW, TAS, TASW, and TAB)		
7c - Child usage and consumption data for ALARA analysis	(same as record type 7a for children, for parameters CHF, CHC, CHA, CHW, CHS, CHSW, and CHB)		
7d - Infant usage and consumption data for ALARA analysis	(same as record type 7a for infants, for parameters TDF, TDC, TDA, TDW, TDS, TDSW, and TDB)		
7e - Surface water dilution data for aquatic food and boating	1-10	I10	IFLAG, river/lake index
	11-20	E10	FV, surface water velocity (ft/sec)
	21-30	E10	DP, surface water depth (ft)
	31-40	E10	DX, downstream distance (ft)
	41-50	E10	YR, offshore distance (ft)
	51-60	E10	BW, river width (ft) or lake discharge depth (ft)
7f - Surface water dilution data for shoreline and swimming	(same as record type 7e)		

Table 2.22 (Contd)

Record Type and Description	Field	Format	Parameter Description
7g - Surface water dilution data for drinking water	(same as record type 7e)		
8 - Selected usage location data	1-10	I10	N, index for reading record types 8a - 8d
	11-20	E10	DILU, dilution factor - all pathways
	21-30	E10	T, transit time (hr)
	31-40	E10	SWF, shore-width factor
	41-50	5A4	LOCA, title for usage location
8a - Adult usage and consumption data	(same as record type 7a)		
8b - Teen usage and consumption data	(same as record type 7b)		
8c - Child usage and consumption data	(same as record type 7c)		
8d - Infant usage and consumption data	(same as record type 7d)		
8e - Surface water dilution data for special locations	(same as record type 7e)		
9 - Sport-harvest fishing usage location data	1-10	E10	CATH, annual local harvest (kg/yr)
	11-20	E10	DILU, dilution factor
	21-30	E10	T, transit time (hr)
	31-50	5A4	LOC, location title
9a - Surface water dilution data for sport fishing	(same as record type 7e)		
10 - Commercial-harvest fishing usage location data	(same as record type 9 for commercial-harvest fishing)		
10a - Surface water dilution data for commercial fishing	(same as record type 7e)		

Table 2.22 (Contd)

Record Type and Description	Field	Format	Parameter Description
11 - Invertebrate sport harvest usage location data	(same as record type 9 for invertebrate sport harvest)		
11a - Surface water dilution data for sport invertebrate harvest	(same as record type 7e)		
12 - Invertebrate commercial harvest usage location data	(same as record type 9 for invertebrate commercial harvest)		
12a - Surface water dilution data for commercial invertebrate harvest	(same as record type 7e)		
13 - Population drinking-water usage location	1-10	E10	P, population using water-supply system
	11-20	E10	DILU, dilution factor
	21-30	E10	T, transit time (hr)
	31-40	E10	GAL, water supply rate (gal/d)
	41-50	E10	GUS, average individual usage rate (gal/d)
	51-70	5A4	SUP, usage location title
13a - Surface water dilution data for population drinking water	(same as record type 7e)		
14 - Population shoreline usage data	1-10	E10	SHU, total shoreline usage time (person-hr/yr)
	11-20	E10	DILU, dilution factor
	21-30	E10	T, transit time
	31-40	E10	SWF, shore-width factor
	41-60	5A4	LOCA, usage location title
14a - Surface water dilution data for population shoreline usage	(same as record type 7e)		
15 - Population swimming usage data	1-10	E10	SWU, total swimming usage time (person-hr/yr)

Table 2.22 (Contd)

Record Type and Description	Field	Format	Parameter Description
	11-20	E10	DILU, dilution factor
	21-30	E10	T, transit time (hr)
	31-40	5A4	LOCA, usage location title
15a - Surface water dilution data for population swimming usage	(same as record type 7e)		
16 Population boating usage data	1-10	E10	BTUSE, total boating usage time (person-hr/yr)
	11-20	E10	DILU, dilution factor
	21-30	E10	T, transit time (hr)
	31-50	5A4	LOCA, usage location title
16a - Surface water dilution data for population boating usage	(same as record type 7e)		
17 - Irrigation food pathway data	1-10	I10	N, pathway selection index: 0<N<4
	11-20	I10	KZ, index to cause reading of record 17a
	21-30	E10	IRRIG, irrigation rate (L/m^2/mo)
	31-40	E10	FFED, fraction of animal feed not contaminated
	41-50	E10	FDH2O, fraction of animal water not contaminated
	51-60	E10	TFMG, total production within 50 miles (kg/yr)
	61-70	E10	TGRW, irrigated growing period (d)
	71-80	E10	YLD, crop yield (kg/m^2)
17a - Food consumption parameters	1-10	E10	ACON, maximum adult consumption rate (kg/yr)
	11-20	E10	TCON, maximum teen consumption rate (kg/yr)
	21-30	E10	CCON, maximum child consumption rate (kg/yr)
	31-40	E10	AC, average adult consumption rate (kg/yr)
	41-50	E10	TC, average teen consumption rate (kg/yr)
	51-60	E10	CC, average child consumption rate (kg/yr)
	61-70	E10	HOLD, holdup time for average population (hr)

Table 2.22 (Contd)

Record Type and Description	Field	Format	Parameter Description
	71-80	E10	HLD1, holdup time for maximum individual (hr)
17a - Food consumption parameters	1-10	E10	ACON, maximum adult consumption rate (kg/yr)
	11-20	E10	TCON, maximum teen consumption rate (kg/yr)
	21-30	E10	CCON, maximum child consumption rate (kg/yr)
	31-40	E10	AC, average adult consumption rate (kg/yr)
	41-50	E10	TC, average teen consumption rate (kg/yr)
	51-60	E10	CC, average child consumption rate (kg/yr)
	61-70	E10	HOLD, holdup time for average population (hr)
	71-80	E10	HLD1, holdup time for maximum individual (hr)
18 - Food product irrigation-water usage location data	1-10	E10	DILU, dilution factor
	11-20	E10	PROD, production rate for location (kg/yr)
	21-30	E10	T, transit time (hr)
	31-40	5A4	LOC, usage location title
18a - Surface water dilution data for irrigation usage	(same as record type 7e)		
19 - Biota exposure location data	1-10	E10	DILU, dilution factor
	11-20	E10	T, transit time (hr)
	21-40	5A4	LOC, usage location title
19a - Surface water dilution data for biota exposure	(same as record type 7e)		

2.1.2 BLOCK DATA Change Records

Several parameters used by LADTAP II have preset values that normally will not require changes by the user. These parameters include age-specific consumption rates, pathway usage parameters, and bioaccumulation factors for each aquatic and terrestrial food pathway. A few of these parameters may be changed on optional case-specific input records as described in Section 2.1.1

(see record types 3a, 7a-d, and 17a). Any BLOCK DATA parameter can also be changed on "BLOCK DATA Change Records" as indicated in Figure 2.1. These change records are read using the Floating Index Data Operations (FIDO) system of subroutines which is a general input processor that allows modification of BLOCK DATA parameter values. Details for the use of the FIDO input processor are described in this section as applied to the BLOCK DATA parameters of LADTAP II.

For convenience, the parameters of common BLOCK DATA have been arranged in groups of variables that have similar definitions or uses. This grouping, used with the FIDO input system, provides the user with a means to override parameter defaults using site-specific data. FIDO identifies each parameter in the input system by referencing the group number and the position of the parameter within the group. This is done using the special notation system defined below. The grouping of parameters and their positions within FIDO are indicated in Table 2.23. The number in brackets by the group number indicates the number of values included in the group.

The FIDO input processor is designed to enter or modify large data arrays with minimum effort. Special advantage is taken of patterns of repetition or symmetry wherever possible. FIDO was developed by W. A. Rhoades and W. W. Engle at Atomics International in the early 1960's (no reference available). Since then, numerous features requested by users have been added, including a free-field option. The description of FIDO presented here only considers the free-field option because this option is the easiest to use and it satisfies the needs of the LADTAP II BLOCK DATA parameters.

Each FIDO input record begins with the number of the group to be modified (as indicated in Table 2.23). This number may begin in any column and is followed immediately (no spaces) by two asterisks (**). The remaining entries on the record define new parameter values for some or all of the parameters within the indicated FIDO group. Key letters may also be used to specify parameters. The key letters are defined in sets that initiate specific actions. These actions include setting values into given positions (A), setting remaining positions to a constant (F), repeating a constant at specific locations

TABLE 2.23. Grouping of Common BLOCK DATA Parameters

FIDO Group Number	Parameter Position	Description (Default Value, Parameter Name Source)
1 [16]		General Parameters
	1	Adult fraction of population (0.71, PERA)
	2	Teenage fraction of population (0.11, PERT)
	3	Child fraction of population (0.18, PERC)
	4	Total U.S. population (2.6E+8, US)
	5	Midpoint of plant life (20 yr, PLNTLF)
	6	Process time of aquatic foods (24 hr, TPROCW)
	7	Process time in water supply system (12 hr, TPROCF)
	8	This position not currently used
	9	This position not currently used
	10	Milk animal's consumption of pasture (50 kg/d, Q1, RG-TE3)
	11	Milk animal's consumption of water (60 L/d, Q2, RG-TE3)
	12	Beef animal's consumption of pasture (50 kg/d, Q3, RG-TE3)
	13	Beef animal's consumption of water (50 L/d, Q4, RG-TE3)
	14	Vegetation capture fraction (0.25, FRAC, RG-TE15)
	15	Weathering half-time of foliar deposition (14 d, TWTH, RG-TE15)
	16	Density thickness of root zone (240 kg/m^2, RZONE, RG-TE15)
2 [7]		Maximum infant usage parameters
	1	Consumption of fish (0 kg/yr, TDF)
	2	Consumption of freshwater invertebrates (0 kg/yr, TDC)
	3	Consumption of aquatic plants (0 kg/yr, TDA)
	4	Consumption of water (330 L/yr, TDW)
	5	Shoreline usage (0 hr/yr, TDS)
	6	Swimming usage (0 hr/yr, TDSW)
	7	Boating usage (0 hr/yr, TDB)
3 [7]		Maximum child usage parameters (RG-TE5)
	1	Consumption of fish (6.9 kg/yr, CHF)
	2	Consumption of freshwater invertebrates (0 kg/yr, CHC)
	3	Consumption of aquatic plants (0 kg/yr, CHA)
	4	Consumption of water (510 L/yr, CHW)
	5	Shoreline exposure (14 hr/yr, CHS)
	6	Swimming usage (0 hr/yr, CHSW)
	7	Boating usage (0 hr/yr, CHB)
4 [7]		Maximum teen usage parameters (RG-TE5)
	1	Consumption of fish (16 kg/yr, TAF)
	2	Consumption of freshwater invertebrates (0 kg/yr, TAC)
	3	Consumption of aquatic plants (0 kg/yr, TAA)
	4	Consumption of water (510 L/yr, TAW)
	5	Shoreline usage (67 hr/yr, TAS)
	6	Swimming usage (0 hr/yr, TASW)
	7	Boating usage (0 hr/yr, TAB)
5 [7]		Maximum adult usage parameters (RG-TE5)
	1	Consumption of fish (21 kg/yr, FIUS)
	2	Consumption of freshwater invertebrates (0 kg/yr, CRUS)
	3	Consumption of aquatic plants (0 kg/yr, ALUS)
	4	Consumption of water (730 L/yr, WUSE)
	5	Shoreline usage (12 hr/yr, SHU)
	6	Swimming usage (0 hr/yr, SWU)
	7	Boating usage (0 hr/yr, BUSE)

Table 2.23 (Contd)

FIDO Group Number	Parameter Position	Description (Default Value, Parameter Name Source)
6 [3]		Saltwater invertebrate consumption (RG-TE5)
	1	Maximum child (1.7 kg/yr, CHCSW)
	2	Maximum teen (3.8 kg/yr, TACSW)
	3	Maximum adult (5.0 kg/yr, CRUSSW)
7 [8]		Irrigated vegetable parameters (Parameter values for FIDO groups 7-10 are stored in parameter array FLOODP)
	1	Average adult consumption (190 kg/yr, RG-TE4)
	2	Average teen consumption (240 kg/yr, RG-TE4)
	3	Average child consumption (200 kg/yr, RG-TE4)
	4	Maximum adult consumption (520 kg/yr, RG-TE5)
	5	Maximum teenager consumption (630 kg/yr, RG-TE5)
	6	Maximum child consumption (520 kg/yr, RG-TE5)
	7	Process time for average individuals (1,440 hr, RG-TE15)
	8	Process time for maximum individuals (336 hr, RG-TE15)
8 [8]		Leafy vegetable parameters (parameter array FLOODP)
	1	Average adult consumption (30 kg/yr)
	2	Average teen consumption (20 kg/yr)
	3	Average child consumption (10 kg/yr)
	4	Maximum adult consumption (64 kg/yr, RG-TE5)
	5	Maximum teen consumption (42 kg/yr, RG-TE5)
	6	Maximum child consumption (26 kg/yr, RG-TE5)
	7	Process time for average individuals (48 hr, RG-TE15)
	8	Process time for maximum individuals (24 hr, RG-TE15)
9 [8]		Milk parameters (parameter array FLOODP)
	1	Average adult consumption (110 L/yr, RG-TE4)
	2	Average teen consumption (200 L/yr, RG-TE4)
	3	Average child consumption (170 L/yr, RG-TE4)
	4	Maximum adult consumption (310 L/yr, RG-TE5)
	5	Maximum teen consumption (400 L/yr, RG-TE5)
	6	Maximum child consumption (330 L/yr, RG-TE5)
	7	Process time for average individual (96 hr, RG-TE15)
	8	Process time for maximum individual (48 hr, RG-TE15)
10 [8]		Meat parameters (parameter array FLOODP)
	1	Average adult consumption (95 kg/yr, RG-TE4)
	2	Average teen consumption (59 kg/yr, RG-TE4)
	3	Average child consumption (37 kg/yr, RG-TE4)
	4	Maximum adult consumption (110 kg/yr, RG-TE5)
	5	Maximum teen consumption (65 kg/yr, RG-TE5)
	6	Maximum child consumption (41 kg/yr, RG-TE5)
	7	Process time for average individual (480 hr, RG-TE15)
	8	Process time for maximum individual (480 hr, RG-TE15)
11 [12]		Parameters for sport and commercial fish and invertebrate harvests (parameter array WHYP)
	1	Process time between harvest and consumption of sport catch (168 hr, RG-TD1)
	2	Process time between harvest and consumption of commercial catch (240 hr, RG-TD1)

Table 2.23 (Contd)

FIDO Group Number	Parameter Position	Description (Default Value, Parameter Name Source)
	3	Commercial harvest of freshwater fish (4.4E+7 kg)
	4	Commercial harvest of freshwater invertebrates (2.3E+6 kg)
	5	Commercial harvest of saltwater fish (6.58E+8 kg)
	6	Commercial harvest of saltwater invertebrates (4.1E+8 kg)
	7	Average adult's consumption of fish (6.9 kg, RG-TE4)
	8	Average teenager's consumption of fish (5.2 kg, RG-TE4)
	9	Average child's consumption of fish (2.2 kg, RG-TE4)
	10	Average adult's consumption of invertebrates (1.0 kg, RG-TE4)
	11	Average teenager's consumption of invertebrates (0.75 kg, RG-TE4)
	12	Average child's consumption of invertebrates (0.33 kg, RG-TE4)
12 [3]		Average individual's annual water consumption (parameter array WATERP)
	1	Adult (370 L/yr, RG-TE4)
	2	Teenager (260 L/yr, RG-TE4)
	3	Child (260 L/yr, RG-TE4)
13 [100]		Bioaccumulation factors for freshwater fish (FACCF, RG-TA1) (One position used for each element - the position for an element is equal to the atomic number of the element. Default values for groups 13-21 are given in Table 3.2.1)
14 [100]		Bioaccumulation factors for freshwater invertebrates (FACCI, RG-TA1) (Same position usage as group 13)
15[100]		Bioaccumulation factors for freshwater plants (FACCA) (Same position usage as group 13)
16[100]		Bioaccumulation factors for saltwater fish (SACCF, RG-TA1) (Same position usage as group 13)
17[100]		Bioaccumulation factors for saltwater invertebrates (SACCI, RG-TA1) (Same position usage as group 13)
18[100]		Bioaccumulation factors for saltwater plants (SACCA) (Same position usage as group 13)
19[100]		Transfer coefficient for meat production (d/kg ZMET, RG-TE1) (Same position usage as group 13)
20[100]		Transfer coefficient for milk production (d/L ZMLK, RG-TE1) (Same position usage as group 13)
21[100]		Soil to plant transfer coefficient (SOIL, RG-TE1) (Same position usage as group 13)

(R) or setting positions to zero (Z). The use of each of these key letters is defined in Table 2.24. Each key letter is included as a set with one or two numerical values and uses the following format: AM, FM, NRM, NZ. Each of these sets must not have embedded spaces and must be preceded and followed by

TABLE 2.24. Use of Key Letters for Preparing FIDO Input Records

Key Letter	Description of Use
A	This letter defines the first position of the array for which actions will be taken. The letter is followed (no spaces) by the position number (as defined in Table 2.1.21) of the parameter of interest, AM, where M is the position number. The position definition may be followed by numerical values or by the specific key letters F, R, or Z.
E	This letter is the last entry on a record and causes the remaining positions to be skipped. Ending a record with E satisfies the requirement of specifying all positions of a FIDO group.
F	This letter causes remaining positions of a FIDO group to be filled with the numerical value that immediately follows the F. No blank spaces are allowed between the F and the number. When an F designation follows the group number and double asterisk, the entire group is set to the defined numerical value.
R	The R key letter is preceded and followed by numbers (no spaces), NRM. The value M is repeated N times starting in the current position of the FIDO group.
T	Reading of FIDO input records is terminated with a T as the last entry on the last record.
Z	A Z is preceded by one number (no spaces), NZ. This sets N positions to zero.

at least one space. In preparing FIDO records for a particular group, the input processor expects data to start at the first position and proceed in sequence to the end of the group. For example, the seven values of FIDO group 2 may be defined by seven numerical values following the group identification (2**). The format limitations for specifying numerical values are as follows:

1. Only nine digits may be used, including the decimal but excluding the exponential field.

2. Numbers must not have imbedded blanks.

3. Exponential representations may use the following forms: 1.0E+4, 1.0E4, 1.0+4, 1E+4, or 1+4.

Two important points must be followed in preparing FIDO input records.

1. The final numerical value provided must be for the last position of the FIDO group.

2. The FIDO input record set must be terminated by a T as the last entry on the last card.

An easy solution to the first requirement is to end each record with an E when the last position changed is not the last position of the group.

Table 2.25 gives several examples of FIDO input records.

TABLE 2.25. Sample FIDO Input Records

Record Image	Description
1** A5 15. E	Set position 5 of group 1 to 15.
5** A2 24. 2Z E	Set position 2 of group 5 to 24., and set positions 3 and 4 to 0.
1** A12 20. A16 300.	Set position 12 of group 1 to 20. and position 16 to 300. Note that an E is not needed because the last position defined (16) is the last position of the group.
4** 2.0 2Z E	Set position 1 of group 4 to 2.0 and positions 2 and 3 to 0.
20** A54 F1.0	Set all positions 54 through 100 of group 20 to 1.0.
19** A54 5R1.0 E T	Set positions 54, 55, 56, 57, and 58 of group 19 to 1.0, and stop reading of FIDO input.
6** 2. 4. 6.	Set the group 6 positions to 2., 4., and 6.
T	Stop reading FIDO input.

2.2 OUTPUT REPORTS

The LADTAP II program uses 23 distinct reports to present information; 5 reports are related to parameter values, and 18 reports give results of the environmental dose analyses. The number of reports generated for a given calculation is variable and is controlled by input information supplied by the user (as described in Section 2.1).

This section presents examples of the 23 report types with examples from the sample problems presented in Section 2.3. The major features and purpose of each report are described in the following discussion. Table 2.26 is a summary list of the 23 report types. Items of special interest on several of the sample output reports are marked by circled numbers. These circled numbers are not generated by the computer, but have been added to aid in the discussion of the reports.

TABLE 2.26. Output Reports Prepared by LADTAP II

Report	Description
1	BLOCK DATA change summary
2	Current BLOCK DATA value list
3	Site definition data
4	Dose factor library
5	Dose factors used for source inventory radionuclides
6	ALARA analysis of adult individual doses for aquatic food ingestion and external exposures
7	Same as report 6 for teens
8	Same as report 6 for children
9	Same as report 6 for infants
10	Adult individual doses at selected water usage locations for same pathways as report 6
11	Same as report 10 for teens
12	Same as report 10 for children
13	Same as report 10 for infants

Table 2.26 (Contd)

Report	Description
14	Population dose from sport harvest of fish for adult, teen, and child age groups
15	Same as report 14 for commercial harvest of fish
16	Same as report 14 for sport harvest of invertebrates
17	Same as report 14 for commercial harvest of invertebrates
18	Population dose from drinking water (includes a sub-report for tritium if included in source inventory)
19	Population doses from recreational activities
20	Individual and population dose report for terrestrial food ingestion (including subtables for NEPA and ALARA population doses)
21	Doses to biota
22	Results of cost-benefit analysis
23	Special report for ALARA analysis for fish and drinking water ingestion normalized to release

2.2.1 Reports 1 and 2: BLOCK DATA Information

These reports are printed by the FIDO subroutines when BLOCK DATA values are changed (report 1) or when requested by the input control integer IFLAG (on record type 2). Report 1 is a cryptic summary of input change records as seen by the FIDO processor. Report 2 is a complete list of values for BLOCK DATA parameters that are used in the current calculation (unless further changes are made to special parameters as allowed on record types 3a, 7a-d, or 17a). Figure 2.2 presents a sample report 1 and indicates changes made to parameters in FIDO groups 1, 5, 13, 19, and 20. Item 1 (circled number 1) of Figure 2.2 indicates the FIDO group number. The number of entries specified on each change record is also given (item 2). Figure 2.3 presents the corresponding list for report 2. In this figure the FIDO group number (item 1) appears above the group data column and the position number of each data value (item 2) appears on the left of the page. Note that for data supplied by element, the position number equals the atomic number of the element (for FIDO groups 13 through 21). Only the first page of the BLOCK DATA report is given in Figure 2.3; a complete list is provided on the Appendix B microfiche in the pocket of the back cover. (These two figures present reports that are generated for sample problem 3 of Section 2.3).

2.2.2 Report 3: Site Definition Data

Report 3 summarizes selected site descriptive parameters that are supplied by the user on input record types 1, 2, 3, and 3a. This report is the first that appears after the BANNER page when BLOCK DATA reports have not been requested. Figure 2.4 presents a sample report 3 as generated by sample problem 1. Sample report 3 contains the title record (item 1), the effluent discharge rate (parameter (CFS of record type 2 - item 2) the source term multiplier (parameter UML of record type 2 - item 3), the total population within 50 miles of the site (parameter POP of record type 3 - item 4), the

①	②
1* ARRAY	16 ENTRIES READ
5* ARRAY	7 ENTRIES READ
1* ARRAY	16 ENTRIES READ
13* ARRAY	100 ENTRIES READ
1* ARRAY	16 ENTRIES READ
19* ARRAY	100 ENTRIES READ
20* ARRAY	100 ENTRIES READ
0T	

FIGURE 2.2. Sample Output Report 1: BLOCK DATA Change Summary

EDIT OF PARAMETER DATA DEFAULTS - SEE MANUAL FOR A DESCRIPTION

	(1) 1 *	2 *	3 *	4 *	5 *	6 *
1	1.0000E+00	0.0000E+00	6.9000E+00	1.6000E+01	2.1000E+01	1.7000E+00
2	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	2.4000E+01	3.8000E+00
3	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	5.0000E+00
4	2.6000E+08	3.3000E+02	5.1000E+02	5.1000E+02	0.0000E+00	
5	1.5000E+01	0.0000E+00	1.4000E+01	6.7000E+01	1.0000E+01	
6	2.4000E+01	0.0000E+00	0.0000E+00	0.0000E+00	2.0000E+01	
7	1.2000E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	
8 (2)	2.0000E+00					
9	3.0000E+01					
10	5.0000E+01					
11	6.0000E+01					
12	2.0000E+01					
13	5.0000E+01					
14	2.5000E-01					
15	1.4000E+01					
16	3.0000E+02					

	7 *	8 *	9 *	10 *	11 *	12 *
1	1.9000E+02	3.0000E+01	1.1000E+02	9.5000E+01	1.6800E+02	3.7000E+02
2	2.4000E+02	2.0000E+01	2.0000E+02	5.9000E+01	2.4000E+02	2.6000E+02
3	2.0000E+02	1.0000E+01	1.7000E+02	3.7000E+01	4.4000E+07	2.6000E+02
4	5.2000E+02	6.4000E+01	3.1000E+02	1.1000E+02	2.3000E+06	
5	6.3000E+02	4.2000E+01	4.0000E+02	6.5000E+01	6.5800E+08	
6	5.2000E+02	2.6000E+01	3.3000E+02	4.1000E+01	4.1000E+08	
7	1.4400E+03	4.8000E+01	9.6000E+01	4.8000E+02	6.9000E+00	
8	3.3600E+02	2.4000E+01	4.8000E+01	4.8000E+02	5.2000E+00	
9					2.2000E+00	
10					1.0000E+00	
11					7.5000E-01	
12					3.3000E-01	

	13 *	14 *	15 *	16 *	17 *	18 *	19 *	20 *	21 *
1	9.0000E-01	9.0000E-01	9.0000E-01	9.0000E-01	9.3000E-01	9.3000E-01	1.2000E-02	1.0000E-02	4.8000E+00
2	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	2.0000E-02	2.0000E-02	5.0000E-02
3	5.0000E-01	4.0000E+01	3.0000E+00	5.0000E-01	5.0000E-01	3.0000E+00	1.0000E-02	5.0000E-02	8.3000E-04
4	2.0000E+00	1.0000E+01	2.0000E+01	2.0000E+02	2.0000E+02	1.0000E+03	1.0000E-03	1.0000E-04	4.2000E-04
5	2.2000E-01	5.0000E+01	2.2000E+00	2.2000E-01	4.4000E-01	2.2000E+00	8.0000E-04	2.7000E-03	1.2000E-01
6	4.6000E+03	9.1000E+03	4.6000E+03	1.8000E+03	1.4000E+03	1.8000E+03	3.1000E-02	1.2000E-02	5.5000E+00
7	1.5000E+05	1.5000E+05	1.3000E+04	6.0000E+04	1.7000E+04	1.0000E+04	7.7000E-02	2.2000E-02	7.5000E+00
8	9.2000E-01	9.2000E-01	9.2000E-01	9.6000E-01	9.6000E-01	9.6000E-01	1.6000E-02	2.0000E-02	1.6000E+00
9	1.0000E+01	1.0000E+02	2.0000E+00	3.6000E+00	3.6000E+00	1.4000E+00	1.5000E-01	1.4000E-02	6.5000E-04
10	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	2.0000E-02	2.0000E-02	1.4000E-01
11	1.0000E+02	2.0000E+02	5.0000E+02	6.7000E-02	1.9000E-01	9.5000E-01	3.0000E-02	4.0000E-02	5.2000E-02
12	5.0000E+01	1.0000E+02	1.0000E+02	7.7000E-01	7.7000E-01	7.7000E-01	5.0000E-03	1.0000E-02	1.3000E-01
13	1.0000E+01	6.3000E+01	4.2000E+02	1.0000E+01	6.0000E+01	6.0000E+02	1.5000E-03	5.0000E-04	1.8000E-04
14	2.5000E+00	2.5000E+01	1.3000E+02	1.0000E+01	3.3000E+01	6.7000E+01	4.0000E-05	1.0000E-04	1.5000E-04
15	1.0000E+05	2.0000E+04	5.0000E+05	2.9000E+04	3.0000E+04	3.0000E+03	4.6000E-02	2.5000E-02	1.1000E+00
16	7.5000E+02	1.0000E+02	1.0000E+02	1.7000E+00	4.4000E-01	4.4000E-01	1.0000E-01	1.8000E-02	5.9000E-01
17	5.0000E+01	1.0000E+02	5.0000E+01	1.3000E-02	1.9000E-02	7.6000E-02	8.0000E-02	5.0000E-02	5.0000E+00
18	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	2.0000E-02	2.0000E-02	6.0000E-01
19	1.0000E+03	8.3000E+02	6.7000E+02	1.1000E+01	6.6000E+00	2.6000E+01	1.2000E-02	1.0000E-02	3.7000E-01
20	4.0000E+01	3.3000E+02	1.3000E+02	5.0000E-01	1.3000E+01	5.0000E+00	4.0000E-03	8.0000E-03	3.6000E-02
21	2.0000E+00	1.0000E+03	1.0000E+04	2.0000E+00	1.0000E+04	1.0000E+05	1.6000E-02	5.0000E-06	1.1000E-03
22	1.0000E+03	3.0000E+03	5.0000E+02	1.0000E+03	1.0000E+03	2.0000E+03	3.1000E-02	5.0000E-06	5.4000E-05
23	1.0000E+01	3.0000E+03	1.0000E+02	1.0000E+01	5.0000E+01	1.0000E+02	2.3000E-03	1.0000E-03	1.3000E-03
24	2.0000E+02	2.0000E+03	4.0000E+03	4.0000E+02	2.0000E+03	2.0000E+03	2.4000E-03	2.2000E-03	2.5000E-04
25	4.0000E+02	9.0000E+04	1.0000E+04	5.5000E+02	4.0000E+02	5.5000E+03	8.0000E-04	2.5000E-04	2.9000E-02

FIGURE 2.3. Sample Output Report 2: Current BLOCK DATA Values

population age fractions (default values or from record type 3A - item 5) and the site type (item 6). The site type is given as either "Freshwater" or "Saltwater" depending on the value given for parameter LT of record type 2.

2.2.3 Report 4: Dose Factor Library Data

The user may request that reports be printed describing data in the dose factor library (see parameter IFLAG of input record type 2). Such reports contain dose factors and other data contained in the library as follows:

Report	Pages	Description
4a	16	Dose factors for ingestion by adults, teens, children, and infants
4b	4	External dose factors for exposure to contaminated ground
4c	4	External dose factors for immersion in contaminated water
4d	4	Radiological decay constant (hr^{-1})
4e	4	Effective energy deposited as a function of organ radius

Each of these reports lists values by radionuclide. Partial listings of these five reports are given in Figures 2.5 through 2.9. Complete listings of these reports are included in the Appendix B listing of sample problem 3 output. The dose factors for ingestion are presented for each of the four age groups, four pages per age group in the order adult, teen, child, and infant. The radiological decay constants (hr^{-1}) printed in report 4d are calculated from

```
(1) SAMPLE PROBLEM 1 - ALL PATHWAYS INCLUDED

(2) DISCHARGE=3.15E+03 CFS            (3) SOURCE TERM MULTIPLIER=1.00E+00

(4) 50-MILE POPULATION=2.20E+06       (5) FRACTION ---  ADULT=0.71
                                                        TEENAGER=0.11
                                                        CHILD=0.18

(6) FRESHWATER SITE
```

FIGURE 2.4. Sample Output Report 3: Site Definition Data

library values (sec^{-1}). The effective deposited energy values are only used to estimate dose factors for ingestion by biota as described in Section 3.

2.2.4 Report 5: Source Inventory Data

This report presents data pertinent to the radionuclides provided in the source inventory. Figure 2.10 presents a sample report 5. This report includes the source term title (item 1 as presented on input record type 4), the reconcentration calculation model used (item 2), a table of radionuclide names (item 3), release rates (item 4), ingestion dose factors (item 5), external dose factors for shoreline exposure (item 6), reconcentration factors (item 7), and a summary of activity released (item 8). Four tables of ingestion factors are printed, one for each age group. External dose factors are printed only once because the external dose factors for the adult age group are used for all age groups. The activity release rates (item 4) include the source terms multiplication factor (see input record type 2).

2.2.5 Reports 6, 7, 8, and 9: Results of ALARA Analysis

Report types 6 through 9 give the results of the ALARA analysis for individual exposure from all aquatic pathways. Figure 2.11 shows a sample report 6 as generated for sample problem 1. This report contains heading information identifying the ALARA analysis and age group (item 1), the individual organ doses by pathway (item 2), the usage parameters supplied by pathway (item 3), and a subreport giving the percentages of radionuclide contribution to each organ dose (item 4). The pathways included in each portion of this report are determined by parameters supplied either as default values or as changes to input records 7a - 7d. Reports 7, 8, and 9 are similar to report 6 except they provide information on teens, children, and infants, respectively. The ALARA analysis is intended to represent the dose to the maximally exposed individual within 50 miles of the site. The percentage contribution reports contain data for organs included in the individual

INGESTION DOSE FACTORS FOR ADULT
(MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
1H - 3	0.00E+00	5.99E-08	5.99E-08	5.99E-08	5.99E-08	5.99E-08	5.99E-08
4BE- 10	3.18E-06	4.91E-07	7.94E-08	0.00E+00	3.71E-07	0.00E+00	2.68E-05
6C - 14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
7N - 13	8.36E-09	8.36E-09	8.36E-09	8.36E-09	8.36E-09	8.36E-09	8.36E-09
9F - 18	6.24E-07	0.00E+00	6.92E-08	0.00E+00	0.00E+00	0.00E+00	1.85E-08
11NA- 22	1.74E-05	1.74E-05	1.74E-05	1.74E-05	1.74E-05	1.74E-05	1.74E-05
11NA- 24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
15P - 32	1.93E-04	1.20E-05	7.46E-06	0.00E+00	0.00E+00	0.00E+00	2.17E-05
20CA- 41	1.85E-04	0.00E+00	2.00E-05	0.00E+00	0.00E+00	0.00E+00	1.84E-07
21SC- 46	5.51E-09	1.07E-08	3.11E-09	0.00E+00	9.99E-09	0.00E+00	5.21E-05
24CR- 51	0.00E+00	0.00E+00	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
25MN- 54	0.00E+00	4.57E-06	8.72E-07	0.00E+00	1.36E-06	0.00E+00	1.40E-05
25MN- 56	0.00E+00	1.15E-07	2.04E-08	0.00E+00	1.46E-07	0.00E+00	3.67E-06
26FE- 55	2.75E-06	1.90E-06	4.43E-07	0.00E+00	0.00E+00	1.06E-06	1.09E-06
26FE- 59	4.34E-06	1.02E-05	3.91E-06	0.00E+00	0.00E+00	2.85E-06	3.40E-05
27CO- 57	0.00E+00	1.75E-07	2.91E-07	0.00E+00	0.00E+00	0.00E+00	4.44E-06
27CO- 58	0.00E+00	7.45E-07	1.67E-06	0.00E+00	0.00E+00	0.00E+00	1.51E-05
27CO- 60	0.00E+00	2.14E-06	4.72E-06	0.00E+00	0.00E+00	0.00E+00	4.02E-05
28NI- 59	9.76E-06	3.35E-06	1.63E-06	0.00E+00	0.00E+00	0.00E+00	6.90E-07
28NI- 63	1.30E-04	9.01E-06	4.36E-06	0.00E+00	0.00E+00	0.00E+00	1.88E-06
28NI- 65	5.28E-07	6.86E-08	3.13E-08	0.00E+00	0.00E+00	0.00E+00	1.74E-06
29CU- 64	0.00E+00	8.33E-08	3.91E-08	0.00E+00	2.10E-07	0.00E+00	7.10E-06
30ZN- 65	4.84E-06	1.54E-05	6.96E-06	0.00E+00	1.03E-05	0.00E+00	9.70E-06
30ZN- 69M	1.70E-07	4.08E-07	3.73E-08	0.00E+00	2.47E-07	0.00E+00	2.49E-05
30ZN- 69	1.03E-08	1.97E-08	1.37E-09	0.00E+00	1.28E-08	0.00E+00	2.96E-09
34SE- 79	0.00E+00	2.63E-06	4.39E-07	0.00E+00	4.55E-06	0.00E+00	5.38E-07
35BR- 82	0.00E+00	0.00E+00	2.26E-06	0.00E+00	0.00E+00	0.00E+00	2.59E-06
35BR- 83	0.00E+00	0.00E+00	4.02E-08	0.00E+00	0.00E+00	0.00E+00	5.79E-08
35BR- 84	0.00E+00	0.00E+00	5.21E-08	0.00E+00	0.00E+00	0.00E+00	4.09E-13
35BR- 85	0.00E+00	0.00E+00	2.14E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37RB- 86	0.00E+00	2.11E-05	9.83E-06	0.00E+00	0.00E+00	0.00E+00	4.16E-06
37RB- 87	0.00E+00	1.23E-05	4.28E-06	0.00E+00	0.00E+00	0.00E+00	5.76E-07
37RB- 88	0.00E+00	6.05E-08	3.21E-08	0.00E+00	0.00E+00	0.00E+00	8.36E-19
37RB- 89	0.00E+00	4.01E-08	2.82E-08	0.00E+00	0.00E+00	0.00E+00	2.33E-21
38SR- 89	3.08E-04	0.00E+00	8.84E-06	0.00E+00	0.00E+00	0.00E+00	4.94E-05
38SR- 90	8.71E-03	0.00E+00	1.75E-04	0.00E+00	0.00E+00	0.00E+00	2.19E-04
38SR- 91	5.67E-06	0.00E+00	2.29E-07	0.00E+00	0.00E+00	0.00E+00	2.70E-05
38SR- 92	2.15E-06	0.00E+00	9.30E-08	0.00E+00	0.00E+00	0.00E+00	4.26E-05
39Y - 90	9.62E-09	0.00E+00	2.58E-10	0.00E+00	0.00E+00	0.00E+00	1.02E-04
39Y - 91M	9.09E-11	0.00E+00	3.52E-12	0.00E+00	0.00E+00	0.00E+00	2.67E-10
39Y - 91	1.41E-07	0.00E+00	3.77E-09	0.00E+00	0.00E+00	0.00E+00	7.76E-05
39Y - 92	8.45E-10	0.00E+00	2.47E-11	0.00E+00	0.00E+00	0.00E+00	1.48E-05
39Y - 93	2.68E-09	0.00E+00	7.40E-11	0.00E+00	0.00E+00	0.00E+00	8.50E-05
40ZR- 93	4.18E-08	2.34E-09	1.09E-09	0.00E+00	8.87E-09	0.00E+00	2.43E-06
40ZR- 95	3.04E-08	9.75E-09	6.60E-09	0.00E+00	1.53E-08	0.00E+00	3.09E-05

FIGURE 2.5. Sample Output Report 4a: Ingestion Dose Factors

EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND
(MREM/HR PER PCI/M**2)

NUCLIDE	SKIN	TOTAL BODY
1H - 3	0.00E+00	0.00E+00
4BE- 10	0.00E+00	0.00E+00
6C - 14	0.00E+00	0.00E+00
7N - 13	8.80E-09	7.60E-09
9F - 18	8.00E-09	6.80E-09
11NA- 22	1.80E-08	1.60E-08
11NA- 24	2.90E-08	2.50E-08
15P - 32	0.00E+00	0.00E+00
20CA- 41	4.01E-09	3.41E-09
21SC- 46	1.50E-08	1.30E-08
24CR- 51	2.60E-10	2.20E-10
25MN- 54	6.80E-09	5.80E-09
25MN- 56	1.30E-08	1.10E-08
26FE- 55	0.00E+00	0.00E+00
26FE- 59	9.40E-09	8.00E-09
27CO- 57	1.00E-09	9.10E-10
27CO- 58	8.20E-09	7.00E-09
27CO- 60	2.00E-08	1.70E-08
28NI- 59	0.00E+00	0.00E+00
28NI- 63	0.00E+00	0.00E+00
28NI- 65	4.30E-09	3.70E-09
29CU- 64	1.70E-09	1.50E-09
30ZN- 65	4.60E-09	4.00E-09
30ZN- 69M	3.40E-09	2.90E-09
30ZN- 69	0.00E+00	0.00E+00
34SE- 79	0.00E+00	0.00E+00
35BR- 82	2.20E-08	1.90E-08
35BR- 83	9.30E-11	6.40E-11
35BR- 84	1.40E-08	1.20E-08
35BR- 85	0.00E+00	0.00E+00
37RB- 86	7.20E-10	6.30E-10
37RB- 87	0.00E+00	0.00E+00
37RB- 88	4.00E-09	3.50E-09
37RB- 89	1.80E-08	1.50E-08
38SR- 89	6.50E-13	5.60E-13
38SR- 90	0.00E+00	0.00E+00
38SR- 91	8.30E-09	7.10E-09
38SR- 92	1.00E-08	9.00E-09
39Y - 90	2.60E-12	2.20E-12
39Y - 91M	4.40E-09	3.80E-09
39Y - 91	2.70E-11	2.40E-11
39Y - 92	1.90E-09	1.60E-09
39Y - 93	7.80E-10	5.70E-10
40ZR- 93	0.00E+00	0.00E+00
40ZR- 95	5.80E-09	5.00E-09

FIGURE 2.6. Sample Output Report 4b: External Dose Factors - Ground

IMMERSION DOSE FACTORS FOR SWIMMING IN CONTAMINATED WATER
(MREM/HR PER PCI/LITER)

NUCLIDE	TOTAL BODY
1H - 3	0.00E+00
4BE- 10	0.00E+00
6C - 14	0.00E+00
7N - 13	1.90E-06
9F - 18	1.80E-06
11NA- 22	4.00E-06
11NA- 24	7.80E-06
15P - 32	6.40E-09
20CA- 41	7.28E-07
21SC- 46	3.70E-06
24CR- 51	5.20E-08
25MN- 54	1.50E-06
25MN- 56	3.20E-06
26FE- 55	6.40E-11
26FE- 59	2.20E-06
27CO- 57	2.20E-07
27CO- 58	1.80E-06
27CO- 60	4.60E-06
28NI- 59	2.30E-09
28NI- 63	0.00E+00
28NI- 65	1.00E-06
29CU- 64	3.70E-07
30ZN- 65	1.10E-06
30ZN- 69M	7.50E-07
30ZN- 69	1.60E-09
34SE- 79	3.40E-11
35BR- 82	5.30E-06
35BR- 83	1.70E-08
35BR- 84	3.50E-06
35BR- 85	1.40E-08
37RB- 86	1.70E-07
37RB- 87	1.20E-10
37RB- 88	1.20E-06
37RB- 89	4.50E-06
38SR- 89	4.60E-09
38SR- 90	5.40E-10
38SR- 91	1.90E-06
38SR- 92	2.60E-06
39Y - 90	1.30E-08
39Y - 91M	1.00E-06
39Y - 91	6.70E-09
39Y - 92	4.60E-07
39Y - 93	1.90E-07
40ZR- 93	0.00E+00
40ZR- 95	1.50E-06

FIGURE 2.7. Sample Output Report 4c: External Dose Factors - Water Immersion

RADIOACTIVE DECAY CONSTANT
(1/HOUR)

NUCLIDE	DECAY CONSTANT
1H - 3	6.41E-06
4BE- 10	4.93E-11
6C - 14	1.38E-08
7N - 13	4.18E+00
9F - 18	3.78E-01
11NA- 22	3.04E-05
11NA- 24	4.61E-02
15P - 32	2.02E-03
20CA- 41	5.65E-10
21SC- 46	3.45E-04
24CR- 51	1.04E-03
25MN- 54	9.25E-05
25MN- 56	2.70E-01
26FE- 55	2.93E-05
26FE- 59	6.48E-04
27CO- 57	1.07E-04
27CO- 58	4.07E-04
27CO- 60	1.50E-05
28NI- 59	1.05E-09
28NI- 63	8.24E-07
28NI- 65	2.75E-01
29CU- 64	5.47E-02
30ZN- 65	1.18E-04
30ZN- 69M	5.04E-02
30ZN- 69	7.31E-01
34SE- 79	1.22E-09
35BR- 82	1.97E-02
35BR- 83	2.90E-01
35BR- 84	1.31E+00
35BR- 85	1.45E+01
37RB- 86	1.54E-03
37RB- 87	1.68E-15
37RB- 88	2.33E+00
37RB- 89	2.73E+00
38SR- 89	5.72E-04
38SR- 90	2.78E-06
38SR- 91	7.31E-02
38SR- 92	2.56E-01
39Y - 90	1.08E-02
39Y - 91M	8.39E-01
39Y - 91	4.93E-04
39Y - 92	1.95E-01
39Y - 93	6.88E-02
40ZR- 93	5.18E-11
40ZR- 95	4.50E-04

FIGURE 2.8. Sample Output Report 4d: Radiological Decay Constant

EFFECTIVE ENERGY DEPOSITED (MEV/DIS) IN ORGANS OF GIVEN RADIUS

NUCLIDE	1.4 CM	2 CM	3 CM	5 CM	7 CM	10 CM	20 CM	30 CM
1H - 3	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
4BE- 10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6C - 14	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02	5.00E-02
7N - 13	5.38E-01	5.57E-01	5.87E-01	6.46E-01	7.01E-01	7.77E-01	9.83E-01	1.13E+00
9F - 18	2.85E-01	3.04E-01	3.34E-01	3.91E-01	4.44E-01	5.18E-01	7.17E-01	8.61E-01
11NA- 22	2.86E-01	3.25E-01	3.87E-01	5.07E-01	6.19E-01	7.75E-01	1.20E+00	1.51E+00
11NA- 24	7.12E-01	7.71E-01	8.68E-01	1.05E+00	1.23E+00	1.48E+00	2.19E+00	2.74E+00
15P - 32	6.95E-01	6.95E-01	6.95E-01	6.95E-01	6.95E-01	6.95E-01	6.95E-01	6.95E-01
20CA- 41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21SC- 46	1.97E-01	2.32E-01	2.90E-01	3.99E-01	5.01E-01	6.44E-01	1.03E+00	1.32E+00
24CR- 51	2.00E-03	3.00E-03	4.00E-03	5.00E-03	7.00E-03	9.00E-03	1.50E-02	1.90E-02
25MN- 54	3.60E-02	5.10E-02	7.60E-02	1.22E-01	1.66E-01	2.27E-01	3.92E-01	5.12E-01
25MN- 56	8.75E-01	9.04E-01	9.51E-01	1.04E+00	1.13E+00	1.24E+00	1.57E+00	1.82E+00
26FE- 55	7.00E-03	7.00E-03	7.00E-03	7.00E-03	7.00E-03	7.00E-03	7.00E-03	7.00E-03
26FE- 59	1.71E-01	1.91E-01	2.24E-01	2.86E-01	3.46E-01	4.28E-01	6.55E-01	8.24E-01
27CO- 57	3.90E-02	4.10E-02	4.40E-02	4.90E-02	5.50E-02	6.30E-02	8.40E-02	1.00E-01
27CO- 58	7.30E-02	9.10E-02	1.19E-01	1.74E-01	2.26E-01	2.97E-01	4.92E-01	6.33E-01
27CO- 60	1.95E-01	2.37E-01	3.06E-01	4.37E-01	5.60E-01	7.32E-01	1.21E+00	1.56E+00
28NI- 59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28NI- 63	1.80E-02	1.80E-02	1.80E-02	1.80E-02	1.80E-02	1.80E-02	1.80E-02	1.80E-02
28NI- 65	6.41E-01	6.51E-01	6.66E-01	6.95E-01	7.23E-01	7.62E-01	8.69E-01	9.49E-01
29CU- 64	1.33E-01	1.37E-01	1.43E-01	1.54E-01	1.65E-01	1.80E-01	2.20E-01	2.49E-01
30ZN- 65	2.90E-02	3.90E-02	5.40E-02	8.50E-02	1.13E-01	1.53E-01	2.61E-01	3.42E-01
30ZN- 69M	4.00E-02	4.80E-02	6.00E-02	8.40E-02	1.07E-01	1.38E-01	2.21E-01	2.82E-01
30ZN- 69	3.20E-01	3.20E-01	3.20E-01	3.20E-01	3.20E-01	3.20E-01	3.20E-01	3.20E-01
34SE- 79	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35BR- 82	2.48E-01	2.94E-01	3.68E-01	5.10E-01	6.43E-01	8.28E-01	1.33E+00	1.70E+00
35BR- 83	3.63E-01	3.63E-01	3.64E-01	3.64E-01	3.64E-01	3.65E-01	3.66E-01	3.67E-01
35BR- 84	1.31E+00	1.34E+00	1.39E+00	1.47E+00	1.56E+00	1.67E+00	2.00E+00	2.25E+00
35BR- 85	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00
37RB- 86	6.66E-01	6.68E-01	6.71E-01	6.76E-01	6.80E-01	6.87E-01	7.05E-01	7.19E-01
37RB- 87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37RB- 88	2.15E+00	2.16E+00	2.18E+00	2.21E+00	2.24E+00	2.28E+00	2.40E+00	2.49E+00
37RB- 89	6.94E-01	7.33E-01	7.97E-01	9.19E-01	1.03E+00	1.20E+00	1.64E+00	1.98E+00
38SR- 89	5.64E-01	5.64E-01	5.64E-01	5.64E-01	5.64E-01	5.64E-01	5.64E-01	5.64E-01
38SR- 90	1.14E+00	1.14E+00	1.14E+00	1.14E+00	1.14E+00	1.14E+00	1.14E+00	1.14E+00
38SR- 91	7.02E-01	7.21E-01	7.52E-01	8.12E-01	8.67E-01	9.44E-01	1.15E+00	1.31E+00
38SR- 92	2.49E-01	2.72E-01	3.10E-01	3.81E-01	4.49E-01	5.43E-01	8.05E-01	1.00E+00
39Y - 90	9.39E-01	9.39E-01	9.39E-01	9.39E-01	9.39E-01	9.39E-01	9.39E-01	9.39E-01
39Y - 91M	5.20E-02	6.20E-02	7.70E-02	1.07E-01	1.35E-01	1.74E-01	2.80E-01	3.55E-01
39Y - 91	5.90E-01	5.90E-01	5.91E-01	5.91E-01	5.91E-01	5.91E-01	5.92E-01	5.92E-01
39Y - 92	1.47E+00	1.47E+00	1.48E+00	1.49E+00	1.51E+00	1.52E+00	1.57E+00	1.61E+00
39Y - 93	1.18E+00	1.18E+00	1.18E+00	1.19E+00	1.19E+00	1.20E+00	1.22E+00	1.23E+00
40ZR- 93	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40ZR- 95	2.27E-01	2.54E-01	2.97E-01	3.80E-01	4.58E-01	5.65E-01	8.57E-01	1.07E+00

FIGURE 2.9. Sample Output Report 4e: Effective Deposited Energy

(1) LIQUID SOURCE TERM FOR SAMPLE PROBLEM 1

(2) PARTIALLY MIXED MODEL-- POND BLOWDOWN (CFS) - 2.00E+02 PLANT FLOW RATE (CFS) - 3.15E+03 POND VOLUME (CF) - 5.00E+04

* * * ADULT DOSE FACTORS * * *

(3)	(4)	(5) INGESTION DOSE FACTORS (MREM/PCI INTAKE)							(6) SHORELINE (MREM/HR)/(PCI/M**2)		(7)
NUCLIDE	CURIE/YEAR	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY	RECON
53I 131	5.20E-04	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	0.00E+00	1.57E-06	3.40E-09	2.80E-09	1.57E+01
53I 133	1.20E-03	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	0.00E+00	2.22E-06	4.50E-09	3.70E-09	1.57E+01
53I 135	1.30E-03	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	0.00E+00	1.31E-06	1.40E-08	1.20E-08	1.56E+01
55CS 134	3.90E-04	6.22E-05	1.48E-04	1.21E-04	0.00E+00	4.79E-05	1.59E-05	2.59E-06	1.40E-08	1.20E-08	1.57E+01
55CS 137	5.50E-03	7.97E-05	1.09E-04	7.14E-05	0.00E+00	3.70E-05	1.23E-05	2.11E-06	4.90E-09	4.20E-09	1.58E+01
55CS 138	2.80E-02	5.52E-08	1.09E-07	5.40E-08	0.00E+00	8.01E-08	7.91E-09	4.65E-13	2.40E-08	2.10E-08	1.45E+01
1H 3	1.80E+01	0.00E+00	5.99E-08	5.99E-08	5.99E-08	5.99E-08	5.99E-08	5.99E-08	0.00E+00	0.00E+00	1.58E+01

