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MODELS AND COMPUTER CODES FOR EVALUATING ENVIRONMENTAL RADIATION DOSES

J.K. Soldat, N.M. Robinson and D.A. Baker

Battelle
Pacific Northwest Laboratories
Richland, Washington 99352

FEBRUARY 1974

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NOTICE

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ERRATA

Page	Correction
ii	The page numbers for Sections 10.1 through 10.11 should be increased by 1. For example, Section 10.1 actually begins on page 10-3.
6-2 to 6-4	The primes in Section 6.1 are subject to misinterpretation. Primes indicate a secondary organism and always refer to the main symbol, not the subscripts.
7-7, 10-62	For Y-93, LAMBDA 1/SEC should be 1.89E-05 and LAMBDA 1/HOURS should be 6.80E-2.
7-10, 7-23, 10-19	The GI-LLI ingestion dose factor for H-3 should be 1.27E-7.
7-36	In the last line of rule 8d, replace "building-wake" with "wind-speed."

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1. INTRODUCTION

Prior to the issuance of construction permits or operating licenses for nuclear power reactors, the U.S. Atomic Energy Comniission is required by the National Environmental Policy Act of 1969 to prepare Detailed Environmental Impact Statements. These statements contain analyses of the balance between benefits and costs of the proposed action, including the radiological impact of operation of the facility. Personnel of Battelle Pacific Northwest Laboratories contributed to the development of methods used for computing environmental radiation doses and for evaluating radiological impact.

One possibility considered for this project was the application of a complex model[1] developed as the final portion of the program HERMES.[2] Among other capabilities, HERMES develops estimates of radiation doses resulting from a nuclear power economy potentially in place in the year 2000. Investigation showed that HERMES was not suitable for present purposes, since it would require coniplex input prepared by a programmer, a large amount of computer running time, and further manipulation of the output to produce a form suitable for environmental statements.

To better meet current needs, a simplified model for calculation of radiation doses from radioactive effluents was developed and programmed into a conversational language, providing the fast turnaround time required. The new model is divided into four independent parts, each written as a separate program:

- ARRRG: calculates individual and population doses from liquid effluents
- CRITR: calculates internal radiation doses to four common classes of aquatic organisms and to organisms which consume them
- FOOD: calculates doses from consumption of food crops and animal products produced on irrigated farms
- GRONK: calculates doses from gaseous effluents, to individuals and to the total population within 50 miles

The model can be used to calculate radiation doses to the total body and selected organs of individuals and population groups, and to organisms other than man. It includes all air and liquid exposure pathways thought to be significant and for which a reasonable amount of supporting data is available. Internal doses to man are based on a 1-year radionuclide intake, assuming no prior accumulation in the body. The radionuclide content of ingested food is assumed to be at equilibrium with the environment.

This paper discusses the models in detail and describes the programs ARRRG, CRITR and GRONK; the program FOOD is still being developed and is not included in this report. The question-and-answer format of these programs allows them to be used by nonprogrammers. Although the programs were originally intended specifically for nuclear reactors, they are applicable to any nuclear facility which releases radioactive effluents to air or water.

2. PATHWAYS OF EXPOSURE

The pathways of consequence by which man can be exposed to radiation from a nuclear facility are illustrated in Figure 2-1. The exposure pathways for man can be grouped into those associated with gaseous effluents, those associated with liquid effluents, and those involving exposure to direct radiation from the facility or from transportation of radioactive materials to or from the facility. The exposure pathways are arranged by group in Table 2-1. Calculations for each pathway are made for those selected organs which could potentially receive the highest radiation dose.[a]

The pathways of consequence by which organisms other than man can be exposed to radiation from a nuclear facility are illustrated in Figure 2-2. Many of the pathways of exposure from these organisms are similar to those for man. Table 2-2 is a more inclusive list of pathways of exposure to organisms other than man.

In this report, aquatic organisms are designated as "primary" organisms if a bioaccumulation factor for them was found in the literature. The bioaccumulation factor relates equilibrium concentration of a radionuclide in the organism to that in its water environment, including contributions from direct assimilation of nuclides from water and ingestion of food and water. "Secondary" aquatic and terrestrial organisms are those that feed upon primary organisms; their dose must be calculated from their diet.

(a) Table 7.1-1 includes a list of these organs for each pathway.

TABLE 2-1

PATHWAYS OF EXPOSURE TO MAN

Pathways	Equation	Computer Program
Water Pathways		
External		
Water immersion and water surface	4.4-1	ARRRG
Exposure to shoreline	4.3-3	ARRRG
Internal		
Ingestion of water	4.1-1	ARRRG
Ingestion of aquatic foods	4.2-1	ARRRG
Ingestion of irrigated food crops	--	FOOD[a]
Ingestion of products from animals fed irrigated foods	--	FOOD[a]
Air Pathways		
External		
Air submersion	5.1-1	GRONK
Exposure to deposited materials[b]	--	--
Internal		
Inhalation	5.1 -1	GRONK
Transpiration of tritium oxide	5.1-1	--
Ingestion of food crops	5.1-1	GRONK
Ingestion of animal products	5.1-1	GRONK
Direct Radiation Pathways		
External		
Direct radiation from the facility	--	--
Exposure during transport of fuels and solid wastes[b]	(c)	--

(a) The program FOOD is still under development and not included in this report.

(b) Doses from these pathways are generally insignificant.

(c) Reference 3.

TABLE 2-2

PATHWAYS OF EXPOSURE TO ORGANISMS OTHER THAN MAN

Pathway and Organism Type	Equation	Computer Program
Water Pathways		
External		
Water immersion and water surface (Primary, Secondary)[a]	4.4-1	ARRRG
Exposure to sediment or shoreline (Primary, Secondary)	4.3-3	ARRRG
Internal		
Ingestion of water and aquatic foods (Primary)	6.1-3	CRITR
Ingestion of water (Secondary)	4.1-1	ARRRG
Ingestion of primary aquatic foods (Secondary)	6.1-7	CRITR
Air Pathways		
External		
Air submersion (Secondary)	5.1-1	GRONK
Exposure to deposited materials (Secondary)[b]	--	--
Internal		
Inhalation (Secondary)[b]	5.1-1	GRONK
Direct Radiation Pathways		
External		
Direct radiation from the facility (Secondary)[b]	--	--

(a) Organism types exposed via the given pathway are listed in parentheses.
(b) Doses from these pathways are generally insignificant.

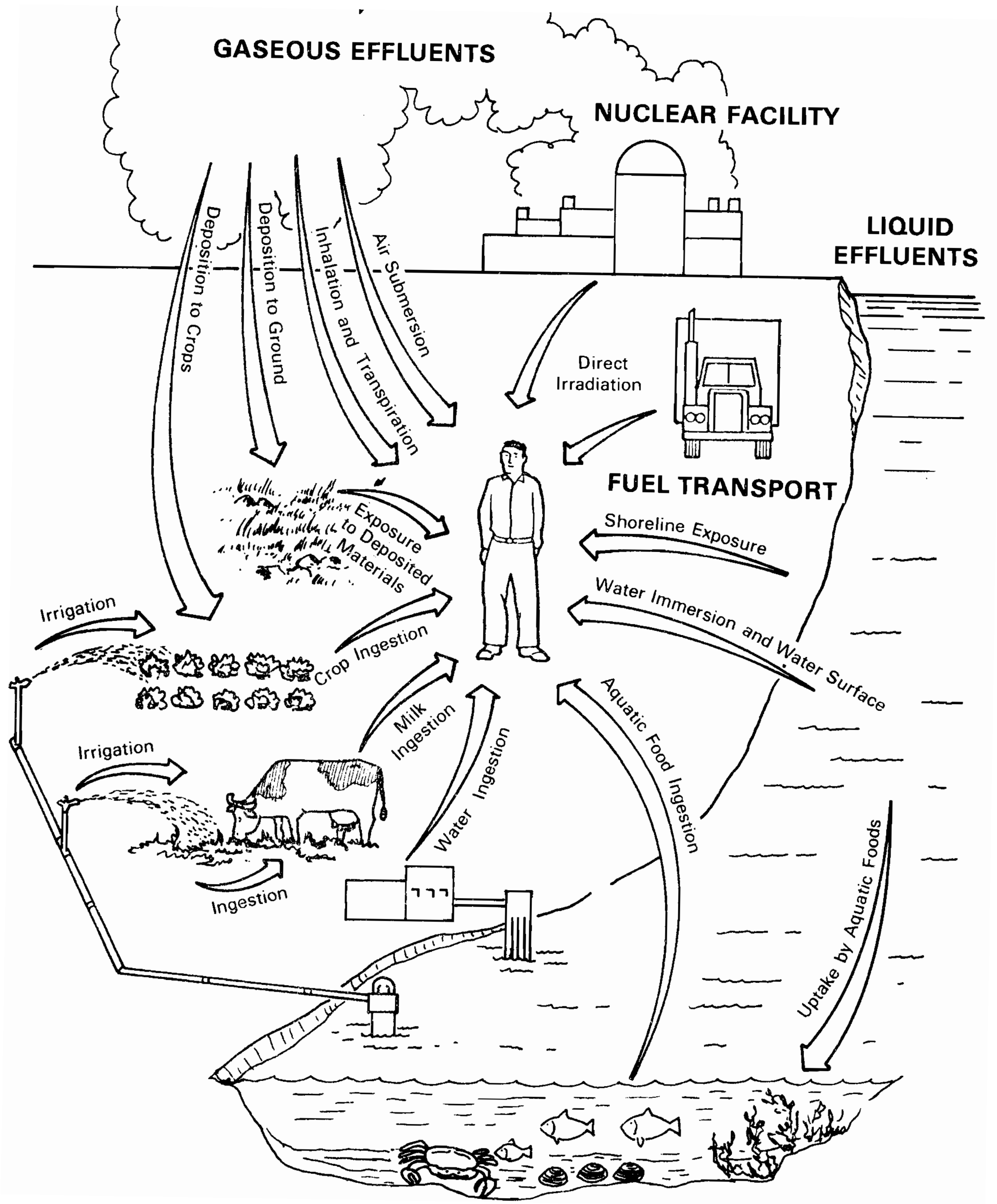

FIGURE 2-1 EXPOSURE PATHWAYS TO MAN

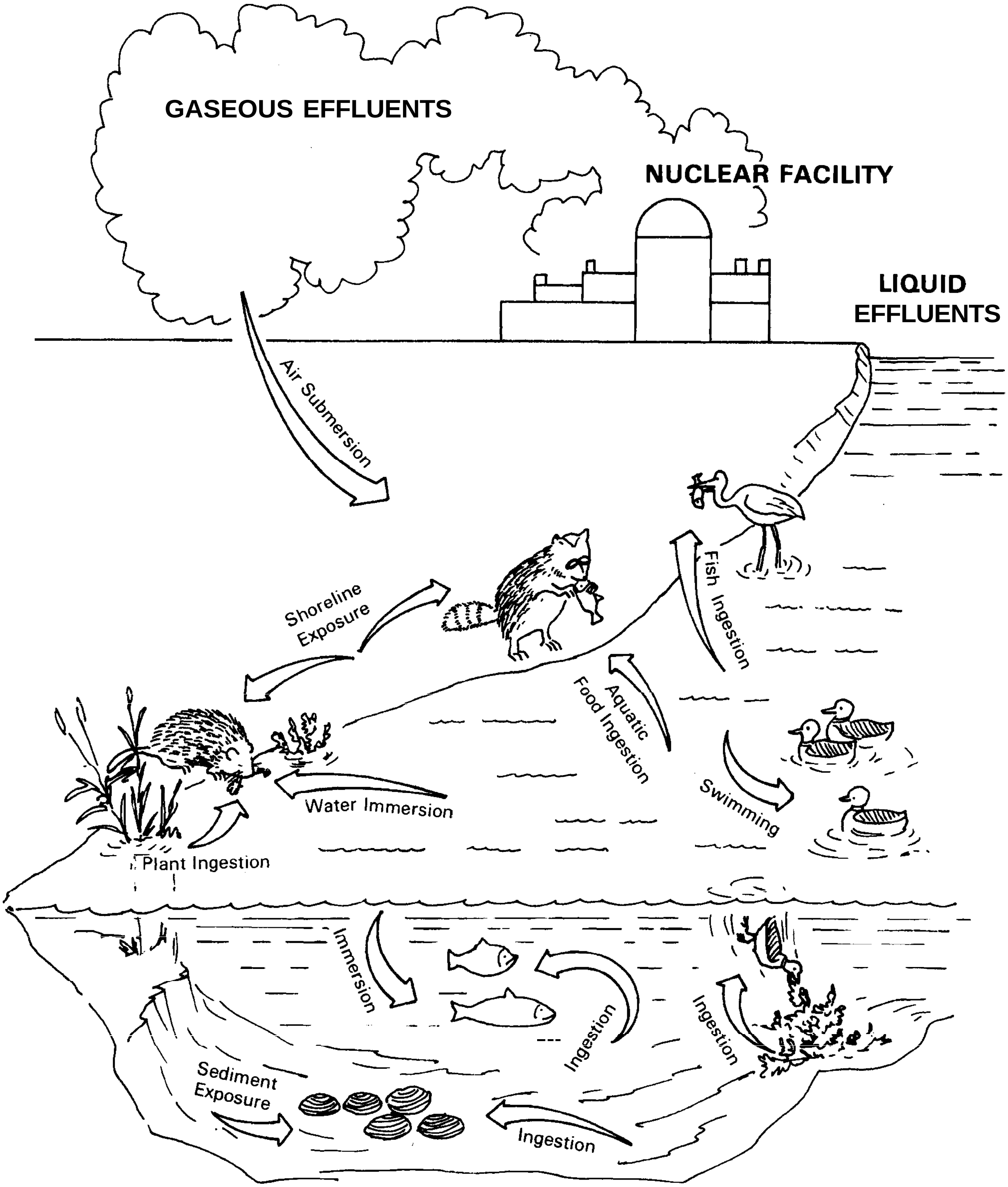

FIGURE 2-2 EXPOSURE PATHWAYS TO ORGANISMS OTHER THAN MAN

3. DOSE TO MAN -- BASIC CONSIDERATIONS

The fundamental equation for calculation of radiation dose from the pathways described above is

$$R_{ipr} = C_{ip} U_p D_{ipr} \qquad (3\text{-}1)$$

where

R_{ipr} = dose rate to organ r from nuclide i via pathway p

C_{ip} = concentration of nuclide i in the medium of pathway p

U_p = usage: the exposure or intake rate associated with pathway p

D_{ipr} = dose factor: a number specific to a given nuclide i, pathway p, and organ r which can be used to calculate radiation dose rate from exposure to a given radionuclide concentration or radionuclide intake

The three terms on the right of Equation 3-1 are discussed in the following subsections.

Equations tailored to each specific exposure pathway are derived from Equation 3-1. The principal difference between pathways is the manner in which the radionuclide concentrations are calculated.

3.1 CONCENTRATIONS OF NUCLIDES IN ENVIRONMENTAL MEDIA, C_{ip}

Concentrations of nuclides in air, water, soil or food are calculated as intermediate steps in the computer programs described in Section 7. Concentrations in water, in aquatic foods, and on shoreline sediment are calculated from the radionuclide release rates, the effluent flow rate, the mixing and dilution in the receiving waters, and bioaccumulation factors for aquatic foods. Concentrations in air and on vegetation from areal deposition are generated from radionuclide release rates and from the equations for atmospheric dispersion given in Equations 5.1-1 and 5.1-2.

Concentrations of nuclides in irrigated farm produce are calculated from concentrations of radionuclides in the irrigation water, irrigation rate, facility lifetime (determines long-term soil buildup), and decay time between nuclide release and produce consumption.

3.2 USAGES, U

Usage refers to duration of exposure to external sources of radiation and to intake rates of ingested water and food. For pathways other than air submersion, the usage depends on the specific situation. Since noble gases are the principal contributors to air submersion dose, the assumption is made that the air concentrations of radionuclides are essentially the same indoors as outdoors. Thus, no shielding and occupancy factors are applied, and 8766 hr/yr is used for the air submersion pathway.

In the absence of site-specific data, the authors employ the usages and exposure times in Table 3.2-1 to calculate individual adult doses. For population dose calculations the usages of the average adult are multiplied by the size of the population.

3.3 DOSE FACTORS, D_{ipr}

Equations for calculating internal dose factors were previously published.[1,2] They were derived originally from those given by the International Commission on Radiological Protection[4] for body burden and maximum permissible concentration. For this study, effective decay energies for the radionuclides are calculated from the ICRP model, which assumes all of the radionuclide is at the center of a spherical organ with an appropriate effective radius. Where data is lacking, metabolic parameters for the Standard Man are used for other ages as well. Internal dose factors have units of mrem/yr per pCi/yr intake via ingestion or inhalation, and represent the first year's dose from one year's intake.

TABLE 3.2-1

RECOMMENDED ADULT VALUES FOR U_p TO BE USED IN LIEU OF SITE-SPECIFIC DATA

Pathway	Maximum Individual Adult	References	Average Adult	References
Air Submersion	8766 hr/yr	(2)	8766 hr/yr	(2)
Inhalation	7300 m^3/yr	(4)	7300 m^3/yr	(4)
Drinking Water	730 liter/yr	(2)	438 liter/yr	(4)
Local Seafood -fish	18 kg/yr	(5)	2.3 kg/yr	(6)
-crustacea	9 kg/yr	(5)	0.9 kg/yr	(6)
-molluscs	9 kg/yr	(5)	0.25 kg/yr	(6)
Local Fresh Water Fish	18 kg/yr	(5)	2.2 kg/yr	(6)
Holdup Time for Aquatic Foods	24 hr	(5)	24 hr	(5)
Aquatic Recreation:				
Ocean - shoreline activ.	500 hr/yr	(7)	4 hr/yr[a]	(2)
- swimming	100 hr/yr	(8)	1 hr/yr[a]	(2)
- boating	100 hr/yr	(8)	1 hr/yr[a]	(2)
River - shoreline activ.	500 hr/yr	(7)	2 hr/yr[b]	(2)
- swimming	100 hr/yr	(8)	4 hr/yr[b]	(2)
- boating	100 hr/yr	(8)	4 hr/yr[b]	(2)
Lake - shoreline activ.	500 hr/yr	(7)	1 hr/yr[a]	(2)
- swimming	100 hr/yr	(8)	2 hr/yr[a]	(2)
- boating	100 hr/yr	(8)	4 hr/yr[a]	(2)

(a) These are hours spent in the vicinity of the site. Other hours are spent in areas unaffected by the liquid effluent from the facility.
(b) These are hours spent downstream of the site. Other hours are spent upstream and at nearby lakes.

For calculating external dose factors from air submersion or water immersion, the penetrating power of the radiation emitted determines whether it contributes to skin dose only, or to both skin and total-body dose. Beta and gamma radiation which can penetrate 7 x 10^{-3} cm of tissue is considered to contribute to skin dose; that which can penetrate 5 cm of tissue is considered to contribute to total-body dose (and dose to internal organs). The dose factors for air submersion and water imniersion are derived by assuming that the contaminated medium is an infinite volume compared to the range of the emitted radiations. Under this assumption the energy emitted per gram of medium equals the energy absorbed per gram of medium. Corrections must be applied for differences in energy absorption between tissue and air or water, physical geometry of the specific exposure situation and the conversion from MeV per disintegration per gram to rem. The resulting dose factors have units of mrem/hr per pCi/m^3 of air or mrem/hr per pCi/liter of water.

Material deposited from the air or from irrigation water onto the ground represents a fairly large, nearly uniform, thin sheet of contamination. The factors for converting surface contamination in pCi/m^2 to gamma dose at 1 meter above a uniformly contaminated plane are described in References 1, 2, and 9. Dose factors for exposure to soil (or river sediment) have units of mrem/hr per pCi/m^2 of surface.

A set of dose factors for 45 radionuclides was calculated originally for the Year 2000 Model.[2] These are recalculated using the latest available decay schemes[10] for an expanded list of 136 nuclides.[a]

(a) The revised list is given in Table 7.1-4. An explanation of the terms "+D" and "D" appearing in this table is given in Section 7.6.

4. DOSE TO MAN -- LIQUID PATHWAYS

4.1 DRINKING WATER

The dose rate from ingestion of water is calculated by.

$$R_{pr} = 1119 \sum_{i=1}^{136} \frac{Q_i N_i}{F} M_p e^{-\lambda_i t_p} U_p D_{ipr} \qquad (4.1\text{-}1)$$

where

R_{pr} = dose rate to organ **r** from all of the nuclides **i** via pathway p (mrem/yr)

N_i = reconcentration factor as defined in Section 7.5

Q_i = release rate of nuclide **i** (Ci/yr)

F = flow rate of the liquid effluent (ft^3/sec)

M_p = mixing ratio at the point of exposure (or the point of with- drawal of drinking water or the point of harvest of aquatic food) as defined in Section 7.5

t_p = transit time required for nuclides to reach the point of exposure. For internal dose, t_p is the total time elapsed between release of the nuclides and ingestion of food or water (hr)

λ_i = radiological decay constant of nuclide **i** (hr^{-1})

1119 = a constant which converts from (Ci/yr)/(ft^3/sec) to pCi/liter

The terms $\frac{Q_i N_i}{F}$ in Equation 4.1-1 define the concentration of nuclide **i** in the effluent at the point of discharge. The expression $\frac{Q_i N_i}{F} M_p \exp(-\lambda_i t_p)$ yields the concentration at the time that the water is consumed. This latter concentration is the term C_{ip} in Equation 3-1.

4.2 AQUATIC FOODS

Concentrations of radionuclides in aquatic foods are directly related to the concentrations of the nuclides in water. Equilibrium ratios between the two concentrations, called bioaccumulation factors in this report, were taken from References 11 and 12 and are listed in Table 7.1-4. The equation for calculation of internal dose rate from consumption of aquatic food is

$$R_{pr} = 1119 \sum_{i=1}^{136} \frac{Q_i N_i}{F} M_p B_{ip} e^{-\lambda_i t_p} U_p D_{ipr} \qquad (4.2\text{-}1)$$

where B_{ip} is the bioaccumulation factor for nuclide i via pathway p (pCi/kg per pCi/liter).

4.3 SHORELINE DEPOSITS

The calculation of sediment load, transport and concentrations of radionuclides associated with suspended and deposited materials is a complex problem. One approach to this problem was used in the Year 2000 Study.[2] For the program ARRRG, a simplified scheme for obtaining an order of magnitude estimate of the concentration of shoreline sediments was developed. The concentration of nuclide i in the sediment can be estimated from

$$S_i = K \frac{A_i (1-e^{-\lambda_i t_s})}{\lambda_i} \qquad (4.3\text{-}1)$$

where

S_i = concentration of nuclide i in sediment (pCi/kg)

A_i = concentration of the nuclide i in the water adjacent to the sediment (pCi/liter)

K = assumed constant in units of liter/kg-d

t_s = total time the sediment is exposed to the contaminated water, nominally taken to be the operating lifetime of the facility (hr)

In the original evaluation of the equation, λ_i was chosen to be the radiological decay constant, although the true value should include an unknown "environmental" removal constant. If the presence of a radionuclide in water and sediment is controlled primarily by radioactive equilibrim with its parent nuclide, then the water concentration and half-life of the parent should be used in the equation.

The relationship was tested and the value of K derived from radionuclide concentrations measured in water and sediment samples collected over a period of several years in the Columbia River between Richland, Washington and the river mouth and in Tillamook Bay, Oregon, 75 km (47 miles) south of the river mouth.[13,14] Since the primary use of the equation is to facilitate estimates of the exposure rate from gamma emitters one meter above the sediment, an effective surface contamination was devised. This surface contamination level was taken to be all of the nuclides contained within the top 2.5 cm (1 in.) of sediment.[a] The dose contribution from the radionuclides below 2.5 cm in depth was ignored. The resulting equation is

$$S_i' = 100\ \tau_i\ A_i\ W\ (1-e^{-\lambda_i t_s}) \tag{4.3-2}$$

where

S_i' = "effective" surface contamination (pCi/m^2)
τ_i = radiological half-life of nuclide i (d)
W = shore width factor (unitless)

Shore width factors were derived from data given in Figure 3.1 (5) of Reference 15 and are summarized in Table 4.3-1.

(a) Calculated by multiplying the concentration (pCi/kg) by a mass thickness (40 kg/m^2).

TABLE 4.3-1

SHORE WIDTH FACTORS FOR USE IN EQUATIONS 4.3-2 AND 4.3-3

Exposure Situation	Shore Width Factor (W)
Discharge canal bank	0.1
River shoreline	0.2
Lake shore	0.3
Nominal ocean site	0.5
Tidal basin	1.0
Organisms on surface or in burrow[a]	2.0

(a) Since the radionuclide concentration normally decreases with depth in the mud, the dose to a buried organism is probably no higher than that to one lying on the mud surface.

The combination of Equations 4.3-2 and 3-1 yields the equation below for calculation of radiation dose from exposure to shoreline sediments.

$$R_{pr} = \sum_{i=1}^{136} S_i' \, U_p \, D_{ipr} = 100 \sum_{i=1}^{136} \tau_i \, A_i \, W \, (1-e^{-\lambda_i t_s}) \, U_p \, D_{ipr}$$

$$= 111{,}900 \sum_{i=1}^{136} \tau_i \frac{Q_i \, N_i}{F} \, M_p \, e^{-\lambda_i t_p} \, W \, (1-e^{-\lambda_i t_s}) \, U_p \, D_{ipr} \qquad (4.3\text{-}3)$$

4.4 SWIMMING AND BOATING

The equation for calculation of external dose to the skin and total-body from swimming (water immersion) or boating (water surface) is

$$R_{pr} = 1119 \sum_{i=1}^{136} \frac{Q_i \, N_i}{F \, K_p} \, M_p \, e^{-\lambda_i t_p} \, U_p \, D_{ipr} \qquad (4.4\text{-}1)$$

where K_p is a geometry correction factor equal to 1 for swimming and 2 for boating.

5. DOSE TO MAN -- GASEOUS PATHWAYS

5.1 AIR SUBMERSION

The formulas used to calculate doses from air submersion are Equations 5.1-1 and 5.1-2 below (Ref. 16, p. 113).

$$R_{pr}(x,\theta,d) = \sum_{i=1}^{136} \bar{\chi}_i \, U_p \, D_{ipr} \qquad (5.1\text{-}1)$$

where

$R_{pr}(x,\theta,d)$ = external dose rate from all of the nuclides i via pathway p to organ r of a person located a point x meters from the source in a direction d, averaged over a sector width of θ radians (mrem/yr)

U_p = 8766 hr/yr for air submersion

D_{ipr} = dose factor for nuclide i via pathway p to organ r based on a half-infinite cloud geometry and corrected for the fractional penetration of beta and gamma radiations to the depth of 7×10^{-3} cm for skin and 5 cm for total body (mrem/hr per pCi/m^3)

and

$$\bar{\chi}_i = \sum_{J=1}^{J'} \left(\frac{2}{\pi}\right)^{1/2} \frac{(0.01 f_j)\, 10^{12}}{\bar{u}_j \, \theta \, \frac{x Q_i'}{x}} \left[\exp\left(-\frac{h^2}{2(\sigma_z)_j^2}\right)\right]\left[\exp\left(-\frac{\lambda_i x}{\bar{u}_j}\right)\right] \qquad (5.1\text{-}2)$$

where

$\bar{\chi}_i$ = annual average concentration (pCi/m^3) of nuclide i at point (x,θ,d)

f_j = percent of time wind blows in direction d under meteorological condition J

10^{12} = picocuries per curie

Q_i' = release rate of nuclide i (Ci/sec)

8 = sector width = $2\pi/n$ radians, where the number of sectors n is normally 16

x = downwind distance (meter)

$\bar{u}_j$ = average wind speed for meteorological condition J (meter/sec)

$\frac{x}{\bar{u}_j}$ = travel time of released material to point (x,θ,d) under meteorological condition J (sec)

λ_i = radiological decay constant for nuclide i (sec^{-1})

h = height of effluent release (meter)

$(\sigma_z)_J$ = standard deviation of vertical dispersion under meteorological condition J ($meter^2$)

J' = number of meteorological conditions ("stability classes")

The standard deviation of vertical dispersion may be derived for the Hanford (Fuquay-Simpson) four-stability-class method from equations given on pp. 141 and 392 of Reference 16, or from tables of σ_z versus x by Pasquill stability category on p. 409 of Reference 16. Both the Hanford and the Pasquill formats are programmed into GRONK since raw meteorology data may be given in either format, depending upon the particular system employed at the nuclear facility.

Equation 5.1-1 yields the yearly external dose to a person located at point (x,θ,d). The population dose in man-rem/yr is determined by multiplying this dose by the population located within the sector of the annulus of concern. Values of the dose at the point (x,θ,d) are assumed to apply to all individuals located in that sector.

5.2 THYROID DOSES FROM RADIOIODINE

Equation 5.1-1 may also be applied to the calculation of thyroid dose from airborne radioiodine. Pathways of importance are inhalation, ingestion of vegetation contaminated via radioiodine deposition on agricultural land, and ingestion of milk from cows which consume such vegetation. The program provides for calculation of thyroid doses to different ages, since the thyroid dose is usually greater to children than to adults.

A standard value for the usage parameter, U_p, is assumed for each of the above pathways and standard transfer factors between air, vegetation, cow, milk and humans are assumed. For ease of calculation, these standard values are multiplied into the thyroid dose factors to create a modified dose factor which converts air concentrations of radioiodine directly into dose rate. The user need only consider those parameters which alter the standard usages: grazing season, vegetation growing season and vegetation consumption rates.

Parameters used to derive the thyroid dose factors are derived from the food pathway model used in the Year 2000 Study[2] and are listed in Table 5.2-1. The dose factors obtained from these parameters are listed in Tables 5.2-2, 5.2-3 and 5.2-4.

TABLE 5.2-1

METABOLIC PARAMETERS USED IN THE THYROID DOSE FACTORS[a][2]

Parameter		2 yr	4 yr	14 yr	Adult
Fractional uptake via ingestion, f_w		0.5	0.5	0.37	0.3
Fractional uptake via inhalation, f_a		0.2	0.2	0.2	0.23
Biological half-life in thyroid (d)		8	13	30	138
Thyroid mass (g)		2	5	15	20
Thyroid radius (cm)		1.4	2	2.7	3
Inhalation rate (m^3/d)		5.6	7.0	13.5	20
Effective MeV per disintegration[b]	^{129}I	0.047	0.047	0.048	0.048
	^{130}I	0.388	0.427	0.472	0.490
	^{131}I	0.206	0.213	0.221	0.224
	^{132}I	0.581	0.624	0.673	0.693
	^{133}I	0.467	0.478	0.491	0.497
	^{134}I	0.779	0.838	0.906	0.934
	^{135}I	0.481	0.514	0.551	0.566

(a) More recent values for some of these parameters are being considered and will be used to revise the dose factors. Projected changes include:
References to 2-yr old will be replaced with 1-yr old.
- Biological half-life in the thyroid for ages 1 yr, 4 yr, 14 yr and adult will be 20, 20, 50 and 100 d, respectively.[17-21]
- Adult values of f_w and f_a will be applied to all ages.

(b) Calculated from formulas of Reference 4, p. 28, and decay schemes of Reference 10.

TABLE 5.2-2

FACTORS FOR CONVERTING AIR CONCENTRATIONS OF RADIOIODINE TO THYROID DOSE VIA INHALATION[(a)]

(mrem/yr per pCi/m^3)

Age	^{129}I	^{130}I	^{131}I	^{132}I	^{133}I	^{134}I	^{135}I
2 yr	5.74	2.88	12.5	0.835	5.51	0.424	2.00
4 yr	4.68	1.62	8.07	0.449	2.93	0.229	1.05
14 yr	6.94	1.17	6.76	0.311	2.03	0.158	0.750
Adult	34.3	1.57	10.6	0.414	2.70	0.209	0.985

(a) Organic and inorganic forms of radioiodine give the same dose via inhalation.
Factors include a breathing rate for ages 2 yr, 4 yr, 14 yr and adult of 5.6, 7.0, 13.5 and 30 m^3/d, respectively.

TABLE 5.2-3

FACTORS FOR CONVERTING AIR CONCENTRATIONS OF RADIOIODINES TO THYROID DOSE VIA MILK[(a)]

(mrem/yr per pCi/m^3)

Age	^{129}I	^{130}I	^{131}I	^{132}I	^{133}I	^{134}I	^{135}I
2 yr	3600	83.0	3620	4.58	262	0.911	31.2
4 yr	2170	34.5	1730	1.82	103	0.363	12.4
14 yr	669	10.4	497	0.524	28.4	0.104	3.53
Adult	3140	6.61	448	0.330	18.7	0.0655	2.28

(a) Factors include the following assumptions:
- Grazing season is 365 d/yr.
- Milk consumption is 1 liter/d for all ages.
- There is no decay between milking and consumption.
- Radioiodine is 100% inorganic (organic forms of radioiodine contribute insignificantly to dose via this pathway).
- Long-term accumulation in the soil is ignored for ^{129}I (adds ~1.4% in 1 yr or 42% in 30 yr).

TABLE 5.2-4

FACTORS FOR CONVERTING AIR CONCENTRATIONS OF RADIOIODINE TO THYROID DOSE VIA LEAFY VEGETABLES[a]

(mrem/yr per pCi/m^3)

Age	^{129}I	^{130}I	^{131}I	^{132}I	^{133}I	^{134}I	^{135}I
2 yr	1485	26.8	1190	1.48	84.1	0.293	10.0
4 yr	1720	21.4	1090	1.13	63.5	0.224	7.62
14 yr	1650	10.0	594	0.507	28.5	0.101	3.53
Adult	5190	8.53	589	0.428	24.1	0.0844	2.94

(a) Factors include the following assumptions:
- Vegetables are from home gardens.
- There is no decay between garden and table.
- Vegetables are exposed 3 mo above ground to air.
- 25% of deposited material remains on vegetables (remainder on ground) with "environmental" half-life of 14 d.
- Radioiodine is 100% inorganic (organic forms of radioiodine contribute insignificantly to dose via this pathway).
- Long-term accumulation in the soil is ignored for ^{129}I (adds ~1.4% in 1 yr or 42% in 30 yr).
- Maximum individual vegetable consumption for ages 2 yr, 4 yr, 14 yr and adult are 18, 32, 54 and 72 kg/yr, respectively.

6. DOSE TO ORGANISMS OTHER THAN MAN

Pathways of exposure associated with liquid effluents are generally the most significant contributors to radiation dose to organisms other than man, since aquatic organisms can concentrate radionuclides from their water environment either directly or via their food chains. For purposes of calculating equilibrium concentrations of radionuclides, organisms other than man are divided into two classifications: "primary organisms" which are aquatic and for which bioaccumulation factors are available, and "secondary organisms" which feed upon primary organisms.

Radionuclide concentrations for primary organisms can be calculated directly from the water concentrations and bioaccumulation factors. The primary organisms are fish, crustacea, molluscs and plants. Radionuclide concentrations for secondary organisms must be calculated from their diet of primary organisms. Representative secondary birds and mammals were selected such that each primary organism would be in the diet of at least one secondary organism. The predatory birds and mammals commonly selected are herons, raccoons, muskrats and plant-eating ducks.

6.1 INTERNAL DOSES VIA LIQUID PATHWAYS

The total-body dose rate to an aquatic organism is

$$R_c = 0.0187 \sum_{i=1}^{136} b_{ic}\, \varepsilon_{ic} \qquad (6.1\text{-}1)$$

where R_c = dose rate to total body of organism c (mrad/yr)

ε_{ic} = effective absorbed energy in MeV per disintegration (dis) for nuclide i in organism c

b_{ic} = specific body burden of nuclide i in organism c (pCi/kg)

0.0187 = conversion factor calculated as follows:

$$\left(3.7 \times 10^{-2} \frac{\text{dis}}{\text{sec-pCi}}\right)\left(3.156 \times 10^{7} \frac{\text{sec}}{\text{yr}}\right)\left(1.6 \times 10^{-6} \frac{\text{erg}}{\text{MeV}}\right)\left(\frac{\text{kg-mrad}}{100 \text{ erg}}\right)$$

$$= 0.0187 \frac{\text{dis-kg-mrad}}{\text{pCi-yr-MeV}}$$

For a primary organism, b_{ic} is given by

$$b_{ic} = A_i\, B_{ic} = 1119 \frac{Q_i\, N_i}{F} M_p\, e^{-\lambda_i t_p}\, B_{ic} \qquad (6.1\text{-}2)$$

where the symbols are as given in Sections 4.1 and 4.2. Combining 6.1-1 and 6.1-2 yields

$$R_c = 20.93 \sum_{i=1}^{136} \frac{Q_i\, N_i}{F}\, M_p\, e^{-\lambda_i t_p}\, B_{ic}\, \varepsilon_{ic} \qquad (6.1\text{-}3)$$

The total-body dose factor, d'_{ik}, from nuclide i for a secondary organism k is(1)

$$D'_{ik} = \frac{0.0021\, (f_i)\, \varepsilon'_{ik}\, (1-e^{-\lambda'_{Ei} t})}{\lambda'_{Ei}\, m'_k} \left(\frac{\text{mrad/yr}}{\text{pCi/yr intake}}\right) \qquad (6.1\text{-}4)$$

where

$(f_w)'_i$ = fraction of ingested nuclide i retained in secondary organism (unitless)

m'_k = mass of secondary organism k (g)

$\lambda_{Ei} = \lambda_i + \lambda'_{Bi}$ = effective decay constant of nuclide i in secondary organism (hr^{-1}), where

λ'_{Bi} = biological removal constant of nuclide i in secondary organism (hr^{-1}),

t = period of exposure (hr)

ε'_{ik} = effective absorbed energy in MeV per disintegration for secondary organism k.

The parameters $(f_w)'_i$ and λ'_{Ei} are taken to be the same as those for Standard Man because data for other organisms are lacking. Since the dose factors tabulated for the ARRRG program include total-body dose factors for man, it is convenient to use an alternate formulation for Equation 6.1-4

$$D'_{ik} = \frac{\varepsilon'_{ik}}{m'_k} \frac{m'_{man} D'_{i,man}}{\varepsilon'_{i,man}} = \frac{\varepsilon'_{ik}}{m'_k} \frac{70{,}000\, D_{i,man}}{\varepsilon_{i,man}} \qquad (6.1\text{-}5)$$

where 70,000 g is the total body mass of the adult.

