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David L. Duncan

A COMPUTER CODE (RVRDOS) TO CALCULATE POPULATION DOSES FROM RADIOACTIVE LIQUID EFFLUENTS AND AN APPLICATION TO NUCLEAR POWER REACTORS ON THE MISSISSIPPI RIVER BASIN

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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A COMPUTER CODE (RVRDOS) TO CALCULATE POPULATION DOSES FROM RADIOACTIVE LIQUID EFFLUENTS AND AN APPLICATION TO NUCLEAR POWER REACTORS ON THE MISSISSIPPI RIVER BASIN

JAMES A. MARTIN, JR.
CHARLES ROBBINS
CHRISTOPHER B. NELSON
ROBERT D. COUSINS, JR.
MARY ANNE CULLITON

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OFFICE OF RADIATION PROGRAMS
ENVIRONMENTAL ANALYSIS DIVISION
WASHINGTON, D. C. 20460

ABSTRACT

A computer program RVRDOS has been developed to calculate population doses due to releases of radionuclides into flowing streams. Concentrations of the radionuclides downstream take into account dilution, decay, and the ingrowth of a daughter product. Population doses to four organs are calculated for drinking water and fish ingestion pathways. Individual doses due to swimming may also be estimated. A program manual for RVRDOS is included in this report.

RVRDOS has been used to calculate population doses due to releases from nuclear power reactors on the Mississippi River Basin during 1973. The data base for these calculations and a summary of the calculations are discussed.

PREFACE

The Office of Radiation Programs is concerned with the evaluation of radiation exposure to the population and the environment. Nuclear facilities may release radioactive materials to the environment from normal operations and thus become a potential source of exposure to the population. The Environmental Analysis Division has responsibilities for evaluating the environmental and public health impact from such releases.

The river dose model discussed in this report was developed to assess the consequences to the general population from the consumption of drinking water and fish from waters which receive radioactive liquid effluents. This is the first step by this Office to introduce a computer code as a working model to investigate the consequences of liquid radioactive discharges into rivers and streams. This model was applied to nuclear power plants on the Mississippi River System and population dose estimates were made which represent order of magnitude calculations. Although these results have not been validated by field measurements, the model and the results are of sufficient interest to warrant this interim report.

Readers are encouraged to write to this Office concerning suggestions, recommendations, and omissions or errors in this report.

Floyd L. Galpin
Director
Environmental Analysis Division
Office of Radiation Programs

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I

INTRODUCTION

I

INTRODUCTION

Under the concept of environmental dose commitment as applied by the Environmental Protection Agency (EPA), doses to all affected populations must be considered in the assessment of the overall risks vs. benefits of nuclear power industry operations (1). The measurement of dose on such a grand scale is normally very difficult because instruments of the required sensitivity are not available, or the extensive monitoring capabilities that would be required are too expensive to be cost effective, or both. EPA therefore suggests that in many cases the use of calculational techniques for dose assessment may be a cost-effective substitute to direct measurement (2). This appears to be the case for the assessment of population dose from the release of radioactive materials into flowing streams where the populations affected may be quite large and diverse and the pollutant concentrations quite small.

A model has been developed that can be used to calculate the dispersion of radioactivity released into flowing streams and the resulting population dose. A computer code called RVRDOS was developed for application of the model. The model has been applied to calculate the dose to affected populations from the release of radioactive materials during 1973 into the Illinois, Missouri, and the Mississippi Rivers by operating nuclear power plants.

The scope of this initial work was bounded by several factors. Individual doses and population doses within fifty miles of nuclear power plants are routinely analyzed in environmental reports, and there was no interest in duplicating these data. Doses to populations beyond fifty miles of operating facilities are not routinely estimated and such an estimate did appear to be desirable in the light of the dose commitment concept. It was shortly recognized that two major pathway parameters, sedimentation and resuspension of insoluble effluents, could not be considered adequately within the time frame and funding of this initial work. Although some rudimentary models are available, the required data base for over 1500 river miles does not exist and the development of such a data base represents an extraordinary task. For the drinking water pathway this difficulty was resolved by ignoring sedimentation and using dose factors for soluble forms of the effluent radionuclides, thereby obtaining a generally conservative (high) estimate of dose. For the fish consumption pathway, sedimentation and resuspension were treated implicitly via the use of measured reconcentration factors that relate the concentration of elements in fish to the concentration in water. These reconcentration factors include the effects of sedimentation and resuspension.

After performing a brief survey of river systems in the United States on which nuclear power reactors are located, the Mississippi River system was selected for study because of the larger number of operating reactors located on its waters and the large population using these waters. As the data base for the calculations was developed and after making a few preliminary calculations, it became clear that the drinking water and fish consumption pathways dominated the population dose and that other pathways, such as immersion (swimming), were trivial by comparison. Consideration was given to direct doses due to shoreline deposits, but this too was found to be a small contributor to population dose, although from an individual dose standpoint, it could be important close to an effluent point. As a result of these and a variety of other factors, the scope of this study was limited to the calculation of population doses via the ingestion pathway, using generally conservative assumptions.

It is stressed at the outset that the results of these calculations are to be considered as order of magnitude, yet generally conservative, results only, even though several significant figures are presented at places in this report. Further development of the model and more accurate or representative demographic and pathway data are expected to change the results. Nonetheless, the present model and especially the data base were considered to be of enough general interest that this initial report of the approach and the results was prepared.

II

SUMMARY AND RESULTS

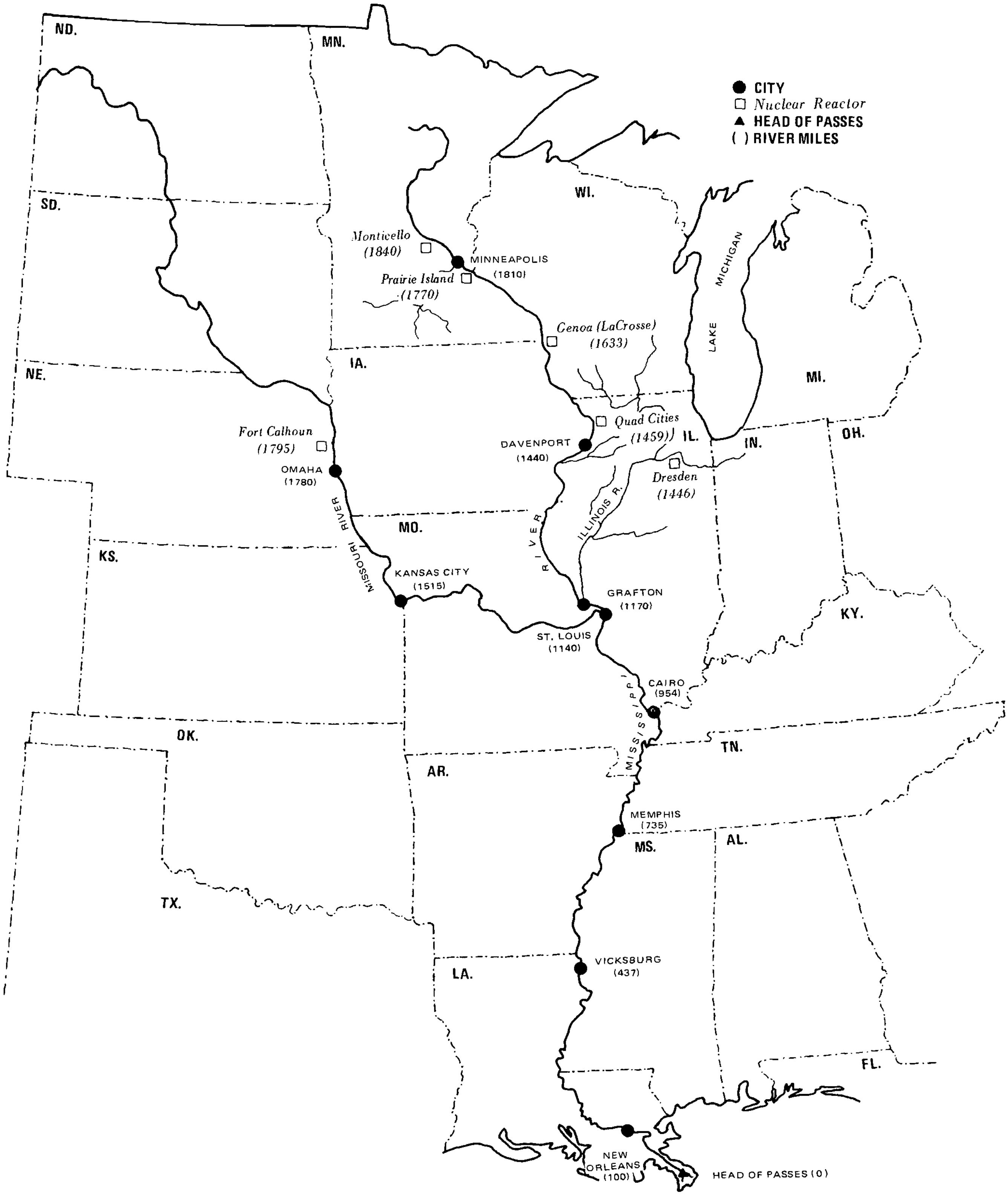

Figure 1 Nuclear power reactors on the Mississippi river basin, 1973

II

SUMMARY AND RESULTS

J. A. Martin, Jr.,[1] and C. Robbins

The geographical extent of the anlysis performed to date is represented graphically in figure 1. Radionuclide activities released in 1973 into the Illinois River by the Dresden 2 and 3 units[2], into the Missouri River by the Ft. Calhoun unit, and into the upper reaches of the Mississippi by the Genoa and Quad Cities units were propagated from the points of release to the Gulf of Mexico. Doses to populations downstream of these units were calculated for the drinking water and fish ingestion pathways. Doses to four organs (whole body, thyroid, GI (LLI), and bone) were calculated using dose factors derived from data for the ICRP standard man (3,4).

Population drinking water statistics were taken directly from data compiled by the U. S. Public Health Service (5). The weight of commercial fish taken from locations along the rivers was obtained from data compiled by the U. S. Department of Commerce (6). Data for sport (creel) fish catches were obtained from State agency creel surveys and generally are not as complete as commercial fishing data. In view of the greater uncertainty, the sport catch data were treated separately from the commercial catch data. The creel catch data listed in the computer printouts in Section VI are a best effort compilation by the authors. Radionuclide reconcentration factors for fish were taken from reference 7.

Volume flow rates, stream speeds, river miles and volumes of dams required for the diffusion calculations were obtained from the U. S. Army Corps of Engineers' data (8-11) and water resources data published for various States by the U. S. Department of Interior Geological Survey. Stream speeds, river miles and volumes of dams were required for radioactive decay and daughter product ingrowth calculations. River miles were obtained directly from the river charts. Stream speeds were chosen by the authors as representative of data reported as estimates by a number of sources. Volumes of dams were calculated using river chart data and generally represent the volume of water in a given reach. Since all of the dams are small, increases in volume flow rates accounted for most of the dilution in the diffusion calculations.

All of these data are included in the printouts of the computer program RVRDOS in Section VI of this report. Representative data are briefly summarized in tables 1 to 5. Table 1 lists the source terms (activities of radionuclides released, by radionuclide) used for the calculations (12). The quantities and mixes of nuclides in effluents

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[1] Present address: U.S. Nuclear Regulary Commission, Wash., DC, 20555

[2] Only gross activity released was available for the Dresden 1 unit for the year 1973; dose calculations were thereby precluded.

Table 1 Radionuclides released in liquid effluents from selected nuclear power plants, Mississippi River Basin, 1973 (Curies)

Radio-nuclide	Genoa (LaCrosse)	Quad Cities 1 & 2	Dresden 2 & 3	Ft. Calhoun
^{140}BaLa	0.07	0.0071	1.48	0.0607
^{58}Co	11.8	0.97	0.144	0.469 (-4)
^{60}Co	1.26	0.83	2.09	.
^{51}Cr	0.81	2.88	1.17	.
^{134}Cs	5.66	0.21	1.17	.
^{137}Cs	10.1	0.53	4.24	.
^{137m}Ba	.	.	.	.
^{3}H	103.0	24.5	25.8	15.8
^{131}I	3.13	3.8	1.41	0.0045
^{131m}Xe	.	.	.	.
^{133}I	2.89	0.43	.	.
^{133}Xe	0.43	.	.	0.058
^{54}Mn	0.085	0.37	0.406	0.219
^{89}Sr	0.05	0.064	0.089	0.116 (-3)
^{89m}Y	.	.	.	0.169 (-4)
^{90}Sr	0.021	0.0025	0.01	.
^{90}Y	.	.	.	.
^{135}Xe	0.18	0.085	.	.
^{135}Cs	.	.	.	.
^{65}Zn	0.216	.	0.037	.
^{95}Zr	.	0.1116	0.009	.
^{95}Nb	.	.	0.007	.

Notes: . = Not reported.
(-N) = 10^{-N}

from different facilities are unrelated to one another and are dependent upon operating history, type of fuel and particular effluent treatment systems used by the various units. Although not used for the population dose calculations, the unit operating data for 1973, shown in table 2, may be of interest from a risk/benefit standpoint.

No activity was released in liquid effluents by Monticello. The 0.016 microcuries mixed fission and activation products and 73 microcuries tritium released in liquid effluents by Prairie Island are considered negligible for these dose calculations.

The activity released in liquids from Dresden 1 is not included because specific radionuclide data are not available. The mixed fission and activation product activity released by this facility in 1973 was 9.2 curies and the tritium activity released in liquid effluents was 18.5 curies.

Table 2 Energy produced by selected nuclear power plants, Mississippi River Basin, 1973

	Authorized Power Level (Megawatts (th))	Electrical Energy Produced (Megawatt-years)
Genoa (LaCrosse)	165	22
Quad Cities-1	2511	547
-2	2511	580
Dresden-1	700	625
-2	2527	558
-3	2527	413
Ft. Calhoun	1420	67
Monticello	1670	368
Prairie Island-1	1650	2
Total energy produced		3182

The results of the calculations are briefly summarized in tables 3, 4, and 5. (Details may be obtained from a perusal of the computer printouts. The RVRDOS code includes an option to print even finer detail, but the bulk prohibits its reproduction in this report.) The dose conversion factors (DCF) used for these calculations are for the first year dose due to an ingestion of the radionuclide. They are equivalent to dose commitment conversion factors with the exception of strontium-90 which has a long biological half-life. Strontium-90, however, contributes so little to the total organ doses from all nuclides released that the first year doses are equivalent to dose commitments and are so indicated in tables 3, 4, and 5.

Table 3 Calculated total population dose commitments for selected nuclear power plants and pathways, Mississippi River Basin, 1973

Facility		Person-rem			
		Total Body	Thyroid	Bone	GI(LLI)
Genoa (LaCrosse)	Drinking Water	10.5	7.	8.7	2.2
	Comm'l Fish	9.8	0.9	8.2	0.4
	Creel Fish	0.7	0.05	0.6	0.03
Quad Cities	Drinking Water	0.63	32.	0.65	0.6
	Comm'l Fish	0.14	0.45	0.12	0.17
	Creel Fish	0.01	0.02	0.006	0.01
Dresden 2,3	Drinking Water	1.5	2.3	1.5	0.45
	Comm'l Fish	0.15	0.02	0.14	0.01
	Creel Fish	0.002	0.0005	0.002	0.0001
Ft. Calhoun	Drinking Water	0.07	0.25	0.009	0.14
	Comm'l Fish	7(-6)	3(-5)	2(-7)	1(-4)
	Creel Fish	2(-6)	1(-5)	5(-7)	3(-5)

Note: (-N) = 10^{-N}

Table 4 Calculated total body population dose commitments (drinking water pathway) at selected locations downstream from nuclear power plants, Mississippi River Basin, 1973

Location	Population Served (Thousand)[a]	River Miles[b]	Total body population dose commitment (person-rem)				
			Genoa (LaCrosse)	Quad Cities	Dresden 2,3	Ft. Calhoun	Subtotal
LaCrosse, WI		1633					
Cordova, IL		1460					
Bettendorf, IA--Moline, IL	55.6	1442	1.0	0.065			1.07
Davenport, IA--Rock Island, IL	142.0	1439	2.6	0.16			2.76
Burlington, IA	35.4	1360	0.57	0.034			0.60
Ft. Madison, IA	15.2	1338	0.24	0.014			0.25
Keokuk, IA	16.3	1320	0.25	0.014			0.26
Quincy, IL	47.5	1283	0.63	0.037			0.67
Hannibal, MO	21.0	1265	0.26	0.015			0.28
Lock & Dam 27	40.0	1141	0.24	0.013			0.25
St. Louis, MO--East St. Louis, IL	670.0	1136	3.5	0.2	1.1	0.007	4.80
Chester, IL	4.2	1065	0.02	0.001	0.007	4.0 (-5)[c]	0.03
Cape Girardeau, MO	26.0	1008	0.13	0.007	0.042	2.0 (-4)	0.18
Thebes, IL	0.5	1000	0.002	0.0001	0.0007	4.0 (-6)	0.003
Vicksburg, MS	41.0	438	0.066	0.004	0.021	1.0 (-4)	0.091
Donaldsville, LA	7.8	177	0.012	0.007	0.004	2.0 (-5)	0.023
New Orleans, LA	652.0	100	1.0	0.056	0.034	0.002	1.09
Totals	1,774.0	-	10.5	0.63	1.5	0.009[d]	12.7[d]

[a]Population actually served drinking water from Mississippi River.

[b]River miles to Head of Passes, LA.

[c]$(-N) = 10^{-N}$

[d]Population dose on Missouri River was calculated as 0.058 person-rem.

The main results are presented in table 3 which lists the calculated total population doses due to the discharges listed in table 1. The doses are broken down by facility, organ and pathway, summed over location. To illustrate the detail considered to date in the analysis, a breakdown of the total body population dose due to drinking water consumption, by source and location, is presented in table 4. In 1973, discharges of radionuclides into the Illinois, Missouri, and Mississippi Rivers as by-products of the production of 2557 megawatt years of electrical energy resulted in a total body population dose of approximately 13 person-rem in a population of 1,774,000 persons consuming drinking water from those streams.

As illustrated in table 5, including drinking water and fish consumption pathways, the calculated total population doses in 1973 for the total body, thyroid, bone and GI(LLI) organs were 24, 43, 20 and 4 person-rem, respectively.

Table 5 Calculated total population dose commitments for selected pathways from nuclear power plants, Mississippi River Basin, 1973

Pathway (Population or catch weight)	Person-rem			
	Total body	Thyroid	Bone	GI (LLI)
Drinking water (1,774,500 persons)	12.7	41.6	10.8	3.4
Commercial fish (11,280,000 lbs.)	10.1	1.4	8.5	0.6
Creel fish (385,000 lbs.)	0.7	0.1	0.6	0.04
Total	24.	43.	20.	4.