* * * TEENAGER DOSE FACTORS * * *

		INGESTION DOSE FACTORS (MREM/PCI INTAKE)							SHORELINE (MREM/HR)/(PCI/M**2)		
NUCLIDE	CURIE/YEAR	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY	RECON
53I 131	5.20E-04	5.85E-06	8.19E-06	4.40E-06	2.39E-03	1.41E-05	0.00E+00	1.62E-06			
53I 133	1.20E-03	2.01E-06	3.41E-06	1.04E-06	4.76E-04	5.98E-06	0.00E+00	2.58E-06			
53I 135	1.30E-03	6.10E-07	1.57E-06	5.82E-07	1.01E-04	2.48E-06	0.00E+00	1.74E-06			
55CS 134	3.90E-04	8.37E-05	1.97E-04	9.14E-05	0.00E+00	6.26E-05	2.39E-05	2.45E-06			
55CS 137	5.50E-03	1.12E-04	1.49E-04	5.19E-05	0.00E+00	5.07E-05	1.97E-05	2.12E-06			
55CS 138	2.80E-02	7.76E-08	1.49E-07	7.45E-08	0.00E+00	1.10E-07	1.28E-08	6.76E-11			
1H 3	1.80E+01	0.00E+00	6.04E-08	6.04E-08	6.04E-08	6.04E-08	6.04E-08	6.04E-08			

* * * CHILD DOSE FACTORS * * *

		INGESTION DOSE FACTORS (MREM/PCI INTAKE)							SHORELINE (MREM/HR)/(PCI/M**2)		
NUCLIDE	CURIE/YEAR	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY	RECON
53I 131	5.20E-04	1.72E-05	1.73E-05	9.83E-06	5.72E-03	2.84E-05	0.00E+00	1.54E-06			
53I 133	1.20E-03	5.92E-06	7.32E-06	2.77E-06	1.36E-03	1.22E-05	0.00E+00	2.95E-06			
53I 135	1.30E-03	1.75E-06	3.15E-06	1.49E-06	2.79E-04	4.83E-06	0.00E+00	2.40E-06			
55CS 134	3.90E-04	2.34E-04	3.84E-04	8.10E-05	0.00E+00	1.19E-04	4.27E-05	2.07E-06			
55CS 137	5.50E-03	3.27E-04	3.13E-04	4.62E-05	0.00E+00	1.02E-04	3.67E-05	1.96E-06			
55CS 138	2.80E-02	2.28E-07	3.17E-07	2.01E-07	0.00E+00	2.23E-07	2.40E-08	1.46E-07			
1H 3	1.80E+01	0.00E+00	1.16E-07	1.16E-07	1.16E-07	1.16E-07	1.16E-07	1.16E-07			

* * * INFANT DOSE FACTORS * * *

		INGESTION DOSE FACTORS (MREM/PCI INTAKE)							SHORELINE (MREM/HR)/(PCI/M**2)		
NUCLIDE	CURIE/YEAR	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY	RECON
53I 131	5.20E-04	3.59E-05	4.23E-05	1.86E-05	1.39E-02	4.94E-05	0.00E+00	1.51E-06			
53I 133	1.20E-03	1.25E-05	1.82E-05	5.33E-06	3.31E-03	2.14E-05	0.00E+00	3.08E-06			
53I 135	1.30E-03	3.64E-06	7.24E-06	2.64E-06	6.49E-04	8.07E-06	0.00E+00	2.62E-06			
55CS 134	3.90E-04	3.77E-04	7.03E-04	7.10E-05	0.00E+00	1.81E-04	7.42E-05	1.91E-06			
55CS 137	5.50E-03	5.22E-04	6.11E-04	4.33E-05	0.00E+00	1.64E-04	6.64E-05	1.91E-06			
55CS 138	2.80E-02	4.81E-07	7.82E-07	3.79E-07	0.00E+00	3.90E-07	6.09E-08	1.25E-06			
1H 3	1.80E+01	0.00E+00	1.76E-07	1.76E-07	1.76E-07	1.76E-07	1.76E-07	1.76E-07			

TOTAL NUMBER IN SOURCE TERM IS 7 TOTAL RELEASE IS 1.8037E+01 (8)

FIGURE 2.10. Sample Output Report 5: Source Inventory Data

* * * AS LOW AS REASONABLY ACHIEVABLE * * *

(1) ADULT DOSES

PATHWAY		SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
		DOSE (MREM PER YEAR INTAKE)							
FISH			1.09E-01	1.55E-01	1.03E-01	2.11E-03	5.23E-02	1.75E-02	3.08E-03
DRINKING			4.76E-04	1.78E-03	1.55E-03	2.37E-03	1.34E-03	1.18E-03	1.12E-03
SHORELINE	(2)	1.52E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04
SWIMMING			6.90E-06	6.90E-06	6.90E-06	6.90E-06	6.90E-06	6.90E-06	6.90E-06
BOATING			3.45E-06	3.45E-06	3.45E-06	3.45E-06	3.45E-06	3.45E-06	3.45E-06
TOTAL		1.52E-04	1.09E-01	1.56E-01	1.05E-01	4.62E-03	5.38E-02	1.88E-02	4.34E-03

		USAGE (KG/YR,HR/YR)	DILUTION	TIME(HR)	SHOREWIDTH FACTOR=0.2
FISH		21.0	1.0	24.10	
DRINKING		730.0	4.0	15.00	
SHORELINE	(3)	12.0	1.0	0.10	
SWIMMING		12.0	1.0	0.10	
BOATING		12.0	1.0	0.10	

* * * INDIVIDUAL ISOTOPE PERCENT CONTRIBUTION * * *

PATHWAY	(4)	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
FISH									
	I 131		3.22E-03	3.24E-03	2.77E-03	7.77E+01	1.64E-02	0.00E+00	4.28E-02
	I 133		1.24E-03	1.51E-03	6.88E-04	1.63E+01	7.79E-03	0.00E+00	6.81E-02
	I 135		7.36E-05	1.36E-04	7.47E-05	6.55E-01	6.42E-04	0.00E+00	7.68E-03
	CS 134		5.24E+00	8.77E+00	1.07E+01	0.00E+00	8.38E+00	8.34E+00	7.70E+00
	CS 137		9.48E+01	9.12E+01	8.92E+01	0.00E+00	9.14E+01	9.10E+01	8.85E+01
	CS 138		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	H 3		0.00E+00	7.38E-02	1.10E-01	5.40E+00	2.18E-01	6.53E-01	3.70E+00
DRINKING									
	I 131		4.40E-01	1.68E-01	1.10E-01	4.14E+01	3.84E-01	0.00E+00	7.07E-02
	I 133		2.21E-01	1.03E-01	3.60E-02	1.14E+01	2.39E-01	0.00E+00	1.48E-01
	I 135		2.54E-02	1.78E-02	7.51E-03	8.78E-01	3.79E-02	0.00E+00	3.19E-02
	CS 134		5.21E+00	3.31E+00	3.10E+00	0.00E+00	1.43E+00	5.38E-01	9.23E-02
	CS 137		9.41E+01	3.44E+01	2.58E+01	0.00E+00	1.55E+01	5.87E+00	1.06E+00
	CS 138		1.22E-09	6.47E-10	3.67E-10	0.00E+00	6.32E-10	7.09E-11	4.39E-15
	H 3		0.00E+00	6.19E+01	7.09E+01	4.64E+01	8.24E+01	9.36E+01	9.86E+01
SHORELINE									
	I 131	1.25E-02			1.20E-02				
	I 133	4.11E-03			3.94E-03				
	I 135	4.33E-03			4.33E-03				
	CS 134	3.60E+00			3.60E+00				
	CS 137	9.64E+01			9.64E+01				
	CS 138	1.07E-02			1.09E-02				
	H 3	0.00E+00			0.00E+00				
SWIMMING									
	I 131				3.95E-01				
	I 133				1.11E+00				
	I 135				4.10E+00				
	CS 134				1.10E+00				
	CS 137				5.35E+00				
	CS 138				8.79E+01				
	H 3				0.00E+00				
BOATING									
	I 131				3.95E-01				
	I 133				1.11E+00				
	I 135				4.10E+00				
	CS 134				1.10E+00				
	CS 137				5.35E+00				
	CS 138				8.79E+01				
	H 3				0.00E+00				

FIGURE 2.11. Sample Output Report 6: Results of ALARA Analysis for Adults

pathway analysis only. Blanks appear where doses have not been calculated. External doses are calculated only for the total body (except for skin dose from shoreline exposure) because doses to other organs are assumed to be approximately equal to the total-body dose. When percent contribution tables are not requested, reports 6 through 9 are printed as one report.

2.2.6 Reports 10, 11, 12, and 13: Individual Doses from Aquatic Pathways

The user may define several water usage locations for aquatic pathways when determining doses to individuals. Analysis of these locations uses the same pathways and usage data as those provided for the ALARA analysis. Results for analyses of additional, selected locations are printed in reports 10, 11, 12, and 13 for adults, teens, children, and infants, respectively. Figure 2.12 shows a sample report 13. The format of this report is identical to reports 6 through 9, except for the heading indicating results are for a selected location (item 1) and the location name (item 2). One set of reports, 10 through 13, is prepared for each usage location that is defined (record type 8).

2.2.7 Reports 14, 15, 16, and 17: Population Doses from Aquatic Foods

Population doses from consumption of fish and invertebrate harvested commercially or for sport are printed in reports as follows:

Report	Aquatic Food	Harvest Type
14	fish	sport
15	fish	commercial
16	invertebrates	sport
17	invertebrates	commercial

Figure 2.13 shows a sample report 14. Headings in this report identify the aquatic food (item 1) and the harvest type (item 2). Population doses are presented for each age group (item 3) based on the dilution and catch data

(1) * * * SELECTED LOCATION * * *

LOCATION IS AT OUTFALL (2)

I N F A N T   D O S E S

	DOSE (MREM PER YEAR INTAKE)							
PATHWAY	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
FISH		3.38E-02	4.07E-02	2.99E-03	7.27E-04	1.09E-02	4.43E-03	1.42E-04
DRINKING		5.63E-03	1.26E-02	6.37E-03	2.39E-02	7.73E-03	6.58E-03	5.88E-03
SHORELINE	1.27E-05	1.09E-05	1.09E-05	1.09E-05	1.09E-05	1.09E-05	1.09E-05	1.09E-05
TOTAL	1.27E-05	3.94E-02	5.33E-02	9.37E-03	2.47E-02	1.86E-02	1.10E-02	6.03E-03

	USAGE (KG/YR,HR/YR)	DILUTION	TIME(HR)
FISH	1.0	1.0	24.10
DRINKING	330.0	1.0	12.10
SHORELINE	1.0	1.0	0.10

SHOREWIDTH FACTOR=0.2

* * * INDIVIDUAL ISOTOPE PERCENT CONTRIBUTION * * *

PATHWAY		SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
FISH									
	I 131		4.25E-03	4.16E-03	2.49E-02	7.65E+01	1.81E-02	0.00E+00	4.25E-02
	I 133		1.67E-03	2.01E-03	8.02E-03	2.05E+01	8.84E-03	0.00E+00	9.76E-02
	I 135		9.27E-05	1.53E-04	7.59E-04	7.68E-01	6.37E-04	0.00E+00	1.59E-02
	CS 134		4.87E+00	7.53E+00	1.03E+01	0.00E+00	7.24E+00	7.31E+00	5.86E+00
	CS 137		9.51E+01	9.24E+01	8.91E+01	0.00E+00	9.26E+01	9.23E+01	8.28E+01
	CS 138		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	H 3		0.00E+00	3.92E-02	5.33E-01	2.19E+00	1.46E-01	3.60E-01	1.12E+01
DRINKING									
	I 131		5.86E-01	3.08E-01	2.69E-01	5.33E+01	5.88E-01	0.00E+00	2.36E-02
	I 133		3.28E-01	2.13E-01	1.24E-01	2.04E+01	4.09E-01	0.00E+00	7.74E-02
	I 135		4.32E-02	3.83E-02	2.77E-02	1.81E+00	6.98E-02	0.00E+00	2.98E-02
	CS 134		4.82E+00	4.01E+00	8.03E-01	0.00E+00	1.69E+00	8.12E-01	2.34E-02
	CS 137		9.42E+01	4.91E+01	6.91E+00	0.00E+00	2.16E+01	1.03E+01	3.30E-01
	CS 138		6.85E-08	4.96E-08	4.77E-08	0.00E+00	4.04E-08	7.42E-09	1.70E-07
	H 3		0.00E+00	4.63E+01	9.19E+01	2.44E+01	7.57E+01	8.89E+01	9.95E+01
SHORELINE									
	I 131	1.25E-02			1.20E-02				
	I 133	4.11E-03			3.94E-03				
	I 135	4.33E-03			4.33E-03				
	CS 134	3.60E+00			3.60E+00				
	CS 137	9.64E+01			9.64E+01				
	CS 138	1.07E-02			1.09E-02				
	H 3	0.00E+00			0.00E+00				

FIGURE 2.12. Sample Output Report 13: Results of Selected Locations for Infants

supplied by the user (input record type 9, item 4). For sport harvest, the population exposed is calculated from catch data and the average individual consumption rates (item 5). In contrast, for commercial harvest, the exposed population represents the population within 50 miles (from input record type 3). The percentages of radionuclide contributions to organ doses are given for each age group used to calculate population dose (item 6). The formats of reports 15, 16, and 17 are similar to report 14. Data for report 15 are provided on input record type 10; data for report 16 are from input record type 11; and data for report 17 are from input record type 12.

(1) * * * FISH CONSUMPTION POPULATION DOSES * * *
PERSON-REM

(2) ----------SPORT HARVEST----------

PATHWAY	AGE GROUP	USAGE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
			DOSE (PERSON-REM)						
FISH	ADULT	5.85E+04	7.56E-02	1.07E-01	7.19E-02	7.59E-04	3.64E-02	1.21E-02	2.14E-03
FISH (3)	TEENAGER	6.82E+03	1.24E-02	1.71E-02	6.13E-03	1.07E-04	5.79E-03	2.25E-03	2.50E-04
FISH	CHILD	4.72E+03	2.50E-02	2.47E-02	3.78E-03	1.74E-04	8.03E-03	2.90E-03	1.65E-04
FISH	TOTAL	7.00E+04	1.13E-01	1.49E-01	8.18E-02	1.04E-03	5.02E-02	1.73E-02	2.56E-03

LOCATION	(4) DILUTION	CATCH	TIME(HR)-INCLUDES FOOD PROCESSING TIME OF 1.68E+02 HR	POPULATION=1.19E+04
FISH DOWNSTREAM	4.00E+00	7.00E+04	1.69E+02	

AVERAGE INDIVIDUAL CONSUMPTION (KG/YR) (5) ADULT=6.90E+00 TEEN=5.20E+00 CHILD=2.20E+00

* * * INDIVIDUAL ISOTOPE PERCENT CONTRIBUTION * * *

AGE GROUP (6)	ISOTOPE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
ADULT								
	I 131	1.91E-03	1.92E-03	1.65E-03	8.93E+01	9.74E-03	0.00E+00	2.55E-02
	I 133	9.92E-06	1.21E-05	5.53E-06	2.53E-01	6.26E-05	0.00E+00	5.48E-04
	I 135	1.79E-11	3.29E-11	1.81E-11	3.07E-07	1.56E-10	0.00E+00	1.87E-09
	CS 134	5.21E+00	8.73E+00	1.07E+01	0.00E+00	8.34E+00	8.30E+00	7.67E+00
	CS 137	9.48E+01	9.12E+01	8.92E+01	0.00E+00	9.14E+01	9.11E+01	8.86E+01
	CS 138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	H 3	0.00E+00	7.38E-02	1.10E-01	1.04E+01	2.18E-01	6.53E-01	3.70E+00
TEENAGER								
	I 131	1.92E-03	1.94E-03	2.91E-03	9.10E+01	9.87E-03	0.00E+00	2.63E-02
	I 133	1.00E-05	1.23E-05	1.05E-05	2.75E-01	6.36E-05	0.00E+00	6.36E-04
	I 135	1.75E-11	3.27E-11	3.38E-11	3.37E-07	1.52E-10	0.00E+00	2.48E-09
	CS 134	5.00E+00	8.52E+00	1.10E+01	0.00E+00	7.99E+00	7.84E+00	7.25E+00
	CS 137	9.50E+01	9.14E+01	8.88E+01	0.00E+00	9.18E+01	9.17E+01	8.90E+01
	CS 138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	H 3	0.00E+00	5.45E-02	1.52E-01	8.76E+00	1.61E-01	4.14E-01	3.73E+00
CHILD								
	I 131	1.94E-03	1.96E-03	7.29E-03	9.25E+01	9.93E-03	0.00E+00	2.61E-02
	I 133	1.01E-05	1.26E-05	3.12E-05	3.34E-01	6.48E-05	0.00E+00	7.61E-04
	I 135	1.73E-11	3.14E-11	9.70E-11	3.96E-07	1.48E-10	0.00E+00	3.57E-09
	CS 134	4.80E+00	7.95E+00	1.10E+01	0.00E+00	7.59E+00	7.55E+00	6.41E+00
	CS 137	9.52E+01	9.20E+01	8.87E+01	0.00E+00	9.23E+01	9.20E+01	8.61E+01
	CS 138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	H 3	0.00E+00	5.02E-02	3.28E-01	7.15E+00	1.54E-01	4.28E-01	7.50E+00

FIGURE 2.13. Sample Output Report 14: Population Doses from Sport Fishing

2.2.8. Report 18: Population Doses from the Drinking Water Pathway

Report 18 presents doses to the population at selected water supply locations. Figure 2.14 shows a sample report 18 as generated for sample problem 3. Heading information in this report includes the descriptive title of the water usage location (item 1). This title introduces the subreport that presents population doses by age group (item 2), parameters for population exposure (items 3 and 4) and percentages of radionuclide contributions

* * * POPULATION WATER CONSUMPTION DOSES * * *

SUPPLIER-WATER USE 16 MI DOWN (1)

PATHWAY	AGE GROUP	USAGE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
			----------DOSE (PERSON-REM)----------						
DRINKING	ADULT	5.78E+08	3.76E-01	1.41E+00	1.23E+00	1.78E+00	1.06E+00	9.31E-01	8.83E-01
DRINKING (2)	TEENAGER	6.29E+07	5.74E-02	1.75E-01	1.24E-01	2.18E-01	1.23E-01	1.06E-01	9.70E-02
DRINKING	CHILD	1.03E+08	2.74E-01	5.72E-01	3.43E-01	7.98E-01	3.91E-01	3.32E-01	3.03E-01
DRINKING	TOTAL	7.44E+08	7.07E-01	2.15E+00	1.70E+00	2.80E+00	1.57E+00	1.37E+00	1.28E+00

POPULATION=2.20E+06 (3) DILUTION=4.00E+00 TRANSIT TIME=2.50E+01 HR (INCLUDING 24 HR FOR TREATMENT FACILITY)

AVERAGE INDIVIDUAL CONSUMPTION (L/YR) (4) ADULT=3.70E+02 TEEN=2.60E+02 CHILD=2.60E+02

* * * INDIVIDUAL ISOTOPE PERCENT CONTRIBUTION * * *

AGE GROUP (5)	ISOTOPE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
ADULT								
	I 131	4.25E-01	1.63E-01	1.07E-01	4.21E+01	3.71E-01	0.00E+00	6.83E-02
	I 133	1.59E-01	7.39E-02	2.58E-02	8.59E+00	1.72E-01	0.00E+00	1.06E-01
	I 135	8.87E-03	6.22E-03	2.62E-03	3.24E-01	1.33E-02	0.00E+00	1.12E-02
	CS 134	5.21E+00	3.32E+00	3.10E+00	0.00E+00	1.43E+00	5.38E-01	9.24E-02
	CS 137	9.42E+01	3.45E+01	2.58E+01	0.00E+00	1.56E+01	5.87E+00	1.06E+00
	CS 138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	H 3	0.00E+00	6.20E+01	7.09E+01	4.90E+01	8.25E+01	9.36E+01	9.87E+01
TEENAGER								
	I 131	4.26E-01	1.96E-01	1.48E-01	4.58E+01	4.79E-01	0.00E+00	6.99E-02
	I 133	1.60E-01	8.93E-02	3.84E-02	9.99E+00	2.22E-01	0.00E+00	1.22E-01
	I 135	8.71E-03	7.36E-03	3.85E-03	3.80E-01	1.65E-02	0.00E+00	1.47E-02
	CS 134	5.00E+00	3.86E+00	2.52E+00	0.00E+00	1.74E+00	7.73E-01	8.66E-02
	CS 137	9.44E+01	4.12E+01	2.02E+01	0.00E+00	1.99E+01	8.99E+00	1.06E+00
	CS 138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	H 3	0.00E+00	5.47E+01	7.71E+01	4.38E+01	7.76E+01	9.02E+01	9.86E+01
CHILD								
	I 131	4.30E-01	2.07E-01	1.96E-01	4.91E+01	4.97E-01	0.00E+00	3.48E-02
	I 133	1.62E-01	9.60E-02	6.06E-02	1.28E+01	2.34E-01	0.00E+00	7.31E-02
	I 135	8.58E-03	7.39E-03	5.84E-03	4.69E-01	1.66E-02	0.00E+00	1.06E-02
	CS 134	4.80E+00	3.77E+00	1.33E+00	0.00E+00	1.71E+00	7.21E-01	3.84E-02
	CS 137	9.46E+01	4.33E+01	1.07E+01	0.00E+00	2.07E+01	8.75E+00	5.13E-01
	CS 138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	H 3	0.00E+00	5.26E+01	8.77E+01	3.77E+01	7.69E+01	9.05E+01	9.93E+01

-----CUMULATIVE TOTAL-----

PATHWAY (6)	AGE GROUP	USAGE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
DRINKING	CUMUL TOTAL	7.44E+08	7.07E-01	2.15E+00	1.70E+00	2.80E+00	1.57E+00	1.37E+00	1.28E+00

----------HYDROSPHERE TRITIUM DOSE----------

AVERAGE INDIVIDUAL WATER CONSUMPTION = 3.0 L/DAY (7)

PATHWAY	AGE GROUP	USAGE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
WATER	TOTAL	2.86E+11	0.00E+00	1.37E-04	1.37E-04	1.37E-04	1.37E-04	1.37E-04	1.37E-04

FIGURE 2.14. Sample Output Report 18: Population Doses from Drinking Water Pathway

to organ doses (item 5). One of these subreports is presented for each usage location defined by the user (i.e., for each record of type 13 that is provided). The total doses for all pathways are given after the last subreport (item 6). If tritium is included in the source inventory, an additional subreport is presented. This subreport (item 7) gives the dose to the U.S. population based on uniform dilution of tritium that is released in the hydrosphere. The adult age group is used for the hydrosphere tritium dose. The hydrosphere tritium subreport is printed even if no population drinking water doses are requested (provided tritium is in the source inventory). Note that drinking water doses are not calculated for saltwater sites (although hydrosphere tritium doses are calculated for all sites).

2.2.9 Report 19: Recreational Population Doses

Population doses from recreational activities are printed in report 19 as illustrated in Figure 2.15. This report consists of a heading (item 1) followed by a series of subreports that present results for the three exposure pathways: shoreline, swimming, and boating. One subreport is prepared for each pathway and usage location that is provided (see record types 14, 15, and 16). Each subreport includes a location title (item 2), pathway data (item 3), a population dose summary (item 4), and percentage of radionuclide contributions to organ dose (item 5). Subreports for shoreline exposure are followed by subreports for swimming exposure (item 6) and boating exposure (item 7). Doses are presented for skin, thyroid, and total-body exposure for the shoreline exposure pathway, and for thyroid and total body for the boating and swimming exposure pathways. Note that the calculated thyroid dose equals the total-body dose. Dose to other internal organs can be considered equal to the total-body dose.

2.2.10 Report 20: Doses from the Terrestrial Food Pathway

This report type presents results of calculations from all terrestrial food pathways. One report is prepared for each of the four main food types that are available in LADTAP II; vegetables, leafy vegetables, milk, and meat. Figure 2.16 is a sample report 20 for consumption of vegetables for sample problem 1. The main features of the report are the title identifying the irrigation pathways (item 1), the current food type (item 2), the population served (item 3), the doses to a maximum individual (item 4), dilution factor used for calculating the maximum individual (item 5), population doses

(1) * * * RECREATION POPULATION DOSES * * *

LOCATION- DOWNSTREAM SHORE (2)

DILUTION= 4.00E+00 (3) TRANSIT TIME= 1.00E+00 HR SWF= 0.2

PATHWAY (4)	AGE GROUP	USAGE	DOSE (PERSON-REM) SKIN	TOTAL BODY	THYROID
SHORELINE	TOTAL POPUL	8.30E+04	2.63E-04	2.26E-04	2.26E-04

* * * INDIVIDUAL ISOTOPE PERCENT CONTRIBUTION * * *

AGE GROUP (5)		SKIN	TOTAL BODY
ADULT			
	I 131	1.25E-02	1.20E-02
	I 133	3.98E-03	3.82E-03
	I 135	3.94E-03	3.94E-03
	CS 134	3.60E+00	3.60E+00
	CS 137	9.64E+01	9.64E+01
	CS 138	3.36E-03	3.43E-03
	H 3	0.00E+00	0.00E+00

LOCATION- DOWNSTREAM SWIMMING (6)

DILUTION= 4.00E+00 TRANSIT TIME= 1.00E+00 HR

PATHWAY	AGE GROUP	USAGE	DOSE (PERSON-REM) SKIN	TOTAL BODY	THYROID
SWIMMING	TOTAL POPUL	1.20E+05		6.77E-06	6.77E-06

* * * INDIVIDUAL ISOTOPE PERCENT CONTRIBUTION * * *

AGE GROUP		TOTAL BODY
ADULT		
	I 131	1.00E+00
	I 133	2.76E+00
	I 135	9.51E+00
	CS 134	2.81E+00
	CS 137	1.36E+01
	CS 138	7.03E+01
	H 3	0.00E+00

LOCATION- DOWNSTREAM BOATING (7)

DILUTION= 4.00E+00 TRANSIT TIME= 1.00E+00 HR

PATHWAY	AGE GROUP	USAGE	DOSE (PERSON-REM) SKIN	TOTAL BODY	THYROID
BOATING	TOTAL POPUL	5.20E+05		1.47E-05	1.47E-05

* * * INDIVIDUAL ISOTOPE PERCENT CONTRIBUTION * * *

AGE GROUP		TOTAL BODY
ADULT		
	I 131	1.00E+00
	I 133	2.76E+00
	I 135	9.51E+00
	CS 134	2.81E+00
	CS 137	1.36E+01
	CS 138	7.03E+01
	H 3	0.00E+00

FIGURE 2.15. Sample Output Report 19: Recreational Population Doses

(1) * * * IRRIGATED FOOD PATHWAY * * *

VEGETATION (2)

(3) TOTAL 50-MILE-PRODUCTION POPULATION SERVED= 1.01E+02
TOTAL POPULATION SERVED FROM IRRIGATED PRODUCTION= 2.53E+00

INDIVIDUAL DOSES(MREM PER YEAR INTAKE)

(4)	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
ADULT	1.47E-01	2.09E-01	1.40E-01	3.45E-02	7.12E-02	2.41E-02	4.80E-03
TEENAGER	2.50E-01	3.45E-01	1.24E-01	5.11E-02	1.18E-01	4.61E-02	5.83E-03
CHILD	6.00E-01	5.94E-01	9.18E-02	1.01E-01	1.94E-01	7.07E-02	5.21E-03

(5) NOTE- INDIVIDUAL DOSES CALCULATED WITH DILUTION= 4.00E+00 AND TRANSIT TIME= 1.00E+00 HRS.

POPULATION DOSES(PERSON-REM)

* * * NEPA DOSES * * *

(6)	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
ADULT	6.15E-05	8.73E-05	5.84E-05	5.94E-07	2.97E-05	1.01E-05	2.00E-06
TEENAGER	1.69E-05	2.33E-05	8.35E-06	1.29E-07	7.92E-06	3.11E-06	3.92E-07
CHILD	6.71E-05	6.63E-05	1.02E-05	3.78E-07	2.16E-05	7.89E-06	5.79E-07
TOTAL	1.45E-04	1.77E-04	7.69E-05	1.10E-06	5.93E-05	2.11E-05	2.97E-06

$ $ $ ALARA DOSES $ $ $

(7)	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
ADULT	6.15E-05	8.73E-05	5.84E-05	5.94E-07	2.97E-05	1.01E-05	2.00E-06
TEENAGER	1.69E-05	2.33E-05	8.35E-06	1.29E-07	7.92E-06	3.11E-06	3.92E-07
CHILD	6.71E-05	6.63E-05	1.02E-05	3.78E-07	2.16E-05	7.89E-06	5.79E-07
TOTAL	1.45E-04	1.77E-04	7.69E-05	1.10E-06	5.93E-05	2.11E-05	2.97E-06

IRRI FOOD (8)
IRRIGATION RATE= 5.00E+03 L/M**2/MON
NON-IRRIGATED FEED FRACTION= 2.00E-01
WATER FRACTION NOT VIA IRRIGATION= 6.00E-01
TOTAL 50 MILE GROW= 2.00E+04 KG/YR
TOTAL CROP IRRIGATION= 5.00E+02
CROP GROWING PERIOD= 6.00E+01 DAYS
CROP YIELD= 2.00E+00 KG/M**2

(9) LOCATION	DILUTION	HARVEST	TRANSIT TIME
FARM	4.00E+00	2.00E+02	1.00E+00
FARM	1.00E+01	3.00E+02	5.00E+00

(10)

INDIVIDUAL CONSUMPTION RATES	ADULT=5.20E+02 KG	TEEN=6.30E+02	CHILD=5.20E+02	FOOD PROCESS TIME=3.36E+02 HR
POPULATION CONSUMPTION RATES	ADULT=1.90E+02 KG	TEEN=2.40E+02	CHILD=2.00E+02	FOOD PROCESS TIME=1.44E+03 HR

* * * INDIVIDUAL ISOTOPE PERCENT CONTRIBUTION * * *

AGE GROUP (11)	ISOTOPE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
ADULT								
	I 131	4.90E-02	4.93E-02	4.23E-02	9.77E+01	2.48E-01	0.00E+00	5.66E-01
	I 133	2.77E-07	3.39E-07	1.54E-07	3.01E-04	1.73E-06	0.00E+00	1.32E-05
	I 135	9.45E-19	1.74E-18	9.60E-19	6.94E-16	8.18E-18	0.00E+00	8.55E-17
	CS 134	4.75E+00	7.95E+00	9.71E+00	0.00E+00	7.54E+00	7.38E+00	6.05E+00
	CS 137	9.52E+01	9.16E+01	8.97E+01	0.00E+00	9.11E+01	8.94E+01	7.71E+01
	CS 138	1.14E-30	1.58E-30	1.17E-30	0.00E+00	3.41E-30	9.94E-31	0.00E+00
	H 3	0.00E+00	3.75E-01	5.60E-01	2.27E+00	1.10E+00	3.24E+00	1.63E+01
TEENAGER								
	I 131	4.92E-02	4.98E-02	7.45E-02	9.81E+01	2.52E-01	0.00E+00	5.83E-01
	I 133	2.79E-07	3.43E-07	2.91E-07	3.23E-04	1.76E-06	0.00E+00	1.53E-05
	I 135	9.28E-19	1.73E-18	1.79E-18	7.51E-16	8.01E-18	0.00E+00	1.13E-16
	CS 134	4.56E+00	7.77E+00	1.00E+01	0.00E+00	7.24E+00	7.05E+00	5.71E+00
	CS 137	9.54E+01	9.19E+01	8.91E+01	0.00E+00	9.17E+01	9.09E+01	7.73E+01
	CS 138	1.14E-30	1.59E-30	2.21E-30	0.00E+00	3.44E-30	1.02E-30	4.26E-32
	H 3	0.00E+00	2.77E-01	7.72E-01	1.87E+00	8.13E-01	2.07E+00	1.64E+01
CHILD								
	I 131	4.96E-02	5.04E-02	1.85E-01	9.85E+01	2.53E-01	0.00E+00	5.11E-01
	I 133	2.82E-07	3.53E-07	8.63E-07	3.87E-04	1.80E-06	0.00E+00	1.62E-05
	I 135	9.14E-19	1.66E-18	5.09E-18	8.70E-16	7.79E-18	0.00E+00	1.44E-16
	CS 134	4.37E+00	7.25E+00	9.89E+00	0.00E+00	6.87E+00	6.77E+00	4.45E+00
	CS 137	9.56E+01	9.24E+01	8.83E+01	0.00E+00	9.21E+01	9.11E+01	6.60E+01
	CS 138	1.15E-30	1.62E-30	6.64E-30	0.00E+00	3.48E-30	1.03E-30	8.50E-29
	H 3	0.00E+00	2.55E-01	1.65E+00	1.51E+00	7.80E-01	2.14E+00	2.91E+01

FIGURE 2.16. Sample Output Report 20: Doses from Terrestrial Food Pathway

(1)
* * * DOSE TO BIOTA * * *

MRADS PER YEAR

FISH AT OUTFALL (2) DILUTION= 1.00E+00 TRANSIT TIME= 1.00E-01 HR

(3)

	INTERNAL	EXTERNAL	TOTAL
FISH	6.12E+00	4.82E-01	6.60E+00
INVERTEBRATE	3.06E+00	9.58E-01	4.02E+00
ALGAE	1.54E+00	5.04E-03	1.54E+00
MUSKRAT	1.83E+00	3.20E-01	2.15E+00
RACCOON	6.87E-01	2.38E-01	9.25E-01
HERON	1.07E+01	3.19E-01	1.11E+01
DUCK	1.66E+00	4.78E-01	2.14E+00

* * * INDIVIDUAL ISOTOPE PERCENT CONTRIBUTION * * *

(4)

BIOTA		INTERNAL
FISH		
	I 131	2.85E-03
	I 133	1.47E-02
	I 135	1.69E-02
	CS 134	3.47E-01
	CS 137	5.04E+00
	CS 138	9.46E+01
	H 3	2.78E-02
INVERTEBRATE		
	I 131	1.90E-03
	I 133	9.78E-03
	I 135	1.13E-02
	CS 134	3.47E-01
	CS 137	5.04E+00
	CS 138	9.45E+01
	H 3	5.56E-02
ALGAE		
	I 131	3.03E-02
	I 133	1.56E-01
	I 135	1.79E-01
	CS 134	3.45E-01
	CS 137	5.02E+00
	CS 138	9.42E+01
	H 3	1.11E-01
MUSKRAT		
	I 131	3.49E-02
	I 133	1.92E-02
	I 135	8.49E-03
	CS 134	7.76E+00
	CS 137	9.11E+01
	CS 138	3.04E-01
	H 3	7.57E-01
RACCOON		
	I 131	2.13E-03
	I 133	1.15E-03
	I 135	5.53E-04
	CS 134	8.56E+00
	CS 137	9.08E+01
	CS 138	2.95E-01
	H 3	3.37E-01
HERON		
	I 131	3.21E-03
	I 133	1.73E-03
	I 135	8.31E-04
	CS 134	8.57E+00
	CS 137	9.10E+01
	CS 138	2.96E-01
	H 3	1.69E-01
DUCK		
	I 131	3.54E-02
	I 133	1.99E-02
	I 135	8.20E-03
	CS 134	7.05E+00
	CS 137	9.17E+01
	CS 138	3.12E-01
	H 3	8.35E-01

FIGURE 2.17. Sample Output Report 21: Dose to Biota

for the NEPA (item 6) and ALARA (item 7) analyses, a summary of pathway parameters (item 8), farm irrigation and production parameters (item 9) all consumption rates (item 10), and percentage of radionuclide contributions to individual organ doses (item 11). Note that the percent contribution values are for individual doses, not for population doses (although percent contribution values for population doses are expected to be similar to those for the individual dose, in most cases).

2.2.11 Report 21: Dose to Biota

The dose to selected biota is calculated for each usage location that is defined by input record type 19. Figure 2.17 shows a sample report 21 as generated by sample problem 1. One report of this type is printed for each usage location defined. Each report consists of a title identifying the report (item 1); dilution data used in the analysis (item 2); a summary of internal, external, and total dose to each biota (item 3); and percentage of radionuclide contribution to the internal dose of each biota (item 4).

2.2.12 Report 22: Results of Cost-Benefit Analysis

Results of the cost-benefit analysis are presented in report 22. This report gives total radionuclide contributions to population doses for total body and thyroid. Also included is the dose per curie of each radionuclide released. Figure 2.18 presents a sample report 22 as prepared by sample problem 1. Dose contributions to this table are included for all pathways except ingestion of aquatic plants (as indicated in Table 1.1).

2.2.13 Report 23: Special ALARA Report

As a special application, the LADTAP II program can generate a table of dose rate per unit concentration of each radionuclide in the source inventory. Figure 2.19 shows a sample report 23 as generated by sample problem 3. This table gives unit dose rate factors for each organ. Units of the dose factors are mrem/hr per μCi/mL in water. Pathways included in the analysis are drinking water and fish ingestion for freshwater sites, and fish and invertebrate ingestion for saltwater sites. This table is calculated based on the general philosophy described in NUREG-0133 (NRC 1978) as described in Section 3.2. However, decay in transit to the usage location is included in the LADTAP II calculation.

* * * COST-BENEFIT ANALYSIS * * *

NUCLIDE	RELEASE	PERSON-REM DOSE		PERSON-REM PER CURIE	
	CI/YR	TOTAL BODY	THYROID	TOTAL BODY	THYROID
53I 131	5.20E-04	2.17E-03	1.24E+00	4.17E+00	2.39E+03
53I 133	1.20E-03	5.73E-04	2.77E-01	4.77E-01	2.31E+02
53I 135	1.30E-03	5.91E-05	1.03E-02	4.54E-02	7.95E+00
55CS 134	3.90E-04	5.48E-02	8.74E-06	1.40E+02	2.24E-02
55CS 137	5.50E-03	4.54E-01	2.20E-04	8.26E+01	4.01E-02
55CS 138	2.80E-02	1.51E-05	1.51E-05	5.38E-04	5.38E-04
1H 3	1.80E+01	1.27E+00	1.27E+00	7.04E-02	7.04E-02
TOTAL		1.78E+00	2.80E+00		

FIGURE 2.18. Sample Output Report 22: Cost-Benefit Analysis

LIQUID EFFLUENT DOSE PARAMETERS

A(I),MREM/HR PER UCI/ML

RADIONUCLIDE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
I 131	1.04E-01	1.49E-01	8.53E-02	4.88E+01	2.55E-01	0.00E+00	3.93E-02
I 133	4.01E-02	6.97E-02	2.13E-02	1.02E+01	1.22E-01	0.00E+00	6.27E-02
I 135	2.40E-03	6.28E-03	2.32E-03	4.14E-01	1.01E-02	0.00E+00	7.09E-03
CS 134	4.27E+00	1.02E+01	8.30E+00	0.00E+00	3.29E+00	1.09E+00	1.78E-01
CS 137	7.72E+01	1.06E+02	6.92E+01	0.00E+00	3.58E+01	1.19E+01	2.04E+00
CS 138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H 3	0.00E+00	5.79E+00	5.79E+00	5.79E+00	5.79E+00	5.79E+00	5.79E+00

INVERTEBRATE DILUTION IN ADDITION TO THAT FOR FISH= 4.0

FIGURE 2.19. Sample Output Report 23: Special ALARA Report

2.3 SAMPLE CALCULATIONS

The three sample problems presented in this section illustrate preparation of LADTAP II input records. The general purpose of each sample problem is as follows:

Sample Problem 1 - All pathways are demonstrated. This is a "standard" LADTAP II calculation.

Sample Problem 2 - Only population doses from drinking water are calculated.

Sample Problem 3 - BLOCK DATA parameters are changed and special output report 23 is prepared.

Preparation of input records is described for each of these sample problems in the following sections. Output from the sample problems is discussed in Section 2.3.4.

The user is cautioned that the sample input parameter values have no significance relative to any real analysis. The values are used for illustration purposes only. When preparing input for a specific site, the user must evaluate each parameter. Using the values given in these sample problems as default values is inappropriate.

2.3.1 Sample Problem 1

This sample problem represents a standard calculation with all exposure pathways included. The impoundment system is described by the partially mixed model. Except for aquatic pathway usage parameters (record types 7a-7d are supplied) and the grazing period for meat production (record type 17), default parameter values are used for all calculations. Table 2.27 presents the input record images for sample problem 1. Each record in Table 2.27 is described by record line number, as listed below:

Line 1:	Title record for sample problem 1
Line 2:	Site data specifying a freshwater site and requesting % contribution tables be printed
Line 3:	Total population within 50 miles
Line 4:	Source inventory title
Lines 5-11:	Radionuclide release inventory specification
Line 12:	Blank record to terminate reading of source inventory records
Line 13:	Reconcentration factor data for partially mixed model
Line 14:	ALARA individual dose calculation data and request for default consumption parameters on record types 7a-7d

TABLE 2.27. Sample Problem 1 Input Record List

Number	Type	Input Record Image
1	1	SAMPLE PROBLEM 1 - ALL PATHWAYS INCLUDED
2	2	0 3150. 1. 1 0
3	3	2200000. 0
4	4	LIQUID SOURCE TERM FOR SAMPLE PROBLEM 1
5	5	I 131 5.2E-04
6	5	I 133 1.2E-03
7	5	I 135 1.3E-03
8	5	CS 134 3.9E-04
9	5	CS 137 5.5E-03
10	5	CS 138 2.8E-02
11	5	H 3 1.8E+01
12	5	
13	6	3 200. 50000.
14	7	1 0.2 1. 1. 4. .1 3.
15	7a	21. 0. 0. 730. 12. 12. 12.
16	7b	16. 0. 20. 510. 67. 0. 10.
17	7c	6.9 10. 0. 510. 14. 2. 5.
18	7d	1. 0. 0. 330. 1. 0. 0.
19	8	0 1. 1. .2 AT OUTFALL
20	8	0 4. .5 .2 DOWNSTREAM
21	8	
22	9	70000. 4. 1. FISH DOWNSTREAM
23	9	
24	10	5000. 4. 1. COM FISH DOWNSTREAM
25	10	
26	11	200. 4. 1. SPORT INVERT DOWNSTREAM
27	11	
28	12	300. 4. 1. COM INVERT DOWNSTREAM
29	12	
30	13	2200000. 4. 1. WATER USE 16 MI DOWNSTREAM
31	13	
32	14	8.3E+04 4. 1. .2 DOWNSTREAM SHORE
33	14	
34	15	1.2E+05 4. 1. DOWNSTREAM SWIMMING
35	15	
36	16	5.2E+05 4. 1. DOWNSTREAM BOATING
37	16	
38	17	1 0. 5000. .2 .6 20000.
39	18	4. 200. 1. FARM
40	18	10. 300. 5. FARM
41	18	
42	17	2 0. 6000. .2 .6 5000.
43	18	4. 130. 1. FARM
44	18	
45	17	3 0. 2000. .2 .6 40000.
46	18	4. 300. 1. FARM
47	18	
48	17	4 0. 200. .2 .6 300. 45.
49	18	4. 150. 1. FARM
50	18	
51	17	
52	19	1. .1 FISH AT OUTFALL
53	19	4. 1. FISH DOWNSTREAM
54	19	

Line 15: Consumption and usage parameters for adults. Note that records 7a-7d as supplied for this sample problem use the same non-zero default parameters as given in Table 2.1.9. Only a few of the zero-value parameters are changed to illustrate inclusions of additional pathways

Line 16: Consumption and usage parameters for teens

Line 17: Consumption and usage parameters for children

Line 18: Consumption and usage parameters for infants

Line 19: Data for first additional usage location for individuals

Line 20: Data for second additional usage location for individuals

Line 21: Blank record to terminate readings of records for selected usage locations

Line 22: Record for first sport fishing usage location

Line 23: Blank record to terminate reading of records for sport fishing

Line 24: Record for first commercial fishing usage location

Line 25: Blank record to terminate reading of records for commercial fishing

Line 26: Record for first sport invertebrate harvest usage location

Line 27: Blank record to terminate reading of records for sport invertebrate harvest

Line 28: Record for first commercial invertebrate harvest usage location

Line 29: Blank record to terminate reading of records for commercial invertebrate harvest

Line 30: Record for first drinking water usage location for population doses

Line 31: Blank record to terminate reading of records for population drinking water

Line 32: Record for first population shoreline exposure location

Line 33: Blank record to terminate reading of record for population shoreline exposure

Line 34: Record for first population swimming exposure location

Line 35: Blank record to terminate reading of records for population swimming exposure

Line 36: Record for first population boating exposure location

Line 37: Blank record to terminate reading of records for population boating exposure

Line 38: Selection of first irrigated food type - vegetables

Line 39: Record for first vegetable production location

Line 40: Record for second vegetable production location

Line 41: Blank record to terminate reading of records for food production locations

Line 42: Selection of second irrigated food type - leafy vegetables

Line 43: Record for first leafy vegetable production location

Line 44: Blank record to terminate reading of records for food production locations

Line 45: Selection of third irrigated food type - milk

Line 46: Record for first milk production location

Line 47: Blank record to terminate reading of records for food production locations

Line 48: Selection of fourth irrigated food type - meat

Line 49: Record for first meat production location

Line 50: Blank record to terminate reading of records for food production locations

Line 51: Blank record to terminate reading of food selection records

Line 52: Record for first biota location

Line 53: Record for second biota location

Line 54: Blank record to terminate reading of records for biota locations

Execution of this sample problem is terminated normally when an attempt is made to read a title record for additional cases (line 55 which is absent), as indicated in the input record logic diagram (Figure 2.1). A complete list of the computer-generated output for this sample problem is presented in the Appendix B microfiche located inside the back cover of this report.

2.3.2 Sample Problem 2

This sample problem illustrates the selection of only one pathway bypassing all other pathways. The pathway selected is population exposure from consumption of drinking water. The dilution factors are calculated for a large river system using the river surface water model in LADTAP II. Five drinking water systems are defined in this sample problem as shown in the input record image list of Table 2.28. Each record in this table is described by record line number, as shown below:

Line 1:	Title record for sample problem 2
Line 2:	Site data specifying a freshwater site and requesting % contribution tables be printed
Line 3:	Total population within 50 miles and request to read record type 3a
Line 4:	Population age group fractions (record type 3a)
Line 5:	Source inventory title
Line 6-11:	Radionuclide release inventory and reconcentration factors
Line 12:	Blank record to terminate input of inventory cards
Line 13:	Reconcentration model selection (none)
Line 14:	Blank record to skip ALARA and selected location individual dose calculations
Line 15:	Blank record to skip sport fishing harvest pathway
Line 16:	Blank record to skip commercial fishing harvest pathway
Line 17:	Blank record to skip sport invertebrate harvest pathway
Line 18:	Blank record to skip commercial invertebrate harvest pathway
Line 19:	Data for first population drinking water usage location
Line 20:	Data for dilution factor calculation for first location

Line 21: Data for second population drinking water usage location

Line 22: Data for dilution factor calculation for second location

Line 23: Data for third population drinking water usage location - Note population exposed is calculated from input data

Line 24: Data for dilution factor calculation for third location

Line 25: Data for fourth population drinking water usage location

Line 26: Data for dilution factor calculation for fourth location

Line 27: Data for fifth population drinking water usage location

Line 28: Data for dilution factor calculation for fifth location

Line 29: Blank record to terminate reading drinking water records

Line 30: Blank record to skip population shoreline activity pathway

Line 31: Blank record to skip population swimming pathway

Line 32: Blank record to skip population boating pathway

Line 33: Blank record to skip irrigated food pathway

Line 34: Blank record to skip biota exposure calculation

Sample Problem 2 terminates when an attempt is made to read a new case title (line 35 which is absent). A complete list of the computer-generated output is provided in the Appendix B microfiche located inside the back cover of this report.

2.3.3 Sample Problem 3

This sample problem illustrates the use of BLOCK DATA change records and selection of special output report 23 (special ALARA analysis). Table 2.29 presents the input record images for this sample problem. The lines of the input file are described below:

Line 1: Title record for sample problem 3

Line 2: Site data specifying a saltwater site, printing of % contribution tables and reading of BLOCK DATA change records

TABLE 2.28. Sample Problem 2 Input Record List

Number	Type	Input Record Image
1	1	SAMPLE PROBLEM 2 - DRINKING WATER PATHWAY ONLY - MULTIPLE LOCATIONS
2	2	0 3150. 1. 1 0.
3	3	2200000. 1.0
4	3a	0.65 0.15 0.20
5	4	LIQUID SOURCE TERM FOR SAMPLE PROBLEM 2
6	5	I 131 5.2E-04 0.80
7	5	I 133 1.2E-03 0.20
8	5	I 135 1.3E-03 0.15
9	5	CS 134 3.9E-04 1.00
10	5	CS 137 5.5E-03 1.00
11	5	CS 138 2.8E-02 0.05
12	5	
13	6	0
14	7	
15	9	
16	10	
17	11	
18	12	
19	13	1000. -1. .3 WATER USE 2 MI DONWSTREAM
20	13a	1 5. 20. 10560. 0. 1320.
21	13	5500. -1. .8 WATER USE 6 MI DONWSTREAM
22	13a	1 5. 20. 31680. 10. 1320.
23	13	0. -1. 1.0 30000. 4. WATER USE 10 MI DOWNSTREAM
24	13a	1 5. 20. 52800. 40. 1320.
25	13	300000. -1. 2.0 WATER USE 20 MI DOWNSTREAM
26	13a	1 5. 20. 105600. 0. 1320.
27	13	1500000. -1. 3.0 WATER USE 35 MI DOWNSTREAM
28	13a	1 1. 30. 184800. 0. 1320.
29	13	
30	14	
31	15	
32	16	
33	17	
34	19	

Line 3: First BLOCK DATA change record--change parameter 5 of FIDO Group 1 to 15 (midpoint of plant life)

Line 4: Second BLOCK DATA change record--change parameters 5, 6, and 7 of FIDO Group 5 to 24, 10, and 20, respectively (usage time for shoreline, swimming and boating for adult individual doses)

Line 5: Third BLOCK DATA change record--change FIDO Group 1 parameter 12 to 20 (beef animal consumption of pasture grass) and parameter 16 to 300 (density thickness of root zone)

Line 6: Fourth BLOCK DATA change record--change parameter 53 of FIDO Group 13 to 30 (freshwater fish bioaccumulation factor for iodine)

Line 7: Fifth BLOCK DATA change record--change FIDO Group 1 parameter 1 to 1.0 (adult population fraction) and parameters 2 and 3 to zero (teen and child population fractions)

Line 8: Sixth BLOCK DATA change record--change all FIDO Group 19 parameters to 1.0 starting with the 54th parameter (transfer coefficient for meat for xenon through fermium)

Line 9: Seventh BLOCK DATA change record--change 24 values of FIDO Group 20 to 1.0 starting with the 54th parameter (transfer coefficient for milk for xenon through iridium)

Line 10: Eighth BLOCK DATA change record--terminate reading of BLOCK DATA change records

Line 11: Population within 50 miles--note that a zero value for population causes special report 23 to be printed

Line 12: Source inventory title

Line 13-19: Radionuclide release inventory and reconcentration factors

Line 20: Blank record to terminate reading of source inventory records

Line 21: Reconcentration model selection (none, reconcentration factors provided on source inventory records)

Line 22: ALARA individual dose calculation data

TABLE 2.29. Sample Problem 3 Input Record List

Number	Type	Input Record Image
1	1	SAMPLE PROBLEM 3 - ALARA ANALYSIS AND SPECIAL REPORT 23
2	2	1 3150. 2. 1 1
3	CR*	1** A5 15 E
4	CR	5** A5 24. 10. 20. E
5	CR	1** A12 20. A16 300.
6	CR	13** A53 30. E
7	CR	1** 1.0 2Z E
8	CR	19** A54 F1.0
9	CR	20** A54 24R1.0 E
10	CR	T
11	3	0. 0.
12	4	LIQUID SOURCE TERM FOR SAMPLE PROBLEM 3, MODIFICATION FACTOR = 2.
13	5	I 131 5.2E-04 .5
14	5	I 133 1.2E-03 .5
15	5	I 135 1.3E-03 .5
16	5	CS 134 3.9E-04 .8
17	5	CS 137 5.5E-03 .8
18	5	CS 138 2.8E-02 .8
19	5	H 3 1.8E+01 1.0
20	5	
21	6	0 0. 0.
22	7	0 0.2 1. 1. 4. .1 3.

