

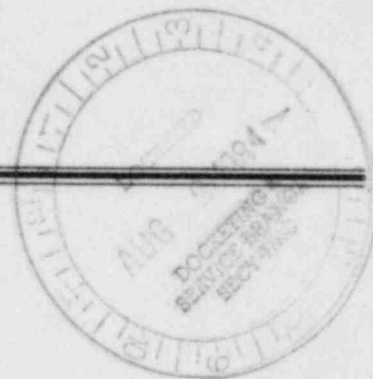
User's Manual for LADTAP II — A Computer Program for Calculating Radiation Exposure to Man from Routine Release of Nuclear Reactor Liquid Effluents

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PREFACE

The main purpose of this manual is to provide a user's guide to the preparation of input for the LADTAP II computer program and to make available in one document essential information for its understanding and use. The basic methodology, published in NRC Regulatory Guides 1.109 and 1.113, is included as appendices with the permission of Technical Information and Document Control Division, Office of Administration, U. S. Nuclear Regulatory Commission. Background information on the original LADTAP code development is referenced.

A brief abstract (page vii) is prepared for use by indexing services. A detailed abstract (Section 1) is furnished for the technical person who needs to make a quick judgment prior to requesting the complete code package from the disseminating agency (Section 1.12).

The authors claim no credit for the original LADTAP development, the work of staff members of the Radiological Assessment Branch of the U. S. Nuclear Regulatory Commission. We acknowledge with deep appreciation their technical guidance throughout the LADTAP revision and documentation process. Since documentation, as well as code development, is subject to change following critical examination and usage, we solicit feedback from the user community.

Questions and feedback from usage concerning the RSIC-distributed code package should be referred to the Radiation Shielding Information Center (RSIC), Oak Ridge National Laboratory, P. O. Box X, Oak Ridge, Tennessee 37830 (Telephone: 615-574-6176 or FTS 624-6176).

We acknowledge with appreciation the work of Ms. Eddie Bryant in the preparation of this document for publication.

