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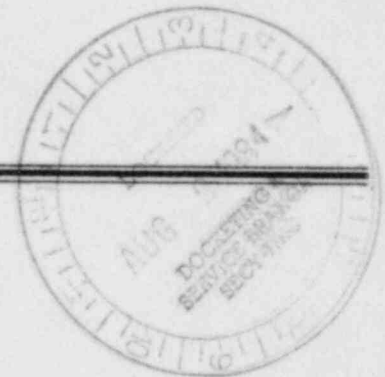 User's Manual for LADTAP II — A Computer Program for Calculating Radiation Exposure to Man from Routine Release of Nuclear Reactor Liquid Effluents

## 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*

# CONTENTS

# 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

GASEOUS EFFLUENTS

NUCLEAR FACILITY

LIQUID
EFFLUENTS

Air Submersion

Shoreline
Exposure

Fish Ingestion

Aquatic
Food Ingestion

Swimming

Water Immersion

Plant Ingestion

Immersion

Ingestion

Ingestion

Sediment
Exposure

Ingestion
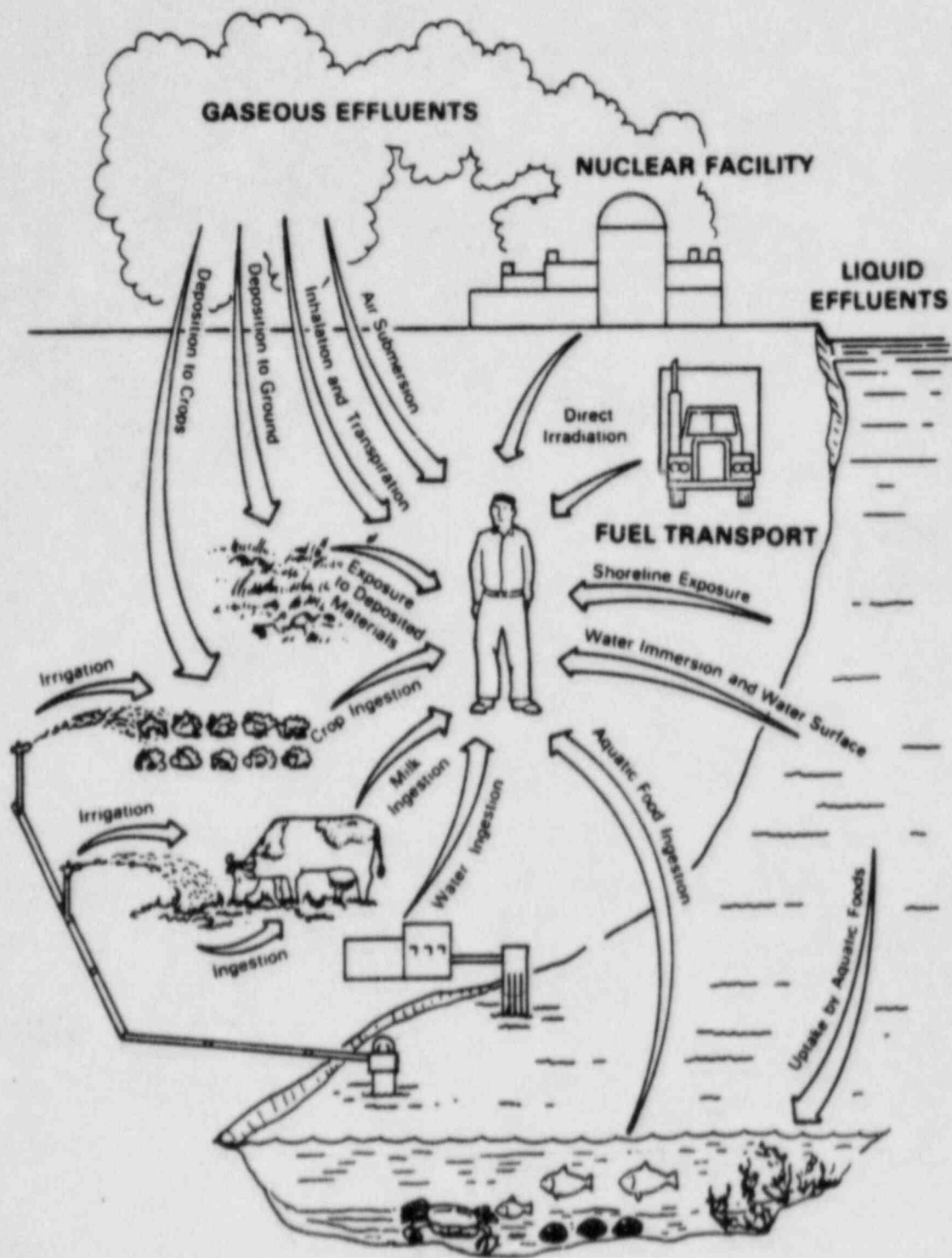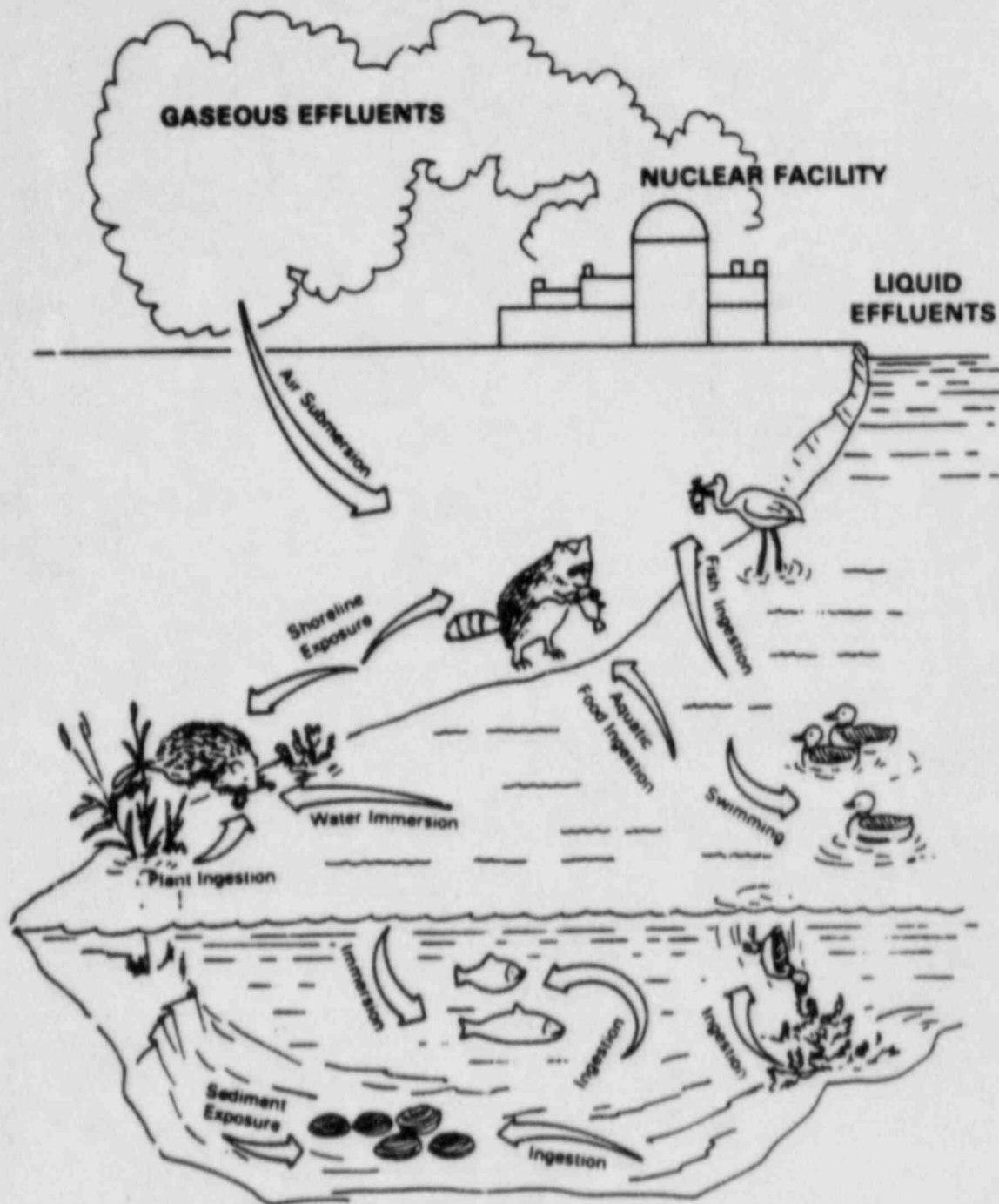
As Modeled in LADTAP II