III

AQUATIC DISPERSON MODEL

III

AQUATIC DISPERSON MODEL

C. B. Nelson

Introduction

The aquatic disperson model used in the RVRDOS code considers dilution, decay, and the ingrowth of a daughter product. Diffusion is not considered; the concentration is considered uniform across a stream. The variations in quantities with downstream distance from the source are treated by dividing the modeled stream into a number of segments or reaches as shown in figure 2. Reach boundaries are chosen so that concentrations calculated for the downstream end of the reach adequately characterize the concentrations within the reach. The stream flow rate is not allowed to decrease in the downstream direction and no explicit provision for branching of the stream is provided. Each reach may incorporate an impoundment such as would occur behind a dam on the stream. Such an impoundment is assumed to be uniformly mixed. The only removal process considered in the model is radioactive decay. To simplify notation, the equations in this section are developed for $i = 1$ (see figure 2) and the nuclide subscript is used only as necessary to distinguish a parent and daughter.

Dilution

Ignoring decay the activity flow (Ci/s) is conserved for the length of the reach, i.e.,

$$C_o W_o = C_1 W_1$$

or solving for C_1

$$C_1 = \frac{C_o W_o}{W_1}$$

Decay

Neglecting for the moment the effect of an impoundment, the decay factor for a reach is $\exp(-\lambda t_1)$ where λ is the decay constant for the particular radionuclide and $t_1 = d_1/V_1$ is the transit time for the reach.

Including the decay factor, then:

$$C_1 = \frac{C_o W_o}{W_1} \exp(-\lambda t_1)$$

Ingrowth of a Daughter

If λ_p and λ_d are the decay constants for the parent and daughter radionuclides and once again the effect of an impoundment is neglected, then:

$$C_{1p} = \frac{C_{op}W_o}{W_1} \exp(-\lambda_p t_1) \qquad \ldots(1)$$

and

$$C_{1d} = \frac{C_{od}W_o}{W_1} \exp(-\lambda_d t_1) \qquad \ldots(2)$$

$$+ \frac{C_{op}W_o}{W_1} \frac{\lambda_d}{\lambda_d-\lambda_p} (\exp(-\lambda_p t_1)-\exp(-\lambda_d t_1))$$

where the decay of the parent branches totally to the ingrowth of the daughter (Provision is made in the RVRDOS code for the actual branching ratio.). Note that the concentration of the daughter at the end of a reach depends upon its initial concentration at the start of the reach as well as the ingrowth from the parent during the course of the reach.

Effect of an Impoundment

To simplify the calculations for a reach with an impoundment, consider initially the case of a reach consisting only of the impoundment, i.e.,

$$d_1 = 0.$$

The impoundment is considered to be uniformly mixed. Quantities with the subscript 0 are those prior to the impoundment and those with the subscript 1 pertain to the impoundment and its outflow. The impoundment is considered to have a turnover rate given by:

$$\lambda_t = W_1/V_1$$

which implies that the impoundment may be fed by additional sources.

The concentrations in the impoundment are obtained from the following differential equations:

$$\frac{dC_{1p}}{dt} = -\lambda_a C_{1p} + \frac{W_o}{V_1} C_{op}$$

and

$$\frac{dC_{1d}}{dt} = \lambda_d C_{1p} - \lambda_b C_{1d} + \frac{W_o}{V_1} C_{od}$$

where $\lambda_a = \lambda_p + \lambda_t$ and $\lambda_b = \lambda_d + \lambda_t$. $\frac{W_o}{V_1} C_{op}$ and $\frac{W_o}{V_1} C_{od}$ are the forcing functions for the system. If C_{op} and C_{od} are set to 0, the resulting homogeneous equations may be solved using standard methods (see reference 13) to obtain the response of the system to a unit concentration of C_{1p} at $t = 0$.

Designating these impulse response solutions as h_{+pp} and h_{+dp}:

$$h_{+pp}(t) = \exp(-\lambda_a t)$$

$$h_{+dp}(t) = \frac{\lambda_d}{\lambda_d - \lambda_p} (\exp(-\lambda_a t) - \exp(-\lambda_b t))$$

where h_{+pp} and h_{+dp} refer to the parent and daughter concentrations in the impoundment, respectively, due to the unit initial concentration of the parent.

Similarly for a unit inital concentration of C_{1d}

$$h_{+pd}(t) = 0$$

and

$$h_{+dd}(t) = \exp(-\lambda_b t)$$

Since the contribution of an initial daughter concentration is only to the daughter, it can be calculated separately and added to the contribution from the parent; the next step of this development will consider the initial daughter concentration to be zero.

The particular solution to the differential equations is obtained by convolution of the forcing function with the impulse response of the system. Since $C_{op}(\tau)$ is constant for $o<\tau<t$, its value can be taken outside the integral sign. Hence,

$$C_{1p}(t) = \int_o^t h_{+pp}(t-\tau)\, C_{op}(\tau)\, \frac{W_o}{V_1}\, d\tau$$

$$= \frac{W_o}{V_1} C_{op} \int_o^t \exp(-\lambda_a(t-\tau))d\tau$$

$$= \frac{W_o}{V_1} C_{op} \frac{1-\exp(-\lambda_a t)}{\lambda_a}$$

and

$$C_{1d}(t) = \int_o^t h_{+dp}(t-\tau)\, C_{op}(\tau)\, \frac{W_o}{V_1}\, d\tau$$

$$= \frac{W_o}{V_1} C_{op} \frac{\lambda_d}{\lambda_d-\lambda_p} \int_o^t (\exp(-\lambda_a(t-\tau))$$

$$-\exp(-\lambda_b(t-\tau)))d\tau$$

$$= \frac{W_o}{V_1} C_{op} \frac{\lambda_d}{\lambda_d - \lambda_p} \frac{\lambda_d - \lambda_p - \lambda_b \exp(-\lambda_a t) + \lambda_a \exp(-\lambda_b t)}{\lambda_a \lambda_b}$$

At equilibrium (i.e., $\lambda_a t >> 1$ and $\lambda_b t >> 1$)

$$C_{1p} = \frac{W_o}{V_1 \lambda_a} C_{op}$$

$$C_{1d} = \frac{W_o}{V_1 \lambda_a} \frac{\lambda_d}{\lambda_b} C_{op}$$

$$= \frac{\lambda_d}{\lambda_b} C_{1p}$$

Alternatively in terms of λ_p and λ_d:

$$C_{1p} = \frac{W_o}{W_1 + V_1 \lambda_p} C_{op} \qquad \ldots(3)$$

$$C_{1d} = \frac{V_1 \lambda_d}{W_1 + V_1 \lambda_d} C_{1p} \qquad \ldots(4)$$

Since the turnover time for an impoundment is short compared to the typical time period for a RVRDOS calculation, equilibrium is assumed for such calculations even for long lived radionuclides.

Returning now to a reach with a finite length, the concentration of the parent radionuclide can be calculated by combining (3) with the decay factor from (1) giving

$$C_{1p} = \frac{W_o}{W_1 + V_1 \lambda_p} \exp(-\lambda_p t_1) C_{op} \qquad \ldots(5)$$

Similarly the daughter ingrowth for a stream with an impoundment can be calculated as:

$$C_{1d} = \left(\frac{W_o}{W_1+V_1\lambda_d}\ \frac{\lambda_d}{\lambda_d-\lambda_p}\ (\exp(-\lambda_p t_1)-\exp(-\lambda_d t_1))\right.$$

$$\left. + \frac{W_o}{W_1+V_1\lambda_p}\ \frac{V_1\lambda_d}{W_1+V_1\lambda_d}\right) C_{op}$$

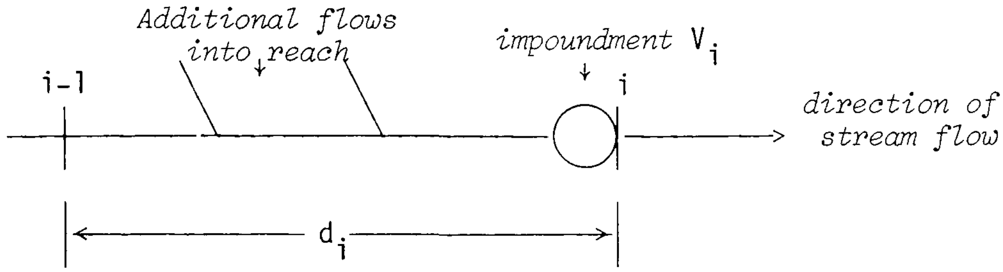
or

$$C_{1d} = \frac{W_o}{W_1+V_1\lambda_d}\ \frac{\lambda_d}{\lambda_d-\lambda_p}\ (\exp(-\lambda_p t_1)-\exp(-\lambda_d t_1))\ C_{op}$$

$$+ \frac{V_1\lambda_d}{W_1+V_1\lambda_d}\ C_{1p} \qquad \ldots(6)$$

Calculations for RVRDOS are based on (5) and (6).(Note that in the RVRDOS code the location corresponding to I=1 is the release point to the stream and I=2 corresponds to the first downstream location.). First the concentration for a specific nuclide is calculated using (5). Then, if the nuclide is a daughter, the ingrowth from its parent is calculated using (6) and added to the original calculation. Calculations proceed from reach to reach in the downstream direction. The concentrations calculated for the end of one reach are used as those for the input to the subsequent one. Note that the variables actually used in RVRDOS have various customary units and that conversion factors are employed as necessary to make them consistent. These conversions have been avoided for this discussion by assigning a consistent set of units to the variables.

Figure 2 Schematic representation of a reach and definition of symbols used in Section III.



W_i = Volume flow rate of the stream at location i (m^3/s)

u_i = Speed of the stream at location i (m/s)

C_{ij} = Concentration of nuclide j at location i (Ci/m^3)

d_i = Distance between location i and i-1 associated with the i^{th} reach (m)

V_i = Volume of an impoundment on the i^{th} reach (m^3)

Note that the values of the variable for the i^{th} reach are assumed to be those for the end of the reach. The following quantities are calculated from the above.

t_i = The transit time associated with reach i (s)

λ_{ti} = The turnover rate for the impoundment on reach i (s^{-1})

IV

RVRDOS PROGRAM MANUAL

A FORTRAN IV PROGRAM TO CALCULATE
POPULATION AND INDIVIDUAL
DOSES DUE TO THE DISCHARGE OF
RADIONUCLIDES INTO FLOWING STREAMS

James A. Martin Jr.
Robert D. Cousins Jr.

Introduction

RVRDOS is an attempt to fill the need for a simple self-inclusive code which, with a minimum of input data, can provide useful estimates of ingestion and immersion doses to individuals or populations served by streams into which radionuclides are released. The user must input data concerning 1) the radioactive releases at the discharge point, and 2) the principal downstream locations (including dams). Principal downstream locations will primarily be those locations where water or fish are taken from the river to be used for human consumption. Branching of a stream is not included.

The essential data required to run RVRDOS are: activity released (by radionuclide, including first daughter product information); dilution volumes; stream speed and volume flow rates at each location; river miles at the locations; volumes of dams on the stream; and the amounts (pounds) of fresh water fish (commercial and sport) taken from the stream at various locations. As many as thirty-five downstream locations and twenty radionuclides may be included. Ingestion dose conversion factors (DCFS) for one to four body organs (by radionuclide) and immersion DCFs for one or two organs must also be included with the input data.

The output consists of a summary of the input data, followed by:

1) Radionuclide concentrations at each of the locations.

2) Drinking water population dose rates for each body organ from each radionuclide at each location, and individual swimming dose rates. (The latter do not appear in the population dose rate tables, or in the summaries.)

3) and 4) Commercial and creel fish ingestion population dose rates to each organ from each nuclide at each location.

5) A summary of the entire run consisting of subtotals of the above doses:

a) summed over all locations listed, by radionuclide and critical organ,

b) summed over all radionuclides listed, by location and critical organ,

c) totaled over all locations and radionuclides, by critical organ.

If the user desires to calculate dose rates to an individual, it is only necessary to input a population of 1 and the appropriate amount of fish caught (See section on Input Data).

In order to be able to run RVRDOS, the user need only read this introduction and the section entitled "Input Data." Further information on the calculations used and on the code itself is contained in the section entitled "Calculations."

Input Data

The precise format for input data may be found in table 6. The following paragraphs contain supplemental information and clarification when necessary.

The first two cards contain information covering the entire run. Next follows a pair of cards for each location on the stream for which dose calculations are to be performed. Location #1 should be the discharge canal, and the volume flow rate for location #1 should be the discharge canal flow rate (ft^3/sec). Location #2 should be downstream from the facility. (The model used for calculations is not applicable to the river at the discharge point, since mixing is not at all complete at this point.) The rest of the locations should be in order of increasing distance downstream. The following conversion factors may be useful:

1 gallon/minute = $2.23 \times 10^{-3} ft^3/sec$
1 liter/year = $1.119 \times 10^{-9} ft^3/sec$

The river miles may be measured from any fixed point (the facility need not have river mile zero), and may either increase or decrease with increasing distance downstream as long as the user is consistent. (The program uses the absolute values of the changes in river miles.) If there is no dam at a location the dam volume is input as Ø. Volumes (i.e., the volume of water behind dams) are in acre-feet:

1 acre-foot = 43,560 ft^3 = .326 million gallons

The pounds of fish taken from the stream between locations N-1 and N are input with the data for location N (the section of the river between any location N and location N-1 is called a reach). Fish data is divided into two categories: that caught commercially and that caught by sports fishermen (so-called creel catch). To calculate an individual ingestion dose rate for a reference man eating 26 gm/day (landed weight), input should be 21 pounds per year creel catch. (It should be recognized that the populations consuming fish and water are quite different.)

When computing population doses due to drinking water, the population which derives its drinking water from the river within the reach is input.

Reaches should be selected such that radionuclide decay between the location of a drinking water system intake and the end of the reach, N, is small. Concentrations used for calculating drinking water doses are the concentrations at point N. If the dose to an individual is desired at location N, then a population of 1 is input.

After the location data cards, two cards follow with the number of radionuclides in the run, and the names of the critical organs for which doses are to be calculated.

Finally, there are three cards for each radionuclide. These contain decay data, dose conversion factor (in the same order as the names appearing on the earlier card), and release data (curies per year). The triplet for a daughter product must immediately follow the triplet for its parent nuclide.

Calculations

The initial concentration (location 1) for each nuclide is simply:

$$CONC_{1,\ell} = \frac{Q\ell}{FLOW_1} \cdot 1.12 \times 10^{-6}$$

where:

$CONC_{1,\ell}$ concentration of radionuclide ℓ in the discharge canal (micro-Ci/ml)

ℓ radionuclide index

$Q\ell$ activity release of nuclide ℓ,(Curies/year into discharge canal)

$FLOW_1$ discharge canal flow rate (ft^3/sec)

1.12×10^{-6} converts Ci/yr per ft^3/sec to micro-Ci/ml

Concentration of parent nuclides at downstream locations are calculated using the equation derived in Section III where:

VOL_n volume of water behind dam, between points N-1 and N (ft^3). If there is no dam, VOL_n = Ø.

$RLMDA_\ell$ radionuclide decay constant (1/sec)

DELAY transit time from N-1 to N, derived from the river mile distance and stream speed (If stream speed is entered as zero, a default value of 3 mph is assigned.).

Account must be taken of the fact that a parent nuclide may decay into more than one daughter. For instance, iodine-131 decays into xenon-131m in only 1% of its decays. In the code, the calculated daughter concentration is multiplied by ($BRANCH_2/100$), where $BRANCH_2$ is the so-called branching ratio, the percentage of decays of p which yield d.

Water Ingestion Doses

Population doses due to water ingestion are calculated using the equation:

$$DPWTR_{n,\ell,m} = CONC_{n,\ell} \cdot DCF_{\ell,m} \cdot POP_n \cdot DRINKS. \, 365. \, 10^6$$

where:

n	location index
ℓ	radionuclide index
m	critical organ index (1, 2, 3, or 4)
DPWTR	population dose (person-rem/yr)
CONC	activity concentration, derived using equation (1) or (2) (micro-Ci/ml)
DCF	ingestion dose conversion factor (millirem per pico-Curie intake)
POP	is the population served by drinking water from the stream at n
DRINKS	is the assumed ingestion rate (liters/day per person)
365	days per year
10^6	pCi per micro-Ci

DRINKS is set equal to 1.95 in the code. It may be easily changed, but the program must then be recompiled.

RVRDOS does not take into account depletion by ingestion or depletion by water and sewage treatment plants. Since a very small fraction of a stream is used for drinking water, depletion by ingestion may be ignored. Although water treatment plants, industrial uses and sewage treatment plants may have large decontamination factors for the water taken from the stream, only a small fraction of a stream is used by any given municipality. By ignoring these decontamination factors, RVRDOS provides a conservative estimate of population dose. Conservatism becomes greater and greater as distance from the source increases.

Swimming (Immersion) Doses (M = 5 and 6)

Individual doses at location n, to organ m, from nuclide ℓ, due to swimming in the stream are calculated using the equation:

$$\text{Dose in rem/yr} = CONC_{n,\ell} \cdot DCF_{\ell,m} \cdot HOURS \cdot 10^6$$

where:

n,ℓ,m — location, nuclide, and organ indexes, respectively (m =5 or 6)

CONC — activity concentration, micro-Ci/ml

DCF — mrem/hr per pCi/liter (note different units from those of ingestion DCFs)

HOURS — assumed time spent swimming (hours/year per person)

Swimming population doses are not calculated, only individual swimming doses.

The parameter HOURS is fixed in the code with the value of 100. Like DRINKS it may be easily changed but the program must be recompiled.

Fish Ingestion Doses

Population doses due to commercial fish ingestion are calculated using the relation:

$$DPCML_{n,\ell,m} = CONC_{n,\ell} \cdot RECONC_{\ell} \cdot DCF_{m,\ell} \cdot CTCHWT_{n,1} \cdot 0.4536 \times 10^6 \cdot CATUSE \cdot CATEAT \cdot CTLELF$$

where:

DPCML — the population dose (person-rem/year)

CONC — the activity concentration (micro-Ci/ml)

RECONC — the fresh water fish reconcentration factor, (ci/gm per Ci/ml)

DCF dose conversion factor (mrem per pCi intake)

$CTCHWT_{n,1}$ the total commercial fish yield between points n-1 and n (pounds/year)

0.4536 (kilograms/pound)

10^6 pico-Ci/micro-Ci

CATUSE the fraction of all commercially caught fish that is available for human consumption

CATEAT the fraction (by weight) of a whole fish that is actually edible

CTLEFT the fraction of nuclide in edible fish that remains after cooking, frying, etc.

The parameters CATUSE, CATEAT, and CTLEFT are set equal to 0.49, 0.45, and 0.80, respectively, based on available data. These values may be changed if the program is recompiled. Fresh water reconcentration factors for all elements up to atomic number ninety-five are also included in the code, and may be similarly changed by the user.

DPCRL, the dose rate due to creel fish ingestion, is calculated from the same equation with two changes:

1) $CTCHWT_{n,2}$ is used rather than $CTCHWT_{n,1}$

2) CATUSE is assumed to be 1, and is therefore omitted.

Sedimentation and resuspension processes are treated implicitly in the reconcentration factors; these factors are grand averages from many observations that have been made and include reconcentration by bottom feeders and other organisms that are eaten by fish.

No decay factor is included in the population dose equation; thus, the tacit assumption is made that the water and fish are consumed immediately and at a uniform rate throughout a year. The former is generally conservative depending upon the nuclide and organ, but this is a trivial perturbation in the light of other sources of error.