* CR indicates FIDO block data change records

Execution of this sample problem is terminated after the printing of special report 23, which is shown in Figure 2.18. A complete list of the computer-generated output is given in the Appendix B microfiche located inside the back cover of this report.

When special report 23 is desired, care must be taken to include the proper contributions to dose. The program is intended to include in the fish and drinking water ingestion pathways for freshwater sites and fish and invertebrate pathways for saltwater sites. To execute the program properly the invertebrate and aquatic plant ingestion pathways must be skipped for freshwater sites. These pathways are skipped when their usage parameters (CRUS and ALUS) are zero. Default values for these two parameters are zero and should not be changed when report 23 is requested. For saltwater sites, the default value for CRUS is 5 kg/yr, and the invertebrate ingestion pathway is automatically included. The release activity must also be set to 1 Ci/yr for each radionuclide.

2.3.4 Sample Problem Output

A summary of reports generated by each sample problem is given in Table 2.30. A complete list of the sample problem output is included in the Appendix B microfiche located inside the back cover of this report.

TABLE 2.30. Summary of Output Report[a] Order for Sample Problems

Sample Problem 1	Sample Problem 2	Sample Problem 3
3	3	1
5	5	2
6	18 (5 locations)	3
7	22	4 (8 reports)
8		5
9		6
10		23
11 ALARA		
12 locations		
13		
10		
11 Selected		
12 locations		
13 (2 sets)		
14		
15		
16		
17		
18		
19		
20 vegetables		
20 leafy vegetables		
20 milk		
20 meat		
21 outfall		
21 downstream		
22		

(a) For report descriptions see Table 2.26.

2.4 ERROR MESSAGES

Fourteen error messages are generated in the LADTAP II program. Table 2.31 lists each error message, the cause of the message, and the action taken by the program when the error is encountered.

TABLE 2.31. Error Messages Generated by LADTAP II

Message	Cause/Correction	Action	Module Printing
***A MODEL CORRESPONDING TO M = "NN" IS NOT INCLUDED---RUN ABORTED---	The value given for parameter M (record type 6) must be 0, 1, 2, or 3.	STOP	RECON
BAD VALUE GIVEN FOR CFS OR UML, MUST BE >0 CFS = X.XEXX UML = X.XEXX	Values of CFS must be >0 and values of UML must be non-negative. Check values on record type 2.	STOP	MAIN
******ERROR "NN" ENTRIES REQUIRED IN "NNA" ARRAY DATA EDIT CONTINUES	Error in BLOCK DATA change record. Wrong number of values given for FIDO group. Check change records.	CONTINUE	FIDOS
******FILL OPTION IGNORED IN "NNA" ARRAY	The fill option "F" was used beyond the end of a FIDO group. Check change records.	CONTINUE	FIDOS
******INCOMPLETE FIELD AT END OF CARD, SOME DATA MAY BE LOST CARD IMAGE FOLLOWS "image of record in error"	A BLOCK DATA change record was not completed within 72 columns. Check change record printed.	CONTINUE	FFREAD
INDEX FOR FOOD PATHWAY DOES NOT EXIST - "NNNNN" STOP	The parameter N on record type 17 must be 0, 1, 2, 3, or 4. Check record 17.	STOP	FLOOD
INVALID INDEX CALCULATED IN SUBROUTINE BANLET IRX = "NNNNN"	A problem was encountered in placing the block letter into the banner page. This is an internal problem in the banner page preparation.	STOP	BANLET
INVALID INDEX IN SUBROUTINE BANNER IBASE = "NNNNN"	A problem was encountered in placing a line of text into the banner page. This is an internal problem in the banner page preparation.	STOP	BANNER

Table 2.31 (Contd)

Message	Cause/Correction	Action	Module Printing
INVALID LETTER PASSED TO SUBROUTINE BANLET IND = "NNNNN"	An invalid character was passed to BANLET. This indicates an internal problem in the banner page preparation.	STOP	BANLET
NEGATIVE VALUE GIVEN FOR LT. MUST BE > = 0. LT VALUE READ = , NNNNN	The site water type selection integer, LT, must not be negative. Check value on record type 2.	STOP	MAIN
PROBLEM IDENTIFYING RADIONUCLIDE "AAAAAAA" X.XEXX	A radionuclide name given on record type 5 could not be identified against the data file radionuclide list. Check input record indicated.	CONTINUE	SOURCE
***THE BLOWDOWN RATE OF "X.XEXX" AND THE DISCHARGE OF "X.XEXX" DO NOT AGREE	The plug flow impoundment model should have CFS (record type 2) and QSUBB (record type 6) the same.	CONTINUE	RECON
******WARNING ADDRESS "NN" IS BEYOND LIMITS OF "NNNA" ARRAY	An attempt to fill a parameter value beyond the end of a FIDO group was made. Check BLOCK DATA change records.	CONTINUE	FIDOS
******WARNING, DILUTION CALCULATION FAILURE*****	The dilution factor calculation estimated a near-zero downstream concentration. A value of 10^{20} is returned for the dilution factor. Doses will likely be very small, check input data for surface water model.	CONTINUE	SWAP

3.0 MATHEMATICAL MODELS

This section presents details of the mathematical models used in LADTAP II. The discussion is divided into three areas: 1) hydrologic models, 2) exposure pathway models, and 3) dosimetry models. Figure 3.1 illustrates the interrelationship between these models as they are applied to consequence analyses of light-water nuclear reactors. The annual radionuclide release rate from the reactor fuel to the reactor plant impoundment system is the starting point in the analysis. The impoundment hydrologic models describe transfer and hold up within the impoundment systems and estimate the annual release rate to surface water. Optional hydrologic models describe dilution in rivers and near-shore lake systems. The hydrologic models and surface-water models available in LADTAP II are presented in Section 3.1.

Surface water transport models are generally used to describe radionuclide concentrations at locations in the environment where exposure of humans or biota may occur. Transport of released activity through surface waters is considered here as part of the terrestrial model because dilution in surface waters is described by dilution factors and corresponding transit times. This representation of surface water transport is easily included in mathematical expressions for terrestrial models. The dilution factors may be provided by the user or calculated by the optional hydrologic models for rivers and near-shore lake systems.

The terrestrial models estimate consumption (by ingestion) of radionuclides, which are contained in various food products including fish, crustacea, water, aquatic plants, and farm products. Contamination of farm products results from the use of contaminated irrigation water. External exposures are also considered for swimming, boating, and shoreline activities. Terrestrial pathway models are described in Section 3.2.

LADTAP II addresses the area of dosimetry by using precalculated dose conversion factors provided in a data file. A description of the basis for these dose factors is presented in Section 3.3.

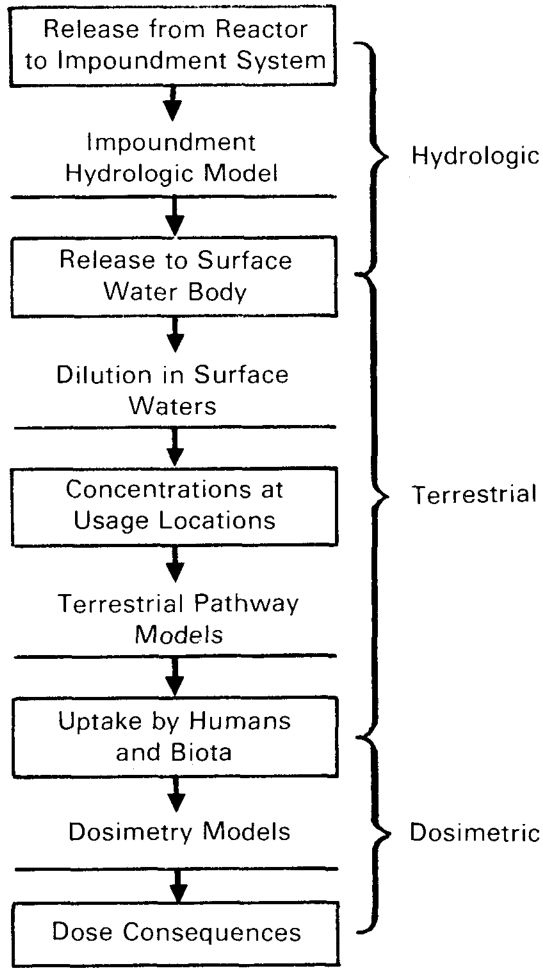


FIGURE 3.1. Interrelationship Between Mathematical Models from LADTAP II and Consequence Analyses for Light-Water Nuclear Reactors

3.1 HYDROLOGIC MODELS

The hydrologic models of LADTAP II describe effects of plant impoundment systems on radionuclide release concentrations to the surface water body and transport and dilution of radionuclides in nontidal rivers and near-shore lake systems. The impoundment system models are described first, followed by the surface water transport models.

3.1.1 Impoundment Models

The impoundment systems delay release to the main receiving water body, allowing additional time for radiological decay and resulting in lower radionuclide concentrations. Added dilution may also occur depending on the impoundment system design and operation. Three impoundment hydrologic models are available in LADTAP II: 1) plug flow, 2) partially mixed, and 3) completely mixed. In addition to these three models, the effects of the impoundment system can be discounted by defining release directly to the receiving water body. Figure 3.2 illustrates schematically the three impoundment models.

The starting point for all releases includes the activity of each radionuclide released from the reactor per year, q_i, and the reactor effluent discharge rate, Q_r. Where no impoundment system is used, the average annual release concentration to the receiving water body is given by the equation:

$$C_{oi} = 3.169 \times 10^{-8} \frac{q_i}{Q_r} \qquad (3.1)$$

where C_{oi} = the annual average water concentration for radionuclide i at the discharge point (Ci/ft^3)

q_i = the annual average release rate of radionuclide i to the coolant water (Ci/yr)

Q_r = the reactor effluent discharge rate in which the released radionuclides are diluted (ft^3/sec)

3.169×10^{-8} = a unit conversion factor (yr/sec)

The plug-flow impoundment model is based on the assumption of uniform, constant flow of water through the pond with negligible evaporation and leakage ($Q_r = Q_b$). The change in concentration flowing through the system is represented as radiological decay for the mean transit time in the impoundment system. With these assumptions, the concentration at the outfall is given by:

$$C_i = C_{oi} \exp [-2.778 \times 10^{-4} \lambda_i V_T/Q_b] \qquad (3.2)$$

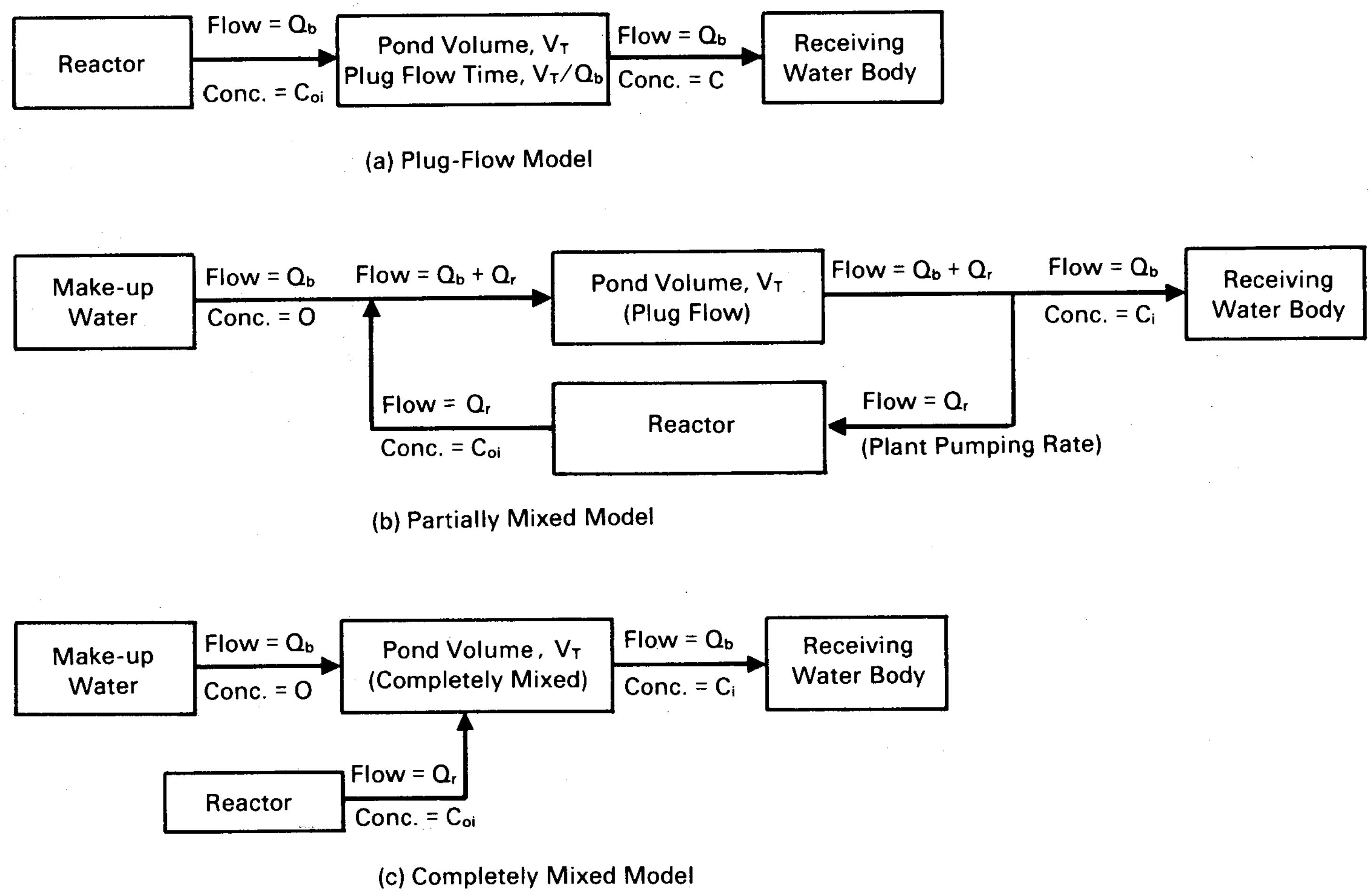


FIGURE 3.2. Schematic Representations of Impoundment Models

where C_i = the annual average water concentration at the outfall for radionuclide i after flow through the impoundment system (Ci/ft^3)

C_{oi} = the annual average water concentration entering the impoundment system (Ci/ft^3)

Q_b = the pond flow-through rate (ft^3/sec)

V_T = the pond volume (ft^3)

λ_i = the radiological decay constant for radionuclide i (hr^{-1})

2.778×10^{-4} = unit conversion factor (hr/sec)

In applying Equations (3.1) and (3.2), a reconcentration factor is calculated for each radionuclide:

$$R_i = \frac{C_i}{C_{oi}} \qquad (3.3)$$

where R_i is the impoundment reconcentration factor for radionuclide i (dimensionless). The reconcentration factor relates the effluent concentration (being discharged to the receiving water body) to the reactor discharge concentration. The effluent concentration is then easily determined as:

$$C_i = \frac{3.169 \times 10^{-8}\ q_i R_i}{Q_r} \qquad (3.4)$$

This expression is used in defining the effluent concentration for all impoundment models. Note that R_i = 1.0 when no impoundment system is used (direct release to the receiving water body).

The reconcentration factor for the partially mixed model is derived from a mass balance for steady-state conditions in Regulatory Guide 1.113 (NRC 1977b). Assuming no losses for evaporation or leakage, the reconcentration factor is given by:

$$R_i = \left(\frac{Q_r}{Q_b}\right) \frac{R}{(R+1)\quad \exp\left(\frac{V_T\ \lambda_i}{3600 Q_r (R+1)} \quad -1\right)} \qquad (3.5)$$

where R is the recirculation factor, Q_b/Q_r, (dimensionless); 3600 is a units conversion factor (sec/hr); and other terms are as previously defined. As expressed in this form, the reconcentration factor relates the concentration in the reactor discharge to the concentration in the effluent to the receiving water body. This differs slightly from the equation for R_i in Regulatory Guide 1.113, which does not include the coefficient Q_r/Q_b. Also, Regulatory Guide 1.113 defines Q_r as Q_p, the reactor pumping rate. The coefficient Q_r/Q_b is necessary to relate the effluent concentration to the reactor discharge concentration. (The Regulatory Guide relates the effluent concentration to q_i/Q_b.) The current representation simplifies computer implementation by relating all releases back to the reactor effluent, allowing Equation (3.4) to be used for all impoundment representations.

The completely mixed impoundment model estimates the effluent reconcentrations at midpoint of the plant life. The equation for the reconcentration factor is based on the assumption of negligible evaporation and leakage losses and complete mixing of the impoundment volume.

$$R_i = \left(\frac{Q_r}{Q_b}\right) \frac{Q_b}{(Q_b + \lambda_i V_T/3600)} \left\{1 - \exp\left[-3.15 \times 10^7 \left(Q_b + \frac{\lambda_i V_T}{3600}\right) \left(\frac{T_{PL}}{V_T}\right)\right]\right\} \quad (3.6)$$

where T_{PL} is the midpoint of plant life (yr); 3.15×10^7 is a units conversion factor (sec/yr); and other terms are as previously defined. This equation also contains the coefficient Q_r/Q_b to make the calculated reconcentration factor consistent with subsequent uses according to Equation (3.4). The Regulatory Guide representation defines the initial concentration as mixed in the input stream, Q_b. The current representation defines the initial concentration as mixed in the small stream, Q_r. Equation (3.6) and Figure 3.2(c) represent the case where the reactor discharge rate, Q_r, is much smaller than the pond blowdown rate, Q_b. This assumption is consistent with Regulatory Guide 1.113 (NRC 1977b).

3.1.2 Surface Water Models

Optional surface water transport models are available in LADTAP II to describe dilution in nontidal rivers and near-shore lake environments. These models may be used to evaluate a mixing ratio for use in exposure pathway evaluations. The mixing ratio is the ratio of water concentration at the locations of interest to the initial concentration.

Nontidal rivers are defined as freshwater bodies with unidirectional flow in definable channels. Near-shore lake environments are defined as surface-water areas that are near the shore of large open bodies of water and that have a straight shoreline, constant depth parallel to the shore, and steady-state, unidirectional flow parallel to the shore. Contaminants released, as a continuous point source, directly into the surface water body are transported through the system by advection and dispersion. Advection represents the solute transport by the mass motion of water, while dispersion represents solute transport by variations in the fluid's velocity field and molecular motion. Steady-state advective-dispersive equations for solute movement through surface water bodies form the basis of all surface water algorithms. The surface water flow is assumed steady and uniform; the algorithms are developed for the limiting case of unidirectional advective transport with lateral dispersion. The surface water program solves for radionuclide concentrations in a river or large lake under the following limiting assumptions (Codell et al. 1982):

- constant flow depth
- constant downstream or longshore velocity
- straight river channel or shoreline
- constant lateral dispersion coefficient
- point discharge release of effluents
- constant river width.

Codell et al. (1982) note that applications of models similar to those employed herein should be restricted to those portions of the near-shore zone of a river or lake that are removed from the influence of the discharge. Initial dilution near the point of discharge is usually controlled by the momentum effects of jets. They also note that when applied to the near-shore zone of a large lake, the model should be considered only for times between wind-induced current events. The surface water pathway can be described with the appropriate boundary and initial conditions by a set of semianalytical expressions that characterize the transport of radionuclides in nontidal river and near-shore lake environments.

Nontidal Rivers

For nontidal rivers with uniform flow and steady-state conditions, the diffusive transport in the flow direction can be neglected as compared with the advective transport. The NRC (1977b) notes that Yotsukura and Cobb (1972), Yotsukura (1972), and Yotsukura and Sayre (1976) have shown that far field transport of dissolved constituents in rivers can be satisfactorily treated by a two-dimensional model in which vertical variations of velocity and concentration are averaged. The advective-dispersive equation for a conservative substance in a nontidal riverine environment with simplified geometries can be described by the following expression:

$$u \frac{\partial C}{\partial x} = E_y \frac{\partial^2 C}{\partial y^2} \qquad (3.7)$$

where C = radionuclide concentration (Ci/ft^3)
u = flow velocity (ft/sec)
E_y = lateral turbulent dispersion coefficient (ft^2/sec)
x = longitudinal distance (ft)
y = lateral distance (ft)

The resulting concentration corresponding to a release of material from a point source located on the bank of a river is described by the following equation (NRC 1977b; Codell et al. 1982):

$$C = \frac{Q_b C_o}{udB} \left\{ 1 + 2 \sum_{i=1}^{\infty} \left[\exp - \left(\frac{i\pi}{udB} \right)^2 E_y u d^2 x \right] \cos \left(\frac{i\pi y}{B} \right) \right\} \qquad (3.8)$$

where C = water concentration at the downstream location of interest, defined by x and y, after continuous radionuclide release for a period equivalent to one-half the plant life (Ci/ft^3)

d = average river flow depth (ft)

B = river width (ft)

Q_b = effluent discharge rate to the receiving water body (ft^3/sec)

C_o = initial concentration of effluent entering the water body

i = index on infinite series

The mixing ratio is calculated as C divided by the initial concentration, C_o. The inverse of the mixing ratio is used in the terrestrial pathway calculation and is referred to as the dilution factor.

Near-Shore Zone of Large Lakes

Field studies in the Great Lakes, as noted by the NRC (1977b), have shown that coastal currents are predominately parallel to the shore, usually persist in one direction for several days, and seldom stagnate for more than several hours (Csanady 1970; Stone and Webster 1971). Observations have shown well-defined pollutant plumes closely following the shoreline for several days. The NRC (1977b) notes that it is possible to construct a quasi-steady-state model valid for simulating contaminant transport in near-shore lake environments for distances up to 16 miles.

Analytical models describing the release of contaminants in open coastal environments are usually based on Gaussian-like solutions to the steady-state, advective-dispersive equation. The advective-dispersive equation for a conservative substance in a near-shore lake environment with simplified geometries can be described by the following expression (NRC 1977b):

$$u \frac{\partial C}{\partial x} = E_y \frac{\partial^2 C}{\partial y^2} + E_z \frac{\partial^2 C}{\partial z^2} \qquad (3.9)$$

where E_z = vertical dispersion coefficient (ft^2/sec).

For the near-shore zone of a large lake, a similar procedure as that presented for nontidal rivers can be developed for computing radionuclide concentrations. For lakes assumed to have straight shorelines, to have a constant depth, and to have constant unidirectional flow, the advective-dispersive equation can be described by the following equation (NRC 1977b):

$$C = \left(\frac{C_o Q_b}{\pi x (E_y E_z)^{\frac{1}{2}}} \right) \exp\left[- \left(\frac{y^2 u}{4_x E_y} \right) \right] \sum_{i=-\infty}^{+\infty} \exp\left[- \left(\frac{(2id - z)^2 u}{4_x E_z} \right) \right] \quad (3.10)$$

where all terms are as previously defined. Equation (3.10) represents the resulting concentration from a point source located on the bank of the shore at point x, y in a lake of constant depth with steady longshore velocity.

Dispersion Coefficients

To use Equations (3.8) and/or (3.10) in any analysis, the lateral (i.e., transverse) and vertical dispersion coefficients have to be defined. Dispersion coefficients should be obtained by site-specific tracer studies whenever possible. Accurately defining dispersion coefficients for all riverine or lake environments under all conditions is difficult, if not impossible at this time. However, rough estimates can be defined. The coefficients are defined such that representative properties of the water body are considered in their estimation.

Fischer et al. (1979) note that lateral dispersion in rivers is generally related to the characteristics of the river using the following relationship:

$$E_y = \phi d\ u^* \quad (3.11)$$

where ϕ is the proportionality constant, and u^* is the shear velocity. All other terms retain their previous definitions. Equation (3.11) is of the same form as Elder's (1959) well-known equation defining the longitudinal dispersion coefficient.

For practical purposes, Fischer (1967) and Fischer et al. (1979) suggest a ϕ of 0.6. Shear velocity was estimated by Fischer (1974) as being roughly one-tenth the average flow velocity (this assumption is based on streams with

Manning roughness coefficients on the order of 0.04). Based on these assumptions, a dispersion coefficient in the lateral direction can be estimated as:

$$E_y = 0.06\ du \tag{3.12}$$

Even though Equation (3.12) was developed for river environments, it is also being used for the near-shore lake environment. Codell et al. (1982) note that studies by Csanady (1970) on the Great Lakes indicate representative dispersion values on the order of 0.5 to 1.0 ft^2/sec for lateral dispersion, which are values on order with Equation (3.12).

Fischer et al. (1979) note that researchers have expressed the vertical dispersion coefficient as a function of the flow depth and shear velocity:

$$E_z = \psi du^* \tag{3.13}$$

where ψ is the proportionality constant, and all other terms retain their previous definition. Fischer et al. (1979) note that based on work by Jobson and Sayre (1970), ψ has a value of approximately 0.067. Work by Csanady (1976) indicates a value of 0.050 for ψ. Assuming that the shear velocity is once again equivalent to one-tenth the average flow velocity and that ψ is equivalent to an average value of 0.059, the vertical dispersion coefficient is estimated as:

$$E_z = 0.0059\ du \tag{3.14}$$

Even though Equation (3.14) was developed for river environments, it is also being used for the near-shore lake environment. The NRC (1977b) notes that studies by Csanady (1970) and Sundaram and Rehm (1973) indicate representative dispersion values on the order of 0.001 to 0.030 ft^2/sec for vertical dispersion, which are values on the order of Equation (3.14). These values are typical only in the near-shore region away from influences of the effluent release point.

3.2 TERRESTRIAL MODELS

The terrestrial models relate effluent concentration to concentrations of various exposure media. As indicated in Section 1, LADTAP II considers several pathways and exposure groups. This section presents models and equations that estimate radiation dose to each of the exposed groups by each pathway. The models presented here are based largely on the models of Regulatory Guide 1.109 (NRC 1977a) and Soldat et al. (1974) as originally developed for the HERMES program (Fletcher and Dotson 1971).

The fundamental equation for estimating radiation dose to an individual from a given pathway is:

$$R_{aipj} = C_{ip} U_{ap} D_{aipj} \tag{3.15}$$

where C_{ip} = the concentration of radionuclide i in media of pathway p (pCi/L, pCi/kg, or pCi/m^2)

D_{aipj} = the dose conversion factor specific to age group a, radionuclide i, pathway p, and organ j (for ingestion pathways the dose factor converts from pCi ingested to mrem, and for external exposure pathways the dose factor converts from pCi/m^2 or pCi/L to dose rate in mrem/hr

R_{aipj} = the dose to an organ j, of an individual of age group a, from radionuclide i, via pathway p (mrem/yr)

U_{ap} = the pathway usage parameter representing exposure time (external exposure) or intake (ingestion) associated with pathway p for age group a (hr/yr, L/yr, or kg/yr as appropriate to the pathway)

The concentration parameter, C_{ip}, is the primary consideration of the exposure pathway models. This parameter is calculated from the initial radionuclide release by using models and data specific to the site and pathway of interest.

The radiation doses calculated by LADTAP II from ingestion pathways (water, aquatic foods and terrestrial foods) represent 50-year dose commitments from one year of uptake. External doses represent the dose received during the year of exposure. Details of the dose conversion factors are presented in Section 3.3.

A following discussion of dose calculations is organized by major pathway. Doses to individuals are discussed with the initial presentation. Special considerations specific to population doses are presented, followed by a discussion of biota pathway models. Default parameter values are presented with the initial discussion of models. Default values taken from Regulatory Guide 1.109 (NRC 1977a) are indicated by reference to specific tables from which they are taken in the Regulatory Guide (for example RG-TE4 refers to Regulatory Guide 1.109 Table E-4). Also indicated are differences in parameter use between individual dose calculations and population dose calculations. Many of the equations for individual doses are applied also to population dose calculations by making minor changes in parameters.

3.2.1 Aquatic Pathways

The aquatic exposure pathways of LADTAP II include exposure from ingestion of water, fish, invertebrates (including crustacea and molluscs) and aquatic plants and external exposure from shoreline activities, boating, and swimming.

Potable water ingestion is a primary pathway for exposure at freshwater sites. The dose from ingestion of water is estimated by:

$$R_{apj} = 1119 \frac{M_p U_{ap}}{Q_r} \sum_{i=1}^{\text{nuclides}} q_i R_i \, D_{aipj} \, e^{-\lambda_i t_p} \qquad (3.16)$$

where R_{apj} = the dose to organ j of an individual of age group a (mrem/yr)

Q_r = the reactor effluent discharge rate (ft^3/sec)

q_i = the average release rate for radionuclide i (Ci/yr)

M_p = the mixing ratio representing dilution from the point of effluent discharge (into the receiving water) to the water system intake location (dimensionless)

R_i = the impoundment system reconcentration factor (dimensionless)

U_{ap} = the water consumption rate for an individual of age group a (L/yr)

t_p = the transit time from the release point (outfall) to the point of consumption (hr)

1119 = a units conversion factor as follows:

$$1119 = 10^{12}\left(\frac{pCi}{Ci}\right)\left(\frac{yr}{3.156 \times 10^{7} sec}\right)\left(\frac{ft^3}{28.316\ L}\right)$$

The mixing ratio, M_p, is actually represented in the program as a dilution factor equal to the inverse of the mixing ratio. The transit time, t_p, includes the transit time from the release point to the water supply system intake plus the transit time in the distribution system to the consumption point. The user can specify the transit time to the water supply system intake for each water system of interest. A default value of 12 hours is used for the individual dose calculations and 24 hours for population dose calculations. The 12-hour value for individuals can be changed by the user (see Section 2.2); the population value cannot be changed without a code modification.

Default parameter values (RG-TE5) for water consumption by the maximum individual, U_{ap}, are as follows: 730 L/yr for adults, 510 L/yr for teens, 510 L/yr for children, and 330 L/yr for infants. Population doses are calculated using default (RG-TE4) average individual consumption rates of 370 L/yr for adults, 260 L/yr for teens, and 260 L/yr for children. The infant age group is not considered in population dose calculations.

Three types of aquatic foods are considered in LADTAP II: fish, invertebrates, and aquatic plants. The dose to an individual from ingestion of these aquatic foods is estimated as follows:

$$R_{apj} = 1119 \frac{M_p U_{ap}}{Q_r} \sum_{i=1}^{\text{nuclides}} q_i R_i B_{ip} D_{aipj} e^{-\lambda_i t_p} \quad (3.17)$$

where R_{apj} = the dose to an organ j of an individual in age group a from ingestion of aquatic food type p (mrem/yr)

B_{ip} = the bioaccumulation factor for radionuclide i in aquatic food pathway p (pCi/kg edible part/pCi/L)

t_p = the transit time from the release point to consumption (hr)

U_{ap} = the consumption rate of aquatic food p by individuals of age group a (kg/yr)

Other terms are as previously defined. The transit time includes 24 hours for processing of aquatic foods (RG-P12) plus the user-defined transit time to the locations of harvest. For population dose calculations, the food processing time is 168 hours for sport harvest and 240 hours for commercial harvest (RG-TD1).

LADTAP II provides bioaccumulation factors for the three aquatic food types for both salt and freshwater species. Default values for these parameters (RG-TA1) are presented in Table 3.1 along with similar concentration factors for irrigated food pathways (RG-TE1). Default values for consumption rates of aquatic foods are given in Table 3.2.

External exposure from waterborne releases is considered for the recreational activities where individuals come near water (swimming and boating) and contaminated sediments (shoreline). Calculating individual dose from exposure to shoreline deposits is complex since it involves estimating sediment load, transport, and concentration of radionuclides associated with suspended and deposited materials. Soldat et al. (1974) have developed a model that

TABLE 3.1. Terrestrial and Aquatic Bioaccumulation Factors in BLOCK DATA

Element	Terrestrial Parameters			Freshwater Parameters[a]			Saltwater Parameters[a]		
	Meat[b]	Milk[c]	Soil[d]	Fish	Invert.	Aq. Plant	Fish	Invert.	Aq. Plant
H	1.2E-02[e]	1.0E-02	4.8E+00	9.0E-01	9.0E-01	9.0E-01	9.0E-01	9.3E-01	9.3E-01
He	2.0E-02	2.0E-02	5.0E-02	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Li	1.0E-02	5.0E-02	8.3E-04	5.0E-01	4.0E+01	3.0E+00	5.0E-01	5.0E-01	3.0E+00
Be	1.0E-03	1.0E-04	4.2E-04	2.0E+00	1.0E+01	2.0E+01	2.0E+02	2.0E+02	1.0E+03
B	8.0E-04	2.7E-03	1.2E-01	2.2E-01	5.0E+01	2.2E+00	2.2E-01	4.4E-01	2.2E+00
C	3.1E-02	1.2E-02	5.5E+00	4.6E+03	9.1E+03	4.6E+03	1.8E+03	1.4E+03	1.8E+03
N	7.7E-02	2.2E-02	7.5E+00	1.5E+05	1.5E+05	1.3E+04	6.0E+04	1.7E+04	1.0E+04
O	1.6E-02	2.0E-02	1.6E+00	9.2E-01	9.2E-01	9.2E-01	9.6E-01	9.6E-01	9.6E-01
F	1.5E-01	1.4E-02	6.5E-04	1.0E+01	1.0E+02	2.0E+00	3.6E+00	3.6E+00	1.4E+00
Ne	2.0E-02	2.0E-02	1.4E-01	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Na	3.0E-02	4.0E-02	5.2E-02	1.0E+02	2.0E+02	5.0E+02	6.7E-02	1.9E-01	9.5E-01
Mg	5.0E-03	1.0E-02	1.3E-01	5.0E+01	1.0E+02	1.0E+02	7.7E-01	7.7E-01	7.7E-01
Al	1.5E-03	5.0E-04	1.8E-04	1.0E+01	6.3E+01	4.2E+02	1.0E+01	6.0E+01	6.0E+02
Si	4.0E-05	1.0E-04	1.5E-04	2.5E+00	2.5E+01	1.3E+02	1.0E+01	3.3E+01	6.7E+01
P	4.6E-02	2.5E-02	1.1E+00	1.0E+05	2.0E+04	5.0E+05	2.9E+04	3.0E+04	3.0E+03
S	1.0E-01	1.8E-02	5.9E-01	7.5E+02	1.0E+02	1.0E+02	1.7E+00	4.4E-01	4.4E-01
Cl	8.0E-02	5.0E-02	5.0E+00	5.0E+01	1.0E+02	5.0E+01	1.3E-02	1.9E-02	7.6E-02
Ar	2.0E-02	2.0E-02	6.0E-01	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
K	1.2E-02	1.0E-02	3.7E-01	1.0E+03	8.3E+02	6.7E+02	1.1E+01	6.6E+00	2.6E+01
Ca	4.0E-03	8.0E-03	3.6E-02	4.0E+01	3.3E+02	1.3E+02	5.0E-01	1.3E+01	5.0E+00
Sc	1.6E-02	5.0E-06	1.1E-03	2.0E+00	1.0E+03	1.0E+04	2.0E+00	1.0E+04	1.0E+05
Ti	3.1E-02	5.0E-06	5.4E-05	1.0E+03	3.0E+03	5.0E+02	1.0E+03	1.0E+03	2.0E+03
V	2.3E-03	1.0E-03	1.3E-03	1.0E+01	3.0E+03	1.0E+02	1.0E+01	5.0E+01	1.0E+02
Cr	2.4E-03	2.2E-03	2.5E-04	2.0E+02	2.0E+03	4.0E+03	4.0E+02	2.0E+03	2.0E+03
Mn	8.0E-04	2.5E-04	2.9E-02	4.0E+02	9.0E+04	1.0E+04	5.5E+02	4.0E+02	5.5E+03
Fe	4.0E-02	1.2E-03	6.6E-04	1.0E+02	3.2E+03	1.0E+03	3.0E+03	2.0E+04	7.3E+02
Co	1.3E-02	1.0E-03	9.4E-03	5.0E+01	2.0E+02	2.0E+02	1.0E+02	1.0E+03	1.0E+03
Ni	5.3E-03	6.7E-03	1.9E-02	1.0E+02	1.0E+02	5.0E+01	1.0E+02	2.5E+02	2.5E+02
Cu	8.0E-03	1.4E-02	1.2E-01	5.0E+01	4.0E+02	2.0E+03	6.7E+02	1.7E+03	1.0E+03
Zn	3.0E-02	3.9E-02	4.0E-01	2.0E+03	1.0E+04	2.0E+04	2.0E+03	5.0E+04	1.0E+03
Ga	1.3E+00	5.0E-05	2.5E-04	3.3E+02	6.7E+02	1.7E+03	3.3E+02	6.7E+02	1.7E+03

Table 3.1 (Contd)

Element	Terrestrial Parameters			Freshwater Parameters[a]			Saltwater Parameters[a]		
	Meat[b]	Milk[c]	Soil[d]	Fish	Invert.	Aq. Plant	Fish	Invert.	Aq. Plant
Ge	2.0E+01	5.0E-04	1.0E-01	3.3E+03	3.3E+01	3.3E+01	3.3E+03	1.7E+04	3.3E+02
As	2.0E-03	6.0E-03	1.0E-02	1.0E+02	4.0E+01	3.0E+03	3.3E+02	3.3E+02	1.7E+03
Se	1.5E-02	4.5E-02	1.3E+00	1.7E+02	1.7E+02	1.0E+03	4.0E+03	1.0E+03	1.0E+03
Br	2.6E-02	5.0E-02	7.6E-01	4.2E+02	3.3E+02	5.0E+01	1.5E-02	3.1E+00	1.5E+00
Kr	2.0E-02	2.0E-02	3.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Rb	3.1E-02	3.0E-02	1.3E-01	2.0E+03	1.0E+03	1.0E+03	8.3E+00	1.7E+01	1.7E+01
Sr	6.0E-04	8.0E-04	1.7E-02	3.0E+01	1.0E+02	5.0E+02	2.0E+00	2.0E+01	1.0E+01
Y	4.6E-03	1.0E-05	2.6E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Zr	3.4E-02	5.0E-06	1.7E-04	3.3E+00	6.7E+00	1.0E+03	2.0E+02	8.0E+01	1.0E+03
Nb	2.8E-01	2.5E-03	9.4E-03	3.0E+04	1.0E+02	8.0E+02	3.0E+04	1.0E+02	5.0E+02
Mo	8.0E-03	7.5E-03	1.2E-01	1.0E+01	1.0E+01	1.0E+03	1.0E+01	1.0E+01	1.0E+01
Tc	4.0E-01	2.5E-02	2.5E-01	1.5E+01	5.0E+00	4.0E+01	1.0E+01	5.0E+01	4.0E+03
Ru	4.0E-01	1.0E-06	5.0E-02	1.0E+01	3.0E+02	2.0E+03	3.0E+00	1.0E+03	2.0E+03
Rh	1.5E-03	1.0E-02	1.3E+01	1.0E+01	3.0E+02	2.0E+02	1.0E+01	2.0E+03	2.0E+03
Pd	4.0E-03	1.0E-02	5.0E+00	1.0E+01	3.0E+02	2.0E+02	1.0E+01	2.0E+03	2.0E+03
Ag	1.7E-02	5.0E-02	1.5E-01	2.3E+00	7.7E+02	2.0E+02	3.3E+03	3.3E+03	2.0E+02
Cd	5.3E-04	1.2E-04	3.0E-01	2.0E+02	2.0E+03	1.0E+03	3.0E+03	2.5E+05	1.0E+03
In	8.0E-03	1.0E-04	2.5E-01	1.0E+05	1.0E+05	1.0E+05	1.0E+05	1.0E+05	1.0E+05
Sn	8.0E-02	2.5E-03	2.5E-03	3.0E+03	1.0E+03	1.0E+02	3.0E+03	1.0E+03	1.0E+02
Sb	4.0E-03	1.5E-03	1.1E-02	1.0E+00	1.0E+01	1.5E+03	4.0E+01	5.0E+00	1.5E+03
Te	7.7E-02	1.0E-03	1.3E+00	4.0E+02	6.1E+03	1.0E+02	1.0E+01	1.0E+02	1.0E+03
I	2.9E-03	6.0E-03	2.0E-02	1.5E+01	5.0E+00	4.0E+01	1.0E+01	5.0E+01	1.0E+03
Xe	2.0E-02	2.0E-02	1.0E+01	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Cs	4.0E-03	1.2E-02	1.0E-02	2.0E+03	1.0E+03	5.0E+02	4.0E+01	2.5E+01	5.0E+01
Ba	3.2E-03	4.0E-04	5.0E-03	4.0E+00	2.0E+02	5.0E+02	1.0E+01	1.0E+02	5.0E+02
La	2.0E-04	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Ce	1.2E-03	1.0E-04	2.5E-03	1.0E+00	1.0E+03	4.0E+03	1.0E+01	6.0E+02	6.0E+02
Pr	4.7E-03	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Nd	3.3E-03	5.0E-06	2.4E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Pm	4.8E-03	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03

Table 3.1 (Contd)

Element	Terrestrial Parameters			Freshwater Parameters[a]			Saltwater Parameters[a]		
	Meat[b]	Milk[c]	Soil[d]	Fish	Invert.	Aq. Plant	Fish	Invert.	Aq. Plant
Sm	5.0E-03	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Eu	4.8E-03	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Gd	3.6E-03	5.0E-06	2.6E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Tb	4.4E-03	5.0E-06	2.6E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Dy	5.3E-03	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Ho	4.4E-03	5.0E-06	2.6E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Er	4.0E-03	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Tm	4.4E-03	5.0E-06	2.6E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Yb	4.0E-03	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Lu	4.4E-03	5.0E-06	2.6E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Hf	4.0E-01	5.0E-06	1.7E-04	3.3E+00	6.7E+00	1.0E+03	2.0E+02	2.0E+01	2.0E+03
Ta	1.6E+00	2.5E-02	6.3E-03	3.0E+04	6.7E+02	8.0E+02	3.0E+04	1.7E+04	1.0E+03
W	1.3E-03	5.0E-04	1.8E-02	1.2E+03	1.0E+01	1.2E+03	3.0E+01	3.0E+01	3.0E+01
Re	8.0E-03	2.5E-02	2.5E-01	1.2E+02	6.0E+01	2.4E+02	4.8E+00	6.0E+01	2.4E+02
Os	4.0E-01	5.0E-03	5.0E-02	1.0E+01	3.0E+02	2.0E+02	1.0E+01	2.0E+03	2.0E+03
Ir	1.5E-03	5.0E-03	1.3E+01	1.0E+01	3.0E+02	2.0E+02	1.0E+01	2.0E+03	2.0E+03
Pt	4.0E-03	5.0E-03	5.0E-01	1.0E+02	3.0E+02	2.0E+02	1.0E+02	2.0E+03	2.0E+03
Au	8.0E-03	5.0E-03	2.5E-03	3.3E+01	5.0E+01	3.3E+01	3.3E+01	3.3E+01	3.3E+01
Hg	2.6E-01	3.8E-02	3.8E-01	1.0E+03	1.0E+05	1.0E+03	1.7E+03	3.3E+04	1.0E+03
Tl	4.0E-02	2.2E-02	2.5E-01	1.0E+04	1.5E+04	1.0E+05	1.0E+04	1.5E+04	1.0E+05
Pb	2.9E-04	6.2E-04	6.8E-02	1.0E+02	1.0E+02	2.0E+02	3.0E+02	1.0E+03	5.0E+03
Bi	1.3E-02	5.0E-04	1.5E-01	1.5E+01	2.4E+01	2.4E+01	1.5E+01	2.4E+01	2.4E+01
Po	1.2E-02	3.0E-04	1.5E-01	5.0E+02	2.0E+04	2.0E+03	3.0E+02	5.0E+03	2.0E+03
At	8.0E+00	5.0E-02	2.5E-01	1.5E+01	5.0E+00	4.0E+01	1.0E+01	5.0E+01	4.0E+03
Rn	2.0E-02	2.0E-02	3.5E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00
Fr	2.0E-02	5.0E-02	1.0E-02	4.0E+02	1.0E+02	8.0E+01	3.0E+01	2.0E+01	2.0E+01
Ra	3.4E-02	8.0E-03	3.1E-04	5.0E+01	2.5E+02	2.5E+03	5.0E+01	1.0E+02	1.0E+02
Ac	6.0E-02	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Th	2.0E-04	5.0E-06	4.2E-03	3.0E+01	5.0E+02	1.5E+03	1.0E+04	2.0E+03	3.0E+03
Pa	8.0E+02	5.0E-06	2.5E-03	1.1E+01	1.1E+02	1.1E+03	1.0E+01	1.0E+01	6.0E+00
U	3.4E-04	5.0E-04	2.5E-03	2.0E+00	6.0E+01	5.0E-01	1.0E+01	1.0E+01	6.7E+01

Table 3.1 (Contd)

Element	Terrestrial Parameters			Freshwater Parameters[a]			Saltwater Parameters[a]		
	Meat[b]	Milk[c]	Soil[d]	Fish	Invert.	Aq. Plant	Fish	Invert.	Aq. Plant
Np	2.0E-04	5.0E-06	2.5E-03	1.0E+01	4.0E+02	3.0E+02	1.0E+01	1.0E+01	6.0E+00
Pu	1.4E-05	2.0E-06	2.5E-04	3.5E+00	1.0E+02	3.5E+02	3.0E+00	2.0E+02	1.0E+03
Am	2.0E-04	5.0E-06	2.5E-04	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Cm	2.0E-04	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Bk	2.0E-04	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Cf	2.0E-04	5.0E-06	2.5E-03	2.5E+01	1.0E+03	5.0E+03	2.5E+01	1.0E+03	5.0E+03
Es	2.0E-04	5.0E-06	2.5E-03	1.0E+01	1.0E+02	1.0E+03	1.0E+01	1.0E+01	6.0E+01
Fm	2.0E-04	5.0E-06	2.5E-03	1.0E+01	1.0E+02	1.0E+03	1.0E+01	1.0E+01	6.0E+01

(a) Units are pCi/kg (edible part) per pCi/L.
(b) Units are pCi/kg (animal product) per pCi/day.
(c) Units are pCi/L (milk) per pCi/day.
(d) Units are pCi/g plant (wet) per pCi/g soil.
(e) 1.2E-02 $\equiv 1.2 \times 10^{-2}$.

TABLE 3.2. Default Values for Consumption Rates of Aquatic Foods (kg/yr)

Pathway/Age Group	Maximum Individual (RG-TE5) Freshwater	Saltwater	Age Group Average (RG-TE4)
Fish:			
adult	21	21	6.9
teen	16	16	5.2
child	6.9	6.9	2.2
infant	0	0	-(a)
Invertebrates:			
adult	0	5.0	1.0
teen	0	3.8	0.75
child	0	1.7	0.33
infant	0	0	-
Aquatic plants:			
adult	0	0	-
teen	0	0	-
child	0	0	-
infant	0	0	-

(a) Dash (-) indicates that this exposure pathway is not included in LADTAP II.

estimates the shoreline radionuclide concentration following a long period of deposition. This model uses the following equation to express shoreline sediment concentration:

$$S_i = 100\ T_i\ C_{wi}\ W[1 - \exp(-\lambda_i T_b)] \qquad (3.18)$$

where S_i = the concentration of radionuclide i in shoreline sediment (pCi/m^2)

C_{wi} = the radionuclide concentration in water adjacent to the sediment (pCi/L)

W = the shore-width factor (dimensionless)

T_i = physical half-life of the radionuclide (d), $\ln(2)/(24\ \lambda_i)$

T_b = the length of time the sediment is exposed to the contaminated water, nominally 20 years, which is the approximate midpoint of plant's operating life (hr)

λ_i = radiological decay constant for radionuclide i (hr^{-1})

100 = transfer constant from water to sediment (L per $m^2 \cdot d$)

The value of the transfer constant (100) was derived for several radionuclides by using data obtained from analysis of water and sediment samples taken from the Columbia River between Richland, Washington, and the river mouth, and from Tillamook Bay, Oregon, 75 km south of the river mouth (Nelson 1965; Toombs and Cutler 1968). Equation (3.18) estimates an effective surface contamination for use in calculating gamma exposure rates to persons standing on the sediment.

The shore-width factor, W, represents the fraction of dose from an infinite plane source that would be received from a given shoreline situation that may not be well described as an infinite plane. The shore-width factor is essentially a geometric correction. Suggested values for W are derived from experimental data (Dunster 1971) and are presented in Table 2.7 on page 2.12 (RG-TA2).

The water concentration adjacent to the sediment may be represented as:

$$C_{wi} = \frac{1119\ q_i\ M_p}{Q_r} R_i \exp(-\lambda_i t_p) \qquad (3.19)$$

where t_p is the transit time from the release point to the exposure location (hr), and other terms are as previously defined. Combining Equations (3.18) and (3.19) into the general equation for dose (Equation 3.15) results in the following equation for external dose from shoreline exposure:

$$R_{apj} = 111{,}900 \frac{U_{ap}\ M_p\ W}{Q_r} \sum_{i=1}^{\text{nuclides}} q_i R_i T_i D_{aipj} \exp(-\lambda_i t_p)[1 - \exp(-\lambda_i t_b)] \qquad (3.20)$$

where R_{apj} = the dose to organ j of an individual in age group a from external exposure to contaminated shoreline (mrem/yr)

U_{ap} = annual exposure time to shoreline for an individual of age group a (hr/yr)

111,900 = the product of 1119 and 100, as previously defined

The external dose evaluations are performed only for the total body. Other internal organs are assumed to receive the same dose as the total body. A discussion of dose factors is presented in Section 3.3.

Recreation activities where individuals come near to or in contact with contaminated water may result in external exposure. Two such pathways are included in LADTAP II: swimming and boating. The doses to an individual from these pathways are calculated by the following expression:

$$R_{apj} = 1119 \frac{U_{ap} M_p}{G_p Q_r} \sum_{i=1}^{\text{nuclides}} q_i R_i D_{aipj} \exp(-\lambda_i t_p) \qquad (3.21)$$

where R_{apj} is the dose to organ j (total body or skin), of an individual in age group a, for exposure from immersion in water (mrem/yr); G_p is an exposure geometry factor (dimensionless), and other terms are as previously defined.

The geometry factor represents the degree of immersion for the particular pathway being evaluated. For swimming exposure the geometry factor is set to unity to represent total immersion. For boating exposure the geometry factor is set to 2.0 to represent half immersion.

Default values for individuals exposed to shoreline, swimming, and boating are presented in Table 3.3 (RG-TE5). Default values for population exposure are not provided.

3.2.2 Irrigated Farm Products

Irrigating farms with contaminated freshwater presents a potential pathway for exposure. Consuming food products produced on such farms contributes to individual and population exposure. LADTAP II considers four specific food

TABLE 3.3. Default Values for External Pathway Exposure Times of Individuals (hr/yr)

Pathway	Adult	Teen	Child	Infant
Shoreline	12	67	14	0
Swimming	0	0	0	0
Boating	0	0	0	0

products: vegetables, leafy vegetables, milk, and meat. Both vegetable types may become contaminated by direct deposition onto plant surfaces and by uptake of contaminants from soil through roots to edible parts of the plant. Animal products become contaminated when animals consume contaminated pasture feed, or consume contaminated water. Details of these exposure pathways are described below.