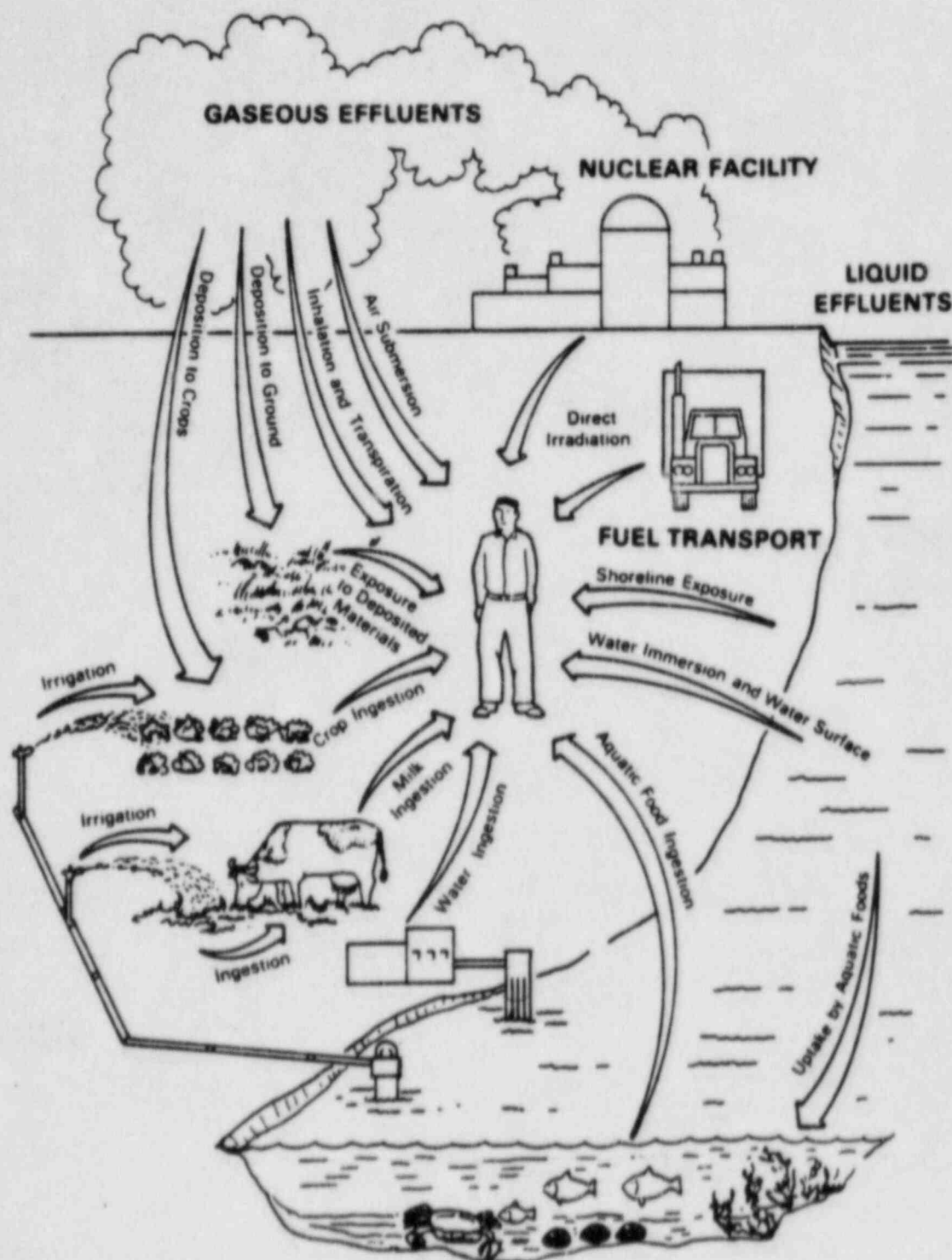
The Authors

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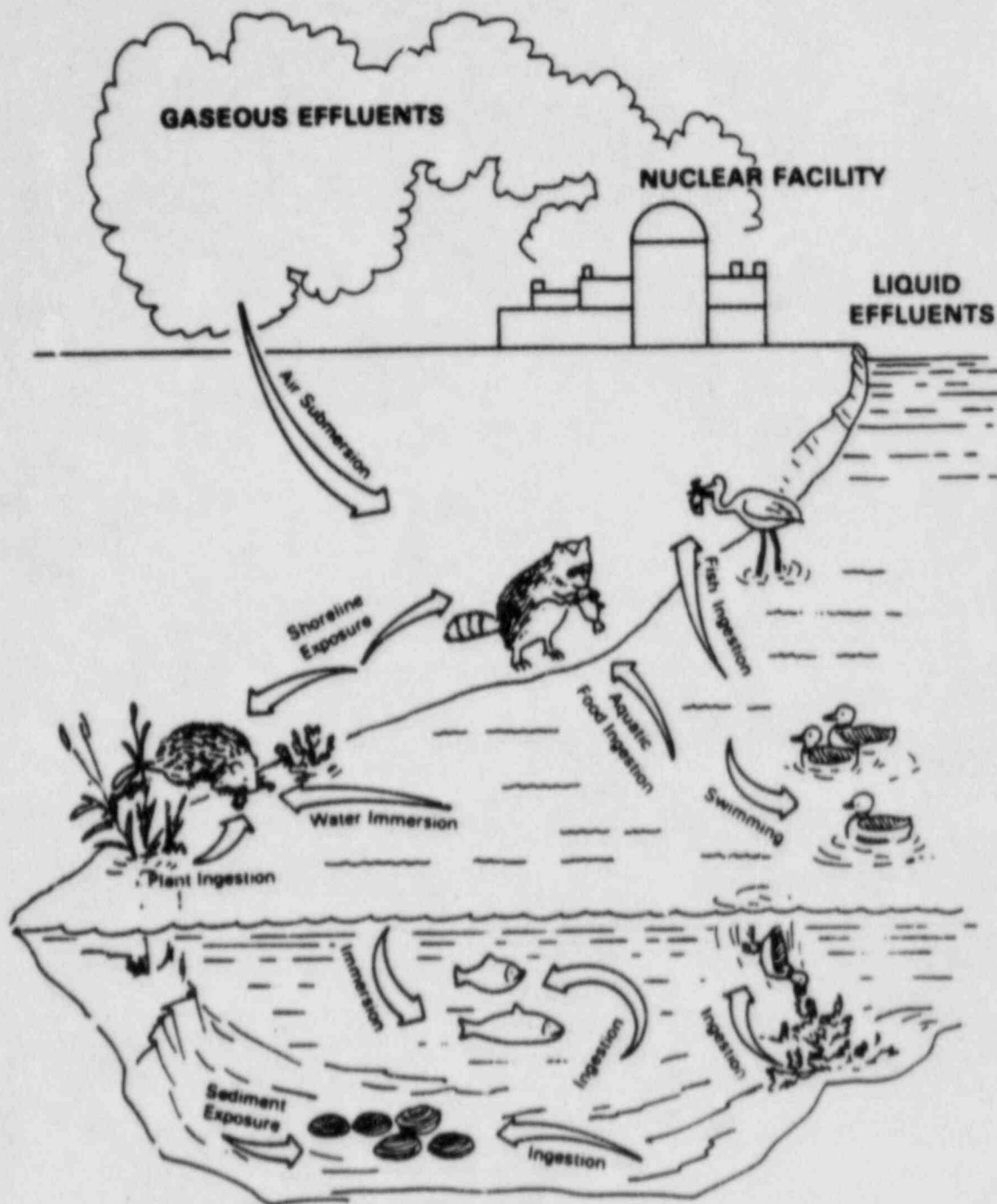
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ABSTRACT

LADTAP II, a revision of the original LADTAP, implements the radiological exposure models of Regulatory Guide 1.109 appropriate for determining the radiation dose to man from the pathways in the aquatic environment - potable water, aquatic foods, shoreline deposits, swimming, boating, and irrigated foods. Doses for both the maximum individual and the general population are calculated as a function of age group and pathway for appropriate body organs. It also implements the models of WASH-1258 for calculation of doses to certain species of biota other than man.