The radiation dose rate to the total body of the secondary organism expressed in the format of Equation 3-1 is

$$R'_i = 0.365 \sum_{i=1}^{136} b_{ic}\, P'_{ck}\, D'_{ik} \qquad (6.1\text{-}6)$$

where P'_{ck} = consumption rate of primary organism c by secondary organism k (g/d)

0.365 = (kg/g) (d/yr)

Substituting the values of b_{ic} and D'_{ik} from Equations 6.1-2 and 6.1-5, respectively, into Equation 6.1-6 yields

$$R_i' = 2.86 \times 10^7 \sum_{i=1}^{136} B_{ic} \frac{Q_i N_i}{F} M_p e^{-\lambda_i t_p} P_{ck}' \frac{\varepsilon_{ik}' D_{i,man}}{m_k' \varepsilon_{i,man}} \qquad (6.1\text{-}7)$$

where

$2.86 \times 10^7 = (0.365)\ (1119)\ (70{,}000)$.

The values for ε and ε' are determined from the effective radius of the organism. Table 10.6 tabulates ε for seven effective radii for organisms other than man and for the total body of man for each of the 136 nuclides. In the absence of site-specific data, the values of the parameters in Table 6.1-1 may be used for Equation 6.1-7.

6.2 OTHER DOSES TO AQUATIC AND TERRESTRIAL ANIMALS

Primary and secondary organisms are also exposed via water immersion, water surface, bottom sediment and shoreline silt. Although these doses are usually relatively insignificant, they may be calculated using the methods of Section 4 or by the program ARRRG. For shoreline exposure, a correction must be made for the difference in height of exposure between animals and men. For small organisms this correction factor is 2, and has been incorporated in the shore width factor of 2.0 in Table 4.3-1.

Secondary organisms are exposed via air submersion, inhalation, and radiation from materials deposited by air. Air submersion doses are of possible significance, depending upon the particular nuclear facility involved, and may be calculated using the methods of Section 5 or by the program GRONK. Exposure from inhalation and materials deposited by air are usually relatively insignificant. Inhalation doses cannot be calculated directly at this time, since the detailed behavior of inhaled radionuclides in animals is not yet known.

TABLE 6.1-1

RECOMMENDED PARAMETERS FOR ORGANISMS OTHER THAN MAN
TO BE USED IN LIEU OF SITE-SPECIFIC DATA

Organism	Body Mass (kg)	Effective Radius (cm)	Source of Nuclide	Intake Rate (g/d)	Annual Exposure (hr)			
					Air	Sediment	Immer-sion	Water Surface
Primary								
Fish	(a)	2	Water	(a)	0	0-8766[b]	8766	
Crustacea	(a)	2	Water	(a)	0	0-8766[b]	8766	
Molluscs	(a)	2	Water	(a)	0	8766		8766
Algae	(a)	2	Water	(a)			8766	
Secondary								
Muskrat	1	6	Plant	100	$\frac{8766}{3}$	$\frac{8766}{3}$	$\frac{8766}{3}$	
Raccoon	12	14	Crustacea & Molluscs	200	8766	$\frac{8766}{4}$		
Heron	4.6	11	Fish	600	8766	$\frac{8766}{3}$		$\frac{8766}{3}$
Duck	1	5	Plant	100	8766	$\frac{8766}{2}$		$\frac{8766}{2}$

(a) Not required for calculation of doses to primary organisms.
(b) The hours spent in contact with the sediments are highly variable.

7. COMPUTER PROGRAMS ARRRG, CRITR AND GRONK

7.1 INTRODUCTION

Three programs are written in the Basic computer language to implement the dose calculation models described in this paper. These programs are executed interactively at a conversational terminal and are designed to be used by personnel untrained in programming. The codes print informative messages if a user error is detected and allow the user the opportunity to correct the faulty information. The data files utilized and items calculated by each program are listed in Table 7.1-1.

Each program produces a summary output at the teletype, with the user controlling the level of detail in the output. ARRRG and GRONK also create fully detailed output at a high-speed printer to serve as a permanent record of the run.

The programs obtain their information from three sources:

(1) Parameters which are highly variable, such as human diets assumed for the particular locality, reactor coolant flow rate and release height, are entered directly at the time each case is run. This is accomplished by interactive questions to be answered by the operator, such as "cooling flow in cfs=?"

(2) Parameters which are applicable only to a given facility are stored once within a file at the time the information is received from the applicant. This information is then automatically accessed each time a case is run for that facility. For ARRRG and CRITR, the liquid release rates for all facilities are stored on a single large file called REL. For GRONK, a file called Gxxxx, where xxxx stands for the first four letters of the reactor name, contains the radionuclide release rates, the population

TABLE 7.1-1

PROGRAMS FOR CALCULATING RADIATION DOSES

Program	Data Files	Item Calculated, Equations Used	Organ Doses Calculated
ARRRG	ARGIN REL	Individual and population doses from ingested water, Equation 4.1-1	Total body, GI-LLI,[(a)] thyroid, bone
		Individual and population doses from aquatic foods (fish, crustacea, molluscs, plants), Equation 4.2-1	Total body, GI-LLI, thyroid, bone
		Individual and population doses from sediment exposure (shoreline), Equation 4.3-3	Skin, total body[(b)]
		Individual and population doses from swimming and boating, Equation 4.4-1	Skin, total body
CRITR	ARGIN REL CRITEN	Internal doses to aquatic biota (fish, crustacea, molluscs, plants), Equation 6.1-3	Total body
		Internal doses to predators of aquatic biota, such as ducks, muskrats, raccoons and herons, Equation 6.1-7	Total body
GRONK	GIN TONIC Gxxxx	Annual average atmospheric dilution factors (Ci/m^3 per Ci/sec released) versus distance and direction from the source ($\overline{\chi}/Q'$), Equation 5.1-2	---
		Individual doses from exposure to half-infinite cloud of effluents, versus distance and direction from the source, Equation 5.1-1	Skin, total body
		Integrated man-rem doses to total population within 50 miles, Equation 5.1-1	Total body
		Doses to child and adult from inhalation, and consumption of milk and leafy vegetables, Equation 5.1-1	Thyroid

(a) GI-LLI means gastrointestinal tract-lower large intestine.

(b) For these pathways, the calculated total-body dose is listed under GI-LLI, thyroid and bone on the printout and is added into the total dose to these organs.

distribution out to 50 miles in 16 sectors and up to 10 annular rings, and meteorological tables of joint frequency of wind speed and direction by stability class in either Hanford or Pasquill format or both.

(3) Parameters which remain constant every time a program is run are stored in permanent data files and accessed by the program when needed.

Table 7.1-2 describes all permanent files of type (2) and (3) and lists the programs which use them.

Discussions of ARRRG, CRITR and GRONK are located in Sections 7.2, 7.3 and 7.4, respectively. Table 7.1-3 is a guide to the contents of these sections and to the program and data file listings in the appendix.

Each program discussion includes a teletype printout for a typical run, with input typed by the user[a] indicated by wavy underlines. Once the user has signed onto the system, he begins execution with the command RUN *name*, where *name* represents ARRRG, CRITR or GRONK. CRITR allows one case to be computed per execution; for additional cases the user enters the command RUN. ARRRG allows any number of cases with varying input to be computed for the specified reactor; to change reactors the user enters the command RUN. GRONK has no restrictions on changing reactors or on the number of cases per reactor.

Constants may be entered with or without a decimal point or in E format. If more than one constant is to be entered on a line, the values may be separated by either blanks or commas. Questions requiring yes-or-no answers may be answered with either Y, YES, N or NO. Titles and reactor names may be more than one word.

(a) Reactor data files and input parameters for the sample runs are intended only to demonstrate operation of the programs. These data files and input parameters are not necessarily those which would be used for an actual reactor.

TABLE 7.1-2

DATA FILES UTILIZED BY THE DOSE CALCULATION PROGRAMS

File	Contents
ARGIN	Decay constants; internal ingestion dose factors for total-body, GI-LLI, thyroid and bone; external dose factors for skin and total body for exposure to sediment and to water for 136 radionuclides; fresh and salt water bioaccumulation factors for fish, crustacea, molluscs and algae by element.
REL	Radionuclides released with liquid effluents (Ci/yr) for each facility under study.
CRITEN	List of effective absorbed energies per disintegration versus radius for 136 radionuclides.
GIN	Decay constants, external skin and total-body dose factors for air submersion for 136 radionuclides; child and adult thyroid dose factors for inhalation, milk and leafy vegetables.
TONIC	Constants used for the Pasquill meteorology calculation.
Gxxxx[a]	File for a particular facility containing radionuclides released with gaseous effluents (Ci/yr), population distribution out to 50 miles in 16 sectors and up to 10 annular rings, and meteorological data in tables of joint frequency of wind speed, direction and stability class in either Hanford or Pasquill format or both.

(a) Where xxxx represents the first four letters of the facility name.

TABLE 7.1-3

INDEX TO PROGRAM DESCRIPTIONS AND LISTINGS

Program Name	Program Description	Program Listing	Date File Listing		Sample Conversational Session	Input Work Sheet	Sample High-Speed Printer Output
ARRRG	Section 7.2 Section 7.5	Section 10.1 (CSTS version) Section 10.2 (CSCX version)	ARGIN REL	Section 10.3 Section 10.4	Table 7.2-1	Table 7.2-2	Table 7.2-3
CRITR	Section 7.3 Section 7.5	Section 10.5	ARGIN REL CRITEN	Section 10.3 Section 10.4 Section 10.6	Table 7.3-1	None	None
GRONK	Section 7.4	Section 10.7 (CSTS version) Section 10.8 (CSCX version)	GIN TONIC Gxxxx	Section 10.9 Section 10.10 {Section 10.11 Table 7.4-2 (rules of formation)}	Table 7.4-3	Table 7.4-1	Table 7.4-4

The programs use a common master list of 136 radionuclides. Section 7-6 details the method by which parent-daughter nuclide pairs are treated in the master list. Table 7.1-4 is a compilation by nuclide of standard decay constants, bioaccumulation factors and dose factors used in the programs. The Nuclide Release Worksheet (Table 7.1-5) is helpful in preparing the release rate input required for REL and Gxxxx files.

Copies of the programs and associated data files may be obtained upon request. These programs are written in the considerably enhanced version of Basic provided by Computer Sciences Corporation for their INFONET time-sharing network. The CSCX operating system is currently available only at the Richland, Washington INFONET installation; the CSTS operating system is in use at all other installations. ARRRG and GRONK are available in both CSCX and CSTS versions; the other programs and files are compatible with either system without change. The sample output reproduced here was created with the CSTS versions of ARRRG and GRONK. The CSCX output shows minor differences in format.

Warning to non-INFONET potential users: the authors studied the possibility of converting ARRRG, CRITR and GRONK to the IBM 360-370 series and to the CDC 6600 series and found that many of the features used in these programs are lacking in the Basic of these other computers. Thus, the authors concluded that these programs are not convertible into IBM and CDC Basic. Presumably, this conclusion would hold true for most other computers and time-sharing companies.

7.2 PROGRAM ARRRG

ARRRG (Aqueous Reactor Release Result Generator) calculates annual individual and population doses resulting from radionuclides released with liquid effluents. The calculation is performed using the equations of Section 4 for doses received via any user-selected combination of eight exposure pathways:

TABLE 7.1-4. Nuclide Master List

MASTER LIST OF CONCENTRATION FACTORS

	ISOTOPE	LAMBDA 1/SEC	LAMBDA 1/HOURS	SALT WATER CONCENTRATION FACTORS, LITER/KG FISH	CRUS-TACEA	MOL-LUSCS	ALGAE	FRESH WATER CONCENTRATION FACTORS, LITER/KG FISH	CRUS-TACEA	MOL-LUSCS	ALGAE
1	H-3	1.79E-09	6.43E-06	1	1	1	1	1	1	1	1
2	C-14	3.83E-12	1.38E-08	1	1	1	1	4600	9100	9100	4600
3	N-13	1.16E-03	4.16E+00	0	0	0	0	0	0	0	0
4	F-18	1.04E-04	3.75E-01	4	4	4	1	10	100	100	2
5	NA-22	8.44E-09	3.04E-05	1	1	1	1	100	200	200	500
6	NA-24	1.28E-05	4.62E-02	1	1	1	1	100	200	200	500
7	P-32	5.61E-07	2.02E-03	10000	10000	10000	100000	100000	20000	20000	500000
8	AR-39	8.17E-11	2.94E-07	1	1	1	1	1	1	1	1
9	AR-41	1.05E-04	3.79E-01	1	1	1	1	1	1	1	1
10	SC-46	9.56E-08	3.44E-04	100	300	300	1000	2	1000	1000	10000
11	CR-51	2.89E-07	1.04E-03	100	1000	1000	1000	20	2000	2000	4000
12	MN-54	2.65E-08	9.53E-05	3000	10000	50000	10000	400	90000	90000	10000
13	MN-56	7.47E-05	2.69E-01	3000	10000	50000	10000	400	90000	90000	10000
14	FE-55	8.44E-09	3.04E-05	1000	4000	20000	6000	100	3200	3200	1000
15	FE-59	1.78E-07	6.42E-04	1000	4000	20000	6000	100	3200	3200	1000
16	CO-57	2.97E-08	1.07E-04	100	10000	300	100	50	200	200	200
17	CO-58	1.12E-07	4.05E-04	100	10000	300	100	50	200	200	200
18	CO-60	4.17E-09	1.50E-05	100	10000	300	100	50	200	200	200
19	NI-63	2.39E-10	8.60E-07	500	100	100	100	100	100	100	50
20	NI-65	7.53E-05	2.71E-01	500	100	100	100	100	100	100	50
21	CU-64	1.51E-05	5.42E-02	1000	5000	5000	1000	50	400	400	2000
22	ZN-65	3.28E-08	1.18E-04	5000	5000	50000	1000	2000	10000	10000	20000
23	ZN-69M+D	1.39E-05	5.02E-02	5000	5000	50000	1000	2000	10000	10000	20000
24	ZN-69	2.02E-04	7.29E-01	5000	5000	50000	1000	2000	10000	10000	20000
25	BR-82	5.44E-06	1.96E-02	3	10	10	100	420	330	330	50
26	BR-83+D	8.03E-05	2.89E-01	3	10	10	100	420	330	330	50
27	BR-84	3.64E-04	1.31E+00	3	10	10	100	420	330	330	50
28	BR-85	3.86E-03	1.39E+01	3	10	10	100	420	330	330	50
29	KR-83M	1.04E-04	3.73E-01	1	1	1	1	1	1	1	1
30	KR-85M	4.39E-05	1.58E-01	1	1	1	1	1	1	1	1
31	KR-85	2.04E-09	7.35E-06	1	1	1	1	1	1	1	1
32	KR-87	1.52E-04	5.47E-01	1	1	1	1	1	1	1	1
33	KR-88	6.86E-05	2.47E-01	1	1	1	1	1	1	1	1
34	RB-86	4.31E-07	1.55E-03	30	50	10	10	2000	1000	1000	1000
35	RB-88	6.47E-04	2.33E+00	30	50	10	10	2000	1000	1000	1000
36	RB-89	7.50E-04	2.70E+00	30	50	10	10	2000	1000	1000	1000
37	SR-89	1.54E-07	5.55E-04	1	1	1	20	30	100	100	500
38	SR-90	7.78E-10	2.80E-06	1	1	1	20	30	100	100	500
39	SR-90D	7.78E-10	2.80E-06	1	1	1	20	30	100	100	500
40	SR-91	1.99E-05	7.17E-02	1	1	1	20	30	100	100	500
41	SR-92	7.11E-05	2.56E-01	1	1	1	20	30	100	100	500
42	Y-90	3.00E-06	1.08E-02	30	100	100	300	25	1000	1000	5000
43	Y-91M	2.31E-04	8.32E-01	30	100	100	300	25	1000	1000	5000
44	Y-91	1.36E-07	4.91E-04	30	100	100	300	25	1000	1000	5000
45	Y-92	5.44E-05	1.96E-01	30	100	100	300	25	1000	1000	5000
46	Y-93	1.89E-06	6.80E-03	30	100	100	300	25	1000	1000	5000
47	ZR-95	1.23E-07	4.44E-04	30	100	100	1000	330	7	7	1000
48	ZR-95D	1.23E-07	4.44E-04	30	100	100	1000	330	7	7	1000
49	ZR-97	1.13E-05	4.08E-02	30	100	100	1000	330	7	7	1000
50	ZR-97D	1.13E-05	4.08E-02	30	100	100	1000	330	7	7	1000
51	NB-95	2.29E-07	8.25E-04	100	200	200	100	30000	100	100	800

TABLE 7.1-4. (contd)

52	NB-97	1.61E-04	5.78E-01	100	200	200	100	30000	100	100	800
53	MO-99+D	2.86E-06	1.03E-02	10	100	100	100	10	10	10	1000
54	MO-99D	2.86E-06	1.03E-02	10	100	100	100	10	10	10	1000
55	TC-99M	3.22E-05	1.16E-01	10	100	100	1000	15	5	5	40
56	TC-99	1.04E-13	3.73E-10	10	100	100	1000	15	5	5	40
57	TC-101	8.25E-04	2.97E+00	10	100	100	1000	15	5	5	40
58	RU-103+D	2.02E-07	7.29E-04	3	100	100	1000	10	300	300	2000
59	RU-105+D	4.33E-05	1.56E-01	3	100	100	1000	10	300	300	2000
60	RU-106+D	2.19E-08	7.87E-05	3	100	100	1000	10	300	300	2000
61	RH-105	5.36E-06	1.93E-02	10	100	100	100	10	300	300	200
62	PD-109+D	1.43E-05	5.15E-02	10	100	100	100	10	300	300	200
63	AG-110M+D	3.17E-08	1.14E-04	1000	5000	5000	1000	2	770	770	200
64	AG-111	1.07E-06	3.85E-03	1000	5000	5000	1000	2	770	770	200
65	SN-125	8.53E-07	3.07E-03	3	3	3	10	3000	1000	1000	100
66	SB-124	1.34E-07	4.81E-04	1000	1000	1000	10000	1	10	10	1500
67	SB-125	8.14E-09	2.93E-05	1000	1000	1000	10000	1	10	10	1500
68	SB-127	2.07E-06	7.46E-03	1000	1000	1000	10000	1	10	10	1500
69	TE-125M	1.38E-07	4.98E-04	10	10	100	1000	400	75	75	100
70	TE-127M	7.36E-08	2.65E-04	10	10	100	1000	400	75	75	100
71	TE-127	2.05E-05	7.37E-02	10	10	100	1000	400	75	75	100
72	TE-129M+D	2.36E-07	8.49E-04	10	10	100	1000	400	75	75	100
73	TE-129	1.68E-04	6.03E-01	10	10	100	1000	400	75	75	100
74	TE-131M	6.42E-06	2.31E-02	10	10	100	1000	400	75	75	100
75	TE-131	4.61E-04	1.66E+00	10	10	100	1000	400	75	75	100
76	TE-132	2.47E-06	8.89E-03	10	10	100	1000	400	75	75	100
77	TE-132D	2.47E-06	8.89E-03	10	10	100	1000	400	75	75	100
78	TE-133M+D	2.31E-04	8.32E-01	10	10	100	1000	400	75	75	100
79	TE-134	2.75E-04	9.89E-01	10	10	100	1000	400	75	75	100
80	I-129	1.29E-15	4.65E-12	20	100	100	10000	15	5	5	40
81	I-130	1.55E-05	5.59E-02	20	100	100	10000	15	5	5	40
82	I-131	9.97E-07	3.59E-03	20	100	100	10000	15	5	5	40
83	I-132	8.36E-05	3.01E-01	20	100	100	10000	15	5	5	40
84	I-133	9.17E-06	3.30E-02	20	100	100	10000	15	5	5	40
85	I-134	2.22E-04	8.00E-01	20	100	100	10000	15	5	5	40
86	I-135	2.86E-05	1.03E-01	20	100	100	10000	15	5	5	40
87	XE-131M	6.81E-07	2.45E-03	1	1	1	1	1	1	1	1
88	XE-133M	3.56E-06	1.28E-02	1	1	1	1	1	1	1	1
89	XE-133	1.52E-06	5.48E-03	1	1	1	1	1	1	1	1
90	XE-135M	7.42E-04	2.67E+00	1	1	1	1	1	1	1	1
91	XE-135	2.09E-05	7.54E-02	1	1	1	1	1	1	1	1
92	XE-137	2.97E-03	1.07E+01	1	1	1	1	1	1	1	1
93	XE-138	6.81E-04	2.45E+00	1	1	1	1	1	1	1	1
94	CS-134M	6.64E-05	2.39E-01	30	50	10	10	2000	100	100	500

TABLE 7.1-4. (contd)

95	CS-134	1.07E-08	3.86E-05	30	50	10	10	2000	100	100	500
96	CS-135	7.33E-09	2.64E-05	30	50	10	10	2000	100	100	500
97	CS-136	6.17E-07	2.22E-03	30	50	10	10	2000	100	100	500
98	CS-137	7.31E-10	2.63E-06	30	50	10	10	2000	100	100	500
99	CS-138	3.58E-04	1.29E+00	30	50	10	10	2000	100	100	500
100	CS-139	1.22E-03	4.38E+00	30	50	10	10	2000	100	100	500
101	BA-139	1.39E-04	5.02E-01	3	3	3	100	4	200	200	500
102	BA-140	6.28E-07	2.26E-03	3	3	3	100	4	200	200	500
103	BA-140D	6.28E-07	2.26E-03	3	3	3	100	4	200	200	500
104	BA-141	6.42E-04	2.31E+00	3	3	3	100	4	200	200	500
105	BA-142	1.05E-03	3.78E+00	3	3	3	100	4	200	200	500
106	LA-140	4.78E-06	1.72E-02	30	100	100	300	25	1000	1000	5000
107	LA-141	4.94E-05	1.78E-01	30	100	100	300	25	1000	1000	5000
108	LA-142	1.26E-04	4.52E-01	30	100	100	300	25	1000	1000	5000
109	CE-141	2.43E-07	8.75E-04	30	100	100	300	1	1000	1000	4000
110	CE-143	5.81E-06	2.09E-02	30	100	100	300	1	1000	1000	4000
111	CE-144+D	2.83E-08	1.02E-04	30	100	100	300	1	1000	1000	4000
112	PR-143	5.89E-07	2.12E-03	100	1000	1000	1000	25	1000	1000	5000
113	PR-144	6.69E-04	2.41E+00	100	1000	1000	1000	25	1000	1000	5000
114	ND-147	7.22E-07	2.60E-03	100	1000	1000	1000	25	1000	1000	5000
115	PM-147	8.39E-09	3.02E-05	100	1000	1000	1000	25	1000	1000	5000
116	PM-148	1.49E-06	5.35E-03	100	1000	1000	1000	25	1000	1000	5000
117	PM-149	3.64E-06	1.31E-02	100	1000	1000	1000	25	1000	1000	5000
118	PM-151	6.86E-06	2.47E-02	100	1000	1000	1000	25	1000	1000	5000
119	SM-153	4.08E-06	1.47E-02	100	1000	1000	1000	25	1000	1000	5000
120	EU-156	5.36E-07	1.93E-03	100	1000	1000	1000	25	1000	1000	5000
121	W-181	5.72E-08	2.06E-04	10	10	100	100	1200	10	10	1200
122	W-185	1.07E-07	3.85E-04	10	10	100	100	1200	10	10	1200
123	W-187	8.06E-06	2.90E-02	10	10	100	100	1200	10	10	1200
124	U-237	1.19E-06	4.28E-03	10	10	10	67	2	60	60	1
125	NP-238	3.83E-06	1.38E-02	10	10	10	6	10	400	400	300
126	NP-239	3.42E-06	1.23E-02	10	10	10	6	10	400	400	300
127	PU-238	2.56E-10	9.20E-07	3	200	200	1000	4	100	100	350
128	PU-239	9.03E-13	3.25E-09	3	200	200	1000	4	100	100	350
129	PU-240	3.33E-12	1.20E-08	3	200	200	1000	4	100	100	350
130	PU-241+D	1.66E-09	5.99E-06	3	200	200	1000	4	100	100	350
131	PU-242	5.81E-14	2.09E-10	3	200	200	1000	4	100	100	350
132	AM-241	4.81E-13	1.73E-09	25	1000	1000	5000	25	1000	1000	5000
133	AM-243+D	2.77E-12	9.96E-09	25	1000	1000	5000	25	1000	1000	5000
134	CM-242	4.92E-08	1.77E-04	25	1000	1000	5000	25	1000	1000	5000
135	CM-244	1.25E-09	4.50E-06	25	1000	1000	5000	25	1000	1000	5000
136	CF-252	8.31E-09	2.99E-05	25	1000	1000	5000	25	1000	1000	5000

TABLE 7.1-4. (contd)

MASTER LIST OF ADULT DOSE FACTORS

ISOTOPE	--AIR SUBMERSION-- MREM/HOUR PER PCI/CUBIC METER		------I N G E S T I O N------ MREM PER PCI INTAKE				-S H O R E L I N E- MREM/HOUR PER PCI/SQUARE METER		-S W I M M I N G-- MREM/HOUR PER PCI/LITER	
	BODY	SKIN	BODY	GI-LLI	THYROID	BONE	SKIN	BODY	SKIN	BODY
1 H-3	0	0	1.27E-07	6.40E-08	1.27E-07	0	0	0	0	0
2 C-14	1.4E-11	3.5E-09	5.29E-07	3.20E-07	5.29E-07	2.64E-06	0	0	3.60E-09	0
3 N-13	8.5E-07	1.4E-06	0	0	0	0	8.80E-09	7.60E-09	2.60E-06	1.90E-06
4 F-18	8.2E-07	1.1E-06	7.00E-06	1.93E-08	0	6.30E-07	8.00E-09	6.80E-09	2.30E-06	1.80E-06
5 NA-22	1.8E-06	2.3E-06	1.77E-05	3.26E-06	1.77E-05	1.77E-05	1.80E-08	1.60E-08	4.80E-06	4.00E-06
6 NA-24	3.5E-06	4.5E-06	1.71E-06	3.73E-06	1.71E-06	1.71E-06	2.90E-08	2.50E-08	9.30E-06	7.80E-06
7 P-32	3.0E-09	6.2E-07	7.44E-06	2.15E-05	0	1.93E-04	0	0	6.80E-07	6.40E-09
8 AR-39	3.3E-10	1.2E-07	0	0	0	0	0	0	1.30E-07	6.20E-10
9 AR-41	1.1E-06	1.6E-06	0	0	0	0	0	0	3.20E-06	2.40E-06
10 SC-46	1.7E-06	2.0E-06	3.07E-09	5.10E-05	0	5.26E-09	1.50E-08	1.30E-08	4.30E-06	3.70E-06
11 CR-51	2.4E-08	2.9E-08	2.67E-09	6.69E-07	1.59E-09	0	2.60E-10	2.20E-10	6.40E-08	5.20E-08
12 MN-54	7.0E-07	8.1E-07	6.68E-07	1.38E-05	0	0	6.80E-09	5.80E-09	1.80E-06	1.50E-06
13 MN-56	1.5E-06	2.4E-06	2.94E-08	3.66E-06	0	0	1.30E-08	1.10E-08	4.60E-06	3.20E-06
14 FE-55	5.5E-11	1.6E-09	1.48E-07	8.41E-07	0	6.78E-07	0	0	3.60E-10	6.40E-11
15 FE-59	1.0E-06	1.2E-06	3.68E-06	3.31E-05	0	4.12E-06	9.40E-09	8.00E-09	2.60E-06	2.20E-06
16 CO-57	1.0E-07	1.2E-07	2.92E-07	4.47E-06	0	0	1.00E-09	9.10E-10	2.70E-07	2.20E-07
17 CO-58	8.2E-07	1.1E-06	1.68E-06	1.52E-05	0	0	8.20E-09	7.00E-09	2.30E-06	1.80E-06
18 CO-60	2.0E-06	2.5E-06	4.70E-06	3.94E-05	0	0	2.00E-08	1.70E-08	5.40E-06	4.60E-06
19 NI-63	0	0	1.20E-06	1.61E-06	0	3.02E-05	0	0	0	0
20 NI-65	4.8E-07	1.1E-06	3.22E-08	1.90E-06	0	5.46E-07	4.30E-09	3.70E-09	1.90E-06	1.00E-06
21 CU-64	1.7E-07	2.8E-07	3.91E-08	6.85E-06	0	0	1.70E-09	1.50E-09	5.20E-07	3.70E-07
22 ZN-65	4.9E-07	5.6E-07	5.08E-06	9.78E-06	0	3.46E-06	4.60E-09	4.00E-09	1.20E-06	1.10E-06
23 ZN-69M+D	3.4E-07	6.8E-07	3.65E-08	2.40E-05	0	1.65E-07	3.40E-09	2.90E-09	1.20E-06	7.50E-07
24 ZN-69	7.1E-10	2.5E-07	1.34E-09	2.90E-09	0	1.00E-08	0	0	2.80E-07	1.60E-09
25 BR-82	2.4E-06	2.9E-06	2.34E-06	2.53E-06	0	0	2.20E-08	1.90E-08	6.30E-06	5.30E-06
26 BR-83+D	7.5E-09	2.7E-07	3.87E-08	5.61E-08	0	0	9.30E-11	6.40E-11	3.10E-07	1.70E-08
27 BR-84	1.6E-06	3.0E-06	5.26E-08	4.15E-13	0	0	1.40E-08	1.20E-08	5.30E-06	3.50E-06
28 BR-85	6.7E-09	9.7E-07	2.29E-09	0	0	0	0	0	1.10E-06	1.40E-08
29 KR-83M	0	7.6E-10	0	0	0	0	0	0	7.90E-09	3.10E-09
30 KR-85M	1.3E-07	3.2E-07	0	0	0	0	0	0	5.10E-07	2.80E-07
31 KR-85	2.2E-09	1.6E-07	0	0	0	0	0	0	1.80E-07	4.70E-09
32 KR-87	1.3E-06	2.7E-06	0	0	0	0	0	0	4.60E-06	2.70E-06
33 KR-88	1.5E-06	2.0E-06	0	0	0	0	0	0	4.10E-06	3.30E-06
34 RB-86	8.0E-08	6.8E-07	1.00E-05	4.27E-06	0	0	7.20E-10	6.30E-10	8.50E-07	1.70E-07
35 RB-88	5.6E-07	2.7E-06	3.26E-08	0	0	0	4.00E-09	3.50E-09	3.60E-06	1.20E-06
36 RB-89	2.1E-06	2.8E-06	2.86E-08	0	0	0	1.80E-08	1.50E-08	5.80E-06	4.50E-06
37 SR-89	2.1E-09	4.9E-07	9.13E-06	4.98E-05	0	3.20E-04	6.50E-13	5.60E-13	5.40E-07	4.60E-09
38 SR-90	2.4E-10	1.3E-07	8.95E-05	1.23E-04	0	3.36E-04	0	0	1.50E-07	5.40E-10
39 SR-90D	6.1E-09	8.6E-07	2.65E-10	1.05E-04	0	9.86E-09	2.60E-12	2.20E-12	9.60E-07	1.30E-08
40 SR-91	8.9E-07	1.6E-06	2.43E-07	2.87E-05	0	5.82E-06	8.30E-09	7.10E-09	2.90E-06	1.90E-06
41 SR-92	1.1E-06	1.3E-06	9.35E-08	4.31E-05	0	2.16E-06	1.00E-08	9.00E-09	3.10E-06	2.60E-06
42 Y-90	6.1E-09	8.6E-07	2.65E-10	1.05E-04	0	9.86E-09	2.60E-12	2.20E-12	9.60E-07	1.30E-08
43 Y-91M	4.6E-07	5.6E-07	3.48E-12	2.91E-10	0	8.89E-11	4.40E-09	3.80E-09	1.20E-06	1.00E-06
44 Y-91	3.1E-09	5.2E-07	3.60E-09	7.50E-05	0	1.36E-07	2.70E-11	2.40E-11	5.70E-07	6.70E-09
45 Y-92	2.1E-07	1.6E-06	2.50E-11	1.49E-05	0	8.57E-10	1.90E-09	1.60E-09	2.00E-06	4.60E-07
46 Y-93	8.7E-08	1.2E-06	5.53E-11	6.31E-05	0	1.98E-09	7.80E-10	5.70E-10	1.40E-06	1.90E-07

TABLE 7.1-4. (contd)

47	ZR-95	6.8E-07	8.4E-07	6.34E-09	2.93E-05	0	2.70E-08	5.80E-09	5.00E-09	1.80E-06	1.50E-06
48	ZR-95D	6.4E-07	7.5E-07	1.81E-09	2.03E-05	0	5.56E-09	6.00E-09	5.10E-09	1.60E-06	1.40E-06
49	ZR-97	6.9E-07	1.4E-06	1.59E-10	1.07E-04	0	1.69E-09	6.40E-09	5.50E-09	2.40E-06	1.50E-06
50	ZR-97D	5.6E-07	1.1E-06	4.70E-12	4.09E-08	0	5.06E-11	5.40E-09	4.60E-09	1.90E-06	1.20E-06
51	NB-95	6.4E-07	7.5E-07	1.81E-09	2.03E-05	0	5.56E-09	6.00E-09	5.10E-09	1.60E-06	1.40E-06
52	NB-97	5.6E-07	1.1E-06	4.70E-12	4.09E-08	0	5.06E-11	5.40E-09	4.60E-09	1.90E-06	1.20E-06
53	MO-99+D	2.2E-07	5.8E-07	7.92E-07	9.85E-06	0	0	2.20E-09	1.90E-09	9.10E-07	4.70E-07
54	MO-99D	1.1E-07	1.3E-07	2.01E-08	2.00E-06	0	1.77E-09	9.50E-10	8.30E-10	2.40E-07	2.10E-07
55	TC-99M	1.1E-07	1.3E-07	2.01E-08	2.00E-06	0	1.77E-09	1.10E-09	9.60E-10	2.70E-07	2.40E-07
56	TC-99	5.8E-11	2.4E-08	4.44E-08	5.38E-06	0	1.11E-07	0	0	2.60E-10	1.30E-10
57	TC-101	5.6E-07	7.6E-07	3.55E-09	6.54E-22	0	2.51E-10	3.00E-09	2.70E-09	1.20E-06	6.80E-07
58	RU-103+D	4.1E-07	4.9E-07	7.87E-08	2.09E-05	0	1.72E-07	4.20E-09	3.60E-09	1.10E-06	8.90E-07
59	RU-105+D	5.4E-07	1.0E-06	6.03E-09	9.19E-06	0	1.49E-08	5.10E-09	4.50E-09	1.80E-06	1.20E-06
60	RU-106+D	1.7E-07	1.5E-06	3.56E-07	1.81E-04	0	2.79E-06	1.80E-09	1.50E-09	1.90E-06	3.80E-07
61	RH-105	7.8E-08	1.6E-07	5.82E-06	1.36E-05	0	1.15E-07	7.70E-10	6.60E-10	3.00E-07	1.70E-07
62	PD-109+D	4.3E-09	3.0E-07	4.16E-08	2.05E-05	0	0	4.00E-11	3.50E-11	3.40E-07	9.30E-09
63	AG-110M+D	2.2E-06	2.4E-06	6.70E-08	5.82E-05	0	1.46E-07	2.10E-08	1.80E-08	5.30E-06	4.90E-06
64	AG-111	2.2E-08	3.2E-07	1.21E-08	4.34E-05	0	5.74E-08	2.10E-10	1.80E-10	3.30E-07	4.80E-08
65	SN-125	7.3E-08	9.1E-07	3.79E-07	1.06E-04	1.40E-07	8.33E-06	6.60E-10	5.70E-10	1.10E-06	1.60E-07
66	SB-124	1.6E-06	2.2E-06	1.10E-06	7.90E-05	6.74E-09	2.80E-06	1.50E-08	1.30E-08	4.50E-06	3.60E-06
67	SB-125	3.6E-07	4.5E-07	4.17E-07	1.86E-05	1.72E-09	1.57E-06	3.50E-09	3.10E-09	9.50E-07	7.80E-07
68	SB-127	6.7E-07	9.0E-07	1.18E-07	6.54E-05	4.07E-09	3.57E-07	6.60E-09	5.70E-09	1.80E-06	1.50E-06
69	TE-125M	1.7E-09	1.1E-08	3.49E-07	1.05E-05	7.94E-07	2.72E-06	4.80E-11	3.50E-11	1.50E-08	3.60E-09
70	TE-127M	1.2E-10	1.6E-09	7.62E-07	2.10E-05	1.61E-06	6.40E-06	1.30E-12	1.10E-12	1.80E-09	2.60E-10
71	TE-127	1.2E-09	1.6E-07	2.21E-08	8.13E-06	7.53E-08	1.03E-07	1.10E-11	1.00E-11	1.70E-07	2.80E-09
72	TE-129M+D	9.4E-08	5.7E-07	1.77E-06	5.79E-05	4.50E-06	1.17E-05	9.00E-10	7.70E-10	7.40E-07	2.10E-07
73	TE-129	8.7E-08	5.3E-07	7.61E-09	2.12E-08	2.40E-08	3.13E-08	8.40E-10	7.10E-10	7.00E-07	1.90E-07
74	TE-131M	1.0E-06	1.3E-06	4.71E-07	3.84E-05	6.92E-07	8.02E-07	9.90E-09	8.40E-09	2.70E-06	2.20E-06
75	TE-131	3.4E-07	1.1E-06	6.25E-09	3.58E-14	1.63E-08	1.95E-08	2.60E-09	2.20E-09	1.60E-06	7.40E-07
76	TE-132	1.8E-07	2.3E-07	1.54E-06	7.79E-05	1.82E-06	2.56E-06	2.00E-09	1.70E-09	4.80E-07	4.00E-07
77	TE-132D	2.0E-06	2.7E-06	1.96E-07	1.07E-07	7.33E-05	2.08E-07	2.00E-08	1.70E-08	5.50E-06	4.40E-06
78	TE-133M+D	1.8E-06	2.4E-06	2.35E-08	1.45E-09	3.52E-08	4.04E-08	1.70E-08	1.50E-08	5.00E-06	3.90E-06
79	TE-134	1.2E-07	1.9E-07	2.20E-08	4.40E-09	2.85E-08	3.25E-08	1.20E-09	1.00E-09	3.50E-07	2.50E-07
80	I-129	1.1E-09	4.0E-09	6.01E-06	3.07E-07	6.18E-03	2.49E-06	9.60E-12	7.00E-12	6.20E-09	2.30E-09
81	I-130	1.8E-06	2.3E-06	8.77E-07	1.89E-06	2.80E-04	7.44E-07	1.70E-08	1.40E-08	4.80E-06	3.90E-06
82	I-131	5.1E-07	4.9E-07	3.37E-06	1.53E-06	1.86E-03	3.93E-06	3.40E-09	2.80E-09	9.30E-07	6.80E-07
83	I-132	2.0E-06	2.7E-06	1.96E-07	1.07E-07	7.33E-05	2.08E-07	2.00E-08	1.70E-08	5.50E-06	4.40E-06
84	I-133	4.4E-07	8.8E-07	7.62E-07	2.25E-06	4.82E-04	1.43E-06	4.50E-09	3.70E-09	1.50E-06	9.60E-07
85	I-134	2.0E-06	2.9E-06	1.02E-07	2.25E-10	3.73E-05	1.07E-07	1.90E-08	1.60E-08	5.50E-06	4.20E-06