The concentration of radionuclides in irrigated farm products is derived from those in the water as defined by Equation (3.19), which is a general expression for all exposure pathways. First, the concentration in the plant (for those consumed by humans and animals) is calculated for root uptake and direct deposition onto plant surfaces. For direct deposition on plant leaves, the plant concentration is calculated as:

$$C_{ipL} = \frac{C_{wi} I\ r}{730 Y_v \lambda_{ei}} \left[1 - \exp(-\lambda_{ei} T_e)\right] \exp(-\lambda_i T_h) \qquad (3.22)$$

where C_{ipL} = the concentration of radionuclide i in plants for pathway p from deposition onto leaves (pCi/kg)

C_{wi} = the irrigation water concentration for radionuclide i (pCi/L)

I = the irrigation rate ($L/m^2/mo$)

r = the fraction of deposited activity retained on leaves (dimensionless)

T_e = the period that crops are exposed to irrigation during the year (hr)

T_h = the holdup time between harvest and consumption (hr)

Y_v = agricultural yield for the crop (kg wet weight/m^2)

λ_i = the radiological decay constant for radionuclide i (hr^{-1})

λ_{ei} = the effective weathering half-time for radionuclide i (hr^{-1})

$\lambda_{ei} = \lambda_w + \lambda_i$

λ_w = the weathering decay constant for removal from plant surfaces (hr^{-1})

730 = the number of hours per month

Default values for several of the parameters listed above (RG-TE15) are provided as follows: retention fraction (r) - 0.25; crop growing period (T_e) - 60 days for vegetable crops and 30 days for animal products; crop yield (Y_v) - 2.0 kg/m^2 vegetable crops and 0.7 kg/m^2 for animal products; and weathering half-time (for λ_w) - 14 days. Table 3.4 presents default values for holdup times for individuals for all four irrigated food pathways (RG-TE15).

TABLE 3.4. Default Holdup Time Values for Irrigated Food Pathways (hrs)

Holdup Times	Vegetables	Leafy Vegetables	Milk	Meat
Average	1,440	48	96	480
Maximum	336	24	48	480

The plant concentration from the root uptake pathway is calculated as:

$$C_{ipr} = \frac{C_{wi}\ I\ B_{iv}}{730\ P\lambda_i} [1 - \exp(-\lambda_i T_b)] \exp(-\lambda_i T_h) \qquad (3.23)$$

where C_{ipr} = the concentration of radionuclide i in plants for pathway p from root uptake (pCi/kg)

B_{iv} = the concentration factor for uptake of radionuclide i from soil by edible parts of plants (pCi/kg wet weight/pCi/kg dry soil)

P = the effective surface density for soil in the root zone (kg/dry soil/m^2)

T_b = the total time for accumulation in soil, taken to be the midpoint of facility operating life (hr)

and other terms are as previously defined. LADTAP II provides default values for concentration factors by element. Table 3.1 includes a list of these parameters. The default value for the effective soil surface density is 240 kg/m^2, which represents the soil weight in an assumed cultivating depth of 15 cm (RG-TE15).

The total concentration in the plant is given as the sum of the root and leafy vegetable uptake.

$$C_{ip} = C_{ipL} + C_{ipr} \quad (3.24)$$

where C_{ip} is the total concentration of radionuclide i in crop p (pCi/kg) and other terms are as previously defined. Equations (3.22) through (3.24) are used for all radionuclides except tritium. It is assumed that tritium is uniformly distributed throughout the plant at the same tritium concentration found in irrigation water.

$$C_{ip} = C_{wi} \text{ (for tritium in plants)} \quad (3.25)$$

The concentration of radionuclides in animal products is calculated from the water concentration given by Equation (3.19) and the plant concentration given by Equations (3.22) and (3.23). For animal product pathways, the latter two equations are evaluated without the exponential term for decay from holdup during food processing and distributing. The concentration of radionuclides in animal products from animal ingestion of drinking water is given by:

$$C_{iaw} = C_{wi}\, F_{ia}(1 - f_w)\, Q_w \exp(-\lambda_i T_h) \quad (3.26)$$

where C_{iaw} = the concentration of radionuclide i in animal product p from animal ingestion of water (pCi/kg for meat and pCi/L for milk)

F_{ia} = the transfer coefficient that relates the daily intake rate by an animal to the concentration in an edible animal product (pCi/L milk per pCi/day or pCi/kg meat per pCi/day)

f_w = the fraction of water intake that is not contaminated (dimensionless)

Q_w = the consumption rate of water by the animal (L/d)

T_h = the holdup time between harvest (or slaughter) and consumption for the animal product (hr)

and other terms are as previously defined. Table 3.1 presents the transfer coefficients, F_{ia}, that are provided in LADTAP II. Table 3.4 presents default holdup times (RG-TE15). Milk animals are assumed to consume 60 L/d of water, and beef animals are assumed to consume 50 L/d (RG-TE3).

The animal product concentration resulting from animals ingesting contaminated feed crops is calculated as:

$$C_{iaf} = C_{ip}\, F_{ia}(1 - f_f)\, Q_f \exp(-\lambda_i T_h) \qquad (3.27)$$

where C_{iaf} = the concentration of radionuclide i in animal product p from animal ingestion of contaminated feed (pCi/L or pCi/kg)

C_{ip} = the concentration of radionuclide i in contaminated feed (pCi/kg)

f_f = the fraction of animal feed that is not contaminated (dimensionless)

Q_f = the consumption rate of feed by the animal (kg/d)

and other terms are as previously defined. Evaluating the feed concentration, C_{ip}, from Equations (3.22) and (3.23) involves using parameters that are representative of animal feed production which differ from vegetable production for human consumption. For example, the growing period is set to 30 days to represent animal grazing habits (RG-TE15). Also the crop yield is less (0.7 kg/m^2) for animal feed production. The animal consumption rate of feed is set to 50 kg/d for both milk and meat production (RG-TE3).

The total concentration of radionuclide i in animal product p is the sum of the contributions from ingestion of water by animals, C_{iaw}, and ingestion of feed by animals, C_{iaf}.

$$C_{iap} = C_{iaf} + C_{iaw} \tag{3.28}$$

Special consideration is given to tritium concentrations in animal products. As for the vegetable pathway, the animal product is assumed to be contaminated at the same concentration as the animal drinking water [which by Equation (3.25) is the same as the animal feed crop concentration]. This concentration is diluted by the fraction of feed and water that is not contaminated. The concentration of tritium for animal products is calculated as

$$C_{tap} = C_{wi} \frac{(1 - f_w) Q_w + (1 - f_f) Q_f}{Q_w + Q_f} \tag{3.29}$$

where C_{tap} is the tritium concentration in animal product p measured in pCi/L or pCi/kg. (Default values are provided for ^3H for transfer to plants, B_{iv}, and animal products, F_{ia}. These values are not used by LADTAP II.)

The dose received by an individual is calculated using the food product concentration (C_{iap} or C_{ip}) for the pathway of interest determined in Equation (3.15). Table 3.5 provides default consumption rates (U_{ap}) used with irrigated food product pathways. Individual doses are calculated using the "maximum" individual values (RG-TE5) for each age group. The average values (RG-TE4) are used to evaluate population exposures as described in the next section.

3.2.3 Population Dose Consideration

The models and parameters used in calculating individual doses were described above. The same models, with slight differences in parameter values, are used to calculate population doses. The individual dose calculations are based on parameter values that maximize the dose for a given pathway and age group. However, population doses are estimated using parameters that represent average conditions. These differences are indicated in some of the parameter default values presented above (see, for example, Tables 3.4 and 3.5).

The general expression for estimating population exposures is:

$$H_{ipj} = 0.001 \sum_{a=1}^{\text{age groups}} P_{ap} C_{ip} U_{ap} D_{aipj} \qquad (3.30)$$

TABLE 3.5. Default Consumption Rate Values for Irrigated Food Pathways (kg/yr or L/yr)

Parameter	Vegetables	Leafy Vegetables	Milk	Meat
Average adult	190	30	110	95
Average teen	240	20	200	59
Average child	200	10	170	37
Maximum adult	520	64	310	110
Maximum teen	630	42	400	65
Maximum child	520	26	330	42

where H_{ipj} = the population dose to organ j from radionuclide i from pathway p summed over age groups (person-rem)

P_{ap} = the population of age group a exposed to pathway p (persons)

U_{ap} = the average individual usage parameter for age group a and pathway p [units as defined for Equation (3.15)]

0.001 = a units conversion factor (rem/mrem)

and other terms are as previously defined.

Defining the exposed population, P_{ap}, is critical to the various exposure pathways and population doses to be calculated. Special considerations for defining the exposed population and applying Equation (3.30) are discussed below.

Sport harvest of fish and invertebrates requires definition of total harvest at each usage location in the surface water system. The population exposure is based on the total harvest as follows:

$$P_T = \frac{A_p}{\sum_{a=1}^{\text{age groups}} F_a U_{ap}} \tag{3.31}$$

where P_T = the total population served by local production of aquatic food p in the form of fish or invertebrates (persons)

A_p = the total aquatic food production (kg/yr)

F_a = the fraction of the population in age group a (dimensionless)

U_{ap} = the average consumption of aquatic food p by individuals in age group a (kg/yr)

The population in each age group is then calculated as:

$$P_{ap} = P_T F_a \tag{3.32}$$

where terms are as previously defined.

The population dose from commercial harvest of fish and invertebrates is based on the total population within 50 miles and the average individual consumption rates. The total consumption of each aquatic food for an age group is calculated as:

$$U_{apT} = P_{50} F_a U_{ap} \tag{3.33}$$

where U_{apT} is the total consumption of aquatic food p by the population in age group a within 50 miles of the site (person kg/yr), P_{50} is the population within 50 miles of the site (persons), and other terms are as previously defined. The population dose to the given age group is then calculated using Equation (3.30) with U_{apT} in place of the product of U_{ap} and P_{ap}. Inherent in this approach to population dose estimates is the assumption that the production is sufficient to feed the entire population within 50 miles of the site. If the production is less than that required for the population, the user of LADTAP II has the option of adjusting the individual average consumption rates.

The population doses from the drinking water pathway are based on the population served by each water supply system. The population served in each age group is calculated using Equation (3.32) with P_T representing the total population served. The population dose from each water supply system is then calculated using Equation (3.30).

When tritium is included in the radionuclide source inventory, a special population dose is calculated, which represents the dose to the total U.S. population (default is 2.6×10^8 people) from uniform dispersion of tritium in the hydrosphere. The tritium hydrosphere dose model is based on a single compartment model presented by the NCRP (1979). In this model the released tritium is assumed to be diluted in the world volume of water (excluding deep ground water and deep ocean water). This dose is calculated for the midpoint of plant operating life as follows:

$$R_{Tpj} = \frac{10^9 \, U_p \, q_t \, P_{us}}{V_h \, \lambda_T \, 8670} \, D_{tpj} \left[1 - \exp(-\lambda_T T_b)\right] \qquad (3.34)$$

where R_{Tpj} = the population dose to organ j from tritium in drinking water calculated at the midpoint of the plant operating life (person-rem/yr)

U_p = the average consumption rate of hydrosphere water by individuals in the U.S. (L/yr)

q_t = the tritium release rate (Ci/yr)

P_{us} = the total U.S. population (persons)

D_{tpj} = the tritium ingestion dose factor for organ j for adults (mrem/yr per pCi ingested)

T_b = the midpoint of plant operating life (hr)

V_h = the effective volume of the hydrosphere for dilution of the released tritium (L)

λ_T = the tritium physical decay constant (hr^{-1})

10^9 = a units conversion factor (pCi•rem per Ci•mrem)

8670 = a units conversion factor (hr/yr)

The hydrosphere volume (2.7×10^{19} L) and the average consumption rate (1100 L/yr) are based on data presented by the NCRP report (1979). The consumption rate is based on a daily intake rate of 3 L, which includes drinking water (1.22 L/d), food, milk, and juice (1.56 L/d); inhalation (0.13 L/d); and passage through skin (0.09 L/d). This special tritium hydrosphere dose is calculated for adults only.

External exposures from recreational aquatic activities are included in population dose estimates. For the pathways of shoreline, swimming, and boating exposure, the population is defined by the user through pathway usage parameters. In relation to Equation (3.30), the user provides a "usage parameter" representing the product of P_{ap} and U_{ap}. This usage parameter represents the total population exposed at the given usage location. No consideration of age groups is made because external exposure is assumed to result in approximately the same dose to individuals of all age groups per unit time of exposure. The usage parameter units are person-hr/yr.

Two types of population doses are calculated for the ingestion of irrigated farm products. The first dose calculated is an ALARA evaluation (for as low as reasonably achievable). This calculation is based on the potential population, within 50 miles, served by the irrigated farm product. The population served is calculated using Equation (3.31) where A_p represents the total irrigated food production in kg/yr, and the usage parameters, U_{ap}, relate to the irrigated food pathways.

The second population dose calculated for irrigated farm products is a NEPA evaluation (for National Environmental Policy Act). This evaluation is similar to the ALARA evaluation except that the exposed population is not limited to the total population within 50 miles. When the population served is less than the 50-mile population, the ALARA and NEPA population doses will be the same.

In addition to the above population doses, a special population dose report is prepared by LADTAP II, and is referred to as a "cost-benefit" analysis. This report presents the total population dose within 50 miles, as contributed by each radionuclide in the source inventory, to total body and thyroid from selected pathways. The pathways included in the cost-benefit population doses are aquatic foods (sport and commercial harvest of fish and invertebrates), drinking water, aquatic recreational activities (shoreline, swimming, and boating), and the ALARA irrigated farm product doses (vegetables, leafy vegetables, milk, and meat). The report gives both the dose for each radionuclide (person-rem) and the dose per curie of each radionuclide released (person-rem/Ci).

3.2.4 Special ALARA Analysis

In addition to the calculations described above, LADTAP II performs a special analysis that gives a composite dose factor for each radionuclide defined in the source inventory. The purpose of the special dose factors is to show compliance with Appendix I of 10 CFR 50 as described in NUREG-0133 (NRC 1978). The dose factors are described as parameters A_{it}, which are defined as the site related ingestion dose commitment factor to the total body or any organ t for each identified principal gamma and beta emitter. These dose parameters are calculated using site parameters defined for the individual ALARA analysis and represent the dose commitment to an adult per hour of exposure to an effluent water concentration of 1 μCi/mL. The dose factors are calculated for fish and drinking water ingestion for freshwater sites, and for fish and invertebrate consumption for saltwater sites. The composite dose factors are calculated as follows:

$$A_{ij} = 101.94\ Q_r\ R_{aipj} \tag{3.35}$$

where A_{ij} = the composite dose factor for organ j and radionuclide i for adult ingestion of fish and drinking water (mrem/hr per μCi/mL)

Q_r = the reactor effluent discharge rate (ft^3/sec)

R_{aipj} = the dose to organ j from radionuclide i for the adult age group a summed over pathways p of fish and drinking water ingestion (mrem/yr)

101.94 = a units conversion factor as follows:

$$101.94 = 10^{-6}\left(\frac{\text{Ci}}{\mu\text{Ci}}\right) 3600 \left(\frac{\text{sec}}{\text{hr}}\right) 28317 \left(\frac{\text{mL}}{\text{ft}^3}\right)$$

To normalize the composite dose factor to unit concentration (μCi/mL), the dose (R_{aipj}) must be based on 1 Ci of each radionuclide released. The user must, therefore, set the source inventory to 1 Ci/yr for each radionuclide released.

3.2.5 Dose to Biota

The LADTAP II program includes models for estimating exposures of organisms other than humans. Calculations are performed for the following biota and exposure pathways:

Fish - internal exposure from bioaccumulation of radionuclides, external exposure from swimming, and external exposure from the shoreline

Invertebrates - internal exposure from bioaccumulation of radionuclides, external exposure from swimming, and external exposure from the shoreline

Algae - internal exposure from bioaccumulation of radionuclides and external exposure from immersion in water

Muskrat - ingestion of aquatic plants, external exposure from swimming, and external exposure from the shoreline

Raccoon - ingestion of invertebrates and external exposure to the shoreline

Heron - ingestion of fish, external exposure from swimming, and external exposure to the shoreline

Duck - ingestion of aquatic plants, external exposure from swimming, and external exposure to the shoreline

The dose to these biota is calculated using the aquatic pathway equations given in Section 3.2.1. The consumption patterns and dose factors are modified to account for differences between biota and humans.

The dose to aquatic organisms from ingesting aquatic foods is calculated as follows:

$$D_c = 21 \frac{M_p}{Q_r} \sum_{i=1}^{\text{nuclides}} q_i R_i B_{ip} E_{ic} \exp(-\lambda_i t_p) \qquad (3.36)$$

where D_c = the dose to aquatic organism c from living in (and ingesting) water (mrad/yr)

M_p = the mixing ratio representing dilution from the impoundment effluent location to the biota location in the surface water system (dimensionless)

Q_r = the reactor effluent discharge rate to the impoundment system (ft^3/sec)

q_i = the annual release rate of radionuclide i (Ci/yr)

R_i = the impoundment system reconcentration factor for radionuclide i (dimensionless)

B_{ip} = the bioaccumulation factor for radionuclide i in the aquatic organism being exposed (pCi/kg per pCi/L)

E_{ic} = the effective energy deposited in biota c per disintegration of radionuclide i (MeV/dis)

T_p = the transit time from the release point to the exposure location (hr)

λ_i = the radioactive decay constant for radionuclide (hr^{-1})

21 = a units conversion factor (0.0187)(1119)

1119 = as defined for Equation (3.16)

$$0.0187 = 3.7 \times 10^{-2}\left(\frac{\text{dis}}{\text{sec}\cdot\text{pCi}}\right) 3.156 \times 10^{7}\left(\frac{\text{sec}}{\text{yr}}\right) 1.6 \times 10^{-6}\left(\frac{\text{erg}}{\text{MeV}}\right) 10^{-2}\left(\frac{\text{kg-rad}}{\text{erg}}\right)$$

The LADTAP II dose factor file provides the effective energy values for several organ radii. When selecting effective energy values, an effective radius of 2 cm is used for all aquatic organisms.

Ingestion exposures of terrestrial biota are calculated using the ingestion of a specific aquatic organism as described above. These ingestion doses are calculated using total-body dose conversion factors for adults, which are modified for body mass and body radius.

$$D_{cp} = 2.86 \times 10^{7} \frac{M_p U_{cp}}{Q_r M_c} \sum_{i=1}^{\text{nuclides}} \frac{q_i R_i E_{ic} D_{aipj} B_{ip}}{E_i} \exp(-\lambda_i T_p) \quad (3.37)$$

where D_{cp} = the dose to terrestrial biota c from ingestion of aquatic organism p (mrad/yr)

U_{cp} = the rate of consumption of aquatic organism p by terrestrial biota c (g/d)

M_c = the body weight of terrestrial biota c (g)

E_i = the effective energy deposited in an adult per disintegration of radionuclide i (MeV/dis)

D_{aipj} = the ingestion dose conversion factor for adults for ingestion of radionuclide i to total body (mrem/yr per pCi/yr ingested)

B_{ip} = the bioaccumulation factor for radionuclide i in aquatic organism p eaten by the terrestrial biota (pCi/kg per pCi/L)

2.86×10^7 = units conversion factor (0.365)(1119)(70,000)

$(0.365) = 365\left(\frac{d}{yr}\right) 10^{-3}\left(\frac{kg}{g}\right)$

1119 = as defined for Equation (3.16)

70,000 = mass of the average adult (g)

and other terms are as previously defined. Equation (3.37) corrects adult dose factors for weight and size differences by using a ratio of masses and effective energies. This approximation gives results that are reasonably conservative by assuming the life spans of biota are generally shorter than humans and that a full dose commitment, as predicted by adult ingestion factors, would probably not be received by the biota. Table 3.6 presents a summary of the default values for terrestrial biota parameters.

Equation (3.20) calculates external exposure of biota to sediment and shoreline with a shore-width factor, W, set to 2.0. This adjustment is made because of the nearness of biota to contamination compared to the 1 m that is assumed for humans.

Swimming exposures are estimated using Equation (3.21) with the appropriate geometry and usage factors. Table 3.7 presents the parameter values used to calculate the shoreline and swimming exposure for biota.

TABLE 3.6. Default Values for Terrestrial Biota Parameters

Terrestrial Biota	Effective Body Radius (cm)	Body Mass (g)	Consumption of Food (g/d)	Food Organism
Muskrat	6	1,000	100	Aquatic plants
Raccoon	14	12,000	200	Invertebrates
Heron	11	4,600	600	Fish
Duck	5	1,000	100	Aquatic plants

TABLE 3.7. Parameter Values for Shoreline and Swimming Exposure to Biota

Biota	Shoreline (sediment) Exposure Time (hr/yr)	Swimming Exposure Time (hr/yr)	Geometry Factor (G_p)
Fish	4380	8760	1
Invertebrates	8760	8760	1
Algae	----	8760	1
Muskrat	2922	2922	1
Raccoon	2191	----	-
Heron	2922	2920	2
Duck	4383	4383	2

3.3 DOSIMETRY MODELS

This section describes the dosimetry models that are used to evaluate factors in the LADTAP II data file. These dose factors are represented in Equation (3.15) by the parameter D_{aipj}, which converts exposure (hr/yr or pCi/yr ingested) to dose to an individual in mrem. The dose factor data file contains dose factor values for ingestion of radionuclides (used for the aquatic food, irrigated farm product and drinking water pathways), for external exposure to contaminated ground (used for the shoreline recreational activity pathway) and for external exposure from immersion in water (used for the swimming and boating pathways). The ingestion dose factors are defined for four age groups (adults, teens, children, and infants) and seven organs (bone, liver, total body, thyroid, kidney, lung, and lower large intestine). The external dose factors are defined only for adults and for whole-body exposures because dose from exposure to external penetrating radiation is not very sensitive to differences in body size or organ depth. A discussion of procedures for calculating ingestion and external dose factors follows.

3.3.1 Ingestion Dose Factors

The ingestion dose factors in the LADTAP II dose factor file are based on values derived by Hoenes and Soldat (1977) with modifications that reflect current values for several internal dosimetry parameters (Boone and Palms

1983). The initial derivation formed the basis for the dose factors presented in Regulatory Guide 1.109 (NRC 1977a). These factors were based primarily on the models in Publication 2 of the International Commission on Radiological Protection (ICRP 1959) as updated by Publications 6 (ICRP 1964) and 10 (ICRP 1968). The modification by Boone incorporated recommendations of ICRP report 19 (1972) regarding dosimetry for actinide elements. A summary of the dosimetry models of these publications follows.

Ingestion dosimetry models consider the gastrointestinal tract as the initial entry into the body. The model presented in ICRP Publication 2 describing the dosimetry of the gastrointestinal tract considers four distinct compartments: stomach, small intestine, upper large intestine, and lower large intestine. The ingested material enters through the stomach and travels sequentially through each compartment. Absorption of material into the blood is considered to occur only in the small intestine. The material entering the stomach is assumed to reside there for 1 hour and then move in a batch mode to the small intestine. Flow through the small intestine and large intestine is assumed to be continuous and linear. The intestinal wall is considered the critical tissue in the intestine. The dose is therefore calculated as one-half the dose to the mass of the contents. For alpha radiation a factor of 0.01 is also applied to the effective energy to account for the ineffectiveness of alpha particles in reaching the sensitive cells of the stomach and intestine walls. The lower large intestine (GI-LLI) is the only portion of the gastrointestinal tract considered in LADTAP II because this portion has the highest dose factor for most radionuclides.

The material absorbed in the small intestine is assumed to be transferred via the blood to other organs. Elimination from the organs is described by a single exponential expression with a biological half-time defined for each organ. In the organ dosimetry model, the radionuclide is assumed to be located in the center of a spherical organ. All particle radiations emitted are absorbed within the organ; all photon radiations are partially absorbed depending on the organ radius and photon energy. The potential contribution to organ dose from photon radiation originating outside of that organ is ignored.

Age dependence of dose factors is considered using the above models as extended by Hoenes and Soldat (1977). Because radiation doses may vary for people of differing ages, four age groups have been defined with dose factors calculated for each group. The age groups considered are "infant" (0 to 1 year old), "child" (1 to 11 years old), "teen" (11 to 17 years old), and "adult" (17 years and older). The "child" is represented by a typical 4-year-old, the "teen" by a 14-year-old and the adult by the definition for Standard Man as described in ICRP Publication 2 (1959). The following text describes features of the dose factor calculations as taken from Hoenes and Soldat (1977):

> Equations for calculating internal dose commitment factors were derived from those given by the ICRP [1959] for body burden and maximum permissible concentration (MPC). Effective absorbed energies for the radionuclides were calculated from the ICRP model. When necessary, these energies were corrected for the ingrowth of daughter radionuclides following ingestion or inhalation of the parent. . . . Quality factors, as listed in ICRP Publication 2, [1959] were applied to the effective energies, including the value of 1.7 (for ^{3}H the current value is 1.0) for beta particles and electrons with energies equal to or less than 30 keV. Age-dependent parameters were applied when available, but, where data were lacking, metabolic parameters for the Standard Man were used for other age groups.
>
> Effective absorbed energies used to compute dose factors are controlled by the size of the organ. Thus, as an individual grows and the sizes of his body organs increase, the total amount of radiation absorbed in an organ will also increase but the amount of energy absorbed per unit mass will generally decrease. If an intake of radioactive material occurs before an individual matures, later increases in organ size and mass may affect the dose commitment. In calculating the dose commitment factors listed in Tables 1 through 8 [Hoenes and Soldat 1977, page 8-39], this change of organ size and mass was considered. To reduce the complexity of the equations, it was necessary to assume that an abrupt change in organ size and mass would occur at the division points between age groups. This assumption significantly simplifies the calculations without underestimating the dose commitment.
>
> The mass of the contents of the gastronintestinal tract (GI tract) was taken to be proportional to total-body mass. The travel time to the lower large intestine (t') and the travel time through the lower large intestine (τ') were also assumed to be proportional to the mass of the total body. Radioactive decay of the radio-

nuclide ingested was accounted for in calculating dose commitment factors for the GI tract.

In certain instances, the energy of a daughter nuclide makes a significant contribution to the effective energy per disintegration of the parent nuclide at the entrance to the lower large intestine (LLI). This occurs when the ratio of daughter decays to parent decays is relatively large. Such a situation arises when the following conditions exist. The parent decays to a daughter nuclide which: 1) is less efficiently absorbed from the small intestine than the parent, 2) has a long enough half-life to persist through the upper large intestine, and 3) has a short enough half-life, compared to the parent, to present a relatively high disintegration rate in the lower large intestine. . . . Some radionuclides have daughter products which will be absorbed into the blood stream before reaching the lower large intestine. In these cases, the energy of the daughters was not included in the dose commitment factors for the GI tract even though it was included for other body organs.

Since specific biological half-lives are available as a function of age for hydrogen, iodine and cesium, that information was used when computing the dose commitment factors for the radionuclides of these elements. For other radionuclides contained in this report, the biological half-lives for Standard Man were used for all age groups. Dose commitment factors calculated without using age specific biological half-lives will generally overestimate the radiation dose for age groups other than adults. This overestimate occurs because biological half-lives for adults tend to be greater than those for younger individuals. Other biological parameters which were assumed to remain constant for all age groups are: fraction reaching organ of reference by ingestion (f_w) and by inhalation (f_a), fraction from GI tract to blood (f_1), and fraction from blood to organ of reference (f_2') [ICRP 1959, 1964, 1968].

The age-specific dose conversion factors calculated and presented by Hoenes and Soldat form the basis for dose factors used in LADTAP II. The values in the LADTAP II dose factor file were updated by Soldat for this report to reflect recent changes in metabolic data and corrections of numeric errors in the original report by Hoenes and Soldat. A summary of changes made to the dose factor file is presented in Table 3.8. This table only describes changes made to the dose factor file as presented in previous documentation (Simpson and McGill 1980). A major change made before the Simpson and McGill report was to revise dose factors for actinide elements as recommended by ICRP (1972). For each age group, internal dose factors for actinides have been

Tb is biological halflife.
Fw is fraction ingested that is retained by critical organ.

TABLE 3.8. Summary of Ingestion Dose Factor Corrections

Radionuclide	Age Group	Organ	Correct Value	Reason for Change
^{3}H	Adult	All	5.99×10^{-8}	Quality factor Q for ^{3}H reduced
	Teen	except	6.04×10^{-8}	from 1.7 to 1.0
	Child	Bone	1.16×10^{-7}	
	Infant		1.76×10^{-7}	
^{90}Sr	Adult	Bone	8.71×10^{-3}	ICRP-10 (ICRP 1968)
		Total Body	1.75×10^{-4}	Change values of T_b and F_w for
	Teen	Bone	1.02×10^{-2}	the organs as follows:
		Total Body	2.04×10^{-4}	Tb Fw
	Child	Bone	2.56×10^{-2}	Bone 4,000 0.051
		Total Body	5.15×10^{-4}	Total Body 4,000 0.051
	Infant	Bone	2.83×10^{-2}	
		Total Body	5.74×10^{-4}	
^{133m}Te	Adult	GI-LLI	9.26×10^{-9}	Typo in Hoenes and Soldat (1977) for epsilon for adult, corrected to 1.62 MeV per dissintegration
^{166m}Ho	Adult	GI-LLI	2.56×10^{-5}	Values defined for uptake from GI
	Teen	GI-LLI	2.71×10^{-5}	tract (1.0) and epsilon (0.2) for
	Child	GI-LLI	2.63×10^{-5}	all ages
	Infant	GI-LLI	2.66×10^{-5}	
^{210}Pb	Adult	GI-LLI	2.24×10^{-6}	Epsilon for all ages changed to
	Teen	GI-LLI	2.37×10^{-6}	0.019
	Child	GI-LLI	2.30×10^{-6}	
	Infant	GI-LLI	2.32×10^{-6}	
^{229}Th	Adult	Bone	1.36×10^{-2}	Epsilon for all ages changed as
		Liver	3.89×10^{-4}	follows:
		Total Body	2.25×10^{-4}	Bone 1600
		Kidney	1.88×10^{-3}	Liver 160
		GI-LLI	7.81×10^{-5}	Total Body 190
	Teen	Bone	1.43×10^{-2}	Kidney 160
		Liver	4.11×10^{-4}	GI-LLI 0.61
		Total Body	2.37×10^{-4}	
		Kidney	1.99×10^{-3}	
		GI-LLI	8.28×10^{-5}	
	Child	Bone	2.35×10^{-2}	
		Liver	5.91×10^{-4}	
		Total Body	3.92×10^{-4}	
		Kidney	2.89×10^{-3}	
		GI-LLI	8.04×10^{-4}	
	Infant	Bone	2.52×10^{-2}	
		Liver	6.33×10^{-4}	
		Total Body	4.20×10^{-4}	
		Kidney	3.03×10^{-3}	
		GI-LLI	8.10×10^{-5}	
^{232}Th	Adult	Bone	2.30×10^{-3}	Correction of epsilon value for
		Total Body	1.50×10^{-6}	bone to 270 as in Hoenes and
	Teen	Bone	2.42×10^{-3}	Soldat (1977)
		Total Body	1.63×10^{-6}	Correction of biological half
	Child	Bone	3.96×10^{-3}	time for total body to 5.7×10^{4}
		Total Body	3.01×10^{-6}	all ages
	Infant	Bone	4.24×10^{-3}	
		Total Body	1.65×10^{-6}	

evaluated by Boone and Palms (1983). The current values in the LADTAP II dose factor file have been found to agree with the values reported by Boone and Palms.

3.3.2 External Exposure to Shoreline

LADTAP II estimates external exposure from recreational activities on contaminated shorelines. The dose conversion factors are based on the exposure rate at 1 m above an infinite plane of uniform contamination. An exponential tissue penetration factor is applied to the infinite plane exposure rate to estimate the total-body dose factor. A tissue depth of 5 cm is used for this calculation, as suggested by the National Council on Radiation Protection and Measurement (1975). Total-body dose factors estimate doses to all organs except the skin, which is based on corrections of the infinite plane values for penetration of 0.007 cm of a dead skin layer. As described in Section 3.2.1, external dose factors are used in conjunction with shore-width factors. Shore-width factors are provided to account for actual shorelines, which are not well represented as infinite planes.

3.3.3 External Exposure from Water Immersion

Swimming and boating activities are represented in LADTAP II as exposures involving immersion in water. The LADTAP II dose factor file contains dose factors based on exposure to penetrating radiation from total immersion in water. For shoreline exposure factors an exponential tissue penetration factor is applied (for 5 cm of tissue) for estimating the dose factors for total-body exposure. Adult immersion dose factors for total body are used for exposures of other age groups and other organs. No immersion dose factors for skin dose are currently included in LADTAP II.

The immersion dose factors are used in swimming and boating dose calculations. A geometry correction of 1/2 is applied to the boating calculations to account for boating as only half immersion (i.e., exposure from only one side).

In reviewing external dose factors (for ground and immersion exposure) during the preparation of this report, the following errors in the dose factor file were detected:

1. Several radionuclides were found to have skin and total-body dose factors reversed for ground exposure and no values given for immersion exposure. These radionuclides are ^{91m}Y, ^{95}Nb, ^{99}Mo, ^{103}Ru, ^{106}Ru, ^{132}I, ^{135}I, ^{140}La, ^{147}Nd, ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Pu.
2. No external dose factors were given for ^{93m}Nb.
3. No external dose factors were given for ^{143}Pr for total-body water immersion.
4. Radionuclide ^{210}Bi (half-life 5.01 days) was incorrectly represented as ^{210m}Bi in the adult portion of the library.

Corrections to all of these errors have been incorporated in the current dose factor file.

4.0 DETAILED PROGRAM INFORMATION

This section provides useful information for modifying the LADTAP II computer program. The reader is assumed to be familiar with the models employed by LADTAP II and to have a working knowledge of standard FORTRAN 77. This section includes structure and logic information, computer requirements, common block usage, module descriptions, and data file descriptions.

4.1 PROGRAM STRUCTURE

This section provides information related to program structure, including 1) module hierarchy, 2) data input location, 3) data output location, and 4) data transfer between modules. The program LADTAP II is composed of 36 modules, including the main program, block data, subroutines, and functions. Data transfer is performed mainly through blank common and nine labeled common blocks. Supplemental transfer is performed through argument call lists. Details of common blocks are given in Section 4.3. Input of dose factors is performed in one subroutine (REDDF), while case-specific input records are read by several subroutines as data are needed in specific portions of the analysis. Similarly, output reports are generated by subroutines that perform the related calculations.

Figure 4.1 presents the subroutine-calling sequence. This diagram indicates the general order in which subroutines are called and gives a summary of where specific tasks are performed. All modules are included in the figure except system functions, the special functions EXFCT and FUN, and the subroutines BANNER and BANLET. The function EXFCT evaluates the expression $1-e^{-x}$ and is called by subroutines FOOD, RECON, and SHORE. The subroutines BANNER and BANLET print a banner page for LADTAP II output and are called at the start of the main program. Module blocks in Figure 4.1 that have double lines on the right indicate the end of a calling sequence, i.e., these subroutines call no other subroutines. Details of each module are given in Section 4.4.

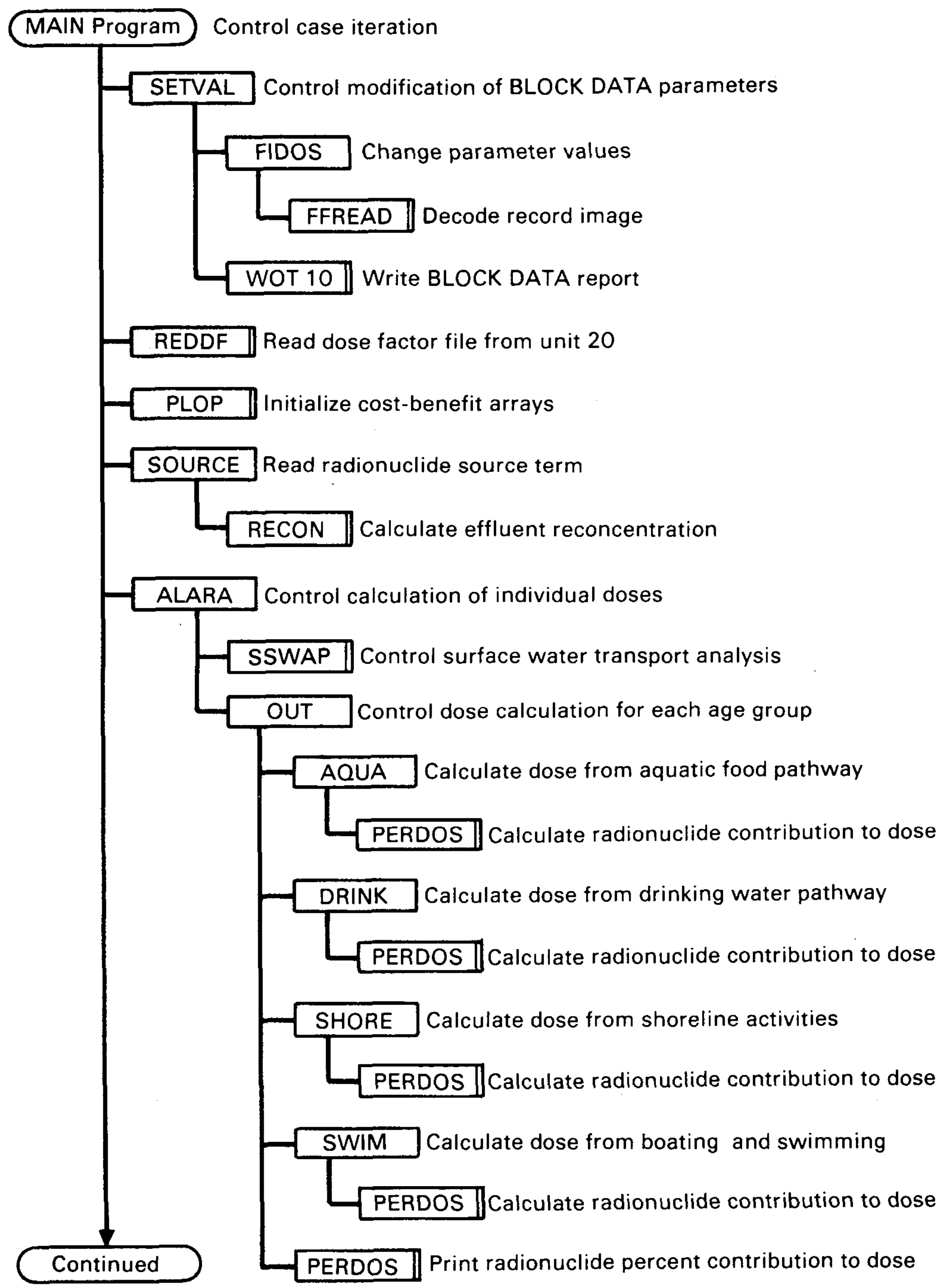


FIGURE 4.1. LADTAP II Calling Sequence Hierarchy

Figure 4.1 (Contd)

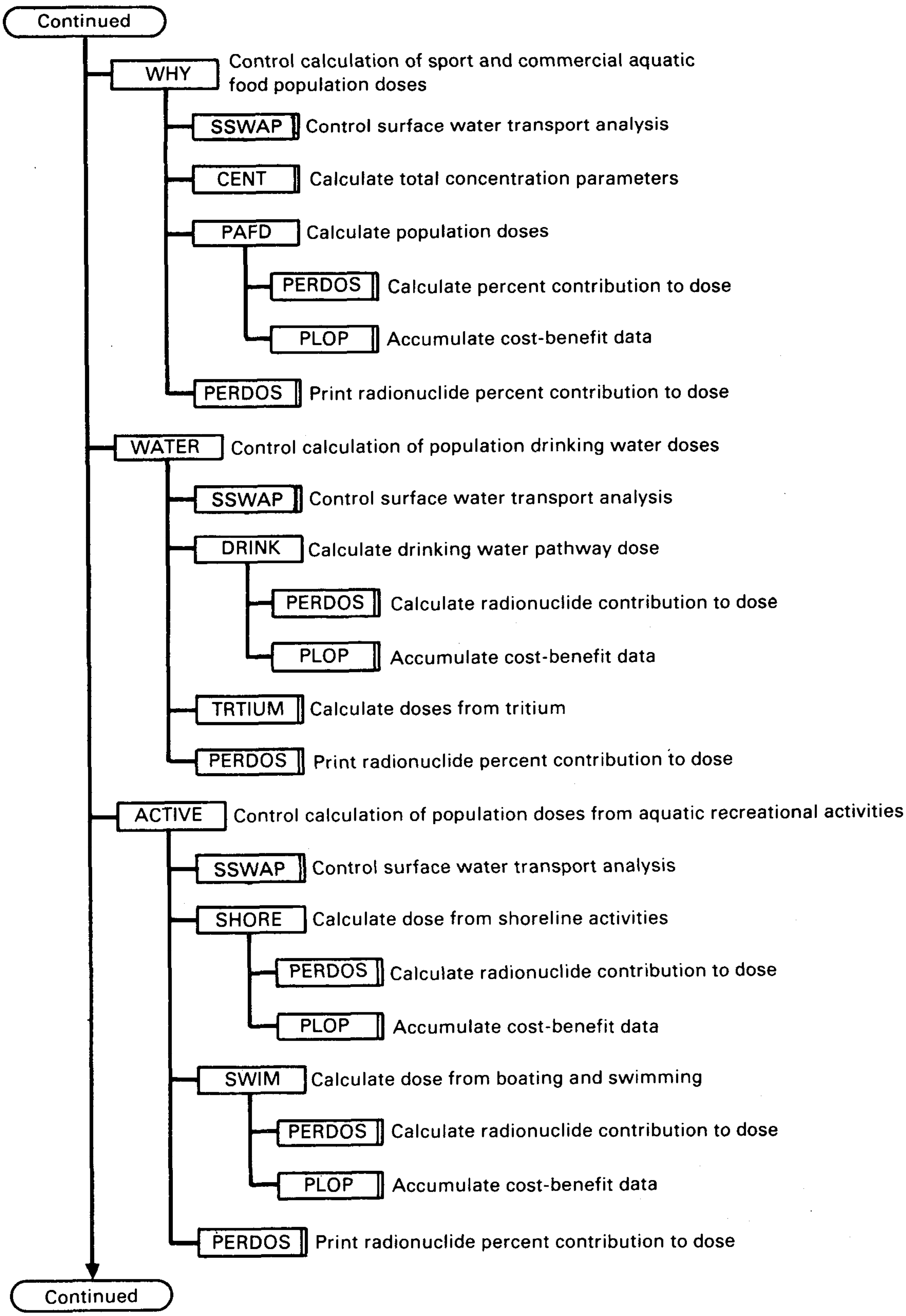
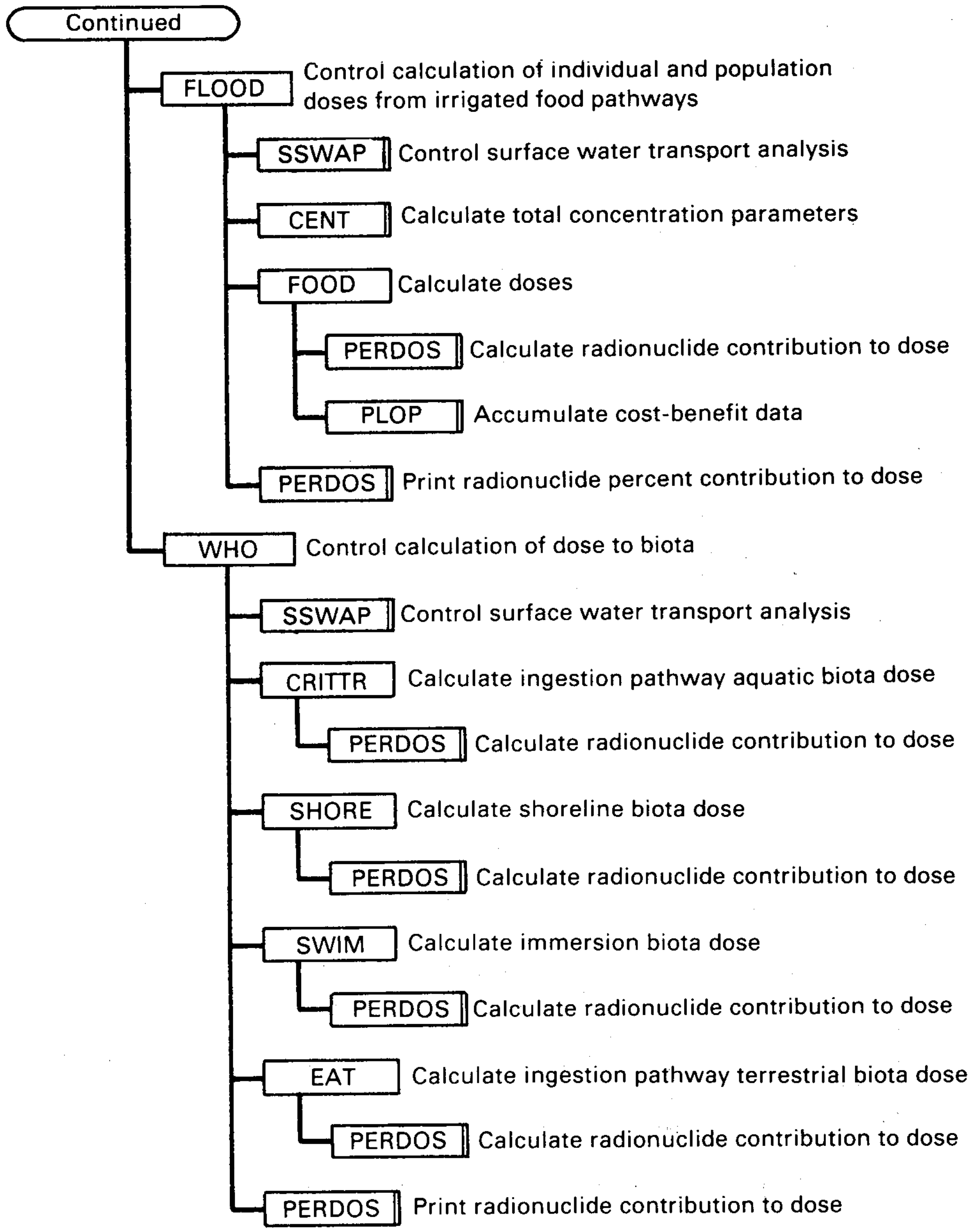


Figure 4.1 (Contd)



Data are supplied to LADTAP II by two input units: 1) standard input records (default logical unit 9), and 2) data library of dose factors (logical unit 20). The standard input records are described in Section 2.1 and the data library is described in Section 4.5.

Table 4.1 indicates the subroutines from which each record type is read. All records in this table are read from the default unit 9 except the dose factor library, which is read from unit 20. The user may change the standard input logical unit from 9 to another value through the common block INUNIT parameter INFIL. This parameter is set to 9 by a DATA statement in the MAIN program. Changing this DATA statement definition of INFIL will change the input logical unit for all input record reads (except the dose factor library).

TABLE 4.1. Data Input Locations

Module Name	Record Type	Record Description
MAIN program	1	Case title
	2	Control parameters and discharge rate
	3	Population data
	3a	Population fractions
FIDOS	CR	BLOCK DATA change records (CR)
REDDF	---	Dose factor library - unit 20
SOURCE	4	Source identification title
	5	Radionuclide release information
RECON	6	Reconcentration model parameters
ALARA	7	Usage location parameters for ALARA analysis
	7a - 7d	Age-specific consumption parameters
	7e - 7g	Surface-water dilution data
	8	Usage location parameters for additional locations
	8a - 8d	Age-specific consumption parameters
	8e	Surface-water dilution data
WHY	9, 9a	Sport fishing usage locations parameters
	10, 10a	Commercial fishing usage locations parameters
	11, 11a	Sport invertebrate harvest usage locations parameters
	12, 12a	Commercial invertebrate harvest usage location parameters
WATER	13, 13a	Population drinking water usage locations parameter
ACTIVE	14, 14a	Population shoreline activity usage location parameters
	15, 15a	Population swimming usage location parameters
	16, 16a	Population boating usage location parameters

Table 4.1 (Contd)

Module Name	Record Type	Record Description
FLOOD	17	Irrigated food product pathway parameters
	17a	Alternate age-specific pathway parameters
	18, 18a	Usage location parameters for food type
WHO	19, 19a	Biota exposure usage location parameters

Output generated by LADTAP II can be described by 23 types of printed reports. A summary definition of each of these reports is given in Table 4.2. The table also indicates modules that are responsible for printing each report. Many of the reports are optional depending on input data and input control integers. Reports selected by control integers are indicated in Table 4.3.

TABLE 4.2. Summary of Output Report Definitions

Report	Module	Description of Report
1	FIDOS	Summary of changes to BLOCK DATA
2	WOT10	Current values in BLOCK DATA
3	MAIN	Site definition data
4	REDDF	Dose factor library
5	SOURCE	Release rate dose factors used for radionuclides in source inventory
6	ALARA, OUT, PERDOS	ALARA analysis of adult individual doses for selected pathways (fish, invertebrate, algae, and drinking-water ingestion; and shoreline swimming and boating external exposure): if LCT>0, print radionuclide % contribution tables
7		Same as 6 for teen age group
8		Same as 6 for child age group
9		Same as 6 for infant age group

Table 4.2 (Contd)

Report	Module	Description of Report
10	ALARA, OUT, PERDOS	Adult individual doses at selected water usage locations for aquatic food ingestion and external exposure pathway (as for report 6): if LCT>0, print radionuclide % contribution tables
11		Same as 10 for teen age group
12		Same as 10 for child age group
13		Same as 10 for infant age group (Reports 10-13 are repeated for each usage location defined)
14	WHY, PERDOS	Population dose from sport harvest of fish for specified usage locations and three age groups (adult, teen, and child): if LCT>0, print radionuclide % contribution tables
15		Same as 14 for commercial harvest of fish - A subtable is also printed for "NEPA" doses which includes contributions from both sport and commercial harvest
16		Same as 14 for sport harvest of invertebrates
17		Same as 15 for commercial harvest of invertebrates
18	WATER, PERDOS	Population doses from drinking-water pathway at specified usage locations: if LCT>0, print radionuclide % contribution tables A subtable of population dose from tritium is also printed if tritium is in the source inventory
19	ACTIVE, PERDOS	Population doses from recreational activities at specified locations - Individual subtables are presented for shoreline, swimming and boating external exposures. In each subtable: if LCT>0, print radionuclide % contribution tables
20	FLOOD, PERDOS	Individual and population dose report for one of four terrestrial food types (vegetables, leafy vegetables, milk, or meat): if LCT>0, print subtables for individual doses, NEPA population doses, ALARA population doses, and radionuclides % contributions These reports are repeated for each set of data provided (record types 17 - 18)

Table 4.2 (Contd)

Report	Module	Description of Report
21	WHO, PERDOS	Dose rates to biota (mrad/yr) for specified usage locations - Doses are presented for "primary biota" (fish, invertebrate, and algae) and "secondary biota" (muskrat, racoon, heron, and duck): if LCF>0, print radionuclide % contribution tables
22	PLOP	Results of the cost-benefit analysis giving total-body and thyroid doses by radionuclide and dose per Ci released
23	PERDOS	Critical organ dose report for the ALARA analysis - This report is printed after report 6 if total population (POP) is specified as zero. Organ dose is the sum of fish and drinking-water ingestion. Execution is terminated after this report is printed. When this report is required, the zero default values for CRUS and ALUS must not be changed.

TABLE 4.3. Output Reports Selected by Control Integers

Control Integer	Value	Report Response
LCT	$0\leq$	No information on % contribution to dose by radionuclide is printed.
	>0	Percent contribution data is printed.
IFLAG	>0	Print report 1 summarizing change records for BLOCK DATA.
	$\lvert IFLAG \rvert=1$	Print report 2 of current values of BLOCK DATA parameters and report 4 of all ingestion and external dose factors in dose factor library.