As Modeled in LADTAP II



As Modeled in LADTAP II

SECTION 1. PROGRAM ABSTRACT

- 1.1. Program: LADTAP II (Liquid Annual Doses to All Persons) -
a revision of the original LADTAP (listed in NUREG-0133).

1.2. Problem Solved

Evaluation of radiological exposure due to the release of radioactive material from nuclear power plants during normal operation via liquid effluent pathways. LADTAP II, as was its predecessor, is used in reactor licensing evaluations to estimate maximum individual and general population doses by the Radiological Assessment Branch (RAB), Division of Site Safety and Environmental Analysis (DSE), Office of Nuclear Reactor Regulation (ONRR), United States Nuclear Regulatory Commission (NRC). It may also be used for calculation of doses to certain representative primary and secondary organisms, other than man, in the aquatic environment.

1.3. Method of Solution

LADTAP II implements the radiological exposure models described in US NRC Regulatory Guide 1.109, Rev. 1 (Appendix A) for radioactivity releases in liquid effluent. The usage factors contained in Regulatory Guide 1.109 have been included as standard assumptions but may easily be replaced with site-specific data.

Up to 200 nuclides may be included in the release source term. Reconcentration, if any, of each nuclide is determined from one of the three models (chosen by the user) available in the program, or the user may input the reconcentration factor if none of the models available in the program is appropriate. Available options include the complete mixing, partial mixing, or the plug-flow model. These models are described in US NRC Regulatory Guide 1.113 (Appendix B). A companion dose factor library is searched to obtain appropriate dose factors for each age group for each nuclide in the release input.

LADTAP II calculates the radiation exposure to man from potable water, aquatic foods, shoreline deposits, swimming, boating, and irrigated foods, and also the dose to biota. Doses are calculated for both the maximum individual and for the population and are summarized for each pathway by age group and organ. It also calculates the doses to certain representative biota, other than man, in the aquatic environment such as fish, invertebrates, algae, muskrat, raccoon, heron, and duck using models presented in WASH-1258.

1.4. Related Material

An external data file of dose factors (the dose factor library) supplied with the code and tabulated in Appendix C is used. The internal dose factors in the library are taken (with revisions for some radio-nuclides) from NUREG-0172, Age Specific Radiation Dose Commitment Factors For a One-Year Chronic Intake, November 1977.

1.5. Restrictions

Limits for the number of dose receptor locations, etc., to be input are given in the input description. Many constant parameter values are stored in block DATA and once a parameter in common block DATA is altered, it remains at that value until altered further.

1.6. Computers

Source decks for both IBM and CDC are available.

1.7. Running Time

The sample problem distributed with the code executes in less than 10 sec. of IBM-360/91 CPU time from the loaded program.

1.8. Programming Languages

FORTRAN IV.

1.9. Operating System

No special requirements or restrictions are made of the operating system.

1.10. Machine Requirements

Approximately 60,000 words of memory are required. A sequential access device is required for the dose factor library.

1.11. References

- (1) Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, U. S. Nuclear Regulatory Commission, Regulatory Guide 1.109, Revision 1, October 1977. (APPENDIX A)
- (2) Estimating Aquatic Dispersion of Effluents From Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I, U. S. Nuclear Regulatory Commission, Regulatory Guide 1.113, Revision 1, April 1977. (APPENDIX B)
- (3) G. R. Hoenes and J. K. Soldat, Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake, NUREG-0172, Battelle Pacific Northwest Laboratories, Richland, Washington, for the U. S. Nuclear Regulatory Commission, Washington, D. C. 20555, November 1977.
- (4) J. S. Boegli, W. L. Britz, R. R. Bellamy, and R. L. Waterfield, Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants, NUREG-0133, U. S. Nuclear Regulatory Commission, Washington, D. C. 20555, October 1978.
- (5) Final Environmental Statement Concerning Proposed Rule Making Action - Vol. 2 Analytical Models and Calculations (Appendix F) - U.S. Atomic Energy Commission, 1973.

* Available for purchase from the NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, and the National Technical Information Service, Springfield, Virginia 22161.

1.12 Availability

The code package, including documentation, is available from the
Radiation Shielding Information Center (RSIC)
Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, TN 37830

A full reel of magnetic tape, furnished by the requester, is required for transmittal of the code package. The requester should include in his letter of request information as to how the tape should be written (what track channel and what density) and on what computer the code will be implemented.

SECTION 2 - USER'S INFORMATION

2.1. Introduction

LADTAP II is a revision and update of LADTAP, originally developed by James S. Bland NRC/ONRR/DSE/RAB. Several modifications to LADTAP suggested by Keith F. Eckerman (formerly with RAB) and Sarbeswar Acharya (RAB) were incorporated, and an independent assessment of the code was performed within the Technical Data Management Center (TDMC), Engineering Physics Division (EPD), Oak Ridge National Laboratory (ORNL).