Depletion of a stream via fish catches is not treated in RVRDOS. This is another conservatism, but likely a trivial one in most cases of interest. For radionuclides other than tritium, the tacit assumption that all radionuclides are soluble in the stream leads to generally conservative estimates of ingestion population doses.

Program Flow

The program flow is straightforward. In order, parameters are initialized; input data are read; concentrations are calculated; water and swimming doses are calculated and printed; commercial and creel fish doses are calculated and printed; and a summary of the run is tabulated and printed. The code includes comments describing the steps performed. The calculations will stop if the absolute value of the distance from location N-1 to location N decreases. Since this model is inapplicable for rivers that branch, the calculations will also stop if a volume flow rate (FLOW) at location N-1 exceeds the rate at N. Various checks to prevent inadvertent division by zero are also included. Several separate decks of cards of data may be processed in one run by merely stacking them one after another.

Data Base

A data base is included in Section VI. These data were compiled for the Illinois, Missouri, and Mississippi Rivers from Head of Passes near the mouth of the Mississippi, upstream to the locations of four nuclear power plants that discharged radionuclides into these rivers in 1973.

Table 6 Format for input data to RVRDOS

Card Sequence	Columns	Content	Format
1 Card	1-20	Facility name	5A4
	22-25	Year of data	A4
	29-30	Number of months of data	A2
	34-45	Source of release data	3A4
	70	Blank or 1. (Print command)	I1
1 Card	4-5	Number of locations on stream, including facility (discharge point) Maximum 35	I2
N pairs of Cards		One pair for each location on stream	
1st Card	4-5	Number of this location (Facility discharge canal is number 1)	I2
	6-25	Name of this location	5A4
2nd Card	1-10	Population deriving drinking* water from the river between location N and N-1.	F10.0
	11-20	Volume flow rate at this location in ft^3/sec. For location 1, this should be the discharge canal blowdown rate. (Computer will then calculate initial concentrations in discharge canal). For the rest of the locations the flow rate is that of the river.	F10.0

*Drinking water population doses are calculated for the entire population which derives its drinking water from the river between locations N and N-1. Reaches should be selected such that the decay between the intake to the supply and the end of the reach is small. Concentrations used to calculate the drinking water dose are those at location N. If the dose to one individual is desired at location N, input a population of 1.

Table 6 Format for input data to RVRDOS (continued)

Card Sequence	Columns	Content	Format
	21-30	Stream speed in mi/hr	F10.2
	31-40	River mile from some fixed reference point. (Facility need not have river mile Ø).	F10.2
	41-50	Volume of water behind dam at location N, in acre-feet. If there is no dam at location N, then this is Ø.	F10.0
	51-60	Pounds of fish caught commercially per year between points N-1 and N.	F10.0
	61-70	Pounds of creel fish caught per year	F10.0
1 Card	4-5	Number of radionuclides released (1 to 20)	I2
1 Card	1-8	Name of 1st critical organ (ingestion)	2A4
	9-16	Name of 2nd organ (ingestion)	2A4
	17-24	Name of 3rd organ (ingestion)	2A4
	25-32	Name of 4th organ (ingestion)	2A4
	33-40	Name of 5th organ (immersion)	2A4
	41-48	Name of 6th organ (immersion)	2A4
Sets of 3 cards		One set for each radionuclide	
1st Card	3-10	Symbol and mass number of nuclide, e.g., Co-58	2A4
	11	Daughter call code Ø for parent, 1 for daughter of immediately preceeding nuclide	I1

Table 6 Format for input data to RVRDOS (continued)

Card Sequence	Columns	Contents	Format
	12-15	Branching ratio: % of decays of preceeding nuclide yielding this nuclide (Ø if parent)	F4.0
	19-20	Atomic number	I2
	21-30	Decay constant, 1/sec	E10.3
2nd Card	1-40	Ingestion dose conversion factors for each of the four critical organs listed on earlier card, mrem per pCi intake	4E10.3
	41-60	Swimming (immersion) dose conversion factors for two organs in mrem/hr per pCi/ liter	2E10.3
3rd Card	1-10	Activity released at facility, Curies/yr	E10.3

GLOSSARY FOR RVRDOS

B, D, E, F, H, I, J, K, A1, A2, B1, B2, D1, D2, DECAYP, NMIN, DECAYS, S1, S2, S3--All are temporary variables of little significance.

ARG--Argument of exponential, equal to RLMDA times DECAY.

BRANCH(L)--Branching ratio (%): the percentage of decays of nuclide L-1 that result in nuclide L. Ø for parent.

CATEAT--Fraction (by weight) of a whole fish that is actually edible; set equal to 0.45.

CATUSE--Fraction of all commercially caught fish that is used for human consumption; set equal to 0.49.

CMLTOT(L,M)--DPCML(N,L,M), summed over N.

CONC(N,L)--Activity concentration in microcuries/milliliter.

CRLTOT(L,M)--DPCRL(N,L,M), summed over N.

CTCHWT(N,1)--Pounds of commercial fish taken from stream at N.

CTCHWT(N,2)--Pounds of creel fish taken from stream at N.

CTLEFT--Fraction of nuclide that remains in fish after cooking, frying, etc; set equal to 0.80.

DCF(M,L)--Dose conversion factors for organ M and nuclide L. For M = 1 - 4: ingestion DCFs in millirem per picocurie intake. For M = 5,6: swimming (immersion) DCFs, in mrem/hr per pcurie/liter.

DCMLNM(N,M)--DPCML(N,L,M), summed over L.

DCRLNM(N,M)--DPCRL(N,LMM), summed over L.

DELAY--|RIVM(N) - RIVM(N-1)| *3600/VEL(N). time in seconds required for river to flow from location N-1 to location N.

DLUTE--Flow (N-1)/(Flow (N) + VOL (N) *RLMDA (L)). Dilution factor for river between N-1 and N, for nuclide L.

DPCML(N,L,M), DPCRL(N,L,M),DPWTR(N,L,M)--Population dose rates for location N, nuclide L, and critical organ M (in person-rem per year), due to ingestion of drinking water (DPWTR), commercial fish (DPCML), and creel fish (DPCRL).

DPCML(M)--DCMLNM(N,M), summed over N.

DPCRLM(M)--DCRLNM(N,M), summed over N.

DPWTR(M)--DWTRNM(N,M), summed over N.

DRINKS--Assumed drinking water consumption rate. Set equal to 1.95 liters/day per person.

DWTRNM(N,M)--DPWTR(N,L,M), summed over L.

FAC1 to FAC5--Facility name, total 20 characters.

FLOW(N)--Volume flow rate at location N, cubic feet per second.

HOURS--Assumed time one person spends swimming in river; set equal to 100 hours per year.

L--Counter for radionuclides, 1-20.

LZ(L)--Atomic number of nuclide L.

M--Counter for locations 1-35. Release point has N=1.

NDTR(L)--Daughter call code=Ø, if parent; 1, if daughter. Data for daughter product must immediately follow data for parent.

NISO--Number of radionuclides in run; maximum of 20.

NMN1(N) to NMN5(N)--Name of Nth location, up to 20 characters.

NMOGN1(M), NMOGN2(M)--Name of critical organ corresponding to DCF for M; up to eight characters

NMOS--Number of months of data, (used only for printing output). NMOS=12 is assumed in all calculations.

NNPC(N)--User-assigned number of location N. Normally NNPC(N)=N.

NPC--Number of locations in run, including release point.

NREF1, NREF2, NREF3--Reference for release data (e.g., EIS, AEC report), up to 12 characters.

NUCL1(L), NUCL2(L)--Name of radionuclide L (e.g., CO-58), up to eight characters.

POP(N)--Population deriving drinking water from the river at location N.

Q(L)--Total curies of radionuclide L released at location during year.

RECONC(LZ(L))--Fresh water fish reconcentration factors. (Included in program for LZ=1 to LZ=95.)

RIVM(N)--River mile at N, from any fixed reference point.

RLMDA(L)--Decay constant of nuclide L, 1/sec.

RMILES(N)--|RIVM(N)-RIVM(1)|: The distance of location N from the discharge point, in river miles.

TIME(N)--Travel time to location N, i.e., the total time available for ingrowth or decay between the release point and location N.

VEL(N)--Stream speed at N, in mi/hr. (Default = 3.0 mi/hr.)

VOL(N)--Volume of water behind dam between N-1 and N, in acre-feet.

WTRTOT(L,M)--DPWTR(N,L,M), summed over N.

V

REFERENCES

V

REFERENCES

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VI

COMPUTER PRINTOUTS FOR RVRDOS MODEL

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```
FORTRAN IV G LEVEL  21                    MAIN                DATE = 76173          17/22/03

             C                                    RVRDOS
             C
             C            A CODE FOR CALCULATING INGESTION POPULATION DOSE
             C         RESULTING FROM DISCHARGES OF RADIONUCLIDES DIRECTLY INTO
             C         A STREAM. THE DIFFUSION EQUATION USED IS A SIMPLE LONG
             C         TERM AVERAGE MODEL BASED UPON VOLUME FLOW RATES, VOLUMES
             C         OF DAMS AND RADIONUCLIDE DECAY CONSTANTS. POPULATION DOSES
             C         DUE TO INGESTION OF STREAM WATER, AND COMMERCIAL AND
             C         SPORT FISH CATCHES ARE CALCULATED AT UP TO THIRTY-FIVE
             C         LOCATIONS ON THE STREAM. DOSES TO FOUR USER SELECTED
             C         INTERNAL ORGANS, FROM UP TO TWENTY RADIONUCLIDES MAY BE
             C         CALCULATED IN A SINGLE RUN. FRESH WATER FISH RECONCEN-
             C         TRATION  FACTORS FOR NINETY-FIVE ELEMENTS ARE INCLUDED
             C         IN THE CODE. INDIVIDUAL SKIN AND WHOLE BODY IMMERSION
             C         DOSES MAY ALSO BE CALCULATED.
             C
             C                    JAMES A. MARTIN, JR.     10/74
             C                    ROBERT D. COUSINS       8/75
             C
 0001                DIMENSION NNPC(35),NMN1(35),NMN2(35),NMN3(35),NMN4(35),NMN5(35),
                   *     POP(35),FLOW(35),VEL(35),RIVM(35),DWTRNM(35,6),CTCHWT(35,2),
                   *     DPWTR(35,20,6),DPWTRM(6),RECONC(95),LZ(20),NUCL1(20),
                   *     NUCL2(20),RLMDA(20),DPCML(35,20,4),VOL(35),CONC(35,20),
                   *     DCF(6,20),Q(20),DPCRL(35,20,4),DPCRLM(4),DPCMLM(4),
                   *     DCRLNM(35,4),DCMLNM(35,4),NMOGN1(6),NMOGN2(6),NDTR(20),
                   *     BRANCH(20),RMILES(35),WTRTCT(20,6),CMLTOT(20,4),
                   *     CRLTOT(20,4),TIME(35)
 0002                DATA RECONC(1) / 0.9/
 0003                DATA RECONC(2) / 1./
 0004                DATA RECONC(3) / 0.5/
 0005                DATA RECONC(4) / 2./
 0006                DATA RECONC(5) / 0.2/
 0007                DATA RECONC(6) / 5000./
 0008                DATA RECONC(7) / 15000./
 0009                DATA RECONC(8) / 0.9/
 0010                DATA RECONC(9) / 10./
 0011                DATA RECONC(10) / 1./
 0012                DATA RECONC(11) / 20./
 0013                DATA RECONC(12) / 50./
 0014                DATA RECONC(13) / 10./
 0015                DATA RECONC(14) / 2.5/
 0016                DATA RECONC(15) / 10000./
 0017                DATA RECONC(16) / 750./
 0018                DATA RECONC(17) / 50./
 0019                DATA RECONC(18) / 1./
 0020                DATA RECONC(19) / 1000./
 0021                DATA RECONC(20) / 40./
 0022                DATA RECONC(21) / 100./
 0023                DATA RECONC(22) / 1000./
 0024                DATA RECONC(23) / 10./
 0025                DATA RECONC(24) / 40./
 0026                DATA RECONC(25) / 100./
 0027                DATA RECONC(26) / 100./
 0028                DATA RECONC(27) / 20./
 0029                DATA RECONC(28) / 100./
 0030                DATA RECONC(29) / 200./
 0031                DATA RECONC(30) / 1000./
 0032                DATA RECONC(31) / 330./
```

Listing of source program for RVRDOS

```
FORTRAN IV G LEVEL  21                MAIN              DATE = 76226          12/23/13

0033            DATA RECONC(32) / 3300./                                            59.
0034            DATA RECONC(33) / 330./                                             60.
0035            DATA RECONC(34) / 170./                                             61.
0036            DATA RECONC(35) / 420./                                             62.
0037            DATA RECONC(36) / 1./                                               63.
0038            DATA RECONC(37) / 2000./                                            64.
0039            DATA RECONC(38) / 5./                                               65.
0040            DATA RECONC(39) / 25./                                              66.
0041            DATA RECONC(40) / 3.3/                                              67.
0042            DATA RECONC(41) / 30000./                                           68.
0043            DATA RECONC(42) / 10./                                              69.
0044            DATA RECONC(43) / 15./                                              70.
0045            DATA RECONC(44) / 10./                                              71.
0046            DATA RECONC(45) / 10./                                              72.
0047            DATA RECONC(46) / 10./                                              73.
0048            DATA RECONC(47) / 2.3/                                              74.
0049            DATA RECONC(48) / 200./                                             75.
0050            DATA RECONC(49) / 10000./                                           76.
0051            DATA RECONC(50) / 3000./                                            77.
0052            DATA RECONC(51) / 1./                                               78.
0053            DATA RECONC(52) / 500./                                             79.
0054            DATA RECONC(53) / 15./                                              80.
0055            DATA RECONC(54) / 1./                                               81.
0056            DATA RECONC(55) / 400./                                             82.
0057            DATA RECONC(56) / 4./                                               83.
0058            DATA RECONC(57) / 25./                                              84.
0059            DATA RECONC(58) / 25./                                              85.
0060            DATA RECONC(59) / 25./                                              86.
0061            DATA RECONC(60) / 25./                                              87.
0052            DATA RECONC(61) / 25./                                              88.
0063            DATA RECONC(62) / 25./                                              89.
0064            DATA RECONC(63) / 25./                                              90.
0065            DATA RECONC(64) / 25./                                              91.
0066            DATA RECONC(65) / 25./                                              92.
0067            DATA RECONC(66) / 25./                                              93.
0068            DATA RECONC(67) / 25./                                              94.
0069            DATA RECONC(68) / 25./                                              95.
0070            DATA RECONC(69) / 25./                                              96.
0071            DATA RECONC(70) / 25./                                              97.
0072            DATA RECONC(71) / 25./                                              98.
0073            DATA RECONC(72) / 3.3/                                              99.
0074            DATA RECONC(73) / 30000./                                          100.
0075            DATA RECONC(74) / 1200./                                           101.
0076            DATA RECONC(75) / 120./                                            102.
0077            DATA RECONC(76) / 10./                                             103.
0078            DATA RECONC(77) / 10./                                             104.
0079            DATA RECONC(78) / 100./                                            105.
0080            DATA RECONC(79) / 33./                                             106.
0081            DATA RECONC(80) / 1000./                                           107.
0082            DATA RECONC(81) / 10000./                                          108.
0083            DATA RECONC(82) / 300./                                            109.
0084            DATA RECONC(83) / 15./                                             110.
0085            DATA RECONC(84) / 50./                                             111.
0086            DATA RECONC(85) / 15./                                             112.
0087            DATA RECONC(86) / 57./                                             113.
0088            DATA RECONC(87) / 400./                                            114.
0089            DATA RECONC(88) / 50./                                             115.
0090            DATA RECONC(89) / 25./                                             116.
```

Listing of source program for RVRDOS (continued)

```
0091          DATA RECONC(90) / 30./
0092          DATA RECONC(91) / 11./
0093          DATA RECONC(92) / 10./
0094          DATA RECONC(93) / 10./
0095          DATA RECONC(94) / 3.5/
0096          DATA RECONC(95) / 25./
0097          WRITE(6,10)
0098       10 FORMAT(1H0,56X,'PROGRAM RVRDOS'//
             *43X,'FOR INFORMATION REGARDING THIS PROGRAM, CONTACT:'//,
             *51X,'ENVIRONMENTAL PROTECTION AGENCY'/
             *51X,'OFFICE OF RADIATION PROGRAMS'/,
             *51X,'401 M ST SW'/,
             *51X,'WASHINGTON, DC  20460'///,
             *61X,'INPUT DATA'/)
        C
0099      900 CONTINUE
        C
        C     INITIALIZE VARIABLES
        C
0100          DO 20 L=1,20
0101          DO 20 N=1,35
0102          DPWTR(N,L,5) = 0.
0103          DPWTR(N,L,6) = 0.
0104          CONC(N,L) = 0.
0105          DO 20 M = 1,4
0106          DPWTR(N,L,M) = 0.
0107          DPCML(N,L,M) = 0.
0108       20 DPCRL(N,L,M) = 0.
0109          IF(CONC(1,1).GT.1.) GO TO 999
0110          DO 25 N=1,35
0111          DWTRNM(N,5)=0.
0112          DWTRNM(N,6)=0.
0113          DO 25 M=1,4
0114          DWTRNM(N,M)=0.
0115          DCMLNM(N,M)=0.
0116       25 DCRLNM(N,M)=0.
        C
        C     READ IN FACILITY DESCRIPTION AND DOWNSTREAM PARAMETERS
        C     READ FACILITY NAME,YEAR, MONTHS, REFERENCES, PRINT COMMAND.
        C     IF NPRINT=0, ONLY SUMMARY IS PRINTED. IF NPRINT=1, ALL DETAILS ARE
        C     PRINTED. NPRINT IS IN COL 70 ON FIRST CARD.
        C
0117          READ(5,100,END=999) FAC1,FAC2,FAC3,FAC4,FAC5,NYR,NMOS,NREF1,
             *                    NREF2,NREF3,NPRINT
0118      100 FORMAT(5A4,1X,A4,3X,A2,3X,3A4,24X,I1)
0119          WRITE(6,101) FAC1,FAC2,FAC3,FAC4,FAC5,NYR,NMOS,NREF1,NREF2,NREF3
0120      101 FORMAT(1H0,6X,'FACILITY',7X,'YEAR OF RELEASES   NO. MONTHS OF ',
             *'DATA   SOURCE OF RELEASE DATA'/,1X,5A4,7X,A4,17X,A2,16X,3A4)
        C
        C     READ IN NUMBER OF LOCATIONS,INCLUDING FACILITY AS FIRST LOCATION
        C      MAXIMUM OF 35 LOCATIONS.
        C
0121          READ(5,110) NPC
0122      110 FORMAT(3X,I2)
0123          WRITE(6,111) NPC
0124      111 FORMAT(1H0,11X,'LOCATIONS ON STREAM (TOTAL OF ',I2,', FACILITY ',
             *'IS NO. 1)')
        C
```

Listing of source program for RVRDOS (continued)