4.2 COMPUTER REQUIREMENTS

The version of LADTAP II presented in this report has been implemented on a VAX 11/780 computer with the VAX FORTRAN 77 compiler. LADTAP II has also been implemented on a Data General MV8000 with a FORTRAN 77 compiler. Standard FORTRAN programming practices have been used in LADTAP II so that the program can easily be adapted to other computers with FORTRAN 77 compilers. The one known, nonstandard statement used in LADTAP II is the system date routine, DATE, called by subroutine BANNER to provide the current date for the banner page. The call to DATE returns a ten-character representation of the current date in the argument TODAY. Also printed in the banner page is a title describing the current version. This title is set in the MAIN program as parameter VERSON, and should be changed to reflect the current application.

LADTAP II is a rapid-running program. Sample problems 1, 2, and 3 of Section 2.2 are executed in 16, 10, and 19 seconds of CPU time, respectively.

Input records are currently read from logical unit 9 as controlled by parameter INFIL, set in a DATA statement in the MAIN program. To change the input unit, it is only necessary to change the value of INFIL in this one DATA statement. The standard output logical unit 6 is used for all report generation. The dose factor data file read in subroutine REDDF is read from logical unit 20.

4.3 COMMON BLOCKS

LADTAP II uses nine common blocks, including BLANK common, to handle most data transfers between modules. A general description of each common block is indicated below:

Common Block	Description
BLANK	Control parameters and source data
BANPAG	Banner page - block letter information
DATA	BLOCK DATA parameters: population, consumption and bioaccumulation data
DFLIB	Dose conversion factors
ELEMEN	Element symbols
INUNIT	Logical input unit number
SORCE	Radionuclide identification and array index pointers

Common Block	Description
STATE	Metastable state indicators
TRANS	Drinking-water dilution factor

Table 4.4 shows the modules that reference each common block. Modules EXFCT, FFREAD, FIDOS, SSWAP, and WOT10 reference no common blocks and are not included in the table.

TABLE 4.4. Common Block Usage in LADTAP II

Module Name	BLANK	BANPAG	DATA	DFLIB	ELEMEN	INUNIT	SORCE	STATE	TRANS
MAIN	used	--	used	--	--	used	--	--	--
ACTIVE	used	--	--	--	--	used	--	--	--
ALARA	used	--	used	--	--	used	--	--	--
AQUA	used	--	--	used	--	--	used	--	--
BANLET	--	used	--	--	--	--	--	--	--
BANNER	--	used	--	--	--	--	--	--	--
BLOCK DATA	--	--	used	--	used	--	--	--	--
CENT	used	--	--	used	--	--	--	--	--
CRITTR	used	--	--	used	--	--	used	--	--
DRINK	used	--	--	used	--	--	used	--	used
EAT	used	--	--	used	--	--	used	--	--
FLOOD	used	--	used	--	--	used	--	--	--
FOOD	used	--	used	used	--	--	used	--	--
OUT	used	--	--	--	--	--	--	--	--
PAFD	used	--	--	used	--	--	used	--	--
PERDOS	used	--	--	--	used	--	used	used	used
PLOP	used	--	--	--	used	--	used	used	--
RECON	used	--	--	used	--	used	--	--	--
REDDF	--	--	--	used	used	--	used	used	--
SETVAL	--	--	used	--	--	used	--	--	--
SHORE	used	--	--	used	--	--	used	--	--
SOURCE	used	--	--	used	used	used	used	used	--
SWIM	used	--	--	used	--	--	used	--	--
TRTIUM	used	--	used	used	--	--	--	--	--
WATER	used	--	used	--	--	used	--	--	--
WHO	used	--	--	--	--	--	--	--	--
WHY	used	--	used	--	--	used	--	--	--

The following sections describe each of the common blocks used in LADTAP II. Information is provided on parameter order, array size, and parameter uses and definitions.

4.3.1 Common Block BLANK

This common block contains several control integers and source data parameters that are used by many subroutines. Definitions of parameters in BLANK common are provided in Table 4.5.

TABLE 4.5. Common Block BLANK

Symbol and Dimension	Type	Definition
Q(200)	Real	Release rate of each radionuclide from the reactor to the effluent stream (Ci/yr) - values are read in subroutine SOURCE as provided on input record type 5. Q is referred to as q_i in equations of Section 3.
PL	Real	Midpoint of facility operating life (yr) - the default value is 20 years and is defined by parameter PLNTLF in common block DATA.
CFS	Real	Discharge rate of reactor coolant to the facility impoundment system (ft^3/sec)
NSOR	Integer	Number of radionuclides defined in the release inventory on type 5 records: $1 \leq NSOR \leq 170$
LT	Integer	Site water type selection index as read on record type 2: LT=0, freshwater sites LT>0, saltwater sites
RECO(200)	Real	Reconcentration factor for the facility impoundment system (dimensionless) - the reconcentration factor is the ratio of radionuclide concentration in the effluent reaching the receiving water body compared to the concentration in the discharge to the impoundment system. Values may be supplied by the user (record type 5) or calculated using one of the impoundment hydrologic models (see Section 3.1).
LIST(200,4)	Integer	This integer array is a cross-reference index list to relate radionuclide position (200) for each age group (4) to data in dose factor arrays.
LCT	Integer	This control integer is read on record type 2 and controls calculation and printing of tables of % contribution to dose by radionuclide.
LZ	Integer	This internal count index is used in subroutine PERDOS to keep track of the number of age groups, biota or pathways for which % contribution calculations are to be printed. LZ is set to 0 in calling routines, and incremented in PERDOS.

Table 4.5 (Contd)

Symbol and Dimension	Type	Definition
CON	Real	Dose unit conversion factor: CON=1.0, individual dose calculation (mrem/mrem) CON=1000, population dose calculation (mrem/rem)
KIT	Integer	Control integer selects the action to be taken in calls to subroutine PERDOS. Usage is as follows:

Value	Action
10	Print % contribution to ALARA doses
20	Print % contribution to drinking water doses
30	Print % contribution to irrigated food doses
40	Print % contribution to aquatic activity doses
50	Print % contribution to swimming and boating doses
70	Print % contribution to biota doses
Other	Calculate % contributions using dose arrays provided in PERDOS call statement

Symbol and Dimension	Type	Definition
POP	Real	Total population within 50 miles of the site, read on input record type 3.

4.3.2 Common Block BANPAG

This common block is used to transfer the banner page block letter information from subroutine BANLET to subroutine BANNER for printing. Table 4.6 indicates usage of the parameters in common block BANPAG.

4.3.3 Common Block DATA

Common block DATA contains parameters for which default values are given in BLOCK DATA. A description of these parameters is given in Table 4.7. The user has the option of modifying these parameters using BLOCK DATA change records as described in Section 2.1.2. Default values for these parameters are presented in Tables 2.21 and 3.1.

TABLE 4.6. Common Block BANPAG

Symbol and Dimension	Type	Definition
BOXSTR(3520)	Char*1	Character representation of banner page array
LET	Char*1	Character to be blocked into page array
NR	Integer	Number of rows in page array, set to 40 in BANNER
NC	Integer	Number of columns in page array, set to 88 in BANNER
IR	Integer	Starting row index of block letter in page array
IC	Integer	Starting column index of block letter in page array

TABLE 4.7. Common Block DATA

Symbol and Dimension	Type	Definition
PERA	Real	Adult fraction of population
PERT	Real	Teenage fraction of population
PERC	Real	Child fraction of population
US	Real	Total U.S. population
PLNTLF	Real	Midpoint of plant life
TPROCF	Real	Processing time of aquatic foods
TPROCW	Real	Processing time in water supply system
YIELD	Real	Yield of irrigated vegetation (not currently used)
GROW	Real	Duration of irrigation (not currently used)
Q1	Real	Pasture-grass consumption by milk animals
Q2	Real	Water consumption by milk animals
Q3	Real	Pasture-grass consumption by beef animals
Q4	Real	Water consumption by beef animals

Table 4.7 (Contd)

Symbol and Dimension	Type	Definition
FRAC	Real	Vegetation capture fraction
TWTH	Real	Weathering half-time of foliar deposition
RZONE	Real	Density of root zone
TDF	Real	Maximum rate of fish consumption by infants (kg/yr)
TDC	Real	Maximum rate of freshwater-invertebrate consumption by infants (kg/yr)
TDA	Real	Maximum rate of aquatic-plant consumption by infants (kg/yr)
TDW	Real	Maximum rate of water consumption by infants (L/yr)
TDS	Real	Shoreline exposure time per year for infants (hr/yr)
TDSW	Real	Swimming exposure time per year for infants (hr/yr)
TDB	Real	Boating exposure time per year for infants (hr/yr)
CHF	Real	Rate of fish consumption by children (kg/yr)
CHC	Real	Rate of freshwater-invertebrate consumption by children (kg/yr)
CHA	Real	Rate of aquatic-plant consumption by children (kg/yr)
CHW	Real	Rate of water consumption by children (L/yr)
CHS	Real	Shoreline exposure time for children (hr/yr)
CHSW	Real	Swimming exposure time for children (hr/yr)
CHB	Real	Boating exposure time for children (hr/yr)
TAF	Real	Rate of fish consumption by teens (kg/yr)
TAC	Real	Rate of freshwater-invertebrate consumption by teens (kg/yr)
TAA	Real	Rate of aquatic-plant consumption by teens (kg/yr)
TAW	Real	Rate of water consumption by teens (L/yr)

Table 4.7 (Contd)

Symbol and Dimension	Type	Definition
TAS	Real	Shoreline exposure time for teens (hr/yr)
TASW	Real	Swimming exposure time for teens (hr/yr)
TAB	Real	Boating exposure time for teens (hr/yr)
FIUS	Real	Rate of fish consumption by adults (kg/yr)
CRUS	Real	Rate of freshwater-invertebrate consumption by adults (kg/yr)
ALUS	Real	Rate of aquatic-plant consumption by adults (kg/yr)
WUSE	Real	Rate of water consumption by adults (L/yr)
SHU	Real	Shoreline exposure time for adults (hr/yr)
SWU	Real	Swimming exposure time for adults (hr/yr)
BUSE	Real	Boating exposure time for adults (hr/yr)
CHCSW	Real	Rate of saltwater-invertebrate consumption by children (kg/yr)
TACSW	Real	Rate of saltwater-invertebrate consumption by teens (kg/yr)
CRUSSW	Real	Rate of saltwater-invertebrate consumption by adults (kg/yr)
FLOODP(8,4)	Real	This array contains four sets of eight parameters related to irrigated food pathways. The four sets are for (in order) vegetables, leafy vegetables, milk, and meat. The eight parameters in each set are (in order): 1. average consumption rate by adults 2. average consumption rate by teens 3. average consumption rate by children 4. maximum consumption rate by adults 5. maximum consumption rate by teens 6. maximum consumption rate by children 7. food processing holdup time for average individuals 8. food processing holdup time for maximum individuals. Consumptions are in units of kg/yr (L/yr for milk). Times are in hours.

Table 4.7 (Contd)

Symbol and Dimension	Type	Definition
WHYP(12)	Real	This array gives parameters for sport and commercial harvest of fish and invertebrates. 1. Processing time between harvest and consumption of sport catch (hr) 2. Processing time between harvest and consumption of commercial catch (hr) 3. Commercial harvest of freshwater fish (kg/yr) 4. Commercial harvest of freshwater invertebrates (kg/yr) 5. Commercial harvest of saltwater fish (kg/yr) 6. Commercial harvest of saltwater invertebrates (kg/yr) 7. Average fish consumption by adults (kg/yr) 8. Average fish consumption by teens (kg/yr) 9. Average fish consumption by children (kg/yr) 10. Average invertebrate consumption by adults (kg/yr) 11. Average invertebrate consumption by teens (kg/yr) 12. Average invertebrate consumption children (kg/yr)
WATERP(3)	Real	Average individual annual water consumption rates (L/yr) for: 1) adults, 2) teens, and 3) children
FACCF(100)	Real	Bioaccumulation factors for transfer of radionuclides from freshwater to fish (L/kg) - Values are provided for 100 elements with atomic numbers from 1 to 100 (in order)
FACCI(100)	Real	Bioaccumulation factors for transfer of radionuclides from freshwater to invertebrates (L/kg) - Values are provided for 100 elements
FACCA(100)	Real	Bioaccumulation factors for transfer of radionuclides from freshwater to aquatic plants (L/kg) - Values are provided for 100 elements
SACCF(100)	Real	Bioaccumulation factors for transfer of radionuclides from saltwater to fish (L/kg) - Values are provided for 100 elements
SACCI(100)	Real	Bioaccumulation factors for transfer of radionuclides from saltwater to invertebrates (L/kg) - Values are provided for 100 elements
SACCA(100)	Real	Bioaccumulation factors for transfer of radionuclides from saltwater to aquatic plants (L/kg) - Values are provided for 100 elements

Table 4.7 (Contd)

Symbol and Dimension	Type	Definition
ZMET(100)	Real	Stable element transfer coefficient for animal meat production (d/kg) - Values are provided for 100 elements
ZMLK(100)	Real	Stable element transfer coefficient for animal milk production (d/L) - Values are provided for 100 elements
SOIL(100)	Real	Concentration factor for uptake of radionuclides from soil by edible parts of crops, kg (dry soil) per kg (wet crop)

4.3.4 Common Block DFLIB

This common block contains dose conversion factors and radiological decay constants as provided in the dose factor data file that is read in subroutine REDDF. Parameters included in this common block are described in Table 4.8.

TABLE 4.8. Common Block DFLIB

Symbol and Dimension	Type	Definition
DFL(700,7)	FP	50-year dose commitment factors for 1 yr of uptake by ingestion (mrem/pCi ingested) - Values are supplied for adults first (for each radionuclide), then for teens, children, and infants (a total of 700 radionuclide/age combinations is allowed). Data for 7 organs may be given. Current organ order is bone, liver, total body, thyroid, kidney, lung and GI-LLI.
EXG(170,2)	FP	External dose conversion factor for exposure to contaminated ground (mrem/hr per pCi/m^2) - Values are read from the "adult" portion of the data library for up to 170 radionuclides. The first position of the second array index is for skin dose, and the second position is for total-body dose.
TAU(170)	FP	Radiological decay constant for each radionuclide (hr^{-1})
EXS(170,2)	FP	External dose conversion factor for immersion in water from swimming and boating (mrem/hr per pCi/L of water) - Values are read from the "adult" portion of the data library for up to 170 radionuclides. The first position of the second array index is for skin dose, and the second position is for total-body dose.

Table 4.8 (Contd)

Symbol and Dimension	Type	Definition
EFF(170,8)	FP	Effective energy deposited per disintegration for each isotope in organs of various radii (MeV/dis) - Values are given in the "adult" portion of the data library for up to 170 radionuclides. Data is provided (in order) for organs of the following radii (cm): 1.4, 2, 3, 5, 7, 10, 20, and 30.

4.3.5 Common Block ELEMEN

This common block contains the element symbol array IELEM (dimension 100). This array contains the two-character name for each element, left justified. Values for IELEM are defined in DATA statements in BLOCK DATA. The array type is integer*2.

4.3.6 Common Block INUNIT

This common block contains the integer parameter INFIL, which is the logical unit to be used for reading of all input records. INFIL is defined a 9 in a DATA statement in the main program.

4.3.7 Common Block SORCE

This array contains index information on data that is provided in the dose factor data file. A description of the parameters in common block SORCE is given in Table 4.9. These parameters are defined or calculated in subroutine REDDF.

4.3.8 Common Block STATE

This common block contains the isomeric state symbol array META (dimension 700). This array contains a one-character symbol to indicate isomeric "M" or ground "blank" states. A position in this array is provided for each radionuclide in each age-group radionuclide list.

4.3.9 Common Block TRANS

This common block is used to transfer the drinking water dilution factor DILW from subroutine DRINK to subroutine PERDOS. DILW is printed from PERDOS to special output report 23.

TABLE 4.9. Common Block SORCE

Symbol and Dimension	Type	Definition
IZ (700)	Integer	Atomic number of each radionuclide in the dose factor file for each age group - There are 4 lists of radionuclides defined by arrays IZ and IMASS. The length of each list is determined by NLIBA, NLIBT, NLIBC, and NLIBI. The lists are for age groups adult, teen, child, infant
IMASS(700)	Integer	Atomic mass of each radionuclide in the dose factor file for each age group
NLIBA	Integer	Number of radionuclides for which dose factors are provided for adults
NLIBT	Integer	Total number of radionuclides for which dose factors are provided for adults and teens
NLIBC	Integer	Total number of radionuclides for which dose factors are provided for adults, teens, and children
NLIBI	Integer	Total number of radionuclides for which dose factors are provided for adults, teens, children, and infants. Note: 0<NLIBA<NLIBT<NLIBC<NLIBI

4.4 MODULE DESCRIPTIONS

Details of each of the 32 modules of the LADTAP II computer program are provided in this section. A list of the modules and a brief description of the purpose of each module is presented in Table 4.10. Information in the following sections describes most modules in detail. However, a few modules are generic in nature and are treated as "black boxes." Only the general purposes for these generic subroutines are provided. These subroutines are the banner page subroutines BANNER and BANLET and the BLOCK DATA change subroutines SETVAL, FIDOS, FFREAD, and WOT10. Listings of all subroutines are included in Appendix B (microfiche).

Information provided in the following sections describes the purpose of each module, interactions (control and data transfer) with other modules, and details of structure and logic useful for persons interested in modifying the program.

TABLE 4.10. Module Summary for LADTAP II

Module Name	Type	Description
MAIN	Main program	Controls case iteration
ACTIVE	Subroutine	Calculates population doses from aquatic recreational activities
ALARA	Subroutine	Calculates individual doses for ALARA analysis
AQUA	Subroutine	Calculates dose from aquatic food pathways
BANNER	Subroutine	Prints banner page
BANLET	Subroutine	Sets block letters into output array for banner page
BLOCK DATA	Block Data	Defines default values for parameters
CENT	Subroutine	Calculates total concentration parameters
CRITTR	Subroutine	Calculates dose to biota from aquatic ingestion pathways
DRINK	Subroutine	Calculates dose from drinking water pathways
EAT	Subroutine	Calculates dose to biota from terrestrial ingestion pathways
EXFCT	Function	Evaluates $1-e^{-x}$
FFREAD	Subroutine	Reads record images and partially decodes
FIDOS	Subroutine	Resets BLOCK DATA parameter values
FLOOD	Subroutine	Calculates individual and population doses from irrigated foods
FOOD	Subroutine	Calculates doses from irrigated foods
OUT	Subroutine	Calculates individual doses for each age group
PAFD	Subroutine	Calculates individual doses from ingestion of aquatic foods
PERDOS	Subroutine	Calculates and prints radionuclide contribution to dose
PLOP	Subroutine	Accumulates and prints cost-benefit data
RECON	Subroutine	Calculates effluent reconcentration factors
REDDF	Subroutine	Reads dose factor file from unit 20
SETVAL	Subroutine	Controls changes to BLOCK DATA values
SHORE	Subroutine	Calculates external dose from shoreline activities
SOURCE	Subroutine	Reads radionuclide source term
SSWAP	Subroutine	Controls surface water dilution analysis
SWIM	Subroutine	Calculates external dose from boating and swimming
TRTIUM	Subroutine	Calculates dose from tritium in the hydrosphere
WATER	Subroutine	Calculates doses to population from drinking water
WHO	Subroutine	Calculates dose to biota
WHY	Subroutine	Calculates population doses from ingestion of sport and commercial aquatic foods
WOT10	Subroutine	Writes BLOCK DATA report

4.4.1 MAIN Program

The main program, MAIN, controls case iteration, input of record types 1, 2, 3, and 3a, and calls subroutines to read the dose factor library, modify BLOCK DATA parameters, and calculate doses. Subroutines called by MAIN are ACTIVE, ALARA, BANNER, FLOOD, PLOP, REDDF, SETVAL, SOURCE, WATER, WHO, and WHY. Common blocks referenced by MAIN are blank common and labeled common block DATA.

A summary of the module structure and control logic is given in Figure 4.2.

The following actions and tests are performed in the main program.

1. The logical unit for reading of input records is set to 9 (parameter INFIL). To change the input unit it is only necessary to change this one statement. The parameter INFIL is transferred to other subroutines through the common block INUNIT.

2. The parameter JSB is used to distinguish the first case from subsequent cases. For the first case JSB has a value of 1, and the subroutine REDDF is called to read the dose conversion factor file. For subsequent cases JSB is incremented by 2, and the dose conversion factor file is not reread.

3. The run is terminated when an end-of-file on the input unit is encountered when reading a title record (record type 1). This is the normal termination mode.

4. Invalid values supplied for UML (source multiplication factor) or CFS (effluent discharge rate) will cause printing of the error message "BAD VALUE GIVEN FOR CFS OR UML, MUST BE >0." The run will be terminated. When UML is equal to zero, it is set to unity.

5. The parameter LT (for selection of salt or freshwater) must be equal to or greater than zero. If LT is less than zero the error message "NEGATIVE VALUE GIVEN FOR LT. MUST BE >=0" is printed and the run is terminated.

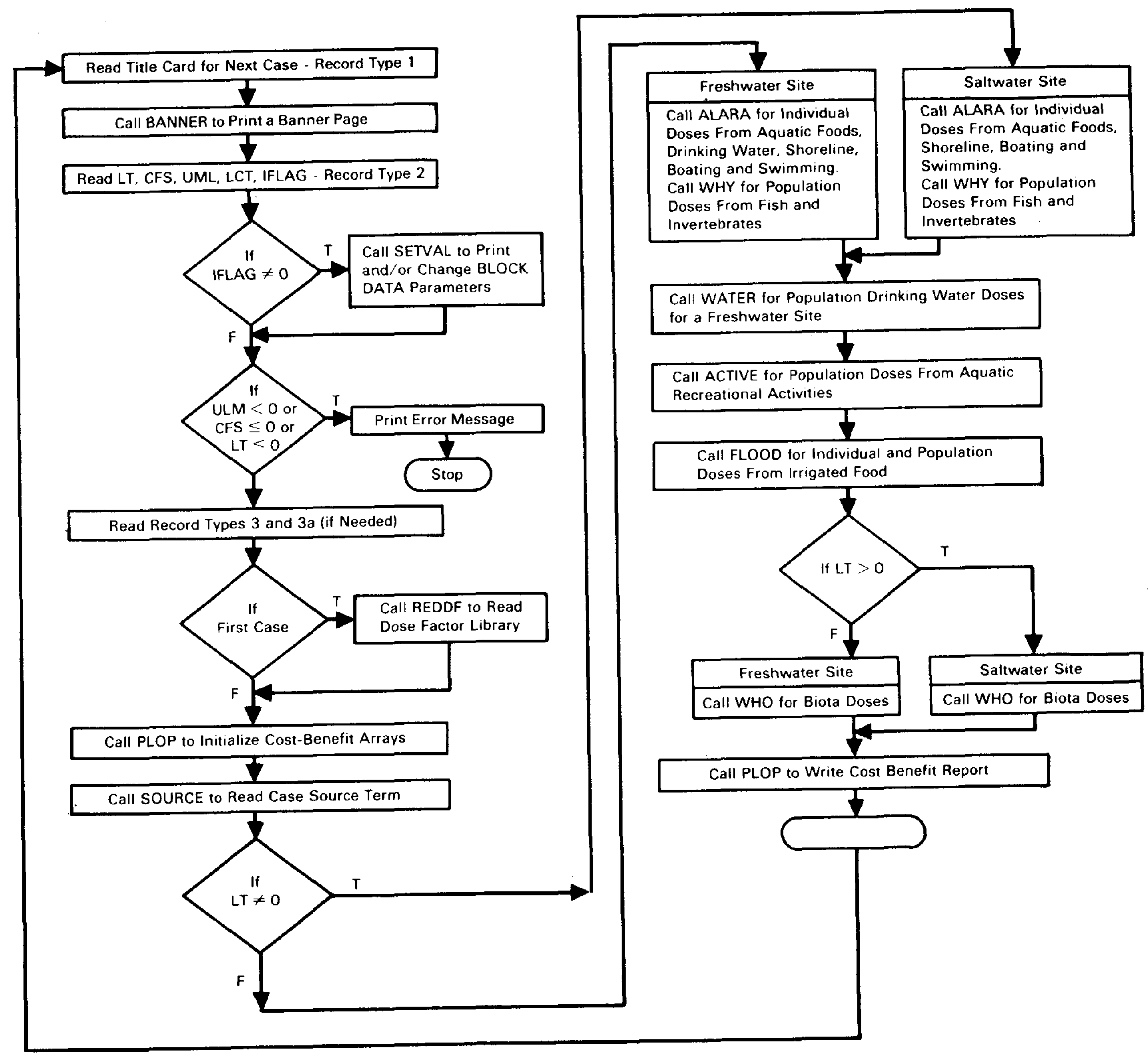


FIGURE 4.2. Main Program Logic Diagram

6. The subroutines ALARA and WHY receive appropriate bioaccumulation factors through their argument lists. For saltwater sites (LT>0) the saltwater bioaccumulation factors SACCF, SACCI, and SACCA are used. For freshwater sites (LT=0) the freshwater bioaccumulation factors FACCF, FACCI, and FACCA are used.

7. The dose array DOSE(200,8) is dimensioned in the main program and passed through argument lists to all subroutines that reference it.

8. The cost/benefit subroutine PLOP is called early in the main program to set the result arrays to zero. Subsequent calls to PLOP from other subroutines establish the dose results. A final call to PLOP from the main program causes the result report (report number 22 described in Section 2.2) to be printed.

9. The site data report (number 3 described in Section 2.2) is printed from the main program.

A summary of internal parameters used in the main program is given in Table 4.11.

TABLE 4.11. Internal Parameters for Main Program

Parameter Name	Type	Description
DOSE(200,8)	Real	Dose storage array by radionuclide (200) and organ (8)
IFLAG	Integer	Control integer to allow changing of BLOCK DATA parameters and printing of BLOCK DATA report and dose factor file report
IPRNT	Integer	Print control integer for dose factor file report (number 4 printed in subroutine REDDF). IPRNT is set equal to the absolute value of IFLAG: if IPRNT=1, print report.
ITITLE(78)	Char*1	Case title for output reports
JSB	Integer	Case indicator to prevent reading of dose factor file after the first case: if JSB=1, read dose factor file

Table 4.11 (Contd)

Parameter Name	Type	Description
TR	Real	Population fractions: if TR<0, read record type 3a
UML	Real	This source term multiplier is used to modify the radionuclide release inventory: UML≥0 if UML=0, reset to 1.0
VERSON(40)	Char*1	Version title defined in the main program and printed in the banner page

4.4.2 Subroutine ACTIVE

Subroutine ACTIVE is called by the main program and controls the calculations of population doses from aquatic recreational activities. Usage location data on record types 14, 15, and are read in ACTIVE and passed to subroutines SHORE and SWIM for calculation of population doses. Subroutine PERDOS calculates and prints tables of percentage contributions to doses by radionuclide. Headings for dose report Table 19 and doses are printed in ACTIVE.

Subroutine ACTIVE is composed of three sections, one for each pathway (shoreline, swimming and boating). Within each section, data records are read, subheadings are printed, subroutines are called to calculate doses, doses are printed, and percentage contributions are calculated (by subroutine PERDOS if LCT>0). An optional calculation of surface water dilution is performed by calling subroutine SSWAP.

The parameter JL, used within each section, causes printing of percentage contribution tables for the first usage location only. JL alternates between values of 10 and -10 for each section of code.

The parameter CON is set to 1000.0 so that calculated doses have units of rem (as calculated in SHORE and SWIM).

The parameter KIT is set equal to zero prior to calls to SHORE and SWIM and causes percentage contributions to be calculated (by calls to PERDOS from SHORE and SWIM). KIT is then reset to 40 prior to calling PERDOS from ACTIVE and initiates printing of the percentage contribution table for shoreline exposure. KIT is set to 50 to initiate printing of percentage contribution tables for boating and swimming.

The geometry factor GEOM is set to 1.0 prior to the first call to SWIM so that swimming exposures represent total immersion. GEOM is set to 2.0 prior to the second call to SWIM so that boating exposures represent partial immersion while boating. Note that GEOM is used in the denominator of the dose equations.

The parameter LZ is set to zero prior to each call to SHORE and SWIM. This causes percentage contribution data in PERDOS to be calculated for only one usage location at a time. The primary purpose for the parameter LZ is to control calculation of percentage contribution information by age group for individual doses in subroutine ALARA. Parameter LZ is a count index for the number of age groups considered and is incremented in PERDOS. (Note that LZ is also used for biota and pathway counting.)

The argument list for subroutine ACTIVE has only the array DOSE(200,8) for storing calculated doses to 8 organs for 200 radionuclides. All references to values in DOSE are made in subroutine ACTIVE and subroutines called by ACTIVE. Values passed back to the main program from ACTIVE are not referenced in the current version of LADTAP II. Internal parameters for subroutine ACTIVE are described in Table 4.12.

4.4.3 Subroutine ALARA

Subroutine ALARA is called by the main program to calculate and print individual doses for comparison with 10 CFR 50 Appendix I guidelines. ALARA calls subroutine OUT to calculate individual doses for each age group. Common blocks referenced in ALARA are BLANK, DATA, and INUNIT. The argument parameters for ALARA are described in Table 4.13, and the internal parameters are described in Table 4.14.

TABLE 4.12. Internal Parameters for Subroutine ACTIVE

Name	Type	Description
A(3)	Char*4	Title for output reports - "TOTAL POPUL"
BTUSE	Real	Population exposure time for boating (person-hr/yr)
BW	Real	Average width of the nontidal river (ft) or discharge depth to a lake (ft)
D(3)	Char*4	Title for output reports - "BOATING"
DILU	Real	Dilution factor for current location and pathway
GEOM	Real	Geometry factor used in subroutine SWIM to distinguish between boating and swimming: GEOM=2, half immersion (boating) GEOM=1, total immersion (swimming)
HR	Real	Average depth of river or lake (ft)
IFLAG	Integer	Surface-water model selection index IFLAG=1, nontidal river model IFLAG=2, near-shore lake model
J	Integer	DO loop index for several READ and PRINT statements
JL	Integer	Control integer to limit printing of dose contribution tables to one usage location for each pathway
LOCA(3)	Char*4	Location identification title
S(3)	Char*4	Title for output reports - "SHORELINE"
SHU	Real	Population exposure time for shoreline activities (person-hr/yr)
SW(3)	Char*4	Title for output reports - "SWIMMING"
SWF	Real	Shore-width factor (see Table 2.7)
SWU	Real	Population exposure time for swimming (person-hr/yr)
SWTITL(2)	Char*5	Title for surface water dilution data output - "RIVER" or "LAKE"
T	Real	Transit time from release location to usage location (hr)
TDOSE(8)	Real	Total dose array from each organ for current location and pathway (person-rem)

Table 4.12 (Contd)

Name	Type	Description
UR	Real	Average flow velocity downstream or along shore (ft/sec)
W(3)	Char*4	Blank title for output reports
XR	Real	Downshore distance from release to usage location (ft)
YR	Real	Offshore distance to water intake at usage location (ft)

TABLE 4.13. Argument Parameters for Subroutine ALARA

Name	Type	Description
ACCA(100)	Real	Bioaccumulation factor for aquatic plants for current water type (salt or fresh) and each element
ACCF(100)	Real	Bioaccumulation factor for fish for current water type (salt or fish) and each element
ACCI(100)	Real	Bioaccumulation factor for invertebrates for current water type (salt or fresh) and each element
DOSE(200,8)	Real	Intermediate dose storage array for each radionuclide (200) and each organ(8)

TABLE 4.14. Internal Parameters for Subroutine ALARA

Name	Type	Description
BDIL	Real	Dilution factor for aquatic foods and boating
BW	Real	Average width of the nontidal river (ft) or discharge depth to a lake (ft)
DILU	Real	For ALARA analysis DILU is the dilution factor for all pathways except drinking water and shoreline exposure - for "selected location" analysis DILU is used for all pathways
DWD	Real	Dilution factor for drinking water
J	Integer	Implied DO loop index on input READ statement
HR	Real	Average depth of river or lake (ft)

Table 4.14 (Contd)

Name	Type	Description
IFLAG	Integer	Surface-water model selection index IFLAG=1, nontidal river model IFLAG=2, near-shore lake model
KK	Integer	Count index for usage locations
LOCA(5)	Char*4	Location title
N	Integer	Control integer for input of record Types 7a-7d: if N=0, do not read Type 7a-7d records if N≠0, read Type 7a-7d records
SHD	Real	Dilution factor for shoreline and swimming exposure
SWD	Real	Dilution factor for swimming exposure
SWF	Real	Shore-width factor
SWTITL(2)	Char*5	Title for surface water dilution data output - "RIVER" or "LAKE"
T	Real	Transit time to usage location (hr)
TD	Real	Transit time to drinking water plant intake (hr)
UR	Real	Average flow velocity downstream or alongshore (ft/sec)
XR	Real	Downshore distance from release to usage location (ft)
YR	Real	Offshore distance to water intake at the usage location (ft)

The first record read by ALARA (type 7) provides data for the ALARA individual dose analysis for all aquatic pathways plus drinking water. The parameter N on the input record controls the reading of record types 7a - 7d, which are used to change default consumption rates for each age group. New values are read if N is not zero. Option records may be read to calculate surface water diltuion. Records 7e, 7f, and 7g provide data that are used to estimate dilution factors DILU, SHD, and DWD, respectively. These records are read when the corresponding dilution factor on record type 7 is set negative.

After each record giving usage location data, subroutine OUT is called four times (once for each age group) to calculate and print doses. For usage location records after the first, reports are prepared for "selected locations." The calculations for the ALARA report and the "selected locations" reports differ only by their definition of dilution factors and transit times. The ALARA analysis allows the definition of dilution factors for aquatic foods, shoreline, and drinking water. The aquatic foods dilution factor is also used for boating. The shoreline dilution factor is also used for swimming. Transit times are defined for drinking water and one for all other pathways. However, for the selected usage locations input record (type 8) only one transit time and one dilution factor are given. When the dilution factor is to be estimated using surface water models, the transit time may also be estimated if a value of zero is supplied. Report headings and subheadings are printed in subroutine ALARA; doses are printed in subroutine OUT; percentage contribution to dose by radionuclide is printed in subroutine PERDOS.

4.4.4 Subroutine AQUA

Subroutine AQUA calculates the ALARA individual doses from ingestion of aquatic foods. AQUA is called by subroutine OUT and calls PERDOS to calculate percent contribution to dose by radionuclide. Common blocks BLANK, DFLIB, and SORCE are referenced by AQUA. Argument parameters and internal parameters for subroutine AQUA are described in Tables 4.15 and 4.16, respectively.

The usage parameter, USE, is tested prior to performing the dose calculations. If the parameter is zero, the calculations are skipped and values of zero are returned for total dose.

4.4.5 Subroutine BANNER

This subroutine controls printing of the LADTAP II banner page. The block letters are set into the output array by subroutine BANLET, which is called for each letter in the title word "LADTAP II." Lines in the banner page include the case input title, the program version title, the current date and lines giving the NRC address for program responsibility. The title is passed from the main program to BANNER through argument parameter ITITLE (character*1 with 78 spaces). The version title is passed from the main

TABLE 4.15. Argument Parameters for Subroutine AQUA

Name	Type	Description
ACC(100)	Real	Bioaccumulation factor array for current water type and aquatic pathway
CRITR(3)	Char*4	Descriptive title for current pathway
DILU	Real	Dilution factor for current usage location
DOSE(200,8)	Real	Intermediate storage location for each radionuclide (200) and each organ (8)
T	Real	Holdup time between release and consumption of aquatic food product (hr)
JJ	Integer	Age-group index: JJ=1, adult JJ=2, teen JJ=3, child JJ=4, infant
TDOSE(8)	Real	Total dose to each organ for current calculation
USE	Real	Rate of current aquatic food consumption by individuals in current age group (kg/yr)

TABLE 4.16. Internal Parameters for Subroutine AQUA

Name	Type	Description
ARGU	Real	Exponential argument for decay in transit from release to consumption
FACT	Real	Intermediate parameter representing activity ingested for current pathway
I	Integer	Loop index for radionuclides in source inventory
J	Integer	Loop index for organs
L	Integer	Intermediate organ index
LL	Integer	Position index for current radionuclide in age-specific data arrays
LM	Integer	Position index for current adult age group data in several parameter arrays
MO	Integer	Element index for current radionuclide

program through argument parameter VERSON (character*1 with 40 spaces). Other information is set in DATA statements in BANNER. The current date is set into the array TODAY by system subroutine DATE. When converting LADTAP II to other machines, the subroutine DATE may need to be replaced with the appropriate system date routine that is compatible with the new machine.

4.4.6 Subroutine BANLET

This subroutine places block letters into the banner page output array. One letter is set per call to BANLET. This subroutine is called by BANNER, and data are transferred through common block BANPAG.

4.4.7 BLOCK DATA

The BLOCK DATA module defines default values to common block DATA parameters and provides the element symbols in common block ELEMEN. Default values have been described elsewhere in this report and are not repeated here.

4.4.8 Subroutine CENT

This subroutine calculates an intermediate food product concentration parameter, CONC, which is defined for each radionuclide. CONC is the sum of concentrations for all usage locations defined for the current exposure pathway. Units for this concentration parameter are $(Ci \cdot sec)/(ft^3 \cdot yr)$. CENT is used for the irrigated food pathways (called by subroutine FLOOD) and for the population aquatic food ingestion pathways (called by subroutine WHY). Common blocks BLANK and DFLIB are referenced by CENT.

Calculation of water concentration at each usage location includes decay during transit from the release point. The concentration parameter includes division by total production, which is defined by either of the two argument parameters AMT or HARV. Use of these parameters is determined by the argument N. The production is defined as follows:

Calling Module	N	Pathway	Production
FLOOD	2	irrigated foods	total 50 mile (HARV)
WHY	1	sport harvest	total local (AMT)
WHY	2	commercial harvest	total 50 mile (HARV)

Argument parameters for CENT are described in Table 4.17, and internal parameters are described in Table 4.18.

TABLE 4.17. Argument Parameters for Subroutine CENT

Name	Type	Description
AMT	Real	Total local production of food type (kg/yr)
CATH(20)	Real	Total harvest at each location (kg/yr)
CONC(200)	Real	Total concentration parameter to be returned for each radionuclide (Ci·sec) per (ft^3·yr)
DILU(20)	Real	Dilution factor for each location
HARV	Real	Total production of food type within 50 miles (kg/yr)
J	Integer	Number of locations to be considered: $1 \leq J \leq 20$
N	Integer	Integer for selecting total food production parameter (see table in text)
T(20)	Real	Transit time to each location (hr)

TABLE 4.18. Internal Parameters for Subroutine CENT

Name	Type	Description
ARGU	Real	Exponential argument for radiological decay during transit to usage location
K	Integer	DO loop index for usage locations
KK	Integer	DO loop index for nuclides in release inventory
LM	Integer	Nuclide index for decay constant array

4.4.9 Subroutine CRITTR

Subroutine CRITTR calculates the internal dose to aquatic biota from living in contaminated water. CRITTR is called by subroutine WHO and references common blocks BLANK, DFLIB and SORCE. CRITTR is called for one aquatic organism at a time: fish, invertebrate, algae. The corresponding bioaccumulation factor is passed through the argument list, ACC. An effective radius of 2 cm is assumed for each organism when calculating the effective deposited energy, EFF(i,2). The argument parameters and internal parameters for subroutine CRITTR are presented in Tables 4.19 and 4.20, respectively.

TABLE 4.19. Argument Parameters for Subroutine CRITTR

Name	Type	Description
ACC(100)	Real	Bioaccumulation factor for current aquatic organism (L/kg) for each element
CRITR(3)	Char*4	Descriptive title for current organism - "FISH," "INVERTEBRATE," or "ALGAE"
DILU	Real	Dilution factor for current biota exposure location
DOSE(200,8)	Real	Dose storage array for each radionuclide (200) (only the first position of the second dimension is used)
T	Real	Transit time from release point to exposure location (hr)
TDOSE(8)	Real	Total dose for current biota (only the first position is used)

TABLE 4.20. Internal Parameters for Subroutine CRITTR

Name	Type	Description
ARGU	Real	Argument for radiological decay in transit
FACT	Real	Intermediate parameter representing water concentration at exposure location
I	Integer	DO loop index for the number of radionuclides in source inventory
J	Integer	DO loop index for the number of organs (only the first position is used)

Table 4.20 (Contd)

Name	Type	Description
LM	Integer	Position index for current radionuclide in the adult data file - used for decay constant and effective energy arrays
MO	Integer	Element index for current radionuclide

4.4.10 Subroutine DRINK

Subroutine DRINK calculates individual and population drinking water doses for one usage location per call. DRINK is called by subroutine ALARA (for individual doses) and by subroutine WATER (for population doses). For individual doses the argument parameter USE gives the annual individual consumption rate for the current age group (defined by JJ) in L/yr. For population doses the parameter represents total consumption by the population age group (person-L/yr). The argument parameters for subroutine DRINK are defined in Table 4.21, and the internal parameters are defined in Table 4.22. The parameter for dose units, CON, is set to 1.0 mrem/mrem for individual doses and to 1000 mrem/rem for population doses. When population doses are calculated (CON=1000), subroutine PLOP is called to include the population doses in the cost-benefit analysis.

Subroutine DRINK calls subroutines PLOP and PERDOS and references common blocks BLANK, DFLIB, and TRANS.

4.4.11 Subroutine EAT

Subroutine EAT calculates doses to specific terrestrial biota from ingestion of contaminated aquatic organisms. The argument list parameters define the aquatic organism and the terrestrial biota. The terrestrial biota is defined by a body mass (MASS), an effective body radius (RAD), and an ingestion rate (CONS) of aquatic organisms. The aquatic organism ingested by

TABLE 4.21. Argument Parameters for Subroutine DRINK

Name	Type	Description
DOSE(200,8)	Real	Intermediate storage array for doses of each radionuclide (200) and each organ (8)
DWD	Real	Dilution factor for drinking water
JJ	Integer	Age-group index for current calculations: JJ=1, adult JJ=2, teen JJ=3, child JJ=4, infant
T	Real	Transit time from release of water to consumption (hr)
TDOSE(8)	Real	Total dose to each organ
USE	Real	Rate of water consumption by current age group (kg/yr)

TABLE 4.22. Internal Parameters for Subroutine DRINK

Name	Type	Description
ARGU	Real	Exponential argument for decay in transit to consumption point for current age group (kg/yr)
FACT	Real	Intermediate parameter representing activity ingested by current age group for drinking water pathway
I	Integer	DO loop index for radionuclides in source inventory
J	Integer	DO loop index for organs
L	Integer	Intermediate array index for organ position
LL	Integer	Position index for current radionuclide in current age group data list
LM	Integer	Position index for current radionuclide in adult age group data list
TYPE(3)	Char*4	Title array for report - "DRINKING"

the current terrestrial biota is identified through the bioaccumulation factor (ACC) supplied in the argument list.

The body radius of the terrestrial biota determines the effective energy data used for the current terrestrial biota. Effective energy data are provided in the dose factor library (read by subroutine REDDF, see Section 4.5) for radii of 1.4, 2, 3, 5, 7, 10, 20 and 30 cm. Data correspond to the library value with the closest radius to the biota radius.

The ingestion dose conversion factor used for terrestrial biota is based on the adult total-body ingestion dose factors corrected for differences in body radius. The body radius correction is to account for differences in deposited energy for penetrating radiation. Adult dose factors are based on a radius of 30 cm. Values assumed for terrestrial biota are: muskrat - 6 cm, raccoon - 14 cm, heron - 11 cm, and duck - 5 cm. The correction is made by multiplying the adult dose factor by the ratio of effective energy for the biota (based on radius of biota) to the effective energy for adults (30 cm radius).

The subroutine PERDOS calculates percent contribution by radionuclide if LCT>0.

The argument parameters for subroutine EAT are described in Table 4.23, and the internal parameters are described in Table 4.24.

4.4.12 Function EXFCT

Function EXFCT is used to evaluate the expression:

$$1 - e^{-x}$$

where x is the dimensionless argument in the call list. The evaluation method depends on the value of the argument, x. If x is greater than or equal to 30, zero is returned. If x is greater than -60 the function is evaluated as EXP(x). Function FUN is called by subroutine LIMITS in the surface water dilution analysis.

TABLE 4.23. Argument Parameters for Subroutine EAT

Name	Type	Description
ACC(100)	Real	Bioaccumulation factor for type of aquatic food ingested by current terrestrial biota (L/kg)
BIOT(4)	CHAR*4	Title array for current terrestrial biota - "MUSKRAT," "RACCOON," "HERON," or "DUCK"
CONS	Real	Rate of aquatic-organism consumption by current terrestrial biota (kg/yr)
DILU	Real	Dilution factor for aquatic organism eaten by current terrestrial biota
DOSE(200,8)	Real	Dose contribution array for radionuclide (200) and the current terrestrial biota (8)
MASS	Real	Body weight of the current terrestrial biota (kg)
RAD	Real	Effective radius of the current terrestrial biota (cm)
T	Real	Transit time from release point to the current usage location (hr)
TDOSE(8)	Real	Total dose for current terrestrial biota (only the first position of the array is used)

the function value is set to 1.0. If the argument is between 0.01 and 30, the above expression is evaluated with the system exponential function, EXP(-x). For argument values equal to or below 0.01 a numeric algorithm is used. This algorithm is defined as:

$$1 - e^{-x} = x + \frac{x^3}{6} - \frac{x^2}{2} - \frac{x^4}{24}$$

The only internal parameters are X2, X3, and X4, which correspond to x^2, x^3, and x^4, respectively.

TABLE 4.24. Internal Parameters for Subroutine EAT

Name	Type	Description
ARGU	Real	Exponential argument for radiological decay from release point to usage location
FACT	Real	Intermediate parameter representing total intake of aquatic organism contamination by the terrestrial biota
I	Integer	DO loop index for radionuclides
J	Integer	DO loop index for organ position
JEB	Integer	Temporary index used to determine radius data for current biota
JOT	Integer	Temporary index used to determine radius data for current biota
L	Integer	Radius index used for effective energy for current biota
MO	Integer	Index of radionuclide in data arrays
PT	Real	Intermediate value used to determine radius index
STAN(9)	Real	Organ radii that correspond to library data on effective energy
TP	Real	Intermediate value used to determine radius index

4.4.13 Subroutine FFREAD

This subroutine reads the record images for the FIDO input record set that is used to change parameters for common block DATA. The subroutine contains logic that interprets both free-field and fixed-field input records; however, only use of the free-field input records is described in Section 2.1.2 (BLOCK DATA Change Records). This is a general purpose subroutine and does not involve mathematical models in the program. Therefore, additional details of this subroutine are not provided.

4.4.14 Subroutine FIDOS

This subroutine decodes FIDO records and resets BLOCK DATA parameter values as designated on the records. A description of the record preparation is given in Section 2.1.2. Additional details are not provided because FIDO is a general input processor and is not involved in calculating consequences.

4.4.15 Subroutine FLOOD

This subroutine calculates individual and population doses that result from ingesting irrigated terrestrial food products. FLOOD is called by the main program and calls subroutines CENT, FOOD, PERDOS and SSWAP. Common block references are BLANK, DATA, and INUNIT.

Four general food products may be represented in the irrigation pathways: 1) vegetables (root crops, cereals, fruit), 2) leafy vegetables, 3) milk, and 4) meat. Food pathway parameters for these food types are provided in BLOCK DATA. Default values are given in Tables 2.18 and 3.1. The major operations performed within FLOOD regarding each food product are as follows:

1. Read record types 17, 17a, 18, and 18a as necessary to define the parameters for the current food product. The food product is identified by parameter N on record type 17.
2. The data provided for each usage location are reviewed to determine the minimum dilution factor and its corresponding transit time. The minimum value is used to calculate maximum individual doses.
3. Subroutine CENT is called to calculate the total water concentration parameter, which is summed over all usage locations. This intermediate parameter is independent of food type and is returned through the call list parameter CONC and passed to subroutine FOOD.
4. Subroutine FOOD is called for each age group to calculate ingestion doses for maximally exposed individuals and population doses for the "ALARA" and "NEPA" reports.
5. Individual and population dose reports are printed for the current food product.

6. If requested (if LCT>0), subroutine PERDOS is called to print percent contributions to dose by radionuclide.

Each of these steps is repeated until no further input is provided (parameter N on record type 17 is set to 0).

The dose array DOSE(200,8) is the only argument parameter for FLOOD. This array contains doses to the maximum individual. However, no reference to values in DOSE are made by the calling module (MAIN) once the call to FLOOD is completed. A description of all internal parameters to FLOOD is provided in Table 4.25.

TABLE 4.25. Internal Parameters for Subroutine FLOOD

Name	Type	Description
A(3)	Char*4	Title array for output report - "ADULT"
AALD(7)	Real	Adult population doses to each organ, calculated for "ALARA" report
AAND(7)	Real	Adult population doses to each organ, calculated for "NEPA" report
AC	Real	Average annual adult consumption rate for current food product (kg/yr)
ACON	Real	Maximum annual adult consumption rate for current food product (kg/yr)
AMT	Real	Dummy parameter for CENT call list (not used in FLOOD)
B(3)	Char*4	Title array for output report - "TEENAGER"
BAD(7)	Real	Total population doses to each organ, summed over age groups, calculated for "ALARA" report
BW	Real	Average width of the nontidal river (ft)
C(3)	Char*4	Title array for output report - "CHILD"
CALD(7)	Real	Child population doses to each organ, calculated for "ALARA" report

Table 4.25 (Contd)

Name	Type	Description
CAND(7)	Real	Child population doses to each organ, calculated for "NEPA" report
CC	Real	Average annual rate of current food product consumption by children (kg/yr)
CCON	Real	Maximum annual rate of current food product consumption by children (kg/yr)
CONC(200)	Real	Intermediate concentration parameter for each radionuclide: calculated in CENT and used in FOOD
D(3)	Char*4	Title array for output report - "TOTAL"
DILU(20)	Real	Dilution factor for up to 19 usage locations for the current terrestrial food product
DL	Real	Minimum dilution factor specified for usage locations for current terrestrial food product
FDH2O	Real	Fraction of animal drinking water not obtained from contaminated irrigation water supply (used for milk and meat only)
FFED	Real	Fraction of animal feed not produced with contaminated irrigation water
GOOD(7)	Real	Sum of population doses to each organ by age group, calculated for "NEPA" report
HLD1	Real	Food processing holdup time for maximum exposure calculations (hr)
HOLD	Real	Food processing average holdup time
HR	Real	Average depth of river or lake (ft)
IFLAG	Integer	Surface-water model selection index: IFLAG=1, nontidal river model IFLAG=2, near-shore lake model
IRRIG	Real	Irrigation rate for current food product ($L/m^2/mo$)

Table 4.25 (Contd)

Name	Type	Description
J	Integer	Count index for the number of usage locations supplied - implied DO loop index on WRITE statement
JM	Integer	Implied loop index for PRINT statements
K	Integer	Implied DO loop index on READ statements
KZ	Integer	Control integer for reading of new consumption data: if KZ>0, read new data
LOC(5,20)	Char*4	Descriptive title for each usage location - 20 characters each (4*5)
LV(3)	Char*4	Title for output reports - "LEAFY VEGE"
M	Integer	Number of usage locations provided for current food product. $1 \leq M \leq 19$
MET(3)	Char*4	Title for output reports - "MEAT"
MLK(3)	Char*4	Title for output reports - "MILK"
N	Integer	Food product selection control index: N=0, stop reading N=1, vegetables N=2, leafy vegetables N=3, milk N=4, meat
P	Real	Number of people served at the average consumption rate within 50 miles
PROD(20)	Real	Production rate of current food product at each usage location (kg/yr or L/yr)
SWTITL(2)	Char*5	Title for surface water dilution data output - "RIVER" or "LAKE"
T(20)	Real	Transit time from effluent release point to current usage location (hr)
TALD(7)	Real	Teen population doses to each organ, calculated for "ALARA" report

Table 4.25 (Contd)

Name	Type	Description
TAND(7)	Real	Teen population doses to each organ, calculated for "NEPA" report
TC	Real	Average annual rate of current food product consumption by teens (kg/yr)
TCON	Real	Maximum annual rate of current food product consumption by teens
TDOSE(8)	Real	Total dose array for each organ
TFMG	Real	Total production of the current food product within 50 miles of the site (kg/yr)
TGROW(4)	Real	Default values for crop-growing period of each food product (d): vegetables 60 leafy vegetables 60 milk 30 meat 30
TGRW	Real	Growing period for current food crop (d)
TM	Real	Transit time supplied with the minimum dilution factor (hr)
TP	Real	Number of people served, based on the sum of production and the average consumption rate specified for the usage location
TTIG	Real	Sum of specified production rates for the current food product (kg/yr)
TYPE(3)	Char*4	Title array for output reports - "IRRI FOOD"
UR	Real	Average flow velocity downstream or alongshore (ft/sec)
VEG(3)	Char*4	Title array for output reports - "VEGETATION"
XR	Real	Downshore distance from release to usage location (ft)

Table 4.25 (Contd)

Name	Type	Description
YILD(4)	Real	Default values for crop yield (kg/m²): vegetables 2.0 leafy vegetables 2.0 milk 0.7 meat 0.7
YLD	Real	Crop yield for current food product (kg/m²)
YR	Real	Offshore distance to water intake at the usage location (ft)

4.4.16 Subroutine FOOD

Subroutine FOOD calculates individual and population doses for irrigated food pathways. FOOD is called by subroutine FLOOD and calls function EXFCT and subroutine PLOP. Common blocks BLANK, DATA, DFLIB, and SORCE are referenced in FOOD. Argument parameters for subroutine FOOD are described in Table 4.26 and internal parameters are described in Table 4.27.