The revisions and the revised code assessment studies to LADTAP were performed by David B. Simpson within the NRC-sponsored ORNL/TDMC. The LADTAP II User's Manual was written by TDMC staff members, Simpson and Betty L. McGill with the liberal assistance of the contract monitor, Sarbeswar Acharya.

Questions and feedback from usage concerning the RSIC-distributed code package should be referred to the Radiation Shielding Information Center (RSIC), ORNL, P. O. Box X, Oak Ridge, Tennessee 37830 (Telephone: 615-574-6176 or FTS 624-6176).

A particular modification performed was the incorporation of a scheme which allows the user to alter easily the standard usage parameters in Regulatory Guide 1.109 (Appendix A) to allow for site-specific data. The FIDO (Floating Index Data Operations) input system (Section 2.4) is used in many computer programs and affords an efficient and well-suited procedure for achieving this capability. Most of the standard usage parameters have been collected into a common block named DATA. A description of this common block is presented in Section 2.2.2 and an edit of the default values may be obtained by placing a '-1' in columns 49 and 50 of the second input data card. This is illustrated in the sample problem in Appendix D.

2.2. Input Specifications

LADTAP II incorporates the calculational models and parameters projected in Regulatory Guide 1.109 (Appendix A) as standard assumptions. The program allows the user to change these parameters to allow for site-specific data. Some parameter defaults may be altered using either of two means. Any parameter stored in common block DATA may be changed using the FIDO input (Section 2.4) described below. The usage factors contained in Tables E.4 and E.5 of Regulatory Guide 1.109 may be altered by selecting the correct options and inserting the appropriate data cards (e.g., card #7a, 7b, 7c, 7d). Once the parameters are changed, they remain at the altered values for further use. The Guide should be consulted for additional information on these models and parameters.

2.2.1. User Input

Input data cards are referenced by a card number. Some data cards contain a field through which the user may specify that optional input will follow. These additional data cards are designated by a lower case alphabetic subscript along with the same card number as that of the previous card containing the option (e.g., card #7). These data cards are input only if the option for their input is chosen.

<u>Card Number</u>	<u>Columns</u>	<u>Format</u>	<u>Description</u>
<u>General site information</u>			
1	3-80	A78	Site identification
2	1-10	I10	0/>0 = Freshwater/saltwater site
	11-20	E10	Total discharge from all units (ft ³ /sec)
	21-30	E10	Release multiplier (i.e., multiplier of source term which is number of reactor units.)
	31-40	I10	0/>0 = no effect/edit percentages as well as printout of A _{ir} factors for Tech. Spec.
	41-50	I10	-1/0/1/2 = Edit only/no effect/override and edit/override only parameter defaults

2a (A FIDO data block, delimited by a T, for overriding data values in common block DATA.)

3	1-10	E10	50 mile population (-ve to printout A ₁₇ factors for Tech. Spec.)
	11-20	I10	0/> 0 = No effect/change the population age distribution
3a	1-10	E10	Adult fraction of population
	11-20	E10	Teenage " " "
	21-30	E10	Child " " "

Source term

4	3-80	A78	Source identification
5.1	3-4	A2	Nuclide symbol, left justified
	5-9	A5	Mass numbers, left justified, including M for metastable states
	11-20	E10	Release rate (1 ci/yr for A ₁₇ factors for Tech. Spec.).
	21-30	E10	Reconcentration factor (used if no reconcentration model is selected in card 6). The default value is 1.
5.2	(One card for each release. Last release must be followed by a blank card to designate the end of the source specification. Maximum number of releases is 200.)		
.			
.			
.			
Etc.			

Reconcentration

6	1-10	I10	0/1/2/3 = No reconcentration/complete mixing/Plug flow model/Partial mixing
	11-20	E10	Blowdown rate from pond (ft ³ /sec)
	21-30	E10	Total volume of impoundment (ft ³)

ALARA specifications (dose to individual)

7	1-10	I10	0/>0 = No effect/change the standard usage and consumption parameters
	11-20	E10	Shorewidth factor
	21-30	E10	Dilution for aquatic foods
	31-40	E10	Dilution for shoreline -
	41-50	E10	Dilution for drinking water
	51-60	E10	Discharge transit time (hr)
	61-70	E10	Transit time to drinking water intake (hr)
7a	(Altered usage: adult parameters)		
	1-10	E10	Fish consumption (kg/yr)
	11-20	E10	Invertebrate consumption (kg/yr)
	21-30	E10	Algae consumption (kg/yr)
	31-40	E10	Water usage (liters/yr)
	41-50	E10	Shoreline usage (hr/yr)
	51-60	E10	Swimming usage (hr/yr)
	61-70	E10	Boating usage (hr/yr)
7b,7c,7d	(As above for teenagers, children, and infants respectively)		

Selected locations (dose to individual)

8	1-10	I10	0/>0 = No effect/change the standard usage and consumption parameters
	11-20	E10	Dilution
	21-30	E10	Transit time (hr)
	31-40	E10	Shorewidth factor
	41-52	A12	Location identification
8a	(Altered usage: adult parameters)		
	1-10	E10	Fish consumption (kg/yr)
	11-20	E10	Invertebrate consumption (kg/yr)
	21-30	E10	Algae consumption (kg/yr)
	31-40	E10	Water usage (liters/yr)
	41-50	E10	Shoreline usage (hr/yr)
	51-60	E10	Swimming usage (hr/yr)
	61-70	E10	Boating usage (hr/yr)
8b,8c,8d	(Same as 8a except for teenagers, children, and infants respectively)		

NOTE: There is one card 8 set used for each selected location. The last location must be followed by a blank card.