```
              C      READ AND WRITE LOCATION DATA,INCLUDING FACILITY AS FIRST LOCATION.
              C      VOLUME FLOW RATE FOR FACILITY IS AT POINT WHERE CURIES ARE
              C      RELEASED.
              C
 0125                WRITE(6,116)
 0126            116 FORMAT(1H0,'REACH',8X,'NAME',13X,'POPULATION  VOLUME FLOW    ',
                    *'STREAM',5X,'RIVER  DAM VOLUME  COMMERCIAL  CREEL FISH'/' NUMBER',
                    *26X,'SERVED     RATE(CFS)   SPEED(MPH)   MILE   ACRE-FEET   FISH '
                    *,'WT,LBS   WT,LBS')
 0127                A=0.
 0128                B=0.
 0129                C=0.
 0130                DO 130 N=1,NPC
 0131                READ(5,113) NNPC(N),NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N)
 0132            113 FORMAT(3X,I2,5A4)
 0133                READ(5,114) POP(N),FLOW(N),VEL(N),RIVM(N),VOL(N),CTCHWT(N,1),
                    *CTCHWT(N,2)
 0134            114 FORMAT(2F10.0,2F10.2,3F10.0)
 0135                A=A+POP(N)
 0136                B=B+CTCHWT(N,1)
 0137                C=C+CTCHWT(N,2)
              C
              C       ASSIGN DEFAULT VALUE FOR VEL
              C
 0138                IF (VEL(N).LE.0) VEL(N)=3.
              C
 0139                WRITE(6,117) NNPC(N),NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),
                    *POP(N),FLOW(N),VEL(N),RIVM(N),VOL(N),CTCHWT(N,1),CTCHWT(N,2)
 0140            117 FORMAT(1H0,2X,I2,3X,5A4,1X,F10.0,3X,F10.0,2(1X,F10.1),1X,F10.0,2X,
                    *F10.0,3X,F10.0)
              C
              C      VOL(N) IS IN ACRE FEET AS INPUT.
              C      CONVERT UNITS TO CUBIC FEET.
              C
 0141                VOL(N) = VOL(N)*43560.
              C
 0142            130 CONTINUE
 0143                TOTPOP=A
 0144                TOTCML=B
 0145                TOTCRL=C
              C
              C             READ/WRITE NUMBER OF ISOTOPES, MAX. OF 20.
              C
 0146                READ(5,200) NISO
 0147            200 FORMAT(3X,I2)
 0148                WRITE(6,210) NISO
 0149            210 FORMAT(1H0,/,50X,'RADIONUCLIDES RELEASED (TOTAL ',I2,')')
              C
              C            READ AND WRITE ISOTOPE DATA
              C
 0150                READ(5,215) ((NMOGN1(M),NMOGN2(M)),M=1,6)
 0151            215 FORMAT(12A4)
 0152                WRITE(6,220) ((NMOGN1(M),NMOGN2(M)),M=1,6)
 0153            220 FORMAT(1H0,85X,'DOSE CONVERSION FACTORS'/,82X,'INGESTION',27X,
                    *'SWIMMING'/,' ISOTOPE  0=PARENT   BRANCH.  ATOMIC  DECAY CONS-',
                    *'   CURIES',9X,'MILLIREM/YEAR PER PICO-CURIE/YEAR INTAKE     MREM'
                    *,'/HR PER PCI/LITER'/,9X,'1=DAUGHTER  RATIO,%  NUMBER  TANT, 1/'.
                    *'SEC  RELEASED',4X,4(3X,2A4),2X,2(3X,2A4))
```

Listing of source program for RVRDOS (continued)

```
0154            DO 240 L=1,NISO
0155            READ(5,230) NUCL1(L),NUCL2(L),NDTR(L),BRANCH(L),LZ(L),RLMDA(L),
               *(DCF(M,L),M=1,6)
0156        230 FORMAT(2X,2A4,I1,F4.0,3X,I2,E10.3,/,6E10.3)
0157            READ(5,231) Q(L)
0158        231 FORMAT(E10.3)
0159        240 WRITE(6,241) NUCL1(L),NUCL2(L),NDTR(L),BRANCH(L),LZ(L),RLMDA(L),
               *Q(L),(DCF(M,L),M=1,6)
0160        241 FORMAT(1H0,2A4,5X,I1,7X,F4.0,6X,I2,4X,E10.3,2X,E10.3,4X,4E11.3,2X,
               *2E11.3)
          C
          C          CHECK AGAINST ZERO FLOW AND  FIRST DAUGHTER.
          C
0161            IF(FLOW(1).GT.0.01) GO TO 248
0162            WRITE(6,246)
0163            STOP
0164        246 FORMAT(1H0,'FLOW IN FIRST LOCATION CANNOT BE ZERO. EXEC. TERM.')
0165        248 IF(NDTR(1).NE.1)  GO TO 249
0166            WRITE(6,247)
0167            STOP
0168        247 FORMAT(1H0,'FIRST NUCLIDE CANNOT BE A DAUGHTER. EXECUTION TERM.')
          C
          C     CALC. CONCS. AT FIRST LOCATION. CHANGE UNITS FROM
          C     CURIES/YR PER CFS TO MICROCI / ML
          C
0169        249 DO 250 L=1,NISO
0170        250 CONC(1,L) = (Q(L) / FLOW (1)) * 1.12E-06
          C
          C     PERFORM VARIOUS DATA CHECKS AND CALC. DOWNSTREAM CONCENTRATIONS.
          C
0171            TIME(1) =0.
0172            RMILES(1) = 0.
0173            DO 300 N=2,NPC
0174            RMILES(N) = ABS(RIVM(N) - RIVM(1))
0175            IF (RMILES(N).GE.RMILES(N-1)) GO TO 260
0176            WRITE(6,255) N
0177        255 FORMAT(1H0,'EXECUTION STOPPED DUE TO ERROR IN INPUT DATA. ',
               *'LOCATION ',I2,' IS FEWER MILES DOWNSTREAM THAN PREVIOUS ',
               *'LOCATION.')
0178            STOP
0179        260 IF (FLOW(N).GE.FLOW(N-1)) GO TO 270
0180            WRITE(6,265) N
0181        265 FORMAT(1H0,'EXECUTION STOPPED DUE TO ERROR IN INPUT DATA. ',
               *'VOLUME FLOW RATE AT LOCATION ',I2,' IS LESS THAN THAT AT ',
               *'PREVIOUS POINT')
0182            STOP
0183        270 TIME(N) = TIME(N-1) + (RMILES(N) - RMILES(N-1))/VEL(N)
          C
0184            DELAY = (RMILES(N) - RMILES(N-1))*3600./VEL(N)
0185            DO 300 L=1,NISO
          C
0186            ARGD = RLMDA(L) * DELAY
          C
          C     AVOID UNDERFLOWS.
          C
0187            DECAYD = 0.
0188            IF(ARGD.LT.100.) DECAYD=EXP(-ARGD)
          C
```

Listing of source program for RVRDOS (continued)

```
0189           DLUTE= FLOW(N-1) /(FLOW(N) + VOL(N) * RLMDA(L))
0190           CONC(N,L) = CONC(N-1,L) * DECAYD * DLUTE
          C
          C    CALC. INGROWTH
          C
0191           IF(NDTR(L).EQ.1)
              *  CONC(N,L) = CONC(N,L) + BRANCH(L) / 100. * (CONC(N-1,L-1) *
              *  RLMDA(L) / (RLMDA(L) - RLMDA(L-1)) * (DECAYP - DECAYD) *
              *  DLUTE + CONC(N,L-1) * RLMDA(L) * VOL(N) / (RLMDA(L) * VOL(N) +
              *  FLOW(N)))
          C
0192       300 DECAYP   DECAYD
          C
          C
0193           WRITE(6,310)
0194       310 FORMAT(1H1,/,44X,'RADIONUCLIDE CONCENTRATIONS DOWNSTREAM',/,49X,
              *'(MICROCURIES PER MILLILITER)'/)
0195           IF(NISO.LT.10) NMIN=NISO
0196           IF(NISO.GE.10) NMIN=10
0197           WRITE(6,311) ((L),L=1,NMIN)
0198       311 FORMAT(1H0,/,25X,10(4X,I2,4X))
0199           WRITE(6,312) ((NUCL1(L),NUCL2(L)),L=1,NMIN)
0200       312 FORMAT( 1H0,27X,10(2A4,2X))
0201           DO 315 N=1,NPC
0202       315 WRITE(6,316) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),
              *(CONC(N,L),L=1,NMIN)
0203       316 FORMAT(1H0,I2,'.',1X,5A4,10E10.2)
0204           IF(NISO.LT.11.) GO TO 400
0205           WRITE(6,311) ((L),L=11,NISO)
0206           WRITE(6,312) ((NUCL1(L),NUCL2(L)),L=11,NISO)
0207           DO 325 N=1,NPC
0208       325 WRITE(6,316) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N).
              *(CONC(N,L),L=11,NISO)
          C
          C
          C     CALCULATE WATER INGESTION DOSES BY NUCLIDE, REACH AND ORGAN
          C     AND SUM OVER NUCLIDES IN EACH REACH.
          C
0209       400 DRINKS=1.95
0210           HOURS = 100.
0211           DO 420 N=1,NPC
0212           IF(POP(N).EQ.0.) GO TO 420
0213           B=POP(N)*DRINKS*365.25*1.E+06
0214           DO 410 M=1,4
0215           D=0.
0216           DO 405 L=1,NISO
0217           DPWTR(N,L,M)=CONC(N,L)*DCF(M,L)*B
0218       405 D = D + DPWTR(N,L,M)
0219       410 DWTRNM(N,M)=D
          C
          C    CALCULATE SWIMMING DOSES AND SUM IN REACHES
          C
0220           B=1.     *HOURS*1.E+06
0221           DO 420 M=5,6
0222           D=0.
0223           DO 415 L=1,NISO
0224           DPWTR(N,L,M)=CONC(N,L)*DCF(M,L)*B
0225       415 D=D+DPWTR(N,L,M)
```

Listing of source program for RVRDOS (continued)

```
0226              DWTRNM(N,M) = D
0227          420 CONTINUE
            C
            C
            C     WRITE DRINKING WATER AND SWIMMING DOSES AT ALL LOCATIONS
0228              IF(NPRINT.NE.1)  GO TO 440
            C
0229              DO 440 N=1,NPC
0230              IF(POP(N).EQ.0.) GO TO 440
0231              WRITE(6,430) DRINKS,HOURS
0232          430 FORMAT(1H1,30X,'DRINKING WATER AND SWIMMING'/,34X,'POPULATION ',
                 *'DOSE RATES'/,25X,'(PERSON-REM PER YEAR   FIRST YEAR RATE)'//22X,
                 *'ASSUMING: 1) UNIFORM RELEASE RATES'/,31X,'2A) DRINKING: CONTI'.
                 *'NUOUS INGESTION RATE'/,35X,'OF ',F4.2,' LITERS PEP DAY'/,31X,
                 *'2B) SWIMMING: ',F5.0,' HOURS OF IMMERSION'/,35X,'PER YEAR',
                 *' - ONE PERSON PER REACH')
            C
            C     WRITE LOCATION DATA
            C
0233              WRITE(6,432) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),RMILES(N),
                 *POP(N)
0234          432 FORMAT(1H0,1X,'LOCATION',10X,'NAME',10X,'MILES DOWNSTREAM',3X,
                 *'POPULATION SERVED',
                 */,3X,I4,5X,5A4,3X,F10.2,10X,F10.0)
            C
            C      WRITE POPULATION DOSES BY NUCLIDE AND ORGAN,
            C      WITH SUBTOTALS FOR EACH REACH BY ORGAN.
            C
0235              WRITE(6,434) ((NMOGN1(M),NMOGN2(M)),M=1,6)
0236          434 FORMAT(1H0,1X,'NUCLIDE',4X,'CURIES     DRINKING WATER DOSES (4 ',
                 *'CRITICAL ORGANS)',8X,'SWIMMING DOSES'/,12X,'RELEASED',1X,
                 *4(3X,2A4),2X,2(3X,2A4))
0237              DO 435 L=1,NISO
0238          435 WRITE(6,436) NUCL1(L),NUCL2(L),Q(L),(DPWTR(N,L,M),M=1,6)
0239          436 FORMAT(1H0,1X,2A4,E10.2,1X,4E11.2,2X,2E11.2)
0240              WRITE(6,438) (DWTRNM(N,M),M=1,6)
0241          438 FORMAT(1H0,6X,'SUBTOTALS',5X,4E11.2,2X,2E11.2/)
0242          440 CONTINUE
            C
            C
            C      SUM TOTAL DRINKING WATER ORGAN DOSES FOR RUN
            C
0243              DO 455 M=1,6
0244              D=0.
0245              DO 450 N=1,NPC
0246          450 D=D+DWTRNM(N,M)
0247          455 DPWTRM(M) = D
            C
            C     CALCULATE COMMERCIAL AND CREEL FISH INGESTION DOSES.
            C
0248              CATUSE=1.-2523./4940.
0249              CATEAT=.45
0250              CTLEFT=.80
0251              A1 = CATUSE*CATEAT*CTLEFT*.4535E+06
0252              A2 = CATEAT*CTLEFT*.4535E+06
0253              DO 520 N=1,NPC
0254              IF(CTCHWT(N,1).GT.0.) GO TO 510
0255              IF(CTCHWT(N,2).LE.0.) GO TO 520
```

Listing of source program for RVRDOS (continued)

```
0256          510 B1=CTCHWT(N,1)*A1
0257              B2=CTCHWT(N,2)*A2
0258              DO 520 L=1,NISO
0259              D1=B1*CONC(N,L)*RECONC(LZ(L))
0260              D2=B2*CONC(N,L)*RECONC(LZ(L))
0261              DO 519 M=1,4
0262              DPCML(N,L,M)=D1*DCF(M,L)
0263              DPCRL(N,L,M)=D2*DCF(M,L)
0264          519 CONTINUE
0265          520 CONTINUE
            C
            C     SUM FISH DOSES IN REACHES AND TOTAL FISH DOSE BY ORGAN
            C
0266              DO 540 M=1,4
0267              F=0.
0268              D=0.
0269              DO 535 N=1,NPC
0270              IF(CTCHWT(N,1).GT.0.) GO TO 525
0271              IF(CTCHWT(N,2).LE.0.) GO TO 535
0272          525 H=0.
0273              E=0.
0274              DO 530 L=1,NISO
0275              H   H + DPCRL(N,L,M)
0276          530 E = E + DPCML(N,L,M)
0277              DCRLNM(N,M) = H
0278              DCMLNM(N,M) = E
0279              F = F + DCRLNM(N,M)
0280              D = D + DCMLNM(N,M)
0281          535 CONTINUE
0282              DPCRLM(M) = F
0283          540 DPCMLM(M) = D
            C
            C     WRITE FISH INGESTION POPULATION DOSES IN REACHES
            C
0284              I=(CATUSE+.005)*100.
0285              J=(CATEAT+.005)*100.
0286              K=(CTLEFT+.005)*100.
0287              IF(NPRINT.NE.1)  GO TO 580
0288              DO 570 N=1,NPC
0289              IF(CTCHWT(N,1).LE.0.) GO TO 570
0290              WRITE(6,550)
0291          550 FORMAT(1H1,22X,'COMMERCIAL FISH INGESTION POPULATION DOSE RATES',
                 */,27X,'(PERSON-REM PER YEAR - FIRST YEAR RATE)')
0292              WRITE(6,551) I,J,K
0293          551 FORMAT(1H0,22X,'ASSUMING: 1) UNIFORM INGESTION RATES'/,33X,
                 *'2) ',I2,
                 *' PERCENT OF ALL COMMERCIALLY CAUGHT FISH IS FOR HUMAN CONSUMTION'
                 */,33X,'3) ',I2,' PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY',
                 *' INGESTED'/,33X,'4) ',I2,' PERCENT OF NUCLIDE REMAINS IN FISH',
                 *' AFTER COOKING'//)
            C
0294              WRITE(6,560) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),RMILES(N),
                 *CTCHWT(N,1)
0295          560 FORMAT( 1H0,1X,'LOCATION',10X,'NAME',10X,'MILES DOWNSTREAM',3X,
                 *'COMMERCIAL FISH CAUGHT (LBS)',
                 */,3X,I4,5X,5A4,3X,F10.2,16X,F10.0)
0296              WRITE(6,564) ((NMOGN1(M),NMOGN2(M)),M=1,4)
0297          564 FORMAT(1H0,1X,'NUCLIDE',4X,'CURIES',4X,4(2A4,3X)/,12X,'RELEASED')
```

Listing of source program for RVRDOS (continued)

```
0298              DO 566 L=1,NISO
0299          566 WRITE(6,567) NUCL1(L),NUCL2(L),Q(L),(DPCML(N,L,M),M=1,4)
0300          567 FORMAT(1H0,1X,2A4,F10.2,4E11.2)
0301              WRITE(6,568) (DCMLNM(N,M),M=1,4)
0302          568 FORMAT(1H0,6X,'SUBTOTALS',4X,4F11.2)
0303          570 CONTINUE
            C
            C
0304              DO 580 N=1,NPC
0305              IF(CTCHWT(N,2).LE.0.) GO TO 580
0306              WRITE(6,572)
0307          572 FORMAT(1H1,22X,'CREEL FISH INGESTION POPULATION DOSE RATES',
                 */,24X,'(PERSON-REM PER YEAR - FIRST YEAR RATE)',/)
0308              WRITE(6,573) J,K
0309          573 FORMAT(1H0,22X,'ASSUMING: 1) UNIFORM INGESTION RATES'/,33X,
                 *'2) ALL CREEL FISH ARE IMMEDIATELY EATEN'.
                 */,33X,'3) ',I2,' PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY',
                 *' INGESTED'/,33X,'4) ',I2,' PERCENT OF NUCLIDE REMAINS IN FISH',
                 *' AFTER COOKING'//)
            C
0310              WRITE(6,574) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),RMILES(N),
                 *CTCHWT(N,2)
0311          574 FORMAT(1H0,1X,'LOCATION',10X,'NAME',10X,'MILES DOWNSTREAM',3X,
                 *'CREEL FISH CAUGHT (LBS)',
                 */,3X,I4,5X,5A4,3X,F10.2,13X,F10.0)
0312              WRITE(6,564) ((NMOGN1(M),NMOGN2(M)),M=1,4)
0313              DO 576 L=1,NISO
0314          576 WRITE(6,567) NUCL1(L),NUCL2(L),Q(L),(DPCRL(N,L,M),M=1,4)
0315              WRITE(6,568) (DCRLNM(N,M),M=1,4)
0316          580 CONTINUE
            C
            C        SUM DOSES OVER ALL LOCATIONS
            C
0317              DO 620 L=1,NISO
0318              DO 610 M=1,6
0319              S1=0.
0320              DO 600 N=1,NPC
0321          600 S1=S1+DPWTR(N,L,M)
0322          610 WTRTOT(L,M)=S1
0323              DO 620 M=1,4
0324              S2=0.
0325              S3=0.
0326              DO 615 N=1,NPC
0327              S2=S2+DPCML(N,L,M)
0328          615 S3=S3+DPCRL(N,L,M)
0329              CMLTOT(L,M)=S2
0330          620 CRLTOT(L,M)=S3
            C
            C
            C     WRITE SUMMARY FOR WHOLE RUN
            C
0331              WRITE(6,621) FAC1,FAC2,FAC3,FAC4,FAC5
0332          621 FORMAT(1H1,21X,'SUMMARY OF RVRDOS(02) RUN FOR ',5A4)
0333              WRITE(6,431) DRINKS
0334          431 FORMAT(1H1,37X,'DRINKING WATER'/,34X,'POPULATION ',
                 *'DOSE RATES'/,25X,'(PERSON-REM PER YEAR - FIRST YEAR RATE)'//22X,
                 *'ASSUMING: 1) UNIFORM RELEASE RATES'/,31X,'2) DRINKING: CONTI',
                 *'NUOUS INGESTION RATE'/,35X,'OF ',F4.2,' LITERS PER DAY')
```

Listing of source program for RVRDOS (continued)