TABLE 4.26. Argument Parameters for Subroutine FOOD

Name	Type	Description
ALD(7)	Real	Total population dose to each organ for "ALARA" report
AND(7)	Real	Total population dose to each organ for "NEPA" report
C	Real	Average rate of current food product consumption by current age group (kg/yr)
CONC(200)	Real	Sum of water concentration of each radionuclide for all usage locations
CONSUM	Real	Maximum annual rate of current food product consumption by current age group (kg/yr)
DL	Real	Minimum dilution factor for all usage locations

Table 4.26 (Contd)

Name	Type	Description
DOSE(200,8)	Real	Dose array by radionuclide and organ for the maximum individual
FDH2O	Real	Fraction of animal drinking water not obtained from contaminated irrigation supply
FFED	Real	Fraction of contaminated feed not produced with contaminated irrigation water
HLD1	Real	Food processing holdup time for maximum individual doses (hr)
HOLD	Real	Food processing holdup time for average doses (hr)
IRRIG	Real	Irrigation rate for current food product (L/m²/mo)
JJ	Integer	Age group index: JJ=1, adult JJ=2, teen JJ=3, child
N	Integer	Food product index: N=1, vegetables N=2, leafy vegetables N=3, milk N=4, meat
P	Real	Number of people served at the average consumption rate within 50 miles for the current food product
TDOSE(8)	Real	Total dose for each organ
TFMG	Real	Total production of current food product within 50 miles of the site (kg/yr)
TGRW	Real	Crop growing period for the current food product (d)
TM	Real	Transit time for minimum dilution factor (hr)
TP	Real	Number of people served by production from all usage locations
TTIG	Real	Sum of production rates for current food product for all usage locations (kg/yr)

Table 4.26 (Contd)

Name	Type	Description
TYPE(3)	Char*4	Title array for output reports - "IRRI FOOD"
YLD	Real	Crop yield for current food product (kg/m•)

TABLE 4.27. Internal Parameters for Subroutine FOOD

Name	Type	Description
CNC1	Real	Maximum individual water concentration
DECAY	Real	Decay constant with weathering for current radionuclide (day^{-1})
DFL(700,7)	Real	Ingestion dose factors
FACT	Real	Intermediate parameter in population dose calculations
FCN1	Real	Intermediate concentration parameter in maximum individual dose calculations
FCON	Real	Intermediate concentration parameter in population dose calculations
FCT1	Real	Intermediate parameter in population dose calculations
J	Integer	DO loop index for organs
LEAF	Real	Intermediate factor for crop contamination through leaves
LL	Integer	Position index for current radionuclide data in age-specific data array
MO	Integer	Element index for current radionuclide
PCN1	Real	Plant concentration parameter for individual doses
PCON	Real	Plant concentration parameter for population doses
POL1	Real	Population dose from current radionuclide for "NEPA" report

Table 4.27 (Contd)

Name	Type	Description
POOL	Real	Population dose from current radionuclide for "ALARA" report
ROOT	Real	Intermediate factor for crop contamination through roots
TERM	Real	Fraction of population in current age group
TRANS	Real	Translocation factor from deposition on leaves to edible parts of plant, set to 1.0
ZIN	Real	Intermediate parameter in animal product pathway for population doses
ZIN1	Real	Intermediate parameter in animal product pathway for individual doses

Subroutine FOOD is called once for each type of irrigated food and each age group that are requested by the user. The food type is identified by the argument integer, N, as follows:

N	Food Type
1	vegetables
2	leafy vegetables
3	milk
4	meat

The age group is identified by parameter JJ (1 - adults, 2 - teens, and 3 - children). The total food product concentration is supplied to FOOD through argument parameter, CONC, which is defined for each radionuclide.

The individual dose calculations are performed for "maximum" conditions to give the highest dose estimate. The population doses are based on average conditions. The calculations for average and maximum conditions are performed in parallel. Intermediate parameters in the maximum individual dose calculation can be identified as those ending in the number "1" (i.e., CNC1, PCN1, FCN1, and ZIN1). The corresponding population dose parameters do not end with "1" (i.e., CONC, PCON, FCON, and ZIN).

Population doses are calculated for an "ALARA" report and a "NEPA" report. To determine the net effect of the difference in the calculation, it is necessary to consider the definition of population parameters P and TP. The ALARA doses are calculated using, P, the population that lives within and is served by production from within 50 miles. The NEPA doses are calculated using TP, the total population that is served by local production. The NEPA and ALARA doses will be the same when the 50-mile production will serve the 50-mile population (P $\leq$ 50-mile population). When the local production will serve more than the population within 50 miles, the NEPA doses will be higher because people outside the 50-mile radius will be included in the calculation.

Special consideration is given to tritium dose calculations. All plants are assumed to have the same tritium concentration as the irrigation water and all animal feed and water are similarly assumed to have the same water tritium concentration.

4.4.17 Subroutine OUT

Subroutine OUT calculates and prints individual doses for the ALARA reports. Subroutine OUT is called by subroutine ALARA and calls subroutines AQUA, DRINK, PERDOS, SHORE, and SWIM. BLANK common is referenced by subroutine OUT.

Subroutine OUT is called for each age group as defined by parameter KOP (1 - adult, 2 - teen, 3 - child, and 4 - infant). Dose calculations are performed in the following subroutines called by OUT:

Subroutine	Dose Pathway
AQUA	fish ingestion
AQUA	invertebrate ingestion
AQUA	aquatic plant ingestion
DRINK	drinking water ingestion
SHORE	shoreline external exposure
SWIM	swimming external exposure
SWIM	boating external exposure
PERDOS	percentage contribution to dose for each organ by radionuclide

Argument and internal parameters used by OUT are described in Tables 4.28 and 4.29, respectively.

TABLE 4.28. Argument Parameters for Subroutine OUT

Name	Type	Description
ACCA(100)	Real	Bioaccumulation factor for aquatic plants for current water type (L/kg)
ACCF(100)	Real	Bioaccumulation factor for fish for current water type and each element (L/kg)
ACCI(100)	Real	Bioaccumulation factor for invertebrates for current water type and each element (L/kg)
ALUS	Real	Rate of aquatic-plant consumption by current age group (kg/yr)
BDIL	Real	Dilution factor for boating
BUSE	Real	Exposure time from boating for current age group (hr/yr)
CRUS	Real	Rate of invertebrate consumption by current age group (kg/yr)
DILU	Real	Dilution factor for aquatic foods
DOSE(200,8)	Real	Dose storage array for each radionuclide (200) and each organ (8)
DWD	Real	Dilution factor for drinking water
FIUS	Real	Rate of fish consumption by current age group (kg/yr)
KK	Integer	Count index for usage locations
KOP	Integer	Age group index: KOP=1, adult KOP=2, teen KOP=3, child KOP=4, infant
N	Integer	Not currently used
SHD	Real	Dilution factor for shoreline exposure
SHU	Real	Exposure time for shoreline activity for current age group (hr/yr)
SWD	Real	Dilution factor for swimming exposure

Table 4.28 (Contd)

Name	Type	Description
SWF	Real	Shore-width factor
SWU	Real	Exposure time for swimming for current age group (hr/yr)
T	Real	Transit time to water usage location, except drinking (hr)
TD	Real	Transit time to drinking water intake plant (hr)
TPROCF	Real	Processing time for aquatic foods (hr)
TPROCW	Real	Processing time for water supply systems (hr)
WUSE	Real	Drinking water consumption rate for current age group (L/yr)
A(3)	Char*4	Title for reports - "SHORELINE"
ADOSE(8)	Real	Dose to each organ from ingestion of aquatic plants
B(3)	Char*4	Title for reports - "SWIMMING"
BDOSE(8)	Real	External dose to each organ from boating
C(3)	Char*4	Title for reports - "BOATING"
CDOSE(8)	Real	Dose to each organ from ingestion of invertebrates
FDOSE(8)	Real	Dose to each organ from ingestion of fish
GEOM	Real	Geometry factor: GEOM=1, swimming GEOM=2, boating
H(3)	Char*4	Title for reports - "DRINKING"
J		Loop index for organs
SDOSE(8)	Real	External dose to each organ from shoreline activities
SWDO(8)	Real	External dose to each organ from swimming
TDOSE(8)	Real	Total dose array for each organ

TABLE 4.29. Internal Parameters for Subroutine OUT

Name	Type	Description
T2	Real	Total decay time from release until consumption of aquatic foods (hr)
T3	Real	Total decay time from release until consumption of drinking water (hr)
W(3)	Char*4	Title for reports - "FISH"
WDOSE(8)	Real	Dose to each organ from ingestion of drinking water
X(3)	Char*4	Title for reports - "INVERTEBRATE"
Z(3)	Char*4	Title for reports - "ALGAE"

4.4.18 Subroutine PAFD

Subroutine PAFD calculates population doses from sport and commercial food ingestion. Subroutine WHY calls PAFD, and PAFD calls subroutine PLOP, which includes population doses in the cost-benefit analysis. Common blocks BLANK, DFLIB, and SORCE are referenced by PAFD. Argument list parameters for PAFD are described in Table 4.30, and internal parameters are described in Table 4.31.

4.4.19 Subroutine PERDOS

Subroutine PERDOS calculates and prints percentage contribution subtables and special ALARA report 23. PERDOS is called by the main program and subroutines ACTIVE, FLOOD, OUT, WATER, WHO, and WHY. Common blocks BLANK, ELEMEN, SORCE, STATE, and TRANS are referenced. Argument and internal parameters for subroutine PERDOS are described in Tables 4.32 and 4.33, respectively.

TABLE 4.30. Argument Parameters for Subroutine PAFD

Name	Type	Description
ACC(100)	Real	Bioaccumulation factor for current water type (salt or fresh), current aquatic food (fish or invertebrate), and each element
CONC(200)	Real	Total concentration parameter $(Ci \cdot sec)/(ft^3 \cdot yr)$
DOSE(200,8)	Real	Dose storage array by radionuclide (200) and organ (8)
JJ	Integer	Age group index: JJ=1, adult JJ=2, teen JJ=3, child JJ=4, infant
LM	Integer	Control integer to allow NEPA doses to be included in cost-benefit results, LM>0 for NEPA
NN	Integer	Control integer for type of aquatic food harvest: NN=1, sport harvest NN=2, commercial harvest
TDOSE(8)	Real	Total dose array for each organ
TYPE(3)	Char*4	Title array passed through to subroutine PERDOS
USE	Real	Total consumption of current aquatic food by current age group (kg/yr)

TABLE 4.31. Internal Parameters for Subroutine PAFD

Name	Type	Description
J	Integer	DO loop index for organs
KJ	Integer	DO loop index for radionuclides
LL	Integer	Position index for current radionuclide data in age-specific data arrays
ML	Integer	Position index for current radionuclide in adult data array
MO	Integer	Element index for current radionuclide

TABLE 4.32. Argument Parameters for Subroutine PERDOS

Name	Type	Description
SPECIE(3)	Char*4	Title for current pathway or biota reports - "PATH"
TDOSE(8)	Real	Total dose array for each organ
DOSE(200,8)	Real	Dose storage array for each radionuclide (200) and each organ (8)

TABLE 4.33. Internal Parameters for Subroutine PERDOS

Name	Type	Description
CDOS	Real	Maximum dose to critical organ for one radionuclide
DOS2(8)	Real	Dose to each organ from fish and invertebrate consumption, as calculated for ALARA (saltwater) or fish and drinking water consumption (freshwater)
DOS(8,200,8)	Real	Special dose array for exposure pathways (8), radionuclides (200), and organs (8) determines information for critical organ doses from fish and drinking-water consumption in ALARA
J	Integer	DO loop index for radionuclides in source inventory
JJ	Integer	DO loop index for organs
K	Integer	DO loop index for age groups or biota types
MO	Integer	Index of current radionuclide in radionuclide list
MT	Integer	Index of current radionuclide in element list
PATH(8,3)	Char*4	Pathway/biota title for up to 8 pathways or biota (three 4-character words are allowed for each title)
PCORG(8)	Real	Highest dose to any organ for each pathway or biota
PER(8,200,8)	Real	Percent contribution to dose for each pathway (8) by radionuclide (200) for each organ (8)
SET(3)	Char*4	Title for identification of specific pathways - "SHOR," "BOAT," "SWIM"

When preparing precentage contribution tables, the first calls to PERDOS are made with KIT=0, to calculate values. (The control integer KIT is provided through BLANK common.) When percent contributions have been calculated for all pathways, age groups, or biota, PERDOS is then called with KIT>0 to print subreports in the correct format. KIT is used to print as follows:

KIT	Report	Formats
10	ALARA Reports 6, 7, 8, and 9 and selected location reports 10, 11, 12, and 13	12, 19, 21, 29
	Special report 23	22, 23
20	Report 18 (population drinking water)	17, 20
30	Report 20 (irrigated foods)	17, 20
40	Report 19 (population shoreline activities)	15, 20
50	Report 19 (population boating and swimming)	14, 20
70	Report 21 (biota doses)	13, 20

Special ALARA report 23 is calculated and printed on the first call to PERDOS when KIT=10 and when the 50-mile population is zero (as defined on input record type 3, parameter POP). Execution of the program is stopped after the report is printed. Note that the dose values printed are taken as the sum over the first two data sets provided to PERDOS (see statement where DOS2 is calculated and also Table 4.33). Using default parameters for the aquatic pathway will result in including fish and drinking-water ingestion in the dose calculation for freshwater sites and fish and invertebrate ingestion for saltwater sites. This is the correct usage. If, however, usages for invertebrate or aquatic-plant ingestion pathways are changed from zero for freshwater sites, then the second data set will be for one of these pathways instead of for drinking water, and the calculated doses will not be as desired.

Typically, PERDOS is called several times to calculate percent contributions and then once more to print the appropriate report. On the initial calls, calculations are made for one "case" as described by the input title name, SPECIE. Each case may represent an age group, an exposure pathway, or a biota specie depending on the calling module. The SPECIE name is saved in array PATH and printed with the corresponding data when the report is requested (KIT>0).

4.4.20 Subroutine PLOP

Subroutine PLOP sums population dose data for the cost-benefit report (number 22), which is also printed by PLOP. Actions taken in PLOP are controlled by the argument parameter N.

The first call to PLOP from the main program (N=4) sets dose arrays to zero. Subsequent calls from subroutines DRINK, FOOD, PAFD, SHORE, and SWIM add population doses to the cost-benefit dose arrays. The cost-benefit report is printed by the final call from the main program (N=3). The control integer, N, initiates the following actions:

N	Action Taken in PLOP	Calling Subroutines
3	print report 22	MAIN
4	initialize dose arrays	MAIN
5	add external doses	SHORE, SWIM
6	add ingestion doses	FOOD, PAFD
7	add ingestion doses	DRINK
Other	not used	

The cost-benefit data are accumulated in array COBEAD, which is dimensioned 200 by 8. Space is available for up to 200 radionuclides and 8 organs. However, the current version of LADTAP II only uses the first two organ positions for total-body and thyroid doses.

Argument parameters for PLOP are described in Table 4.34, and internal parameters are described in Table 4.35.

TABLE 4.34. Argument Parameters for Subroutine PLOP

Name	Type	Description
DOSE(200,8)	Real	Dose storage array for each radionuclide (200) and organ (8)
N	Integer	Control integer for action on current call: N=3, print report N=4, initialize dose arrays N=5, add external doses N=6, add ingestion doses N=7, add ingestion doses Other, not currently used

TABLE 4.35. Internal Parameters for Subroutine PLOP

Name	Type	Description
CIB	Real	Total body dose for current radionuclide (person-rem/Ci)
CIT	Real	Thyroid dose for current radionuclide (person-rem/Ci)
COBEAD(200,8)	Real	Cost-benefit dose for each radionuclide (200) and organ (8) - the only organ positions used are 1 for total body and 2 for thyroid.
IK	Integer	Element index for current radionuclide
J	Integer	Do loop index for radionuclides
LL	Integer	Radionuclide index for data in dose factor arrays
TOB	Real	Total dose to total body (person-rem)
TOT	Real	Total dose to thyroid (person-rem)

4.4.21 Subroutine RECON

Subroutine RECON is called by subroutine SOURCE and calculates reconcentration factors for each radionuclide in the source inventory. Subroutine RECON references common blocks BLANK, DFLIB, and INUNIT and calls function EXFCT. Internal parameters for RECON are given in Table 4.36.

RECON uses record type 6 to select the impoundment model used in the calculation of reconcentration factors. The model selection is controlled by parameter M as follows:

M	Model
0	None, use values supplied on record type 5 or set to 1.0
1	completely mixed model
2	plug-flow model
3	partially mixed model

When the value given for M is none of the above, an error message is printed and program execution is stopped. The reconcentration models are described in Section 3.1.

TABLE 4.36. Internal Parameters for Subroutine RECON

Name	Type	Description
ARG	Real	Exponential argument for several equations
IPRNT	Integer	Logical unit for output reports, set to 6
J	Integer	DO loop index for number of input radionuclides
M	Integer	Input index for reconcentration model: M=0, none M=1, completely mixed model M=2, plug flow model M=3, partially mixed model
MO	Integer	Radionuclide index for decay constant array
QSUBB	Real	Input value for blowdown rate from pond (ft^3/sec)
QSUBP	Real	Discharge rate from reactor (set to parameter CFS)
R	Real	Recirculation ratio: QSUBB/QSUBP
RPLUS	Real	Intermediate parameter: R+1
VSUBT	Real	Total volume of impoundment (ft^3)
ZLABE	Real	Intermediate parameter in completely mixed model for reconcentration

When the plug-flow model is selected, the discharge rate (CFS) and the blowdown rate (QSUBB) should be equal. The values given for these parameters are tested for equality to within one percent. If the two parameters are not equal, an error message is printed, but execution of the program is allowed to continue.

4.4.22 Subroutine REDDF

Subroutine REDDF reads the dose factor file on unit 20 and prints reports giving dose factors, radiological decay constants, and values for effective energy deposited. The main program calls REDDF at the beginning of the first case: REDDF is only called once during a run. Common blocks DFLIB, ELEMEN, SORCE, and STATE are referenced. The argument parameter IPRNT controls printing of the dose factor file data reports (print if IPRNT=1). Internal parameters for subroutine REDDF are described in Table 4.37.

The adult dose factors are read first and are followed by teen, child, and infant dose factors. Section 4.5 describes the dose factor file. The adult portion of the file includes ingestion factors, inhalation factors, external exposure factors, and radiological decay constants. The file portions for other age groups include only ingestion and inhalation factors. Because the inhalation factors are not needed by LADTAP II, they are skipped by using a dummy read statement [i.e., READ(20,25)DFA].

TABLE 4.37. Internal Parameters for Subroutine REDDF

Name	Type	Description
DFA	Real	Dummy read parameter to skip past inhalation dose factors in the data file
J	Integer	Implied DO loop index on several read and print statements
K	Integer	Count index for input of radionuclide data
KK	Integer	Temporary index to element name array for printing
K1	Integer	Temporary index for array location of first age group radionuclide
LS	Integer	Dummy input parameter to read beyond unused titles in the dose factor file

Data from the dose factor file are stored in arrays by radionuclide and age group in sequential order (see arrays DFL, IZ, IMASS, and META). Data for adults are stored first for all radionuclides, followed by data for teens, children, and infants. The last position of data for each age group is saved for reference in accessing the data. The positions are saved as parameters NLIBA, NLIBT, NLIBC, and NLIBI for adults, teens, children, and infants, respectively.

The following reports[a] are printed by REDDF:

Report Number	Contents of Reports
4a	Ingestion dose factors for each age group (four reports)
4b	External dose factors for ground exposure
4c	External dose factors for water immersion
4d	Radiological decay constants
4e	Effective energy deposited by organ radius

4.4.23 Subroutine SETVAL

The main program calls subroutine SETVAL to modify BLOCK DATA parameters and print BLOCK DATA report (2). SETVAL calls subroutine FIDOS to read BLOCK DATA change records (described in Section 2.1) and modify requested parameter values if the argument, IFLAG, is greater than zero. BLOCK DATA report is printed by subroutine WOT10 if the absolute value of parameter IFLAG is equal to one.

4.4.24 Subroutine SHORE

Subroutine SHORE calculates doses from external exposure of individuals, populations, and biota to contaminated shorelines and sediments. SHORE is called by ACTIVE (for population doses), OUT (for individual doses), and WHO (for biota doses). Function EXFCT and subroutine PLOP are called by SHORE. Common blocks BLANK, DFLIB, and SORCE are referenced by SHORE. Argument parameters and internal parameters for SHORE are described in Tables 4.38 and 4.39, respectively.

(a) The formats for these reports were provided by Mr. Ed Bradley of the Sacramento Municipal Utility District.

TABLE 4.38. Argument Parameters for Subroutine SHORE

Name	Type	Description
DOSE(200,8)	Real	Dose storage array by radionuclide (200) and organ (8)
DILU	Real	Dilution factor for current location
SWF	Real	Shore-width factor for current location
T	Real	Transit time to current location (hr)
TDOSE(8)	Real	Total organ doses for current location
TYPE(3)	Char*4	Exposure pathway title

TABLE 4.39. Internal Parameters for Subroutine SHORE

Name	Type	Description
ARGU	Real	Exponential argument for decay
FACT	Real	Intermediate factor in dose calculation (organ independent)
I	Integer	Loop index for source radionuclides
J	Integer	Loop index for organs
LM	Integer	Radionuclide position index for arrays
TP	Real	Exponential argument for decay

When SHORE is called to calculate individual doses and biota doses the units factor, CON, is set to 1.0 mrem/mrem to give dose in units of mrem. The usage parameter USE gives the individual exposure time in hours per year. For population dose calculations, CON is set to 1000 mrem/rem to give dose in rem, and USE gives the cumulative annual exposure for the population (person-hr/yr).

Subroutine PERDOS is called to calculate percent contributions to dose by organ and radionuclide if LCT is greater than zero. This calculation is not allowed for biota doses. To stop the calculation for biota doses, the usage parameter, USE, is tested. Usages for biota doses are greater than 1000 hr/yr and usages for individuals are less than 1000 hr/yr (default values). The parameter CON is tested in conjunction with the USE test to ensure that percent contribution calculations for population doses are not eliminated.

If a value has been given for usage, USE, subroutine PLOP is called to include population doses in the cost-benefit analysis.

4.4.25 Subroutine SOURCE

Subroutine SOURCE controls the reading of release inventory records, calls subroutine RECON to calculate reconcentration factors, and prints a summary report of inventory and dose factor data (report 5). Common blocks BLANK, DFLIB, ELEMEN, INUNIT, SORCE, and STATE are referenced by SOURCE. The only argument parameter for SOURCE is the source term multiplication factor, UML, which is used as a multiplication factor for input activities of all radionuclides read on source inventory records. The internal parameters of SOURCE are described in Table 4.40.

The first record read is the source inventory title record (type 4). Radionuclide release data records are read next, one radionuclide per record, until a blank record is encountered. The radionuclide names are decoded and compared against the radionuclide names for adult, teen, child, and infant dose-factor data. If the radionuclide cannot be found in the adult portion of the dose factor data, an error message is printed and the radionuclide is not included in the calculation. If the radionuclide is found in the adult portion but not in one of the other age-group portions, then the adult data are used for that age group.

Reconcentration factors are initialized to 1.0. If a positive value is supplied for the reconcentration factor on the radionuclide input record (parameter R), this value is used. Alternatively, reconcentration factors may be calculated using one of the three impoundment models in the call to RECON. Using RECON to calculate reconcentration factors overrides values supplied on radionuclide input records.

TABLE 4.40. Internal Parameters for Subroutine SOURCE

Name	Type	Description
BKELM(14)	Integer*2	Single character element name array (i.e., H, B, C, N, etc.) used to identify input radionuclides
I	Integer	Count index for number of radionuclides in input inventory
IA	Integer*2	Input variable for element name
IK	Integer	DO loop index for testing for single-character element names
IM(5)	Char*1	Input variable array to hold radionuclide atomic mass
ISOR(78)	Char*1	Title array for radionuclide source identification
JJ	Integer	DO loop index over five characters in atomic weight symbol
JT	Integer	DO loop index over age groups for printing source data and dose factors
K	Integer	Character count index for testing input atomic weights
KK(14)	Integer	Atomic number for each single-character element
L	Integer	Character count index for testing numerical values of atomic mass
LA	Integer	Temporary index for position of radionuclide/age group in dose factor array
LL	Integer	DO loop index for position of radionuclide data in library data arrays
MASS	Integer	Calculated value of radionuclide atomic mass
MET	Char*1	Character variable for testing metastable state indicator
NUM(13)	Char*1	Character data array for testing input atomic masses
QQ	Real	Input radionuclide activity (Ci/yr)
QT	Real	Sum of total curies of all radionuclides released (Ci/yr)
R	Real	Input reconcentration factor

A summary report of radionuclide releases, dose factors, and reconcentration factors is printed for those radionuclides included in the release inventory.

4.4.26 Subroutine SSWAP

Subroutine SSWAP performs the dilution factor calculations for the optional steady-state surface water analysis models. SSWAP is called by subroutines that read usage location data (subroutines ACTIVE, ALARA, FLOOD, WATER, WHO, and WHY). Because the dilution factor is used in the denominator of exposure pathway calculations, zero values are not allowed. When the calculated value is zero (or less than 10^{-20}), an error message is printed, and the dilution factor is set to 10^{20}. The argument parameters for subroutine SSWAP are defined in Table 4.41.

TABLE 4.41. Argument Parameters for Subroutine SSWAP

Name	Type	Description
IFLAG	Integer	Surface-water model selection index: IFLAG=1, nontidal river model IFLAG=2, near-shore lake model
QB	Real	Reactor discharge rate (ft^3/sec)
U	Real	Average flow velocity (ft/sec)
H	Real	Average water depth (ft)
X	Real	Downstream distance from source to usage location (ft)
Y	Real	Offshore distance to water intake (ft)
Z	Real	Depth of discharge, used only for lake model (ft)
B	Real	Average river width, used only for river model (ft)
DILU	Real	Dilution factor (dimensionless)

4.4.27 Subroutine SWIM

External exposures from water immersion (swimming and boating) are calculated by subroutine SWIM for individuals, populations and biota. SWIM is called by subroutine ACTIVE to calculate population doses, by subroutine OUT to calculate individual doses, and by subroutine WHO to calculate biota doses. The argument parameters for SWIM are described in Table 4.42 and internal parameters are described in Table 4.43.

TABLE 4.42. Argument Parameters for Subroutine SWIM

Name	Type	Description
DILU	Real	Dilution factor for current usage location
DOSE(200,8)	Real	Intermediate dose storage array for each radionuclide (200) and each organ (8)
GEOM	Real	Geometry factor for exposure to water (see text)
T	Real	Transit time from release point to exposure point (hr)
TDOSE(8)	Real	Total dose array for each organ
TYPE(3)	Char*4	Title array for current pathway, passed through to subroutine PERDOS
USE	Real	Exposure time for current calculation (hr/yr or person-hr/yr)

TABLE 4.43. Internal Parameters for Subroutine SWIM

Name	Type	Description
FACT	Real	Intermediate factor in external dose calculation representing total exposure time for the current radionuclide
I	Integer	DO loop index for the number of radionuclides
J	Integer	DO loop for organs
LM	Integer	Position index for current radionuclide in adult age group data array

SWIM is used for swimming exposure, boating exposure and biota exposure (from living in water). The geometry factor, GEOM, is supplied to SWIM to distinguish between these exposure types. This factor is used as a correction factor (1/GEOM) for the water immersion dose factors, EXS. Values supplied to SWIM for the current exposure calculations are as follows:

Exposure Type	GEOM Value	
Swimming	1.0	full immersion
Boating	2.0	half immersion
Fish	1.0	full immersion
Invertebrates	1.0	full immersion
Algae	1.0	full immersion
Muskrat	1.0	full immersion
Heron	2.0	half immersion
Duck	2.0	half immersion

The units conversion factor, CON, is set to 1.0 (mrem/mrem) for individual and biota exposures and to 1000 (mrem/rem) for population exposures.

Percentage contributions to dose for each organ and radionuclide are calculated by calling subroutine PERDOS if parameter LCT is greater than zero. The calculation is not allowed for biota doses by testing the usage parameter USE and the units factor CON. For biota doses USE is greater than 1000 and CON is 1.

For population dose calculations (CON=1000), subroutine PLOP is called to add current population doses to the cost-benefit results.

4.4.28 Subroutine TRTIUM

The dose to the U.S. population from release of tritium to the hydrosphere is calculated by subroutine TRTIUM. Subroutine WATER calls TRTIUM to calculate the tritium doses for the special tritium subreport printed as part of report 18. The bone and total-body doses are calculated. The total-body dose is printed as the dose to all organs except bone. Common blocks BLANK, DATA, and DFLIB are referenced by TRTIUM. Argument parameters and internal parameters for subroutine TRTIUM are presented in Tables 4.44 and 4.45, respectively.

TABLE 4.44. Argument Parameters for Subroutine TRTIUM

Name	Type	Description
CIYR	Real	Release rate of tritium (Ci/yr)
H3B	Real	Bone dose from tritium (person-rem)
H3T	Real	Total-body dose from tritium (person-rem)
P	Real	Total population within 50 miles (not currently used in TRTIUM)

TABLE 4.45. Internal Parameters for Subroutine TRTIUM

Name	Type	Description
ARGU	Real	Exponential argument for radiological decay to mid-point of plant life
CONSUM	Real	Total rate of water consumption by average individual (L/yr), set to 1100
HYDRO	Real	Dilution parameter for dispersion of released tritium in the world hydrosphere, set to 2.7×10^{19}
H3CON	Real	Calculated water concentration for average individual in U.S.

Dose to the U.S. population from consuming tritium from the hydrosphere is calculated assuming:

1. The tritium released is uniformily dispersed in the hydrosphere water, which has a volume of 2.7×10^{19} L (parameter HYDRO)
2. The average individual consumes 1100 L/yr (parameter CONSUM)
3. The U.S. population is 2.6×10^{8} people (parameter US)
4. The tritium release is at a uniform rate to the midpoint of plant life, 20 yr (parameter PL).

4.4.29 Subroutine WATER

Subroutine WATER calculates population doses from the drinking water pathway. Water usage data is read (on record types 13 and 13a) and subroutines DRINK, PERDOS, and TRTIUM are called to perform the dose calculations. Subroutine SSWAP is called when dilution factors are to be calculated for lakes or rivers. Results of the calculations are printed by WATER and PERDOS in report type 18. The argument array DOSE(200,8) contains calculated doses by radionuclide and organ (although the dose values are not referenced by the calling module, MAIN). The internal parameters are described in Table 4.46. Common blocks BLANK, DATA, and INUNIT are referenced by WATER.

Three inline functions are used in WATER to calculate the total water consumption by individuals of the population for a given age group. The functions are AUSE, TUSE, and CUSE for adults, teens, and children, respectively. The functions have two arguments. The first argument is the total population served by the water supply system, and the second parameter is the average annual usage for an individual in the age group considered (L/yr).

Data read on record type 13 include the population served and alternate data to calculate the population if the population is not known. The alternate data are the total water supply rate (gal/yr) and the average usage rate by individuals (gal/yr/person).

The transit times provide the time of transit from the release point to the water supply system intake. A time of 24 hours is added to the transit time to include the time for distribution through the supply system to the population. When dilution factors are to be calculated (record type 13a), the program will also calculate the transit time if no value has been given for record type 13.

The call to subroutine TRTIUM returns two dose values, bone dose (H3B) and total-body dose (H3T). The total-body dose is printed as dose to all organs other than bone.

TABLE 4.46. Internal Parameters for Subroutine WATER

Name	Type	Description
A(3)	Char*4	Title for reports - "ADULT"
AU	Real	Average consumption rate of water for adults (L/yr)
AUSE	Real	Inline function value representing total adult population consumption of water (L/yr)
B(3)	Char*4	Title for reports - "TEENAGER"
BW	Real	Average width of the nontidal river (ft)
C(3)	Char*4	Title for reports - "CHILD"
CU	Real	Average consumption rate of water for teens (L/yr)
CUM(8)	Real	Cumulative population dose over all age groups, (person-rem) for each organ
CUSE	Real	Inline function value representing total child population consumption of water (L/yr)
D(3)	Char*4	Title for reports - "TOTAL"
DILU	Real	Dilution factor for current drinking water usage location
E(3)	Char*4	Title for reports - "CUMUL TOTAL"
EUS	Real	Total water consumption for all usage locations (L/yr)
GAL	Real	Supply rate of drinking water for the current water plant (gal/d)
GUS	Real	Average individual usage rate of water for the current water plant service area (gal)
H3B	Real	Bone population dose from tritium in drinking water for U.S. population (person-rem)
H3T	Real	Total-body population dose from tritium in drinking water for U.S. population (person-rem)
HR	Real	Average depth of river or lake (ft)
I	Integer	DO loop index for radionuclides in source inventory

Table 4.46 (Contd)

Name	Type	Description
IFLAG	Integer	Surface-water model selection index: IFLAG=1, nontidal river model IFLAG=2, near-shore lake model
JK	Integer	DO loop index for organs
JM	Integer	DO loop index for organs
M	Integer	Position of current radionuclide in data arrays - used to test for tritium: M=1, tritium present
P	Real	Total population served by current water usage system
PD(8)	Real	Total population dose for current usage location for all age groups (person-rem)
SUP(5)	Char*4	Descriptive title for current water usage location
SWTITL(2)	Char*5	Title for surface water dilution data output - "RIVER" or "LAKE"
T	Real	Transit time from release point to the water supply intake (hr)
TDOSE(8)	Real	Total population dose for current usage location for current age group for each organ (person-rem)
TRI(3)	Char*4	Title for reports - "WATER"
TU	Real	Average rate of water consumption by teens (L/yr)
TUS	Real	Total water usage for all age groups for current location (L/yr)
TUSE	Real	Inline function value representing rate of water consumption by total teen population (L/yr)
TYPE(3)	Char*4	Title for reports - "DRINKING"
UR	Real	Average flow velocity downstram or alongshore (ft/sec)
USE	Real	Calculated water usage for current usage location and age group (L/yr)

Table 4.46 (Contd)

Name	Type	Description
XR	Real	Downshore distance from release to usage location (ft)
YR	Real	Offshore distance to water intake at the usage location (ft)

4.4.30 Subroutine WHO

The biota dose calculations are controlled by subroutine WHO. Calls are made to subroutines CRITTR, EAT, PERDOS, SHORE, SSWAP, and SWIM to perform dose calculations. Common blocks BLANK and INUNIT are referenced by subroutine WHO. Argument parameters and internal parameters are described for subroutine WHO in Tables 4.47 and 4.48, respectively.

TABLE 4.47. Argument Parameters for Subroutine WHO

Name	Type	Description
ACCA(100)	Real	Bioaccumulation factors for aquatic plants for current water type (salt or fresh) for each element
ACCF(100)	Real	Bioaccumulation factors for fish for current water type (salt or fresh) for each element
ACCI(100)	Real	Bioaccumulation factors for invertebrates for current water type (salt or fresh) for each element
DOSE(200,8)	Real	Dose contribution array for each radionuclide (200) and each organ (8)

TABLE 4.48. Internal Parameters for Subroutine WHO

Name	Type	Description
A(3)	Char*4	Title for reports - "MUSKRAT"
B(3)	Char*4	Title for reports - "RACCOON"
BW	Real	Average width of the nontidal river (ft)
C(3)	Char*4	Title for reports - "HERON"

Table 4.48 (Contd)

Name	Type	Description
CSWF	Real	Shore-width factor for exposure of fish, set to 2.0
D(3)	Char*4	Title for reports - "DUCK"
DILU	Real	Dilution factor for current location
DUCK	Real	Effective radius of a duck body (cm), set to 5
DUCMAS	Real	Average mass of a duck (g), set to 1,000
DUCUSE	Real	Rate of water consumption by an average duck, set to 100 L/yr
EXI(8)	Real	Dose from water immersion for current biota and location (mrem)
EXT(8)	Real	Dose from shoreline or sediment exposure for the current biota and location (mrem)
HERMAS	Real	Average mass of a heron (g), set to 4,600
HERON	Real	Effective radius of a heron body (g), set to 11
HERUSE	Real	Rate of water consumption by an average heron (L/yr), set to 600
HR	Real	Average depth of river or lake (ft)
IFLAG	Integer	Surface water model selection index IFLAG=1, nontidal river model IFLAG=2, near-shore lake model
LOC(5)	Char*4	Title for current usage location
RAC	Real	Effective radius of a raccoon body (cm), set to 14
RACMAS	Real	Average mass of a raccoon (g), set to 12,000
RACUSE	Real	Rate of water consumption by an average raccoon (L/yr), set to 200
RAT	Real	Effective radius of a muskrat (cm), set to 6
RATMAS	Real	Average mass of a muskrat body (g), set to 1,000
RATUSE	Real	Rate of water consumption by an average muskrat (L/yr), set to 100

Table 4.48 (Contd)

Name	Type	Description
SWTITL(2)	Char*5	Title for surface water dilution data output - "RIVER" or "LAKE"
T	Real	Transit time from release point to exposure location (hr)
TDOSE(8)	Real	Dose to current aquatic biota from ingestion pathways - only first position is used (mrem)
TEXT	Real	Total external dose to current biota at current location (mrem)
TOT	Real	Total dose to current biota at current location (mrem)
TYPE(3)	Char*4	Title array (not currently assigned a value in WHO)
UR	Real	Average flow velocity downstream or alongshore (ft/sec)
W(3)	Char*4	Title for reports - "FISH"
XR	Real	Downshore distance from release to usage location (ft)
X(3)	Char*4	Title for reports - "INVERTEBRATE"
YR	Real	Offshore distance to water intake at the usage location (ft)
Z(3)	Char*4	Title for reports - "ALGAE"

Doses are estimated for seven biota: three aquatic (fish, invertebrates, and algae) and four terrestrial (muskrat, raccoon, heron, and duck). The exposure pathways and subroutines called for each biota are as follows:

Biota	Pathway	Subroutine
Fish	bioaccumulation in water	CRITTR
	sediment - external	SHORE
	swimming - external	SWIM
Invertebrates	bioaccumulation in water	CRITTR
	sediment - external	SHORE
	swimming - external	SWIM

Biota	Pathway	Subroutine
Algae	bioaccumulation in water water immersion	CRITTR SWIM
Muskrat	aquatic plant ingestion shoreline - external swimming - external	EAT SHORE SWIM
Raccoon	invertebrate ingestion shoreline - external	EAT SWIM
Heron	fish ingestion shoreline - external swimming/wading - external	EAT SHORE SWIM
Duck	aquatic plant ingestion shoreline - external swimming - external	EAT SHORE (1.5*heron swimming dose)

The percentage contribution tables calculated for biota exposure are based on only the ingestion pathways as calculated by subroutines CRITTR and EAT.

4.4.31 Subroutine WHY

Subroutine WHY calculates and prints population doses from sport and commercial harvest of fish and invertebrates. The main program calls WHY once for each calculation as identified by the argument parameters I and N.

Harvest Calculation	I	N
Sport - fish	1	1
Commercial - fish	1	2
Sport - invertebrates	2	1
Commercial - invertebrates	2	2

The calculations are performed by subroutines CENT, PAFD, PERDOS, and SSWAP. Common blocks BLANK, DATA, and INUNIT are referenced by WHY. Argument parameters for WHY are described in Table 4.49 and internal parameters are described in Table 4.50.

TABLE 4.49. Argument Parameters for Subroutine WHY

Name	Type	Description
ACC(100)	Real	Bioaccumulation factor for current water type (salt or fresh), current aquatic food (fish or invertebrate) and each element
DOSE(200,8)	Real	Intermediate dose storage array for each radionuclide (200) and each organ (8)
I	Integer	Index for aquatic food selection for current calculation: I=1, fish I=2, invertebrate
N	Integer	Index for type of harvest: N=1, sport N=2, commercial

TABLE 4.50. Internal Parameters for Subroutine WHY

Name	Type	Description
A(3)	Char*4	Title for reports - "ADULT"
AMT	Real	Total production of current aquatic food (kg/yr)
AU	Real	Rate of current aquatic food consumption by adults (kg/yr)
AUSE	Real	Inline function value for total usage by adults for current aquatic food (kg/yr)
B(3)	Char*4	Title for reports - "TEENAGER"
BW	Real	Average width of the nontidal river (ft)
C(3)	Char*4	Title for reports - "CHILD"
CATH(20)	Real	Rate of current aquatic food production for each usage location
CONC(200)	Real	Total concentration parameter calculated in CENT and used in PAFD

Table 4.50 (Contd)

Name	Type	Description
CU	Real	Rate of current aquatic food consumption by children (kg/yr)
CUSE	Real	Inline function value for total usage by children for current aquatic food (kg/yr)
D(3)	Char*4	Title for reports - "TOTAL"
DILU	Real	Dilution factor for current location
FPT	Real	Food processing time for current harvest type (hr)
HARV	Real	Commercial harvest of current aquatic food type (kg/yr)
HR	Real	Average depth of river or lake (ft)
IFLAG	Integer	Surface-water model selection index: IFLAG=1, nontidal river model IFLAG=2, near-shore lake model
IN	Integer	DO loop index for usage locations
J	Integer	Count index for number of usage locations
JK	Integer	Implied DO loop index for organs
K	Integer	Implied DO loop index for data input
LM	Integer	Control integer to include sport harvest in NEPA dose evaluation
LOC(5,20)	Char*4	Title array for usage location identification
M	Integer	Number of locations defined for current calculation: $1 \le M \le 19$
NL	Integer	Harvest type index, initially set to N - Reset to 1 after commercial harvest to include sport harvest in NEPA evaluation
NN	Integer	Harvest type index with same usage as N
P	Real	Inline function value for total population served

Table 4.50 (Contd)

Name	Type	Description
PD(7)	Real	Population dose by organ (7) for all age groups (person-rem)
PEO	Real	Exposed population for current harvest type
SUM	Real	Total usage for current harvest (kg/yr)
SWTITL(2)	Char*5	Title for surface water diltuion data output - "RIVER" or "LAKE"
UR	Real	Average flow velocity downstream or alongshore (ft/sec)
T(20)	Real	Transit time from release point to usage location for each location (hr)
TDOSE(8)	Real	Total population dose for each organ(8) for current age group and harvest type (person-rem)
TPD(7,3)	Real	Total population dose for each organ(7) and each age group (3) for sport harvest (person-rem)
TU	Real	Rate of current aquatic food consumption by teens (kg/yr)
TUSE	Real	Inline function value for total usage by teens for current aquatic food (kg/yr)
TYPE(3)	Char*4	Title for current aquatic food type - "INVER" or "FISH"
USE	Real	Total usage for current calculation (kg/yr)
USEA	Real	Total sport harvest consumed by adults (kg/yr)
USEB	Real	Total sport harvest consumed by teens (kg/yr)
USEC	Real	Total sport harvest consumed by children (kg/yr)
W(3)	Char*4	Title for reports - "FISH"
X(3)	Char*4	Title for reports - "INVER"
XR	Real	Downshore distance from release to usage location (ft)
YR	Real	Offshore distance to water intake at the usage location (ft)

Four inline functions are used in WHY to calculate the population served by specific production rates and to estimate total usage for each age group. The population served function, P, is equivalent to Equation 3.31. The age-specific usage functions (AUSE for adults, TUSE for teens, and CUSE for children) have two argument parameters. The first parameter is the total population involved, and the second is the average consumption rate for the age group. The functions calculate the total consumption by the population in the age group (person-kg/yr).

For each aquatic food (fish and invertebrates), subroutine WHY is called twice - first for sport harvest and second for commercial harvest. When the sport harvest doses are calculated, the doses are saved in array TPD. Then when the commercial harvest doses are calculated, the sport harvest doses are added so the NEPA report includes both sport and commercial harvest population doses. The sport usage rates are also saved (parameters USEA for adults, USEB for teens, and USEC for children) and printed in the NEPA report. The parameters LM, N, and NL control the addition of sport and commercial harvest doses.

Output from WHY is printed in the four similar output reports 14, 15, 16, and 17 for the four calculations that are controlled by WHY.

4.4.32 Subroutine WOT10

Subroutine WOT10 prepared the BLOCK DATA output report (number 2). Subroutine SETVAL calls WOT10 when the parameter IFLAG (input record type 2) is set to either +1 or -1. No common blocks or subroutines are referenced by WOT10.

4.5 DATA FILE DESCRIPTION

LADTAP II references one data file that provides dose conversion factors and effective energy data. The dose factors relate radionuclide concentrations in environmental media (shoreline, water, and foods) to dose received by individuals and population groups. The effective energy data estimates only the radiation dose received by biota. This section describes the data contained in the file, the file structure, and the program parameters through which data transfers are made. A complete list of the dose factor file is included on the Appendix B microfiche, which is located in the back cover pocket. The third sample problem output listing also contains the library data in a format that is easily read (Appendix B).

The dose factor file is composed of four main sections, one section for each age group: adult, teen, child, and infant. Each of these sections begins with an age group title record and ends with a blank record (blank or negative in the first four columns). Data for each radionuclide are provided in sets. The structure of the file is illustrated in Figure 4.3. The first few records of the file are shown in Figure 4.4.

Each radionuclide in the adult portion of the data file has four records of data. The first record gives radionuclide identification parameters and external dose factors for exposure to contaminated surfaces and immersion in contaminated water. Data on the first record is described in Table 4.55. The decay constant, TAU, for each radionuclide has units of inverse seconds in the data library. However, upon reading in subroutine REDDF, the decay constant is converted to units of inverse hours. All values for skin dose conversion factors for water immersion are currently zero in the data library.

The second record for each radionuclide provides ingestion dose conversion factors for each organ. These dose factors have units of mrem in 50 years (commitment period) per pCi intake in the first year. Values on each record are provided for seven organs in the order: bone, liver, total body, thyroid, kidney, lung, and GI-LLI (gastrointestinal tract, lower-large intestine). The record format is 7E8.0 and the values are read into array DFL.

The third record for each radionuclide contains inhalation dose conversion factors (for the same seven organs as for the ingestion dose factor records). Because these dose factors are not needed by LADTAP II, the ingestion records are skipped and the data are not saved in the program.

Adult

- Adult Dose Factor Title Record
- First Radionuclide Identification and External Dose Factors
- First Radionuclide Adult Ingestion Dose Factors
- First Radionuclide Adult Inhalation Dose Factors
- First Radionuclide Effective Energy Data
- Second Radionuclide Identification and External Dose Factors
- Second Radionuclide Adult Ingestion Dose Factors
- Second Radionuclide Adult Inhalation Dose Factors
- Second Radionuclide Effective Energy Data
- .
- .
- .
- Blank Record

Teen

- Teen Dose Factor Title Record
- First Radionuclide Identification
- First Radionuclide Teen Ingestion Dose Factors
- First Radionuclide Teen Inhalation Dose Factors
- Second Radionuclide Identification
- Second Radionuclide Teen Ingestion Dose Factors
- Second Radionuclide Teen Inhalation Dose Factors
- .
- .
- .
- Blank Record

Child

- Child Dose Factor Title Record
- (Same organization as for teen)
- Blank Record

Infant

- Infant Dose Factor Title Record
- (Same organization as for teen)
- Blank Record

FIGURE 4.3. Dose Factor Library Structure

```
  ADULT DOSE FACTORS
   1  3 1.78E-090.0      0.0      0.0      0.00E+00
0.0      5.99E-085.99E-085.99E-085.99E-085.99E-085.99E-08
0.0      1.58E-071.58E-071.58E-071.58E-071.58E-071.58E-07
 1.00E-031.00E-031.00E-031.00E-031.00E-031.00E-031.00E-031.00E-03
   4 10 1.37E-140.0      0.0      0.0      0.0
3.18E-064.91E-077.94E-080.0      3.71E-070.0      2.68E-05
1.98E-043.06E-054.96E-060.0      0.0      2.22E-041.67E-05
 0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
   6 14 3.84E-120.0      0.0      0.0      0.0
2.84E-065.68E-075.68E-075.68E-075.68E-075.68E-075.68E-07
2.27E-064.26E-074.26E-074.26E-074.26E-074.26E-074.26E-07
 5.00E-025.00E-025.00E-025.00E-025.00E-025.00E-025.00E-025.00E-02
   7 13 1.16E-037.60E-091.90E-068.80E-090.0
8.36E-098.36E-098.36E-098.36E-098.36E-098.36E-098.36E-09
6.27E-096.27E-096.27E-096.27E-096.27E-096.27E-096.27E-09
 5.38E-015.57E-015.87E-016.46E-017.01E-017.77E-019.83E-011.13E 00
   9 18 1.05E-046.80E-091.80E-068.00E-090.0
6.24E-070.0      6.92E-080.0      0.0      0.0      1.85E-08
4.71E-070.0      5.19E-080.0      0.0      0.0      9.24E-09
 2.85E-013.04E-013.34E-013.91E-014.44E-015.18E-017.17E-018.61E-01
  11 22 8.44E-091.60E-084.00E-061.80E-080.0
1.74E-051.74E-051.74E-051.74E-051.74E-051.74E-051.74E-05
1.30E-051.30E-051.30E-051.30E-051.30E-051.30E-051.30E-05
 2.86E-013.25E-013.87E-015.07E-016.19E-017.75E-011.20E 001.51E 00
  11 24 1.28E-052.50E-087.80E-062.90E-080.0
1.70E-061.70E-061.70E-061.70E-061.70E-061.70E-061.70E-06
1.28E-061.28E-061.28E-061.28E-061.28E-061.28E-061.28E-06
 7.12E-017.71E-018.68E-011.05E 001.23E 001.48E 002.19E 002.74E 00
  15 32 5.61E-070.0      6.40E-090.0      0.0
1.93E-041.20E-057.46E-060.0      0.0      0.0~     2.17E-05
1.65E-049.64E-066.26E-060.0      0.0      0.0      1.08E-05
 6.95E-016.95E-016.95E-016.95E-016.95E-016.95E-016.95E-016.95E-01
  20 41 1.57E-133.41E-097.28E-074.01E-090.0
1.85E-040.0      2.00E-050.0      0.0      0.0      1.84E-07
3.83E-050.0      4.13E-060.0      0.0      3.83E-062.86E-07
 0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  21 46 9.57E-081.30E-083.70E-061.50E-080.0
5.51E-091.07E-083.11E-090.0      9.99E-090.0      5.21E-05
5.51E-051.07E-043.11E-050.0      9.99E-050.0      3.23E-05
 1.97E-012.32E-012.90E-013.99E-015.01E-016.44E-011.03E 001.32E 00
  24 51 2.90E-072.20E-105.20E-082.60E-100.0
0.0      0.0      2.66E-091.59E-095.86E-103.53E-096.69E-07
0.0      0.0      1.25E-087.44E-092.85E-091.80E-064.15E-07
 2.00E-033.00E-034.00E-035.00E-037.00E-039.00E-031.50E-021.90E-02
  25 54 2.57E-085.80E-091.50E-066.80E-090.0
0.0      4.57E-068.72E-070.0      1.36E-060.0      1.40E-05
0.0      4.95E-067.87E-070.0      1.23E-061.75E-049.67E-06
 3.60E-025.10E-027.60E-021.22E-011.66E-012.27E-013.92E-015.12E-01
```

FIGURE 4.4. Sample Listing of Dose Factor Library

TABLE 4.51. Radionuclide Identification Record

Parameter Name	Format	Columns	Description
IZ(I)	IX, I3	2 - 4	Atomic number of radionuclide I
IMASS(I)	I3	5 - 7	Atomic weight of radionuclide I
META(I)	A1	8	Indicator for isomeric state of radionuclide I - blank for ground state and M for metastable
TAU(I)	E8.0	9 - 16	Radiological decay constant for radionuclide I - units are per second.
EXG(I,2)	E8.0	17-24	External total-body dose conversion factor for shoreline exposure for radionuclide I - units are mrem/hr per pCi/m^2.
EXS(I,2)	E8.0	25-32	External total-body dose conversion factor for water immersion for radionuclide I - units are mrem/hr per pCi/L.
EXG(I,1)	E8.0	33-40	External skin dose conversion factor for shoreline exposure for radionuclide I - units are mrem/hr per pCi/m^2.
EXS(I,1)	E8.0	41-48	External skin dose conversion factor for water immersion for radionuclide I - units are mrem/hr per pCi/L.