TABLE 7.1-4. (contd)

86	I-135	1.5E-06	2.0E-06	4.50E-07	1.41E-06	1.76E-04	5.01E-07	1.40E-08	1.20E-08	4.00E-06	3.30E-06
87	XE-131M	2.8E-09	4.8E-08	0	0	0	0	0	0	5.60E-08	6.20E-09
88	XE-133M	2.7E-08	6.0E-08	0	0	0	0	0	0	1.00E-07	6.00E-08
89	XE-133	2.5E-08	6.9E-08	0	0	0	0	0	0	1.10E-07	5.70E-08
90	XE-135M	3.5E-07	5.0E-07	0	0	0	0	0	0	1.00E-06	7.60E-07
91	XE-135	2.1E-07	4.9E-07	0	0	0	0	0	0	7.90E-07	4.50E-07
92	XE-137	1.2E-07	1.8E-06	0	0	0	0	0	0	2.10E-06	2.70E-07
93	XE-138	1.2E-06	1.7E-06	0	0	0	0	0	0	3.40E-06	2.60E-06
94	CS-134M	7.3E-08	9.1E-08	2.43E-08	1.63E-08	0	2.25E-08	7.30E-10	6.20E-10	1.90E-07	1.60E-07
95	CS-134	1.3E-06	1.7E-06	1.00E-04	2.56E-06	0	5.29E-05	1.40E-08	1.20E-08	3.50E-06	2.90E-06
96	CS-135	2.8E-11	8.8E-09	5.64E-06	3.71E-08	0	1.44E-05	0	0	1.10E-08	6.60E-11
97	CS-136	1.9E-06	2.2E-06	1.81E-05	2.86E-06	0	6.24E-06	1.70E-08	1.50E-08	4.80E-06	4.10E-06
98	CS-137	4.7E-07	7.0E-07	5.60E-05	2.05E-06	0	6.37E-05	4.90E-09	4.20E-09	1.40E-06	1.00E-06
99	CS-138	1.8E-06	3.1E-06	5.49E-08	4.89E-13	0	5.66E-08	2.40E-08	2.10E-08	5.70E-06	4.00E-06
100	CS-139	8.0E-07	2.1E-06	1.97E-08	3.54E-30	0	3.18E-08	7.20E-09	6.30E-09	3.20E-06	1.70E-06
101	BA-139	3.7E-08	8.9E-07	2.88E-09	1.68E-07	0	9.85E-08	2.70E-09	2.40E-09	1.00E-06	7.70E-08
102	BA-140	2.2E-07	4.4E-07	1.33E-06	4.02E-05	0	2.02E-05	2.40E-09	2.10E-09	7.60E-07	4.90E-07
103	BA-140D	1.9E-06	2.7E-06	3.34E-10	9.32E-05	0	2.53E-09	1.70E-08	1.50E-08	5.30E-06	4.10E-06
104	BA-141	5.2E-07	1.6E-06	1.73E-09	1.40E-17	0	5.18E-08	4.90E-09	4.30E-09	2.40E-06	1.10E-06
105	BA-142	1.0E-06	1.6E-06	1.37E-09	0	0	2.20E-08	9.00E-09	7.90E-09	3.00E-06	2.20E-06
106	LA-140	1.9E-06	2.7E-06	3.34E-10	9.32E-05	0	2.53E-09	1.70E-08	1.50E-08	5.30E-06	4.10E-06
107	LA-141	2.3E-09	9.2E-07	2.03E-11	1.24E-05	0	3.90E-10	2.80E-10	2.50E-10	1.00E-06	5.10E-08
108	LA-142	2.0E-06	3.1E-06	1.44E-11	4.10E-07	0	1.29E-10	1.80E-08	1.50E-08	5.90E-06	4.50E-06
109	CE-141	5.9E-08	1.5E-07	6.88E-10	2.28E-05	0	8.83E-09	6.20E-10	5.50E-10	2.40E-07	1.30E-07
110	CE-143	2.6E-07	6.3E-07	1.33E-10	4.39E-05	0	1.60E-09	2.50E-09	2.20E-09	1.00E-06	5.70E-07
111	CE-144+D	4.0E-08	1.2E-06	1.98E-08	1.69E-04	0	3.27E-07	3.70E-10	3.20E-10	1.40E-06	8.60E-08
112	PR-143	7.5E-10	2.5E-07	4.39E-10	3.86E-05	0	8.96E-09	0	0	2.80E-07	1.60E-09
113	PR-144	2.6E-08	1.2E-06	1.59E-12	4.51E-18	0	3.13E-11	2.30E-10	2.00E-10	1.30E-06	5.60E-08
114	ND-147	1.3E-07	3.1E-07	4.03E-10	3.34E-05	0	5.43E-09	1.20E-09	1.00E-09	5.00E-07	2.80E-07
115	PM-147	3.3E-11	1.2E-08	1.22E-09	7.93E-06	0	2.36E-08	0	0	1.30E-08	7.50E-11
116	PM-148	5.2E-07	1.2E-06	6.11E-10	9.43E-05	0	7.29E-09	5.30E-09	4.60E-09	2.00E-06	1.10E-06
117	PM-149	6.9E-09	3.1E-07	8.64E-11	4.00E-05	0	1.50E-09	2.90E-11	2.50E-11	3.50E-07	1.50E-08
118	PM-151	2.3E-07	5.0E-07	6.06E-11	3.35E-05	0	7.23E-10	2.30E-09	2.20E-09	8.40E-07	5.00E-07
119	SM-153	3.0E-08	2.0E-07	5.98E-11	2.86E-05	0	9.86E-10	3.00E-10	2.70E-10	2.50E-07	6.50E-08
120	EU-156	9.8E-07	1.5E-06	1.69E-09	7.24E-05	0	1.36E-08	8.70E-09	7.60E-09	2.80E-06	2.10E-06
121	W-181	2.5E-10	3.2E-10	3.49E-10	3.68E-07	0	1.01E-08	2.80E-12	2.10E-12	6.80E-10	5.30E-10
122	W-185	1.4E-10	7.2E-08	1.48E-08	1.60E-05	0	4.26E-07	0	0	7.90E-08	3.20E-10
123	W-187	3.8E-07	6.3E-07	3.12E-08	3.01E-05	0	1.11E-07	3.60E-09	3.10E-09	1.20E-06	8.30E-07
124	U-237	1.2E-07	1.6E-07	1.47E-10	1.94E-05	0	5.53E-10	1.30E-09	1.00E-09	3.40E-07	2.60E-07
125	NP-238	3.5E-07	5.7E-07	2.11E-10	3.43E-05	0	4.27E-09	3.20E-09	2.80E-09	1.10E-06	7.70E-07
126	NP-239	1.1E-07	2.1E-07	6.46E-11	2.40E-05	0	1.20E-09	1.10E-09	9.50E-10	3.70E-07	2.40E-07
127	PU-238	6.8E-11	1.7E-09	4.39E-07	7.30E-05	0	1.76E-05	1.80E-11	1.30E-12	4.00E-09	1.50E-10
128	PU-239	5.6E-11	7.6E-10	4.12E-07	6.66E-05	0	1.65E-05	7.70E-12	7.90E-13	1.70E-09	1.20E-10
129	PU-240	6.5E-11	1.7E-09	4.16E-07	6.78E-05	0	1.65E-05	1.80E-11	1.30E-12	4.00E-09	1.40E-10
130	PU-241+D	2.8E-11	4.2E-11	4.21E-10	6.78E-07	0	1.44E-08	6.80E-12	4.60E-12	9.50E-11	6.10E-11
131	PU-242	5.1E-11	1.6E-09	3.92E-07	6.53E-05	0	1.57E-05	1.60E-11	1.10E-12	3.60E-09	1.10E-10
132	AM-241	1.8E-08	2.7E-08	1.46E-06	7.42E-05	0	1.83E-05	2.60E-10	1.80E-10	6.10E-08	3.90E-08
133	AM-243+D	1.4E-07	2.5E-07	1.41E-06	9.73E-05	0	1.77E-05	1.50E-09	1.30E-09	4.60E-07	3.10E-07
134	CM-242	1.6E-10	2.1E-09	8.26E-07	7.92E-05	0	1.25E-05	2.30E-11	5.50E-12	4.70E-09	3.40E-10
135	CM-244	1.2E-10	1.7E-09	1.51E-06	7.55E-05	0	2.28E-05	1.80E-11	2.90E-12	3.90E-09	2.60E-10
136	CF-252	6.6E-06	7.9E-06	1.16E-06	2.88E-04	0	4.65E-05	7.20E-08	6.60E-08	1.70E-05	1.40E-05

TABLE 7.1-4. (contd)

MASTER LIST OF THYROID DOSE FACTORS

ISOTOPE	MREM/YEAR PER PCI/CUBIC METER					
	---INHALATION---		----M I L K-----		LEAFY VEGETABLES	
	2 YEAR	ADULT	2 YEAR	ADULT	2 YEAR	ADULT
77 TE-132D	0.	0.	126.	9.11	4.04	1.17
80 I-129	5.74	34.3	3600.	3140.	1485.	5190.
81 I-130	2.88	1.57	83.	6.61	26.8	8.53
82 I-131	12.5	10.6	3620.	448.	1190.	589.
83 I-132	0.835	0.414	4.58	0.330	1.48	0.428
84 I-133	5.51	2.70	262.	18.7	84.1	24.1
85 I-134	0.424	0.209	0.911	0.0655	0.293	0.0844
86 I-135	2.00	0.985	31.2	2.28	10.0	2.94

TABLE 7.1-5. Nuclide Release Worksheet

1 H-3	35 RB-88	69 TE-125M	103 BA-140D
2 C-14	36 RB-89	70 TE-127M	104 BA-141
3 N-13	37 SR-89	71 TE-127	105 BA-142
4 F-18	38 SR-90	72 TE-129M+D	106 LA-140
5 NA-22	39 SR-90D	73 TE-129	107 LA-141
6 NA-24	40 SR-91	74 TE-131M	108 LA-142
7 P-32	41 SR-92	75 TE-131	109 CE-141
8 AR-39	42 Y-90	76 TE-132	110 CE-143
9 AR-41	43 Y-91M	77 TE-132D	111 CE-144+D
10 SC-46	44 Y-91	78 TE-133M+D	112 PR-143
11 CR-51	45 Y-92	79 TE-134	113 PR-144
12 MN-54	46 Y-93	80 I-129	114 ND-147
13 MN-56	47 ZR-95	81 I-130	115 PM-147
14 FE-55	48 ZR-95D	82 I-131	116 PM-148
15 FE-59	49 ZR-97	83 I-132	117 PM-149
16 CO-57	50 ZR-97D	84 I-133	118 PM-151
17 CO-58	51 NB-95	85 I-134	119 SM-153
18 CO-60	52 NB-97	86 I-135	120 EU-156
19 NI-63	53 MO-99+D	87 XE-131M	121 W-181
20 NI-65	54 MO-99D	88 XE-133M	122 W-185
21 CU-64	55 TC-99M	89 XE-133	123 W-187
22 ZN-65	56 TC-99	90 XE-135M	124 U-237
23 ZN-69M+D	57 TC-101	91 XE-135	125 NP-238
24 ZN-69	58 RU-103+D	92 XE-137	126 NP-239
25 BR-82	59 RU-105+D	93 XE-138	127 PU-238
26 BR-83+D	60 RU-106+D	94 CS-134M	128 PU-239
27 BR-84	61 RH-105	95 CS-134	129 PU-240
28 BR-85	62 PD-109+D	96 CS-135	130 PU-241+D
29 KR-83M	63 AG-110M+D	97 CS-136	131 PU-242
30 KR-85M	64 AG-111	98 CS-137	132 AM-241
31 KR-85	65 SN-125	99 CS-138	133 AM-243+D
32 KR-87	66 SB-124	100 CS-139	134 CM-242
33 KR-88	67 SB-125	101 BA-139	135 CM-244
34 RB-86	68 SB-127	102 BA-140	136 CF-252

ingesting fish, molluscs, crustacea and marine plants; drinking water; standing on contaminated shoreline; and swimming and boating in contaminated water.

Internal radiation doses along the fish, crustacea, molluscs, marine-plants and drinking-water pathways are computed for four organs of reference: total body, GI-LLI, thyroid and bone. External radiation doses along the shoreline,[a] swimming and boating pathways are computed for two organs of reference: skin and total body. These external total-body doses are also listed under GI-LLI, thyroid and bone, and are included in the totals for these organs.

Program output at the user's conversational terminal consists of the total dose by pathway and organ, and an optional table of the percent contribution to the total dose by nuclide for each pathway-organ combination. A more detailed output is automatically sent to a high-speed printer. The printout includes the above information plus the section of the REL file containing the releases for the specified facility; tables of dose factors, bioaccumulation factors, decay constants, concentrations of radionuclides in the liquid effluent; and a copy of the parameters entered by the user at the time of the run.

ARRRG obtains its data from three sources:

(1) The holdups, usages and mixing ratios by pathway, the reactor coolant flow, shoreline width factor, and the reconcentration factor parameters are entered by the user at the time of the run. Section 7.5 discusses the choice of parameters to use for the reconcentration factor and mixing ratios. The standard input to be used for the other parameters in absence of information specific to the site is given in Table 3.2-1.

(a) For the shoreline calculation (Equation 4.3-3), the operating lifetime of the facility, t_s, is taken to be 40 yr.

(2) The radionuclide release rates for all facilities are stored on a single large file called REL (Section 10.4). Release rates for the given facility are stored once within REL at the time the information is received from the applicant; this is the only file ever modified by the user of ARRRG and CRITR. ARRRG automatically accesses that portion of REL headed by the facility name entered by the user at the time the run is made. There is no limit to the number of facilities and they may be in any order, although facility names must be unique. Each facility within REL requires:

   (a) A line containing the facility name, optionally followed by comments. This line is printed as part of the heading on the first page and on the top of each result page.
   (b) The word SALT or FRESH to indicate which set of bioaccumulation factors to use.
   (c) The 136 liquid releases (Ci/yr) in the nuclide order given in Table 7.1-4. Isotopes which are not released must be listed as zero, but ARRRG accepts the shorthand notation rZ to represent r consecutive zero releases.
   (d) A blank line of one or more spaces.

(3) The 136 nuclide names, decay constants, dose factors, and fresh and salt water bioaccumulation factors required by ARRRG are stored in the permanent file ARGIN (Section 10.3).

Table 7.2-1 shows teletype printout for a typical run, with user input indicated by wavy underlines. The worksheet of Table 7.2-2 is helpful in preparing the input. The reactor name determines which set of releases from REL will be accessed by the program. The user must specify a population dose or an individual dose calculation. If a population dose calculation is specified, the user enters yearly usages for the entire population of interest; dose will be calculated in man-rem/year and appropriate table titles will be printed. If an individual dose calculation is specified, the user enters individual yearly usages; dose will be calculated in mrem/year and appropriate table titles will be printed. For a population dose calculation,

TABLE 7.2-1. Teletype Printout for Sample ARRRG Run

```
RUN ARRRG

ARRRG    12:49    01/14/74

REACTOR NAME?PIKES PEAK
DOSE TO POPULATION OR INDIVIDUAL (P OR I)?I
ENTER HOLDUP IN HOURS, USAGES, MIXING RATIOS
 FISH?24 33.6 .03
 CRUSTACEA?0 0 0
 MOLLUSCS?0 0 0
 ALGAE?0 0 0
 DRINKING WATER?24 1430 .03
 SHORELINE?5 106 .14
 SWIMMING?5 416 .14
 BOATING?5 416 .14
SHORE WIDTH FACTOR=?.5
COOLANT FLOW IN CFS=?790
WHICH RECONCENTRATION FORMULA?3

PIKES PEAK    FLOW= 790    CONSTANT RECONCENTRATION= 1
  PLANT LIFE= 30 YEARS    SHORE WIDTH FACTOR= .5

         HOLDUP USAGE MIXING
FISH        24    33.6   .03
DRINKING    24    1430   .03
SHORELINE   5     106    .14
SWIMMING    5     416    .14
BOATING     5     416    .14

CONSTANTS OK?YES
PRINT PERCENTS AT TELETYPE?Y
ENTER TITLE FOR THIS CASE?SAMPLE ARRRG RUN

     *  *  *  ISOTOPES CONTRIBUTING AT LEAST 4%  *  *  *

-TOTAL BODY--    ---GI-LLI----    ---THYROID---    ----BONE-----
FISH
CS-134    64%    H-3         5%   I-131     87%    CS-134    47%
CS-137    31%    TE-129M+    6%   I-133     12%    CS-137    49%
                 TE-132     38%
                 CS-134     18%
                 CS-136      5%
                 CS-137     12%

DRINKING WATER
H-3       91%    H-3        88%   I-131     85%    I-131     54%
I-131      4%                     I-133     11%    I-133     10%
                                                   CS-134    16%
                                                   CS-137    17%

----SKIN-----    -TOTAL BODY--
SHORELINE
CS-134    29%    CS-134     29%
CS-137    64%    CS-137     64%

SWIMMING
I-131     26%    I-131      27%
I-132      4%    I-132       5%
I-133     39%    I-133      35%
I-135     20%    I-135      23%

BOATING
        SAME AS SWIMMING

     *  *  *  INDIVIDUAL DOSE IN MREM/YR  *  *  *

              SKIN      BODY      GI-LLI    THYROID   BONE
FISH                    1.64E-02  1.51E-03  7.56E-02  1.18E-02
DRINKING                8.45E-03  4.42E-03  2.20E-01  7.29E-04

SHORELINE    1.40E-03  1.20E-03  1.20E-03  1.20E-03  1.20E-03
SWIMMING     5.15E-04  3.68E-04  3.68E-04  3.68E-04  3.68E-04
BOATING      2.57E-04  1.84E-04  1.84E-04  1.84E-04  1.84E-04

TOTALS       2.18E-03  2.66E-02  7.69E-03  2.97E-01  1.43E-02

RUN ANOTHER CASE?N

NOW AT END
SRU'S:6.6
READY
```

TABLE 7.2-2

ARRRG INPUT WORKSHEET

REACTOR NAME ______________________

☐ POPULATION or ☐ INDIVIDUAL dose calculation

	HOLDUP	USAGE	MIXING RATIO
Fish	______ hr	______ kg/yr	______
Crustacea	______ hr	______ kg/yr	______
Molluscs	______ hr	______ kg/yr	______
Plants	______ hr	______ kg/yr	______
Drinking water	______ hr	______ ℓ/yr	______
Shoreline	______ hr	______ hr/yr	______
Swimming	______ hr	______ hr/yr	______
Boating	______ hr	______ hr/yr	______

SHORE WIDTH FACTOR ________ COOLANT FLOW ________ cfs

RECONCENTRATION MODELS

☐ 1 Simplified theoretical model

VOLUME ________ ft^3 TURNOVER RATE ________ day^{-1}

MAKEUP FLOW ________ cfs CYCLE TIME ________ hr

☐ 2 Empirical model

RECYCLE FRACTION ________ CYCLE TIME ________ hr

☐ 3 No reconcentration

TITLE FOR THIS CASE ______________________

REMARKS:

specific site data is used for consumption of aquatic foods and hours of recreation. In the absence of such information, default data on per capita usage such as in Table 3.2-1 is multiplied by the population living within a 50-mile radius of the site.

The holdup, mixing ratio and usage parameters are then entered by pathway. For unused pathways 0 0 0 is entered. Usages are in the units kg/yr for the four food pathways, liter/yr for the drinking water pathway, and hr/yr for the shoreline, swimming and boating pathways. After the user enters shoreline width, coolant flow and reconcentration data, the program summarizes the input for the user to check. If the response to "constants OK?" is N or NO, the user is permitted to re-enter all the parameters.

The program prints a table of dose by pathway and organ and prints totals by organ. At the user's option, a table of percent contribution to the total dose by nuclide is printed for each pathway-organ combination. If the user responds Y or YES to "run another case?", he may run ARRRG for the same facility with a different set of input constants.

Table 7.2-3 shows the high-speed printer output resulting from this run. On the last page is a summary of all cases contained in the printout. The ARRRG program listings are in Sections 10.1 (CSTS version) and 10.2 (CSCX version).

7.3 PROGRAM CRITR

CRITR calculates annual internal total-body doses to organisms resulting from radionuclides ingested with their food, using Equations 6.1-3 and 6.1-7. CRITR always calculates the internal dose to four primary organisms which are directly exposed to the radionuclides in the water: fish, crustacea, molluscs and algae. At the user's option, internal dose can also be calculated for up to six secondary organisms which feed upon one of the primary organisms.

TABLE 7.2-3. High Speed Printer Output for Sample ARRRG Run

```
ARRRG ** ARRRG ** ARRRG ** ARRRG ** ARRRG          01/14/74     12:49          ARRRG ** ARRRG ** ARRRG ** ARRRG ** ARRRG

LISTING OF  PIKES PEAK PORTION OF REL FILE:

 PIKES PEAK
  FRESH 1000 0 0 0 0 0 0 0 0 0 0 5.7E-4 6.1E-4 0 1.3E-3 6.6E-4 0
  6.9E-3 5.6E-4 0 0 0 0 0 0 9.6E-4 3.4E-3 4.9E-5 0 0 0 0 0 0 6.2E-5
  2.1E-2 1.1E-5 3.6E-4 1.3E-5 1.3E-5 2.4E-4 1.1E-5 1.9E-5 1.5E-4
  3.4E-3 4.1E-5 4.3E-5 6E-5 6E-5 1.7E-5 1.7E-5 6.3E-5 1.8E-5 .26
  .23 .21 0 0 4E-5 5.8E-6 1.3E-5 1.5E-5 1.4E-6 0 7E-7 0 0 0 1.4E-6
  3.3E-5 2.9E-4 2.9E-4 2.8E-3 1.8E-3 1.2E-3 2.4E-4 1.6E-2 1.6E-2
  7.8E-6 6.3E-6 0 6.2E-3 1.8 .21 1.9 2E-3 .52 0 0 0 0 0 0 0 1.4E-5
  .037 0 9E-3 3.2E-2 1.5E-4 5.1E-6 1.5E-4 3.3E-4 3.3E-4 0 0 2E-4
  3.3E-5 7.1E-7 6E-5 2.5E-5 5.1E-5 4.4E-5 0 1.8E-5 2.9E-6 6.5E-6
  8.8E-6 2.5E-6 4.6E-6 2.3E-6 0 0 0 1.1E-5 2.4E-6 3.4E-4 0 0 0
  1.8E-6 0 0 0 0 0 0
```

TABLE 7.2-3. (contd)

01/14/74

	ISOTOPE	LAMBDA 1/HOURS	INITIAL RELEASE CI/YR	RECON. FACTOR	CONC. PCI/ LITER	BIOACCUMULATION FACTORS, L/KG FISH	CRUS- TACEA	MOL- LUSCS	ALGAE
1	H-3	6.43E-06	1.00E+03	1.00	1.42E+03	1	1	1	1
11	CR-51	1.04E-03	5.70E-04	1.00	8.07E-04	20	2000	2000	4000
12	MN-54	9.53E-05	6.10E-04	1.00	8.64E-04	400	90000	90000	10000
14	FE-55	3.04E-05	1.30E-03	1.00	1.84E-03	100	3200	3200	1000
15	FE-59	6.42E-04	6.60E-04	1.00	9.35E-04	100	3200	3200	1000
17	CO-58	4.05E-04	6.90E-03	1.00	9.77E-03	50	200	200	200
18	CO-60	1.50E-05	5.60E-04	1.00	7.93E-04	50	200	200	200
25	BR-82	1.96E-02	9.60E-04	1.00	1.36E-03	420	330	330	50
26	BR-83+D	2.89E-01	3.40E-03	1.00	4.82E-03	420	330	330	50
27	BR-84	1.31E+00	4.90E-05	1.00	6.94E-05	420	330	330	50
34	RB-86	1.55E-03	6.20E-05	1.00	8.78E-05	2000	1000	1000	1000
35	RB-88	2.33E+00	2.10E-02	1.00	2.97E-02	2000	1000	1000	1000
36	RB-89	2.70E+00	1.10E-05	1.00	1.56E-05	2000	1000	1000	1000
37	SR-89	5.55E-04	3.60E-04	1.00	5.10E-04	30	100	100	500
38	SR-90	2.80E-06	1.30E-05	1.00	1.84E-05	30	100	100	500
39	SR-90D	2.80E-06	1.30E-05	1.00	1.84E-05	30	100	100	500
40	SR-91	7.17E-02	2.40E-04	1.00	3.40E-04	30	100	100	500
41	SR-92	2.56E-01	1.10E-05	1.00	1.56E-05	30	100	100	500
42	Y-90	1.08E-02	1.90E-05	1.00	2.69E-05	25	1000	1000	5000
43	Y-91M	8.32E-01	1.50E-04	1.00	2.12E-04	25	1000	1000	5000
44	Y-91	4.91E-04	3.40E-03	1.00	4.82E-03	25	1000	1000	5000
45	Y-92	1.96E-01	4.10E-05	1.00	5.81E-05	25	1000	1000	5000
46	Y-93	6.80E-02	4.30E-05	1.00	6.09E-05	25	1000	1000	5000
47	ZR-95	4.44E-04	6.00E-05	1.00	8.50E-05	330	7	7	1000
48	ZR-95D	4.44E-04	6.00E-05	1.00	8.50E-05	330	7	7	1000
49	ZR-97	4.08E-02	1.70E-05	1.00	2.41E-05	330	7	7	1000
50	ZR-97D	4.08E-02	1.70E-05	1.00	2.41E-05	330	7	7	1000
51	NB-95	8.25E-04	6.30E-05	1.00	8.92E-05	30000	100	100	800
52	NB-97	5.78E-01	1.80E-05	1.00	2.55E-05	30000	100	100	800
53	MO-99+D	1.03E-02	2.60E-01	1.00	3.68E-01	10	10	10	1000
54	MO-99D	1.03E-02	2.30E-01	1.00	3.26E-01	10	10	10	1000
55	TC-99M	1.16E-01	2.10E-01	1.00	2.97E-01	15	5	5	40
58	RU-103+D	7.29E-04	4.00E-05	1.00	5.67E-05	10	300	300	2000
59	RU-105+D	1.56E-01	5.80E-06	1.00	8.22E-06	10	300	300	2000
60	RU-106+D	7.87E-05	1.30E-05	1.00	1.84E-05	10	300	300	2000
61	RH-105	1.93E-02	1.50E-05	1.00	2.12E-05	10	300	300	200
62	PD-109+D	5.15E-02	1.40E-06	1.00	1.98E-06	10	300	300	200
64	AG-111	3.85E-03	7.00E-07	1.00	9.92E-07	2	770	770	200
68	SB-127	7.46E-03	1.40E-06	1.00	1.98E-06	1	10	10	1500
69	TE-125M	4.98E-04	3.30E-05	1.00	4.67E-05	400	75	75	100

TABLE 7.2-3. (contd)

70	TE-127M	2.65E-04	2.90E-04	1.00	4.11E-04	400	75	75	100
71	TE-127	7.37E-02	2.90E-04	1.00	4.11E-04	400	75	75	100
72	TE-129M+D	8.49E-04	2.80E-03	1.00	3.97E-03	400	75	75	100
73	TE-129	6.03E-01	1.80E-03	1.00	2.55E-03	400	75	75	100
74	TE-131M	2.31E-02	1.20E-03	1.00	1.70E-03	400	75	75	100
75	TE-131	1.66E+00	2.40E-04	1.00	3.40E-04	400	75	75	100
76	TE-132	8.89E-03	1.60E-02	1.00	2.27E-02	400	75	75	100
77	TE-132D	8.89E-03	1.60E-02	1.00	2.27E-02	400	75	75	100
78	TE-133M+D	6.32E-01	7.80E-06	1.00	1.10E-05	400	75	75	100
79	TE-134	9.89E-01	6.30E-06	1.00	8.92E-06	400	75	75	100
81	I-130	5.59E-02	6.20E-03	1.00	8.78E-03	15	5	5	40
82	I-131	3.59E-03	1.80E+00	1.00	2.55E+00	15	5	5	40
83	I-132	3.01E-01	2.10E-01	1.00	2.97E-01	15	5	5	40
84	I-133	3.30E-02	1.90E+00	1.00	2.69E+00	15	5	5	40
85	I-134	8.00E-01	2.00E-03	1.00	2.83E-03	15	5	5	40
86	I-135	1.03E-01	5.20E-01	1.00	7.37E-01	15	5	5	40
94	CS-134M	2.39E-01	1.40E-05	1.00	1.98E-05	2000	100	100	500
95	CS-134	3.86E-05	3.70E-02	1.00	5.24E-02	2000	100	100	500
97	CS-136	2.22E-03	9.00E-03	1.00	1.27E-02	2000	100	100	500
98	CS-137	2.63E-06	3.20E-02	1.00	4.53E-02	2000	100	100	500
99	CS-138	1.29E+00	1.50E-04	1.00	2.12E-04	2000	100	100	500
100	CS-139	4.38E+00	5.10E-06	1.00	7.22E-06	2000	100	100	500
101	BA-139	5.02E-01	1.50E-04	1.00	2.12E-04	4	200	200	500
102	BA-140	2.26E-03	3.30E-04	1.00	4.67E-04	4	200	200	500
103	BA-140D	2.26E-03	3.30E-04	1.00	4.67E-04	4	200	200	500
106	LA-140	1.72E-02	2.00E-04	1.00	2.83E-04	25	1000	1000	5000
107	LA-141	1.78E-01	3.30E-05	1.00	4.67E-05	25	1000	1000	5000
108	LA-142	4.52E-01	7.10E-07	1.00	1.01E-06	25	1000	1000	5000
109	CE-141	8.75E-04	6.00E-05	1.00	8.50E-05	1	1000	1000	4000
110	CE-143	2.09E-02	2.50E-05	1.00	3.54E-05	1	1000	1000	4000
111	CE-144+D	1.02E-04	5.10E-05	1.00	7.22E-05	1	1000	1000	4000
112	PR-143	2.12E-03	4.40E-05	1.00	6.23E-05	25	1000	1000	5000
114	ND-147	2.60E-03	1.80E-05	1.00	2.55E-05	25	1000	1000	5000
115	PM-147	3.02E-05	2.90E-06	1.00	4.11E-06	25	1000	1000	5000
116	PM-148	5.35E-03	6.50E-06	1.00	9.21E-06	25	1000	1000	5000
117	PM-149	1.31E-02	8.80E-06	1.00	1.25E-05	25	1000	1000	5000
118	PM-151	2.47E-02	2.50E-06	1.00	3.54E-06	25	1000	1000	5000
119	SM-153	1.47E-02	4.60E-06	1.00	6.52E-06	25	1000	1000	5000
120	EU-156	1.93E-03	2.30E-06	1.00	3.26E-06	25	1000	1000	5000
124	U-237	4.28E-03	1.10E-05	1.00	1.56E-05	2	60	60	1
125	NP-238	1.38E-02	2.40E-06	1.00	3.40E-06	10	400	400	300
126	NP-239	1.23E-02	3.40E-04	1.00	4.82E-04	10	400	400	300
130	PU-241+D	5.99E-06	1.80E-06	1.00	2.55E-06	4	100	100	350

TABLE 7.2-3. (contd)

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	ADULT DOSE FACTORS							
	INGESTION				SHORELINE		SWIMMING	
ISOTOPE	BODY	GI-LLI	THYROID	BONE	SKIN	BODY	SKIN	BODY
1 H-3	1.27E-07	6.40E-06	1.27E-07	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
11 CR-51	2.67E-09	6.69E-07	1.59E-09	.00E+00	2.60E-10	2.20E-10	6.40E-08	5.20E-08
12 MN-54	8.68E-07	1.38E-05	.00E+00	.00E+00	6.80E-09	5.80E-09	1.80E-06	1.50E-06
14 FE-55	1.48E-07	8.41E-07	.00E+00	6.78E-07	.00E+00	.00E+00	3.60E-10	6.40E-11
15 FE-59	3.66E-06	3.31E-05	.00E+00	4.12E-06	9.40E-09	8.00E-09	2.60E-06	2.20E-06
17 CO-58	1.68E-06	1.52E-05	.00E+00	.00E+00	8.20E-09	7.00E-09	2.30E-06	1.80E-06
18 CO-60	4.70E-06	3.94E-05	.00E+00	.00E+00	2.00E-08	1.70E-08	5.40E-06	4.60E-06
25 BR-82	2.34E-06	2.53E-06	.00E+00	.00E+00	2.20E-08	1.90E-08	6.30E-06	5.30E-06
26 BR-83+D	3.87E-08	5.61E-08	.00E+00	.00E+00	9.30E-11	6.40E-11	3.10E-07	1.70E-08
27 BR-84	5.26E-08	4.15E-13	.00E+00	.00E+00	1.40E-08	1.20E-08	5.30E-06	3.50E-06
34 RB-86	1.00E-05	4.27E-06	.00E+00	.00E+00	7.20E-10	6.30E-10	8.50E-07	1.70E-07
35 RB-88	3.26E-08	.00E+00	.00E+00	.00E+00	4.00E-09	3.50E-09	3.60E-06	1.20E-06
36 RB-89	2.86E-08	.00E+00	.00E+00	.00E+00	1.80E-08	1.50E-08	5.80E-06	4.50E-06
37 SR-89	9.13E-06	4.98E-05	.00E+00	3.20E-04	6.50E-13	5.60E-13	5.40E-07	4.60E-09
38 SR-90	8.95E-05	1.23E-04	.00E+00	3.36E-04	.00E+00	.00E+00	1.50E-07	5.40E-10
39 SR-90D	2.65E-10	1.05E-04	.00E+00	9.86E-09	2.60E-12	2.20E-12	9.60E-07	1.30E-08
40 SR-91	2.43E-07	2.87E-05	.00E+00	5.82E-06	8.30E-09	7.10E-09	2.90E-06	1.90E-06
41 SR-92	9.35E-08	4.31E-05	.00E+00	2.16E-06	1.00E-08	9.00E-09	3.10E-06	2.60E-06
42 Y-90	2.65E-10	1.05E-04	.00E+00	9.86E-09	2.60E-12	2.20E-12	9.60E-07	1.30E-08
43 Y-91M	3.48E-12	2.91E-10	.00E+00	8.89E-11	4.40E-09	3.80E-09	1.20E-06	1.00E-06
44 Y-91	3.60E-09	7.50E-05	.00E+00	1.36E-07	2.70E-11	2.40E-11	5.70E-07	6.70E-09
45 Y-92	2.50E-11	1.49E-05	.00E+00	8.57E-10	1.90E-09	1.60E-09	2.00E-06	4.60E-07
46 Y-93	5.53E-11	6.31E-05	.00E+00	1.98E-09	7.80E-10	5.70E-10	1.40E-06	1.90E-07
47 ZR-95	6.34E-09	2.93E-05	.00E+00	2.70E-08	5.80E-09	5.00E-09	1.80E-06	1.50E-06
48 ZR-95D	1.81E-09	2.03E-05	.00E+00	5.56E-09	6.00E-09	5.10E-09	1.60E-06	1.40E-06
49 ZR-97	1.59E-10	1.07E-04	.00E+00	1.69E-09	6.40E-09	5.50E-09	2.40E-06	1.50E-06
50 ZR-97D	4.70E-12	4.09E-08	.00E+00	5.06E-11	5.40E-09	4.60E-09	1.90E-06	1.20E-06
51 NB-95	1.81E-09	2.03E-05	.00E+00	5.56E-09	6.00E-09	5.10E-09	1.60E-06	1.40E-06
52 NB-97	4.70E-12	4.09E-08	.00E+00	5.06E-11	5.40E-09	4.60E-09	1.90E-06	1.20E-06
53 MO-99+D	7.92E-07	9.85E-06	.00E+00	.00E+00	2.20E-09	1.90E-09	9.10E-07	4.70E-07
54 MO-99D	2.01E-08	2.00E-06	.00E+00	1.77E-09	9.50E-10	8.30E-10	2.40E-07	2.10E-07
55 TC-99M	2.01E-08	2.00E-06	.00E+00	1.77E-09	1.10E-09	9.60E-10	2.70E-07	2.40E-07
58 RU-103+D	7.87E-08	2.09E-05	.00E+00	1.72E-07	4.20E-09	3.60E-09	1.10E-06	8.90E-07
59 RU-105+D	6.03E-09	9.19E-06	.00E+00	1.49E-08	5.10E-09	4.50E-09	1.80E-06	1.20E-06
60 RU-106+D	3.56E-07	1.81E-04	.00E+00	2.79E-06	1.80E-09	1.50E-09	1.90E-06	3.80E-07
61 RH-105	5.82E-08	1.36E-05	.00E+00	1.15E-07	7.70E-10	6.60E-10	3.00E-07	1.70E-07
62 PD-109+D	4.16E-08	2.05E-05	.00E+00	.00E+00	4.00E-11	3.50E-11	3.40E-07	9.30E-09
64 AG-111	1.21E-08	4.34E-05	.00E+00	5.74E-08	2.10E-10	1.80E-10	3.80E-07	4.80E-08
68 SB-127	1.18E-07	6.54E-05	4.07E-09	3.57E-07	6.60E-09	5.70E-09	1.80E-06	1.50E-06
69 TE-125M	3.49E-07	1.05E-05	7.94E-07	2.72E-06	4.80E-11	3.50E-11	1.50E-08	3.60E-09