POPULATION (dose specifications)

Card Number	Columns	Format	Description
-------------	---------	--------	-------------

Sport fish harvest (One card for each location; last location followed by a blank card. Maximum number of locations is 20.)

9	1-10	E10	Fish harvest (kg/yr)
	11-20	E10	Dilution
	21-30	E10	Transit time (hr)
	31-50	A20	Location identification

Commercial fish harvest (One card for each location; last location followed by a blank card. Maximum number of locations is 20.)

10	1-10	E10	Fish harvest (kg/yr)
	11-20	E10	Dilution
	21-30	E10	Transit time (hr)
	31-50	A20	Location identification

Sport invertebrate harvest (One card for each location; last location followed by a blank card. Maximum number of locations is 20.)

11	1-10	E10	Invertebrate harvest (kg/yr)
	11-20	E10	Dilution
	21-30	E10	Transit time (hr)
	31-50	A20	Location identification

Commercial invertebrate harvest (One card for each location; last location followed by a blank card. Maximum number of locations is 20.)

12	1-20	E10	Invertebrate harvest (kg/yr)
	11-20	E10	Dilution
	21-30	E10	Transit time (hr)
	31-50	A20	Location identification

Population drinking water (One card for each supplier; last supplier followed by a blank card. For each supplier, provide either card 13A or 13B.)

13A	1-10	E10	Population
	11-20	E10	Dilution
	21-30	E10	Transit time (hr)
	51-70	A20	Supplier identification
13B	11-20	E10	Dilution
	21-30	E10	Transit time (hr)
	31-40	E10	System supply (gallons/day)
	41-50	E10	Average individual use (gallons/day)
	51-70	A20	Supplier identification

Population shoreline (One card for each location of recreational activity; last location followed by a blank card.)

14	1-10	E10	Usage (man-hours)
	11-20	E10	Dilution
	21-30	E10	Transit time (hr)
	31-40	E10	Shorewidth factor
	41-52	A12	Location identification

Population swimming (One card for each location of recreational activity; last location followed by a blank card.)

15	1-10	E10	Usage (man-hours)
	11-20	E10	Dilution
	21-30	E10	Transit time (hrs)
	31-42	A12	Location identification

Population boating (One card for each location of recreational activity; last location followed by a blank card.)

16	1-10	E10	Usage (man-hours)
	11-20	E10	Dilution
	21-30	E10	Transit time (hrs)
	31-42	A12	Location identification

Irrigated foods: individual and population

(Cards 17 and 18 are treated as a set: one set of cards 17 and 18 for each food type. In the absence of irrigation pathway, use a blank card after card 16 to skip cards 17 and 18. For each food type specified by card 17, there is a maximum of 20 locations specified by card 18 with a blank card following the last card 18 for each location set. The program recycles to card 17 for another food type. Recycling is terminated by providing a blank card.)

17	1-10	I10	1/2/3/4 = vegetation/leafy vegetation/milk/meat
	11-20	I10	0/>0=no effect/change consumption parameters
	21-30	E10	Irrigation rate (liters/m ² /month)
	31-40	E10	Fraction of animal feed which is not irrigated
	41-50	E10	Fraction of animal water intake not obtained from irrigation system
	51-60	E10	Total 50 mile yield (kg)
17a	1-10	E10	Maximum adult consumption (kg/yr)
	11-20	E10	Maximum teenager consumption (kg/yr)
	21-30	E10	Maximum child consumption (kg/yr)
	31-40	E10	Average adult consumption (kg/yr)
	41-50	E10	Average teenager consumption (kg/yr)
	51-60	E10	Average child consumption (kg/yr)
	61-70	E10	Transfer time (hr) - maximum individual
18	71-80	E10	Transfer time (hr) - average individual
	1-10	E10	Dilution
	11-20	E10	Production (kg/yr)
	21-30	E10	Transit time (hr)
	31-50	A20	Location identification

Biota Dose (One card for each location; last location must be followed by a blank card.)

19	1-10	E10	Dilution
	11-20	E10	Transit time (hr)
	21-40	A20	Location identification

2.2.2. Additional Input Instructions

The 994 words of common block DATA have been arranged for convenience in groups of variables having similar definition or usage. This arbitrary grouping was chosen for use with the FIDO input system to provide the user a means of easily overriding parameter defaults with site specific data. For example, to change the default values of the yield of irrigated vegetation (2.0 kg) and the duration of the irrigation (30 days) to 2.5 kg and 60 days, card 2a would appear as '1** A8 2.5 60 E T'.