```
0335          WRITE(6,622)
0336      622 FORMAT(1H0,23X,'DOSES BY NUCLIDE, SUMMED OVER LOCATIONS')
0337          WRITE(6,6221) ((NMOGN1(M),NMOGN2(M)),M=1,4)
0338     6221 FORMAT(1H0,1X,'NUCLIDE',4X,'CURIES     DRINKING WATER DOSES (4 ',
             *'CRITICAL ORGANS)'/12X,'RELEASED',1X,4(3X,2A4),2X,2(3X,2A4))
0339          DO 623 L=1,NISO
0340      623 WRITE(6,435) NUCL1(L),NUCL2(L),Q(L),(WTRTOT(L,M),M=1,4)
0341          WRITE(6,624) (DPWTRM(M),M=1,4)
0342      624 FORMAT(1H0,8X,'TOTALS',6X,4E11.2,2X,2E11.2)
0343          WRITE(6,431) DRINKS
0344          WRITE(6,626)
0345      626 FORMAT(1H0,23X,'DOSES BY LOCATION, SUMMED OVER NUCLIDES')
0346          WRITE(6,627) ((NMOGN1(M),NMOGN2(M)),M=1,4)
0347      627 FORMAT(1H0,4X,'LOCATION',16X,'MILES     POPULATION    DRINKING ',
             *'WATER DOSES (4 CRITICAL ORGANS)',/,27X,
             *'DOWNSTREAM    SERVED',3X,4(3X,2A4),2X,2(3X,2A4))
0348          DO 630 N=1,NPC
0349      630 WRITE(6,631) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),
             *RMILES(N),POP(N),(DWTRNM(N,M),M=1,4)
0350      631 FORMAT(1H0,I2,'. ',5A4,F9.1,3X,F10.0,3X,4E11.2,2X,2E11.2)
0351          WRITE(6,632) TOTPOP,(DPWTRM(M),M=1,4)
0352      632 FORMAT(1H0,4X,'TOTALS',28X,F10.0,4E11.2,2X,2E11.2)
0353          WRITE(6,550)
0354          WRITE(6,551) I,J,K
0355          WRITE(6,622)
0356          WRITE(6,564) ((NMOGN1(M),NMOGN2(M)),M=1,4)
0357          DO 700 L=1,NISO
0358      700 WRITE(6,567) NUCL1(L),NUCL2(L),Q(L),(CMLTOT(L,M),M=1,4)
0359          WRITE(6,701) (DPCMLM(M),M=1,4)
0360      701 FORMAT(1H0,8X,'TOTALS',5X,4E11.2)
0361          WRITE(6,550)
0362          WRITE(6,551) I,J,K
0363          WRITE(6,626)
0364          WRITE(6,710) ((NMOGN1(M),NMOGN2(M)),M=1,4)
0365      710 FORMAT(1H0,4X,'LOCATION',16X,'MILES     COMMERCIAL FISH ',
             *4(3X,2A4),/,27X,'DOWNSTREAM   CAUGHT (LBS)')
0366          DO 720 N=1,NPC
0367      720 WRITE(6,721) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N).NMN5(N),
             *RMILES(N),CTCHWT(N,1),(DCMLNM(N,M),M=1,4)
0368      721 FORMAT(1H0,I2,'. ',5A4,F9.1,6X,F10.0,5X,4E11.2)
0369          WRITE(6,722) TOTCML,(DPCMLM(M),M=1,4)
0370      722 FORMAT(1H0,4X,'TOTALS',33X,F10.0,4E11.2)
0371          WRITE(6,572)
0372          WRITE(6,573) J,K
0373          WRITE(6,622)
0374          WRITE(6,564) ((NMOGN1(M),NMOGN2(M)),M=1,4)
0375          DO 800 L=1,NISO
0376      800 WRITE(6,567) NUCL1(L),NUCL2(L),Q(L),(CRLTOT(L,M),M=1,4)
0377          WRITE(6,701) (DPCRLM(M),M=1,4)
0378          WRITE(6,572)
0379          WRITE(6,573) J,K
0380          WRITE(6,626)
0381          WRITE(6,810) ((NMOGN1(M),NMOGN2(M)),M=1,4)
0382      810 FORMAT(1H0,4X,'LOCATION',16X,'MILES        CREEL FISH   ',
             *4(3X,2A4),/,27X,'DOWNSTREAM   CAUGHT (LBS)')
0383          DO 820 N=1,NPC
0384      820 WRITE(6,721) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),
             *RMILES(N),CTCHWT(N,2),(DCRLNM(N,M),M=1,4)
```

Listing of source program for RVRDOS (continued)