TABLE 7.2-3. (contd)

70	TE-127M	7.62E-07	2.10E-05	1.61E-06	6.40E-06	1.30E-12	1.10E-12	1.80E-09	2.60E-10
71	TE-127	2.21E-08	5.13E-06	7.53E-08	1.03E-07	1.10E-11	1.00E-11	1.70E-07	2.80E-09
72	TE-129M+D	1.77E-06	5.79E-05	4.50E-06	1.17E-05	9.00E-10	7.70E-10	7.40E-07	2.10E-07
73	TE-129	7.61E-09	2.12E-06	2.40E-08	3.13E-08	8.40E-10	7.10E-10	7.00E-07	1.90E-07
74	TE-131M	4.71E-07	3.64E-05	6.92E-07	8.02E-07	9.90E-09	8.40E-09	2.70E-06	2.20E-06
75	TE-131	6.25E-09	3.58E-14	1.63E-08	1.95E-08	2.60E-09	2.20E-09	1.60E-06	7.40E-07
76	TE-132	1.54E-06	7.79E-05	1.82E-06	2.56E-06	2.00E-09	1.70E-09	4.80E-07	4.00E-07
77	TE-132D	1.96E-07	1.07E-07	7.33E-05	2.08E-07	2.00E-08	1.70E-08	5.50E-06	4.40E-06
78	TE-133M+D	2.35E-08	1.45E-09	3.52E-08	4.04E-08	1.70E-08	1.50E-08	5.00E-06	3.90E-06
79	TE-134	2.20E-08	4.40E-09	2.85E-08	3.25E-08	1.20E-09	1.00E-09	3.50E-07	2.50E-07
81	I-130	8.77E-07	1.89E-06	2.80E-04	7.44E-07	1.70E-08	1.40E-08	4.80E-06	3.90E-06
82	I-131	3.37E-06	1.53E-06	1.86E-03	3.93E-06	3.40E-09	2.80E-09	9.30E-07	6.80E-07
83	I-132	1.96E-07	1.07E-07	7.33E-05	2.08E-07	2.00E-08	1.70E-08	5.50E-06	4.40E-06
84	I-133	7.62E-07	2.25E-06	4.82E-04	1.43E-06	4.50E-09	3.70E-09	1.50E-06	9.60E-07
85	I-134	1.02E-07	2.25E-10	3.73E-05	1.07E-07	1.90E-08	1.60E-08	5.50E-06	4.20E-06
86	I-135	4.50E-07	1.41E-06	1.76E-04	5.01E-07	1.40E-08	1.20E-08	4.00E-06	3.30E-06
94	CS-134M	2.43E-08	1.63E-08	.00E+00	2.25E-08	7.30E-10	6.20E-10	1.90E-07	1.60E-07
95	CS-134	1.00E-04	2.56E-06	.00E+00	5.29E-05	1.40E-08	1.20E-08	3.50E-06	2.90E-06
97	CS-136	1.81E-05	2.66E-06	.00E+00	6.24E-06	1.70E-08	1.50E-08	4.80E-06	4.10E-06
98	CS-137	5.60E-05	2.05E-06	.00E+00	6.37E-05	4.90E-09	4.20E-09	1.40E-06	1.00E-06
99	CS-138	5.49E-08	4.89E-13	.00E+00	5.66E-08	2.40E-08	2.10E-08	5.70E-06	4.00E-06
100	CS-139	1.97E-08	3.54E-30	.00E+00	3.18E-08	7.20E-09	6.30E-09	3.20E-06	1.70E-06
101	BA-139	2.88E-09	1.68E-07	.00E+00	9.85E-08	2.70E-09	2.40E-09	1.00E-06	7.70E-08
102	BA-140	1.33E-06	4.02E-05	.00E+00	2.02E-05	2.40E-09	2.10E-09	7.60E-07	4.90E-07
103	BA-140D	3.34E-10	9.32E-05	.00E+00	2.53E-09	1.70E-08	1.50E-08	5.30E-06	4.10E-06
106	LA-140	3.34E-10	9.32E-05	.00E+00	2.53E-09	1.70E-08	1.50E-08	5.30E-06	4.10E-06
107	LA-141	2.03E-11	1.24E-05	.00E+00	3.90E-10	2.80E-10	2.50E-10	1.00E-06	5.10E-08
108	LA-142	1.44E-11	4.10E-07	.00E+00	1.29E-10	1.80E-08	1.50E-08	5.90E-06	4.50E-06
109	CE-141	6.88E-10	2.28E-05	.00E+00	8.83E-09	6.20E-10	5.50E-10	2.40E-07	1.30E-07
110	CE-143	1.33E-10	4.39E-05	.00E+00	1.60E-09	2.50E-09	2.20E-09	1.00E-06	5.70E-07
111	CE-144+D	1.98E-08	1.69E-04	.00E+00	3.27E-07	3.70E-10	3.20E-10	1.40E-06	8.60E-08
112	PR-143	4.39E-10	3.86E-05	.00E+00	8.96E-09	.00E+00	.00E+00	2.80E-07	1.60E-09
114	ND-147	4.03E-10	3.34E-05	.00E+00	5.43E-09	1.20E-09	1.00E-09	5.00E-07	2.80E-07
115	PM-147	1.22E-09	7.93E-06	.00E+00	2.36E-08	.00E+00	.00E+00	1.30E-08	7.50E-11
116	PM-148	6.11E-10	9.43E-05	.00E+00	7.29E-09	5.30E-09	4.60E-09	2.00E-06	1.10E-06
117	PM-149	8.64E-11	4.00E-05	.00E+00	1.50E-09	2.90E-11	2.50E-11	3.50E-07	1.50E-08
118	PM-151	6.06E-11	3.35E-05	.00E+00	7.23E-10	2.30E-09	2.20E-09	8.40E-07	5.00E-07
119	SM-153	5.98E-11	2.86E-05	.00E+00	9.86E-10	3.00E-10	2.70E-10	2.50E-07	6.50E-08
120	EU-156	1.69E-09	7.24E-05	.00E+00	1.36E-08	8.70E-09	7.60E-09	2.80E-06	2.10E-06
124	U-237	1.47E-10	1.94E-05	.00E+00	5.53E-10	1.30E-09	1.00E-09	3.40E-07	2.60E-07
125	NP-238	2.11E-10	3.43E-05	.00E+00	4.27E-09	3.20E-09	2.80E-09	1.10E-06	7.70E-07
126	NP-239	6.46E-11	2.40E-05	.00E+00	1.20E-09	1.10E-09	9.50E-10	3.70E-07	2.40E-07
130	PU-241+D	4.21E-10	6.78E-07	.00E+00	1.44E-08	6.80E-12	4.60E-12	9.50E-11	6.10E-11

TABLE 7.2-3. (contd)

CASE 1: SAMPLE ARRRG RUN 01/14/74

ISOTOPES CONTRIBUTING AT LEAST 4% TO DOSE

	--TOTAL BODY--			-----GI-LLI------			----THYROID-----			--------BONE--------		
FISH	CS-134	1.06E-02	64%	H-3	8.22E-05	5%	I-131	6.58E-02	87%	CS-134	5.58E-03	47%
	CS-137	5.12E-03	31%	TE-129M+	9.07E-05	6%	I-133	8.88E-03	12%	CS-137	5.82E-03	49%
				TE-132	5.75E-04	38%						
				CS-134	2.70E-04	18%						
				CS-136	6.97E-05	5%						
				CS-137	1.87E-04	12%						
TOTALS	BODY	1.64E-02		GI-LLI	1.51E-03		THYROID	7.56E-02		BONE	1.18E-02	
DRINKING WATER	H-3	7.72E-03	91%	H-3	3.89E-03	88%	I-131	1.87E-01	85%	I-131	3.94E-04	54%
	I-131	3.38E-04	4%				I-133	2.52E-02	11%	I-133	7.48E-05	10%
										CS-134	1.19E-04	16%
										CS-137	1.24E-04	17%
TOTALS	BODY	8.45E-03		GI-LLI	4.42E-03		THYROID	2.20E-01		BONE	7.29E-04	

	-------SKIN--------			--TOTAL BODY--		
SHORELINE	CS-134	4.07E-04	29%	CS-134	3.49E-04	29%
	CS-137	9.04E-04	64%	CS-137	7.74E-04	64%
TOTALS	SKIN	1.40E-03		BODY	1.20E-03	
SWIMMING	I-131	1.36E-04	26%	I-131	9.92E-05	27%
	I-132	2.12E-05	4%	I-132	1.69E-05	5%
	I-133	1.99E-04	39%	I-133	1.28E-04	35%
	I-135	1.03E-04	20%	I-135	8.46E-05	23%
TOTALS	SKIN	5.15E-04		BODY	3.68E-04	
BOATING	SAME AS SWIMMING					
TOTALS	SKIN	2.57E-04		BODY	1.84E-04	

TABLE 7.2-3. (contd)

CASE 1: SAMPLE ARRRG RUN

01/14/74

	HOLDUP TIME HOURS	USAGE PER YR	MIXING RATIO
FISH	24	33.6	.03
DRINKING WATER	24	1430	.03
SHORELINE	5	106	.14
SWIMMING	5	416	.14
BOATING	5	416	.14

PLANT LIFE= 30 YEARS SHORE WIDTH FACTOR= .5

RECONCENTRATION FORMULA NUMBER 3

COOLANT FLOW TO PLANT = 790 CUBIC FEET/SEC = 7.06E+11 LITERS/YEAR

	---------DOSE TO INDIVIDUAL, MREM/YEAR---------				
	SKIN	BODY	GI-LLI	THYROID	BONE
FISH		1.64E-02	1.51E-03	7.56E-02	1.18E-02
DRINKING WATER		8.45E-03	4.42E-03	2.20E-01	7.29E-04
SHORELINE	1.40E-03	1.20E-03	1.20E-03	1.20E-03	1.20E-03
SWIMMING	5.15E-04	3.68E-04	3.68E-04	3.68E-04	3.68E-04
BOATING	2.57E-04	1.84E-04	1.84E-04	1.84E-04	1.84E-04
TOTALS	2.18E-03	2.66E-02	7.69E-03	2.97E-01	1.43E-02

TABLE 7.2-3. (contd)

```
S U M M A R Y   O F   R U N          PIKES PEAK

CASE 1:   SAMPLE ARRRG RUN

ARRRG ** ARRRG ** ARRRG ** ARRRG ** ARRRG          01/14/74     12:54          ARRRG ** ARRRG ** ARRRG ** ARRRG ** ARRRG




MAIL TO:  NM ROBINSON, 3717 BLDG, 300 AREA, RICHLAND, WASHINGTON  99352
```

Program output at the user's terminal consists of internal dose to all four primary organisms of the selected organ radius, internal dose to the selected secondary organisms, optional percentage contribution to internal dose by nuclide for each selected primary and secondary organism, and an optional table of release rates and concentrations of radionuclides in the liquid effluent by isotope. CRITR produces no high-speed printer output.

CRITR obtains its input from three sources:

(1) The reactor coolant flow, reconcentration parameters, holdup, mixing ratio and information characterizing each organism are entered by the user at the time of the run. Section 7.5 discusses the choice of parameters to use for the reconcentration factor and mixing ratios. The standard input we use for the other parameters in absence of information specific to the site is given in Table 6.1-1.

(2) The reactor release rate file REL is shared by ARRRG and CRITR. The discussion of REL in Section 7.2 also applies to CRITR.

(3) The file ARGIN is also shared by ARRRG and CRITR, and the discussion of ARGIN in Section 7.2 also applies to CRITR. The file CRITEN (Section 10.6) contains a tabulation by nuclide of effective energy per disintegration for seven critter[a] radii between 1.4 cm and 20 cm and for the total body of man.

Table 7.3-1 shows teletype printout for a typical run, with user input indicated by wavy underlines. The reactor name determines which set of releases from REL will be accessed by the program. A title is entered to identify the teletype printout, but is not otherwise used by the program. Holdup time in hours, mixing ratio and effective critter radius in cm is then entered for the primary critter. The program summarizes the input for the user to check, and if the response to "constants OK?" is N or NO,

---

(a) In CRITR jargon, "critter" means "organism."

TABLE 7.3-1. Teletype Printout for Sample CRITR Run

```
RUN CRITR

CRITR   13:30   01/14/74

REACTOR NAME?PIKES PEAK

TITLE?SAMPLE CRITR RUN

ENTER COOLING FLOW IN CFS?800
WHICH RECONCENTRATION FORMULA?3

FOR PRIMARY CRITTER * * * *

ENTER HOLDUP TIME IN HOURS & MIXING RATIO?0 1
ENTER CRITTER RADIUS IN CM. ?2

PIKES PEAK     FLOW= 800      CONSTANT RECONC=1

HOLDUP= 0      MIXING RATIO= 1      RADIUS= 2

CONSTANTS OK?YES

FISH INTERNAL DOSE =       4.5 MRAD/YR

CRUSTACEA INTERNAL DOSE = 1.84 MRAD/YR

MOLLUSC INTERNAL DOSE =   1.84 MRAD/YR

ALGAE INTERNAL DOSE =     7.17 MRAD/YR


FOR SECONDARY CRITTER * * * *

NAME OF CRITTER?HERON
ENTER HOLDUP TIME IN HOURS & MIXING RATIO?0 1
ENTER CRITTER RADIUS IN CM. ?7
ENTER FOOD TYPE?FISH
ENTER FOOD INTAKE RATE IN GRAMS/DAY?600
ENTER CRITTER MASS IN KG?4.6

HOLDUP = 0      MIXING RATIO = 1

FOOD TYPE =FISH    INTAKE RATE = 600

RADIUS= 7    MASS= 4.6      CONSTANTS OK?Y

INTERNAL DOSE FOR HERON =  25.6827  MRAD/YR

ANOTHER SECONDARY CRITTER?N

PERCENTAGES?Y
MINIMUM %?5

     * * *  CONTRIBUTIONS TO CRITTER DOSE > 5 %  * * *
```

ISOTOPE	RELEASE CI/YR	RECONC. FACTOR	CONC. PCI/L	BIOACCUM. FACTOR	BODY BUR. PCI/KG	DOSE MRAD/YR	PERCENT
FISH							
RB-88	2.10E-02	1.00	2.9E-02	2000	5.9E+01	2.4E+00	52.7
I-133	1.90E+00	1.00	2.7E+00	15	4.0E+01	3.6E-01	7.9
CS-134	3.70E-02	1.00	5.2E-02	2000	1.0E+02	5.0E-01	11.1
CS-137	3.20E-02	1.00	4.5E-02	2000	9.0E+01	4.5E-01	9.9
CRUSTACEA							
H-3	1.00E+03	1.00	1.4E+03	1	1.3E+03	1.4E-01	7.4
RB-88	2.10E-02	1.00	2.9E-02	1000	2.9E+01	1.2E+00	64.5
I-133	1.90E+00	1.00	2.7E+00	5	1.3E+01	1.2E-01	6.5
MOLLUSC							
H-3	1.00E+03	1.00	1.4E+03	1	1.3E+03	1.4E-01	7.4
RB-88	2.10E-02	1.00	2.9E-02	1000	2.9E+01	1.2E+00	64.5
I-133	1.90E+00	1.00	2.7E+00	5	1.3E+01	1.2E-01	6.5
ALGAE							
RB-88	2.10E-02	1.00	2.9E-02	1000	2.9E+01	1.2E+00	16.5
MO-99+D	2.60E-01	1.00	3.6E-01	1000	3.6E+02	2.9E+00	40.1
MO-99D	2.30E-01	1.00	3.2E-01	1000	3.2E+02	5.1E-01	7.0
I-131	1.80E+00	1.00	2.5E+00	40	1.0E+02	4.0E-01	5.6
I-133	1.90E+00	1.00	2.7E+00	40	1.1E+02	9.5E-01	13.3
HERON							
CS-134	3.70E-02	1.00	5.2E-02	2000	1.6E+03	1.4E+01	56.4
CS-137	3.20E-02	1.00	4.5E-02	2000	1.5E+03	9.9E+00	38.6

TABLE 7.3-1 (contd)

DO YOU WANT TOTAL LIST OF RELEASES?Y

ISOTOPE	RELEASE CI/YR	CONCENTRATION PCI/LITER
H-3	1.00E+03	1.40E+03
CR-51	5.70E-04	7.97E-04
MN-54	6.10E-04	8.53E-04
FE-55	1.30E-03	1.82E-03
FE-59	6.60E-04	9.23E-04
CO-58	6.90E-03	9.65E-03
CO-60	5.60E-04	7.83E-04
BR-82	9.60E-04	1.34E-03
BR-83+D	3.40E-03	4.76E-03
BR-84	4.90E-05	6.85E-05
RB-86	6.20E-05	8.67E-05
RB-88	2.10E-02	2.94E-02
RB-89	1.10E-05	1.54E-05
SR-89	3.60E-04	5.04E-04
SR-90	1.30E-05	1.82E-05
SR-90D	1.30E-05	1.82E-05
SR-91	2.40E-04	3.36E-04
SR-92	1.10E-05	1.54E-05
Y-90	1.90E-05	2.66E-05
Y-91M	1.50E-04	2.10E-04
Y-91	3.40E-03	4.76E-03
Y-92	4.10E-05	5.73E-05
Y-93	4.30E-05	6.01E-05
ZR-95	6.00E-05	8.39E-05
ZR-95D	6.00E-05	8.39E-05
ZR-97	1.70E-05	2.38E-05
ZR-97D	1.70E-05	2.38E-05
NB-95	6.30E-05	8.81E-05
NB-97	1.80E-05	2.52E-05
MO-99+D	2.60E-01	3.64E-01
MO-99D	2.30E-01	3.20E-01
TC-99M	2.10E-01	2.94E-01
RU-103+D	4.00E-05	5.59E-05
RU-105+D	5.80E-06	8.11E-06
RU-106+D	1.30E-05	1.82E-05
RH-105	1.50E-05	2.10E-05
PD-109+D	1.40E-06	1.96E-06
AG-111	7.00E-07	9.79E-07
SB-127	1.40E-06	1.96E-06
TE-125M	3.30E-05	4.62E-05
TE-127M	2.90E-04	4.06E-04
TE-127	2.90E-04	4.06E-04
TE-129M+D	2.80E-03	3.92E-03
TE-129	1.80E-03	2.52E-03
TE-131M	1.20E-03	1.68E-03
TE-131	2.40E-04	3.36E-04
TE-132	1.60E-02	2.24E-02
TE-132D	1.60E-02	2.24E-02
TE-133M+D	7.80E-06	1.09E-05
TE-134	6.30E-06	8.81E-06
I-130	6.20E-03	8.67E-03
I-131	1.80E+00	2.52E+00
I-132	2.10E-01	2.94E-01
I-133	1.90E+00	2.66E+00
I-134	2.00E-03	2.80E-03
I-135	5.20E-01	7.27E-01
CS-134M	1.40E-05	1.96E-05
CS-134	3.70E-02	5.18E-02
CS-136	9.00E-03	1.26E-02
CS-137	3.20E-02	4.48E-02
CS-138	1.50E-04	2.10E-04
CS-139	5.10E-06	7.13E-06
BA-139	1.50E-04	2.10E-04
BA-140	3.30E-04	4.62E-04
BA-140D	3.30E-04	4.62E-04
LA-140	2.00E-04	2.80E-04
LA-141	3.30E-05	4.62E-05
LA-142	7.10E-07	9.93E-07
CE-141	6.00E-05	8.39E-05
CE-143	2.50E-05	3.50E-05
CE-144+D	5.10E-05	7.13E-05
PR-143	4.40E-05	6.15E-05
ND-147	1.80E-05	2.52E-05
PM-147	2.90E-06	4.06E-06
PM-148	6.50E-06	9.09E-06
PM-149	8.80E-06	1.23E-05
PM-151	2.50E-06	3.50E-06
SM-153	4.60E-06	6.43E-06
EU-156	2.30E-06	3.22E-06
U-237	1.10E-05	1.54E-05
NP-238	2.40E-06	3.36E-06
NP-239	3.40E-04	4.76E-04
PU-241+D	1.80E-06	2.52E-06

DON'T FORGET EXTERNAL DOSES

THANK YOU ----- CALL AGAIN

NOW AT END
SRU'S:4.6
READY

the user is given a chance to re-enter the parameters. CRITR then calculates and prints the internal dose to the four primary organisms of the given radius: fish, crustacea, molluscs and algae.

Any name is allowed for the secondary critter. The holdup time, mixing ratio and the radius are entered. The tabulated radius in CRITEN closest to the user-specified radius is used to scale this dose factor to the size of the organism. The food type may be specified using any of the following names:

Response to "food type?"	Organism used for dose calculation
fish	fish
crustacea, shellfish, lobsters	crustacea
molluscs, oysters, clams	molluscs
algae, plants	algae

The program examines only the first two letters of "food type" so the operator need not be concerned whether his response is singular or plural, or is a variant spelling. After entering the food intake rate and mass, the user is given a chance to examine and reject the parameters. CRITR uses the adult total-body ingestion dose factors to calculate internal doses, then calculates and prints the internal dose for the secondary critter.

By answering Y or YES to "another secondary critter?" the user may repeat the secondary critter portion of the calculation, up to a maximum of six secondary critters. At user option, a table of percent contribution to each internal dose by nuclide is printed, for each nuclide contributing at least a user-specified minimum percent. The release, recirculation factor, concentration, bioaccumulation factor, body burden, dose and percent contribution is printed for each nuclide. Also at user option, a list of releases and water concentrations is printed for all nuclides. The CRITR program listing is in Section 10.5.

7.4 PROGRAM GRONK

GRONK (Gas Release of NuKlides) calculates annual dose resulting from radionuclide releases in gaseous effluents, using Equations 5.1-1 and 5.1-2. Skin and total-body dose to an individual and total-body dose to the population are calculated in 16 sectors and in up to 10 annular rings out to 50 miles from the point of release. An optional calculation is the thyroid dose via the inhalation, milk and leafy vegetable pathways at a user-specified set of ranges.

Meteorology is accepted in either the Pasquill or Hanford format. The user may specify the release height of the effluents, a plume rise constant, a building-wake correction and a meteorology height correction. If the optional thyroid dose calculation is selected, the user may specify a grazing period, vegetable consumption period and the vegetable consumption rate.

A detailed output is automatically sent to a high-speed printer. This output contains: the population table supplied by the user; the meteorology tables supplied by the user; the meteorology tables after any normalization is performed by the program; the releases, decay constants and dose factors used by the program; the percent contribution by nuclide to dose at the point of release (termed "at the stack" in the printout); a table of computed $\bar{\chi}/Q'$; tables of skin and total-body dose to individual and total-body dose to population; average dose to population in annular rings; and tables of thyroid dose if that option has been selected. At the time of the run, the user may request that any combination of these tables also be printed at his conversational terminal.

GRONK obtains its data from three sources:

(1) The user specifies at the time of the run the items indicated in Table 7.4-1. Due to the large number of possible user

TABLE 7.4-1 GRONK Input Worksheet

REACTOR NAME: ____________________

RELEASE LIST NAME: ____________________ (if more than one set of release rates)

COMMENTS: ____

MODEL:	☐ PASQUILL MODEL	H ☐ HANFORD MODEL	
RELEASE HEIGHT:	☐ SAME AS PREVIOUS CASE (=0 if case #1)	G ☐ GROUND RELEASE	L ☐ ELEVATED RELEASE height= ________
EXTERNAL RANGES:	☐ BUILT-IN RANGES	R ☐ NEW RANGES (miles): ____________	S ☐ SAME AS PREVIOUS CASE
PLUME RISE:	☐ SAME AS PREVIOUS CASE (=0 if case #1)	P ☐ PLUME RISE CONSTANT= ______ meter^2/second	
WAKE FACTOR:	W ☐ USE BUILDING WAKE FACTOR		
WIND SPEED:	M ☐ USE METEOROLOGY HEIGHT CORRECTION		
THYROID:	T ☐ ALSO CALCULATE THYROID DOSES		

GRAZING PERIOD ________ month/year
VEGETABLE CONSUMPTION PERIOD ________ month/year
CHILD VEGETABLE CONSUMPTION ________ kilogram/year
ADULT VEGETABLE CONSUMPTION ________ kilogram/year
NEW RANGES (miles): ____________________ or same as external ranges ("escape" key)

ADD TABLES: A ☐ ADD SUCCESSIVE CASES (Use for all except last case in group)

PRINTING TABLES AT TELETYPE:

- 0 ☐ Print population table at teletype
- 1 ☐ Print raw meteorology tables at teletype
- 2 ☐ Print derived meteorology tables at teletype
- 3 ☐ Print releases, decay constants and dose factors at teletype
- 4 ☐ Print percent by nuclide at teletype
- 5 ☐ Print χ/Q table at teletype
- 6 ☐ Print individual skin dose table at teletype
- 7 ☐ Print individual total body dose table at teletype
- 8 ☐ Print population total body dose table at teletype
- 9 ☐ Print thyroid dose tables at teletype
- X ☐ Print average population dose table at teletype

For additional cases, fill out another sheet or list differences below:

FOR OPERATOR'S USE:

Option words: #1 ________ #2 ________ #3 ________ #4 ________ #5 ________

Final options: E ☐ END RUN F ☐ END RUN, THEN OFF N ☐ END RUN, THEN RERUN GRONK FOR A NEW REACTOR options, GRONK does not operate in a question-and-answer mode as do ARRRG and CRITR. Instead, at the beginning of the case the user enters letters representing his chosen options. If any of the selected options require user-specified parameters, GRONK will request only those parameters required.

(2) A single file contains all the information necessary to characterize a facility for GRONK. This file is named Gxxxx, where xxxx stands for the first four letters of the facility name, and is the only file every modified by the user of GRONK. The information for a given reactor is stored once in Gxxxx at the time the information is received from the applicant. The program automatically accesses the Gxxxx file indicated by the reactor name entered by the user at the time the run is made. Gxxxx contains the radionuclide release rates, population distribution out to 50 miles in 16 sectors and up to 10 annular rings, meteorological data in tables of joint frequency of occurrence of wind speed, direction and stability condition, and certain miscellaneous input. The stability classifications may be those of the Pasquill or Hanford model, or both models may be entered for use in separate runs. Detailed rules for the formation of file Gxxxx are given in Table 7.4-2, and sample Gxxxx file (GMARC) is listed in Section 10.11.

(3) The 136 nuclide names, decay constants, total-body and skin dose factors, and thyroid dose factors required by GRONK are stored in the permanent file GIN (Section 10.9). A table of Pasquill σ_z versus range by stability condition is stored in the permanent file TONIC (Section 10.10). In the past some applicants have specified nonstandard Pasquill conditions G and G+; we have taken the σ_z for these conditions to be 0.6 times the σ_z for condition F. GRONK uses linear interpolation for ranges which fall between the tabulated ranges in TONIC.

Table 7.4-3 shows the teletype printout for a typical run, with user input indicated by wavy underlines. A worksheet such as that in Table 7.4-1 is essential in preparing the input and should be referred to during the following discussion of input to GRONK.

TABLE 7.4-2

RULES OF FORMATION FOR FILE Gxxxx

Before running GRONK for a new facility, you must create a master file containing the permanent data GRONK will need for that facility. The file shall contain the following data in order.

1. The facility name optionally followed by comments, all on a single line. This line is printed as part of the heading on the first page and on the top of each result page. The total length of this line cannot exceed 72 characters.

2. For each release list:

   a. The word RELEASE, followed by the release list title (enclose title in quotes if more than one word). These items are optional if there is only one release list.

   b. The 136 releases for the facility in Ci/yr in the nuclide order given in Table 7.1-5. Use as many lines as you need. Nuclides which are not released must be listed as zero, but the program accepts the shorthand notation rZ to represent r consecutive zero releases. (This notation is not allowed anywhere else in the file.)

3. The word RANGES.

4. The ranges in miles for which the data in the population table are tabulated. Up to ten ranges are allowed.

5. A blank line of at least one space.

6. A line containing:

   a. The word POPULATION.

   b. The date of the population table. If the date is not known, use two adjacent quotation marks. If more than one word is needed to characterize the date of the population table, enclose the words in quotation marks (example: "1970 seasonal").

   c. The name of the sector direction which begins the population table (but see step 18).

7. The population table. Enter the numbers in the same order that GRONK prints them. Use as many lines as you need. The first sector direction must be the same one you specified in step 6, and the sectors must follow in clockwise order.

TABLE 7.4-2 (contd)

8. A line containing:

   a. The name of the model (HANFORD or PASQUILL).

   b. The number of sectors in the meteorology tables (only allowed value is 16).

   c. The name of the sector direction which begins the meteorology tables (but see step 18).

   d. The wind-sensor height in meters to use in the wind-speed correction formula. Enter zero if you do not know the height; this will cause building-wake correction requests to be ignored.

   e. The building height in meters to use in the building-wake correction formula. Enter zero if you do not know the height; this will cause building-wake correction requests to be ignored.

9. The average speed in mph for each column in the meteorology table. A maximum of ten speed categories are allowed.

10. A blank line of at least one space.

11. The column heading (maximum five characters each) to appear in the printout for each speed column of the meteorology table.

12. For each stability condition, the following information:

   a. An abbreviation for the name of the stability condition (quote marks required if more than one word).

   b. If the meteorology table is given in percent of all occurrences across all stability conditions, enter the number 100.

      If the meteorology table is given in number of observations: enter the total number of observations for all conditions combined. If the total number of observations is not known, enter the number zero. The program will automatically sum and print the total number of observations, and you should then use this number to change Gxxxx before the next run. When zero is used, the "standard form" meteorology output is supressed.

      If the meteorology data for each stability condition table sums to 100%: enter the percentage of time that the given stability condition occurs.

TABLE 7.4-2 (contd)

c. The percentage (or number) of times the wind direction is listed as variable for each speed interval; use zeroes if not listed. Each value will be distributed equally among all directions in its speed interval.

d. The percentage (or number) of times the wind is listed as calm; use zero if not listed. This value will be distributed equally amoung all directions in the lowest speed interval.

e. The meteorology table for the given stability condition. Enter the numbers in the same order that GRONK prints them. Use as many lines as you need. The first sector direction must be the same one you specified in step 8c, and the sectors must follow in clockwise order.[a]

13. For the Hanford model, the stability conditions must be in the order: very stable, moderately stable, neutral and unstable. For the Pasquill model, the stability conditions must be in the order: A, B, C, D, E, F, G (optional), and G+ (optional). Both Hanford and Pasquill model meteorology (steps 8 to 12) may be listed for the same reactor, but the Hanford model must be first.

14. (Optional) The word NOTES, followed by as many lines of descriptive comments as you require.

15. The name of the master file containing the data will be G + the first four letters of the reactor name. Example: The Aquirre reactor data is stored on file GAGUI.

16. Naming directions: Direction names in GRONK are the 16 primary compass directions (N, NNE, NE, ENE, etc.), and the 16 directions midway between them (N-NNE, NNE-NE, NE-ENE, etc.).

17. Naming sectors: All sectors are named for the direction of the center of the sector. Examples: if the sector boundaries are NW and NNW, the sector name is NW-NNW. If the sector boundaries are NE-ENE and ENE-E, the sector name is ENE.

18. Agreement Between Population and Meteorology Sectors

- Any desired sector may be chosen to begin the meteorology tables;[a] that same starting sector must be used for every stability condition.

(a) The directions used by GRONK are the directions of the people receiving dose (the direction towards which the wind blows). Since meteorology tables received from applicants usually use the direction from which the winds originate, the sector data must be rotated 180° for use in GRONK.

TABLE 7.4-2 (contd)

- If the population sectors are offset one-half sector from the meteorology sectors, then for population dose computations the population is adjusted by averaging adjacent sectors. The sector chosen to begin the population table must be one of the two closest to the sector which begins the meteorology tables.

- If there is no offset between population and meteorology sectors, then the same sector must begin the population and meteorology tables.

Example: if the first meteorology sector is N (S in meteorologist's terminology), allowed first population sectors are either NNW-N, N or N-NNE.

TABLE 7.4-3. Teletype Printout for Sample GRONK Run

```
RUN GRONK

GRONK    13:11    01/14/74

REACTOR NAME?MARC FOUR

OPTION WORD?LTMW
ENTER COMMENTS FOR THIS CASE?SAMPLE GRONK RUN
RELEASE HEIGHT+UNITS=?30M
ENTER GRAZING PERIOD, VEGETABLE CONSUMPTION PERIOD (MO/YR)?10 5
ENTER 2-YEAR-OLD VEG CONSUMPTION, ADULT VEG CONSUMPTION (KG/YR)?18 72
ENTER THYROID RANGES IN MILES.  END THE SET WITH A BLANK LINE
?.5 1.5
?

POPULATION TOTAL BODY DOSE= .72 MANREM/YEAR

OPTION WORD?E
NOW AT END
SRU'S:16.3
READY
```

The reactor name determines which reactor data file will be accessed by the program. The option word is a combination of letters which tells GRONK the features that the user desires in the calculation. The letters may be entered in any order and spaces are allowed. The user may select one option from each of the following categories:

Meteorology Model

- Option H: use Hanford meteorology tables.
- Option H not selected: use Pasquill meteorology tables.

Release Height

- Option G: the effluents are released from ground level.
- Option L: GRONK will later ask for the release height desired by the user. Sample responses are 100F to represent 100 ft or 70M to represent 70 meters.
- Neither options G nor L selected: the release height will be the same as that used in the previous case [it will be assumed equal to zero (ground level release) if this selection is made for the first case].

External Ranges

- Option R: the user will be asked later to enter the ranges for which $\bar{\chi}/Q'$ and skin and total-body dose to individual will be calculated. If this option is selected, GRONK will not have the information necessary to calculate total-body dose to population.
- Option S: the ranges for skin and total-body calculations will be the same as those used in the previous case (built-in ranges will be assumed if this selection is made for the first case).
- Neither options R nor S selected: the "built-in" ranges specified for the population table in paragraph 4 of Table 7.4-2 will be used for skin and total-body calculation. Total-body dose to population will be calculated.

Plume Rise

- Option P: the release height h in Equation 5.1-2 is replaced by
$$h + \frac{\text{plume rise constant (meter}^2\text{/sec)}}{\bar{u}_j}$$ (Ref. 16, p. 191)
- Option P not selected: the plume rise constant will be the same as that used in the previous case (it will be assumed equal to zero if this selection is made for the first case).

Wake Factor

- Option W: in Equation 5.1-2, $\sigma_z{}^2$ is everywhere replaced by $\sigma_z{}^2$ + (building height)$^2/2\pi$, but is not allowed to increase beyond the maximum value of $3\sigma_z{}^2$. The building height is that specified in paragraph 8e of Table 7.4-2.
- Option W not selected: no building-wake correction is applied.

Wind Speed

- Option M: let h_a be the larger of the effluent release height or 10 meters. Let h_s be the wind sensor height specified in paragraph 8d of Table 7.4-2. Then the average wind speeds $\bar{u}_J$ are corrected by the factor $(h_a/h_s)^{0.25}$ for Hanford neutral and unstable, and for Pasquill A, B, C and D stability conditions; and by the factor $(h_a/h_s)^{0.5}$ for Hanford moderately stable and very stable, and for Pasquill E, F, G and G+ stability conditions.
- Option M not selected: no meteorological height correction factor is applied.

Thyroid

- Option T: a thyroid dose calculation will follow the skin and total-body dose calculations. GRONK will ask the user to enter grazing period, vegetable consumption periods and desired ranges for the thyroid calculation. Special feature: if the user presses the "escape" key when asked to enter thyroid ranges, the ranges previously selected for external doses are automatically used.

- Option T not selected: no thyroid calculation is made.

Adding Tables It is sometimes desirable to sum the doses for a group of successive cases; for example, when both stack and vent releases occur. To invoke this feature, the option letter A is used for all cases except the last case in the group. GRONK will compute and print both summed and unsummed tables.

Printing Tables at Teletype The user may select as many options as desired from the list in Table 7.4-1. If printing option "8" is not chosen, the integrated man-rem total-body dose to population, if calculated, will be printed at the teletype. The selected tables will be printed at the teletype in the same format as they appear on the high-speed printer output. It is possible that some of the tables may be folded unless the user's conversational terminal has a width of at least 125 columns.

More than one set of release rates may be stored on the file Gxxxx. If GRONK determines that more than one list of releases is present, it will ask the user to enter the name of the desired list. (This feature was not used in the sample run.)

When the case is completed, GRONK will again request an option word. If the user desires to run another case for the same facility, he may enter another option word as described above. To indicate that the run is completed, he enters one of the following option letters:

- E End the run
- F End the run, then end the session as if an OFF command had been issued
- N End the run, then rerun GRONK for a new facility.

Table 7.4-4 shows the high-speed printer output resulting from the sample run. On the last page is a summary of all cases contained in the printout. The GRONK program listing is in Section 10.7 (CSTS version) and Section 10.8 (CSCX version).

7.5 MIXING RATIOS AND RECONCENTRATION FORMULA

Mixing ratios and reconcentration factors are required by both ARRRG and CRITR. This section discusses the methods of choosing the proper parameters to use as input for these sections of the programs.

The mixing ratio, M_p, accounts for the dilution of the liquid effluent between the point of discharge and the point of exposure, and is best determined from hydrological studies. If the temperature increase which would result at the point of exposure solely from mixing is known, then the mixing ratio may be estimated from

$$M_p = \frac{T_p - T_A}{T_0 - T_A}$$

where T_A = ambient temperature of the receiving sink

T_p = temperature which would exist at the point of exposure for pathway p if no evaporation or radiation effects were present

T_0 = temperature of the effluent at the outlet.

The value for T_p can be estimated from a plot of isotherms due to mixing only in the receiving waters.

The reconcentration factor, N_i, accounts for the extent to which effluent is recycled through the reactors. ARRRG and CRITR allow the user a choice of the following reconcentration models.