The adult portion of the data library contains a fourth record for each radionuclide which provides the effective energy by organ radius. Values are provided for the eight radii defined for parameter STAN of subroutine EAT. These organ radii are (in cm) 1.4, 2., 3., 5., 7., 10., 20., and 30. The effective energy values have units of MeV/dis and are provided in 8E8.0 format in array EFF.

Data for teen, child and infant age groups are similar to that for adults, with two exceptions. First, the identification record does not include the decay constant or external dose factors. Second, the effective energy record is not included; only three records are provided for each radionuclide. The data file is read from logical unit 20.

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APPENDIX A

GLOBAL DICTIONARY

APPENDIX A

GLOBAL DICTIONARY

This appendix is a global dictionary of parameters used in LADTAP II. The dictionary includes all parameters that are 1) listed in common blocks, 2) supplied through input, 3) involved in control logic, and 4) used as major loop indexes. Minor parameters, such as implied loop indexes in PRINT statements, are not included. However, all parameters are included in the definitions contained in the module listing and module specifications (see Section 4.4). An entry is provided for each parameter for the modules in which the parameter is used.

The global dictionary is organized alphabetically by parameter name with array dimensions also noted. The "Type" column indicates if the parameter is used as an integer, or real variable, or a character parameter. Character parameter word size is indicated by an asterisk followed by the number of characters per word. The size of integer parameters used for character information is also indicated.

The "Module" column identifies the program module in which the parameter is used. (Secondary ordering within the global dictionary is by module name.) The "data interchange" column indicates the mode used for transferring parameters between modules. The three representations used are internal, argument, and common. Internal representation is used for parameters that are defined and used within a given module. Internal parameters may be passed through argument lists to subroutines where they will appear with an ARGUMENT data interchange. Argument representation is used for parameters passed into the module through an argument list. Common representation refers to parameters provided in common blocks. The COMMON label name is also indicated under data interchange. Common block parameters are defined only for modules where they are set or used.

The "Usage" column indicates whether the parameter value is changed in the module (set, "S") or just referenced in an equation, IF statement, CALL list, or PRINT statement (used, "U").

The "Description" column gives detailed information on the use of the parameters. Special uses within a particular module, such as parameter input, are also noted.

GLOBAL DICTIONARY INFORMATION

Parameter Name	Type	Module	Data Interchange	Usage	Description
A(3)	Char*4	ACTIVE	Internal	-	Title for output reports - "TOTAL POPUL"
A(3)	Char*4	FLOOD	Internal	-	Title array for output report - "ADULT"
A(3)	Char*4	OUT	Internal	-	Title for output reports - "SHORELINE"
A(3)	Char*4	WATER	Internal	-	Title for output reports - "ADULT"
A(3)	Char*4	WHO	Internal	-	Title for output reports - "MUSKRAT"
A(3)	Char*4	WHY	Internal	-	Title for output reports - "ADULT"
AALD(7)	Real	FLOOD	Internal	-	Adult-population doses to each organ for "ALARA" report
AAND(7)	Real	FLOOD	Internal	-	Adult-population doses to each organ for "NEPA" report
AC	Real	FLOOD	Internal	-	Average annual rate of current food product consumption by adults (kg/yr)
ACC(100)	Real	AQUA	Argument	U	Bioaccumulation factor array for current aquatic pathway and site water type
ACC(100)	Real	CRITTR	Argument	U	Same as ACC in AQUA
ACC(100)	Real	EAT	Argument	U	Bioaccumulation factor array for aquatic food type ingested by the current terrestrial biota (L/kg)
ACC(100)	Real	PAFD	Argument	U	Same as ACC in AQUA
ACC(100)	Real	WHY	Argument	U	Same as ACC in AQUA

Parameter Name	Type	Module	Data Interchange	Usage	Description
ACCA(100)	Real	ALARA	Argument	U	Aquatic plant bioaccumulation factor array for each element for current water type (salt or fresh) (L/kg)
ACCA(100)	Real	OUT	Argument	U	Same as ACCA in ALARA
ACCA(100)	Real	WHO	Argument	U	Same as ACCA in ALARA
ACCF(100)	Real	ALARA	Argument	U	Fish bioaccumulation factor array for each element for current water type (salt or fresh) (L/kg)
ACCF(100)	Real	OUT	Argument	U	Same as ACCF in ALARA
ACCF(100)	Real	WHO	Argument	U	Same as ACCF in ALARA
ACCI(100)	Real	ALARA	Argument	U	Invertebrate bioaccumulation factor array for each element for current water type (salt or fresh) (L/kg)
ACCI(100)	Real	OUT	Argument	U	Same as ACCI in ALARA
ACCI(100)	Real	WHO	Argument	U	Same as ACCI in ALARA
ACON	Real	FLOOD	Internal	-	Maximum annual rate of current food product consumption by adults (kg/yr)
ADOSE(8)	Real	OUT	Internal	-	Dose to each organ from ingestion of aquatic plants (mrem)
ALD(7)	Real	FOOD	Argument	S/U	Total population dose to each organ for "ALARA" report
ALUS	Real	ALARA	DATA Common	S/U	Rate of aquatic-plant consumption by adults (kg/yr)

Parameter Name	Type	Module	Data Interchange	Usage	Description
ALUS	Real	BLOCK DATA	DATA Common	S	Same as ALUS in ALARA
ALUS	Real	OUT	Argument	U	Rate of aquatic-plant consumption by current age group (kg/yr)
AMT	Real	FLOOD	Internal	-	Dummy parameter for call to CENT - not used in FLOOD
AMT	Real	WHY	Internal	-	Total production of current aquatic food (kg/yr)
AND(7)	Real	FOOD	Argument	S/U	Total population dose to each organ for "NEPA" report
ARG	Real	RECON	Internal	-	Exponential argument for several expressions
ARGU	Real	AQUA	Internal	-	Exponential argument for decay in transit from release to consumption, including food processing time (TPROCF) (hr)
ARGU	Real	CRITTR	Internal	-	Exponential argument for radiological decay in transit to the biota exposure location
ARGU	Real	DRINK	Internal	-	Exponential argument for decay in transit of drinking water from release to consumption
ARGU	Real	EAT	Internal	-	Same as ARGU in CRITTR
ARGU	Real	SHORE	Internal	-	Exponential argument for radiological decay at midpoint of plant life
ARGU	Real	TRTIUM	Internal	-	Same as ARGU in SHORE

Parameter Name	Type	Module	Data Interchange	Usage	Description
AU	Real	WATER	Internal	-	Average rate of water consumption by adults (L/yr)
AU	Real	WHY	Internal	-	Rate of current aquatic food consumption by adults (kg/yr)
AUSE	Real	WATER	Internal	-	Inline function value for total water consumption by adult population (L/yr)
AUSE	Real	WHY	Internal	-	Inline function value for total current aquatic food usage by adult population (L/yr)
B	Real	SSWAP	Argument	U	Average width of the river or discharge depth to the lake (ft) (See also parameter BW)
B(3)	Char*4	FLOOD	Internal	-	Title array for output report - "TEENAGER"
B(3)	Char*4	OUT	Internal	-	Title for output reports - "SWIMMING"
B(3)	Char*4	WATER	Internal	-	Title for output reports - "TEENAGER"
B(3)	Char*4	WHO	Internal	-	Title for output reports - "RACCOON"
B(3)	Char*4	WHY	Internal	-	Title for output reports - "TEENAGER"
BAD(7)	Real	FLOOD	Internal	-	Sum of population doses to each organ by age group for "ALARA" report
BDIL	Real	ALARA	Internal	-	Dilution factor for boating and aquatic foods pathways
BDIL	Real	OUT	Argument	U	Same as BDIL in ALARA
BDOSE(8)	Real	OUT	Internal	-	External dose to each organ from boating (mrem)

Parameter Name	Type	Module	Data Interchange	Usage	Description
BIOT(4)	Char*4	EAT	Argument	U	Title array for current terrestrial biota name
BKELM(14)	Integer*2	SOURCE	Internal	-	Name array for single-character elements (i.e., H, C, N, etc.), used to decode input radionuclide element names
BTUSE	Real	ACTIVE	Internal	-	Population exposure time for boating (person-hr/yr)
BUSE	Real	ALARA	DATA Common	S/U	Adult exposure time for boating (hr/yr)
BUSE	Real	BLOCK DATA	DATA Common	S	Same as BUSE in ALARA
BUSE	Real	OUT	Argument	U	Exposure time of current age group for boating (hr/yr)
BW	Real	ACTIVE	Internal	-	Average width of the river or discharge depth to the lake (ft)
BW	Real	ALARA	Internal	-	Same as BW in ACTIVE
BW	Real	FLOOD	Internal	-	Same as BW in ACTIVE
BW	Real	WATER	Internal	-	Same as BW in ACTIVE
BW	Real	WHO	Internal	-	Same as BW in ACTIVE
BW	Real	WHY	Internal	-	Same as BW in ACTIVE
C	Real	FOOD	Argument	U	Average rate of current food product consumption by current age group (kg/yr)
C(3)	Char*4	FLOOD	Internal	-	Title array for output report - "CHILD"
C(3)	Char*4	OUT	Internal	-	Title array for output reports - "BOATING"

Parameter Name	Type	Module	Data Interchange	Usage	Description
C(3)	Char*4	WATER	Internal	-	Title for output reports - "CHILD"
C(3)	Char*4	WHO	Internal	-	Title for output reports - "HERON"
C(3)	Char*4	WHY	Internal	-	Title for output reports - "CHILD"
CALD(7)	Real	FLOOD	Internal	-	Child-population doses to each organ for "ALARA" report
CAND(7)	Real	FLOOD	Internal	-	Child-population doses to each organ for "NEPA" report
CATH(20)	Real	WHY	Internal	-	Rate of current aquatic food production for each usage location (kg/yr)
CC	Real	FLOOD	Internal	-	Average annual rate of current food product consumption by children (kg/yr)
CCON	Real	FLOOD	Internal	-	Maximum annual rate of current food product consumption by children (kg/yr)
CDOS	Real	PERDOS	Internal	-	Maximum dose to the critical organ for one radionuclide
CDOSE(8)	Real	OUT	Internal	-	Dose to each organ from ingestion of invertebrates (mrem)
CFS	Real	AQUA	BLANK Common	U	Rate of liquid-effluent discharge to the receiving water body - read on input record 2 (ft^3/sec)
CFS	Real	CRITTR	BLANK Common	U	Same as CFS in AQUA
CFS	Real	DRINK	BLANK Common	U	Same as CFS in AQUA
CFS	Real	EAT	BLANK Common	U	Same as CFS in AQUA

Parameter Name	Type	Module	Data Interchange	Usage	Description
CFS	Real	FOOD	BLANK Common	U	Same as CFS in AQUA
CFS	Real	MAIN	BLANK Common	S/U	Same as CFS in AQUA
CFS	Real	PERDOS	BLANK Common	U	Same as CFS in AQUA
CFS	Real	RECON	BLANK Common	U	Same as CFS in AQUA
CFS	Real	SHORE	BLANK Common	U	Same as CFS in AQUA
CFS	Real	SWIM	BLANK Common	U	Same as CFS in AQUA
CHA	Real	ALARA	DATA Common	S/U	Rate of aquatic-plant consumption by children (kg/yr)
CHA	Real	BLOCK DATA	DATA Common	S	Same as CHA in ALARA
CHB	Real	ALARA	DATA Common	S/U	Child exposure time for boating (hr/yr)
CHB	Real	BLOCK DATA	DATA Common	S	Same as CHB in ALARA
CHC	Real	ALARA	DATA Common	S/U	Rate of freshwater-invertebrate consumption by children (kg/yr)
CHC	Real	BLOCK DATA	DATA Common	S	Same as CHB in ALARA
CHCSW	Real	ALARA	DATA Common	U	Rate of saltwater-invertebrate consumption by children (kg/yr)
CHCSW	Real	BLOCK DATA	DATA Common	S	Same as CHCSW in ALARA
CHF	Real	ALARA	DATA Common	S/U	Rate of fish consumption by children (kg/yr)
CHF	Real	BLOCK DATA	DATA Common	S	Same as CHF in ALARA

Parameter Name	Type	Module	Data Interchange	Usage	Description
CHS	Real	ALARA	DATA Common	S/U	Child exposure time for shoreline activities (hr/yr)
CHS	Real	BLOCK DATA	DATA Common	S	Same as CHS in ALARA
CHSW	Real	ALARA	DATA Common	S/U	Child exposure time for swimming (hr/yr)
CHSW	Real	BLOCK DATA	DATA Common	S	Same as CHSW in ALARA
CHW	Real	ALARA	DATA Common	S/U	Rate of water consumption by children (L/yr)
CHW	Real	BLOCK DATA	DATA Common	S	Same as CHW in ALARA
CIB	Real	PLOP	Internal	-	Total body dose per curie released for current radionuclide (person-rem/Ci)
CIT	Real	PLOP	Internal	-	Thyroid dose per curie released for current radionuclide (person-rem/Ci)
CIYR	Real	TRTIUM	Argument	U	Release rate for tritium (Ci/yr)
COBEAD(200,8)	Real	PLOP	Internal	-	Cost-benefit population doses for each radionuclide (200) and organ (8) - The only organ positions used are 1 for total body and 2 for thyroid. (person-rem)
CON	Real	ACTIVE	BLANK Common	S	Unit conversion factor, set to 1.0 for individual doses (mrem) and 1000 for population doses (person-rem)
CON	Real	ALARA	BLANK Common	S	Same as CON in ACTIVE

Parameter Name	Type	Module	Data Interchange	Usage	Description
CON	Real	AQUA	BLANK Common	U	Same as CON in ACTIVE
CON	Real	DRINK	BLANK Common	U	Same as CON in ACTIVE
CON	Real	PAFD	BLANK Common	U	Same as CON in ACTIVE
CON	Real	SHORE	BLANK Common	U	Same as CON in ACTIVE
CON	Real	SWIM	BLANK Common	U	Same as CON in ACTIVE
CON	Real	TRTIUM	BLANK Common	U	Same as CON in ACTIVE
CON	Real	WATER	Internal	-	Same as CON in ACTIVE
CON	Real	WHO	BLANK Common	S	Same as CON in ACTIVE
CON	Real	WHY	BLANK Common	S	Same as CON in ACTIVE
CONC(200)	Real	CENT	Argument	S/U	Total water concentration for each radionuclide (Ci•sec) per (ft^3•yr)
CONC(200)	Real	FLOOD	Internal	-	Intermediate concentration for each radionuclide, calculated in CENT and used in FOOD - see CONC in CENT
CONC(200)	Real	FOOD	Argument	U	Same as CONC in CENT
CONC(200)	Real	PAFD	Argument	U	Same as CONC in CENT
CONC(200)	Real	WHY	Internal	-	Total concentration parameter for each radionuclide calculated in CENT and used in PAFD
CONS	Real	EAT	Argument	U	Rate of aquatic-organism consumption by current terrestrial biota (kg/yr)

Parameter Name	Type	Module	Data Interchange	Usage	Description
CONSUM	Real	FOOD	Argument	U	Maximum annual rate of food-product consumption by current age group (kg/yr)
CONSUM	Real	TRTIUM	Internal	-	Total rate of water consumption by the average U.S. individual (L/yr), set to 800
CRITR(3)	Char*4	AQUA	Argument	U	Descriptive title array for current pathway
CRITR(3)	Char*4	CRITTR	Argument	U	Same as CRITR in AQUA
CRUS	Real	ALARA	DATA Common	S/U	Rate of freshwater-invertebrate consumption by adults (kg/yr) - CRUS is reset to CRUSSW when a saltwater site is selected
CRUS	Real	BLOCK DATA	DATA Common	S	Same as CRUS in ALARA
CRUS	Real	OUT	Argument	U	Rate of invertebrate consumption by current age group
CRUSSW	Real	ALARA	DATA Common	U	Rate of saltwater-invertebrate consumption by adults (kg/yr)
CRUSSW	Real	BLOCK DATA	DATA Common	S	Same as CRUSSW in ALARA
CSWF	Real	WHO	Internal	-	Shore-width factor for exposure of fish and invertebrates to sediment, set to 2
CU	Real	WATER	Internal	-	Average rate of water consumption per child (L/yr)
CU	Real	WHY	Internal	-	Rate of current aquatic food consumption by children (kg/yr)

Parameter Name	Type	Module	Data Interchange	Usage	Description
CUM(8)	Real	WATER	Internal	-	Cumulative population dose to each organ for all age groups and usage locations (person-rem)
CUSE	Real	WHY	Internal	-	Inline function value for current aquatic food usage by children (kg/yr)
CUSE	Real	WATER	Internal	-	Inline function value for total water consumption by child population (L/yr)
D(3)	Char*4	ACTIVE	Internal	-	Title array for output reports - "BOATING"
D(3)	Char*4	FLOOD	Internal	-	Title array for output reports - "TOTAL"
D(3)	Char*4	WATER	Internal	-	Title for output reports - "TOTAL"
D(3)	Char*4	WHO	Internal	-	Title for output reports - "DUCK"
D(3)	Char*4	WHY	Internal	-	Title for output reports - "TOTAL"
DFL(700,7)	Real	AQUA	DFLIB Common	U	Ingestion dose factors for each radionuclide, age group (700), and organ (7) (mrem/pCi ingested)
DFL(700,7)	Real	DRINK	DFLIB Common	U	Same as DFL in AQUA
DFL(700,7)	Real	EAT	DFLIB Common	U	Same as DFL in AQUA - data for adult age group are used for terrestrial biota in EAT
DFL(700,7)	Real	FOOD	DFLIB Common	U	Same as DFL in AQUA
DFL(700,7)	Real	PAFD	DFLIB Common	U	Same as DFL in AQUA
DFL(700,7)	Real	REDDF	DFLIB Common	S/U	Same as DFL in AQUA

Parameter Name	Type	Module	Data Interchange	Usage	Description
DFL(700,7)	Real	TRTIUM	DFLIB Common	U	Same as DFL in AQUA
DILU	Real	ACTIVE	Internal	-	Dilution factor for current location and pathway
DILU	Real	ALARA	Internal	-	Dilution factor for all ALARA pathways (except drinking water and shoreline for first usage location)
DILU	Real	AQUA	Argument	U	Dilution factor for current aquatic pathway usage location
DILU	Real	CRITTR	Argument	U	Same as DILU in AQUA
DILU	Real	EAT	Argument	U	Dilution factor for location of production of aquatic food type eaten by current terrestrial biota
DILU	Real	OUT	Argument	U	Same as DILU in ALARA
DILU	Real	SHORE	Argument	U	Dilution factor for shoreline exposure at current location
DILU	Real	SWIM	Argument	U	Dilution factor for terrestrial pathways for current location
DILU	Real	WATER	Internal	-	Dilution factor for drinking water usage location
DILU	Real	WHO	Internal	-	Dilution factor for exposure location of current biota
DILU	Real	WHY	Internal	-	Same as DILU in ACTIVE
DILU(20)	Real	FLOOD	Internal	-	Dilution factor for terrestrial pathways - up to 19 usage locations (20th position of the array is not usable)

Parameter Name	Type	Module	Data Interchange	Usage	Description
DILW	Real	DRINK	TRANS Common	S	Dilution factor for drinking water usage location
DILW	Real	PERDOS	TRANS Common	U	Same as DILW in DRINK
DL	Real	FLOOD	Internal	-	Minimum dilution factor specified for usage locations for current terrestrial food pathway
DL	Real	FOOD	Argument	U	Same as DL in FLOOD
DOS2(8)	Real	PERDOS	Internal	-	Dose to organs from consumption of fish and invertebrates (saltwater) or fish and drinking water (freshwater) as calculated for the ALARA analysis
DOSE(200,8)	Real	ACTIVE	Argument	S/U	Intermediate storage array for doses of each radionuclide (200) and each organ (8) used in the % contribution calculation - organ positions are: skin 1 bone 2 liver 3 whole body 4 thyroid 5 kidney 6 lung 7 GI-LLI 8 DOSE is passed to other subroutines through argument lists.

Parameter Name	Type	Module	Data Interchange	Usage	Description
DOSE(200,8)	Real	ALARA	Argument	U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	AQUA	Argument	S/U	Same as DOSE in ACTIVE, also used for biota doses
DOSE(200,8)	Real	CRITTR	Argument	S/U	Same as DOSE in AQUA
DOSE(200,8)	Real	DRINK	Argument	S/U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	EAT	Argument	S/U	Intermediate storage array for doses of each radionuclide for the current terrestrial biota
DOSE(200,8)	Real	FLOOD	Argument	U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	FOOD	Argument	U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	MAIN	Internal	-	Same as DOSE in ACTIVE - DOSE is dimensioned in MAIN and passed through argument lists to other subroutines
DOSE(200,8)	Real	OUT	Argument	U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	PAFD	Argument	S/U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	PERDOS	Argument	U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	PLOP	Argument	U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	SHORE	Argument	S/U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	SWIM	Argument	S/U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	WATER	Argument	U	Same as DOSE in ACTIVE
DOSE(200,8)	Real	WHO	Argument	U	Same as DOSE in EAT

Parameter Name	Type	Module	Data Interchange	Usage	Description
DOSE(200,8)	Real	WHY	Argument	U	Same as DOSE in ACTIVE
DOS(8,100,8)	Real	PERDOS	Internal	-	Special dose array for exposure pathways (8), radionuclides (200), and organs (8) - DOS determines information for critical organ doses from consumption of fish and drinking water in the ALARA analysis.
DUCK	Real	WHO	Internal	-	Effective radius of a duck body (cm), set to 5
DUCMAS	Real	WHO	Internal	-	Average mass of a duck (g), set to 1,000
DUCUSE	Real	WHO	Internal	-	Rate of water consumption by an average duck (L/yr), set to 100
DWD	Real	ALARA	Internal	-	Dilution factor for drinking water
DWD	Real	DRINK	Argument	U	Same as DWD in ALARA
DWD	Real	OUT	Argument	U	Same as DWD in ALARA
E(3)	Char*4	WATER	Internal	-	Title for output reports - "CUMUL TOTAL"
EFF(170,8)	Real	CRITTR	DFLIB Common	U	Effective energy deposited in organs of various radii per disintegration, calculated for each isotope (MeV/dis)
EFF(170,8)	Real	EAT	DFLIB Common	U	Same as EFF in CRITTR
EFF(170,8)	Real	REDDF	DFLIB Common	U	Same as EFF in CRITTR
EUS	Real	WATER	Internal	-	Total water consumption for all usage locations and age groups (L/yr)

Parameter Name	Type	Module	Data Interchange	Usage	Description
EXG(170,2)	Real	REDDF	DFLIB Common	S/U	External dose conversion factors for shoreline exposure for each radionuclide (170) and each organ (2 - skin and whole body) (mrem/hr per pCi/m^2)
EXG(170,2)	Real	SHORE	DFLIB Common	U	Same as EXG in REDDF
EXI(8)	Real	WHO	Internal	-	Dose from water immersion for current biota and location (mrem)
EXS(170,2)	Real	REDDF	DFLIB Common	S/U	External dose conversion factors for immersion in water for each radionuclide (170) and each organ (2 - skin and whole body) (mrem/hr per pCi/L)
EXS(170,2)	Real	SWIM	DFLIB Common	U	Same as EXS in REDDF
EXT(8)	Real	WHO	Internal	-	Dose from shoreline or sediment exposure for current biota and location (mrem)
FACCA(100)	Real	BLOCK DATA	DATA Common	S	Bioaccumulation factors for freshwater aquatic plants by element (L/kg) - default values given in Table 3.1
FACCA(100)	Real	MAIN	DATA Common	U	Bioaccumulation factors for freshwater aquatic plants by element (L/kg)
FACCF(100)	Real	BLOCK DATA	DATA Common	S	Bioaccumulation factors for freshwater fish by element (L/kg) - default values given in Table 3.1
FACCF(100)	Real	MAIN	DATA Common	U	Bioaccumulation factors for freshwater fish by element (L/kg)
FACCI(100)	Real	BLOCK DATA	DATA Common	S	Bioaccumulation factors for freshwater invertebrates by element (L/kg) - default values given in Table 3.1

Parameter Name	Type	Module	Data Interchange	Usage	Description
FACCI(100)	Real	MAIN	DATA Common	U	Bioaccumulation factors for freshwater invertebrates by element (L/kg)
FACT	Real	AQUA	Internal	-	Intermediate factor in aquatic food pathway - represents the total activity of the current radionuclide ingested per year (pCi/yr)
FACT	Real	CRITTR	Internal	-	Same as FACT in AQUA
FACT	Real	DRINK	Internal	-	Intermediate factor in drinking water pathway - represents the total activity of the current radionuclide ingested per year (pCi/yr)
FACT	Real	EAT	Internal	-	Intermediate factor representing total intake of aquatic organism by terrestrial biota
FACT	Real	FOOD	Internal	-	Intermediate parameter for population dose calculation for terrestrial food products
FACT	Real	SHORE	Internal	-	Intermediate factor for external dose calculation (organ independent) equivalent to exposure time integral (hr)
FACT	Real	SWIM	Internal	-	Intermediate factor representing total exposure time for the current radionuclide
FCN1	Real	FOOD	Internal	-	Intermediate concentration factor for calculation of maximum individual dose from terrestrial food products
FCON	Real	FOOD	Internal	-	Intermediate concentration factor for calculation of population dose from terrestrial food products

Parameter Name	Type	Module	Data Interchange	Usage	Description
FDH2O	Real	FLOOD	Internal	-	Fraction of animal drinking water not obtained from contaminated irrigation supply (used for milk and meat only)
FDH2O	Real	FOOD	Argument	U	Same as FDH2O in FLOOD
FDOSE(8)	Real	OUT	Internal	-	Dose to each organ from ingestion of fish (mrem)
FFED	Real	FLOOD	Internal	-	Fraction of animal feed not produced with contaminated irrigation water (used for milk and meat only)
FFED	Real	FOOD	Argument	U	Same as FFED in FLOOD
FIUS	Real	ALARA	DATA Common	S/U	Rate of fish consumption by adults (kg/yr)
FIUS	Real	BLOCK DATA	DATA Common	S	Same as FIUS in ALARA
FIUS	Real	OUT	Argument	U	Rate of fish consumption by current age group (kg/yr)
FLOODP(8,4)	Real	BLOCK DATA	DATA Common	S	Array for consumption rates and food processing holdup times (8) of irrigated food pathways (4 - vegetables, leafy vegetables, milk, meat) (kg/yr or L/yr) - default values given in Table 3.2. The eight parameters are: 1. Average adult consumption rate 2. Average teen consumption rate 3. Average child consumption rate 4. Maximum adult consumption rate 5. Maximum teen consumption rate

Parameter Name	Type	Module	Data Interchange	Usage	Description
					6. Maximum child consumption rate 7. Food processing holdup time for average individuals (hr) 8. Food processing holdup time for maximum individuals (hr)
FLOODP(8,4)	Real	FLOOD	DATA Common	U	Same as FLOODP in BLOCK DATA
FPT	Real	WHY	Internal	-	Food processing time for current harvest type (hr)
FRAC	Real	BLOCK DATA	DATA Common	S	The fraction of deposited activity retained on edible parts of plants - default is 0.25
FRAC	Real	FOOD	DATA Common	U	Same as FRAC in BLOCK DATA
GAL	Real	WATER	Internal	-	Rate of drinking water supply by current water plant system (gal/d)
GEOM	Real	ACTIVE	Internal	-	Geometry factor for exposure to water used in module SWIM: GEOM=1, total immersion (swimming) GEOM=2, half immersion (boating)
GEOM	Real	OUT	Internal	-	Same as GEOM in ACTIVE
GEOM	Real	SWIM	Argument	U	Same as GEOM in ACTIVE
GOOD(7)	Real	FLOOD	Internal	-	Sum of population doses to each organ by age group for "NEPA" report
GROW	Real	BLOCK DATA	DATA Common	S	Duration of irrigation period (d) - default is 30

Parameter Name	Type	Module	Data Interchange	Usage	Description
GUS	Real	WATER	Internal	-	Average individual rate of water usage for the current water plant service area (gal/d)
H	Real	SSWAP	Argument	U	Average water depth (ft) (see parameter HR in ACTIVE)
H(3)	Char*4	OUT	Internal	-	Title for output reports - "DRINKING"
H3B	Real	TRTIUM	Argument	S	Total dose to bone from tritium in drinking water for the U.S. population (person-rem)
H3B	Real	WATER	Internal	-	Same as H3B in TRTIUM
H3CON	Real	TRTIUM	Internal	-	Calculated average U.S. water concentration for individual drinking water pathway at midpoint of plant life (pCi/L)
H3T	Real	TRTIUM	Argument	S	Total body dose from tritium in drinking water for the U.S. population (person-rem)
H3T	Real	WATER	Internal	-	Same as H3T in TRTIUM
HARV	Real	WHY	Internal	-	Commercial harvest of current aquatic food type (kg/yr)
HERMAS	Real	WHO	Internal	-	Average mass of a heron (g), set to 4,600
HERON	Real	WHO	Internal	-	Effective radius of a heron body (cm); set to 11

Parameter Name	Type	Module	Data Interchange	Usage	Description
HERUSE	Real	WHO	Internal	-	Rate of water consumption by an average heron (L/yr), set to 600
HLD1	Real	FLOOD	Internal	-	Shortest food processing holdup time for calculations of maximum exposure (hr)
HLD1	Real	FOOD	Argument	U	Same as HLD1 in FLOOD
HOLD	Real	FLOOD	Internal	-	Average food processing holdup time (hr)
HOLD	Real	FOOD	Argument	U	Same as HOLD in FLOOD
HR	Real	ACTIVE	Internal	-	Average depth of the river or lake (ft)
HR	Real	ALARA	Internal	-	Same as HR in ACTIVE
HR	Real	FLOOD	Internal	-	Same as HR in ACTIVE
HR	Real	WATER	Internal	-	Same as HR in ACTIVE
HR	Real	WHO	Internal	-	Same as HR in ACTIVE
HR	Real	WHY	Internal	-	Same as HR in ACTIVE
HYDRO	Real	TRTIUM	Internal	-	Dilution factor for dispersion of released tritium in the world hydrosphere (L), set to 2.7×10^{19}
I	Integer	SOURCE	Internal	-	Count index for radionuclides in source inventory
I	Integer	WHY	Argument	U	Index for aquatic food selection for current calculation: I=1, fish I=2, invertebrates

Parameter Name	Type	Module	Data Interchange	Usage	Description
IA	Integer*2	SOURCE	Internal	-	Input variable for element name
IELEM(100)	Integer*2	BLOCK DATA	ELEMEN Common	S	Name symbol for each element (left justified)
IELEM(100)	Integer*2	PERDOS	ELEMEN Common	U	Same as IELEM in BLOCK DATA
IELEM(100)	Integer*2	PLOP	ELEMEN Common	U	Same as IELEM in BLOCK DATA
IELEM(100)	Integer*2	REDDF	ELEMEN Common	U	Same as IELEM in BLOCK DATA
IELEM(100)	Integer*2	SOURCE	ELEMEN Common	U	Same as IELEM in BLOCK DATA
IFLAG	Integer	ACTIVE	Internal	-	Surface-water model selection index: IFLAG=1 for nontidal rivers IFLAG=2 for near-shore lakes
IFLAG	Integer	ALARA	Internal	-	Same as IFLAG in ACTIVE
IFLAG	Integer	FLOOD	Internal	-	Same as IFLAG in ACTIVE
IFLAG	Integer	MAIN	Internal	-	Control integer to allow printing of BLOCK DATA and dose-factor reports and to allow changing of BLOCK DATA parameter values. IFLAG is read on input record type 2 with the following uses: IFLAG=0 or IFLAG<-1, no effect IFLAG=-1, print BLOCK DATA and dose factors IFLAG=1, print BLOCK DATA and dose factors, and change BLOCK DATA parameters IFLAG>1, change BLOCK DATA parameters

Parameter Name	Type	Module	Data Interchange	Usage	Description
IFLAG	Integer	SSWAP	SSWAP Common	U	Same as IFLAG in ACTIVE
IFLAG	Integer	WATER	Internal	-	Same as IFLAG in ACTIVE
IFLAG	Integer	WHO	Internal	-	Same as IFLAG in ACTIVE
IFLAG	Integer	WHY	Internal	-	Same as IFLAG in ACTIVE
IM(5)	Char*1	SOURCE	Internal	-	Input array for 5-character, atomic-mass symbol
IMASS(700)	Integer	PERDOS	SORCE Common	U	Atomic weight of each radionuclide of the dose factor library, by age group
IMASS(700)	Integer	PLOP	SORCE Common	U	Same as IMASS in PERDOS
IMASS(700)	Integer	REDDF	SORCE Common	S/U	Same as IMASS in PERDOS
IMASS(700)	Integer	SOURCE	SORCE Common	U	Same as IMASS in PERDOS
INFIL	Integer	ACTIVE	INUNIT Common	U	Logical unit for reading data input records, set to 9 in MAIN
INFIL	Integer	ALARA	INUNIT Common	U	Same as INFIL in ACTIVE
INFIL	Integer	FLOOD	INUNIT Common	U	Same as INFIL in ACTIVE
INFIL	Integer	MAIN	INUNIT Common	S/U	Same as INFIL in ACTIVE
INFIL	Integer	RECON	INUNIT Common	U	Same as INFIL in ACTIVE

Parameter Name	Type	Module	Data Interchange	Usage	Description
INFIL	Integer	SOURCE	INUNIT Common	U	Same as INFIL in ACTIVE
INFIL	Integer	WATER	INUNIT Common	U	Same as INFIL in ACTIVE
INFIL	Integer	WHO	INUNIT Common	U	Same as INFIL in ACTIVE
INFIL	Integer	WHY	INUNIT Common	U	Same as INFIL in ACTIVE
IPRNT	Integer	MAIN	Internal	-	Print-control integer - dose factors printed only if IPRNT=1
IPRNT	Integer	RECON	Internal	-	Logical unit for output reports, set to 6
IPRNT	Integer	REDDF	Argument	U	Same as IPRNT in MAIN.
IRRIG	Real	FLOOD	Internal	-	Irrigation rate for the current food product ($L/m^2/mo$)
IRRIG	Real	FOOD	Argument	U	Same as IRRIG in FLOOD
ISOR(78)	Char*1	SOURCE	Internal	-	Input title array for radionuclide source identification
ITITLE(78)	Char*1	MAIN	Internal	-	Case title array - read as input record type 1 and printed on banner page
IZ(700)	Integer	AQUA	SORCE Common	U	Atomic number of each radionuclide in the dose factor library, by age group
IZ(700)	Integer	CRITTR	SORCE Common	U	Same as IZ in AQUA
IZ(700)	Integer	DRINK	SORCE Common	U	Same as IZ in AQUA

Parameter Name	Type	Module	Data Interchange	Usage	Description
IZ(700)	Real	EAT	SORCE Common	U	Same as IZ in AQUA
IZ(700)	Integer	FOOD	SORCE Common	U	Same as IZ in AQUA
IZ(700)	Integer	PAFD	SORCE Common	U	Same as IZ in AQUA
IZ(700)	Integer	PERDOS	SORCE Common	U	Same as IZ in AQUA
IZ(700)	Integer	PLOP	SORCE Common	U	Same as IZ in AQUA
IZ(700)	Integer	REDDF	SORCE Common	S/U	Same as IZ in AQUA
IZ(700)	Integer	SOURCE	SORCE Common	U	Same as IZ in AQUA
J	Integer	CENT	Argument	U	Number of usage locations to be considered: $1 \leq J \leq 19$
JJ	Integer	AQUA	Argument	U	Age group index: JJ=1, adult JJ=2, teen JJ=3, child JJ=4, infant
JJ	Integer	DRINK	Argument	U	Same as JJ in AQUA
JJ	Integer	FOOD	Argument	U	Age group index: JJ=1, adult JJ=2, teen JJ=3, child
JJ	Integer	PAFD	Argument	U	Same as JJ in AQUA

Parameter Name	Type	Module	Data Interchange	Usage	Description
JL	Integer	ACTIVE	Internal	-	Control integer to limit printing of % dose contribution subreport for the first usage location only
JSB	Integer	MAIN	Internal	-	Case indicator to control calling of subroutine REDDF (dose factor library input) - for first case: JSB=1, REDDF is called; for subsequent cases: JSB>1, REDDF is not called
K	Integer	REDDF	Internal	-	Count index for input of radionuclide data
KIT	Integer	ACTIVE	BLANK Common	S	Control integer to select action in calls to subroutine PERDOS. Usage is as follows: KIT=10, print % contribution to ALARA doses KIT=20, print % contribution to drinking water doses KIT=30, print % contribution to irrigated food doses KIT=40, print % contribution to shoreline activity doses KIT=50, print % contribution to swimming and boating doses KIT=70, print % contribution to biota doses Other, calculate % contributions using dose arrays provided in PERDOS CALL statement.
KIT	Integer	FLOOD	BLANK Common	S/U	Same as KIT in ACTIVE

Parameter Name	Type	Module	Data Interchange	Usage	Description
KIT	Integer	OUT	BLANK Common	S/U	Same as KIT in ACTIVE
KIT	Integer	PERDOS	BLANK Common	U	Same as KIT in ACTIVE
KIT	Integer	WATER	BLANK Common	S	Same as KIT in ACTIVE
KIT	Integer	WHO	BLANK Common	S	Same as KIT in ACTIVE
KIT	Integer	WHY	BLANK Common	S	Same as KIT in ACTIVE
KK	Integer	ALARA	Internal	-	Count index for number of usage locations considered
KK	Integer	OUT	Argument	U	Same as KK in ALARA
KK(14)	Integer	SOURCE	Internal	-	Atomic number of each single-character element (i.e., H, C, etc.)
KOP	Integer	OUT	Argument	U	Age-group index: KOP=1, adult KOP=2, teen KOP=3, child KOP=4, infant
KZ	Integer	FLOOD	Internal	-	Control integer to allow reading of new consumption data on record type 17a: if KZ>0, read
LCT	Integer	ACTIVE	BLANK Common	U	Control integer to calculate and print % contribution to doses by radionuclide - read on input record type 4 if LCT>0, calculate percentages
LCT	Integer	ALARA	BLANK Common	U	Same as LCT in ACTIVE

Parameter Name	Type	Module	Data Interchange	Usage	Description
LCT	Integer	AQUA	BLANK Common	U	Same as LCT in ACTIVE
LCT	Integer	CRITTR	BLANK Common	U	Same as LCT in ACTIVE
LCT	Integer	DRINK	BLANK Common	U	Same as LCT in ACTIVE
LCT	Integer	EAT	BLANK Common	U	Same as LCT in ACTIVE
LCT	Integer	FOOD	BLANK Common	U	Same as LCT in ACTIVE
LCT	Integer	MAIN	BLANK Common	S	Same as LCT in ACTIVE
LCT	Integer	OUT	BLANK Common	U	Same as LCT in ACTIVE
LCT	Integer	PAFD	BLANK Common	U	Same as LCT in ACTIVE
LCT	Integer	SHORE	BLANK Common	U	Same as LCT in ACTIVE
LCT	Integer	SWIM	BLANK Common	U	Same as LCT in ACTIVE
LCT	Integer	WHO	BLANK Common	U	Same as LCT in ACTIVE
LEAF	Real	FOOD	Internal	-	Intermediate concentration parameter for crop contamination through deposition onto leaves
LIST(200,4)	Integer	AQUA	BLANK Common	U	Index array relating position of each radionuclide (200) and age group (4) to data in parameter arrays
LIST(200,4)	Integer	CRITTR	BLANK Common	U	Same as LIST in AQUA
LIST(200,4)	Integer	EAT	BLANK Common	U	Same as LIST in AQUA
LIST(200,4)	Integer	FOOD	BLANK Common	U	Same as LIST in AQUA

Parameter Name	Type	Module	Data Interchange	Usage	Description
LIST(200,4)	Integer	PAFD	BLANK Common	U	Same as LIST in AQUA
LIST(200,4)	Integer	PERDOS	BLANK Common	U	Same as LIST in AQUA
LIST(200,4)	Integer	RECON	BLANK Common	U	Same as LIST in AQUA
LIST(200,4)	Integer	SHORE	BLANK Common	U	Same as LIST in AQUA
LIST(200,4)	Integer	SOURCE	BLANK Common	S/U	Same as LIST in AQUA
LIST(200,4)	Integer	SWIM	BLANK Common	U	Same as LIST in AQUA
LIST(200,4)	Integer	WATER	BLANK Common	U	Same as LIST in AQUA
LM	Integer	PAFD	Argument	U	Control integer to allow NEPA doses to be included in cost-benefit results
LM	Integer	WHY	Internal	-	Control integer to include sport harvest in NEPA dose evaluation
LOC(5)	Char*4	WHO	Internal	-	Title for current usage location
LOC(5,20)	Char*4	FLOOD	Internal	-	Title array for usage location names - 5 words for each location
LOC(5,20)	Char*4	WHY	Internal	-	Title array for identification of sport and commercial aquatic food harvest usage location
LOCA(3)	Char*4	ACTIVE	Internal	-	Location identification title (from various input records)
LOCA(3)	Char*4	ALARA	Internal	-	Same as LOCA in ACTIVE

Parameter Name	Type	Module	Data Interchange	Usage	Description
LT	Integer	ALARA	BLANK Common	U	Selection index for site water type - read on input record type 2 LT=0, freshwater LT>0, saltwater
LT	Integer	DRINK	BLANK Common	U	Same as LT in ALARA
LT	Integer	MAIN	BLANK Common	S/U	Same as LT in ALARA
LT	Integer	OUT	BLANK Common	U	Same as LT in ALARA
LT	Integer	SWIM	BLANK Common	U	Same as LT in ALARA
LV(3)	Char*4	FLOOD	Internal	-	Title for output reports - "LEAFY VEGE"
LZ	Integer	ACTIVE	BLANK Common	S	Control index for calculation of radionuclide % contribution in subroutine PERDOS - LZ is set to 0 in calling routines, and increased in PERDOS to count the number of pathways, age groups, or biota considered
LZ	Integer	FLOOD	BLANK Common	S	Same as LZ in ACTIVE
LZ	Integer	OUT	BLANK Common	S	Same as LZ in ACTIVE
LZ	Integer	PERDOS	BLANK Common	S/U	Same as LZ in ACTIVE
LZ	Integer	WATER	BLANK Common	S	Same as LZ in ACTIVE
LZ	Integer	WHO	BLANK Common	S	Same as LZ in ACTIVE
LZ	Integer	WHY	BLANK Common	S	Same as LZ in ACTIVE

Parameter Name	Type	Module	Data Interchange	Usage	Description
M	Integer	FLOOD	Internal	-	Number of usage locations provided for current food product
M	Integer	RECON	Internal	-	Input index for reconcentration model selections: M=0, none M=1, completely mixed M=2, plug flow M=3, partially mixed
MASS	Real	EAT	Argument	U	Body weight of current terrestrial biota (kg)
MASS	Integer	SOURCE	Internal	-	Calculated value of radionuclide atomic mass - based on decoding of input character representation
MET	Char*1	SOURCE	Internal	-	Character variable for testing input metastable state indicator
MET(3)	Char*4	FLOOD	Internal	-	Title for output reports - "MEAT"
META(700)	Char*1	PERDOS	STATE Common	U	Indicator for isomeric state (M) for each radionuclide in each age group - used in output reports
META(700)	Char*1	PLOP	STATE Common	U	Same as META in PERDOS
META(700)	Char*1	REDDF	STATE Common	S/U	Same as META in PERDOS
META(700)	Char*1	SOURCE	STATE Common	U	Same as META in PERDOS
MLK(3)	Char*1	FLOOD	Internal	-	Title for output reports - "MILK"
MO	Integer	PERDOS	Internal	-	Index for current radionuclide in radionuclide list

Parameter Name	Type	Module	Data Interchange	Usage	Description
MT	Integer	PERDOS	Internal	-	Index for current radionuclide in element list
N	Integer	ALARA	Internal	-	Control integer to allow changes in standard usage and consumption parameters: if N≠0, read new values
N	Integer	FLOOD	Internal	-	Control index for food-type selection: N=0, stop reading food-type information N=1, vegetables N=2, leafy vegetables N=3, milk N=4, meat Other, result unpredictable
N	Integer	FOOD	Argument	U	Same as N in FLOOD
N	Integer	OUT	Argument	U	Not currently used
N	Integer	PLOP	Argument	U	Control integer for action on current call to PLOP: N=3, print cost-benefit report 22 N=4, initialize dose arrays N=5, add external doses N=6, add ingestion doses N=7, add ingestion doses Other, add ingestion doses
N	Integer	WHY	Argument	U	Index for type of harvest: N=1, sport N=2, commercial
NLIBA	Integer	REDDF	SORCE Common	S/U	Location of last radionuclide in data arrays for adult age group

Parameter Name	Type	Module	Data Interchange	Usage	Description
NLIBA	Integer	SOURCE	SORCE Common	U	Same as NLIBA in REDDF
NLIBC	Integer	REDDF	SORCE Common	S/U	Location of last radionuclide in data arrays for child age group
NLIBC	Integer	SOURCE	SORCE Common	U	Same as NLIBC in REDDF
NLIBI	Integer	REDDF	SORCE Common	S/U	Location of last radionuclide data arrays for infant age group
NLIBI	Integer	SOURCE	SORCE Common	U	Same as NLIBI in REDDF
NLIBT	Integer	REDDF	SORCE Common	S/U	Location of last radionuclide in data arrays for teen age group
NLIBT	Integer	SOURCE	SORCE Common	U	Same as NLIBT in REDDF
NN	Integer	PAFD	Argument	U	Control integer: NN=1, sport harvest NN=2, commercial harvest
NSOR	Integer	AQUA	BLANK Common	U	Number of radionuclides in input source inventory: $1 \leq NSOR \leq 100$
NSOR	Integer	CRITTR	BLANK Common	U	Same as NSOR in AQUA
NSOR	Integer	DRINK	BLANK Common	U	Same as NSOR in AQUA
NSOR	Integer	EAT	BLANK Common	U	Same as NSOR in AQUA
NSOR	Integer	FOOD	BLANK Common	U	Same as NSOR in AQUA
NSOR	Integer	PAFD	BLANK Common	U	Same as NSOR in AQUA

Parameter Name	Type	Module	Data Interchange	Usage	Description
NSOR	Integer	PERDOS	BLANK Common	U	Same as NSOR in AQUA
NSOR	Integer	PLOP	BLANK Common	U	Same as NSOR in AQUA
NSOR	Integer	RECON	BLANK Common	U	Same as NSOR in AQUA
NSOR	Integer	SHORE	BLANK Common	U	Same as NSOR in AQUA
NSOR	Integer	SOURCE	BLANK Common	S/U	Same as NSOR in AQUA
NSOR	Integer	SWIM	BLANK Common	U	Same as NSOR in AQUA
NSOR	Integer	WATER	BLANK Common	U	Same as NSOR in AQUA
NUM(13)	Char*1	SOURCE	Internal	-	Character data array for decoding input atomic mass titles
P	Real	FLOOD	Internal	-	Number of people served the current food type within 50 miles, calculated at the average consumption rate
P	Real	FOOD	Argument	U	Same as P in FLOOD
P	Real	WATER	Internal	-	Total population served at current drinking water usage location
P	Real	WHY	Internal	-	Inline function value for total population served
PATH(8,3)	Char*4	PERDOS	Internal	-	Pathway/biota/age group title for up to 8 pathways, biota, or age groups - three 4-character words are allowed for each title
PCN1	Real	FOOD	Internal	-	Plant concentration parameter for individual doses received from terrestrial food products

Parameter Name	Type	Module	Data Interchange	Usage	Description
PCON	Real	FOOD	Internal	-	Plant concentration parameter for population doses received from terrestrial food products
PCORG(8)	Real	PERDOS	Internal	-	Highest dose to any organ for each pathway or biota
PD(7)	Real	WHY	Internal	-	Population dose by organ (7) for all age groups (person-rem)
PEO	Real	WHY	Internal	-	Population exposed for type of current aquatic food harvest
PER(8,200,8)	Real	PERDOS	Internal	-	% contribution to dose array for pathways (8), radionuclides (200), and organs (8)
PERA	Real	BLOCK DATA	DATA Common	S	Fraction of population in adult age group - read on input record type 3A
PERA	Real	FLOOD	DATA Common	U	Same as PERA in BLOCK DATA
PERA	Real	FOOD	DATA Common	U	Same as PERA in BLOCK DATA
PERA	Real	MAIN	DATA Common	S/U	Same as PERA in BLOCK DATA
PERA	Real	WATER	DATA Common	U	Same as PERA in BLOCK DATA
PERA	Real	WHY	DATA Common	U	Same as PERA in BLOCK DATA
PERC	Real	BLOCK DATA	DATA Common	S	Fraction of population in child age group - read on input record type 3A
PERC	Real	FLOOD	DATA Common	U	Same as PERC in BLOCK DATA
PERC	Real	FOOD	DATA Common	U	Same as PERC in BLOCK DATA

Parameter Name	Type	Module	Data Interchange	Usage	Description
PERC	Real	MAIN	DATA Common	S/U	Same as PERC in BLOCK DATA
PERC	Real	WATER	DATA Common	U	Same as PERC in BLOCK DATA
PERC	Real	WHY	DATA Common	U	Same as PERC in BLOCK DATA
PERT	Real	BLOCK DATA	DATA Common	S	Fraction of population in teen age group - read on input record type 3A
PERT	Real	FLOOD	DATA Common	U	Same as PERT in BLOCK DATA
PERT	Real	FOOD	DATA Common	U	Same as PERT in BLOCK DATA
PERT	Real	MAIN	DATA Common	S/U	Same as PERT in BLOCK DATA
PERT	Real	WATER	DATA Common	U	Same as PERT in BLOCK DATA
PERT	Real	WHY	DATA Common	U	Same as PERT in BLOCK DATA
PL	Real	FOOD	BLANK Common	U	Midpoint of reactor plant operating period (yr), set equal to PLNTLF
PL	Real	MAIN	BLANK Common	S	Same as PL in FOOD
PL	Real	RECON	BLANK Common	U	Same as PL in FOOD
PL	Real	SHORE	BLANK Common	U	Same as PL in FOOD
PL	Real	TRTIUM	BLANK Common	U	Same as PL in FOOD
PLNTLF	Real	BLOCK DATA	DATA Common	S	Midpoint of reactor plant operating period (yr) - default is 20
PLNTLF	Real	MAIN	DATA Common	U	Same as PLNTLF in BLOCK DATA