The ordering of the variables by FIDO array number is summarized below. The number of words in each FIDO array is given in brackets. LADTAP II uses only one call to FIDO (one data block), so as many cards as are needed are used for the input of card 2a. The last card needed for this input must contain a 'T' as the last entry on the card. The FIDO input system is described in a later section of this document (Section 2.4).

FIDO Array Description

1* [16] General parameters

1. Adult fraction of population (0.71)
2. Teenage fraction of population (0.11)
3. Child fraction of population (0.18)
4. Total US population ($2.6E+8$)
5. Midpoint of plant life (15 years)
6. Process time of aquatic foods (24 hrs.)
7. Process time in water supply system (12 hrs.)
8. Yield of irrigated vegetation (2.0 kg)
9. Duration of irrigation (30 days)
10. Milk animal's consumption of pasture (50 kg/day)
11. Milk animal's consumption of water (60 liters/day)
12. Beef animal's consumption of pasture (50 kg/day)
13. Beef animal's consumption of water (50 liters/day)
14. Vegetation capture fraction (0.25)
15. Weathering half-time of foliar deposition (14 days)
16. Density thickness of root zone (240 kg/m^2)

2* [7] Maximum infant's usage parameters

1. Consumption of fish
2. Consumption of freshwater invertebrates
3. Consumption of aquatic plants
4. Consumption of water
5. Shoreline usage
6. Swimming usage
7. Boating usage

3* [7] Maximum child's usage parameters (see 2*)

4* [7] Maximum teenager's usage parameters (see 2*)

5* [7] Maximum adult's usage parameters (see 2*)

6* [3] Saltwater invertebrate consumption

1. Maximum child
2. Maximum teenager
3. Maximum adult

- 7* [8] Irrigated vegetation parameters
 - 1. Average adult consumption
 - 2. Average teenager consumption
 - 3. Average child consumption
 - 4. Maximum adult consumption
 - 5. Maximum teenager consumption
 - 6. Maximum child consumption
 - 7. Process time for average individuals
 - 8. Process time for maximum individuals
- 8* [8] Leafy vegetation parameters (see 7*)
- 9* [8] Milk parameters (see 7*)
- 10* [8] Meat parameters (see 7*)
- 11* [12] Parameters for sport and commercial fish and invertebrate harvests
 - 1. Process time between harvest and consumption of sport catch (168 hrs.)
 - 2. Process time between harvest and consumption of commercial catch (240 hrs.)
 - 3. Freshwater commercial harvest of fish (44E+6 kg.)
 - 4. Freshwater commercial harvest of invertebrates (2.3E+6 kg.)
 - 5. Saltwater commercial harvest of fish (6.58E+8 kg.)
 - 6. Saltwater commercial harvest of invertebrates (4.1E+8 kg.)
 - 7. Average adult's consumption of fish (6.9 kg.)
 - 8. Average teenager's consumption of fish (5.2 kg.)
 - 9. Average child's consumption of fish (2.2 kg.)
 - 10. Average adult's consumption of invertebrates (1.0 kg.)
 - 11. Average teenager's consumption of invertebrates (0.75 kg.)
 - 12. Average child's consumption of invertebrates (0.33 kg.)
- 12* [3] Average individual's annual water consumption
 - 1. Adult (370 liters)
 - 2. Teenager (260 liters)
 - 3. Child (260 liters)
- 13* [100] Freshwater BAF's for fish
- 14* [100] Freshwater BAF's for invertebrates
- 15* [100] Freshwater BAF's for aquatic plants
- 16* [100] Saltwater BAF's for fish
- 17* [100] Saltwater BAF's for invertebrates

- 18* [100] Saltwater BAF's for aquatic plants
- 19* [100] Meat transfer parameters (day/kg.)
- 20* [100] Milk transfer parameters (days/liter)
- 21* [100] Soil to plant transfer parameters

2.3. Additional User Information

Cards 7 and 8 are used for individual doses. Card 7 is designed for the Appendix I of 10 CFR 50 individual dose determination since more flexibility is allowed in the dilution and downstream transit time input. Cards 9 to 16 are used for population doses only.

The dilution factor in all inputs should be a real number of 1.0 or greater (i.e., inverse of mixing ratio).

Cards 17 and 18 are for the irrigated food pathway. Both individual and population doses are calculated for this pathway. The maximum individual doses are calculated at the downstream location of minimum dilution.

An option is included to tabulate factors for inclusion into the Offsite Dose Computational Manual (ODCM)⁴ of the technical specifications. To execute the options, the standard LADTAP II input deck is prepared with the following restrictions:

1. An integer >0 in cols. 31-40 on card 2.
2. A negative 50 mile population should be specified on Card 3.
3. The nuclides of interest should be included in the source term with a release of 1 ci/yr. (Cards 5.1, 5.2, etc.).
4. For Card 7, the dilution for aquatic foods should be specified as 1.0 and the dilution for drinking water (fresh water site) should be supplied relative to the discharge region. The appropriate transit times should also be used or default to zero.

Data beyond card 7 need not be prepared for this option.