(1) If the cooling water is drawn from a cooling pond, small lake or reservoir which is connected to a larger body of water or is fed by a stream, then:

TABLE 7.4-4. High-Speed Printer Output for Sample GRONK Run

GRONK ** GRONK ** GRONK ** GRONK ** GRONK 01/14/74 13:12 GRONK ** GRONK ** GRONK ** GRONK ** GRONK

1 9 8 0 P O P U L A T I O N T A B L E

RANGE	.5 MI	1.5 MI	2.5 MI	3.5 MI	4.5 MI	7.5 MI	15 MI	25 MI	35 MI	45 MI	TOTALS
N	0	0	29	21	67	575	37,850	131,050	18,000	13,200	200,792
NNE	0	3	67	218	80	831	7,950	14,450	15,650	6,850	46,099
NE	0	15	0	70	33	2,486	59,950	55,050	17,800	12,000	147,404
ENE	0	0	0	0	17	989	53,250	52,800	20,950	11,850	139,856
E	0	0	0	0	5	1,804	7,250	9,900	7,250	12,950	39,159
ESE	0	0	0	0	17	3,511	6,000	4,950	19,100	14,100	47,678
SE	0	0	0	0	12	953	4,900	15,150	6,100	6,700	33,815
SSE	0	0	0	0	10	430	4,500	12,500	33,750	23,850	75,040
S	0	0	0	0	0	82	3,250	12,450	83,850	88,350	187,982
SSW	0	0	0	0	37	314	5,650	5,900	6,450	11,400	29,751
SW	0	0	0	7	34	196	7,900	10,850	6,250	16,300	41,537
WSW	0	0	0	38	48	743	6,750	6,950	7,500	9,300	31,329
W	0	0	4	90	34	833	2,150	4,050	9,500	31,000	47,661
WNW	0	0	83	18	64	131	3,800	3,950	15,350	17,850	41,246
NW	0	2	7	0	22	162	2,150	7,750	16,250	72,900	99,243
NNW	0	19	82	18	15	131	37,650	13,250	16,750	15,350	83,265
TOTALS	0	39	272	480	495	14,171	250,950	361,000	300,500	363,950	1,291,857
CUM TOTL	0	39	311	791	1,286	15,457	266,407	627,407	927,907	1,291,857	1,291,857

TABLE 7.4-4. (contd)

MARC FOUR 2 UNITS

01/14/74

PASQUILL A CATEGORY
METEOROLOGY AS INPUT FROM FILE
PERCENT OF ALL OCCURRENCES

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.05	.07	.03	.00	.00	.16
NNE	.03	.05	.02	.01	.00	.11
NE	.08	.12	.06	.00	.00	.25
ENE	.01	.12	.05	.00	.00	.17
E	.08	.15	.03	.00	.00	.27
ESE	.03	.13	.05	.00	.00	.21
SE	.06	.20	.03	.01	.00	.30
SSE	.06	.09	.02	.01	.00	.18
S	.08	.08	.02	.00	.00	.18
SSW	.04	.03	.01	.00	.00	.09
SW	.03	.08	.07	.00	.00	.18
WSW	.03	.08	.05	.00	.00	.16
W	.05	.14	.02	.00	.00	.21
WNW	.02	.08	.01	.00	.00	.11
NW	.03	.05	.02	.00	.00	.10
NNW	.02	.12	.00	.00	.00	.14
VARBL	.00	.00	.00	.00	.00	.00
CALM	.00					.00
TOTALS	.69	1.57	.51	.03	.00	2.80

PASQUILL A CATEGORY
METEOROLOGY IN STANDARD FORM
PERCENT OF ALL OCCURRENCE

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.05	.07	.03	.00	.00	.16
NNE	.03	.05	.02	.01	.00	.11
NE	.08	.12	.06	.00	.00	.25
ENE	.01	.12	.05	.00	.00	.17
E	.08	.15	.03	.00	.00	.27
ESE	.03	.13	.05	.00	.00	.21
SE	.06	.20	.03	.01	.00	.30
SSE	.06	.09	.02	.01	.00	.18
S	.08	.08	.02	.00	.00	.18
SSW	.04	.03	.01	.00	.00	.09
SW	.03	.08	.07	.00	.00	.18
WSW	.03	.08	.05	.00	.00	.16
W	.05	.14	.02	.00	.00	.21
WNW	.02	.08	.01	.00	.00	.11
NW	.03	.05	.02	.00	.00	.10
NNW	.02	.12	.00	.00	.00	.14
TOTALS	.69	1.57	.51	.03	.00	2.80

TABLE 7.4-4. (contd)

MARC FOUR 2 UNITS

01/14/74

PASQUILL B CATEGORY
METEOROLOGY AS INPUT FROM FILE
PERCENT OF ALL OCCURRENCES

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.11	.24	.06	.00	.00	.41
NNE	.05	.09	.07	.00	.00	.22
NE	.13	.31	.33	.02	.00	.80
ENE	.04	.31	.38	.03	.00	.77
E	.09	.28	.21	.06	.00	.63
ESE	.04	.18	.10	.00	.00	.32
SE	.04	.20	.23	.05	.00	.51
SSE	.04	.13	.06	.00	.00	.25
S	.13	.27	.20	.02	.00	.61
SSW	.01	.09	.13	.01	.00	.24
SW	.05	.17	.25	.02	.00	.50
WSW	.02	.07	.15	.03	.00	.27
W	.03	.24	.20	.00	.00	.47
WNW	.05	.15	.07	.01	.00	.28
NW	.05	.22	.02	.00	.00	.29
NNW	.04	.09	.07	.00	.00	.20
VARBL	.00	.00	.00	.00	.00	.00
CALM	.00					.00
TOTALS	.91	3.05	2.55	.27	.00	6.77

PASQUILL B CATEGORY
METEOROLOGY IN STANDARD FORM
PERCENT OF ALL OCCURRENCE

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.11	.24	.06	.00	.00	.41
NNE	.05	.09	.07	.00	.00	.22
NE	.13	.31	.33	.02	.00	.80
ENE	.04	.31	.38	.03	.00	.77
E	.09	.28	.21	.06	.00	.63
ESE	.04	.18	.10	.00	.00	.32
SE	.04	.20	.23	.05	.00	.51
SSE	.04	.13	.08	.00	.00	.25
S	.13	.27	.20	.02	.00	.61
SSW	.01	.09	.13	.01	.00	.24
SW	.05	.17	.25	.02	.00	.50
WSW	.02	.07	.15	.03	.00	.27
W	.03	.24	.20	.00	.00	.47
WNW	.05	.15	.07	.01	.00	.28
NW	.05	.22	.02	.00	.00	.29
NNW	.04	.09	.07	.00	.00	.20
TOTALS	.91	3.05	2.55	.27	.00	6.77

TABLE 7.4-4. (contd)

MARC FOUR 2 UNITS 01/14/74

PASQUILL C CATEGORY
METEOROLOGY AS INPUT FROM FILE
PERCENT OF ALL OCCURRENCES

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.06	.24	.16	.05	.00	.51
NNE	.04	.18	.30	.09	.00	.62
NE	.05	.32	1.00	.30	.07	1.74
ENE	.04	.38	.92	.25	.06	1.66
E	.10	.42	.45	.24	.02	1.23
ESE	.03	.10	.25	.15	.02	.56
SE	.09	.18	.28	.14	.02	.71
SSE	.04	.15	.15	.01	.01	.36
S	.12	.18	.33	.10	.01	.75
SSW	.05	.24	.21	.03	.00	.53
SW	.06	.36	.80	.25	.02	1.49
WSW	.03	.27	.54	.12	.00	.96
W	.08	.40	.58	.06	.00	1.11
WNW	.03	.23	.31	.03	.00	.61
NW	.03	.16	.16	.01	.00	.36
NNW	.03	.16	.10	.00	.00	.30
VARBL	.00	.00	.00	.00	.00	.00
CALM	.00					.00
TOTALS	.88	3.99	6.55	1.85	.24	13.51

PASQUILL C CATEGORY
METEOROLOGY IN STANDARD FORM
PERCENT OF ALL OCCURRENCE

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.06	.24	.16	.05	.00	.51
NNE	.04	.18	.30	.09	.00	.62
NE	.05	.32	1.00	.30	.07	1.74
ENE	.04	.38	.92	.25	.06	1.66
E	.10	.42	.45	.24	.02	1.23
ESE	.03	.10	.25	.15	.02	.56
SE	.09	.18	.28	.14	.02	.71
SSE	.04	.15	.15	.01	.01	.36
S	.12	.18	.33	.10	.01	.75
SSW	.05	.24	.21	.03	.00	.53
SW	.06	.36	.80	.25	.02	1.49
WSW	.03	.27	.54	.12	.00	.96
W	.08	.40	.58	.06	.00	1.11
WNW	.03	.23	.31	.03	.00	.61
NW	.03	.16	.16	.01	.00	.36
NNW	.03	.16	.10	.00	.00	.30
TOTALS	.88	3.99	6.55	1.85	.24	13.51

TABLE 7.4-4. (contd)

MARC FOUR 2 UNITS 01/14/74

PASQUILL D CATEGORY
METEOROLOGY AS INPUT FROM FILE
PERCENT OF ALL OCCURRENCES

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.10	.24	.61	.22	.03	1.21
NNE	.10	.25	.85	.47	.02	1.70
NE	.15	.52	2.17	.76	.10	3.71
ENE	.07	.55	1.07	.42	.07	2.18
E	.08	.39	.47	.36	.09	1.40
ESE	.13	.28	.20	.33	.09	1.03
SE	.08	.29	.44	.54	.25	1.60
SSE	.06	.20	.33	.30	.14	1.03
S	.12	.40	.76	.43	.07	1.78
SSW	.11	.42	1.06	.37	.02	1.98
SW	.17	.82	2.08	.66	.09	3.82
WSW	.07	.42	1.28	.54	.03	2.35
W	.07	.50	.96	.12	.00	1.64
WNW	.05	.20	.28	.06	.00	.58
NW	.08	.35	.32	.08	.00	.83
NNW	.06	.16	.16	.07	.01	.46
VARBL	.00	.00	.00	.00	.00	.00
CALM	.00					.00
TOTALS	1.50	5.98	13.05	5.72	1.04	27.29

PASQUILL D CATEGORY
METEOROLOGY IN STANDARD FORM
PERCENT OF ALL OCCURRENCE

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.10	.24	.61	.22	.03	1.21
NNE	.10	.25	.85	.47	.02	1.70
NE	.15	.52	2.17	.76	.10	3.71
ENE	.07	.55	1.07	.42	.07	2.18
E	.08	.39	.47	.36	.09	1.40
ESE	.13	.28	.20	.33	.09	1.03
SE	.08	.29	.44	.54	.25	1.60
SSE	.06	.20	.33	.30	.14	1.03
S	.12	.40	.76	.43	.07	1.78
SSW	.11	.42	1.06	.37	.02	1.98
SW	.17	.82	2.08	.66	.09	3.82
WSW	.07	.42	1.28	.54	.03	2.35
W	.07	.50	.96	.12	.00	1.64
WNW	.05	.20	.28	.06	.00	.58
NW	.08	.35	.32	.08	.00	.83
NNW	.06	.16	.16	.07	.01	.46
TOTALS	1.50	5.98	13.05	5.72	1.04	27.29

TABLE 7.4-4. (contd)

MARC FOUR 2 UNITS 01/14/74

PASQUILL E CATEGORY
METEOROLOGY AS INPUT FROM FILE
PERCENT OF ALL OCCURRENCES

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.20	.43	.55	.07	.00	1.25
NNE	.07	.32	.75	.09	.00	1.24
NE	.21	.75	1.85	.20	.00	3.00
ENE	.13	.46	.54	.03	.00	1.17
E	.15	.53	.24	.03	.00	.95
ESE	.16	.17	.20	.09	.01	.63
SE	.26	.43	.73	.32	.13	1.87
SSE	.21	.31	.61	.37	.06	1.56
S	.15	.44	.97	.38	.06	2.00
SSW	.12	.32	.67	.12	.01	1.24
SW	.18	.73	1.21	.13	.00	2.25
WSW	.05	.37	.45	.05	.00	.92
W	.16	.53	.40	.02	.00	1.12
WNW	.08	.35	.23	.01	.00	.66
NW	.12	.40	.36	.01	.00	.89
NNW	.15	.46	.24	.05	.00	.90
VARBL	.00	.00	.00	.00	.00	.00
CALM	.00					.00
TOTALS	2.41	7.00	10.00	1.97	.27	21.66

PASQUILL E CATEGORY
METEOROLOGY IN STANDARD FORM
PERCENT OF ALL OCCURRENCE

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.20	.43	.55	.07	.00	1.25
NNE	.07	.32	.75	.09	.00	1.24
NE	.21	.75	1.85	.20	.00	3.00
ENE	.13	.46	.54	.03	.00	1.17
E	.15	.53	.24	.03	.00	.95
ESE	.16	.17	.20	.09	.01	.63
SE	.26	.43	.73	.32	.13	1.87
SSE	.21	.31	.61	.37	.06	1.56
S	.15	.44	.97	.38	.06	2.00
SSW	.12	.32	.67	.12	.01	1.24
SW	.18	.73	1.21	.13	.00	2.25
WSW	.05	.37	.45	.05	.00	.92
W	.16	.53	.40	.02	.00	1.12
WNW	.08	.35	.23	.01	.00	.66
NW	.12	.40	.36	.01	.00	.89
NNW	.15	.46	.24	.05	.00	.90
TOTALS	2.41	7.00	10.00	1.97	.27	21.66

TABLE 7.4-4. (contd)

MARC FOUR 2 UNITS

01/14/74

PASQUILL F CATEGORY
METEOROLOGY AS INPUT FROM FILE
PERCENT OF ALL OCCURRENCES

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.21	.72	1.29	.03	.00	2.26
NNE	.15	.66	1.50	.03	.00	2.35
NE	.21	1.08	2.80	.05	.00	4.14
ENE	.24	.87	.96	.00	.00	2.07
E	.28	.74	.50	.05	.00	1.56
ESE	.19	.44	.32	.02	.00	.98
SE	.16	.57	.73	.07	.00	1.52
SSE	.14	.55	.55	.10	.00	1.35
S	.22	.69	.88	.05	.00	1.84
SSW	.22	.54	.80	.02	.00	1.58
SW	.15	.69	1.04	.03	.00	1.91
WSW	.10	.45	.53	.01	.00	1.10
W	.07	.37	.77	.00	.00	1.21
WNW	.09	.43	.60	.01	.00	1.13
NW	.20	.68	1.03	.01	.00	1.92
NNW	.15	.43	.46	.02	.00	1.06
VARBL	.00	.00	.00	.00	.00	.00
CALM	.00					.00
TOTALS	2.79	9.90	14.76	.52	.00	27.97

PASQUILL F CATEGORY
METEOROLOGY IN STANDARD FORM
PERCENT OF ALL OCCURRENCE

	0-3	4-7	8-12	13-18	19+	TOTALS
N	.21	.72	1.29	.03	.00	2.26
NNE	.15	.66	1.50	.03	.00	2.35
NE	.21	1.08	2.80	.05	.00	4.14
ENE	.24	.87	.96	.00	.00	2.07
E	.28	.74	.50	.05	.00	1.56
ESE	.19	.44	.32	.02	.00	.98
SE	.16	.57	.73	.07	.00	1.52
SSE	.14	.55	.55	.10	.00	1.35
S	.22	.69	.88	.05	.00	1.84
SSW	.22	.54	.80	.02	.00	1.58
SW	.15	.69	1.04	.03	.00	1.91
WSW	.10	.45	.53	.01	.00	1.10
W	.07	.37	.77	.00	.00	1.21
WNW	.09	.43	.60	.01	.00	1.13
NW	.20	.68	1.03	.01	.00	1.92
NNW	.15	.43	.46	.02	.00	1.06
TOTALS	2.79	9.90	14.76	.52	.00	27.97

TABLE 7.4-4. (contd)

CASE 1: MARC FOUR 2 UNITS 30 METER RELEASE SAMPLE GRONK RUN 01/14/74

ISOTOPE	RELEASE CI/YEAR	LAMBDA 1/SEC	EXTERNAL DOSE FACTORS MREM/HR PER PCI/CUBIC METER		THYROID DOSE FACTORS -- MREM/YEAR PER PCI/CUBIC METER					
					---INHALATION---		----M I L K-----		LEAFY VEGETABLES	
			TOTAL BODY	SKIN	2 YEAR	ADULT	2 YEAR	ADULT	2 YEAR	ADULT
29 KR-83M	11.896	1.04E-04	0	7.6E-10						
30 KR-85M	64.16	4.39E-05	1.3E-07	3.2E-07						
31 KR-85	3186.8	2.04E-09	2.2E-09	1.6E-07						
32 KR-87	34.616	1.52E-04	1.3E-06	2.7E-06						
33 KR-88	111.12	6.86E-05	1.5E-06	2.0E-06						
36 RB-89	0.546	7.50E-04	2.1E-06	2.8E-06						
82 I-131	0.170	9.97E-07	3.1E-07	4.9E-07	12.5	10.6	3620.	448.	1190.	589.
84 I-133	0.130	9.17E-06	4.4E-07	8.8E-07	5.51	2.70	262.	18.7	84.1	24.1
87 XE-131M	80.04	6.81E-07	2.8E-09	4.8E-08						
88 XE-133M	123.48	3.56E-06	2.7E-08	6.0E-08						
89 XE-133	10036	1.52E-06	2.5E-08	6.9E-08						
90 XE-135M	7.352	7.42E-04	3.5E-07	5.0E-07						
91 XE-135	186.88	2.09E-05	2.1E-07	4.9E-07						
92 XE-137	5.392	2.97E-03	1.2E-07	1.8E-06						
93 XE-138	25.544	6.81E-04	1.2E-06	1.7E-06						

PASQUILL MODEL
30 METER RELEASE
BUILT-IN TOTAL BODY/SKIN RANGES
BUILDING WAKE FACTOR APPLIED. BUILDING HEIGHT= 56.3 METERS
WIND SPEEDS CORRECTED FROM 36.576 METERS TO 30 METERS
PERFORM THYROID CALCULATION
  GRAZING PERIOD= 10 MONTHS/YEAR
  VEGETABLE CONSUMPTION PERIOD= 5 MONTHS/YEAR
  2-YEAR-OLD VEGETABLE CONSUMPTION= 18 KILOGRAMS/YEAR
  ADULT VEGETABLE CONSUMPTION= 72 KILOGRAMS/YEAR

TABLE 7.4-4. (contd)

CASE 1: MARC FOUR 2 UNITS 30 METER RELEASE SAMPLE GRONK RUN 01/14/74

CONTRIBUTION TO DOSE AT RELEASE POINT

ISOTOPE	TOTAL BODY	SKIN	INHALATION 2 YR	INHALATION ADULT	---MILK---- 2 YR	---MILK---- ADULT	VEGETABLES 2 YR	VEGETABLES ADULT
31 KR-85		30 %						
32 KR-87	8 %	5 %						
33 KR-88	30 %	13 %						
82 I-131			69 %	80 %	93 %	96 %	93 %	96 %
84 I-133			31 %	20 %	7 %		7 %	
89 XE-133	45 %	41 %						
91 XE-135	7 %	5 %						
93 XE-138	6 %							

CASE 1: MARC FOUR 2 UNITS 30 METER RELEASE SAMPLE GRONK RUN 01/14/74

T A B L E O F C H I / Q PASQUILL MODEL

RANGE	.5 MI	1.5 MI	2.5 MI	3.5 MI	4.5 MI	7.5 MI	15 MI	25 MI	35 MI	45 MI	TOTALS
N	9.38E-07	2.46E-07	1.18E-07	7.50E-08	5.25E-08	2.60E-08	1.03E-08	5.61E-09	3.66E-09	2.66E-09	1.48E-06
NNE	8.73E-07	2.30E-07	1.10E-07	6.99E-08	4.88E-08	2.41E-08	9.47E-09	5.24E-09	3.41E-09	2.47E-09	1.38E-06
NE	1.79E-06	4.46E-07	2.12E-07	1.35E-07	9.39E-08	4.61E-08	1.81E-08	1.01E-08	6.54E-09	4.73E-09	2.77E-06
ENE	1.08E-06	2.68E-07	1.27E-07	8.14E-08	5.66E-08	2.77E-08	1.08E-08	6.05E-09	3.94E-09	2.85E-09	1.67E-06
E	9.29E-07	2.30E-07	1.09E-07	7.05E-08	4.91E-08	2.41E-08	9.47E-09	5.22E-09	3.41E-09	2.48E-09	1.43E-06
ESE	6.13E-07	1.53E-07	7.29E-08	4.63E-08	3.23E-08	1.59E-08	6.25E-09	3.49E-09	2.27E-09	1.64E-09	9.47E-07
SE	9.40E-07	2.27E-07	1.08E-07	6.83E-08	4.76E-08	2.34E-08	9.18E-09	5.05E-09	3.28E-09	2.38E-09	1.43E-06
SSE	7.38E-07	1.86E-07	8.87E-08	5.61E-08	3.92E-08	1.94E-08	7.63E-09	4.16E-09	2.70E-09	1.96E-09	1.14E-06
S	1.06E-06	2.59E-07	1.23E-07	7.83E-08	5.46E-08	2.68E-08	1.05E-08	5.85E-09	3.80E-09	2.76E-09	1.63E-06
SSW	8.78E-07	2.19E-07	1.04E-07	6.59E-08	4.58E-08	2.24E-08	8.77E-09	4.95E-09	3.20E-09	2.31E-09	1.35E-06
SW	1.41E-06	3.20E-07	1.50E-07	9.46E-08	6.53E-08	3.17E-08	1.22E-08	7.06E-09	4.55E-09	3.27E-09	2.10E-06
WSW	7.54E-07	1.73E-07	8.11E-08	5.16E-08	3.56E-08	1.72E-08	6.64E-09	3.86E-09	2.49E-09	1.79E-09	1.13E-06
W	8.28E-07	1.86E-07	8.67E-08	5.57E-08	3.85E-08	1.87E-08	7.21E-09	4.09E-09	2.65E-09	1.92E-09	1.23E-06
WNW	5.11E-07	1.29E-07	6.14E-08	3.94E-08	2.75E-08	1.35E-08	5.32E-09	2.91E-09	1.90E-09	1.38E-09	7.93E-07
NW	7.44E-07	2.01E-07	9.72E-08	6.16E-08	4.32E-08	2.14E-08	8.49E-09	4.63E-09	3.01E-09	2.19E-09	1.19E-06
NNW	5.65E-07	1.46E-07	7.01E-08	4.45E-08	3.12E-08	1.54E-08	6.09E-09	3.29E-09	2.14E-09	1.56E-09	8.86E-07
TOTALS	1.47E-05	3.62E-06	1.72E-06	1.09E-06	7.62E-07	3.74E-07	1.46E-07	8.16E-08	5.30E-08	3.83E-08	2.26E-05
CUM TOTL	1.47E-05	1.83E-05	2.00E-05	2.11E-05	2.19E-05	2.22E-05	2.24E-05	2.25E-05	2.25E-05	2.26E-05	2.26E-05

TABLE 7.4-4. (contd)

CASE 1: MARC FOUR 2 UNITS 30 METER RELEASE SAMPLE GRONK RUN 01/14/74

SKIN DOSE TO INDIVIDUAL, MREM/YEAR PASQUILL MODEL

RANGE	.5 MI	1.5 MI	2.5 MI	3.5 MI	4.5 MI	7.5 MI	15 MI	25 MI	35 MI	45 MI	TOTALS
N	4.33E-01	1.11E-01	5.20E-02	3.25E-02	2.24E-02	1.07E-02	3.98E-03	2.07E-03	1.30E-03	9.21E-04	6.70E-01
NNE	4.05E-01	1.04E-01	4.90E-02	3.06E-02	2.11E-02	1.00E-02	3.73E-03	1.97E-03	1.24E-03	8.70E-04	6.27E-01
NE	8.33E-01	2.02E-01	9.46E-02	5.91E-02	4.06E-02	1.93E-02	7.17E-03	3.80E-03	2.38E-03	1.68E-03	1.26E+00
ENE	5.02E-01	1.21E-01	5.61E-02	3.54E-02	2.42E-02	1.14E-02	4.21E-03	2.24E-03	1.41E-03	9.94E-04	7.58E-01
E	4.29E-01	1.03E-01	4.79E-02	3.03E-02	2.08E-02	9.82E-03	3.62E-03	1.90E-03	1.20E-03	8.49E-04	6.49E-01
ESE	2.83E-01	6.83E-02	3.18E-02	1.98E-02	1.36E-02	6.42E-03	2.37E-03	1.26E-03	7.92E-04	5.59E-04	4.28E-01
SE	4.35E-01	1.02E-01	4.74E-02	2.96E-02	2.03E-02	9.63E-03	3.56E-03	1.87E-03	1.17E-03	8.29E-04	6.51E-01
SSE	3.41E-01	8.35E-02	3.90E-02	2.43E-02	1.67E-02	7.96E-03	2.96E-03	1.53E-03	9.63E-04	6.81E-04	5.19E-01
S	4.91E-01	1.17E-01	5.43E-02	3.39E-02	2.33E-02	1.11E-02	4.09E-03	2.17E-03	1.36E-03	9.60E-04	7.39E-01
SSW	4.06E-01	9.87E-02	4.60E-02	2.85E-02	1.96E-02	9.24E-03	3.40E-03	1.83E-03	1.14E-03	8.02E-04	6.15E-01
SW	6.55E-01	1.45E-01	6.64E-02	4.13E-02	2.81E-02	1.32E-02	4.80E-03	2.65E-03	1.65E-03	1.15E-03	9.59E-01
WSW	3.50E-01	7.84E-02	3.60E-02	2.26E-02	1.53E-02	7.18E-03	2.61E-03	1.45E-03	9.03E-04	6.32E-04	5.15E-01
W	3.84E-01	8.40E-02	3.84E-02	2.42E-02	1.65E-02	7.74E-03	2.82E-03	1.52E-03	9.54E-04	6.72E-04	5.60E-01
WNW	2.37E-01	5.81E-02	2.71E-02	1.71E-02	1.18E-02	5.59E-03	2.07E-03	1.08E-03	6.78E-04	4.81E-04	3.61E-01
NW	3.44E-01	9.06E-02	4.28E-02	2.67E-02	1.84E-02	8.80E-03	3.28E-03	1.70E-03	1.07E-03	7.57E-04	5.38E-01
NNW	2.61E-01	6.55E-02	3.07E-02	1.91E-02	1.32E-02	6.27E-03	2.33E-03	1.20E-03	7.53E-04	5.34E-04	4.00E-01
TOTALS	6.79E+00	1.63E+00	7.59E-01	4.75E-01	3.26E-01	1.54E-01	5.70E-02	3.02E-02	1.90E-02	1.34E-02	1.03E+01
CUM TOTL	6.79E+00	8.42E+00	9.18E+00	9.65E+00	9.98E+00	1.01E+01	1.02E+01	1.02E+01	1.02E+01	1.03E+01	1.03E+01

TABLE 7.4-4. (contd)

CASE 1: MARC FOUR 2 UNITS 30 METER RELEASE SAMPLE GRONK RUN 01/14/74

TOTAL BODY DOSE TO INDIVIDUAL, MREM/YEAR PASQUILL MODEL

RANGE	.5 MI	1.5 MI	2.5 MI	3.5 MI	4.5 MI	7.5 MI	15 MI	25 MI	35 MI	45 MI	TOTALS
N	1.40E-01	3.47E-02	1.60E-02	9.83E-03	6.68E-03	3.06E-03	1.06E-03	5.19E-04	3.13E-04	2.14E-04	2.12E-01
NNE	1.31E-01	3.29E-02	1.52E-02	9.35E-03	6.35E-03	2.92E-03	1.02E-03	5.05E-04	3.03E-04	2.06E-04	2.00E-01
NE	2.69E-01	6.42E-02	2.95E-02	1.81E-02	1.23E-02	5.65E-03	1.96E-03	9.83E-04	5.89E-04	4.01E-04	4.03E-01
ENE	1.62E-01	3.80E-02	1.73E-02	1.08E-02	7.25E-03	3.29E-03	1.13E-03	5.66E-04	3.40E-04	2.32E-04	2.41E-01
E	1.38E-01	3.23E-02	1.47E-02	9.12E-03	6.14E-03	2.78E-03	9.49E-04	4.68E-04	2.83E-04	1.94E-04	2.05E-01
ESE	9.09E-02	2.13E-02	9.70E-03	5.93E-03	3.99E-03	1.80E-03	6.16E-04	3.08E-04	1.85E-04	1.27E-04	1.35E-01
SE	1.40E-01	3.21E-02	1.46E-02	8.96E-03	6.06E-03	2.76E-03	9.51E-04	4.70E-04	2.82E-04	1.93E-04	2.06E-01
SSE	1.10E-01	2.62E-02	1.20E-02	7.34E-03	4.98E-03	2.28E-03	7.88E-04	3.85E-04	2.31E-04	1.58E-04	1.64E-01
S	1.58E-01	3.68E-02	1.68E-02	1.03E-02	6.96E-03	3.17E-03	1.10E-03	5.45E-04	3.27E-04	2.24E-04	2.35E-01
SSW	1.31E-01	3.10E-02	1.42E-02	8.65E-03	5.83E-03	2.65E-03	9.07E-04	4.59E-04	2.75E-04	1.87E-04	1.95E-01
SW	2.12E-01	4.58E-02	2.06E-02	1.26E-02	8.47E-03	3.83E-03	1.30E-03	6.77E-04	4.03E-04	2.72E-04	3.06E-01
WSW	1.13E-01	2.48E-02	1.12E-02	6.90E-03	4.62E-03	2.09E-03	7.09E-04	3.71E-04	2.21E-04	1.49E-04	1.64E-01
W	1.24E-01	2.65E-02	1.19E-02	7.39E-03	4.96E-03	2.24E-03	7.62E-04	3.87E-04	2.31E-04	1.58E-04	1.78E-01
WNW	7.63E-02	1.83E-02	8.39E-03	5.21E-03	3.53E-03	1.61E-03	5.56E-04	2.71E-04	1.63E-04	1.12E-04	1.14E-01
NW	1.11E-01	2.85E-02	1.32E-02	8.08E-03	5.49E-03	2.52E-03	8.75E-04	4.26E-04	2.56E-04	1.75E-04	1.70E-01
NNW	8.39E-02	2.05E-02	9.41E-03	5.75E-03	3.90E-03	1.78E-03	6.12E-04	2.95E-04	1.77E-04	1.22E-04	1.26E-01
TOTALS	2.19E+00	5.14E-01	2.35E-01	1.44E-01	9.75E-02	4.44E-02	1.53E-02	7.64E-03	4.58E-03	3.12E-03	3.26E+00
CUM TOTL	2.19E+00	2.70E+00	2.94E+00	3.08E+00	3.18E+00	3.23E+00	3.24E+00	3.25E+00	3.25E+00	3.26E+00	3.26E+00

TABLE 7.4-4. (contd)

CASE 1: MARC FOUR 2 UNITS 30 METER RELEASE SAMPLE GRONK RUN 01/14/74

TOTAL BODY DOSE TO POPULATION, MAN-REM/YEAR PASQUILL MODEL

RANGE	.5 MI	1.5 MI	2.5 MI	3.5 MI	4.5 MI	7.5 MI	15 MI	25 MI	35 MI	45 MI	TOTALS
N	.00E+00	.00E+00	4.65E-04	2.06E-04	4.47E-04	1.76E-03	4.02E-02	6.80E-02	5.63E-03	2.82E-03	1.20E-01
NNE	.00E+00	9.87E-05	1.02E-03	2.04E-03	5.08E-04	2.43E-03	8.09E-03	7.30E-03	4.74E-03	1.41E-03	2.76E-02
NE	.00E+00	9.62E-04	.00E+00	1.27E-03	4.06E-04	1.40E-02	1.18E-01	5.41E-02	1.05E-02	4.81E-03	2.04E-01
ENE	.00E+00	.00E+00	.00E+00	.00E+00	1.23E-04	3.26E-03	6.02E-02	2.99E-02	7.12E-03	2.75E-03	1.03E-01
E	.00E+00	.00E+00	.00E+00	.00E+00	3.07E-05	5.01E-03	6.88E-03	4.64E-03	2.05E-03	2.51E-03	2.11E-02
ESE	.00E+00	.00E+00	.00E+00	.00E+00	6.79E-05	6.33E-03	3.69E-03	1.52E-03	3.54E-03	1.79E-03	1.69E-02
SE	.00E+00	.00E+00	.00E+00	.00E+00	7.27E-05	2.63E-03	4.66E-03	7.12E-03	1.72E-03	1.30E-03	1.75E-02
SSE	.00E+00	.00E+00	.00E+00	.00E+00	4.98E-05	9.79E-04	3.54E-03	4.81E-03	7.81E-03	3.78E-03	2.10E-02
S	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	2.60E-04	3.56E-03	6.79E-03	2.75E-02	1.98E-02	5.78E-02
SSW	.00E+00	.00E+00	.00E+00	.00E+00	2.16E-04	8.31E-04	5.13E-03	2.71E-03	1.77E-03	2.13E-03	1.28E-02
SW	.00E+00	.00E+00	.00E+00	8.84E-05	2.88E-04	7.51E-04	1.03E-02	7.35E-03	2.52E-03	4.44E-03	2.57E-02
WSW	.00E+00	.00E+00	.00E+00	2.62E-04	2.22E-04	1.55E-03	4.79E-03	2.58E-03	1.66E-03	1.39E-03	1.24E-02
W	.00E+00	.00E+00	4.76E-05	6.65E-04	1.69E-04	1.86E-03	1.64E-03	1.57E-03	2.20E-03	4.88E-03	1.30E-02
WNW	.00E+00	.00E+00	6.96E-04	9.37E-05	2.26E-04	2.11E-04	2.11E-03	1.07E-03	2.51E-03	1.99E-03	8.91E-03
NW	.00E+00	5.70E-05	9.23E-05	.00E+00	1.21E-04	4.08E-04	1.88E-03	3.30E-03	4.16E-03	1.28E-02	2.28E-02
NNW	.00E+00	3.90E-04	7.71E-04	1.03E-04	5.85E-05	2.33E-04	2.30E-02	3.90E-03	2.97E-03	1.87E-03	3.33E-02
TOTALS	.00E+00	1.51E-03	3.09E-03	4.73E-03	3.01E-03	4.26E-02	2.97E-01	2.07E-01	8.83E-02	7.04E-02	7.18E-01
CUM TOTL	.00E+00	1.51E-03	4.60E-03	9.33E-03	1.23E-02	5.49E-02	3.52E-01	5.59E-01	6.47E-01	7.18E-01	7.18E-01

TABLE 7.4-4. (contd)

CASE 1: MARC FOUR 2 UNITS 30 METER RELEASE SAMPLE GRONK RUN 01/14/74

CUMULATIVE RADIUS (MILES)	CUMULATIVE 1980 POPULATION	CUMULATIVE DOSE (MAN-REM/YR)	AVERAGE ANNUAL DOSE (MREM/YR)
1	0	0	
2	39	.0015	.039
3	311	.0046	.015
4	791	.0093	.012
5	1,286	.012	.0096
10	15,457	.055	.0036
20	266,407	.35	.0013
30	627,407	.56	.00089
40	927,907	.65	.0007
50	1,291,857	.72	.00056

TABLE 7.4-4. (contd)

CASE 1: MARC FOUR 2 UNITS 30 METER RELEASE SAMPLE GRONK RUN 01/14/74

T H Y R O I D D O S E .5 MILES PASQUILL MODEL

	CHI/Q SEC/M**3	NUCLIDE CONCENTRATION, PCI/CUBIC METER							DOSE FROM PATHWAY MREM/YR INHALATION		MILK		LEAFY VEGETABLES	
		TE-132D	I-129	I-130	I-131	I-132	I-133	I-135	2 YR	ADULT	2 YR	ADULT	2 YR	ADULT
N	9.4E-07				5.1E-03		3.8E-03		8.4E-02	6.4E-02	1.6E+01	1.9E+00	2.6E+00	1.3E+00
NNE	8.7E-07				4.7E-03		3.6E-03		7.9E-02	6.0E-02	1.5E+01	1.8E+00	2.5E+00	1.2E+00
NE	1.8E-06				9.7E-03		7.4E-03		1.6E-01	1.2E-01	3.1E+01	3.7E+00	5.0E+00	2.4E+00
ENE	1.1E-06				5.8E-03		4.4E-03		9.7E-02	7.4E-02	1.9E+01	2.2E+00	3.0E+00	1.5E+00
E	9.3E-07				5.0E-03		3.8E-03		8.4E-02	6.3E-02	1.6E+01	1.9E+00	2.6E+00	1.3E+00
ESE	6.1E-07				3.3E-03		2.5E-03		5.5E-02	4.2E-02	1.1E+01	1.3E+00	1.7E+00	8.4E-01
SE	9.4E-07				5.1E-03		3.9E-03		8.5E-02	6.4E-02	1.6E+01	1.9E+00	2.6E+00	1.3E+00
SSE	7.4E-07				4.0E-03		3.0E-03		6.6E-02	5.0E-02	1.3E+01	1.5E+00	2.1E+00	1.0E+00
S	1.1E-06				5.7E-03		4.4E-03		9.5E-02	7.2E-02	1.8E+01	2.2E+00	3.0E+00	1.4E+00
SSW	8.8E-07				4.7E-03		3.6E-03		7.9E-02	6.0E-02	1.5E+01	1.8E+00	2.5E+00	1.2E+00
SW	1.4E-06				7.6E-03		5.8E-03		1.3E-01	9.6E-02	2.4E+01	2.9E+00	4.0E+00	1.9E+00
WSW	7.5E-07				4.1E-03		3.1E-03		6.8E-02	5.1E-02	1.3E+01	1.6E+00	2.1E+00	1.0E+00
W	8.3E-07				4.5E-03		3.4E-03		7.4E-02	5.6E-02	1.4E+01	1.7E+00	2.3E+00	1.1E+00
WNW	5.1E-07				2.8E-03		2.1E-03		4.6E-02	3.5E-02	8.8E+00	1.1E+00	1.4E+00	7.0E-01
NW	7.4E-07				4.0E-03		3.1E-03		6.7E-02	5.1E-02	1.3E+01	1.5E+00	2.1E+00	1.0E+00
NNW	5.[illegible]E-07				3.0E-03		2.3E-03		5.1E-02	3.9E-02	9.7E+00	1.2E+00	1.6E+00	7.7E-01

TABLE 7.4-4. (contd)

CASE 1: MARC FOUR 2 UNITS 30 METER RELEASE SAMPLE GRONK RUN 01/14/74

THYROID DOSE
1.5 MILES

PASQUILL MODEL

	CHI/Q SEC/M**3	NUCLIDE CONCENTRATION, PCI/CUBIC METER							DOSE FROM PATHWAY MREM/YR INHALATION		MILK		LEAFY VEGETABLES	
		TE-132D	I-129	I-130	I-131	I-132	I-133	I-135	2 YR	ADULT	2 YR	ADULT	2 YR	ADULT
N	2.5E-07				1.3E-03		1.0E-03		2.2E-02	1.7E-02	4.2E+00	5.1E-01	6.9E-01	3.3E-01
NNE	2.3E-07				1.2E-03		9.4E-04		2.1E-02	1.6E-02	3.9E+00	4.8E-01	6.5E-01	3.1E-01
NE	4.5E-07				2.4E-03		1.8E-03		4.0E-02	3.0E-02	7.6E+00	9.3E-01	1.3E+00	6.1E-01
ENE	2.7E-07				1.4E-03		1.1E-03		2.4E-02	1.8E-02	4.6E+00	5.5E-01	7.5E-01	3.6E-01
E	2.3E-07				1.2E-03		9.3E-04		2.1E-02	1.6E-02	3.9E+00	4.8E-01	6.5E-01	3.1E-01
ESE	1.5E-07				8.2E-04		6.2E-04		1.4E-02	1.0E-02	2.6E+00	3.2E-01	4.3E-01	2.1E-01
SE	2.3E-07				1.2E-03		9.2E-04		2.0E-02	1.5E-02	3.9E+00	4.7E-01	6.4E-01	3.1E-01
SSE	1.9E-07				1.0E-03		7.5E-04		1.7E-02	1.3E-02	3.2E+00	3.8E-01	5.2E-01	2.5E-01
S	2.6E-07				1.4E-03		1.1E-03		2.3E-02	1.8E-02	4.4E+00	5.4E-01	7.3E-01	3.5E-01
SSW	2.2E-07				1.2E-03		8.9E-04		2.0E-02	1.5E-02	3.8E+00	4.5E-01	6.2E-01	3.0E-01
SW	3.2E-07				1.7E-03		1.3E-03		2.9E-02	2.2E-02	5.5E+00	6.6E-01	9.0E-01	4.4E-01
WSW	1.7E-07				9.3E-04		7.1E-04		1.6E-02	1.2E-02	3.0E+00	3.6E-01	4.9E-01	2.4E-01
W	1.9E-07				1.0E-03		7.6E-04		1.7E-02	1.3E-02	3.2E+00	3.9E-01	5.2E-01	2.5E-01
WNW	1.3E-07				6.9E-04		5.2E-04		1.2E-02	8.8E-03	2.2E+00	2.7E-01	3.6E-01	1.8E-01
NW	2.0E-07				1.1E-03		8.2E-04		1.8E-02	1.4E-02	3.4E+00	4.2E-01	5.7E-01	2.7E-01
NNW	1.5E-07				7.9E-04		5.9E-04		1.3E-02	9.9E-03	2.5E+00	3.0E-01	4.1E-01	2.0E-01

TABLE 7.4-4. (contd)

```
S U M M A R Y   O F   R U N          MARC FOUR  2 UNITS

CASE 1:  SAMPLE GRONK RUN
         PASQUILL MODEL   30 METER RELEASE   WAKE FACTOR   WINDSPEED   THY

GRONK ** GRONK ** GRONK ** GRONK ** GRONK        01/14/74     13:12        GRONK ** GRONK ** GRONK ** GRONK ** GRONK
```

MAIL TO: NM ROBINSON, BATTELLE-NORTHWEST, 3717 BLDG, 300 AREA, RICHLAND, WASHINGTON 99352

$$N_i = \left[1 - \frac{(F - L)\, e^{-\lambda_i t_c}}{F + V \lambda_T}\right]^{-1} \quad (7.5\text{-}1)$$

(2) If the cooling water intake is downriver from the outfall or on a lake or ocean site and arranged such that recirculation occurs, then

$$N_i = \frac{1 - \left[g\, e^{-\lambda_i t_c}\right]^{n+1}}{1 - g\, e^{-\lambda_i t_c}} \quad (7.5\text{-}2)$$

(3) If there is no reconcentration, for example, if the cooling water is drawn from a river in which the outfall is below the intake, then

$$N_i = 1.0 \quad (7.5\text{-}3)$$

where g = recycle fraction (the mixing ratio at the point of intake) (unitless)

F = coolant flow (ft^3/sec)

L = makeup flow (water drawn into the intake to replace losses) (ft^3/sec)

V = pond volume (ft^3)

λ_T = pond turnover rate (sec^{-1})

t_c = cycle time (hr)

λ_i = decay constant (hr^{-1})

n = number of cycles during facility lifetime = $\frac{\text{plant life (hr)}}{t_c}$

The above three models were chosen for the programs because they apply to the most common reconcentration situations. Unusual cases could require that special reconcentration formulas be added to the program.