```
FORTRAN IV G LEVEL  21                    MAIN                DATE = 76225          12/23/13

 0385              WRITE(6,722) TOTCRL,(DPCRLM(M),M=1,4)
 0386              WRITE(6,723)
 0387          723 FORMAT(1H1,21X,'TRAVEL TIME TO DOWNSTREAM POINTS (HRS.)')
 0388              DO 830 N=1,NPC
 0389          830 WRITE(6,724) N,NMN1(N),NMN2(N),NMN3(N),NMN4(N),NMN5(N),TIME(N)
 0390          724 FORMAT(1H0,I2,'. ',5A4,F10.1)
             C
 0391              WRITE(6,901)
 0392          901 FORMAT(1H1)
 0393              GO TO 900
             C
 0394          999 CALL EXIT
 0395              STOP
 0396              END
```

Listing of source program for RVRDOS (continued)

PROGRAM RVRDOS

FOR INFORMATION REGARDING THIS PROGRAM, CONTACT:

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION PROGRAMS
401 M ST SW
WASHINGTON, DC 20460

INPUT DATA

FACILITY	YEAR OF RELEASES	NO. MONTHS OF DATA	SOURCE OF RELEASE DATA
GENOA (LACROSSE)	1973	12	

LOCATIONS ON STREAM (TOTAL OF 29, FACILITY IS NO. 1)

REACH NUMBER	NAME	POPULATION SERVED	VOLUME FLOW RATE(CFS)	STREAM SPEED(MPH)	RIVER MILE	DAM VOLUME ACRE-FEET	COMMERCIAL FISH WT,LBS	CREEL FISH WT,LBS
1	GENOA	1.	276.	1.9	-1633.3	0.	0.	111.
2	LOCK AND DAM 8	0.	28199.	1.9	-1633.0	100400.	1112264.	0.
3	LOCK AND DAM 9	0.	30691.	1.9	-1603.8	195800.	2040780.	0.
4	LOCK AND DAM 10	0.	34277.	1.9	-1571.0	149700.	675405.	0.
5	LOCK AND DAM 11	0.	38585.	1.9	-1539.8	157400.	528808.	142927.
6	LOCK AND DAM 12	0.	44778.	1.9	-1510.5	88400.	405587.	0.
7	LOCK AND DAM 13	0.	46678.	1.9	-1478.3	185600.	884603.	118932.
8	LOCK AND DAM 14	0.	49660.	1.9	-1449.1	80000.	396522.	0.
9	BETTENDORF-MOLINE	55555.	50363.	1.9	-1441.8	30000.	151214.	0.
10	DAVENPORT-ROCKISLAND	141580.	50652.	1.9	-1438.8	89400.	458510.	0.
11	LOCK AND DAM 17	0.	55065.	1.9	-1393.0	51400.	450113.	0.
12	LOCK AND DAM 18	0.	57638.	1.9	-1366.3	95800.	928489.	83669.
13	BURLINGTON, IOWA	35400.	58245.	1.9	-1360.0	0.	0.	0.
14	FT. MADISON	15245.	60335.	1.9	-1338.3	0.	0.	0.
15	KEOKUK, L&D 19	16315.	62119.	1.9	-1319.8	214000.	920778.	0.
16	LOCK AND DAM 20	0.	66636.	1.9	-1299.0	73600.	75657.	0.
17	QUINCY, ILL.	47500.	70155.	1.9	-1282.8	76400.	138218.	0.
18	HANNIBAL, MO.	21000.	74065.	1.9	-1264.8	91000.	128689.	0.
19	LOCK AND DAM 24	0.	81776.	1.9	-1229.8	29745.	214530.	0.

Genoa: Input data

Genoa: Input data (continued)

20	LOCK AND DAM 25	0.	88727.	1.9	-1197.3	49674.	336105.	0.
21	LOCK AND DAM 26	0.	97090.	1.9	-1158.8	107082.	353487.	38761.
22	LOCK AND DAM 27	40073.	157739.	1.9	-1141.1	0.	264390.	0.
23	ST.LOUIS,E.ST.LOUIS	670015.	175900.	1.9	-1135.8	0.	0.	0.
24	CHESTER, ILL.	4200.	180600.	2.9	-1065.3	0.	0.	0.
25	CAPE GIRARDEAU, MO.	25700.	184550.	2.9	-1007.8	0.	0.	0.
26	THEBES, ILL.	450.	185100.	2.9	-999.8	0.	0.	0.
27	VICKSBURG, MISS.	41000.	574000.	3.2	-438.0	0.	0.	0.
28	DONALDSVILLE, LA.	7750.	579000.	3.2	-177.0	0.	0.	0.
29	NEW ORLEANS, LA.	652125.	579000.	3.2	-100.0	0.	0.	0.

RADIONUCLIDES RELEASED (TOTAL 20)

						DOSE CONVERSION FACTORS					
						INGESTION				SWIMMING	
						MILLIREM/YEAR PER PICO-CURIE/YEAR INTAKE				MREM/HR PER PCI/LITER	
ISOTOPE	0=PARENT 1=DAUGHTER	BRANCH. RATIO,%	ATOMIC NUMBER	DECAY CONSTANT, 1/SEC	CURIES RELEASED	BODY	THYROID	BONE	GI-LLI	SWIMSKIN	SWIMBODY
BALA-140	0	0.	56	0.211E-04	0.740E-01	0.133E-05	0.0	0.202E-04	0.402E-04	0.760E-06	0.490E-06
CO-58	0	0.	27	0.113E-06	0.118E+02	0.168E-05	0.0	0.0	0.152E-04	0.230E-05	0.180E-05
CO-60	0	0.	27	0.418E-08	0.126E+01	0.470E-05	0.0	0.0	0.394E-04	0.540E-05	0.460E-05
CR-51	0	0.	24	0.289E-06	0.810E-01	0.267E-08	0.159E-08	0.0	0.669E-06	0.640E-07	0.520E-07
CS-134	0	0.	55	0.107E-07	0.566E+01	0.100E-03	0.0	0.529E-04	0.255E-05	0.350E-05	0.290E-05
CS-137	0	0.	55	0.733E-09	0.101E+02	0.560E-04	0.0	0.637E-04	0.205E-05	0.140E-05	0.100E-05
BA-137M	1	100.	56	0.163E+02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H-3	0	0.	1	0.179E-08	0.103E+03	0.127E-06	0.127E-06	0.0	0.640E-07	0.0	0.0
I-131	0	0.	53	0.996E-06	0.313E+01	0.337E-05	0.186E-02	0.393E-05	0.153E-05	0.930E-06	0.680E-06
XE-131M	1	1.	54	0.680E-06	0.0	0.0	0.0	0.0	0.0	0.560E-07	0.620E-08
I-133	0	0.	53	0.916E-05	0.289E+01	0.702E-06	0.482E-03	0.143E-05	0.225E-05	0.150E-05	0.960E-06
XE-133	1	100.	54	0.152E-05	0.430E+00	0.0	0.0	0.0	0.0	0.110E-06	0.570E-07
MN-54	0	0.	25	0.265E-07	0.850E-01	0.868E-06	0.0	0.0	0.138E-04	0.180E-05	0.150E-05
SR-89	0	0.	38	0.154E-06	0.500E-01	0.913E-05	0.0	0.320E-03	0.498E-04	0.540E-06	0.460E-08
Y-89M	1	0.	39	0.431E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SR-90	0	0.	38	0.778E-09	0.210E-01	0.895E-03	0.0	0.336E-03	0.123E-03	0.150E-06	0.540E-09
Y-90	1	100.	39	0.301E-05	0.0	0.285E-09	0.0	0.986E-08	0.105E-03	0.960E-06	0.130E-07

XE-135	0	0.	54	0.209E-04	0.180E+00	0.0	0.0	0.0	0.0	0.790E-06	0.450E-06
CS-135	0	0.	55	0.730E-14	0.0	0.564E-05	0.0	0.144E-04	0.371E-07	0.110E-07	0.660E-10
ZN-65	0	0.	30	0.328E-07	0.216E+00	0.508E-05	0.0	0.345E-05	0.978E-05	0.120E-05	0.110E-05

Genoa: Input data
(continued)

Genoa: Radionuclide concentrations by downstream location

RADIONUCLIDE CONCENTRATIONS DOWNSTREAM
(MICROCURIES PER MILLILITER)

	1	2	3	4	5	6	7	8	9	10
	BALA-140	CO-58	CO-60	CR-51	CS-134	CS-137	BA-137M	H-3	I-131	XE-131M
1. GENOA	0.30E-09	0.48E-07	0.51E-08	0.33E-09	0.23E-07	0.41E-07	0.0	0.42E-06	0.13E-07	0.0
2. LOCK AND DAM 8	0.68E-12	0.46E-09	0.50E-10	0.31E-11	0.22E-09	0.40E-09	0.40E-09	0.41E-08	0.11E-09	0.10E-12
3. LOCK AND DAM 9	0.28E-13	0.41E-09	0.46E-10	0.26E-11	0.21E-09	0.37E-09	0.37E-09	0.38E-08	0.73E-10	0.22E-12
4. LOCK AND DAM 10	0.14E-14	0.35E-09	0.41E-10	0.21E-11	0.18E-09	0.33E-09	0.33E-09	0.34E-08	0.52E-10	0.25E-12
5. LOCK AND DAM 11	0.70E-16	0.31E-09	0.37E-10	0.18E-11	0.16E-09	0.29E-09	0.29E-09	0.30E-08	0.37E-10	0.25E-12
6. LOCK AND DAM 12	0.69E-17	0.26E-09	0.31E-10	0.15E-11	0.14E-09	0.25E-09	0.25E-09	0.26E-08	0.28E-10	0.22E-12
7. LOCK AND DAM 13	0.40E-18	0.24E-09	0.30E-10	0.13E-11	0.13E-09	0.24E-09	0.24E-09	0.25E-08	0.21E-10	0.21E-12
8. LOCK AND DAM 14	0.47E-19	0.23E-09	0.28E-10	0.12E-11	0.13E-09	0.23E-09	0.23E-09	0.23E-08	0.18E-10	0.20E-12
9. BETTENDORF-MOLINE	0.22E-19	0.22E-09	0.28E-10	0.12E-11	0.12E-09	0.22E-09	0.22E-09	0.23E-08	0.17E-10	0.20E-12
10. DAVENPORT-ROCKISLAND	0.75E-20	0.22E-09	0.28E-10	0.11E-11	0.12E-09	0.22E-09	0.22E-09	0.23E-08	0.15E-10	0.19E-12
11. LOCK AND DAM 17	0.59E-21	0.20E-09	0.26E-10	0.10E-11	0.11E-09	0.20E-09	0.20E-09	0.21E-08	0.13E-10	0.17E-12
12. LOCK AND DAM 18	0.77E-22	0.19E-09	0.24E-10	0.93E-12	0.11E-09	0.20E-09	0.20E-09	0.20E-08	0.11E-10	0.16E-12
13. BURLINGTON, IOWA	0.59E-22	0.18E-09	0.24E-10	0.92E-12	0.11E-09	0.19E-09	0.19E-09	0.20E-08	0.10E-10	0.16E-12
14. FT. MADISON	0.24E-22	0.18E-09	0.23E-10	0.87E-12	0.10E-09	0.19E-09	0.19E-09	0.19E-08	0.96E-11	0.15E-12
15. KEOKUK, L&D 19	0.27E-23	0.17E-09	0.23E-10	0.81E-12	0.10E-09	0.18E-09	0.18E-09	0.19E-08	0.78E-11	0.14E-12
16. LOCK AND DAM 20	0.54E-24	0.16E-09	0.21E-10	0.73E-12	0.93E-10	0.17E-09	0.17E-09	0.17E-08	0.67E-11	0.13E-12
17. QUINCY, ILL.	0.13E-24	0.15E-09	0.20E-10	0.68E-12	0.88E-10	0.16E-09	0.16E-09	0.16E-08	0.59E-11	0.12E-12
18. HANNIBAL, MO.	0.29E-25	0.14E-09	0.19E-10	0.63E-12	0.84E-10	0.15E-09	0.15E-09	0.16E-08	0.51E-11	0.11E-12
19. LOCK AND DAM 24	0.48E-26	0.12E-09	0.17E-10	0.56E-12	0.76E-10	0.14E-09	0.14E-09	0.14E-08	0.43E-11	0.95E-13
20. LOCK AND DAM 25	0.80E-27	0.11E-09	0.16E-10	0.50E-12	0.70E-10	0.13E-09	0.13E-09	0.13E-08	0.36E-11	0.85E-13
21. LOCK AND DAM 26	0.78E-28	0.10E-09	0.14E-10	0.44E-12	0.64E-10	0.12E-09	0.12E-09	0.12E-08	0.29E-11	0.74E-13
22. LOCK AND DAM 27	0.24E-28	0.62E-10	0.89E-11	0.27E-12	0.39E-10	0.71E-10	0.71E-10	0.73E-09	0.17E-11	0.45E-13
23. ST.LOUIS,E.ST.LOUIS	0.17E-28	0.56E-10	0.80E-11	0.24E-12	0.35E-10	0.64E-10	0.64E-10	0.65E-09	0.16E-11	0.40E-13
24. CHESTER, ILL.	0.26E-29	0.54E-10	0.77E-11	0.23E-12	0.34E-10	0.62E-10	0.62E-10	0.64E-09	0.14E-11	0.38E-13
25. CAPE GIRARDEAU, MO.	0.57E-30	0.52E-10	0.76E-11	0.22E-12	0.33E-10	0.61E-10	0.61E-10	0.62E-09	0.13E-11	0.36E-13
26. THEBES, ILL.	0.46E-30	0.52E-10	0.76E-11	0.22E-12	0.33E-10	0.61E-10	0.61E-10	0.62E-09	0.12E-11	0.35E-13

27. VICKSBURG, MISS.	0.29E-36	0.16E-10	0.24E-11	0.59E-13	0.11E-10	0.20E-10	0.20E-10	0.20E-09	0.22E-12	0.85E-14
28. DONALDSVILLE, LA.	0.62E-39	0.15E-10	0.24E-11	0.53E-13	0.11E-10	0.19E-10	0.19E-10	0.20E-09	0.15E-12	0.72E-14
29. NEW ORLEANS, LA.	0.10E-39	0.15E-10	0.24E-11	0.52E-13	0.11E-10	0.19E-10	0.19E-10	0.20E-09	0.15E-12	0.69E-14

	11	12	13	14	15	16	17	18	19	20
	I-133	XE-133	MN-54	SR-89	Y-89M	SR-90	Y-90	XE-135	CS-135	ZN-65
1. GENOA	0.12E-07	0.17E-08	0.35E-09	0.20E-09	0.0	0.85E-10	0.0	0.73E-09	0.0	0.88E-09
2. LOCK AND DAM 8	0.47E-10	0.23E-10	0.34E-11	0.19E-11	0.17E-15	0.83E-12	0.27E-12	0.17E-11	0.0	0.85E-11
3. LOCK AND DAM 9	0.74E-11	0.18E-10	0.31E-11	0.17E-11	0.15E-15	0.77E-12	0.53E-12	0.71E-13	0.0	0.78E-11
4. LOCK AND DAM 10	0.14E-11	0.12E-10	0.27E-11	0.15E-11	0.13E-15	0.69E-12	0.57E-12	0.35E-14	0.0	0.69E-11
5. LOCK AND DAM 11	0.25E-12	0.77E-11	0.24E-11	0.13E-11	0.11E-15	0.61E-12	0.55E-12	0.18E-15	0.0	0.61E-11
6. LOCK AND DAM 12	0.78E-13	0.54E-11	0.21E-11	0.11E-11	0.95E-16	0.52E-12	0.49E-12	0.18E-16	0.0	0.52E-11
7. LOCK AND DAM 13	0.16E-13	0.37E-11	0.20E-11	0.98E-12	0.88E-16	0.50E-12	0.49E-12	0.11E-17	0.0	0.50E-11
8. LOCK AND DAM 14	0.57E-14	0.29E-11	0.18E-11	0.90E-12	0.81E-16	0.47E-12	0.46E-12	0.13E-18	0.0	0.46E-11
9. BETTENDORF-MOLINE	0.40E-14	0.27E-11	0.18E-11	0.88E-12	0.79E-16	0.47E-12	0.46E-12	0.61E-19	0.0	0.46E-11
10. DAVENPORT-ROCKISLAND	0.22E-14	0.24E-11	0.18E-11	0.87E-12	0.78E-16	0.45E-12	0.46E-12	0.21E-19	0.0	0.45E-11
11. LOCK AND DAM 17	0.67E-15	0.18E-11	0.17E-11	0.78E-12	0.70E-16	0.43E-12	0.42E-12	0.17E-20	0.0	0.42E-11
12. LOCK AND DAM 18	0.24E-15	0.15E-11	0.16E-11	0.73E-12	0.66E-16	0.41E-12	0.40E-12	0.22E-21	0.0	0.40E-11
13. BURLINGTON, IOWA	0.21E-15	0.14E-11	0.15E-11	0.72E-12	0.55E-16	0.40E-12	0.40E-12	0.17E-21	0.0	0.39E-11
14. FT. MADISON	0.14E-15	0.13E-11	0.15E-11	0.69E-12	0.62E-16	0.39E-12	0.39E-12	0.70E-22	0.0	0.38E-11
15. KEOKUK, L&D 19	0.42E-16	0.96E-12	0.15E-11	0.66E-12	0.59E-16	0.38E-12	0.38E-12	0.79E-23	0.0	0.36E-11
16. LOCK AND DAM 20	0.19E-16	0.78E-12	0.13E-11	0.60E-12	0.54E-16	0.35E-12	0.35E-12	0.16E-23	0.0	0.34E-11
17. QUINCY, ILL.	0.95E-17	0.66E-12	0.13E-11	0.57E-12	0.51E-16	0.33E-12	0.33E-12	0.40E-24	0.0	0.32E-11
18. HANNIBAL, MO.	0.44E-17	0.55E-12	0.12E-11	0.53E-12	0.48E-16	0.32E-12	0.32E-12	0.89E-25	0.0	0.30E-11
19. LOCK AND DAM 24	0.19E-17	0.44E-12	0.11E-11	0.47E-12	0.43E-16	0.29E-12	0.29E-12	0.15E-25	0.0	0.27E-11
20. LOCK AND DAM 25	0.81E-18	0.36E-12	0.10E-11	0.43E-12	0.39E-16	0.26E-12	0.26E-12	0.25E-26	0.0	0.25E-11
21. LOCK AND DAM 26	0.26E-18	0.27E-12	0.91E-12	0.39E-12	0.35E-16	0.24E-12	0.24E-12	0.25E-27	0.0	0.23E-11
22. LOCK AND DAM 27	0.12E-18	0.16E-12	0.56E-12	0.24E-12	0.21E-16	0.15E-12	0.15E-12	0.77E-28	0.0	0.14E-11
23. ST.LOUIS,E.ST.LOUIS	0.98E-19	0.14E-12	0.50E-12	0.21E-12	0.19E-16	0.13E-12	0.13E-12	0.55E-28	0.0	0.13E-11
24. CHESTER, ILL.	0.43E-19	0.12E-12	0.49E-12	0.20E-12	0.19E-16	0.13E-12	0.13E-12	0.88E-29	0.0	0.12E-11
25. CAPE GIRARDEAU, MO.	0.22E-19	0.11E-12	0.48E-12	0.20E-12	0.18E-16	0.13E-12	0.13E-12	0.19E-29	0.0	0.12E-11

Genoa: Radionuclide concentrations by downstream location
(continued)

Genoa: Radionuclide concentrations by downstream location (continued)

26. THEBES, ILL.	0.20F-19	0.10E-12	0.48E-12	0.20E-12	0.18E-16	0.13E-12	0.13E-12	0.16E-29	0.0	0.12E-11
27. VICKSBURG, MISS.	0.21E-22	0.13E-13	0.15E-12	0.57E-13	0.52E-17	0.41E-13	0.41E-13	0.11E-35	0.0	0.38E-12
28. DONALDSVILLE, LA.	0.15E-23	0.82E-14	0.15E-12	0.54E-13	0.49E-17	0.41E-13	0.41E-13	0.25E-38	0.0	0.37E-12
29. NEW ORLEANS, LA.	0.67E-24	0.72E-14	0.15E-12	0.54E-13	0.48E-17	0.41E-13	0.41E-13	0.42E-39	0.0	0.37E-12

DRINKING WATER
POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM RELEASE RATES
2) DRINKING: CONTINUOUS INGESTION RATE
OF 1.95 LITERS PER DAY

DOSES BY NUCLIDE, SUMMED OVER LOCATIONS

NUCLIDE	CURIES RELEASED	DRINKING WATER DOSES (4 CRITICAL ORGANS) BODY	THYROID	BONE	GI-LLI
BALA-14C	0.74E-01	0.28E-06	0.0	0.43E-05	0.86E-05
CO-58	0.12E+02	0.14E+00	0.0	0.0	0.13E+01
CO-60	0.13E+01	0.54E-01	0.0	0.0	0.45E+00
CR-51	0.81E-01	0.10E-05	0.62E-06	0.0	0.26E-03
CS-134	0.57E+01	0.50E+01	0.0	0.27E+01	0.13E+00
CS-137	0.10E+02	0.51E+01	0.0	0.58E+01	0.19E+00
BA-137M	0.0	0.0	0.0	0.0	0.0
H-3	0.10E+03	0.12E+00	0.12E+00	0.0	0.60E-01
I-131	0.31E+01	0.13E-01	0.72E+01	0.15E-01	0.59E-02
XE-131M	0.0	0.0	0.0	0.0	0.0
I-133	0.29E+01	0.61E-05	0.42E-02	0.13E-04	0.20E-04
XE-133	0.43E+00	0.0	0.0	0.0	0.0
MN-54	0.85E-01	0.63E-03	0.0	0.0	0.10E-01
SR-89	0.50E-01	0.29E-02	0.0	0.10E+00	0.16E-01
Y-89M	0.0	0.0	0.0	0.0	0.0
SR-90	0.21E-01	0.17E+00	0.0	0.64E-01	0.23E-01
Y-90	0.0	0.54E-07	0.0	0.19E-05	0.20E-01
XE-135	0.18E+00	0.0	0.0	0.0	0.0
CS-135	0.0	0.0	0.0	0.0	0.0
ZN-65	0.22E+00	0.93E-02	0.0	0.63E-02	0.18E-01
TOTALS		0.11E+02	0.73E+01	0.87E+01	0.22E+01

Genoa: Drinking water doses by nuclide

Genoa: Drinking water doses by location

DRINKING WATER
POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM RELEASE RATES
2) DRINKING: CONTINUOUS INGESTION RATE
OF 1.95 LITERS PER DAY

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	POPULATION SERVED	DRINKING WATER DOSES (4 CRITICAL ORGANS) BODY	THYROID	BONE	GI-LLI
1. GENOA	0.0	1.	0.35E-02	0.21E-01	0.28E-02	0.85E-03
2. LOCK AND DAM 8	0.3	0.	0.0	0.0	0.0	0.0
3. LOCK AND DAM 9	29.5	0.	0.0	0.0	0.0	0.0
4. LOCK AND DAM 10	62.3	0.	0.0	0.0	0.0	0.0
5. LOCK AND DAM 11	94.5	0.	0.0	0.0	0.0	0.0
6. LOCK AND DAM 12	122.8	0.	0.0	0.0	0.0	0.0
7. LOCK AND DAM 13	155.0	0.	0.0	0.0	0.0	0.0
8. LOCK AND DAM 14	184.2	0.	0.0	0.0	0.0	0.0
9. BETTENDORF-MOLINE	191.5	55555.	0.10E+01	0.12E+01	0.84E+00	0.22E+00
10. DAVENPORT-ROCKISLAND	194.5	141580.	0.26E+01	0.29E+01	0.21E+01	0.56E+00
11. LOCK AND DAM 17	240.3	0.	0.0	0.0	0.0	0.0
12. LOCK AND DAM 18	267.0	0.	0.0	0.0	0.0	0.0
13. BURLINGTON, IOWA	273.3	35400.	0.57E+00	0.49E+00	0.46E+00	0.12E+00