2.4. FIDO (Floating Index Data Operation) Input System

The FIDO (Floating Index Data Operations) input method is especially devised to allow the entering or modifying of large data arrays with minimum effort. Special advantage is taken of patterns of repetition or symmetry wherever possible. Developed by W. A. Rhoades and W. W. Engle at Atom'cs International in the early 1960's for use in a one-dimensional discrete ordinates code (DTF-II), FIDO was patterned after an input method used with the early FLOCO coding system at Los Alamos Scientific Laboratory. Since that time, numerous features requested by users have been added, a free-field option has been developed, and FIDO applications are widespread.

Use of FIDO provides powerful and attractive advantages to the programmer as well as the user. The programmer may insure efficient core utilization as well as relieve himself of the worry with read statements and associated formatting. The user is relieved of the burden of formatted input requirements (when using free-field input) and may enter or modify lengthy data arrays with a minimum of effort.

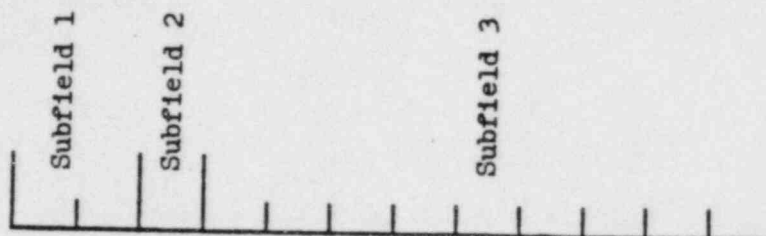
Efficient core utilization is achieved by the flexible dimensioning inherent with FIDO usage. With flexible dimensioning, the length of arrays read by FIDO in one block may be determined by parameters read in a previous block. This is similar to FORTRAN run-time dimensioning. The important feature is that one contiguous area of storage is available for all data arrays and is denoted as an array whose dimension is the length of that area. The displacements needed for referencing subarrays are also stored contiguously in the same or a different area. When the 'N' array is read by FIDO, the origin of that array is determined by the N-th displacement and the length is determined by the difference between the N+1 and N-th displacements. This feature is further enhanced when dynamic storage allocation is possible.

A group of one or more arrays read with a single call to the FIDO package forms a block, and a special delimiter is used to signify the end of each block. Arrays may be read in any order within a block, but

an array belonging to one block should not be placed within another block. An array can be entered more than once within a block, in which case the last value read for each location within the array is stored. If no entries to the arrays within a block are required, the delimiter alone satisfies the input requirement. Arrays may be read as fixed-field, free-field, or user-field input.

2.4.1. Fixed-Field Input

Each card is divided into six 12-column data fields, each of which is divided into three subfields. The following sketch illustrates a typical data field. The three subfields always comprise 2, 1, and 9 columns, respectively.



To begin the first array of a block, an array originator field is placed in any field on a card:

Subfield 1: An integer array identifier < 100 specifying the data array to be read in.

Subfield 2: An array-type indicator:
"\$" if the array is integer data
"*" if the array is real data

Subfield 3: Blank

Data are then placed in successive fields until the required number of entries has been accounted for. A sample data sheet shown below illustrates this input.

In entering data, it is convenient to think of an "index" or "pointer" which is under control of the user, and which specifies the position in the array into which the next data entry is to go. The pointer is always positioned at array location #1 by entering the array originator field. The pointer subsequently moves according to the data operator chosen. Blank fields are a special case, in that they do not cause any data modification and do not move the pointer.

A data field has the following form:

Subfield 1: The data numerator, an integer < 100 . We refer to this entry as N_1 in the following discussion.

Subfield 2: One of the special data operators listed below.

Subfield 3: A nine-character data entry, to be read in F9.0 format. It will be converted to an integer if the array is a "\$" array or if a special array operator such as Q is being used. Note that an exponent is permissible but not required. Likewise, a decimal is permissible but not required. If no decimal is supplied it is assumed to be immediately to the left of the exponent, if any; and otherwise to the right of the last column. This entry is referred to as N_3 in the following discussion.

A list of data operators and their effect on the array being input follows:

<u>Operator</u>	<u>Description</u>
-----------------	--------------------

blank	"Blank" indicates a single entry of data. The data entry in the third subfield is entered in the location indicated by the pointer, and the pointer is advanced by one. However, an entirely blank field is ignored.
-------	--

- + " " or " " indicates exponentiation. The data entry in the third field is entered and multiplied by 10^{+N_1} , where N_1 is the data numerator in the first subfield, given the sign indicated by the data operator itself. The pointer advances by one. In cases where an exponent is needed, this option allows the entering of more significant figures than the blank option.
- & "&" has the same effect as "+".
- R "R" indicates that the data entry is to be repeated N_1 times. The pointer advances by N_1 .
- I "I" indicates linear interpolation. The data numerator, N_1 , indicates the number of interpolated points to be supplied. The data entry in the third subfield is entered, followed by N_1 interpolated entries equally spaced between that value and the data entry found in the third subfield of the next non-blank field. The pointer is advanced by $N_1 + 1$. The field following an "I" field is then processed normally, according to its own data operator. In "\$" arrays, interpolated values will be rounded to the nearest integer.
- L "L" indicates logarithmic interpolation. The effect is the same as that of "I" except that the resulting data are evenly separated in log-space.
- Q "Q" is used to repeat sequences of numbers. The length of the sequence is given by the third subfield, N_3 . The sequence of N_3 entries is to be repeated N_1 times. The pointer advances by $N_1 * N_3$. If either N_1 or N_3 is 0, then a sequence of $N_1 + N_3$ is repeated one time only, and the pointer advances by $N_1 + N_3$.
- N The "N" option has the same effect as "Q", except that the order of the sequence is reversed each time it is entered.