Equation 7.5-2 is the closed form of the series

$$N_i \doteq 1 + G_i + G_i^2 + G_i^3 + \ldots\ldots + G_i^n \quad (7.5\text{-}2a)$$

where $G_i = g \exp(-\lambda_i t_c)$ for nuclide i.

Formula 1, the most complex of the reconcentration models, is used for sites on a cooling pond, lake or reservoir where the water is exchanged by stream flow or connection with a larger body of water such as the ocean. It can also be used for a system of cooling canals where a fresh dilution stream (makeup) is injected into the inlet pipe along with the recycled water from the cooling pond. From elementary considerations of mass balance, assuming steady state conditions and instantaneous mixing in the cooling pond, Formula 1 is of the form of Formula 2 with $n \to \infty$ and with the recycle fraction a function of hydrological parameters and the radionuclide decay constant (see Figure 7.5-1),

$$N_i = \left[1 - \frac{(F - L)\, e^{-\lambda_i t_c}}{(F - L) + V(\lambda_T + \frac{L}{V})}\right]^{-1} \qquad (7.5\text{-}1)$$

The volume, V, for Formula 1 may be taken to be a series of canals, a pond, small bay, small lake, etc. However, the model loses credibility if V is very large since instantaneous mixing in V was assumed; therefore, Formula 2 should be used for large V.

During an ARRRG or CRITR run, the program will ask "which reconcentration formula?" The user should then enter one of the numbers 1, 2 or 3. The programs will next ask for only those parameters which are needed for the selected reconcentration formula.

7.6 TREATMENT OF PARENT-DAUGHTER NUCLIDE PAIRS

Parent-daughter nuclide pairs require special consideration, since decay of parent into daughter represents an additional source of the daughter nuclide in the environment and in the body. Effects of parent decay subsequent to intake into the body are already accounted for in the calculation of decay energy and internal dose factors by ICRP methods.

Accumulation of a daughter nuclide in primary aquatic organisms may be controlled by the bioaccumulation factor of either the parent or daughter,

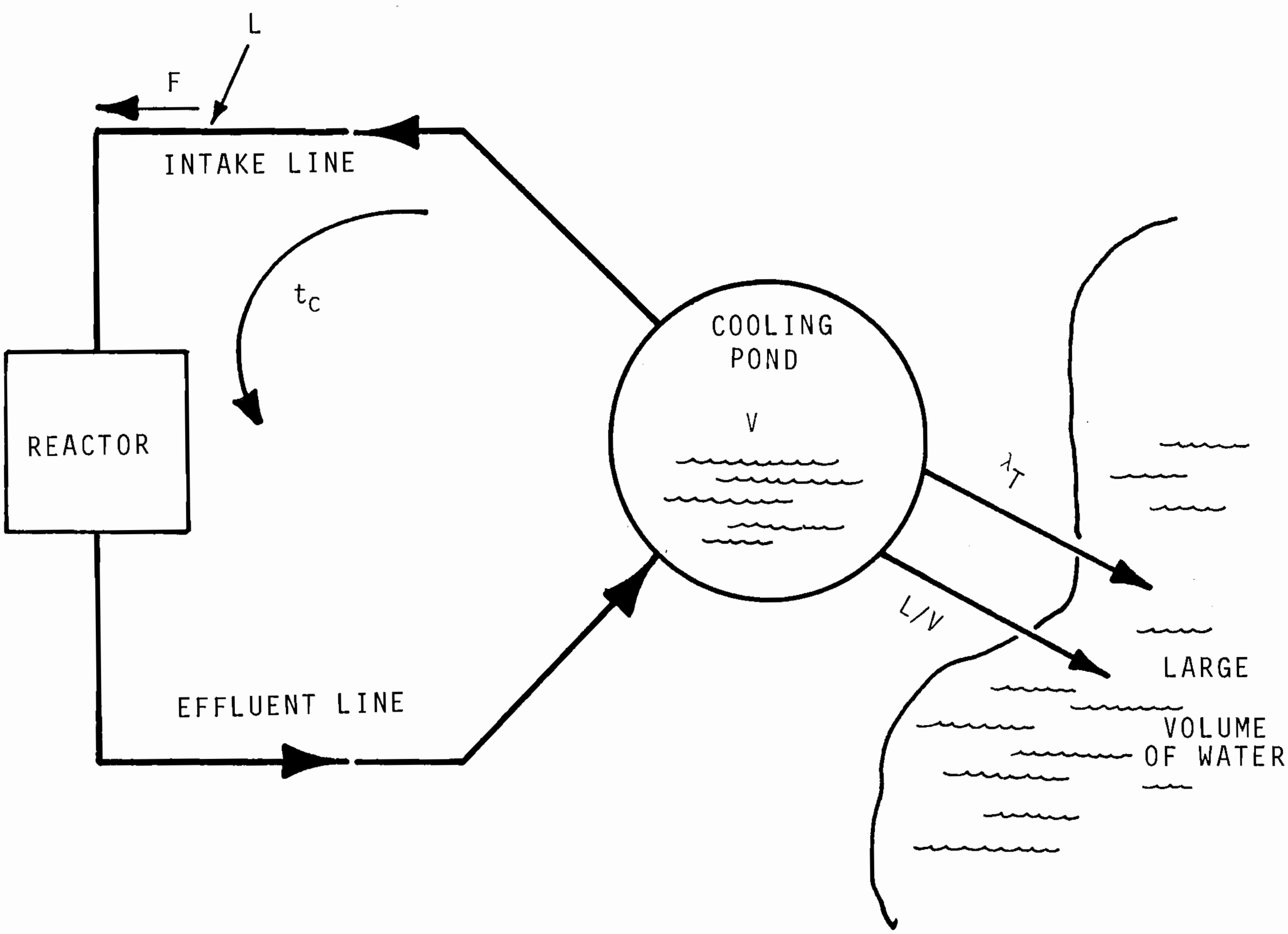

FIGURE 7.5-1

RECONCENTRATION IN REACTOR EFFLUENT DUE TO RECYCLING THROUGH A COOLING POND or both. To ensure that calculated doses are always conservative, a pseudo-nuclide is devised which has the half-life and bioaccumulation factors of the parent, but the decay energy and dose factors of the daughter. Pseudo-nuclides are placed in the nuclide master list with a name formed by appending the letter D to the parent name. The release rate assigned to the pseudo-nuclide is the release of the parent multiplied by the fraction of the parent decay which passes through the daughter nuclide.

The doses calculated from the combination of the pseudo-nuclide plus daughter nuclide will always be at least as large as the true dose from the daughter. Furthermore, accumulation of the daughter on sediments is conservatively calculated, since the longer half-life of the parent is used for the pseudo-nuclide.

A simplification of the above method is possible when the daughter has a radiological half-life which is short compared to that of its parent and compared to the elapsed time between release of the nuclide and exposure. Since the environmental behavior of the daughter will always follow that of the parent, the decay energy of the daughter is included with that of the parent for the calculation of external dose factors. The symbol "+D" is appended to the parent name to indicate that the external dose factors are modified. Thus, whenever a parent nuclide release is specified, the result of the dose calculations will be as though an additional equilibrium amount of the daughter nuclide is specified. The daughter nuclide itself will appear separately in the master list if it can be released independently of the parent.

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10. APPENDIX

LISTINGS OF COMPUTER PROGRAMS AND FILES

10.1 Program ARRRG - CSTS Version

```
100 'THIS PROGRAM CALCULATES THE DOSE RESULTING FROM A WATER RELEASE OF RADIOACTIVE ISOTOPES,  JANUARY 1974
110 'FOR HELP CONTACT NORM ROBINSON,    509 942-3754
120 DIM D(136),C(136,5),H(9)          'DECAY CONSTS, PATHWAY CONCS, HOLDUP TIMES
130 DIM B(9),J(6,136),K(3,136),P(4)   'TEMPORARIES
140 DIM E(136,4),A(136,2),S(136,2)    'DOSE FACTORS FOR EATING, SHORELINE, SWIMMING
150 DIM M(9),T(50)$(60),$(132)        'MIXING RATIOS, CASE TITLES, STRING LENGTH SPEC
160 DIM R(200),Q(136,4),T(5),U(9)     'RELEASES, SUBTOTALS, TOTALS, USAGE TIME
170 DIM X(6,4),Y(3,2),Z(136)          'DOSES 1 TO 6, 7 TO 9, RECONCENTRATION FACTORS
180 DIM F(9)$(14),N(136)$(9),O(5)$(8) 'NAMES OF PATHWAY, ISOTOPE, AND ORGAN
190 'NON-DIMENSIONED VARIABLES USED IN THIS PROGRAM:
200 '    C F F1 G I I1 K K1 M M1 N O O4 R R7 S T T2 V W     A$ B$ O$ I$ P$ Q$ R$ T$ W$
210
220 REM *********************READ INITAL CONSTANTS*******************
230 I1=136
240 T2=30    'PLANT LIFE
250 FILE #2=ARGIN,#3=REL
260 GET#2, I$,I$         'SPACE PAST TITLES
270 FOR I=1 TO I1      'READ ISOTOPE NAME, DECAY CONST AND DOSE FACTORS FROM 'ARGIN'
280  INPUT#2, N(I)$,D(I),E(I,1),E(I,2),E(I,3),E(I,4),A(I,1),A(I,2),S(I,1),S(I,2)
290 NEXT I
300 GET#2, I$,I$  'SPACE PAST TITLES
310 READ F(1)$,F(2)$,F(3)$,F(4)$,F(5)$,F(6)$,F(7)$,F(8)$,F(9)$      'INPUT PATHWAY NAMES
320 READ O(1)$,O(2)$,O(3)$,O(4)$,O(5)$      'INPUT ORGAN NAMES
330 DATA FISH,CRUSTACEA,MOLLUSCS,ALGAE,NOT-USED,"DRINKING WATER",SHORELINE,SWIMMING,BOATING
340 DATA SKIN,BODY,GI-LLI,THYROID,BONE
350
360 REM *********************GET USER INPUT*************************
370 'FIND OUT REACTOR NAME FROM USER
380 OUTPUT "REACTOR NAME";
390 GET R$
400 '**GET REACTOR RELEASES FROM FILE 'REL'
410 IF END#3 GOTO 460
420 GET#3, Q$      'TRY TO MATCH THIS LINE OF 'REL' WITH REACTOR NAME
430 IF LEN(Q$)<1+LEN(R$) GOTO 410
440 IF Q$(2,LEN(R$))<>R$ GOTO 410
450 GOTO 490
460 OUTPUT "**NO "R$;" RELEASES ON FILE 'REL'**"
470 RESTORE#3
480 GOTO 380
490 FILE SCRATCH WIDTH(144,144) #1=TEMPA
500 I$=TIM
510 OUTPUT#1, " ARRRG ** ARRRG ** ARRRG ** ARRRG ** ARRRG";TAB(54)DAT;TAB(67)I$(1,5);TAB(83)"ARRRG ** ARRRG ** ARRRG ** ARRRG ** ARR
550 OUTPUT#1, "-LISTING OF "Q$;" PORTION OF REL FILE:"
560 OUTPUT#1, "0"Q$
570 MAT R=ZER
580 I=-1
590 F=1
600 GET#3, Q$
610 OUTPUT#1, " "Q$
620 G=0
630 FOR F1=0 TO LEN(Q$)-F
640  IF Q$(F+F1,I)=" " GOTO 670
650  G=1
660  GOTO 680
670  IF G>0 GOTO 710
```

10.1 Program ARRRG - CSTS Version (contd)

```
680 NEXT F1
690 IF G=0 AND F=1 GOTO 840
700 IF G=0 GOTO 590
710 IF I>=0 GOTO 770
720 IF Q$(F+F1-1,1)="T" OR Q$(F+F1-I,1)="H" GOTO 750
730 OUTPUT "**SPECIFY 'SALT' OR 'FRESH' IN REL FILE**"
740 GOTO 4110
750 W$=Q$(F,F1)
760 GOTO 810
770 IF Q$(F+F1-1,1)<>"Z" GOTO 800
780 I=I+VAL(Q$(F,F1-1))
790 GOTO 820
800 R(I+1)=VAL(Q$(F,F1))
810 I=I+1
820 F=F+F1+1
830 GOTO 620
840 IF I=I1 GOTO 870
850 OUTPUT "**I NEED TO EAT"I1;"RELEASES, BUT WAS FED"I
860 GOTO 4110
870 '**GET CONCENTRATIONS FROM 'ARGIN' -- SALT OR FRESH
880 N(0)$=B$(131,2)="  "
890 FOR I=1 TO I1
900  IF N(I)$(1,2)=N(I-1)$(1,2) GOTO 960
910  IF W$(LEN(W$),1)="H" GOTO 940
920  INPUT#2,I$,C(I,1),C(I,2),C(I,3),C(I,4),I$,I$,I$,I$     'INPUT STATEMENT FOR SALT CONCENTRATIONS
930  GOTO 1000
940  INPUT#2,I$,I$,I$,I$,I$,C(I,1),C(I,2),C(I,3),C(I,4)     'INPUT STATEMENT FOR FRESH CONCENTRATIONS
950  GOTO 1000
960  C(I,1)=C(I-1,1)
970  C(I,2)=C(I-1,2)
980  C(I,3)=C(I-1,3)                                         IF ELEMENT NAME IS UNCHANGED
990  C(I,4)=C(I-1,4)
1000 NEXT I
1010 FILE CLOSE#2, CLOSE#3
1020 K1=1
1030 OUTPUT "DOSE TO POPULATION OR INDIVIDUAL (P OR I)";
1040 GET A$
1050 IF A$="I" GOTO 1100
1060 IF A$="P" GOTO 1090
1070 OUTPUT "**TYPE P FOR POPULATION CALCULATION OR I FOR INDIVIDUAL CALCULATION**"
1080 GOTO 1030
1090 K1=.001
1100 '**GET HOLDUPS, USAGES, MIXING RATIOS FROM USER
1110 OUTPUT "ENTER HOLDUP IN HOURS, USAGES, MIXING RATIOS"
1120 ON ERROR GOTO 4060
1130 DISABLE ALL
1140 FOR F=1 TO 9
1150  IF F=5 GOTO 1180
1160  OUTPUT " "F(F)$;
1170  INPUT H(F),U(F),M(F)
1180 NEXT F
1190 '**INPUT SHORE WIDTH FACTOR, COOLANT FLOW AND RECONCENTRATION CONSTANTS
1200 IF U(7)=0 GOTO 1230
1210 OUTPUT "SHORE WIDTH FACTOR=";
1220 INPUT S
1230 OUTPUT "COOLANT FLOW IN CFS=";
1240 INPUT W
1250 C=1
```

10.1 Program ARRRG - CSTS Version (contd)

```
1260 M=V=-1
1270 OUTPUT "WHICH RECONCENTRATION FORMULA";
1280 INPUT R
1290 ON R GOTO 1320,1370,1400
1300 OUTPUT "**ENTER ONE OF THE NUMBERS 1, 2, OR 3**"
1310 GOTO 1270
1320 OUTPUT "ENTER VOLUME IN CUBIC FEET, FRACTIONAL TURNOVER RATE IN 1/DAY,","      MAKEUP FLOW IN CFS, CYCLE TIME IN HOURS";
1330 INPUT V,M1,M,C
1340 IF M<W GOTO 1400
1350 OUTPUT "**MAKEUP FLOW MUST BE LESS THAN COOLANT FLOW**"
1360 GOTO 1320
1370 OUTPUT "ENTER RECYCLE FRACTION, CYCLE TIME IN HOURS";
1380 INPUT V,C
1390 '**PRINT CONSTANTS AT TELETYPE
1400 ON ATTENTION GOTO 1580
1410 OUTPUT
1420 ON R GOTO 1430,1450,1470
1430 OUTPUT R$;"   FLOWS ARE"W;"&"M;"  VOLUME="V;"  CYCLE="C;TAB(71)"      TURNOVER="M1
1440 GOTO 1490
1450 OUTPUT R$;"   FLOW="W;"  FRACTION="V;"  CYCLE="C
1460 GOTO 1490
1470 OUTPUT R$;"   FLOW="W;"  CONSTANT RECONCENTRATION="C
1480 IF U(7)=0 GOTO 1500
1490 OUTPUT "  PLANT LIFE="T2;"YEARS   SHORE WIDTH FACTOR="S
1500 OUTPUT
1510 OUTPUT TAB(10)"HOLDUP USAGE MIXING"
1520 FOR F=1 TO 9
1530  IF U(F)=0 GOTO 1550
1540  OUTPUT F(F)$(1,(LEN(F(F)$)+9-ABS(LEN(F(F)$)-9))/2);TAB(11)H(F);TAB(17)U(F);TAB(23)M(F)
1550 NEXT F
1560 OUTPUT
1570 ON ATTENTION
1580 OUTPUT "CONSTANTS OK";
1590 GET A$
1600 IF A$(1,1)="N" GOTO 1020
1610 IF A$(1,1)="Y" GOTO 1650
1620 OUTPUT "**TYPE Y FOR YES OR N FOR NO**"
1630 GOTO 1580
1640 '**GET OUTPUT INSTRUCTIONS AND TITLE
1650 K=K+1
1660 IF K>1 GOTO 1720
1670 OUTPUT "PRINT PERCENTS AT TELETYPE";
1680 GET P$
1690 IF P$(1,1)="Y" OR P$(1,1)="N" GOTO 1720
1700 OUTPUT "**TYPE Y FOR YES OR N FOR NO**"
1710 GOTO 1670
1720 OUTPUT "ENTER TITLE FOR THIS CASE";
1730 GET T(K)$
1740 ON ERROR
1750 ENABLE
1760
1770 REM *********************CALCULATE RESULTS***********************
1780 FOR F=1 TO 9
1790  B(F)=M(F)*U(F)*KI*1119.11/W
1800 NEXT F
1810 B(7)=100*B(7)*S*LOG(2)/24
1820 B(9)=B(9)/2
1830 FOR I=1 TO I1
```

10.1 Program ARRRG - CSTS Version (contd)

```
1840  IF R(I)=0 GOTO 1990
1850  IF R=3 GOTO 1910
1860  IF R=2 GOTO 1890
1870  Z(I)=1/(1-(W-M)/(W+V*M1/86400)*EXP(-D(I)*C))
1880  GOTO 1920
1890  Z(I)=(1-(V*EXP(-D(I)*C))↑(T2*8766/C+1))/(1-V*EXP(-D(I)*C))
1900  GOTO 1920
1910  Z(I)=1
1920  FOR F=1 TO 4
1930   J(F,I)=R(I)*Z(I)*C(I,F)*B(F)*EXP(-D(I)*H(F))
1940  NEXT F
1950  J(6,I)=R(I)*Z(I)*B(6)*EXP(-D(I)*H(6))
1960  K(1,I)=R(I)*Z(I)*B(7)*EXP(-D(I)*H(7))*(1-EXP(-D(I)*T2*8766))/D(I)
1970  K(2,I)=R(I)*Z(I)*B(8)*EXP(-D(I)*H(8))
1980  K(3,I)=R(I)*Z(I)*B(9)*EXP(-D(I)*H(9))
1990 NEXT I
2000
2010 REM *********************PRINT INITIAL CONSTANTS*****************
2020 IF K>1 GOTO 2270
2030 OUTPUT#1, "1"
2040 OUTPUT#1, TAB(16)Q$;TAB(114)DAT
2050 OUTPUT#1, "0"
2060 OUTPUT#1, "0  ISOTOPE       LAMBDA     INITIAL  RECON.   CONC.       BIOACCUMULATION FACTORS, L/KG"
2070 OUTPUT#1, TAB(17)"1/HOURS    RELEASE  FACTOR    PCI/          FISH    CRUS-     MOL-    ALGAE"
2080 OUTPUT#1, TAB(28)"CI/YR               LITER";TAB(65)"TACEA   LUSCS"
2090 FOR I=1 TO I1
2100  IF R(I)=0 GOTO 2130
2110  T=R(I)*Z(I)*1119.II/W
2120  OUTPUT#1 USING 2140, I,N(I)$,D(I),R(I),Z(I),T,C(I,1),C(I,2),C(I,3),C(I,4)
2130 NEXT I
2140 : ### ######### #.##!!!!   #.##!!!! ##.##   #.##!!!!     ######  ######  ######  ######
2150 OUTPUT#1, "1"
2160 OUTPUT#1, TAB(16)Q$;TAB(114)DAT
2170 OUTPUT#1, "0"
2180 OUTPUT#1, "0                 ------------------------A D U L T   D O S E   F A C T O R S-----------------------"
2190 OUTPUT#1, "0                 ----------I N G E S T I O N-----------  -S H O R E L I N E-    -S W I M M I N G--"
2200 OUTPUT#1, "   ISOTOPE          BODY      GI-LLI     THYROID     BONE        SKIN       BODY         SKIN      BODY"
2210 FOR I=1 TO I1
2220  IF R(I)=0 GOTO 2240
2230  OUTPUT#1 USING 2250, I,N(I)$,E(I,1),E(I,2),E(I,3),E(I,4),A(I,1),A(I,2),S(I,1),S(I,2)
2240 NEXT I
2250 : ### #########  #.##!!!!  #.##!!!!  #.##!!!!  #.##!!!!    #.##!!!!  #.##!!!!    #.##!!!!  #.##!!!!
2260
2270 REM ********************CALCULATE AND PRINT PERCENTS BY ISOTOPE*******
2280 I$="     ######## #.##!!!!     "
2290 D$="---------------"
2300 OUTPUT#1, "1"
2310 OUTPUT#1, STR(K,"     CASE##:   ");Q$;"   "T(K)$;TAB(114)DAT
2320 OUTPUT#1, "0";TAB(42)"ISOTOPES CONTRIBUTING AT LEAST 4% TO DOSE"
2330 IF P$(1,1)="N" GOTO 2370
2340 OUTPUT
2350 OUTPUT "      *  *  *  ISOTOPES CONTRIBUTING AT LEAST 4%  *  *  *"
2360 OUTPUT
2370 IF U(1)+U(2)+U(3)+U(4)+U(5)+U(6)=0 GOTO 2410
2380 OUTPUT#1, "0";TAB(21)"--T O T A L  B O D Y--     -----G I - L L I------     ----T H Y R O I D-----     -------B O N E--------";
2390 IF P$(1,1)="N" GOTO 2410
2400 OUTPUT "-TOTAL BODY--   ---GI-LLI----   ---THYROID---   ----BONE-----"
2410 O4=4
```

10.1 Program ARRRG - CSTS Version (contd)

```
2420 FOR F=1 TO 6
2430  IF U(F)=0 GOTO 2570
2440  DISABLE
2450  FOR O=1 TO 4
2460   P(O)=1
2470   FOR I=1 TO I1
2480    IF R(I)=0 GOTO 2510
2490    Q(I,O)=J(F,I)*E(I,O)
2500    X(F,O)=X(F,O)+Q(I,O)
2510   NEXT I
2520   T(O+1)=T(O+1)+X(F,O)
2530  NEXT O
2540  ENABLE
2550  GOSUB 3650 '**PRINT PERCENTS BY ISOTOPE
2560  OUTPUT#1 USING I$, O(2)$;X(F,1);O(3)$;X(F,2);O(4)$;X(F,3);O(5)$;X(F,4)
2570 NEXT F
2580 IF U(7)+U(8)+U(9)=0 GOTO 2630
2590 OUTPUT#1
2600 OUTPUT#1, "0";TAB(21)"-------S K I N--------      --T O T A L  B O D Y--";
2610 IF P$(1,1)="N" GOTO 2630
2620 OUTPUT "----SKIN-----   -TOTAL BODY--"
2630 O4=2
2640 FOR F=7 TO 9
2650  IF U(F)=0 GOTO 2830
2660  F1=F-6
2670  DISABLE
2680  FOR O=1 TO 2
2690   P(O)=1
2700   FOR I=1 TO I1
2710    IF R(I)=0 GOTO 2770
2720    IF F1>1 GOTO 2750
2730    Q(I,O)=K(1,I)*A(I,O)
2740    GOTO 2760
2750    Q(I,O)=K(F1,1)*S(I,O)
2760    Y(F1,O)=Y(F1,O)+Q(I,O)
2770   NEXT I
2780   T(O)=T(O)+Y(F1,O)
2790  NEXT O
2800  ENABLE
2810  GOSUB 3650 '**PRINT PERCENTS BY ISOTOPE
2820  OUTPUT#1 USING I$, O(1)$;Y(F1,1);O(2)$;Y(F1,2)
2830 NEXT F
2840 T(3)=T(3)+Y(1,2)+Y(2,2)+Y(3,2)
2850 T(4)=T(4)+Y(1,2)+Y(2,2)+Y(3,2)
2860 T(5)=T(5)+Y(1,2)+Y(2,2)+Y(3,2)
2870
2880 REM *********************PRINT REMAINING RESULTS*********************
2890 OUTPUT#1, "1"
2900 OUTPUT#1, STR(K,"      CASE##:   ");Q$;"   "T(K)$;TAB(114)DAT
2910 OUTPUT#1, "0"
2920 OUTPUT#1, "0";TAB(17)"HOLDUP TIME    USAGE   MIXING"
2930 OUTPUT#1, TAB(20)"HOURS       PER YR    RATIO"
2940 FOR F=1 TO 9
2950  IF U(F)=0 GOTO 2980
2960  OUTPUT#1, " ";F(F)$;
2970  OUTPUT#1, TAB(24-LEN(STR(H(F))))H(F);TAB(37-LEN(STR(U(F))))U(F);TAB(46-LEN(STR(M(F))))M(F)
2980 NEXT F
2990 OUTPUT#1, "0"
```

10.1 Program ARRRG - CSTS Version (contd)

```
3000 IF U(7)=0 GOTO 3020
3010 OUTPUT#1, "0PLANT LIFE="T2;"YEARS      SHORE WIDTH FACTOR="S
3020 OUTPUT#1, "0RECONCENTRATION FORMULA NUMBER"R
3030 OUTPUT#1, "0      COOLANT FLOW TO PLANT ="W;"CUBIC FEET/SEC ="STR(8.9371E8*W," #.##!!!! LITERS/YEAR")
3040 IF V=-1 GOTO 3120
3050 IF M=-1 GOTO 3100
3060 OUTPUT#1, "0      VOLUME OF COOLING POND="V;"CUBIC FEET ="28.3*V;"LITERS"
3070 OUTPUT#1, "0      TURNOVER RATE           ="M1;"PER DAY"
3080 OUTPUT#1, "0      MAKEUP COOLANT FLOW    ="M;"CUBIC FEET/SEC ="STR(8.9371E8*M," #.##!!!! LITERS/YEAR")
3090 GOTO 3110
3100 OUTPUT#1, "0      RECYCLE FRACTION        ="V
3110 OUTPUT#1, "0      CYCLE TIME              ="C;"HOURS"
3120 OUTPUT#1, "0"
3130 OUTPUT#1, "0"
3140 IF K1=.001 GOTO 3170
3150 OUTPUT#1, "0";TAB(20)"---------DOSE TO INDIVIDUAL,  MREM/YEAR---------"
3160 GOTO 3180
3170 OUTPUT#1, "0";TAB(20)"--------DOSE TO POPULATION,  MANREM/YEAR--------"
3180 OUTPUT#1, "0";TAB(22)"SKIN       BODY      GI-LLI     THYROID     BONE"
3190 FOR F=1 TO 6
3200  IF U(F)=0 GOTO 3220
3210  OUTPUT#1 USING 3230, F(F)$," ",X(F,1),X(F,2),X(F,3),X(F,4)
3220 NEXT F
3230 : ##############    #.##!!!!  #.##!!!!  #.##!!!!  #.##!!!!  #.##!!!!
3240 FOR F=7 TO 9
3250  IF U(F)=0 GOTO 3270
3260  OUTPUT#1 USING 3230, F(F)$,Y(F-6,1),Y(F-6,2),Y(F-6,2),Y(F-6,2),Y(F-6,2)
3270 NEXT F
3280 OUTPUT#1
3290 OUTPUT#1 USING 3230, "TOTALS",T(1),T(2),T(3),T(4),T(5)
3300 '**PRINT DOSES AT TELETYPE
3310 ON ATTENTION GOTO 3520
3320 OUTPUT
3330 IF K1=.001 GOTO 3360
3340 OUTPUT "       *   *   *  INDIVIDUAL DOSE IN MREM/YR  *   *   *"
3350 GOTO 3370
3360 OUTPUT "     *   *   *  POPULATION DOSE IN MAN-REM/YR  *   *   *"
3370 OUTPUT
3380 OUTPUT TAB(15);"SKIN      BODY     GI-LLI    THYROID    BONE"
3390 :#########    #.##!!!! #.##!!!! #.##!!!! #.##!!!! #.##!!!!
3400 FOR F=1 TO 6
3410  IF U(F)=0 GOTO 3430
3420  OUTPUT USING 3390, F(F)$," ",X(F,1),X(F,2),X(F,3),X(F,4)
3430 NEXT F
3440 OUTPUT
3450 FOR F=7 TO 9
3460  IF U(F)=0 GOTO 3480
3470  OUTPUT USING 3390, F(F)$,Y(F-6,1),Y(F-6,2),Y(F-6,2),Y(F-6,2),Y(F-6,2)
3480 NEXT F
3490 OUTPUT
3500 OUTPUT USING 3390, "TOTALS",T(1),T(2),T(3),T(4),T(5)
3510 OUTPUT
3520 ON ATTENTION
3530 OUTPUT "RUN ANOTHER CASE";
3540 GET A$
3550 IF A$(1,1)="N" GOTO 4170
3560 IF A$(1,1)="Y" GOTO 3590
3570 OUTPUT "**TYPE Y FOR YES OR N FOR NO**"
```

10.1 Program ARRRG - CSTS Version (contd)

```
3580 GOTO 3530
3590 MAT T=ZER
3600 MAT X=ZER
3610 MAT Y=ZER
3620 OUTPUT
3630 GOTO 1020
3640
3650'BEGIN SUBROUTINE *******PRINTS PERCENTS BY ISOTOPE AT PRINTER***********
3660 OUTPUT#1
3670 OUTPUT#1 USING 4020, D$(1,LEN(F(F)$))
3680 OUTPUT#1 USING 4020, F(F)$;
3690 IF P$(1,1)="N" GOTO 3710
3700 OUTPUT F(F)$
3710 IF F<9 OR H(8)<>H(9) GOTO 3770
3720 OUTPUT#1 USING "SAME AS SWIMMING"
3730 IF P$(1,1)="N" GOTO 4030
3740 OUTPUT TAB(9)"SAME AS SWIMMING"
3750 GOTO 4030
3760 OUTPUT#1 USING 4020, "";
3770 N=0
3780 FOR O=1 TO O4
3790  FOR I=P(O) TO I1
3800   IF F>6 GOTO 3840
3810   IF Q(I,O)<=.04*X(F,O) GOTO 3870
3820   R7=100*Q(I,O)/X(F,O)
3830   GOTO 3920
3840   IF Q(I,O)<=.04*Y(F1,O) GOTO 3870
3850   R7=100*Q(I,O)/Y(F1,O)
3860   GOTO 3920
3870  NEXT I
3880  OUTPUT#1 USING I$, "","";
3890  IF P$(1,1)="N" GOTO 3960
3900  OUTPUT USING B$(1,16);
3910  GOTO 3960
3920  OUTPUT#1 USING "     ######## #.##!!!! ###%", N(I)$,Q(I,O),R7;
3930  IF P$(1,1)="N" GOTO 3950
3940  OUTPUT USING "######## ###%   ", N(I)$,R7;
3950  N=N+1
3960  P(O)=I+1
3970 NEXT O
3980 OUTPUT#1 USING ""
3990 IF P$(1,1)="N" GOTO 4010
4000 OUTPUT USING ""
4010 IF N>0 GOTO 3760
4020 : ##############
4030 OUTPUT#1 USING "          TOTALS";
4040RETURN
4050
4060 OUTPUT "**TILT**  ";
4070 T=ESL-10
4080 ON ERROR GOTO 4060
4090 JUMP T
4100
4110 REM ********************FINISH THE RUN********************
4120 '**ABORT TEMPA FILE
4130 DISABLE
4140 FILE
4150 REMOVE TEMPA
```

10.1 Program ARRRG - CSTS Version (contd)

```
4160 GOTO 4320
4170 '**SUBMIT FILE TO HIGH-SPEED TERMINAL FOR LISTING
4180 OUTPUT#1, "1S U M M A R Y   O F   R U N          "Q$

4200 FOR C=1 TO K
4210  OUTPUT#1, STR(C,"0CASE##:   ");T(C)$
4220 NEXT C
4230 I$=TIM
4250 OUTPUT#1, "-ARRRG ** ARRRG ** ARRRG ** ARRRG ** ARRRG";TAB(54)DAT;TAB(67)I$(1,5);TAB(83)"ARRRG ** ARRRG ** ARRRG ** ARRRG ** AR
4260 OUTPUT#1, "1MAIL TO:  NM ROBINSON, 3717 BLDG, 300 AREA, RICHLAND, WASHINGTON  99352"
4270 DISABLE
4280 FILE
4290 SUBMIT TEMPA,A=LISTBCC
4300 REMOVE TEMPA
4310 OUTPUT
4320 ENABLE
```