14. FT. MADISON	295.0	15245.	0.24E+00	0.20E+00	0.19E+00	0.50E-01
15. KEOKUK, L&D 19	313.5	16315.	0.25E+00	0.17E+00	0.20E+00	0.51E-01
16. LOCK AND DAM 20	334.3	0.	0.0	0.0	0.0	0.0
17. QUINCY, ILL.	350.5	47500.	0.63E+00	0.38E+00	0.51E+00	0.13E+00
18. HANNIBAL, MO.	368.5	21000.	0.26E+00	0.15E+00	0.22E+00	0.54E-01
19. LOCK AND DAM 24	403.5	0.	0.0	0.0	0.0	0.0
20. LOCK AND DAM 25	436.0	0.	0.0	0.0	0.0	0.0
21. LOCK AND DAM 26	474.5	0.	0.0	0.0	0.0	0.0
22. LOCK AND DAM 27	492.2	40073.	0.24E+00	0.95E-01	0.19E+00	0.47E-01
23. ST.LOUIS,E.ST.LOUIS	497.5	670015.	0.35E+01	0.14E+01	0.29E+01	0.71E+00
24. CHESTER, ILL.	568.0	4200.	0.22E-01	0.80E-02	0.18E-01	0.43E-02

25.	CAPE GIRARDEAU, MO.	525.5	25700.	0.13E+00	0.44E-01	0.11E+00	0.26E-01
26.	THEBES, ILL.	633.5	450.	0.23E-02	0.77E-03	0.18E-02	0.45E-03
27.	VICKSBURG, MISS.	1195.3	41000.	0.66E-01	0.12E-01	0.54E-01	0.13E-01
28.	DONALDSVILLE, LA.	1456.3	7750.	0.12E-01	0.18E-02	0.10E-01	0.23E-02
29.	NEW ORLEANS, LA.	1533.3	652125.	0.10E+01	0.14E+00	0.85E+00	0.19E+00
	TOTALS		1773909.	0.11E+02	0.73E+01	0.87E+01	0.22E+01

Genoa: Drinking water doses by location
(continued)

Genoa: Commercial fish ingestion doses by location

COMMERCIAL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) 49 PERCENT OF ALL COMMERCIALLY CAUGHT FISH IS FOR HUMAN CONSUMTION
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

	LOCATION	MILES DOWNSTREAM	COMMERCIAL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1.	GENOA	0.0	0.	0.0	0.0	0.0	0.0
2.	LOCK AND DAM 8	0.3	1112264.	0.16E+01	0.30E+00	0.13E+01	0.74E-01
3.	LOCK AND DAM 9	29.5	2040780.	0.27E+01	0.34E+00	0.22E+01	0.12E+00
4.	LOCK AND DAM 10	62.3	675405.	0.80E+00	0.79E-01	0.66E+00	0.36E-01
5.	LOCK AND DAM 11	94.5	528808.	0.55E+00	0.43E-01	0.46E+00	0.25E-01
6.	LOCK AND DAM 12	122.8	405587.	0.37E+00	0.25E-01	0.30E+00	0.17E-01
7.	LOCK AND DAM 13	155.0	884603.	0.76E+00	0.42E-01	0.64E+00	0.34E-01
8.	LOCK AND DAM 14	184.2	396522.	0.32E+00	0.16E-01	0.27E+00	0.14E-01
9.	BETTENDORF-MOLINE	191.5	151214.	0.12E+00	0.57E-02	0.10E+00	0.54E-02
10.	DAVENPORT-ROCKISLAND	194.5	458510.	0.36E+00	0.16E-01	0.30E+00	0.16E-01
11.	LOCK AND DAM 17	240.3	450113.	0.33E+00	0.13E-01	0.27E+00	0.15E-01
12.	LOCK AND DAM 18	267.0	928489.	0.65E+00	0.22E-01	0.54E+00	0.29E-01
13.	BURLINGTON, IOWA	273.3	0.	0.0	0.0	0.0	0.0
14.	FT. MADISON	295.0	0.	0.0	0.0	0.0	0.0
15.	KEOKUK, L&D 19	313.5	920778.	0.59E+00	0.16E-01	0.50E+00	0.26E-01
16.	LOCK AND DAM 20	334.3	75657.	0.46E-01	0.11E-02	0.38E-01	0.20E-02
17.	QUINCY, ILL.	350.5	138218.	0.79E-01	0.18E-02	0.66E-01	0.35E-02
18.	HANNIBAL, MO.	368.5	128689.	0.70E-01	0.15E-02	0.58E-01	0.31E-02
19.	LOCK AND DAM 24	403.5	214530.	0.11E+00	0.20E-02	0.88E-01	0.46E-02
20.	LOCK AND DAM 25	436.0	336105.	0.15E+00	0.27E-02	0.13E+00	0.67E-02
21.	LOCK AND DAM 26	474.5	353487.	0.15E+00	0.23E-02	0.12E+00	0.64E-02
22.	LOCK AND DAM 27	492.2	264390.	0.67E-01	0.10E-02	0.56E-01	0.29E-02
23.	ST.LOUIS,E.ST.LOUIS	497.5	0.	0.0	0.0	0.0	0.0

24. CHESTER, ILL.	568.0	0.	0.0	0.0	0.0	0.0
25. CAPE GIRARDEAU, MO.	625.5	0.	0.0	0.0	0.0	0.0
26. THEBES, ILL.	633.5	0.	0.0	0.0	0.0	0.0
27. VICKSBURG, MISS.	1195.3	0.	0.0	0.0	0.0	0.0
28. DONALDSVILLE, LA.	1456.3	0.	0.0	0.0	0.0	0.0
29. NEW ORLEANS, LA.	1533.3	0.	0.0	0.0	0.0	0.0
TOTALS		10464149.	0.98E+01	0.93E+00	0.82E+01	0.44E+00

Genoa: Commercial fish ingestion doses by location
(continued)

Genoa: Creel fish ingestion doses by location

CREEL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) ALL CREEL FISH ARE IMMEDIATELY EATEN
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	CREEL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. GENOA	0.0	111.	0.33E-01	0.80E-02	0.28E-01	0.16E-02
2. LOCK AND DAM 8	0.3	0.	0.0	0.0	0.0	0.0
3. LOCK AND DAM 9	29.5	0.	0.0	0.0	0.0	0.0
4. LOCK AND DAM 10	62.3	0.	0.0	0.0	0.0	0.0
5. LOCK AND DAM 11	94.5	142927.	0.31E+00	0.24E-01	0.25E+00	0.14E-01
6. LOCK AND DAM 12	122.8	0.	0.0	0.0	0.0	0.0
7. LOCK AND DAM 13	155.0	118932.	0.21E+00	0.12E-01	0.17E+00	0.94E-02
8. LOCK AND DAM 14	184.2	0.	0.0	0.0	0.0	0.0
9. BETTENDORF-MOLINE	191.5	0.	0.0	0.0	0.0	0.0
10. DAVENPORT-ROCKISLAND	194.5	0.	0.0	0.0	0.0	0.0
11. LOCK AND DAM 17	240.3	0.	0.0	0.0	0.0	0.0
12. LOCK AND DAM 18	267.0	83669.	0.12E+00	0.40E-02	0.99E-01	0.53E-02
13. BURLINGTON, IOWA	273.3	0.	0.0	0.0	0.0	0.0
14. FT. MADISON	295.0	0.	0.0	0.0	0.0	0.0
15. KEOKUK, L&D 19	313.5	0.	0.0	0.0	0.0	0.0
16. LOCK AND DAM 20	334.3	0.	0.0	0.0	0.0	0.0
17. QUINCY, ILL.	350.5	0.	0.0	0.0	0.0	0.0
18. HANNIBAL, MO.	368.5	0.	0.0	0.0	0.0	0.0
19. LOCK AND DAM 24	403.5	0.	0.0	0.0	0.0	0.0
20. LOCK AND DAM 25	436.0	0.	0.0	0.0	0.0	0.0
21. LOCK AND DAM 26	474.5	38761.	0.33E-01	0.52E-03	0.27E-01	0.14E-02
22. LOCK AND DAM 27	492.2	0.	0.0	0.0	0.0	0.0
23. ST.LOUIS,E.ST.LOUIS	497.5	0.	0.0	0.0	0.0	0.0

24. CHESTER, ILL.	568.0	0.	0.0	0.0	0.0	0.0
25. CAPE GIRARDEAU, MO.	625.5	0.	0.0	0.0	0.0	0.0
26. THEBES, ILL.	633.5	0.	0.0	0.0	0.0	0.0
27. VICKSBURG, MISS.	1195.3	0.	0.0	0.0	0.0	0.0
28. DONALDSVILLE, LA.	1456.3	0.	0.0	0.0	0.0	0.0
29. NEW ORLEANS, LA.	1533.3	0.	0.0	0.0	0.0	0.0
TOTALS		384400.	0.70E+00	0.48E-01	0.58E+00	0.32E-01

Genoa: Creel fish ingestion doses by location
(continued)

	TRAVEL TIME TO DOWNSTREAM POINTS (HRS.)
1. GENOA	0.0
2. LOCK AND DAM 8	0.2
3. LOCK AND DAM 9	15.5
4. LOCK AND DAM 10	32.8
5. LOCK AND DAM 11	49.7
6. LOCK AND DAM 12	64.6
7. LOCK AND DAM 13	81.6
8. LOCK AND DAM 14	96.9
9. BETTENDORF-MOLINE	100.8
10. DAVENPORT-ROCKISLAND	102.4
11. LOCK AND DAM 17	126.5
12. LOCK AND DAM 18	140.5
13. BURLINGTON, IOWA	143.8
14. FT. MADISON	155.3
15. KEOKUK, L&D 19	165.0
16. LOCK AND DAM 20	175.9
17. QUINCY, ILL.	184.5
18. HANNIBAL, MO.	193.9
19. LOCK AND DAM 24	212.4
20. LOCK AND DAM 25	229.5
21. LOCK AND DAM 26	249.7
22. LOCK AND DAM 27	259.1
23. ST.LOUIS,E.ST.LOUIS	261.8
24. CHESTER, ILL.	286.2
25. CAPE GIRARDEAU, MO.	306.0
26. THEBES, ILL.	308.7
27. VICKSBURG, MISS.	482.1
28. DONALDSVILLE, LA.	562.7
29. NEW ORLEANS, LA.	586.5

Genoa: Travel time to downstream locations

FACILITY	YEAR OF RELEASES	NO. MONTHS OF DATA	SOURCE OF RELEASE DATA
QUAD CITIES	1973	12	

LOCATIONS ON STREAM (TOTAL OF 23, FACILITY IS NO. 1)

REACH NUMBER	NAME	POPULATION SERVED	VOLUME FLOW RATE(CFS)	STREAM SPEED(MPH)	RIVER MILE	DAM VOLUME ACRE-FEET	COMMERCIAL FISH WT,LBS	CREEL FISH WT,LBS
1	QUAD CITIES	1.	1915.	1.9	-1458.8	0.	0.	111.
2	LOCK AND DAM 14	0.	49660.	1.9	-1449.1	80000.	396522.	0.
3	BETTENDORF-MOLINE	55555.	50363.	1.9	-1441.8	30000.	151214.	0.
4	DAVENPORT-ROCKISLAND	141580.	50652.	1.9	-1438.8	89400.	458510.	0.
5	LOCK AND DAM 17	0.	55065.	1.9	-1393.0	51400.	450113.	0.
6	LOCK AND DAM 18	0.	57638.	1.9	-1366.3	95800.	928489.	83669.
7	BURLINGTON, IOWA	35400.	58245.	1.9	-1360.0	0.	0.	0.
8	FT. MADISON	15245.	60336.	1.9	-1338.3	0.	0.	0.
9	KEOKUK, L&D 19	16315.	62119.	1.9	-1319.8	214000.	920778.	0.
10	LOCK AND DAM 20	0.	66636.	1.9	-1299.0	73600.	75657.	0.
11	QUINCY, ILL.	47500.	70155.	1.9	-1282.8	76400.	138218.	0.
12	HANNIBAL, MO.	21000.	74065.	1.9	-1264.8	91000.	128689.	0.
13	LOCK AND DAM 24	0.	81776.	1.9	-1229.8	29745.	214530.	0.
14	LOCK AND DAM 25	0.	88727.	1.9	-1197.3	49674.	336105.	0.
15	LOCK AND DAM 26	0.	97090.	1.9	-1158.8	107082.	353487.	38761.
16	LOCK AND DAM 27	40073.	157739.	1.9	-1141.1	0.	264390.	0.
17	ST.LOUIS,E.ST.LOUIS	670015.	175900.	1.9	-1135.8	0.	0.	0.
18	CHESTER, ILL.	4200.	180600.	2.9	-1065.3	0.	0.	0.
19	CAPE GIRARDEAU, MO.	25700.	184550.	2.9	-1007.8	0.	0.	0.
20	THEBES, ILL.	450.	185100.	2.9	-999.8	0.	0.	0.
21	VICKSBURG, MISS.	41000.	574000.	3.2	-438.0	0.	0.	0.
22	DONALDSVILLE, LA.	7750.	579000.	3.2	-177.0	0.	0.	0.
23	NEW ORLEANS, LA.	652125.	579000.	3.2	-100.0	0.	0.	0.

RADIONUCLIDES RELEASED (TOTAL 20)

DOSE CONVERSION FACTORS

INGESTION SWIMMING

ISOTOPE	0=PARENT 1=DAUGHTER	BRANCH. RATIO.%	ATOMIC NUMBER	DECAY CONSTANT, 1/SEC	CURIES RELEASED	MILLIREM/YEAR PER PICO-CURIE/YEAR INTAKE BODY	THYROID	BONE	GI-LLI	MREM/HR PER PCI/LITER SWIMSKIN	SWIMBODY
BALA-140	0	0.	56	0.211E-04	0.710E-02	0.133E-05	0.0	0.202E-04	0.402E-04	0.760E-06	0.490E-06
CO-58	0	0.	27	0.113E-06	0.970E+00	0.168E-05	0.0	0.0	0.152E-04	0.230E-05	0.180E-05
CO-60	0	0.	27	0.418E-08	0.830E+00	0.470E-05	0.0	0.0	0.394E-04	0.540E-05	0.460E-05
CR-51	0	0.	24	0.289E-06	0.288E+01	0.267E-08	0.159E-08	0.0	0.669E-06	0.640E-07	0.520E-07
CS-134	0	0.	55	0.107E-07	0.210E+00	0.100E-03	0.0	0.529E-04	0.256E-05	0.350E-05	0.290E-05
CS-137	0	0.	55	0.733E-09	0.530E+00	0.560E-04	0.0	0.637E-04	0.205E-05	0.140E-05	0.100E-05
BA-137M	1	100.	56	0.163E+02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H-3	0	0.	1	0.179E-08	0.245E+02	0.127E-06	0.127E-06	0.0	0.640E-07	0.0	0.0
I-131	0	0.	53	0.996E-06	0.380E+01	0.337E-05	0.186E-02	0.393E-05	0.153E-05	0.930E-06	0.680E-06
XE-131M	1	1.	54	0.680E-06	0.0	0.0	0.0	0.0	0.0	0.560E-07	0.620E-08
I-133	0	0.	53	0.916E-05	0.430E+00	0.702E-06	0.482E-03	0.143E-05	0.225E-05	0.150E-05	0.960E-06
XE-133	1	100.	54	0.152E-05	0.0	0.0	0.0	0.0	0.0	0.110E-06	0.570E-07
MN-54	0	0.	25	0.265E-07	0.370E+00	0.868E-06	0.0	0.0	0.138E-04	0.180E-05	0.150E-05
SR-89	0	0.	38	0.154E-06	0.640E-01	0.913E-05	0.0	0.320E-03	0.498E-04	0.540E-06	0.460E-08
Y-89M	1	0.	39	0.431E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SR-90	0	0.	38	0.778E-09	0.250E-02	0.895E-03	0.0	0.336E-03	0.123E-03	0.150E-06	0.540E-09
Y-90	1	100.	39	0.301E-05	0.0	0.285E-09	0.0	0.986E-08	0.105E-03	0.960E-06	0.130E-07
ZN-65	0	0.	30	0.328E-07	0.850E-01	0.508E-05	0.0	0.346E-05	0.978E-05	0.120E-05	0.110E-05
ZR-95	0	0.	40	0.122E-06	0.116E+00	0.634E-08	0.0	0.270E-07	0.229E-04	0.180E-05	0.150E-05
NB-95	1	100.	41	0.229E-06	0.0	0.181E-08	0.0	0.556E-08	0.203E-04	0.160E-05	0.140E-05

Quad Cities: Input data
(continued)

Quad Cities: Drinking water doses by location

DRINKING WATER
POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM RELEASE RATES
2) DRINKING: CONTINUOUS INGESTION RATE OF 1.95 LITERS PER DAY

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	POPULATION SERVED	DRINKING WATER DOSES (4 CRITICAL ORGANS) BODY	THYROID	BONE	GI-LLI
1. QUAD CITIES	0.0	1.	0.32E-04	0.30E-02	0.34E-04	0.30E-04
2. LOCK AND DAM 14	9.7	0.	0.0	0.0	0.0	0.0
3. BETTENDORF-MOLINE	17.0	55555.	0.65E-01	0.56E+01	0.70E-01	0.62E-01
4. DAVENPORT-ROCKISLAND	20.0	141580.	0.16E+00	0.13E+02	0.17E+00	0.15E+00
5. LOCK AND DAM 17	65.8	0.	0.0	0.0	0.0	0.0
6. LOCK AND DAM 18	92.5	0.	0.0	0.0	0.0	0.0
7. BURLINGTON, IOWA	98.8	35400.	0.34E-01	0.22E+01	0.36E-01	0.33E-01
8. FT. MADISON	120.5	15245.	0.14E-01	0.86E+00	0.15E-01	0.14E-01
9. KEOKUK, L&D 19	139.0	16315.	0.14E-01	0.75E+00	0.15E-01	0.14E-01
10. LOCK AND DAM 20	159.8	0.	0.0	0.0	0.0	0.0
11. QUINCY, ILL.	176.0	47500.	0.37E-01	0.16E+01	0.38E-01	0.35E-01
12. HANNIBAL, MO.	194.0	21000.	0.15E-01	0.63E+00	0.16E-01	0.15E-01
13. LOCK AND DAM 24	229.0	0.	0.0	0.0	0.0	0.0
14. LOCK AND DAM 25	261.5	0.	0.0	0.0	0.0	0.0
15. LOCK AND DAM 26	300.0	0.	0.0	0.0	0.0	0.0
16. LOCK AND DAM 27	317.7	40073.	0.13E-01	0.41E+00	0.14E-01	0.13E-01
17. ST.LOUIS,E.ST.LOUIS	323.0	670015.	0.20E+00	0.61E+01	0.20E+00	0.19E+00
18. CHESTER, ILL.	393.5	4200.	0.12E-02	0.34E-01	0.12E-02	0.12E-02
19. CAPE GIRARDEAU, MO.	451.0	25700.	0.72E-02	0.19E+00	0.73E-02	0.69E-02
20. THEBES, ILL.	459.0	450.	0.13E-03	0.33E-02	0.13E-03	0.12E-03
21. VICKSBURG, MISS.	1020.8	41000.	0.36E-02	0.52E-01	0.36E-02	0.34E-02
22. DONALDSVILLE, LA.	1281.8	7750.	0.67E-03	0.73E-02	0.65E-03	0.64E-03
23. NEW ORLEANS, LA.	1358.8	652125.	0.56E-01	0.57E+00	0.55E-01	0.53E-01
TOTALS		1773909.	0.63E+00	0.32E+02	0.65E+00	0.60E+00

COMMERCIAL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) 49 PERCENT OF ALL COMMERCIALLY CAUGHT FISH IS FOR HUMAN CONSUMTION
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	COMMERCIAL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. QUAD CITIES	0.0	0.	0.0	0.0	0.0	0.0
2. LOCK AND DAM 14	9.7	396522.	0.15E-01	0.71E-01	0.13E-01	0.32E-02
3. BETTENDORF-MOLINE	17.0	151214.	0.56E-02	0.25E-01	0.50E-02	0.14E-02
4. DAVENPORT-ROCKISLAND	20.0	458510.	0.17E-01	0.70E-01	0.15E-01	0.51E-02
5. LOCK AND DAM 17	65.8	450113.	0.15E-01	0.56E-01	0.14E-01	0.60E-02
6. LOCK AND DAM 18	92.5	528489.	0.30E-01	0.97E-01	0.27E-01	0.14E-01
7. BURLINGTON, IOWA	98.8	0.	0.0	0.0	0.0	0.0
8. FT. MADISON	120.5	0.	0.0	0.0	0.0	0.0
9. KEOKUK, L&D 19	139.0	920778.	0.28E-01	0.71E-01	0.24E-01	0.17E-01
10. LOCK AND DAM 20	159.8	75657.	0.21E-02	0.50E-02	0.19E-02	0.14E-02
11. QUINCY, ILL.	176.0	138218.	0.37E-02	0.81E-02	0.32E-02	0.26E-02
12. HANNIBAL, MO.	194.0	128689.	0.32E-02	0.65E-02	0.29E-02	0.25E-02
13. LOCK AND DAM 24	229.0	214530.	0.49E-02	0.91E-02	0.43E-02	0.40E-02
14. LOCK AND DAM 25	261.5	336105.	0.70E-02	0.12E-01	0.62E-02	0.60E-02
15. LOCK AND DAM 26	300.0	353467.	0.68E-02	0.10E-01	0.60E-02	0.62E-02
16. LOCK AND DAM 27	317.7	264390.	0.31E-02	0.46E-02	0.27E-02	0.29E-02
17. ST.LOUIS,E.ST.LOUIS	323.0	0.	0.0	0.0	0.0	0.0
18. CHESTER, ILL.	393.5	0.	0.0	0.0	0.0	0.0
19. CAPE GIRARDEAU, MO.	451.0	0.	0.0	0.0	0.0	0.0
20. THEBES, ILL.	459.0	0.	0.0	0.0	0.0	0.0
21. VICKSBURG, MISS.	1020.8	0.	0.0	0.0	0.0	0.0
22. DONALDSVILLE, LA.	1281.8	0.	0.0	0.0	0.0	0.0
23. NEW ORLEANS, LA.	1358.8	0.	0.0	0.0	0.0	0.0
TOTALS		4816702.	0.14E+00	0.45E+00	0.12E+00	0.73E-01

Quad Cities: Commercial fish ingestion doses by location

Quad Cities: Creel fish ingestion doses by location

CREEL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) ALL CREEL FISH ARE IMMEDIATELY EATEN
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	CREEL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. QUAD CITIES	0.0	111.	0.22E-03	0.12E-02	0.20E-03	0.33E-04
2. LOCK AND DAM 14	9.7	0.	0.0	0.0	0.0	0.0
3. BETTENDORF-MOLINE	17.0	0.	0.0	0.0	0.0	0.0
4. DAVENPORT-ROCKISLAND	20.0	0.	0.0	0.0	0.0	0.0
5. LOCK AND DAM 17	65.8	0.	0.0	0.0	0.0	0.0
6. LOCK AND DAM 18	92.5	83669.	0.56E-02	0.18E-01	0.49E-02	0.26E-02
7. BURLINGTON, IOWA	98.8	0.	0.0	0.0	0.0	0.0
8. FT. MADISON	120.5	0.	0.0	0.0	0.0	0.0
9. KEOKUK, L&D 19	139.0	0.	0.0	0.0	0.0	0.0