Parameter Name	Type	Module	Data Interchange	Usage	Description
POL1	Real	FOOD	Internal	-	Population dose of current radionuclide in terrestrial food pathway for "NEPA" report
POP	Real	FLOOD	BLANK Common	U	Total population within 50 miles - read on record type 3
POP	Real	MAIN	BLANK Common	S	Same as POP in FLOOD
POP	Real	PERDOS	BLANK Common	U	Same as POP in FLOOD
POP	Real	WHY	BLANK Common	U	Same as POP in FLOOD
POOL	Real	FOOD	Internal	-	Population dose for current radionuclide in terrestrial food pathway for "ALARA" report
PROD(20)	Real	FLOOD	Internal	-	Production rate of current food product at each usage location (kg/yr or L/yr)
Q(200)	Real	AQUA	BLANK Common	U	Release rates for input source radionuclides (Ci/yr)
Q(200)	Real	CRITTR	BLANK Common	U	Same as Q in AQUA
Q(200)	Real	DRINK	BLANK Common	U	Same as Q in AQUA
Q(200)	Real	EAT	BLANK Common	U	Same as Q in AQUA
Q(200)	Real	FOOD	BLANK Common	U	Same as Q in AQUA
Q(200)	Real	PLOP	BLANK Common	U	Same as Q in AQUA
Q(200)	Real	SHORE	BLANK Common	U	Same as Q in AQUA

Parameter Name	Type	Module	Data Interchange	Usage	Description
Q(200)	Real	SOURCE	BLANK Common	S/U	Same as Q in AQUA
Q1	Real	BLOCK DATA	DATA Common	S	Rate of pasture-grass consumption by milk animals (kg/d) - default is 50
Q1	Real	FOOD	DATA Common	U	Same as Q1 in BLOCK DATA
Q2	Real	BLOCK DATA	DATA Common	S	Rate of water consumption by milk animals (L/d) - default is 60
Q2	Real	FOOD	DATA Common	U	Same as Q2 in BLOCK DATA
Q3	Real	BLOCK DATA	DATA Common	S	Rate of pasture-grass consumption by beef animals (kg/d) - default is 50
Q3	Real	FOOD	DATA Common	U	Same as Q3 in BLOCK DATA
Q4	Real	BLOCK DATA	DATA Common	S	Rate of water consumption by beef animals (L/d) - default is 50
Q4	Real	FOOD	DATA Common	U	Same as Q4 in BLOCK DATA
QB	Real	SSWAP	Internal	S/U	Same as CFS in MAIN
QQ	Real	SOURCE	Internal	-	Input radionuclide activity (Ci/yr)
QSUBB	Real	RECON	Internal	-	Input value for blowdown rate from pond (ft^3/sec)
QSUBP	Real	RECON	Internal	-	Discharge rate from plant (ft^3/sec), set equal to CFS
QT	Real	SOURCE	Internal	-	Sum of release rates for all radionuclides (Ci/yr)

Parameter Name	Type	Module	Data Interchange	Usage	Description
R	Real	RECON	Internal	-	Recirculation factor: QSUBB/QSUBP
R	Real	SOURCE	Internal	-	Input reconcentration factor
RAC	Real	WHO	Internal	-	Effective radius of a raccoon body (cm), set to 14
RACMAS	Real	WHO	Internal	-	Average mass of a raccoon (g), set to 12,000
RACUSE	Real	WHO	Internal	-	Rate of water consumption by an average raccoon (L/yr), set to 200
RAD	Real	EAT	Argument	U	Effective radius of the current terrestrial biota, used to determine the effective energy deposited per disintegration
RAT	Real	WHO	Internal	-	Effective radius of a muskrat (cm), set to 6
RATMAS	Real	WHO	Internal	-	Average mass of a muskrat body (g), set to 1,000
RATUSE	Real	WHO	Internal	-	Average rate of water consumption by muskrat (L/yr), set to 100
RECO(200)	Real	AQUA	BLANK Common	U	Reconcentration factor for each radionuclide in the source inventory
RECO(200)	Real	CRITTR	BLANK Common	U	Same as RECO in AQUA
RECO(200)	Real	DRINK	BLANK Common	U	Same as RECO in AQUA
RECO(200)	Real	EAT	BLANK Common	U	Same as RECO in AQUA

Parameter Name	Type	Module	Data Interchange	Usage	Description
RECO(200)	Real	FOOD	BLANK Common	U	Same as RECO in AQUA
RECO(200)	Real	RECON	BLANK Common	S	Same as RECO in AQUA
RECO(200)	Real	SHORE	BLANK Common	U	Same as RECO in AQUA
RECO(200)	Real	SOURCE	BLANK Common	S/U	Same as RECO in AQUA
RECO(200)	Real	SWIM	BLANK Common	U	Same as RECO in AQUA
ROOT	Real	FOOD	Internal	-	Intermediate concentration parameter for crop contamination through root uptake
RZONE	Real	BLOCK DATA	DATA Common	S	Areal density of root zone (kg/m^2) - default is 240
RZONE	Real	FOOD	DATA Common	U	Same as RZONE in BLOCK DATA
S(3)	Char*4	ACTIVE	Internal	-	Title for output reports - "SHORELINE"
SACCA(100)	Real	BLOCK DATA	DATA Common	S	Bioaccumulation factors for saltwater aquatic plants, by element (L/kg) - default values given in Table 3.1
SACCA(100)	Real	MAIN	DATA Common	U	Same as SACCA in BLOCK DATA
SACCF(100)	Real	BLOCK DATA	DATA Common	S	Bioaccumulation factors for saltwater fish, by element (L/kg) - default values given in Table 3.1
SACCF(100)	Real	MAIN	DATA Common	U	Same as SACCF in BLOCK DATA
SACCI(100)	Real	BLOCK DATA	DATA Common	S	Bioaccumulation factors for saltwater invertebrates (L/kg) - default values given in Table 3.1

Parameter Name	Type	Module	Data Interchange	Usage	Description
SACCI(100)	Real	MAIN	DATA Common	U	Same as SACCI in BLOCK DATA
SDOSE(8)	Real	OUT	Internal	-	External dose to each organ from shoreline activities (mrem)
SET(3)	Char*4	PERDOS	Internal	-	Character title words for identification of specific pathways - "SHOR," "BOAT," "SWIM"
SHD	Real	ALARA	Internal	-	Dilution factor for shoreline and swimming exposure
SHD	Real	OUT	Argument	U	Dilution factor for shoreline exposure
SHU	Real	ACTIVE	Internal	-	Population exposure time for shoreline activities (person-hr/yr)
SHU	Real	ALARA	DATA Common	S/U	Adult exposure time for shoreline activities (hr/yr)
SHU	Real	BLOCK DATA	DATA Common	S	Same as SHU in ALARA
SHU	Real	OUT	Argument	U	Exposure time of current age group for shoreline activities (hr/yr)
SOIL(100)	Real	BLOCK DATA	DATA Common	S	Concentration factors for uptake of elements from soil by edible parts of crops (kg dry soil/kg wet plant) - default values given in Table 3.1
SOIL(100)	Real	FOOD	DATA Common	U	Same as SOIL in BLOCK DATA
SPECIE(3)	Char*4	PERDOS	Argument	U	Title for current pathway or biota type - stored in array PATH for printing in output reports

Parameter Name	Type	Module	Data Interchange	Usage	Description
STAN(9)	Real	EAT	Internal	-	Organ radii corresponding to library data - current values are (cm): 0, 1.4, 2, 3, 5, 7, 10, 20, and 30
SUM	Real	WHY	Internal	-	Total usage for harvest of current aquatic food (kg/yr)
SUP(5)	Char*4	WATER	Internal	-	Descriptive title for current water usage
SW(3)	Char*4	ACTIVE	Internal	-	Title for output reports - "SWIMMING"
SWD	Real	ALARA	Internal	-	Dilution factor for swimming exposure
SWD	Real	OUT	Argument	U	Same as SWD in ALARA
SWDO(8)	Real	OUT	Internal	-	External dose to each organ from swimming (mrem)
SWF	Real	ACTIVE	Internal	-	Shore-width factor
SWF	Real	ALARA	Internal	-	Same as SWF in ACTIVE
SWF	Real	OUT	Argument	U	Same as SWF in ACTIVE
SWF	Real	SHORE	Argument	U	Same as SWF in ACTIVE
SWU	Real	ACTIVE	Internal	-	Population exposure time for swimming (person-hr/yr)
SWU	Real	ALARA	DATA Common	S/U	Adult exposure time for swimming (hr/yr)
SWU	Real	BLOCK DATA	DATA Common	S	Same as SWU in ALARA

Parameter Name	Type	Module	Data Interchange	Usage	Description
SWU	Real	OUT	Argument	U	Exposure time of current age group for swimming (hr/yr)
T	Real	ACTIVE	Internal	-	Transit time from release point to usage location (hr)
T	Real	ALARA	Internal	-	Same as T in ACTIVE
T	Real	AQUA	Argument	U	Transit and holdup time from release to consumption for aquatic food pathways and current usage location (hr)
T	Real	CRITTR	Argument	U	Same as T in ACTIVE
T	Real	DRINK	Argument	U	Transit time of drinking water from release to consumption (hr)
T	Real	EAT	Argument	U	Same as T in ACTIVE
T	Real	OUT	Argument	U	Transit time of water (except drinking water) from release to water-usage location (hr)
T	Real	SHORE	Argument	U	Same as T in ACTIVE
T	Real	SWIM	Argument	U	Same as T in ACTIVE
T	Real	WATER	Internal	-	Same as T in ACTIVE
T	Real	WHO	Internal	-	Same as T in ACTIVE
T2	Real	OUT	Internal	-	Total decay time from release until consumption of aquatic foods (hr)

Parameter Name	Type	Module	Data Interchange	Usage	Description
T3	Real	OUT	Internal	-	Total decay time from release until consumption of drinking water (hr)
T(20)	Real	FLOOD	Internal	-	Transit time from effluent release point to current usage location for each usage location (hr)
T(20)	Real	WHY	Internal	-	Transit time from release point to usage location (hr)
TAA	Real	ALARA	DATA Common	S/U	Rate of aquatic-plant consumption by teens (kg/yr)
TAA	Real	BLOCK DATA	DATA Common	S	Same as TAA in ALARA
TAB	Real	ALARA	DATA Common	S/U	Teen exposure time for boating (hr/yr)
TAB	Real	BLOCK DATA	DATA Common	S	Same as TAB in ALARA
TAC	Real	ALARA	DATA Common	S/U	Rate of freshwater-invertebrate consumption by teens (kg/yr)
TAC	Real	BLOCK DATA	DATA Common	S	Same as TAC in ALARA
TACSW	Real	ALARA	DATA Common	U	Rate of saltwater-invertebrate consumption by teens (kg/yr)
TACSW	Real	BLOCK DATA	DATA Common	S	Same as TACSW in ALARA
TAF	Real	ALARA	DATA Common	S/U	Rate of fish consumption by teens (kg/yr)
TAF	Real	BLOCK DATA	DATA Common	S	Same as TAF in ALARA
TALD(7)	Real	FLOOD	Internal	-	Teen population doses to each organ for "ALARA" report

Parameter Name	Type	Module	Data Interchange	Usage	Description
TAND(7)	Real	FLOOD	Internal	-	Teen population doses to each organ for "NEPA" report
TAS	Real	ALARA	DATA Common	S/U	Teen exposure time for shoreline activities (hr/yr)
TAS	Real	BLOCK DATA	DATA Common	S	Same as TAS in ALARA.
TASW	Real	ALARA	Data Common	S/U	Teen exposure time for swimming (hr/yr)
TASW	Real	BLOCK DATA	DATA Common	S	Same as TASW in ALARA
TAU(170)	Real	AQUA	DFLIB Common	U	Radiological decay constant for each radionuclide (hr^{-1})
TAU(170)	Real	CRITTR	DFLIB Common	U	Same as TAU in AQUA
TAU(170)	Real	DRINK	DFLIB Common	U	Same as TAU in AQUA
TAU(170)	Real	EAT	DFLIB Common	U	Same as TAU in AQUA
TAU(170)	Real	FOOD	DFLIB Common	U	Same as TAU in AQUA
TAU(170)	Real	SWIM	DFLIB Common	U	Same as TAU in AQUA
TAU(170)	Real	TRTIUM	DFLIB Common	U	Same as TAU in AQUA
TAU(170)	Real	RECON	DFLIB Common	U	Same as TAU in AQUA
TAU(170)	Real	REDDF	DFLIB Common	S/U	Same as TAU in AQUA
TAU(170)	Real	SHORE	DFLIB Common	U	Same as TAU in AQUA
TAW	Real	ALARA	DATA Common	S/U	Rate of water consumption by teens (kg/yr)

Parameter Name	Type	Module	Data Interchange	Usage	Description
TAW	Real	BLOCK DATA	DATA Common	S	Same as TAW in ALARA
TC	Real	FLOOD	Internal	-	Average annual rate of current food product consumption by teens (kg/yr)
TCON	Real	FLOOD	Internal	-	Maximum annual rate of current food product consumption by teens (kg/yr)
TD	Real	ALARA	Internal	-	Transit time of drinking water from release to consumption (hr)
TD	Real	OUT	Argument	U	Same as TD in ALARA
TDA	Real	ALARA	DATA Common	S/U	Rate of aquatic-plant consumption by infants (kg/yr)
TDA	Real	BLOCK DATA	DATA Common	S	Same as TDA in ALARA
TDB	Real	ALARA	DATA Common	S/U	Infant exposure time for boating (hr/yr)
TDB	Real	BLOCK DATA	DATA Common	S	Same as TDB in ALARA
TDC	Real	ALARA	DATA Common	S/U	Rate of freshwater-invertebrate consumption by infants (kg/yr)
TDC	Real	BLOCK DATA	DATA Common	S	Same as TDC in ALARA
TDF	Real	ALARA	DATA Common	S/U	Rate of fish consumption by infants (kg/yr)
TDF	Real	BLOCK DATA	DATA Common	S	Same as TDF in ALARA
TDOSE(8)	Real	ACTIVE	Internal	-	Total dose array for each organ for current location (mrem for individual doses, person-rem for population doses)
TDOSE(8)	Real	AQUA	Argument	S/U	Same as TDOSE in ACTIVE

Parameter Name	Type	Module	Data Interchange	Usage	Description
TDOSE(8)	Real	CRITTR	Argument	S/U	Total dose array for one aquatic organism - only one position is used
TDOSE(8)	Real	DRINK	Argument	S/U	Same as TDOSE in ACTIVE
TDOSE(8)	Real	EAT	Argument	S/U	Total dose for current terrestrial biota
TDOSE(8)	Real	FLOOD	Internal	-	Same as TDOSE in ACTIVE
TDOSE(8)	Real	FOOD	Argument	S/U	Same as TDOSE in ACTIVE
TDOSE(8)	Real	OUT	Internal	-	Same as TDOSE in ACTIVE
TDOSE(8)	Real	PAFD	Argument	S/U	Same as TDOSE in ACTIVE
TDOSE(8)	Real	PERDOS	Argument	U	Same as TDOSE in ACTIVE
TDOSE(8)	Real	SHORE	Argument	U	Same as TDOSE in ACTIVE
TDOSE(8)	Real	SWIM	Argument	S/U	Same as TDOSE in ACTIVE
TDOSE(8)	Real	WATER	Argument	U	Same as TDOSE in ACTIVE
TDOSE(8)	Real	WHO	Argument	U	Dose to current aquatic biota from ingestion pathways - only one position in used (mrem)
TDOSE(8)	Real	WHY	Argument	U	Same as TDOSE in ACTIVE
TDS	Real	ALARA	DATA Common	S/U	Infant exposure time for shoreline activities (hr/yr)
TDS	Real	BLOCK DATA	DATA Common	S	Same as TDS in ALARA
TDSW	Real	ALARA	DATA Common	S/U	Infant exposure time for swimming (hr/yr)

Parameter Name	Type	Module	Data Interchange	Usage	Description
TDSW	Real	BLOCK DATA	DATA Common	S	Same as TDSW in ALARA
TDW	Real	ALARA	DATA Common	S/U	Rate of water consumption by infants (L/yr)
TDW	Real	BLOCK DATA	DATA Common	S	Same as TDSW in ALARA
TERM	Real	FOOD	Internal	-	Fraction of population in current age group
TEXT	Real	WHO	Internal	-	Total external dose to current biota at current location (mrem)
TFMG	Real	FLOOD	Internal	-	Total production of current food product within 50 miles of the site (kg/yr)
TFMG	Real	FOOD	Argument	U	Same as TFMG in FLOOD
TGRW	Real	FLOOD	Internal	-	Crop-growing period for current food product (d)
TGRW	Real	FOOD	Argument	U	Same as TGRW in FLOOD
TGROW(4)	Real	FLOOD	Internal	-	Default values for crop growing period for each food product (d): Vegetables 60 Leafy Vegetables 60 Milk (grazing) 30 Meat 30
TM	Real	FLOOD	Internal	-	Transit time supplied with the minimum dilution factor (hr)
TM	Real	FOOD	Argument	U	Same as TM in FLOOD

Parameter Name	Type	Module	Data Interchange	Usage	Description
TOB	Real	PLOP	Internal	-	Total dose to whole body (person-rem)
TOT	Real	PLOP	Internal	-	Total dose to thyroid (person-rem)
TOT	Real	WHO	Internal	-	Total dose to current biota at current location (mrem)
TP	Real	FLOOD	Internal	-	Total number of people served calculated from the sum of production data specified for all usage locations and the average consumption rate
TP	Real	FOOD	Argument	U	Same as TP in FLOOD
TPD(7,3)	Real	WHY	Internal	-	Total population dose to each organ (7) and each age group (3) for sport harvest (person-rem)
TPROCF	Real	ALARA	DATA Common	U	Processing time for aquatic foods (hr)
TPROCF	Real	BLOCK DATA	DATA Common	S	Same as TPROCF in ALARA
TPROCF	Real	OUT	Argument	U	Same as TPROCF in ALARA
TPROCW	Real	ALARA	DATA Common	U	Processing time for water supply systems (hr)
TPROCW	Real	BLOCK DATA	DATA Common	S	Same as TPROCW in ALARA
TPROCW	Real	OUT	Argument	U	Same as TPROCW in ALARA
TR	Real	MAIN	Internal	-	Control parameter to initiate reading of population fractions on input record type 3A: TR>0, read input record type 3A

Parameter Name	Type	Module	Data Interchange	Usage	Description
TRANS	Real	FOOD	Internal	-	Factor for translocation from deposition on leaves to edible parts of plants, set to 1.0
TRI(3)	Char*4	WATER	Internal	-	Title for output reports - "WATER"
TTIG	Real	FLOOD	Internal	-	Sum of specified production rates for current food product for all usage locations (kg/yr)
TTIG	Real	FOOD	Argument	U	Same as TTIG in FLOOD
TU	Real	WATER	Internal	-	Average water consumption rate per teen (L/yr)
TU	Real	WHY	Internal	-	Rate of current aquatic food consumption by teens (kg/yr)
TUS	Real	WATER	Internal	-	Total water usage by all age groups for current location (L/yr)
TUSE	Real	WATER	Internal	-	Inline function value representing total water consumption by teen population (L/yr)
TUSE	Real	WHY	Internal	-	Inline function value for total current aquatic food usage by teens (kg/yr)
TWTH	Real	BLOCK	DATA Common	S	Weathering half-time for foliar deposition (d) - default is 14.0
TWTH	Real	FOOD	DATA Common	U	Same as TWTH in BLOCK DATA
TYPE(3)	Char*4	DRINK	Internal	-	Title array for output - "DRINKING"

Parameter Name	Type	Module	Data Interchange	Usage	Description
TYPE(3)	Char*4	FLOOD	Internal	-	Title array for output reports - "IRRI FOOD"
TYPE(3)	Char*4	FOOD	Argument	U	Same as TYPE in FLOOD
TYPE(3)	Char*4	PAFD	Argument	U	Exposure-pathway title
TYPE(3)	Char*4	SHORE	Argument	U	Exposure-pathway title
TYPE(3)	Char*4	SWIM	Argument	U	Title array for current pathway, passed through to subroutine PERDOS
TYPE(3)	Char*4	WATER	Internal	-	Title for output reports - "DRINKING"
TYPE(3)	Char*4	WHO	Internal	-	Title array (not currently assigned a value in WHO)
TYPE(3)	Char*4	WHY	Internal	-	Title for current aquatic food type - "INVER" or "FISH"
U	Real	SSWAP	Argument	U	Average water velocity (ft/yr), see UR in ALARA
UML	Real	MAIN	Internal	-	Source-term multiplier for release activity for each radionuclide - read on input record type 2: UML>0, pass to SOURCE for total release calculation UML=0, reset to 1.0 and pass to SOURCE for total release calculation UML<0, program interrupt
UML	Real	SOURCE	Argument	U	Same as UML in MAIN
UR	Real	ACTIVE	Internal	-	Average flow velocity for the river or lake (ft/sec)

Parameter Name	Type	Module	Data Interchange	Usage	Description
UR	Real	ALARA	Internal	-	Same as UR in ACTIVE
UR	Real	FLOOD	Internal	-	Same as UR in ACTIVE
UR	Real	WATER	Internal	-	Same as UR in ACTIVE
UR	Real	WHO	Internal	-	Same as UR in ACTIVE
UR	Real	WHY	Internal	-	Same as UR in ACTIVE
US	Real	BLOCK DATA	DATA Common	S	Total United States population - default is 2.6×10^8
US	Real	TRTIUM	DATA Common	U	Same as US in BLOCK DATA
USE	Real	AQUA	Argument	U	Rate of current aquatic food consumption by individuals in current age group (kg/yr)
USE	Real	DRINK	Argument	U	Rate of drinking-water consumption by current age group (L/yr or person-L/yr)
USE	Real	PAFD	Argument	U	Total consumption for current aquatic food by current age group (person-kg/yr)
USE	Real	WATER	Internal	-	Calculated water usage for current drinking water usage location and age group (L/yr)
USE	Real	WHY	Internal	-	Total usage for current calculation (kg/yr)
USE	Real	SHORE	Argument	U	Exposure time for current location (hr/yr)

Parameter Name	Type	Module	Data Interchange	Usage	Description
USE	Real	SWIM	Argument	U	Exposure time for water immersion (hr/yr)
USEA	Real	WHY	Internal	-	Total sport harvest consumption by adults (kg/yr)
USEB	Real	WHY	Internal	-	Total sport harvest consumption by teens (kg/yr)
USEC	Real	WHY	Internal	-	Total sport harvest consumption by children (kg/yr)
VEG(3)	Char*4	FLOOD	Internal	-	Title array for output reports - "VEGETATION"
VSUBT	Real	RECON	Internal	-	Input value for total volume of the impoundment (ft^3)
W(3)	Char*4	ACTIVE	Internal	-	Blank title for output reports
W(3)	Char*4	OUT	Internal	-	Title for output reports - "FISH"
W(3)	Char*4	WHO	Internal	-	Title for output reports - "FISH"
W(3)	Char*4	WHY	Internal	-	Title for output reports - "FISH"
WATERP(3)	Real	BLOCK DATA	DATA Common	S	Average annual rate of water consumption for individuals (L/yr) - defaults are: 1. adults, 370 2. teens, 260 3. children, 260
WATERP(3)	Real	WATER	DATA Common	U	Same as WATERP in BLOCK DATA
WDOSE(8)	Real	OUT	Internal	-	Dose to each organ from ingestion of drinking water (mrem)

Parameter Name	Type	Module	Data Interchange	Usage	Description
WHYP(12)	Real	BLOCK DATA	DATA Common	S	Parameters for sport and commercial harvest of fish and invertebrates are as follows: 1. Processing time between harvest and consumption of sport catch (hr) - default is 168 2. Processing time between harvest and consumption of commercial catch (hr) - default is 240 3. Commercial freshwater fish harvest (kg/yr) - default is 4.4×10^7 4. Commercial freshwater invertebrate harvest (kg/yr) - default is 2.3×10^6 5. Commercial saltwater fish harvest (kg/yr) - default is 6.58×10^8 6. Commercial saltwater invertebrate harvest (kg/yr) - default is 4.1×10^8 7. Average rate of fish consumption by adults (kg/yr) - default is 6.9 8. Average rate of fish consumption by teens (kg/yr) - default is 5.2 9. Average rate of fish consumption by children (kg/yr) - default is 2.2 10. Average rate of invertebrate consumption by adults (kg/yr) - dafault is 1.0 11. Average rate of invertebrate consumption by teens (kg/yr) - default is 0.75 12. Average rate of invertebrate consumption by children (kg/yr) - default is 0.33

Parameter Name	Type	Module	Data Interchange	Usage	Description
WHYP(12)	Real	WHY	DATA Common	U	Same as WHYP in BLOCK DATA
WUSE	Real	ALARA	DATA Common	S/U	Rate of water consumption by adults (L/yr)
WUSE	Real	BLOCK DATA	DATA Common	S	Same as WUSE in ALARA
WUSE	Real	OUT	Argument	U	Rate of drinking-water consumption by current age group (L/yr)
X	Real	SSWAP	Argument	U	Downstream (or longshore) distance (ft) see XR in ACTIVE
X(3)	Char*4	OUT	Internal	-	Title for output reports - "INVERTEBRATE"
X(3)	Char*4	WHO	Internal	-	Title for output reports - "INVERTEBRATE"
X(3)	Char*4	WHY	Internal	-	Title for output reports - "INVER"
XR	Real	ACTIVE	Internal	-	Downstream (or longshore) distance between source and usage location (ft)
XR	Real	ALARA	Internal	-	Same as XR in ACTIVE
XR	Real	FLOOD	Internal	-	Same as XR in ACTIVE
XR	Real	WATER	Internal	-	Same as XR in ACTIVE
XR	Real	WHO	Internal	-	Same as XR in ACTIVE
XR	Real	WHY	Internal	-	Same as XR in Active
Y	Real	SSWAP	Argument	U	Distance from shore to water intake (ft) (see YR in ACTIVE)

Parameter Name	Type	Module	Data Interchange	Usage	Description
YIELD	Real	BLOCK DATA	DATA Common	S	Crop yield for irrigated vegetation (kg/m^2)
YILD(4)	Real	FLOOD	Internal	-	Default values for crop yield (kg/m^2): vegetables 2.0 leafy vegetables 2.0 milk 0.7 meat 0.7
YLD	Real	FLOOD	Internal	-	Crop yield for current food product (kg/m^2)
YLD	Real	FOOD	Argument	U	Same as YLD in FLOOD
YR	Real	ACTIVE	Internal	-	Distance from shore to water intake (ft)
YR	Real	ALARA	Internal	-	Same as YR in ACTIVE
YR	Real	FLOOD	Internal	-	Same as YR in ACTIVE
YR	Real	WATER	Internal	-	Same as YR in ACTIVE
YR	Real	WHO	Internal	-	Same as YR in ACTIVE
YR	Real	WHY	Internal	-	Same as YR in ACTIVE
Z	Real	SSWAP	Argument	U	Depth of effluent discharge (ft), used only for lake model
Z(3)	Char*4	WHO	Internal	-	Title for output reports - "ALGAE"
Z(3)	Char*4	OUT	Internal	-	Title for output reports - "ALGAE"
ZIN	Real	FOOD	Internal	-	Intermediate parameter for population doses in animal product pathway
ZIN1	Real	FOOD	Internal	-	Intermediate parameter for individual doses in animal product pathway

Parameter Name	Type	Module	Data Interchange	Usage	Description
ZMET(100)	Real	BLOCK DATA	DATA Common	S	Stable element coefficient for transfer from animal intake to meat product (d/kg) - default values given in Table 3.1
ZMET(100)	Real	FOOD	DATA Common	U	Same as ZMET in BLOCK DATA
ZMLK(100)	Real	BLOCK DATA	DATA Common	S	Stable element coefficient for transfer from animal intake to milk (d/L) - default values given in Table 3.1
ZMLK(100)	Real	FOOD	DATA Common	U	Same as ZMLK in BLOCK DATA

APPENDIX B

PROGRAM, DATA FILE, AND SAMPLE PROBLEM LIST

APPENDIX B

PROGRAM, DATA FILE, AND SAMPLE PROBLEM LIST

This appendix provides a listing of each module in the current version of LADTAP II, a listing of the radionuclide dose factor library, and complete computer-generated output listings for the three sample problems described in Section 2.3. The listings are contained on microfiche in the back cover of this report. The order of information presented is as follows:

APPENDIX C

CHANGES TO LADTAP II

APPENDIX C

CHANGES TO LADTAP

During preparation of this report, several changes were made to the previous version of LADTAP II (Simpson and McGill 1980). These changes can be categorized as cosmetic or functional. Cosmetic changes relate to added comment lines (for better understanding of the program listings) and to modifications of ouput reports for correct representation of calculated results. Functional changes are modifications that affect calculated values or parameter usage.

This appendix provides a detailed summary of functional changes and a general summary of cosmetic, output-report changes to LADTAP II, with reference to the modules and lines affected. Details of cosmetic, comment-line changes are not provided here, as they are apparent in reviewing program listings.

Modules BANLET, BANNER, and SWAP are entirely new to LADTAP II.

SUMMARY OF FUNCTIONAL CHANGES TO LADTAP II

Module(s)	Line(s)	Description of Change
ACTIVE	84	Parameters A and LOCA added to CHARACTER statement
ACTIVE	97	LOCA dimension increased to 5
ACTIVE	118, 168, 215, 265	READ and PRINT references to LOCA changed to use 5 words
ACTIVE	122, 172	Parameter JL reset to correct potential logic error
ACTIVE	111, 127, 128, 177, 178, 223, 224	Logic added (parameter IPR) to only print report heading when a pathway is specified
ACTIVE	135-142, 282-288,	Read data, calculate and print surface-water dilution factor
ACTIVE	180, 216	Parameter KIT set to integer zero
ACTIVE	193, 239	KIT set to 50 for printing swimming and boating percent contributions to dose
ACTIVE	252, 255	Lines added to print percent contributions to boating doses
ACTIVE	205, 252, 280	PRINT and FORMAT statements changed for printing swimming and boating doses
ACTIVE	91, 118, 136, 168, 186, 215, 232	All case input records are read from input unit INFIL, set to 9 in MAIN
ALARA	127, 158, 159, 165-168, 182, 190, 197	
FLOOD	199, 228, 237, 247, 263	
MAIN	68, 89, 94, 104, 119, 120	
RECON	72, 81	
SETVAL	25, 52	
SOURCE	113, 131, 140	
WATER	141, 186, 203	
WHO	115, 143, 159	
WHY	151, 205, 232	
ALARA	136	Parameter SWTITL added to CHARACTER statement
ALARA	137	Parameter LOCA added to CHARACTER statement
ALARA	151, 158	Statement label 1 moved to avoid resetting saltwater invertebrate consumption parameters to default values

Module(s)	Line(s)	Description of Change
ALARA	182-202, 281-287	Read data, calculate and print surface-water dilution factor
BLOCK DATA	122, 123	Bioaccumulation factor for freshwater invertebrates corrected for Te (6.1×10^3) and Cs (1.0×10^3)
BLOCK DATA	170	Bioaccumulation factor for saltwater invertebrates corrected for Te (1.0×10^2)
BLOCK DATA	91	Milk transfer factor corrected for Ce (1.0×10^{-4})
CENT	before 63, after 88	Unnecessary statements eliminated
DRINK	before 82 after 113	Unnecessary statements eliminated
FLOOD	185, 186	Parameters A, B, C, D, LOC, LV, MET, MLK, SWTITL, and VEG added to CHARACTER statement
FLOOD	207	Dimensions added for growing period (TGROW) and crop yield (YILD)
FLOOD	228	Parameters TGRW and YLD added to Record Type 17 READ statement
FLOOD	220, 221	Default parameters for growing period and crop yield set
FLOOD	241, 242	Reset growing period and/or crop yield if values not given on input record type 17
FLOOD	262-269, 425-431	Read data, calculate and print surface-water dilution factor
FLOOD	280, 281	Logic changed so that TM is set prior to resetting DL
FLOOD	293	PRINT statement modified to include printing of bad value for N
FLOOD	294	RETURN statement changed to STOP
FLOOD	332, 340, 346	Call list to FOOD expanded to include TGRW and YLD
FLOOD	375	Parameters TGRW and YLD added to PRINT statement
FOOD PAFD SHORE	227, 228 99 114	Dose equation coefficient changed to 1119 (111900 in SHORE)
FOOD	233	Growing period changed to parameter TGRW
FOOD	3	Argument list expanded to include parameters TGRW and YLD

Module(s)	Line(s)	Description of Change
FOOD	238	Crop yield changed to parameter YLD
MAIN	94, 192	Statement label added to STOP to transfer on end-of-file at title record read
MAIN	112	Definition of PL=PLNTLF moved to allow user changes to be effective
MAIN	72-74, 78, 85-88, 99, 100	Modifications to print banner page by subroutine BANNER
MAIN	114, 115, 196, 197, 216, 217	Modifications to test values given for UML and CFS and print error message
MAIN	126	POP compared to real zero
MAIN	127, 201, 202, 218, 219	Parameter LT tested to ensure that it is $\geq$0, else an error message is printed
OUT	167, 200	Test on POP added to skip external pathways when special ALARA report 23 is requested
OUT	115	Parameters H and Y added to CHARACTER statement
PERDOS	118, 123	Unnecessary common block LCM eliminated and parameters defined in a DIMENSION statement
PERDOS	109, 117	Common block PRPATH eliminated, parameter PATH and PCORG defined in DIMENSION statement
PERDOS	119, 229	Parameter DOS2 dimensioned to allow printing of values for all organs (report 23)
PERDOS	199-204, 292, 303	PRINT and FORMAT statements changed to improve output report 19
PERDOS	223-229, 297	Changes made to print values for all organs in special ALARA report 23
PERDOS	264, 266, 267	PRINT statement changed to improve output report 19
PERDOS	279-303	Various modifications to FORMAT statements to improve output reports
PLOP	76	COBEAD DIMENSION statement replaces common block BEAD, which only contained internal parameters
RECON	76, 81	References to parameter ICRD deleted or changed to input file unit INFIL

Module(s)	Line(s)	Description of Change
REDDF	75, 103, 132, 156, 179	Common block DFACOM eliminated and dimensions removed from parameter DFA because inhalation dose factors need not be saved
REDDF	193-375	New statements providing output reports of library data
SETVAL	23, 24	Unnecessary common block CMLOC eliminated
SHORE	110	Parameter TP is compared to real 100
SHORE	76, 99	Unnecessary statement and common block eliminated
SHORE	105	Parameter ARGU set to real 100
SWIM	81, 106	Unnecessary statements eliminated
SWIM	127	Statement eliminated to allow calculation of percent contributions for boating doses and to include boating dose in cost-benefit analysis
TRTIUM	66	Consumption rate changed to 1100 L/yr per person
TRTIUM	83, 84	Reference positions for bone (H3B) and other organs (H3T) corrected for dose factor array (DFL)
WATER	202-208, 337-343	Read data, calculate and print surface-water dilution factor
WATER	335	Usage parameter for report set to 3 L/day
WATER	300	Total population usage set to 1100 x U.S. population
WATER	311	PRINT statement changed to print H3B for bone dose and H3T for other organ doses
WATER	310	Index of Q in TRTIUM call list changed to I to use correct value for tritium activity
WATER	199, 304	Print logic changed to print page heading if drinking water doses are requested (parameter IPR)
WATER	194	Parameter DILU tested against real zero (not integer zero)
WATER	128, 129	Parameters A, B, C, D, E, SWTITL, TRI, and SUP added to CHARACTER statements
WHO	108, 109	Parameters LOC and SWTITL added to CHARACTER statements
WHO	152, 153	PRINT statements moved to avoid printing a heading when no calculations are requested

Module(s)	Line(s)	Description of Change
WHO	158-164, 277-283	Read data, calculate and print surface-water dilution factor
WHY	138, 139	Parameters A, B, C, D, LOC, and SWTITL added to CHARACTER statements
WHY	181, 220-226	Logic changed to avoid printing except for first location
WHY	231-238, 415-421	Read data, calculate and print surface-water dilution factor

* APPENDIX D

SAMPLE PROBLEM 1 OUTPUT LISTING

*Omitted from document, on RSIC tape

APPENDIX E

DATA GENERAL MV8000 SPECIFIC CHANGES TO LADTAP II

CHANGES TO PROGRAM MAIN

```
C***********************************************************************C MAIN   1
C                                                                        C MAIN   2
C   MAIN PROGRAM OF LADTAP II       LATEST MODIFICATION: OCTOBER 16, 1985    C MAIN   3
                                     .
                                     .
                                     .
                                     .
C---- CHARACTER AND DIMENSION SPECIFICATIONS ----------------------------C MAIN  70
C                                                                        C MAIN  71
      CHARACTER*40 VER                                                     MAIN  72
C***** MODIFICATION FOR DATA GENERAL (DG), CHARACTER ARRAY FOR VERSON      MAIN DG1
C     DIMENSION VERSON(40)                                                 MAIN  73
C     CHARACTER*1 VERSON                                                   MAIN  74
      CHARACTER*1 ITITLE                                                   MAIN  75
      CHARACTER*1 VERSON (40)                                              MAIN DG2
C***** END OF MODIFICATION                                                 MAIN DG3
      DIMENSION ITITLE(78)                                                 MAIN  76
      DIMENSION DOSE(200,8)                                                MAIN  77
      EQUIVALENCE (VERSON(1),VER)                                          MAIN  78
C                                                                        C MAIN  79
C---- BEGINNING OF CALCULATIONS  ---------------------------------------C MAIN  80
C---- SET VERSION TITLE INTO TITLE ARRAY VERSON ------------------------C MAIN  81
C---- SET INPUT FILE UNIT TO 9   ---------------------------------------C MAIN  82
C---- SET CASE CONTROL INDEX TO 1 --------------------------------------C MAIN  83
C                                                                        C MAIN  84
      DO 102 I=1,40                                                        MAIN  85
      VERSON(I)=' '                                                        MAIN  86
  102 CONTINUE                                                             MAIN  87
C***** MODIFICATION FOR DG, TITLE FOR BANNER PAGE                          MAIN DG4
      VER='NRC DATA GENERAL, DECEMBER 1985         '                       MAIN DG5
C     VER = 'PNL VAX - OCTOBER 1985                 '                      MAIN  88
C***** END OF MODIFICATION                                                 MAIN DG6
      INFIL=9                                                              MAIN  89
      JSB=1                                                                MAIN  90
C***** MODIFICATION FOR DG, OPEN DOSE FACTOR FILE TO UNIT 20               MAIN DG7
      OPEN (UNIT=20, FILE='LADTAP.LIB', PAD='YES')                         MAIN DG8
C***** END OF MODIFICATION                                                 MAIN DG9
C                                                                        C MAIN  91
C     ---- START OF CASE.  READ INPUT RECORD TYPE 1, CASE TITLE. -------C MAIN  92
C                                                                        C MAIN  93
                                     .
                                     .
                                     .
                                     .
 11   FORMAT (1H0,'  50-MILE POPULATION=',1PE8.2,5X,'FRACTION ---  ADULT    MAIN 213
     1=',0PF4.2,/,49X,'TEENAGER=',F4.2,/,49X,'CHILD=',F4.2)                MAIN 214
 12   FORMAT (1H1)                                                         MAIN 215
C***** MODIFICATION FOR DG, NEW PRINT STATEMENT 13, 14                     MAIN DGA
 13   FORMAT ('0NEGATIVE VALUE GIVEN FOR LT. MUST BE GREAT'                MAIN DGB
     1'ER THAN OR EQUAL TO 0. '/' LT VALUE READ = 'I5)                     MAIN DGC
 14   FORMAT ('0BAD VALUE GIVEN FOR CFS OR UML, MUST BE GREAT'             MAIN DGD
     1'ER THAN 0. '/' CFS = ',1PE10.2,'     UML = ',E10.2)                 MAIN DGE
C13   FORMAT ('0BAD VALUE GIVEN FOR CFS OR UML, MUST BE > 0.'/             MAIN 216
C    1         ' CFS = ',1PE10.2,'   UML = ',E10.2)                        MAIN 217
C14   FORMAT ('0NEGATIVE VALUE GIVEN FOR LT.  MUST BE >= 0.'/              MAIN 218
C    1         ' LT VALUE READ = ',I5)                                     MAIN 219
C***** END MODIFICATION                                                    MAIN DGF
C***********************************************************************C MAIN 220
      END                                                                  MAIN 221
```

CHANGES TO SUBROUTINE BANLET

```
C*****************************************************************************C BANL   1
      SUBROUTINE BANLET                                                         BANL   2
C                                                                               BANL   3
C     A MODULE OF LADTAP II, LATEST MODIFICATION - MARCH 22, 1985               BANL   4
                                     .
                                     .
                                     .
                                     .
C---------------------------------------------------------------------------C   BANL  45
C                                                                               BANL  46
C                                                                               BANL  47
C***** MODIFICATION TO DG, SPLIT BANPAG INTO TWO PARTS BY TYPE                  BANL DG1
      COMMON /BANPAG1/BOXSTR(3520), LET                                         BANL DG2
      COMMON /BANPAG2/NR,NC,IR,IC                                               BANL DG3
C     COMMON /BANPAG/ BOXSTR(3520), LET, NR, NC, IR, IC                         BANL  48
C***** END OF MODIFICATION                                                      BANL DG4
      CHARACTER*1, BOXSTR, LET                                                  BANL  49
C                                                                               BANL  50
      DIMENSION MATRIX(6,5,50), INDEX(50)                                       BANL  51
      CHARACTER*1 INDEX                                                         BANL  52
C                                                                               BANL  53
                                     .
                                     .
                                     .
                                     .
C****************************************************************************C  BANL 125
      END                                                                       BANL 126
```

CHANGES TO SUBROUTINE BANNER

```
C**********************************************************************C BANN   1
      SUBROUTINE BANNER (VERSON,ITITLE)                                  BANN   2
C                                                                      C BANN   3
C   A MODULE OF LADTAP II, LATEST MODIFICATION - FEBRUARY 1, 1985      C BANN   4
                                    .
                                    .
                                    .
                                    .
C-----PARAMETER TYPE DEFINITIONS ---------------------------------------C BANN  60
C                                                                      C BANN  61
      CHARACTER*1 ITITLE                                                 BANN  62
      CHARACTER*1 VERSON(40)                                             BANN  63
      CHARACTER*10 TODAY                                                 BANN  64
      CHARACTER*1 TODAY1                                                 BANN  65
      CHARACTER*1  BOXSTR, LET                                           BANN  66
      CHARACTER*1  STAR, LINSTR, BOX                                     BANN  67
      CHARACTER*80 LINE                                                  BANN  68
C***** MODIFICATION FOR DG, ADD CHARACTER ARRAY NUM, SLASH                BANN DG1
      CHARACTER*1 NUM(10),SLASH                                          BANN DG2
C***** END OF MODIFICATION                                               BANN DG3
C                                                                      C BANN  69
C----- DIMENSION STATEMENTS --------------------------------------------C BANN  70
C                                                                      C BANN  71
C***** MODIFICATION FOR DG, ADD IDATE ARRAY                              BANN DG4
      DIMENSION IDATE(3)                                                 BANN DG5
C***** END OF MODIFICATION                                               BANN DG6
      DIMENSION ITITLE(78)                                               BANN  72
      DIMENSION TODAY1(10)                                               BANN  73
      DIMENSION BOX(88,40)                                               BANN  74
      DIMENSION LINE(10), LINSTR(80,10), IRL(10), ICL(10)                BANN  75
C                                                                      C BANN  76
C----- COMMON BLOCK DEFINITIONS ----------------------------------------C BANN  77
C                                                                      C BANN  78
C***** MODIFICATION FOR DG, SPLIT BANPAG INTO TWO PARTS BY TYPE          BANN DG7
      COMMON /BANPAG1/BOXSTR(3520),LET                                   BANN DG8
      COMMON /BANPAG2/NR,NC,IR,IC                                        BANN DG9
C     COMMON /BANPAG/ BOXSTR(3520), LET, NR, NC, IR, IC                  BANN  79
C*****END OF MODIFICATION                                                BANN DGA
C                                                                      C BANN  80
C----- EQUIVALENCE STATEMENTS ------------------------------------------C BANN  81
C                                                                      C BANN  82
      EQUIVALENCE (TODAY, TODAY1(1))                                     BANN  83
      EQUIVALENCE (BOX(1,1), BOXSTR(1))                                  BANN  84
      EQUIVALENCE (LINE(1), LINSTR(1,1))                                 BANN  85
C                                                                      C BANN  86
C----- DATA DEFINITIONS ------------------------------------------------C BANN  87
C                                                                      C BANN  88
C***** MODIFICATION FOR DG, DEFINE NUM ARRAY, 0, 9                       BANN DGB
      DATA NUM/'0','1','2','3','4','5','6','7','8','9'/                  BANN DGC
      DATA SLASH/'/'/                                                    BANN DGD
C***** END OF MODIFICATION                                               BANN DGE
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      DATA LINE(1) /'EVALUATION OF RADIATION DOSES FROM RELEASES OF RADIO          BANN  89
      ACTIVITY'/                                                                   BANN  90
      DATA LINE(2) /'IN NUCLEAR POWER PLANTS LIQUID EFFLUENTS'/                    BANN  91
                                      .
                                      .
                                      .
                                      .
      IF (IFIRST .LT. 1) THEN                                                      BANN 119
C                                                                                  BANN 120
C     ---- GET SYSTEM DATE ----                                                    BANN 121
C***** MODIFICATION FOR DG, DATE PARAMETER CHANGED TO IDATE                        BANN DGF
      CALL DATE (IDATE)                                                            BANN DGG
C     CALL DATE (TODAY)                                                            BANN 122
C***** END OF MODIFICATION                                                         BANN DGH
C                                                                                  BANN 123
C     ---- DRAW LINE AROUND THE BOX ----                                           BANN 124
                                      .
                                      .
                                      .
                                      .
C                                                                                  BANN 233
      IX = 0                                                                       BANN 234
C*****MODIFICATION FOR DG, SET CURRENT DATE INTO ARRAY FOR OUTPUT                  BANN DGI
      IDATE(1)=IDATE(1)-1900                                                       BANN DGJ
      INUMB=1+IDATE(2)/10                                                          BANN DGK
      TODAY1(1)=NUM(INUMB)                                                         BANN DGL
      INUMB=1 + (IDATE(2)-(IDATE(2)/10)*10)                                        BANN DGM
      TODAY1(2)=NUM(INUMB)                                                         BANN DGN
      TODAY1(3)=SLASH                                                              BANN DGO
      INUMB=1 + (IDATE(3)/10)                                                      BANN DGP
      TODAY1(4)=NUM(INUMB)                                                         BANN DGQ
      INUMB=1 + (IDATE(3)-(IDATE(3)/10)*10)                                        BANN DGR
      TODAY1(5)=NUM(INUMB)                                                         BANN DGS
      TODAY1(6)=SLASH                                                              BANN DGT
      INUMB=1 + (IDATE(1)/10)                                                      BANN DGU
      TODAY1(7)=NUM(INUMB)                                                         BANN DGV
      INUMB=1 + (IDATE(1)-(IDATE(1)/10)*10)                                        BANN DGW
      TODAY1(8)=NUM(INUMB)                                                         BANN DGX
      TODAY1(9)=' '                                                                BANN DGY
      TODAY1(10)=' '                                                               BANN DGZ
C***** END OF MODIFICATION                                                         BANN DG*
      DO 560 ICX = IC, IC+8                                                        BANN 235
        IX = IX + 1                                                                BANN 236
        BOX(ICX,IR) = TODAY1(IX)                                                   BANN 237
                                      .
                                      .
                                      .
                                      .
C**********************************************************************************C BANN 263
      END                                                                          BANN 264
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CHANGES TO SUBROUTINE PERDOS

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C***************************************************************************C PERD    1
      SUBROUTINE PERDOS (SPECIE,TDOSE,DOSE)                                   PERD    2
C                                                                           C PERD    3
C    A MODULE OF LADTAP II, LATEST MODIFICATION - MARCH 22, 1985            C PERD    4
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     1POP                                                                     PERD 107
      COMMON /ELEMEN/ IELEM(100)                                              PERD 108
C***** MODIFICATION FOR DG, SET PATH PCORG INTO COMMONS                        PERD DG1
      COMMON /PRPATH/PATH(8,3)                                                PERD DG2
      COMMON /PPCORG/PCORG(8)                                                 PERD DG3
C**** COMMON/PRPATH/ PATH(8,3),PCORG(8)                                        PERD 109
C***** END OF MODIFICATION                                                     PERD DG4
      COMMON /SORCE/ IZ(700),IMASS(700),NLIBA,NLIBT,NLIBC,NLIBI               PERD 110
      COMMON /STATE/ META(700)                                                PERD 111
      COMMON /TRANS/ DILW                                                     PERD 112
C***** MODIFICATION FOR DG, ACTIVATE COMMON BLOCK FOR LCM                      PERD DG5
      COMMON /LCM/ DOS(8,100,8),PER(8,100,8)                                  PERD 113
C***** END OF MODIFICATION                                                     PERD DG6
C                                                                             PERD 114
C----- DIMENSION STATEMENTS ------------------------------------------------C PERD 115
C                                                                             PERD 116
C***** MODIFICATION FOR DG, REMOVE PATH AND PCORG FROM DIMENSION STATEMENT     PERD DG7
C     DIMENSION PATH(8,3),PCORG(8)                                            PERD 117
      DIMENSION SPECIE(3), TDOSE(8), DOSE(200,8), SET(3)                      PERD 118
      DIMENSION DOS2(8)                                                       PERD DG8
C     DIMENSION DOS(8,100,8),PER(8,100,8),DOS2(8)                             PERD 119
C***** END OF MODIFICATION                                                     PERD DG9
C                                                                           C PERD 120
C----- DATA STATEMENTS -----------------------------------------------------C PERD 121
C                                                                           C PERD 122
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C***************************************************************************C PERD 304
      END                                                                     PERD 305
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CHANGES TO SUBROUTINE PLOP

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C****************************************************************************C PLOP   1
      SUBROUTINE PLOP (DOSE,N)                                                 PLOP   2
C                                                                           C PLOP   3
C   A MODULE OF LADTAP II, LATEST MODIFICATION - MARCH 22, 1985             C PLOP   4
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                                      .
                                      .
                                      .
C                                                                           C PLOP  65
C---- COMMON BLOCK DEFINITIONS ---------------------------------------------C PLOP  66
C                                                                           C PLOP  67
C***** MODIFICATION FOR DG, ADD COBEAD TO COMMON STATEMENT                     PLOP DG1
      COMMON /COSTB/COBEAD(200,8)                                              PLOP DG2
C***** END OF MODIFICATION                                                     PLOP DG3
      COMMON /SORCE/ IZ(700),IMASS(700),NLIBA,NLIBT,NLIBC,NLIBI                PLOP  68
      COMMON /STATE/ META(700)                                                 PLOP  69
      COMMON /ELEMEN/ IELEM(100)                                               PLOP  70
      COMMON Q(200),PL,CFS,NSOR,LT,RECO(200),LIST(200,4),LCT,LZ,CON,KIT,       PLOP  71
     1POP                                                                      PLOP  72
C                                                                           C PLOP  73
C---- DIMENSION STATEMENTS -------------------------------------------------C PLOP  74
C                                                                           C PLOP  75
C***** MODIFICATION FOR DG, REMOVE COBEAD FROM DIMENSION STATEMENT             PLOP DG4
C     DIMENSION COBEAD(200,8)                                                  PLOP  76
C***** END OF MODIFICATION                                                     PLOP DG5
      DIMENSION DOSE(200,8)                                                    PLOP  77
C                                                                           C PLOP  78
C---- START OF CALCULATIONS ------------------------------------------------C PLOP  79
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C****************************************************************************C PLOP 143
      END                                                                      PLOP 145
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