10.2 Program ARRRG - CSCX Version

```
100 'THIS PROGRAM CALCULATES THE DOSE RESULTING FROM A WATER RELEASE OF RADIOACTIVE ISOTOPES,  APRIL 1973
110 'FOR HELP CONTACT NORM ROBINSON,    509 942-3754
120 DIM D(136),C(136,5),H(9)            'DECAY CONSTS, PATHWAY CONCS, HOLDUP TIMES
130 DIM B(9),J(6,136),K(3,136),P(4)     'TEMPORARIES
140 DIM E(136,4),A(136,2),S(136,2)      'DOSE FACTORS FOR EATING, SHORELINE, SWIMMING
150 DIM M(9),T(50)$(60),$(132)          'MIXING RATIOS, CASE TITLES, STRING LENGTH SPEC
160 DIM R(200),G(136,4),T(5),U(9)       'RELEASES, SUBTOTALS, TOTALS, USAGE TIME
170 DIM X(6,4),Y(3,2),Z(136)            'DOSES 1 TO 6, 7 TO 9, RECONCENTRATION FACTORS
180 DIM F(9)$(14),N(136)$(9),O(5)$(8)  'NAMES OF PATHWAY, ISOTOPE, AND ORGAN
190 'NON-DIMENSIONED VARIABLES USED IN THIS PROGRAM:
200 '    C F F1 G I I1 K K1 M M1 N O O4 R R7 S T T2 V W     A$ B$ D$ I$ P$ Q$ R$ T$ W$
210
220 REM ********************READ INITAL CONSTANTS******************
230 I1=136
240 T2=30    'PLANT LIFE
250 FILL #2=ARGIN,#3=REL
260 GET#2, I$,I$          'SPACE PAST TITLES
270 FOR I=1 TO I1       'READ ISOTOPE NAME, DECAY CONST AND DOSE FACTORS FROM 'ARGIN'
280  INPUT#2, N(I)$,D(I),E(I,1),E(I,2),E(I,3),E(I,4),A(I,1),A(I,2),S(I,1),S(I,2)
290 NEXT I
300 GET#2, I$   'SPACE PAST TITLES
310 READ F(1)$,F(2)$,F(3)$,F(4)$,F(5)$,F(6)$,F(7)$,F(8)$,F(9)$      'INPUT PATHWAY NAMES
320 READ O(1)$,O(2)$,O(3)$,)(4)$,O(5)$       'INPUT ORGAN NAMES
330 DATA FISH,CRUSTACEA,MOLLUSCS,ALGAE,NOT-USED,"DRINKING WATER",SHORELINE,SWIMMING,BOATING
340 DATA SKIN,BODY,GI-LLI,THYROID,BONE
350
360 REM ********************GET USER INPUT************************
370 WIDTH 132
380 'FIND OUT REACTOR NAME FROM USER
390 OUTPUT "REACTOR NAME";
400 GET R$
410 '**GET REACTOR RELEASES FROM FILE 'REL'
420 IF END#3 GOTO 470
430 GET#3, Q$      'TRY TO MATCH THIS LINE OF 'REL' WITH REACTOR NAME
440 IF LEN(Q$)<1+LEN(R$) GOTO 420
450 IF Q$(2,LEN(R$))<>R$ GOTO 420
460 GOTO 500
470 OUTPUT "**NO "R$;" RELEASES ON FILE 'REL'**"
480 RESTORE#3
490 GOTO 390
500 FOR I=0 TO 9          'FIND UNUSED TEMPX FILE
510  T$=EDT(STR(I),"TEMP#")
520  FILE #1=T$
530  IF END#1 GOTO 590
540  GET#1, A$(1,121)
550  IF A$(114)<>DAT GOTO 590
560 NEXT I
570 OUTPUT "**TOO MANY WAITING RUNS - TRY AGAIN LATER**"
```

10.2 Program ARRRG - CSCX Version (contd)

```
580 GOTO 4190
590 FILE SCRATCH#1=T$      'RESERVE PRINT FILE
600 OUTPUT#1, TAB(114)DAT
610 DISABLE
620 FILE SCRATCH#1=T$
630 ENABLE
640 OUTPUT#1, ¤1¤;TAB(16)Q$;TAB(114)DAT
650 OUTPUT#1, ¤0¤
660 OUTPUT#1, ¤0LISTING OF ¤Q$;¤ PORTION OF REL FILE:¤
670 OUTPUT#1, ¤0¤Q$
680 MAT R=ZER
690 I=-1
700 F=1
710 GET#3, Q$
720 OUTPUT#1, ¤ ¤Q$
730 G=0
740 FOR F1=0 TO LEN(Q$)-F
750  IF Q$(F+F1,1)=¤ ¤ GOTO 780
760  G=1
770  GOTO 790
780  IF G>0 GOTO 820
790 NEXT F1
800 IF G=0 AND F=1 GOTO 950
810 IF G=0 GOTO 700
820 IF I>=0 GOTO 880
830 IF Q$(F+F1-1,1)=¤T¤ OR Q$(F+F1-1,1)=¤H¤ GOTO 860
840 OUTPUT ¤**SPECIFY 'SALT' OR 'FRESH' IN REL FILE**¤
850 GOTO 4190
860 W$=Q$(F,F1)
870 GOTO 920
880 IF Q$(F+F1-1,1)<>¤Z¤ GOTO 910
890 I=1+VAL(Q$(F,F1-1))
900 GOTO 930
910 R(I+1)=VAL(Q$(F,F1))
920 I=I+1
930 F=F+F1+1
940 GOTO 730
950 IF I=I1 GOTO 980
960 OUTPUT ¤**I NEED TO EAT¤I1;¤RELEASES, BUT WAS FED¤I
970 GOTO 4190
980 '**GET CONCENTRATIONS FROM 'ARGIN' -- SALT OR FRESH
990 N(0)$=B$(131,2)=¤  ¤
1000 FOR I=1 TO I1
1010  IF N(I)$(1,2)=N(I-1)$(1,2) GOTO 1070
1020  IF W$(LEN(W$),1)=¤H¤ GOTO 1050
1030  INPUT#2,I$,C(I,1),C(I,2),C(I,3),C(I,4),I$,I$,I$,I$     'INPUT STATEMENT FOR SALT CONCENTRATIONS
1040  GOTO 1100
1050  INPUT#2,I$,I$,I$,I$,I$,C(I,1),C(I,2),C(I,3),C(I,4)     'INPUT STATEMENT FOR FRESH CONCENTRATIONS
1060  GOTO 1100
1070  FOR F=1 TO 4
1080   C(I,F)=C(I-1,F)                                       'INPUT STATEMENT IF ELEMENT NAME IS UNCHANGED
1090  NEXT F
1100 NEXT I
1110 K1=1
1120 OUTPUT ¤DOSE TO POPULATION OR INDIVIDUAL (P OR I)¤;
1130 GET A$
1140 IF A$=¤I¤ GOTO 1190
1150 IF A$=¤P¤ GOTO 1180
1160 OUTPUT ¤**TYPE P FOR POPULATION CALCULATION OR I FOR INDIVIDUAL CALCULATION**¤
```

10.2 Program ARRRG - CSCX Version (contd)

```
1170 GOTO 1120
1180 K1=.001
1190 '**GET HOLDUPS, USAGES, MIXING RATIOS FROM USER
1200 OUTPUT "ENTER HOLDUP IN HOURS, USAGES, MIXING RATIOS"
1210 ON ERROR GOTO 4140
1220 DISABLE ALL
1230 FOR F=1 TO 9
1240  IF F=5 GOTO 1270
1250  OUTPUT " "F(F)$;
1260  INPUT H(F),U(F),M(F)
1270 NEXT F
1280 '**INPUT SHORE WIDTH FACTOR, COOLANT FLOW AND RECONCENTRATION CONSTANTS
1290 IF U(7)=0 GOTO 1320
1300 OUTPUT "SHORE WIDTH FACTOR="; 
1310 INPUT S
1320 OUTPUT "COOLANT FLOW IN CFS=";
1330 INPUT W
1335 C=1
1340 M=V=-1
1350 OUTPUT "WHICH RECONCENTRATION FORMULA";
1360 INPUT R
1370 ON R GOTO 1400,1450,1480
1380 OUTPUT "**ENTER ONE OF THE NUMBERS 1, 2, OR 3**"
1390 GOTO 1350
1400 OUTPUT "ENTER VOLUME IN CUBIC FEET, FRACTIONAL TURNOVER RATE IN 1/DAY,","      MAKEUP FLOW IN CFS, CYCLE TIME IN HOURS"
        ;
1410 INPUT V,M1,M,C
1420 IF M<W GOTO 1480
1430 OUTPUT "**MAKEUP FLOW MUST BE LESS THAN COOLANT FLOW**"
1440 GOTO 1400
1450 OUTPUT "ENTER RECYCLE FRACTION, CYCLE TIME IN HOURS";
1460 INPUT V,C
1470 '**PRINT CONSTANTS AT TELETYPE
1480 ON ATTENTION GOTO 1660
1490 OUTPUT
1500 ON R GOTO 1510,1530,1550
1510 OUTPUT R$;"   FLOWS ARE"W;"&"M;"  VOLUME="V;"  CYCLE="C;TAB(71)"       TURNOVER="M1
1520 GOTO 1570
1530 OUTPUT R$;"   FLOW="W;"  FRACTION="V;"  CYCLE="C
1540 GOTO 1570
1550 OUTPUT R$;"   FLOW="W;"  CONSTANT RECONCENTRATION="C
1560 IF U(7)=0 GOTO 1580
1570 OUTPUT "  PLANT LIFE="T2;"YEARS   SHORE WIDTH FACTOR="S
1580 OUTPUT
1590 OUTPUT TAB(10)"HOLDUP USAGE MIXING"
1600 FOR F=1 TO 9
1610  IF U(F)=0 GOTO 1630
1620  OUTPUT F(F)$(1,(LEN(F(F)$)+9-ABS(LEN(F(F)$)-9))/2);TAB(11)H(F);TAB(17)U(F);TAB(23)M(F)
1630 NEXT F
1640 OUTPUT
1650 ON ATTENTION
1660 OUTPUT "CONSTANTS OK";
1670 GET A$
1680 IF A$(1,1)="N" GOTO 1110
1690 IF A$(1,1)="Y" GOTO 1730
1700 OUTPUT "**TYPE Y FOR YES OR N FOR NO**"
1710 GOTO 1660
1720 '**GET OUTPUT INSTRUCTIONS AND TITLE
1730 K=K+1
```

10.2 Program ARRRG - CSCX Version (contd)

```
1740 IF K>1 GOTO 1800
1750 OUTPUT ¤PRINT PERCENTS AT TELETYPE¤;
1760 GET P$
1770 IF P$(1,1)=¤Y¤ OR P$(1,1)=¤N¤ GOTO 1800
1780 OUTPUT ¤**TYPE Y FOR YES OR N FOR NO**¤
1790 GOTO 1750
1800 OUTPUT ¤ENTER TITLE FOR THIS CASE¤;
1810 GET T(K)$
1820 ON ERROR
1830 ENABLE
1840
1850 REM ********************CALCULATE RESULTS***********************
1860 FOR F=1 TO 9
1870  B(F)=M(F)*U(F)*K1*1119.11/W
1880 NEXT F
1890 B(7)=100*B(7)*S*LOG(2)/24
1900 B(9)=B(9)/2
1910 FOR I=1 TO I1
1920  IF R(I)=0 GOTO 2070
1930  IF R=3 GOTO 1990
1940  IF R=2 GOTO 1970
1950  Z(I)=1/(1-(W-M)/(W+V*M1/86400)*EXP(-D(I)*C))
1960  GOTO 2000
1970  Z(I)=(1-(V*EXP(-D(I)*C))Δ(T2*8766/C+1))/(1-V*EXP(-D(I)*C))
1980  GOTO 2000
1990  Z(I)=1
2000  FOR F=1 TO 4
2010   J(F,I)=R(I)*Z(I)*C(I,F)*B(F)*EXP(-D(I)*H(F))
2020  NEXT F
2030  J(6,I)=R(I)*Z(I)*B(6)*EXP(-D(I)*H(6))
2040  K(1,I)=R(I)*Z(I)*B(7)*EXP(-D(I)*H(7))*(1-EXP(-D(I)*T2*8766))/D(I)
2050  K(2,I)=R(I)*Z(I)*B(8)*EXP(-D(I)*H(8))
2060  K(3,I)=R(I)*Z(I)*B(9)*EXP(-D(I)*H(9))
2070 NEXT I
2080
2090 REM ********************PRINT INITIAL CONSTANTS*****************
2100 IF K>1 GOTO 2350
2110 OUTPUT#1, ¤1¤
2120 OUTPUT#1, TAB(16)Q$;TAB(114)DAT
2130 OUTPUT#1, ¤0¤
2140 OUTPUT#1, ¤0  ISOTOPE      LAMBDA    INITIAL  RECON.   CONC.        BIOACCUMULATION FACTORS, L/KG¤
2150 OUTPUT#1, TAB(17)¤1/HOURS   RELEASE  FACTOR   PCI/        FISH   CRUS-     MOL-    ALGAE¤
2160 OUTPUT#1, TAB(28)¤CI/YR              LITER¤;TAB(65)¤TACEA   LUSCS¤
2170 FOR I=1 TO I1
2180  IF R(I)=0 GOTO 2210
2190  T=R(I)*Z(I)*1119.11/W
2200  OUTPUT#1 USING 2220, I,N(I)$,D(I),R(I),Z(I),T,C(I,1),C(I,2),C(I,3),C(I,4)
2210 NEXT I
2220 : ### #########  #.##!!!!   #.##!!!! ##.##   #.##!!!!     ######  ######  ######  ######
2230 OUTPUT#1, ¤1¤
2240 OUTPUT#1, TAB(16)Q$;TAB(114)DAT
2250 OUTPUT#1, ¤0¤
2260 OUTPUT#1, ¤0              -----------------------A D U L T   D O S E   F A C T O R S----------------------¤
2270 OUTPUT#1, ¤0              ----------I N G E S T I O N-----------  -S H O R E L I N E-   -S W I M M I N G--¤
2280 OUTPUT#1, ¤  ISOTOPE       BODY     GI-LLI    THYROID    BONE       SKIN      BODY       SKIN      BODY¤
2290 FOR I=1 TO I1
2300  IF R(I)=0 GOTO 2320
2310  OUTPUT#1 USING 2330, I,N(I)$,E(I,1),E(I,2),E(I,3),E(I,4),A(I,1),A(I,2),S(I,1),S(I,2)
2320 NEXT I
```

10.2 Program ARRRG - CSCX Version (contd)

```
2330 : ### ######### #.##!!!! #.##!!!! #.##!!!! #.##!!!!   #.##!!!! #.##!!!!   #.##!!!! #.##!!!!
2340
2350 REM *******************CALCULATE AND PRINT PERCENTS BY ISOTOPE*******
2360 I$="     ####### #.##!!!!     "
2370 D$="---------------"
2380 OUTPUT#1, "1"
2390 OUTPUT#1, STR(K,"     CASE##:   ");G$;"   "T(K)$;TAB(114)DAT
2400 OUTPUT#1, "0";TAB(42)"ISOTOPES CONTRIBUTING AT LEAST 4% TO DOSE"
2410 IF P$(1,1)="N" GOTO 2450
2420 OUTPUT
2430 OUTPUT "     *  *  *  ISOTOPES CONTRIBUTING AT LEAST 4%  *  *  *"
2440 OUTPUT
2450 IF U(1)+U(2)+U(3)+U(4)+U(5)+U(6)=0 GOTO 2490
2460 OUTPUT#1, "0";TAB(21)"--T O T A L  B O D Y--     -----G I - L L I-----     ----T H Y R O I D-----     -------B O N E--
     ------";
2470 IF P$(1,1)="N" GOTO 2490
2480 OUTPUT "-TOTAL BODY--   ---GI-LLI----   ---THYROID---   ----BONE-----"
2490 U4=4
2500 FOR F=1 TO 6
2510  IF U(F)=0 GOTO 2650
2520  DISABLE
2530  FOR O=1 TO 4
2540   P(O)=1
2550   FOR I=1 TO I1
2560    IF R(I)=0 GOTO 2590
2570    Q(I,O)=J(F,I)*E(I,O)
2580    X(F,O)=X(F,O)+Q(I,O)
2590   NEXT I
2600   T(O+1)=T(O+1)+X(F,O)
2610  NEXT O
2620  ENABLE
2630  GOSUB 3730 '**PRINT PERCENTS BY ISOTOPE
2640  OUTPUT#1 USING I$, O(2)$;X(F,1);O(3)$;X(F,2);O(4)$;X(F,3);O(5)$;X(F,4)
2650 NEXT F
2660 IF U(7)+U(8)+U(9)=0 GOTO 2710
2670 OUTPUT#1
2680 OUTPUT#1, "0";TAB(21)"-------S K I N--------     --T O T A L  B O D Y--";
2690 IF P$(1,1)="N" GOTO 2710
2700 OUTPUT "----SKIN-----   -TOTAL BODY--"
2710 U4=2
2720 FOR F=7 TO 9
2730  IF U(F)=0 GOTO 2910
2740  F1=F-6
2750  DISABLE
2760  FOR O=1 TO 2
2770   P(O)=1
2780   FOR I=1 TO I1
2790    IF R(I)=0 GOTO 2850
2800    IF F1>1 GOTO 2830
2810    Q(I,O)=K(1,I)*A(I,O)
2820    GOTO 2840
2830    Q(I,O)=K(F1,I)*S(I,O)
2840    Y(F1,O)=Y(F1,O)+Q(I,O)
2850   NEXT I
2860   T(O)=T(O)+Y(F1,O)
2870  NEXT O
2880  ENABLE
2890  GOSUB 3730 '**PRINT PERCENTS BY ISOTOPE
2900  OUTPUT#1 USING I$, O(1)$;Y(F1,1);O(2)$;Y(F1,2)
```

10.2 Program ARRRG - CSCX Version (contd)

```
2910 NEXT F
2920 T(3)=T(3)+Y(1,2)+Y(2,2)+Y(3,2)
2930 T(4)=T(4)+Y(1,2)+Y(2,2)+Y(3,2)
2940 T(5)=T(5)+Y(1,2)+Y(2,2)+Y(3,2)
2950
2960 REM *********************PRINT REMAINING RESULTS*********************
2970 OUTPUT#1, ¤1¤
2980 OUTPUT#1, STR(K,¤     CASE##:    ¤);Q$;¤    ¤T(K)$;TAB(114)DAT
2990 OUTPUT#1, ¤0¤
3000 OUTPUT#1, ¤0¤;TAB(17)¤HOLDUP TIME    USAGE   MIXING¤
3010 OUTPUT#1, TAB(20)¤HOURS       PER YR    RATIO¤
3020 FOR F=1 TO 9
3030  IF U(F)=0 GOTO 3060
3040  OUTPUT#1, ¤ ¤;
3050  OUTPUT#1, F(F)$;TAB(24-LEN(STR(H(F))))H(F);TAB(37-LEN(STR(U(F))))U(F);TAB(46-LEN(STR(M(F))))M(F)
3060 NEXT F
3070 OUTPUT#1, ¤0¤
3080 IF U(7)=0 GOTO 3100
3090 OUTPUT#1, ¤0PLANT LIFE=¤T2;¤YEARS      SHORE WIDTH FACTOR=¤S
3100 OUTPUT#1, ¤0RECONCENTRATION FORMULA NUMBER¤R
3110 OUTPUT#1, ¤0      COOLANT FLOW TO PLANT =¤W;¤CUBIC FEET/SEC =¤STR(8.937₁E8*W,¤ #.##!!!! LITERS/YEAR¤)
3120 IF V=-1 GOTO 3200
3130 IF M=-1 GOTO 3180
3140 OUTPUT#1, ¤0      VOLUME OF COOLING POND=¤V;¤CUBIC FEET =¤28.3*V;¤LITERS¤
3150 OUTPUT#1, ¤0      TURNOVER RATE            =¤M1;¤PER DAY¤
3160 OUTPUT#1, ¤0      MAKEUP COOLANT FLOW      =¤M;¤CUBIC FEET/SEC =¤STR(8.937₁E8*M,¤ #.##!!!! LITERS/YEAR¤)
3170 GOTO 3190
3180 OUTPUT#1, ¤0      RECYCLE FRACTION         =¤V
3190 OUTPUT#1, ¤0      CYCLE TIME               =¤C;¤HOURS¤
3200 OUTPUT#1, ¤0¤
3210 OUTPUT#1, ¤0¤
3220 IF K1=.001 GOTO 3250
3230 OUTPUT#1, ¤0¤;TAB(20)¤---------DOSE TO INDIVIDUAL,  MREM/YEAR---------¤
3240 GOTO 3260
3250 OUTPUT#1, ¤0¤;TAB(20)¤--------DOSE TO POPULATION,  MANREM/YEAR--------¤
3260 OUTPUT#1, ¤0¤;TAB(22)¤SKIN       BODY      GI-LLI      THYROID     BONE¤
3270 FOR F=1 TO 6
3280  IF U(F)=0 GOTO 3300
3290  OUTPUT#1 USING 3310, F(F)$,¤ ¤,X(F,1),X(F,2),X(F,3),X(F,4)
3300 NEXT F
3310 : #############    #.##!!!!  #.##!!!!  #.##!!!!  #.##!!!!  #.##!!!!
3320 FOR F=7 TO 9
3330  IF U(F)=0 GOTO 3350
3340  OUTPUT#1 USING 3310, F(F)$,Y(F-6,1),Y(F-6,2),Y(F-6,2),Y(F-6,2),Y(F-6,2)
3350 NEXT F
3360 OUTPUT#1
3370 OUTPUT#1 USING 3310, ¤TOTALS¤,T(1),T(2),T(3),T(4),T(5)
3380 '**PRINT DOSES AT TELETYPE
3390 ON ATTENTION GOTO 3600
3400 OUTPUT
3410 IF K1=.001 GOTO 3440
3420 OUTPUT ¤       *  *  *  INDIVIDUAL DOSE IN MREM/YR  *  *  *¤
3430 GOTO 3450
3440 OUTPUT ¤     *  *  *  POPULATION DOSE IN MAN-REM/YR  *  *  *¤
3450 OUTPUT
3460 OUTPUT TAB(15);¤SKIN      BODY     GI-LLI    THYROID    BONE¤
3470 :#########    #.##!!!! #.##!!!! #.##!!!! #.##!!!! #.##!!!!
3480 FOR F=1 TO 6
3490  IF U(F)=0 GOTO 3510
```

10.2 Program ARRRG - CSCX Version (contd)

```
3500  OUTPUT USING 3470, F(F)$,¤ ¤,X(F,1),X(F,2),X(F,3),X(F,4)
3510 NEXT F
3520 OUTPUT
3530 FOR F=7 TO 9
3540  IF U(F)=0 GOTO 3560
3550  OUTPUT USING 3470, F(F)$,Y(F-6,1),Y(F-6,2),Y(F-6,2),Y(F-6,2),Y(F-6,2)
3560 NEXT F
3570 OUTPUT
3580 OUTPUT USING 3470, ¤TOTALS¤,T(1),T(2),T(3),T(4),T(5)
3590 OUTPUT
3600 ON ATTENTION
3610 OUTPUT ¤RUN ANOTHER CASE¤;
3620 GET A$
3630 IF A$(1,1)=¤N¤ GOTO 4250
3640 IF A$(1,1)=¤Y¤ GOTO 3670
3650 OUTPUT ¤**TYPE Y FOR YES OR N FOR NO**¤
3660 GOTO 3610
3670 MAT T=ZER
3680 MAT X=ZER
3690 MAT Y=ZER
3700 OUTPUT
3710 GOTO 1110
3720
3730'BEGIN SUBROUTINE *******PRINTS PERCENTS BY ISOTOPE AT PRINTER**********
3740 OUTPUT#1
3750 OUTPUT#1 USING 4100, D$(1,LEN(F(F)$))
3760 OUTPUT#1 USING 4100, F(F)$;
3770 IF P$(1,1)=¤N¤ GOTO 3790
3780 OUTPUT F(F)$
3790 IF F<9 OR H(8)<>H(9) GOTO 3850
3800 OUTPUT#1 USING ¤SAME AS SWIMMING¤
3810 IF P$(1,1)=¤N¤ GOTO 4110
3820 OUTPUT TAB(9)¤SAME AS SWIMMING¤
3830 GOTO 4110
3840 OUTPUT#1 USING 4100, ¤¤;
3850 N=0
3860 FOR O=1 TO O4
3870  FOR I=P(O) TO I1
3880   IF F>6 GOTO 3920
3890   IF Q(I,O)<=.04*X(F,O) GOTO 3950
3900   R7=100*Q(I,O)/X(F,O)
3910   GOTO 4000
3920   IF Q(I,O)<=.04*Y(F1,O) GOTO 3950
3930   R7=100*Q(I,O)/Y(F1,O)
3940   GOTO 4000
3950  NEXT I
3960  OUTPUT#1 USING I$, ¤¤,¤¤;
3970  IF P$(1,1)=¤N¤ GOTO 4040
3980  OUTPUT USING B$(1,16);
3990  GOTO 4040
4000  OUTPUT#1 USING ¤     ######## #.##!!!! ###%¤, N(I)$,Q(I,O),R7;
4010  IF P$(1,1)=¤N¤ GOTO 4030
4020  OUTPUT USING ¤######## ###%   ¤, N(I)$,R7;
4030  N=N+1
4040  P(O)=I+1
4050 NEXT O
4060 OUTPUT#1 USING ¤¤
4070 IF P$(1,1)=¤N¤ GOTO 4090
4080 OUTPUT USING ¤¤
```

10.2 Program ARRRG - CSCX Version (contd)

```
4090 IF N>0 GOTO 3840
4100 : ##############
4110 OUTPUT#1 USING ¤         TOTALS¤;
4120RETURN
4130
4140 OUTPUT ¤**TILT**  ¤;
4150 T=ESL-10
4160 ON ERROR GOTO 4140
4170 JUMP T
4180
4190 REM *******************FINISH THE RUN*****************
4200 '**ABORT TEMPX FILE
4210 DISABLE
4220 FILE
4230 REMOVE T$
4240 GOTO 4410
4250 '**CREATE A CRJE RUN TO PRINT RESULTS AT HIGH-SPEED TERMINAL
4260 OUTPUT#1, ¤1¤
4270 FILE SCRATCH#4=PSUB
4280 I$=TIM
4290 OUTPUT#4, ¤ @ RUN,S ARRRG¤T$(5);¤,¤UID;¤,,¤PID;¤,20,2000¤;TAB(42)¤DL HAGGARD¤;TAB(62)¤3717 BLDG  942-5282¤
4300 OUTPUT#4, ¤ @PRL TEL CUB600¤;TAB(32)DAT;¤  ¤I$(1,5);TAB(82-LEN(R$))R$
4310 FOR C=1 TO K
4320  OUTPUT#4, STR(C,¤ @N MSG    CASE##:   ¤);Q$;¤ ¤T(C)$
4330 NEXT C
4340 OUTPUT#4, ¤ @DLN CPY ¤UID;¤,¤T$
4350 OUTPUT#4, ¤ @ APR ¤UID;¤//¤T$
4360 DISABLE
4370 FILE
4380 SUBMIT PSUB
4390 REMOVE PSUB
4400 OUTPUT
4410 ENABLE
```

10.3 File ARGIN

100	ISOTOPE	DECAY	-----INGESTION DOSE FACTORS------				-SHORELINE DF-		-SWIMMING DF-	
110		CONSTANT	BODY	GI-LLI	THYROID	BONE	SKIN	BODY	SKIN	BODY
120	H-3	6.43E-6	1.27E-7	6.40E-8	1.27E-7	0	0	0	0	0
130	C-14	1.38E-8	5.29E-7	3.20E-7	5.29E-7	2.64E-6	0	0	3.8E-9	0
140	N-13	4.16	0	0	0	0	8.8E-9	7.6E-9	2.6E-6	1.9E-6
150	F-18	3.75E-1	7.00E-8	1.93E-8	0	6.30E-7	8.0E-9	6.8E-9	2.3E-6	1.8E-6
160	NA-22	3.04E-5	1.77E-5	3.26E-6	1.77E-5	1.77E-5	1.8E-8	1.6E-8	4.8E-6	4.0E-6
170	NA-24	4.62E-2	1.71E-6	3.73E-6	1.71E-6	1.71E-6	2.9E-8	2.5E-8	9.3E-6	7.8E-6
180	P-32	2.02E-3	7.44E-6	2.15E-5	0	1.93E-4	0	0	6.8E-7	6.4E-9
190	AR-39	2.94E-7	0	0	0	0	0	0	1.3E-7	6.2E-10
200	AR-41	3.79E-1	0	0	0	0	0	0	3.2E-6	2.4E-6
210	SC-46	3.44E-4	3.07E-9	5.10E-5	0	5.26E-9	1.5E-8	1.3E-8	4.3E-6	3.7E-6
220	CR-51	1.04E-3	2.67E-9	6.69E-7	1.59E-9	0	2.6E-10	2.2E-10	6.4E-8	5.2E-8
230	MN-54	9.53E-5	8.68E-7	1.38E-5	0	0	6.8E-9	5.8E-9	1.8E-6	1.5E-6
240	MN-56	2.69E-1	2.04E-8	3.66E-6	0	0	1.3E-8	1.1E-8	4.6E-6	3.2E-6
250	FE-55	3.04E-5	1.48E-7	8.41E-7	0	6.78E-7	0	0	3.6E-10	6.4E-11
260	FE-59	6.42E-4	3.68E-6	3.31E-5	0	4.12E-6	9.4E-9	8.0E-9	2.6E-6	2.2E-6
270	CO-57	1.07E-4	2.92E-7	4.47E-6	0	0	1.0E-9	9.1E-10	2.7E-7	2.2E-7
280	CO-58	4.05E-4	1.68E-6	1.52E-5	0	0	8.2E-9	7.0E-9	2.3E-6	1.8E-6
290	CO-60	1.50E-5	4.70E-6	3.94E-5	0	0	2.0E-8	1.7E-8	5.4E-6	4.6E-6
300	NI-63	8.60E-7	1.20E-6	1.61E-6	0	3.02E-5	0	0	0	0
310	NI-65	2.71E-1	3.22E-8	1.90E-6	0	5.46E-7	4.3E-9	3.7E-9	1.9E-6	1.0E-6
320	CU-64	5.42E-2	3.91E-8	6.85E-6	0	0	1.7E-9	1.5E-9	5.2E-7	3.7E-7
330	ZN-65	1.18E-4	5.08E-6	9.78E-6	0	3.46E-6	4.6E-9	4.0E-9	1.2E-6	1.1E-6
340	ZN-69M+D	5.02E-2	3.65E-8	2.40E-5	0	1.65E-7	3.4E-9	2.9E-9	1.2E-6	7.5E-7
350	ZN-69	7.29E-1	1.34E-9	2.90E-9	0	1.00E-8	0	0	2.8E-7	1.6E-9
360	BR-82	1.96E-2	2.34E-6	2.53E-6	0	0	2.2E-8	1.9E-8	6.3E-6	5.3E-6
370	BR-83+D	2.89E-1	3.87E-8	5.61E-8	0	0	9.3E-11	6.4E-11	3.1E-7	1.7E-8
380	BR-84	1.31	5.26E-8	4.15E-13	0	0	1.4E-8	1.2E-8	5.3E-6	3.5E-6
390	BR-85	13.9	2.29E-9	0	0	0	0	0	1.1E-6	1.4E-8
400	KR-83M	3.73E-1	0	0	0	0	0	0	7.9E-9	3.1E-9
410	KR-85M	1.58E-1	0	0	0	0	0	0	5.1E-7	2.8E-7
420	KR-85	7.35E-6	0	0	0	0	0	0	1.8E-7	4.7E-9
430	KR-87	5.47E-1	0	0	0	0	0	0	4.6E-6	2.7E-6
440	KR-88	2.47E-1	0	0	0	0	0	0	4.1E-6	3.3E-6
450	RB-86	1.55E-3	1.00E-5	4.27E-6	0	0	7.2E-10	6.3E-10	8.5E-7	1.7E-7
460	RB-88	2.33	3.26E-8	0	0	0	4.0E-9	3.5E-9	3.6E-6	1.2E-6
470	RB-89	2.70	2.86E-8	0	0	0	1.8E-8	1.5E-8	5.8E-6	4.5E-6
480	SR-89	5.55E-4	9.13E-6	4.98E-5	0	3.20E-4	6.5E-13	5.6E-13	5.4E-7	4.6E-9
490	SR-90	2.80E-6	8.95E-5	1.23E-4	0	3.36E-4	0	0	1.5E-7	5.4E-10
500	SR-90D	2.80E-6	2.65E-10	1.05E-4	0	9.86E-9	2.6E-12	2.2E-12	9.6E-7	1.3E-8
510	SR-91	7.17E-2	2.43E-7	2.87E-5	0	5.82E-6	8.3E-9	7.1E-9	2.9E-6	1.9E-6
520	SR-92	2.56E-1	9.35E-8	4.31E-5	0	2.16E-6	1.0E-8	9.0E-9	3.1E-6	2.6E-6
530	Y-90	1.08E-2	2.65E-10	1.05E-4	0	9.86E-9	2.6E-12	2.2E-12	9.6E-7	1.3E-8
540	Y-91M	8.32E-1	3.48E-12	2.91E-10	0	8.89E-11	4.4E-9	3.8E-9	1.2E-6	1.0E-6
550	Y-91	4.91E-4	3.60E-9	7.50E-5	0	1.36E-7	2.7E-11	2.4E-11	5.7E-7	6.7E-9
560	Y-92	1.96E-1	2.50E-11	1.49E-5	0	8.57E-10	1.9E-9	1.6E-9	2.0E-6	4.6E-7
570	Y-93	6.80E-2	5.53E-11	6.31E-5	0	1.98E-9	7.8E-10	5.7E-10	1.4E-6	1.9E-7
580	ZR-95	4.44E-4	6.34E-9	2.93E-5	0	2.70E-8	5.8E-9	5.0E-9	1.8E-6	1.5E-6
590	ZR-95D	4.44E-4	1.81E-9	2.03E-5	0	5.56E-9	6.0E-9	5.1E-9	1.6E-6	1.4E-6
600	ZR-97	4.08E-2	1.59E-10	1.07E-4	0	1.69E-9	6.4E-9	5.5E-9	2.4E-6	1.5E-6
610	ZR-97D	4.08E-2	4.70E-12	4.09E-8	0	5.06E-11	5.4E-9	4.6E-9	1.9E-6	1.2E-6
620	NB-95	8.25E-4	1.81E-9	2.03E-5	0	5.56E-9	6.0E-9	5.1E-9	1.6E-6	1.4E-6
630	NB-97	5.78E-1	4.70E-12	4.09E-8	0	5.06E-11	5.4E-9	4.6E-9	1.9E-6	1.2E-6
640	MO-99+D	1.03E-2	7.92E-7	9.85E-6	0	0	2.2E-9	1.9E-9	9.1E-7	4.7E-7
650	MO-99D	1.03E-2	2.01E-8	2.00E-6	0	1.77E-9	9.5E-10	8.3E-10	2.4E-7	2.1E-7
660	TC-99M	1.16E-1	2.01E-8	2.00E-6	0	1.77E-9	1.1E-9	9.6E-10	2.7E-7	2.4E-7
670	TC-99	3.73E-10	4.44E-8	5.38E-6	0	1.11E-7	0	0	2.6E-10	1.3E-10
680	TC-101	2.97	3.55E-9	6.54E-22	0	2.51E-10	3.0E-9	2.7E-9	1.2E-6	6.8E-7
690	RU-103+D	7.29E-4	7.87E-8	2.09E-5	0	1.72E-7	4.2E-9	3.6E-9	1.1E-6	8.9E-7
700	RU-105+D	1.56E-1	6.03E-9	9.19E-6	0	1.49E-8	5.1E-9	4.5E-9	1.8E-6	1.2E-6
710	RU-106+D	7.87E-5	3.56E-7	1.81E-4	0	2.79E-6	1.8E-9	1.5E-9	1.9E-6	3.8E-7
720	RH-105	1.93E-2	5.82E-8	1.36E-5	0	1.15E-7	7.7E-10	6.6E-10	3.0E-7	1.7E-7
730	PD-109+D	5.15E-2	4.16E-8	2.05E-5	0	0	4.0E-11	3.5E-11	3.4E-7	9.3E-9
740	AG-110M+D	1.14E-4	8.70E-8	5.82E-5	0	1.46E-7	2.1E-8	1.8E-8	5.3E-6	4.9E-6
750	AG-111	3.85E-3	1.21E-8	4.34E-5	0	5.74E-8	2.1E-10	1.8E-10	3.8E-7	4.8E-8
760	SN-125	3.07E-3	3.79E-7	1.06E-4	1.40E-7	8.33E-6	6.6E-10	5.7E-10	1.1E-6	1.6E-7
770	SB-124	4.81E-4	1.10E-6	7.90E-5	6.74E-9	2.80E-6	1.5E-8	1.3E-8	4.5E-6	3.6E-6