10. LOCK AND DAM 20	159.8	0.	0.0	0.0	0.0	0.0
11. QUINCY, ILL.	176.0	0.	0.0	0.0	0.0	0.0
12. HANNIBAL, MO.	194.0	0.	0.0	0.0	0.0	0.0
13. LOCK AND DAM 24	229.0	0.	0.0	0.0	0.0	0.0
14. LOCK AND DAM 25	261.5	0.	0.0	0.0	0.0	0.0
15. LOCK AND DAM 26	300.0	38761.	0.15E-02	0.23E-02	0.13E-02	0.14E-02
16. LOCK AND DAM 27	317.7	0.	0.0	0.0	0.0	0.0
17. ST.LOUIS,E.ST.LOUIS	323.0	0.	0.0	0.0	0.0	0.0
18. CHESTER, ILL.	393.5	0.	0.0	0.0	0.0	0.0
19. CAPE GIRARDEAU, MO.	451.0	0.	0.0	0.0	0.0	0.0
20. THEBES, ILL.	459.0	0.	0.0	0.0	0.0	0.0
21. VICKSBURG, MISS.	1020.8	0.	0.0	0.0	0.0	0.0
22. DONALDSVILLE, LA.	1281.8	0.	0.0	0.0	0.0	0.0
23. NEW ORLEANS, LA.	1358.8	0.	0.0	0.0	0.0	0.0
TOTALS		122541.	0.73E-02	0.21E-01	0.64E-02	0.40E-02

PROGRAM RVRDOS

FOR INFORMATION REGARDING THIS PROGRAM, CONTACT:

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION PROGRAMS
401 M ST SW
WASHINGTON, DC 20460

INPUT DATA

FACILITY	YEAR OF RELEASES	NO. MONTHS OF DATA	SOURCE OF RELEASE DATA
DRESDEN UNITS 2/3	1973	12	

LOCATIONS ON STREAM (TOTAL OF 13, FACILITY IS NO. 1)

REACH NUMBER	NAME	POPULATION SERVED	VOLUME FLOW RATE(CFS)	STREAM SPEED(MPH)	RIVER MILE	DAM VOLUME ACRE-FEET	COMMERCIAL FISH WT,LBS	CREEL FISH WT,LBS
1	DRESDEN	1.	1690.	1.2	-1445.7	0.	0.	111.
2	MARSEILLES LOCK,DAM	0.	10750.	2.5	-1420.3	18009.	0.	0.
3	STARVED ROCK L&D	0.	11280.	1.6	-1404.3	11344.	0.	0.
4	PEORIA LOCK AND DAM	0.	13740.	0.9	-1331.0	49630.	26204.	0.
5	LAGRANGE LOCK,DAM	0.	19880.	0.9	-1253.5	57287.	143104.	0.
6	ALTON, MO.	0.	97090.	1.2	-1158.8	0.	231463.	0.
7	ST.LOUIS, E.ST.LOUIS	670015.	175900.	1.9	-1135.8	0.	0.	0.
8	CHESTER, ILL.	4200.	180600.	2.9	-1065.3	0.	0.	0.
9	CAPE GIRARDEAU, MO.	25700.	184550.	2.9	-1007.8	0.	0.	0.
10	THEBES, ILL.	450.	185100.	2.9	-999.8	0.	0.	0.
11	VICKSBURG, MISS.	41000.	574000.	3.2	-438.0	0.	0.	0.
12	DONALDSVILLE, LA.	7750.	579000.	3.2	-177.0	0.	0.	0.
13	NEW ORLEANS, LA.	652125.	579000.	3.2	-100.0	0.	0.	0.

RADIONUCLIDES RELEASED (TOTAL 18)

ISOTOPE	0=PARENT 1=DAUGHTER	BRANCH. RATIO,%	ATOMIC NUMBER	DECAY CONSTANT, 1/SEC	CURIES RELEASED	DOSE CONVERSION FACTORS — INGESTION: MILLIREM/YEAR PER PICO-CURIE/YEAR INTAKE — BODY	THYROID	BONE	GI-LLI	SWIMMING: MREM/HR PER PCI/LITER — SWIMSKIN	SWIMBODY
BALA-140	0	0.	56	0.211E-04	0.148E+01	0.133E-05	0.0	0.202E-04	0.402E-04	0.760E-06	0.490E-06
CO-58	0	0.	27	0.113E-06	0.144E+00	0.158E-05	0.0	0.0	0.152E-04	0.230E-05	0.180E-05

Dresden 2/3: Input data

Dresden 2/3: Input data (continued)

CO-60	0	0.	27	0.418E-08	0.209E+01	0.470E-05	0.0	0.0	0.394E-04	0.540E-05	0.460E-05
CR-51	0	0.	24	0.289E-06	0.117E+01	0.267E-08	0.159E-08	0.0	0.669E-06	0.640E-07	0.520E-07
CS-134	0	0.	55	0.107E-07	0.117E+01	0.100E-03	0.0	0.529E-04	0.256E-05	0.350E-05	0.290E-05
CS-137	0	0.	55	0.733E-09	0.424E+01	0.560E-04	0.0	0.637E-04	0.205E-05	0.140E-05	0.100E-05
BA-137M	1	100.	56	0.163E+02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H-3	0	0.	1	0.179E-08	0.258E+02	0.127E-06	0.127E-06	0.0	0.640E-07	0.0	0.0
I-131	0	0.	53	0.996E-06	0.141E+01	0.337E-05	0.186E-02	0.393E-05	0.153E-05	0.930E-06	0.680E-06
XE-131M	1	1.	54	0.680E-06	0.0	0.0	0.0	0.0	0.0	0.560E-07	0.620E-08
MN-54	0	0.	25	0.265E-07	0.406E+00	0.868E-06	0.0	0.0	0.138E-04	0.180E-05	0.150E-05
SR-89	0	0.	38	0.154E-06	0.890E-01	0.913E-05	0.0	0.320E-03	0.498E-04	0.540E-06	0.460E-08
Y-89M	1	0.	39	0.431E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SR-90	0	0.	38	0.778E-09	0.100E-01	0.895E-03	0.0	0.336E-03	0.123E-03	0.150E-06	0.540E-09
Y-90	1	100.	39	0.301E-05	0.0	0.285E-09	0.0	0.986E-08	0.105E-03	0.960E-06	0.130E-07
ZN-65	0	0.	30	0.328E-07	0.370E-01	0.508E-05	0.0	0.346E-05	0.978E-05	0.120E-05	0.110E-05
ZR-95	0	0.	40	0.122E-06	0.900E-02	0.634E-08	0.0	0.270E-07	0.229E-04	0.180E-05	0.150E-05
NB-95	1	100.	41	0.229E-06	0.700E-02	0.181E-08	0.0	0.556E-08	0.203E-04	0.160E-05	0.140E-05

DRINKING WATER
POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM RELEASE RATES
2) DRINKING: CONTINUOUS INGESTION RATE
OF 1.95 LITERS PER DAY

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	POPULATION SERVED	DRINKING WATER DOSES (4 CRITICAL ORGANS) BODY	THYROID	BONE	GI-LLI
1. DRESDEN	0.0	1.	0.18E-03	0.12E-02	0.19E-03	0.81E-04
2. MARSEILLES LOCK,DAM	25.4	0.	0.0	0.0	0.0	0.0
3. STARVED ROCK L&D	41.4	0.	0.0	0.0	0.0	0.0
4. PEORIA LOCK AND DAM	114.7	0.	0.0	0.0	0.0	0.0
5. LAGRANGE LOCK,DAM	192.2	0.	0.0	0.0	0.0	0.0
6. ALTON, MO.	286.9	0.	0.0	0.0	0.0	0.0
7. ST.LOUIS, E.ST.LOUIS	309.9	670015.	0.11E+01	0.20E+01	0.11E+01	0.33E+00
8. CHESTER, ILL.	380.4	4200.	0.70E-02	0.11E-01	0.66E-02	0.20E-02
9. CAPE GIRARDEAU, MO.	437.9	25700.	0.42E-01	0.64E-01	0.40E-01	0.12E-01
10. THEBES, ILL.	445.9	450.	0.73E-03	0.11E-02	0.69E-03	0.21E-03
11. VICKSBURG, MISS.	1007.7	41000.	0.21E-01	0.17E-01	0.20E-01	0.62E-02
12. DONALDSVILLE, LA.	1268.7	7750.	0.40E-02	0.25E-02	0.38E-02	0.12E-02
13. NEW ORLEANS, LA.	1345.7	652125.	0.34E+00	0.19E+00	0.32E+00	0.97E-01
TOTALS		1401241.	0.16E+01	0.23E+01	0.15E+01	0.45E+00

Dresden 2/3: Drinking water doses by location

Dresden 2/3: Commercial fish ingestion doses by location

COMMERCIAL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) 49 PERCENT OF ALL COMMERCIALLY CAUGHT FISH IS FOR HUMAN CONSUMTION
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

	LOCATION	MILES DOWNSTREAM	COMMERCIAL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1.	DRESDEN	0.0	0.	0.0	0.0	0.0	0.0
2.	MARSEILLES LOCK,DAM	25.4	0.	0.0	0.0	0.0	0.0
3.	STARVED ROCK L&D	41.4	0.	0.0	0.0	0.0	0.0
4.	PEORIA LOCK AND DAM	114.7	26204.	0.24E-01	0.35E-02	0.23E-01	0.20E-02
5.	LAGRANGE LOCK,DAM	192.2	143104.	0.91E-01	0.89E-02	0.86E-01	0.76E-02
6.	ALTON, MO.	286.9	231463.	0.30E-01	0.22E-02	0.28E-01	0.25E-02
7.	ST.LOUIS, E.ST.LOUIS	309.9	0.	0.0	0.0	0.0	0.0
8.	CHESTER, ILL.	380.4	0.	0.0	0.0	0.0	0.0
9.	CAPE GIRARDEAU, MO.	437.9	0.	0.0	0.0	0.0	0.0
10.	THEBES, ILL.	445.9	0.	0.0	0.0	0.0	0.0
11.	VICKSBURG, MISS.	1007.7	0.	0.0	0.0	0.0	0.0
12.	DONALDSVILLE, LA.	1268.7	0.	0.0	0.0	0.0	0.0
13.	NEW ORLEANS, LA.	1345.7	0.	0.0	0.0	0.0	0.0
	TOTALS		400771.	0.15E+00	0.15E-01	0.14E+00	0.12E-01

CREEL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) ALL CREEL FISH ARE IMMEDIATELY EATEN
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

	LOCATION	MILES DOWNSTREAM	CREEL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1.	DRESDEN	0.0	111.	0.17E-02	0.47E-03	0.16E-02	0.14E-03
2.	MARSEILLES LOCK,DAM	25.4	0.	0.0	0.0	0.0	0.0
3.	STARVED ROCK L&D	41.4	0.	0.0	0.0	0.0	0.0
4.	PEORIA LOCK AND DAM	114.7	0.	0.0	0.0	0.0	0.0
5.	LAGRANGE LOCK,DAM	192.2	0.	0.0	0.0	0.0	0.0
6.	ALTON, MO.	286.9	0.	0.0	0.0	0.0	0.0
7.	ST.LOUIS, E.ST.LOUIS	309.9	0.	0.0	0.0	0.0	0.0
8.	CHESTER, ILL.	380.4	0.	0.0	0.0	0.0	0.0
9.	CAPE GIRARDEAU, MO.	437.9	0.	0.0	0.0	0.0	0.0
10.	THEBES, ILL.	445.9	0.	0.0	0.0	0.0	0.0
11.	VICKSBURG, MISS.	1007.7	0.	0.0	0.0	0.0	0.0
12.	DONALDSVILLE, LA.	1268.7	0.	0.0	0.0	0.0	0.0
13.	NEW ORLEANS, LA.	1345.7	0.	0.0	0.0	0.0	0.0
	TOTALS		111.	0.17E-02	0.47E-03	0.16E-02	0.14E-03

Dresden 2/3: Creel fish ingestion doses by location

Fort Calhoun: Input data

FACILITY	YEAR OF RELEASES	NO. MONTHS OF DATA	SOURCE OF RELEASE DATA
FORT CALHOUN	1973	12	

LOCATIONS ON STREAM (TOTAL OF 18, FACILITY IS NO. 1)

REACH NUMBER	NAME	POPULATION SERVED	VOLUME FLOW RATE(CFS)	STREAM SPEED(MPH)	RIVER MILE	DAM VOLUME ACRE-FEET	COMMERCIAL FISH WT,LBS	CREEL FISH WT,LBS
1	FORT CALHOUN	1.	242.	2.6	-1795.0	0.	0.	111.
2	OMAHA, NEB.	303305.	26750.	2.6	-1776.0	0.	0.	0.
3	COUNCIL BLUFFS, IOWA	56000.	26950.	2.6	-1775.0	0.	0.	0.
4	PLATTSMOUTH, NEB.	0.	30360.	3.3	-1740.1	0.	29752.	0.
5	ST. JOSEPH, MO.	92000.	38340.	2.9	-1597.6	0.	0.	0.
6	ATCHISON, KAN.	15000.	43360.	2.6	-1571.6	0.	0.	0.
7	LEAVENWORTH, KAN.	23600.	48460.	2.7	-1546.1	0.	0.	0.
8	KANSAS CITY, KAN, MO	825000.	54580.	3.4	-1514.1	0.	48815.	0.
9	LEXINGTON, MO.	4900.	55330.	3.0	-1466.4	0.	0.	0.
10	JEFFERSON CITY, MO.	31500.	68950.	2.9	-1293.0	0.	0.	0.
11	GRANITE CITY, ILL.	43000.	158800.	2.6	-1139.8	0.	335022.	0.
12	ST.LOUIS, E.ST.LOUIS	670015.	175900.	1.9	-1135.8	0.	0.	0.
13	CHESTER, ILL.	4200.	180600.	2.9	-1065.3	0.	0.	0.
14	CAPE GIRARDEAU, MO.	25700.	184550.	2.9	-1007.8	0.	0.	0.
15	THEBES, ILL.	450.	185100.	2.9	-999.8	0.	0.	0.
16	VICKSBURG, MISS.	41000.	574000.	3.2	-438.0	0.	0.	0.
17	DONALDSVILLE, LA.	7750.	579000.	3.2	-177.0	0.	0.	0.
18	NEW ORLEANS, LA.	652125.	579000.	3.2	-100.0	0.	0.	0.

RADIONUCLIDES RELEASED (TOTAL 11)

						DOSE CONVERSION FACTORS					
						INGESTION MILLIREM/YEAR PER PICO-CURIE/YEAR INTAKE				SWIMMING MREM/HR PER PCI/LITER	
ISOTOPE	0=PARENT 1=DAUGHTER	BRANCH. RATIO,%	ATOMIC NUMBER	DECAY CONS-TANT, 1/SEC	CURIES RELEASED	BODY	THYROID	BONE	GI-LLI	SWIMSKIN	SWIMBODY
BALA-140	0	0.	56	0.211E-04	0.607E-01	0.133E-05	0.0	0.202E-04	0.402E-04	0.760E-06	0.490E-06
CO-58	0	0.	27	0.113E-06	0.469E-04	0.168E-05	0.0	0.0	0.152E-04	0.230E-05	0.180E-05
H-3	0	0.	1	0.179E-08	0.158E+02	0.127E-06	0.127E-06	0.0	0.640E-07	0.0	0.0
I-131	0	0.	53	0.996E-06	0.448E-02	0.337E-05	0.186E-02	0.393E-05	0.153E-05	0.930E-06	0.680E-06

XE-131M	1	1.	54	0.680E-06	0.0	0.0	0.0	0.0	0.0	0.550E-07	0.620E-08
XE-133	1	100.	54	0.152E-05	0.580E-01	0.0	0.0	0.0	0.0	0.110E-06	0.570E-07
MN-54	0	0.	25	0.265E-07	0.219E+00	0.868E-06	0.0	0.0	0.138E-04	0.180E-05	0.150E-05
SR-89	0	0.	38	0.154E-06	0.116E-03	0.913E-05	0.0	0.320E-03	0.498E-04	0.540E-06	0.460E-08
Y-89M	1	0.	39	0.431E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SR-90	0	0.	38	0.778E-09	0.169E-04	0.895E-03	0.0	0.336E-03	0.123E-03	0.150E-06	0.540E-09
Y-90	1	100.	39	0.301E-05	0.0	0.285E-09	0.0	0.986E-08	0.105E-03	0.960E-06	0.130E-07

Fort Calhoun: Input data
(continued)

Fort Calhoun: Drinking water doses by location

DRINKING WATER
POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM RELEASE RATES
2) DRINKING: CONTINUOUS INGESTION RATE
OF 1.95 LITERS PER DAY

DOSES BY LOCATION, SUMMED OVER NUCLIDES

	LOCATION	MILES DOWNSTREAM	POPULATION SERVED	DRINKING WATER DOSES (4 CRITICAL ORGANS) BODY	THYROID	BONE	GI-LLI
1.	FORT CALHOUN	0.0	1.	0.76E-05	0.34E-04	0.42E-05	0.21E-04
2.	OMAHA, NEB.	19.0	303305.	0.21E-01	0.92E-01	0.70E-02	0.49E-01
3.	COUNCIL BLUFFS, IOWA	19.0	56000.	0.38E-02	0.17E-01	0.13E-02	0.90E-02
4.	PLATTSMOUTH, NEB.	54.9	0.	0.0	0.0	0.0	0.0
5.	ST. JOSEPH, MO.	197.4	92000.	0.42E-02	0.16E-01	0.12E-03	0.77E-02
6.	ATCHISON, KAN.	223.4	15000.	0.61E-03	0.23E-02	0.16E-04	0.11E-02
7.	LEAVENWORTH, KAN.	248.9	23600.	0.86E-03	0.31E-02	0.22E-04	0.16E-02
8.	KANSAS CITY, KAN, MO	280.9	825000.	0.27E-01	0.95E-01	0.65E-03	0.48E-01
9.	LEXINGTON, MO.	328.6	4900.	0.16E-03	0.53E-03	0.37E-05	0.28E-03
10.	JEFFERSON CITY, MO.	502.0	31500.	0.81E-03	0.24E-02	0.18E-04	0.15E-02
11.	GRANITE CITY, ILL.	655.2	43000.	0.48E-03	0.12E-02	0.99E-05	0.86E-03
12.	ST.LOUIS, E.ST.LOUIS	659.2	670015.	0.67E-02	0.17E-01	0.14E-03	0.12E-01
13.	CHESTER, ILL.	729.7	4200.	0.41E-04	0.98E-04	0.83E-06	0.74E-04
14.	CAPE GIRARDEAU, MO.	787.2	25700.	0.24E-03	0.56E-03	0.49E-05	0.44E-03
15.	THEBES, ILL.	795.2	450.	0.43E-05	0.98E-05	0.85E-07	0.77E-05
16.	VICKSBURG, MISS.	1357.0	41000.	0.13E-03	0.21E-03	0.22E-05	0.22E-03
17.	DONALDSVILLE, LA.	1618.0	7750.	0.23E-04	0.34E-04	0.38E-06	0.41E-04
18.	NEW ORLEANS, LA.	1695.0	652125.	0.20E-02	0.28E-02	0.32E-04	0.35E-02
	TOTALS		2795546.	0.67E-01	0.25E+00	0.33E-02	0.14E+00

COMMERCIAL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) 49 PERCENT OF ALL COMMERCIALLY CAUGHT FISH IS FOR HUMAN CONSUMTION
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

LOCATION	MILES DOWNSTREAM	COMMERCIAL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1. FORT CALHOUN	0.0	0.	0.0	0.0	0.0	0.0
2. OMAHA, NEB.	19.0	0.	0.0	0.0	0.0	0.0
3. COUNCIL BLUFFS, IOWA	19.0	0.	0.0	0.0	0.0	0.0
4. PLATTSMOUTH, NEB.	54.9	29752.	0.19E-05	0.10E-04	0.15E-06	0.27E-04
5. ST. JOSEPH, MO.	197.4	0.	0.0	0.0	0.0	0.0
6. ATCHISON, KAN.	223.4	0.	0.0	0.0	0.0	0.0
7. LEAVENWORTH, KAN.	248.9	0.	0.0	0.0	0.0	0.0
8. KANSAS CITY, KAN, MO	280.9	48815.	0.17E-05	0.72E-05	0.32E-07	0.24E-04
9. LEXINGTON, MO.	328.6	0.	0.0	0.0	0.0	0.0
10. JEFFERSON CITY, MO.	502.0	0.	0.0	0.0	0.0	0.0
11. GRANITE CITY, ILL.	655.2	335022.	0.39E-05	0.11E-04	0.58E-07	0.56E-04
12. ST.LOUIS, E.ST.LOUIS	659.2	0.	0.0	0.0	0.0	0.0
13. CHESTER, ILL.	729.7	0.	0.0	0.0	0.0	0.0
14. CAPE GIRARDEAU, MO.	787.2	0.	0.0	0.0	0.0	0.0
15. THEBES, ILL.	795.2	0.	0.0	0.0	0.0	0.0
16. VICKSBURG, MISS.	1357.0	0.	0.0	0.0	0.0	0.0
17. DONALDSVILLE, LA.	1618.0	0.	0.0	0.0	0.0	0.0
18. NEW ORLEANS, LA.	1695.0	0.	0.0	0.0	0.0	0.0
TOTALS		413589.	0.74E-05	0.28E-04	0.24E-06	0.11E-03

Fort Calhoun: Commercial fish ingestion doses by location

Fort Calhoun: Creel fish ingestion doses by location

CREEL FISH INGESTION POPULATION DOSE RATES
(PERSON-REM PER YEAR - FIRST YEAR RATE)

ASSUMING: 1) UNIFORM INGESTION RATES
2) ALL CREEL FISH ARE IMMEDIATELY EATEN
3) 45 PERCENT (BY WEIGHT) OF A WHOLE FISH IS ACTUALLY INGESTED
4) 80 PERCENT OF NUCLIDE REMAINS IN FISH AFTER COOKING

DOSES BY LOCATION, SUMMED OVER NUCLIDES

	LOCATION	MILES DOWNSTREAM	CREEL FISH CAUGHT (LBS)	BODY	THYROID	BONE	GI-LLI
1.	FORT CALHOUN	0.0	111.	0.18E-05	0.11E-04	0.45E-06	0.26E-04
2.	OMAHA, NEB.	19.0	0.	0.0	0.0	0.0	0.0
3.	COUNCIL BLUFFS, IOWA	19.0	0.	0.0	0.0	0.0	0.0
4.	PLATTSMOUTH, NEB.	54.9	0.	0.0	0.0	0.0	0.0
5.	ST. JOSEPH, MO.	197.4	0.	0.0	0.0	0.0	0.0
6.	ATCHISON, KAN.	223.4	0.	0.0	0.0	0.0	0.0
7.	LEAVENWORTH, KAN.	248.9	0.	0.0	0.0	0.0	0.0
8.	KANSAS CITY, KAN, MO	280.9	0.	0.0	0.0	0.0	0.0
9.	LEXINGTON, MO.	328.6	0.	0.0	0.0	0.0	0.0
10.	JEFFERSON CITY, MO.	502.0	0.	0.0	0.0	0.0	0.0
11.	GRANITE CITY, ILL.	555.2	0.	0.0	0.0	0.0	0.0
12.	ST.LOUIS, E.ST.LOUIS	659.2	0.	0.0	0.0	0.0	0.0
13.	CHESTER, ILL.	729.7	0.	0.0	0.0	0.0	0.0
14.	CAPE GIRARDEAU, MO.	787.2	0.	0.0	0.0	0.0	0.0
15.	THEBES, ILL.	795.2	0.	0.0	0.0	0.0	0.0
16.	VICKSBURG, MISS.	1357.0	0.	0.0	0.0	0.0	0.0
17.	DONALDSVILLE, LA.	1618.0	0.	0.0	0.0	0.0	0.0
18.	NEW ORLEANS, LA.	1695.0	0.	0.0	0.0	0.0	0.0
	TOTALS		111.	0.18E-05	0.11E-04	0.45E-06	0.26E-04