M "M" has the same effect as "N" except that the sign of each entry in the sequence is reversed each time the sequence is entered. For example, the entries:

1 2 3 2M2

would be equivalent to

1 2 3 -3 -2 2 3.

Z "Z" causes $N_1 + N_3$ locations to be set to 0. The pointer is advanced by $N_1 + N_3$.

C "C" causes the position of the last array item entered to be printed. This is the position of the pointer, less 1. The pointer is not moved.

Ø "Ø" causes the print trigger to be changed. The trigger is originally off. Successive "Ø" fields turn it on and off alternately. When the trigger is on, each card image is listed as it is read.

S "S" indicates that the pointer is to skip N_1 positions leaving those array positions unchanged. If the third subfield is blank, the pointer is advanced by N_1 . If the third subfield is non-blank that data entry is entered following the skip, and the pointer is advanced by $N_1 + 1$.

A "A" moves the pointer to the position, N_3 , specified in the third subfield.

F "F" fills the remainder of the array with the datum entered in the third subfield.

E "E" skips over the remainder of the array. The array length criterion is always satisfied by an E, no matter how many entries have been specified. No more entries to an array may be given following an "E", except that data entry may be restarted with an "A".

The reading of data to an array is terminated when a new array origin field is supplied, or when the block is terminated. If an incorrect number of positions has been filled, an error edit is given, and a flag is set which may later abort execution of the problem. FIDO then continues with the next array if an array origin was read.

A block termination consists of a field having "T" in the second subfield. All entries following "T" on a card are ignored, and control is returned from FIDO to the calling program.

Comment cards can be entered within a block by placing an apostrophe (') in column 1. Then columns 2-80 will be listed, with column 2 being used for printer carriage control. Such cards have no effect on the data array or pointer.

2.4.2. Free-Field Input

With free-field input, data are written without fixed restrictions as to field and subfield size and positioning on the card. The options used with fixed-field input are available, although some are slightly restricted in form. In general, fewer data cards are required for a problem, a card listing is more intelligible, the cards are easier to keypunch, and certain common keypunch errors are tolerated without affecting the problem. Data arrays using fixed- and free-field input can be intermingled at will within a given block.

The concept of three subfields per field is still applicable to free-field input, but if no entry for a field is required, no space for it need be left. Only columns 1-72 may be used, as with fixed-field input.

The array originator field can begin in any position. The array identifiers and type indicators are used as in fixed-field input. The type indicator is entered twice, to designate free-field input (i.e., "\$\$" or "***"). The blank third subfield required in fixed-field input is not required. For example:

31**

indicates that array 31, a real-data array, will follow in free-field format.

Data fields may follow the array origin field immediately. The data field entries are identical to the fixed-field entries with the following restrictions:

- (1) Any number of blanks may separate fields, but at least one blank must follow a third subfield entry if one is used.
- (2) If both first- and second-subfield entries are used, no blanks may separate them, i.e., 24S, but not 24 S.
- (3) Numbers written with exponents must not have imbedded blanks, i.e., 1.OE+4, 1.OE4, 1.O+4, or even 1+4, but not 1.O E4.
- (4) In third-subfield data entries, only 9 digits, including the decimal but not including the exponent field, can be used, i.e., 123456.89E07, but not 123456.789E07.
- (5) The Z entry must be of the form: 738Z, not Z738 or 738 Z.
- (6) The + or - data operators are not needed and are not available.
- (7) The Q, N, and M entries are restricted: 3Q4, 1N4, or M4, but not 4Q, 4N, or 4M.

2.4.3. User-Field Input

If the user follows the array identifier in the array originator field with the character "U" or "V", the input format is to be specified by the user. If "U" is specified, the FORTRAN FORMAT to be used must be supplied in columns 1-72 of the next card. The format must be enclosed by the usual parentheses. Then the data for the entire array must follow on successive cards. The rules of ordinary FORTRAN input as to exponents, blanks, etc., apply. If the array data do not fill the last card, the remainder must be left blank.

"V" has the same effect as "U" except that the format read in the last preceding "U" array is used.

Example of FIDO Free-Field Input

```
1$$ FO
2** 12.34-1 4Z
3** A5 60 E
4$$ 2I1 2R4 2Q5
T
```

```
Zero out the 1$ array
Enter 1.234 and 4 zeroes in the 2* array
Enter 60.0 as the 5th entry of the 3* array
Enter 1,2,3,4,4,1,2,3,4,4,1,2,3,4,4
Terminate the block
```