# SECTION 1.  PROGRAM ABSTRACT

1.1. <u>Program</u>:  LADTAP II (<u>L</u>iquid <u>A</u>nnual <u>D</u>oses <u>t</u>o <u>A</u>ll <u>P</u>ersons) -
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 popula-
tion 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, invertabrates, 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 radionuclides) 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.

## 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.

## 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 re  rred 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.

| Card Number | Columns | Format | Description |
|---|---|---|---|
| General site information | | | |
| 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 $A_{i\tau}$ factors for Tech. Spec. |
| | 41-50 | I10 | -1/0/1/2 = Edit only/no effect/override and edit/override only parameter defaults |

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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 $A_{i\tau}$ 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 $A_{i\tau}$ 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) | | |

<u>Selected locations</u>   <u>(dose to individual)</u>

| | | | |
|---|---|---|---|
| 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.

<u>POPULATION (dose specifications)</u>

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

<u>Sport fish harvest</u>  (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 |

<u>Commercial fish harvest</u>  (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 |

<u>Sport invertebrate harvest</u>  (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 |

<u>Commercial invertebrate harvest</u>  (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 |

<u>Population drinking water</u>  (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 |

<u>Population shoreline</u>  (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 |

<u>Population swimming</u>  (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 |

<u>Population boating</u>  (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 |

<u>Irrigated foods: individual and population</u>

(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 |
| | 71-80 | E10 | Transfer time (hr) - average individual |
| 18 | 1-10 | E10 | Dilution |
| | 11-20 | E10 | Production (kg/yr) |
| | 21-30 | E10 | Transit time (hr) |
| | 31-50 | A20 | Location identification |

<u>Biota Dose</u> (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

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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 Calculational 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.

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## 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 Atomics 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

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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.
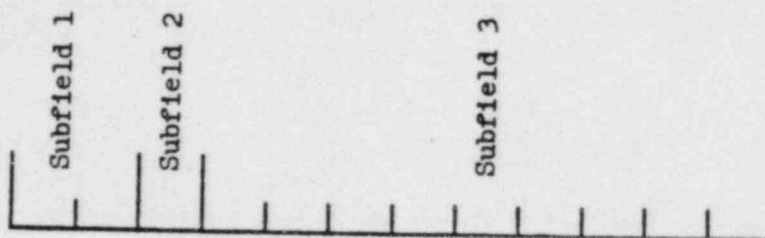


To begin the first array of a block, an array originator field is placed in any field on a card:

> 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:

Operator Description

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.

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+  "+" or "-" indicates exponentiation. The data entry in the
or  third field is entered and multiplied by $10^{\pm N_1}$, 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.

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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.

∅          "∅" causes the print trigger to be changed. The trigger is originally off. Successive "∅" 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 writ en 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.

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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., 1.0E+4, 1.0E4, 1.0+4, or even 1+4, but not 1.0 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.

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## 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$$  FO | Zero out the 1$ array |
| 2**  12.34-1  4Z | Enter 1.234 and 4 zeroes in the 2* array |
| 3**  A5  60  E | Enter 60.0 as the 5th entry of the 3* array |
| 4$$  2I1  2R4  2Q5 | Enter 1,2,3,4,4,1,2,3,4,4,1,2,3,4,4 |
| T | Terminate the block |