10.3 File ARGIN (contd)

```
780 SB-125     2.93E-5 4.17E-7  1.86E-5  1.72E-9 1.57E-6  3.5E-9 3.1E-9 9.5E-7 7.8E-7
790 SB-127     7.46E-3 1.18E-7  6.54E-5  4.07E-9 3.57E-7  6.6E-9 5.7E-9 1.8E-6 1.5E-6
800 TE-125M    4.98E-4 3.49E-7  1.05E-5  7.94E-7 2.72E-6 4.8E-11 3.5E-11 1.5E-8 3.6E-9
810 TE-127M    2.65E-4 7.62E-7  2.10E-5  1.61E-6 6.40E-6 1.3E-12 1.1E-12 1.8E-9 2.6E-10
820 TE-127     7.37E-2 2.21E-8  8.13E-6  7.53E-8 1.03E-7 1.1E-11 1.0E-11 1.7E-7 2.8E-9
830 TE-129M+D  8.49E-4 1.77E-6  5.79E-5  4.50E-6 1.17E-5 9.0E-10 7.7E-10 7.4E-7 2.1E-7
840 TE-129     6.03E-1 7.61E-9  2.12E-8  2.40E-8 3.13E-8 8.4E-10 7.1E-10 7.0E-7 1.9E-7
850 TE-131M    2.31E-2 4.71E-7  3.84E-5  6.92E-7 8.02E-7  9.9E-9 8.4E-9 2.7E-6 2.2E-6
860 TE-131     1.66    6.25E-9  3.58E-14 1.63E-8 1.95E-8  2.6E-9 2.2E-9 1.6E-6 7.4E-7
870 TE-132     8.89E-3 1.54E-6  7.79E-5  1.82E-6 2.56E-6  2.0E-9 1.7E-9 4.8E-7 4.0E-7
880 TE-132D    8.89E-3 1.96E-7  1.07E-7  7.33E-5 2.08E-7  2.0E-8 1.7E-8 5.5E-6 4.4E-6
890 TE-133M+D  8.32E-1 2.35E-8  1.45E-9  3.52E-8 4.04E-8  1.7E-8 1.5E-8 5.0E-6 3.9E-6
900 TE-134     9.89E-1 2.20E-8  4.40E-9  2.85E-8 3.25E-8  1.2E-9 1.0E-9 3.5E-7 2.5E-7
910 I-129      4.65E-12 6.01E-6 3.07E-7  6.18E-3 2.49E-6 9.6E-12 7.0E-12 6.2E-9 2.3E-9
920 I-130      5.59E-2 8.77E-7  1.89E-6  2.80E-4 7.44E-7  1.7E-8 1.4E-8 4.8E-6 3.9E-6
930 I-131      3.59E-3 3.37E-6  1.53E-6  1.86E-3 3.93E-6  3.4E-9 2.8E-9 9.3E-7 6.8E-7
940 I-132      3.01E-1 1.96E-7  1.07E-7  7.33E-5 2.08E-7  2.0E-8 1.7E-8 5.5E-6 4.4E-6
950 I-133      3.30E-2 7.62E-7  2.25E-6  4.82E-4 1.43E-6  4.5E-9 3.7E-9 1.5E-6 9.6E-7
960 I-134      8.00E-1 1.02E-7  2.25E-10 3.73E-5 1.07E-7  1.9E-8 1.6E-8 5.5E-6 4.2E-6
970 I-135      1.03E-1 4.50E-7  1.41E-6  1.76E-4 5.01E-7  1.4E-8 1.2E-8 4.0E-6 3.3E-6
980 XE-131M    2.45E-3 0        0        0       0        0      0      5.6E-8 6.2E-9
990 XE-133M    1.28E-2 0        0        0       0        0      0      1.0E-7 6.0E-8
1000 XE-133     5.48E-3 0        0        0       0        0      0      1.1E-7 5.7E-8
1010 XE-135M    2.67    0        0        0       0        0      0      1.0E-6 7.6E-7
1020 XE-135     7.54E-2 0        0        0       0        0      0      7.9E-7 4.5E-7
1030 XE-137     10.7    0        0        0       0        0      0      2.1E-6 2.7E-7
1040 XE-138     2.45    0        0        0       0        0      0      3.4E-6 2.6E-6
1050 CS-134M    2.39E-1 2.43E-8  1.63E-8  0       2.25E-8 7.3E-10 6.2E-10 1.9E-7 1.6E-7
1060 CS-134     3.86E-5 1.00E-4  2.56E-6  0       5.29E-5  1.4E-8 1.2E-8 3.5E-6 2.9E-6
1070 CS-135     2.64E-11 5.64E-6 3.71E-8  0       1.44E-5  0      0     1.1E-8 6.6E-11
1080 CS-136     2.22E-3 1.81E-5  2.86E-6  0       6.24E-6  1.7E-8 1.5E-8 4.8E-6 4.1E-6
1090 CS-137     2.63E-6 5.60E-5  2.05E-6  0       6.37E-5  4.9E-9 4.2E-9 1.4E-6 1.0E-6
1100 CS-138     1.29    5.49E-8  4.89E-13 0       5.66E-8  2.4E-8 2.1E-8 5.7E-6 4.0E-6
1110 CS-139     4.38    1.97E-8  3.54E-30 0       3.18E-8  7.2E-9 6.3E-9 3.2E-6 1.7E-6
1120 BA-139     5.02E-1 2.88E-9  1.68E-7  0       9.85E-8  2.7E-9 2.4E-9 1.0E-6 7.7E-8
1130 BA-140     2.26E-3 1.33E-6  4.02E-5  0       2.02E-5  2.4E-9 2.1E-9 7.6E-7 4.9E-7
1140 BA-140D    2.26E-3 3.34E-10 9.32E-5  0       2.53E-9  1.7E-8 1.5E-8 5.3E-6 4.1E-6
1150 BA-141     2.31    1.73E-9  1.40E-17 0       5.18E-8  4.9E-9 4.3E-9 2.4E-6 1.1E-6
1160 BA-142     3.78    1.37E-9  0        0       2.20E-8  9.0E-9 7.9E-9 3.0E-6 2.2E-6
1170 LA-140     1.72E-2 3.34E-10 9.32E-5  0       2.53E-9  1.7E-8 1.5E-8 5.3E-6 4.1E-6
1180 LA-141     1.78E-1 2.03E-11 1.24E-5  0      3.90E-10 2.8E-10 2.5E-10 1.0E-6 5.1E-8
1190 LA-142     4.52E-1 1.44E-11 4.10E-7  0       1.29E-10 1.8E-8 1.5E-8 5.9E-6 4.5E-6
1200 CE-141     8.75E-4 6.88E-10 2.28E-5  0       8.83E-9 6.2E-10 5.5E-10 2.4E-7 1.3E-7
1210 CE-143     2.09E-2 1.33E-10 4.39E-5  0       1.60E-9  2.5E-9 2.2E-9 1.0E-6 5.7E-7
1220 CE-144+D   1.02E-4 1.96E-8  1.69E-4  0       3.27E-7 3.7E-10 3.2E-10 1.4E-6 8.6E-8
1230 PR-143     2.12E-3 4.39E-10 3.86E-5  0       8.96E-9  0      0      2.8E-7 1.6E-9
1240 PR-144     2.41    1.59E-12 4.51E-18 0      3.13E-11 2.3E-10 2.0E-10 1.3E-6 5.6E-8
1250 ND-147     2.60E-3 4.03E-10 3.34E-5  0       5.43E-9  1.2E-9 1.0E-9 5.0E-7 2.8E-7
1260 PM-147     3.02E-5 1.22E-9  7.93E-6  0       2.36E-8  0      0      1.3E-8 7.5E-11
1270 PM-148     5.35E-3 6.11E-10 9.43E-5  0       7.29E-9  5.3E-9 4.6E-9 2.0E-6 1.1E-6
1280 PM-149     1.31E-2 8.64E-11 4.00E-5  0       1.50E-9 2.9E-11 2.5E-11 3.5E-7 1.5E-8
1290 PM-151     2.47E-2 6.06E-11 3.35E-5  0       7.23E-10 2.3E-9 2.2E-9 8.4E-7 5.0E-7
1300 SM-153     1.47E-2 5.98E-11 2.86E-5  0      9.86E-10 3.0E-10 2.7E-10 2.5E-7 6.5E-8
1310 EU-156     1.93E-3 1.69E-9  7.24E-5  0       1.36E-8  8.7E-9 7.6E-9 2.8E-6 2.1E-6
1320 W-181      2.06E-4 3.49E-10 3.68E-7  0       1.01E-8 2.8E-12 2.1E-12 6.8E-10 5.3E-10
1330 W-185      3.85E-4 1.48E-8  1.60E-5  0       4.26E-7  0      0      7.9E-8 3.2E-10
1340 W-187      2.90E-2 3.12E-8  3.01E-5  0       1.11E-7  3.6E-9 3.1E-9 1.2E-6 8.3E-7
1350 U-237      4.28E-3 1.47E-10 1.94E-5  0       5.53E-10 1.3E-9 1.0E-9 3.4E-7 2.6E-7
1360 NP-238     1.38E-2 2.11E-10 3.43E-5  0       4.27E-9  3.2E-9 2.8E-9 1.1E-6 7.7E-7
1370 NP-239     1.23E-2 6.46E-11 2.40E-5  0       1.20E-9  1.1E-9 9.5E-10 3.7E-7 2.4E-7
1380 PU-238     9.20E-7 4.39E-7  7.30E-5  0       1.76E-5 1.8E-11 1.3E-12 4.0E-9 1.5E-10
1390 PU-239     3.25E-9 4.12E-7  6.66E-5  0       1.65E-5 7.7E-12 7.9E-13 1.7E-9 1.2E-10
1400 PU-240     1.20E-8 4.16E-7  6.78E-5  0       1.65E-5 1.8E-11 1.3E-12 4.0E-9 1.4E-10
1410 PU-241+D   5.99E-6 4.21E-10 6.78E-7  0       1.44E-8 6.8E-12 4.6E-12 9.5E-11 6.1E-11
1420 PU-242     2.09E-10 3.92E-7 6.53E-5  0       1.57E-5 1.6E-11 1.1E-12 3.6E-9 1.1E-10
1430 AM-241     1.73E-7 1.46E-6  7.42E-5  0       1.83E-5 2.6E-10 1.8E-10 6.1E-8 3.9E-8
1440 AM-243+D   9.96E-9 1.41E-6  9.73E-5  0       1.77E-5  1.5E-9 1.3E-9 4.6E-7 3.1E-7
1450 CM-242     1.77E-4 8.26E-7  7.92E-5  0       1.25E-5 2.3E-11 5.5E-12 4.7E-9 3.4E-10
1460 CM-244     4.50E-6 1.51E-6  7.55E-5  0       2.28E-5 1.8E-11 2.9E-12 3.9E-9 2.6E-10
1470 CF-252     2.99E-5 1.16E-6  2.88E-4  0       4.65E-5  7.2E-8 6.6E-8 1.7E-5 1.4E-5
1480 ELMT -SALT WATER CONCENTRATIONS-  -FRESH WATER CONCENTRATIONS-
```

10.3 File ARGIN (contd)

1490		FISH	CRUS.	MOLL.	ALGAE	FISH	CRUS.	MOLL.	ALGAE
1500	H	1	1	1	1	.9	.9	.9	.9
1510	C	1	1	1	1	4600	9100	9100	4600
1520	N	0	0	0	0	0	0	0	0
1530	F	4	4	4	1	10	100	100	2
1540	NA	1	1	1	1	100	200	200	500
1550	P	10000	10000	10000	100000	100000	20000	20000	500000
1560	AR	1	1	1	1	1	1	1	1
1570	SC	100	300	300	1000	2	1000	1000	10000
1580	CR	100	1000	1000	1000	20	2000	2000	4000
1590	MN	3000	10000	50000	10000	400	90000	90000	10000
1600	FE	1000	4000	20000	6000	100	3200	3200	1000
1610	CO	100	10000	300	100	50	200	200	200
1620	NI	500	100	100	100	100	100	100	50
1630	CU	1000	5000	5000	1000	50	400	400	2000
1640	ZN	5000	5000	50000	1000	2000	10000	10000	20000
1650	BR	3	10	10	100	420	330	330	50
1660	KR	1	1	1	1	1	1	1	1
1670	RB	30	50	10	10	2000	1000	1000	1000
1680	SR	1	1	1	20	30	100	100	500
1690	Y	30	100	100	300	25	1000	1000	5000
1700	ZR	30	100	100	1000	330	6.7	6.7	1000
1710	NB	100	200	200	100	30000	100	100	800
1720	MO	10	100	100	100	10	10	10	1000
1730	TC	10	100	100	1000	15	5	5	40
1740	RU	3	100	100	1000	10	300	300	2000
1750	RH	10	100	100	100	10	300	300	200
1760	PD	10	100	100	100	10	300	300	200
1770	AG	1000	5000	5000	1000	2.3	770	770	200
1780	SN	3	3	3	10	3000	1000	1000	100
1790	SB	1000	1000	1000	10000	1	10	10	1500
1800	TE	10	10	100	1000	400	75	75	100
1810	I	20	100	100	10000	15	5	5	40
1820	XE	1	1	1	1	1	1	1	1
1830	CS	30	50	10	10	2000	100	100	500
1840	BA	3	3	3	100	4	200	200	500
1850	LA	30	100	100	300	25	1000	1000	5000
1860	CE	30	100	100	300	1	1000	1000	4000
1870	PR	100	1000	1000	1000	25	1000	1000	5000
1880	ND	100	1000	1000	1000	25	1000	1000	5000
1890	PM	100	1000	1000	1000	25	1000	1000	5000
1900	SM	100	1000	1000	1000	25	1000	1000	5000
1910	EU	100	1000	1000	1000	25	1000	1000	5000
1920	W	10	10	100	100	1200	10	10	1200
1930	U	10	10	10	67	2	60	60	.5
1940	NP	10	10	10	6	10	400	400	300
1950	PU	3	200	200	1000	3.5	100	100	350
1960	AM	25	1000	1000	5000	25	1000	1000	5000
1970	CM	25	1000	1000	5000	25	1000	1000	5000
1980	CF	25	1000	1000	5000	25	1000	1000	5000

10.4 File REL

```
100 MARC FOUR
110  SALT 1000 0 0 0 0 0 0 0 0 0 .018 6.2E-3 0 .018 5.3E-3 0 .18 .018
120  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1E-3 0 0 5E-3 1.6E-4 1.6E-4 6.1E-3
130  0 2.6E-4 3.7E-3 8.8E-2 0 1.3E-3 8E-4 8E-4 4E-4 4E-4 7.3E-4 4.1E-4
140  .073 .064 .021 0 0 5.6E-4 0 1.3E-4 2.7E-4 0 0 0 5E-6 0 2E-6 2.7E-5
150  4.2E-4 3.5E-3 6.7E-3 .037 .021 .028 1.2E-3 .34 .34 0 0 0 .013
160  3.5 .04 4.2 0 .31 0 0 0 0 0 0 0 0 .34 0 .18 .31 0 0 0 5.9E-3
170  5.9E-3 0 0 1.5E-3 0 0 9E-4 5.4E-4 4.9E-4 7.3E-4 4.9E-4 2.4E-4
180  6E-5 0 1.8E-4 0 1.2E-4 0 0 0 0 0 8.8E-3 0 0 0 0 0 0 0 0 0 0
190
200 PIKES PEAK
210  FRESH 1000 9Z 5.7E-4 6.1E-4 0 1.3E-3 6.6E-4 0 6.9E-3 5.6E-4
220  6Z 9.6E-4 3.4E-3 4.9E-5 6Z 6.2E-5 .021 1.1E-5 3.6E-4 1.3E-5
230  2.4E-4 1.1E-5 1.9E-5 1.5E-4 .0034 4.1E-5 4.3E-5 6E-5 6E-5
240  1.7E-5 1.7E-5 6.3E-5 1.8E-5 .26 .23 .21 2Z 4E-5 5.8E-6
250  1.3E-5 1.5E-5 1.4E-6 0 7E-7 3Z 1.4E-6 3.3E-5 2.9E-4 2.9E-4
260  .0028 .0018 .0012 2.4E-4 .016 .016 7.8E-6 6.3E-6 0 .0062
270  1.8 .21 1.9 .002 .52 7Z 1.4E-5 .037 0 .009 .032 1.5E-4
280  5.1E-6 1.5E-4 3.3E-4 3.3E-4 2Z 2E-4 3.3E-5 7.1E-7 6E-5
290  2.5E-5 5.1E-5 4.4E-5 0 1.8E-5 2.9E-6 6.5E-6 8.8E-6 2.5E-6
300  4.6E-6 2.3E-6 3Z 1.1E-5 2.4E-6 3.4E-4 3Z 1.8E-6 6Z
310
```

10.5 Program CRITR

```
100 ' THIS PROGRAM CALCULATES INTERNAL DOSES TO AQUATIC ORGANISMS AND THEIR PREDATORS.
110 ' FOR INFORMATION CALL DAVID A. BAKER (509) 942-5126.
120
130 DIM A(10)                        ' RADII IN CM.
140 DIM B(10,200), C(200,5)          ' SPECIFIC BODY BURDENS, BIOACCUM. FACTORS
150 DIM D(200),     E(200)           ' DECAY CONST., BODY DOSE FACTORS
160 DIM H(10),      L(200)           ' HOLD-UP TIMES, CONCENTRATIONS
170 DIM M(10),      P(10)            ' MIXING RATIOS, CRITTER NUMBERS
180 DIM Q(10,200), R(200)            ' DOSES, RELEASES
190 DIM T(25)                        ' DOSE TOTALS
200 DIM W(10,200), Z(200)            ' ENERGIES, RECONC. FACTORS
210 DIM $(132), N(200)$(9)            ' DEFAULT STRING LENGTH, ISOTOPE NAMES
220 DIM F(10)$(20)                   ' CRITTER NAMES
230
240 'NON-DIMENSIONED VARIABLES USED IN THIS PROGRAM:
250 ' A A1 A2 C F F1 F3 I K M M1 M2 N N1 P P1 R T T1 V V1 W  A$ C$ I$ P$ Q$ R$ W$
260
270 ' * * * READ IN CONSTANTS * * *
280
290 N1=136          ' NUMBER OF NUCLIDES IN ARGIN FILE
300 DATA FISH, CRUSTACEA, MOLLUSC, ALGAE
310 READ F(1)$, F(2)$, F(3)$, F(4)$
320 MAT READ A(9)
330 DATA 1.4, 2, 3, 5, 7, 10, 20, 30, 40
340
350 FILE #2=ARGIN, #3=REL, #4=CRITEN
360
370 GET#2, I$,I$          'SPACE PAST TITLES
380 FOR I=1 TO N1       '  READ IN ISOTOPE NAMES & DECAY CONST
390  INPUT#2, N(I)$,D(I),E(I),I$,I$,I$,I$,I$,I$,I$
400 NEXT I
410 GET#2, I$,I$  'SPACE PAST TITLES
420 MAT T=ZER
430
440 REM ********************GET USER INPUT*************************
450
460 'FIND OUT REACTOR NAME FROM USER
470 OUTPUT "REACTOR NAME";
480 GET R$
490 '**GET REACTOR RELEASES FROM FILE 'REL'
500 IF END#3 GOTO 550
510 GET#3, Q$      'TRY TO MATCH THIS LINE OF 'REL' WITH REACTOR NAME
520 IF LEN(Q$)<1+LEN(R$)  GOTO 500
530 IF Q$(2,LEN(R$))<>R$  GOTO 500
540 GOTO 580
550 OUTPUT "**NO ";R$;" RELEASES ON FILE 'REL'**"
560 RESTORE#3
570 GOTO 470
580 MAT R=ZER
590 I=-1
600 F=1
610 GET#3, Q$
620 P=0
630 FOR F1=0 TO LEN(Q$)-F
640  IF Q$(F+F1,1)=" " GOTO 670
650  P=1
660  GOTO 680
670  IF P>0 GOTO 710
680 NEXT F1
690 IF P=0 AND F=1 GOTO 840
700 IF P=0 GOTO 600
710 IF I>=0 GOTO 770
720 IF Q$(F+F1-1,1)="T" OR Q$(F+F1-1,1)="H" GOTO 750
730 PRINT "**SPECIFY 'SALT' OR 'FRESH' IN REL FILE**"
740 GOTO 3040
750 W$=Q$(F,F1)
760 GOTO 810
770 IF Q$(F+F1-1,1)<>"Z" GOTO 800
```

10.5 Program CRITR (contd)

```
780 I=I+VAL(Q$(F,F1-1))
790 GOTO 820
800 R(I+1)=VAL(Q$(F,F1))
810 I=I+1
820 F=F+F1+1
830 GOTO 620
840 IF I=N1 GOTO 870
850 PRINT "**I NEED TO EAT"N1;"RELEASES, BUT WAS FED"I
860 GOTO 3040
870 ' * * * GET SALT OR FRESH BIOACCUMULATION FACTORS FROM ARGIN FILE * * *
880 N(0)$="  "
890 FOR I=1 TO N1
900  IF N(I)$(1,2)=N(I-1)$(1,2)  GOTO 960
910  IF W$(LEN(W$),1)="H"  GOTO 940
920  INPUT#2, I$,C(I,1),C(I,2),C(I,3),C(I,4),I$,I$,I$,I$
930  GOTO 990
940  INPUT#2, I$,I$,I$,I$,I$,C(I,1),C(I,2),C(I,3),C(I,4)
950  GOTO 990
960  FOR F=1 TO 4
970   C(I,F)=C(I-1,F)
980  NEXT F
990 NEXT I
1000 GET#4, I$, I$               'SPACE PAST TITLES
1010 FOR I=1 TO N1           'READ IN CRITTER ENERGIES
1020  INPUT #4, I$, W(1,I),W(2,I),W(3,I),W(4,I),W(5,I),W(6,I),W(7,I),W(8,I)
1030 NEXT I
1040
1050 ' * * * * USER ENTERS DATA AT TTY
1060 PRINT
1070 PRINT "TITLE";
1080 GET I$      ' DUMMY
1090 PRINT
1100 GOTO 1240
1110
1120 '*********SUB. TO SELECT CORRECT CRITTER ENERGY BY RADIUS*****
1130 PRINT "ENTER CRITTER RADIUS IN CM. ";
1140 INPUT A2
1150 IF A2>=1 AND A2<=30 GOTO 1180
1160 PRINT "PICK A RADIUS BETWEEN 1 AND 30 CM."
1170 GOTO 1140
1180 FOR A=1 TO 6
1190  IF A2<(A(A)+A(A+1))/2 GOTO 1210
1200 NEXT A
1210 A1=A(A)    'SETS INPUT RADIUS TO STANDARD.
1220 RETURN
1230
1240 '**INPUT COOLING FLOW AND RECONCENTRATION CONSTANTS
1250
1260 PRINT "ENTER COOLING FLOW IN CFS";
1270 INPUT W
1280 M=V=-1
1290 PRINT "WHICH RECONCENTRATION FORMULA";
1300 INPUT R
1310 ON R GOTO 1340,1440,1470
1320 OUTPUT "**ENTER ONE OF THE NUMBERS 1, 2, OR 3**"
1330 GOTO 1290
1340 PRINT "ENTER COOLING POND VOLUME IN CUBIC FEET AND"
1350 PRINT "     FRACTIONAL TURNOVER RATE IN 1/DAY";
1360 INPUT V1,M1
1370 PRINT "ENTER MAKEUP FLOW IN CFS AND CYCLE TIME IN HOURS";
1380 INPUT M,C
1390 IF M<=W GOTO 1470
1400 PRINT "CHECK YOUR FLOWS"
1410 GOTO 1370
1420 GOTO 1470
1430
1440 OUTPUT "ENTER RECYCLE FRACTION, CYCLE TIME IN HOURS";
1450 INPUT V,C
1460
1470 PRINT
1480 PRINT "FOR PRIMARY CRITTER * * * *"
```

10.5 Program CRITR (contd)

```
1490 PRINT
1500 PRINT "ENTER HOLDUP TIME IN HOURS & MIXING RATIO";
1510 INPUT H(1),M(1)
1520 GOSUB 1130
1530
1540 '  PRINT CONSTANTS AT TTY
1550
1560 OUTPUT
1570 ON R GOTO 1580,1610,1630
1580 PRINT R$;"    FLOWS="W;"&"M;"    VOLUME="V1;"    CYCLE="C
1590 PRINT R$;"    TURNOVER RATE="M1
1600 GOTO 1640
1610 PRINT R$;"    FLOW="W;"     FRACTION="V;"     CYCLE="C
1620 GOTO 1640
1630 PRINT R$;"    FLOW="W;"    CONSTANT RECONC=1"
1640 OUTPUT
1650 PRINT "HOLDUP=";H(1);"     MIXING RATIO=";M(1);"    RADIUS=";A1
1660 PRINT
1670 OUTPUT "CONSTANTS OK";
1680 GET A$
1690 IF A$(1,1)="N" GOTO 1240
1700 IF A$(1,1)="Y" GOTO 1740
1710 OUTPUT "**TYPE Y FOR YES OR N FOR NO**"
1720 GOTO 1670
1730 '**GET OUTPUT INSTRUCTIONS AND TITLE
1740 K=K+1
1750
1760 REM *********************CALCULATE RESULTS***********************
1770
1780 ' * * * FOR PRIMARY CRITTER * * *
1790
1800 FOR F=1 TO 4
1810  FOR I=1 TO N1
1820   IF R(I)=0  GOTO 1940
1830   IF R=3 GOTO 1890
1840   IF R=2 GOTO 1870
1850   Z(I)=1/(1-(W-M)/(W+V1*M1/86400)*EXP(-D(I)*C))
1860   GOTO 1900
1870   Z(I)=(1-(V*EXP(-D(I)*C))↑(30*8766/C+1))/(1-V*EXP(-D(I)*C))
1880   GOTO 1900
1890   Z(I)=1
1900   L(I)=Z(I)*R(I)*M(1)*EXP(-D(I)*H(1))/(W*8.937E-4)     'CONCENTRATIONS IN PCI/L
1910   B(F,I)=L(I)*C(I,F)       ' SPECIFIC BODY BURDEN IN PCI/KG
1920   Q(F,I)=0.0187*W(A,I)*B(F,I)      ' DOSE
1930   T(F)=T(F)+Q(F,I)
1940  NEXT I
1950  PRINT
1960  PRINT F(F)$;" INTERNAL DOSE =";TAB(26)VAL(STR(T(F),".###!!!!"));"MRAD/YR"
1970 NEXT F
1980 PRINT
1990 ' * * * FOR SECONDARY CRITTER * * *
2000
2010 PRINT
2020 P=1
2030 PRINT
2040 PRINT "FOR SECONDARY CRITTER * * * *"
2050 PRINT
2060 PRINT "NAME OF CRITTER";
2070 GET F(4+P)$
2080 ON ATTENTION GOTO 2060
2090 PRINT "ENTER HOLDUP TIME IN HOURS & MIXING RATIO";
2100 INPUT H(1), M(1)
2110 GOSUB 1130
2120 PRINT "ENTER FOOD TYPE";
2130 GET A$
2140 A$(1,2)=A$
2150 P(P)=1     'FISH
2160 IF A$(1,2)="FI" GOTO 2250
2170 P(P)=P     'CRUS.
2180 IF A$(1,2)="CR" OR A$(1,2)="SH" OR A$(1,2)="LO" GOTO 2250
2190 P(P)=3     'MOLL.
```

10.5 Program CRITR (contd)

```
2200 IF A$(1,2)="MO" OR A$(1,2)="OY" OR A$(1,2)="CL" GOTO 2250
2210 P(P)=4     'ALGAE
2220 IF A$(1,2)="AL" OR A$(1,2)="PL" GOTO 2250
2230 PRINT "TRY AGAIN"
2240 GOTO 2120
2250 PRINT "ENTER FOOD INTAKE RATE IN GRAMS/DAY";
2260 INPUT I1
2270 PRINT "ENTER CRITTER MASS IN KG";
2280 INPUT M2
2290 PRINT
2300 FOR I=1 TO N1
2310  IF R(I)=0 GOTO 2380
2320  C1=P(P)
2330  B(C1,I)=C(I,C1)*Z(I)*R(I)*M(I)*EXP(-D(I)*H(1))/(W*8.937E-4)      ' FOOD BODY BURDEN
2340  IF W(8,I)=0 GOTO 2380
2350  B(4+P,I)=19.46*I1*B(C1,I)/M2 * (E(1)*70/W(8,1))    ' SPECIFIC BODY BURDEN IN PCI/KG
2360  Q(4+P,I)= 0.0187*W(A,I)*B(4+P,I)            ' DOSE
2370  T(4+P)=T(4+P) + Q(4+P,I)      ' TOTAL
2380 NEXT I
2390 PRINT "HOLDUP =";H(1);"      MIXING RATIO =";M(1)
2400 PRINT
2410 PRINT "FOOD TYPE =";A$;"     INTAKE RATE =";I1
2420 PRINT
2430 PRINT "RADIUS=";A2;"    MASS=";M2;"      CONSTANTS OK";
2440 GET C$
2450 IF C$(1,1)<>"Y" GOTO 2090
2460 PRINT
2470 PRINT "INTERNAL DOSE FOR ";F(4+P)$;" =";VAL(STR(T(4+P),".###!!!!"));" MRAD/YR"
2480 PRINT
2490 P=P+1
2500 PRINT "ANOTHER SECONDARY CRITTER";
2510 GET C$
2520 IF C$(1,1)<>"Y" GOTO 2530
2530 OUTPUT
2540 ON ATTENTION
2550 PRINT
2560 PRINT "PERCENTAGES";
2570 GET A$
2580 IF A$(1,1)="N" GOTO 2860
2590 IF A$(1,1)="Y" GOTO 2620
2600 PRINT " ANSWER YES OR NO"
2610 GOTO 2560
2620 PRINT "MINIMUM %";
2630 INPUT P1
2640 PRINT
2650 ON ATTENTION GOTO 2860
2660 PRINT"       * * *  CONTRIBUTIONS TO CRITTER DOSE >";P1;"%  * * *"
2670 PRINT
2680 PRINT "ISOTOPE    RELEASE    RECONC.  CONC.  BIOACCUM. BODY BUR.  DOSE     PERCENT"
2690 PRINT "           CI/YR      FACTOR   PCI/L    FACTOR   PCI/KG   MRAD/YR "
2700 FOR F=1 TO 3+P
2710  PRINT
2720  PRINT F(F)$    'CRITTER
2730  PRINT
2740  IF F<5 GOTO 2770
2750  C1=P(F-4)
2760  GOTO 2780
2770  CI=F
2780  FOR I=1 TO N1
2790   IF R(I)=0 GOTO 2830
2800   T1=100*Q(F,I)/T(F)
2810   IF T1<=P1 GOTO 2830
2820   PRINT USING 2850, N(1)$, R(I), Z(I), L(1), C(I,C1), B(F,I), Q(F,I), T1
2830  NEXT I
2840 NEXT F
2850 :######### #.##!!!!   ##.##   #.#!!!!  ######    #.#!!!!  #.#!!!!   ###.#
2860 ON ATTENTION
2870 PRINT
2880 PRINT "DO YOU WANT TOTAL LIST OF RELEASES";
2890 GET C$
2900 IF C$(1,1)="N" GOTO 3000
```

10.5 Program CRITR (contd)

```
2910 PRINT
2920 PRINT "ISOTOPE     RELEASE  CONCENTRATION"
2930 PRINT "             CI/YR     PCI/LITER"
2940 PRINT
2950 FOR I=1 TO N1
2960  IF R(I)=0 GOTO 2980
2970  PRINT USING 2990, N(I)$, R(I), L(I)
2980 NEXT I
2990 :#########  #.##!!!!   #.##!!!!
3000 PRINT
3010 PRINT "           DON'T FORGET EXTERNAL DOSES"
3020 PRINT
3030 PRINT "            THANK YOU ----- CALL AGAIN"
3040 PRINT
```

10.6 File CRITEN

1 FILE FOR CRITR. ENERGIES (MEV) FOR VARIOUS EFFECTIVE RADII OF MUSCLE

2	ISO	1.4 CM	2 CM	3 CM	5 CM	7 CM	10 CM	20 CM	MAN
10	H-3	.0058	.0058	.0058	.0058	.0058	.0058	.0058	.01
20	C-14	.05	.05	.05	.05	.05	.05	.05	.05
30	N-13	.538	.557	.587	.646	.701	.777	.983	1.13
40	F-18	.285	.304	.334	.391	.444	.518	.717	.861
50	NA-22	.286	.325	.387	.507	.619	.775	1.20	1.51
60	NA-24	.712	.771	.868	1.05	1.23	1.48	2.19	2.74
70	P-32	.695	.695	.695	.695	.695	.695	.695	.695
80	AR-39	.194	.194	.194	.194	.194	.194	.194	.194
90	AR-41	.519	.541	.576	.642	.705	.793	1.04	1.22
100	SC-46	.197	.232	.290	.399	.501	.644	1.03	1.32
110	CR-51	.00222	.00276	.00363	.00529	.00685	.00901	.0149	.0191
120	MN-54	.0364	.0514	.0758	.122	.166	.227	.392	.512
130	MN-56	.875	.904	.951	1.04	1.13	1.24	1.57	1.82
140	FE-55	.00726	.00726	.00726	.00726	.00726	.00726	.00726	.00726
150	FE-59	.171	.191	.224	.286	.346	.428	.655	.824
160	CO-57	.0390	.0409	.0439	.0496	.0550	.0626	.0840	.100
170	CO-58	.0728	.0905	.119	.174	.226	.297	.492	.633
180	CO-60	.195	.237	.306	.437	.560	.732	1.21	1.56
190	NI-63	.0176	.0176	.0176	.0176	.0176	.0176	.0176	.0176
200	NI-65	.641	.651	.666	.695	.723	.762	.869	.949
210	CU-64	.133	.137	.143	.154	.165	.180	.220	.249
220	ZN-65	.0289	.0386	.0544	.0846	.113	.153	.261	.342
230	ZN-69M+D	.0400	.0477	.0603	.0842	.107	.138	.221	.282
240	ZN-69	.32	.32	.32	.32	.32	.32	.32	.32
250	BR-82	.248	.294	.368	.510	.643	.828	1.33	1.70
260	BR-83+D	.363	.363	.364	.364	.364	.365	.366	.367
270	BR-84	1.31	1.34	1.39	1.47	1.56	1.67	2.00	2.25
280	BR-85	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
290	KR-83M	.0438	.0438	.0438	.0438	.0438	.0438	.0438	.0438
300	KR-85M	.245	.248	.252	.260	.268	.279	.309	.331
310	KR-85	.224	.224	.224	.224	.224	.225	.225	.225
320	KR-87	1.21	1.24	1.27	1.34	1.41	1.50	1.77	1.97
330	KR-88	.449	.475	.517	.599	.677	.786	1.09	1.33
340	RB-86	.666	.668	.671	.676	.680	.687	.705	.719
350	RB-88	2.15	2.16	2.18	2.21	2.24	2.28	2.40	2.49
360	RB-89	.694	.733	.797	.919	1.03	1.20	1.64	1.98
370	SR-89	.564	.564	.564	.564	.564	.564	.564	.564
380	SR-90	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
390	SR-90D	.939	.939	.939	.939	.939	.939	.939	.939
400	SR-91	.702	.721	.752	.812	.867	.944	1.15	1.31
410	SR-92	.249	.272	.310	.381	.449	.543	.805	1.00
420	Y-90	.939	.939	.939	.939	.939	.939	.939	.939
430	Y-91M	.0518	.0615	.0773	.107	.135	.174	.280	.355
440	Y-91	.590	.590	.591	.591	.591	.591	.592	.592
450	Y-92	1.47	1.47	1.48	1.49	1.51	1.52	1.57	1.61
460	Y-93	1.18	1.18	1.18	1.19	1.19	1.20	1.22	1.23
470	ZR-95	.227	.254	.297	.380	.458	.565	.857	1.07
480	ZR-95D	.0767	.0906	.113	.156	.197	.253	.405	.515
490	ZR-97	.763	.778	.802	.848	.891	.951	1.11	1.23
500	ZR-97D	.500	.512	.532	.570	.606	.656	.790	.887
510	NB-95	.0767	.0906	.113	.156	.197	.253	.405	.515
520	NB-97	.500	.512	.532	.570	.606	.656	.790	.887
530	MO-99+D	.419	.423	.430	.444	.457	.475	.524	.561
540	MO-99D	.084	.084	.084	.084	.084	.084	.084	.084
550	TC-99M	.132	.134	.138	.144	.150	.158	.181	.199
560	TC-99	.084	.084	.084	.084	.084	.084	.084	.084
570	TC-101	.485	.492	.503	.524	.543	.570	.643	.697
580	RU-103+D	.116	.125	.140	.168	.194	.230	.328	.399
590	RU-105+D	.496	.508	.527	.563	.597	.644	.772	.865
600	RU-106+D	1.44	1.44	1.45	1.46	1.47	1.49	1.53	1.56
610	RH-105	.158	.159	.162	.167	.172	.179	.198	.212
620	PD-109+D	.389	.389	.389	.389	.389	.390	.390	.391
630	AG-110M+D	.188	.235	.311	.456	.593	.782	1.30	1.68
640	AG-111	.361	.362	.362	.364	.365	.367	.372	.376
650	SN-125	.906	.907	.910	.914	.919	.925	.942	.954
660	SB-124	.459	.491	.544	.644	.739	.871	1.24	1.51

10.6 File CRITEN (contd)

670	SB-125	.105	.113	.126	.150	.173	.205	.291	.353
680	SB-127	.433	.448	.472	.518	.561	.620	.782	.899
690	TE-125M	.111	.111	.112	.112	.112	.113	.113	.114
700	TE-127M	.00197	.00197	.00197	.00198	.00199	.00200	.00203	.00205
710	TE-127	.223	.223	.223	.223	.223	.224	.224	.224
720	TE-129M+D	.599	.601	.605	.612	.619	.627	.651	.667
730	TE-129	.535	.538	.541	.548	.555	.563	.585	.601
740	TE-131M	.269	.291	.327	.396	.460	.550	.796	.978
750	TE-131	.786	.791	.800	.817	.833	.855	.916	.961
760	TE-132	.121	.125	.131	.143	.154	.169	.211	.242
770	TE-132D	.581	.624	.693	.826	.950	1.12	1.59	1.94
780	TE-133M+D	.502	.542	.605	.726	.840	.998	1.43	1.74
790	TE-134	.114	.117	.122	.130	.138	.148	.175	.194
800	I-129	.0474	.0475	.0476	.0478	.0479	.0481	.0485	.0487
810	I-130	.388	.427	.490	.611	.724	.881	1.31	1.61
820	I-131	.206	.213	.224	.245	.266	.293	.368	.422
830	I-132	.581	.624	.693	.826	.950	1.12	1.59	1.94
840	I-133	.467	.478	.497	.533	.566	.613	.738	.829
850	I-134	.779	.838	.934	1.12	1.29	1.53	2.19	2.67
860	I-135	.481	.514	.566	.667	.761	.893	1.26	1.53
870	XE-131M	.136	.136	.136	.137	.137	.137	.138	.139
880	XE-133M	.176	.177	.178	.180	.182	.184	.191	.196
890	XE-133	.137	.137	.138	.140	.141	.143	.148	.152
900	XE-135M	.118	.126	.139	.163	.186	.217	.302	.363
910	XE-135	.330	.335	.342	.355	.368	.386	.434	.469
920	XE-137	1.68	1.68	1.68	1.69	1.70	1.71	1.74	1.76
930	XE-138	.505	.527	.562	.630	.694	.784	1.04	1.23
940	CS-134M	.0483	.0496	.0517	.0558	.0597	.0652	.0805	.0922
950	CS-134	.230	.259	.306	.396	.480	.596	.913	1.14
960	CS-135	.058	.058	.058	.058	.058	.058	.058	.058
970	CS-136	.233	.273	.337	.458	.573	.732	1.17	1.49
980	CS-137	.257	.267	.284	.316	.346	.388	.500	.582
990	CS-138	1.18	1.22	1.27	1.38	1.48	1.62	2.02	2.32
1000	CS-139	1.61	1.61	1.62	1.64	1.66	1.68	1.75	1.79
1010	BA-139	.927	.927	.929	.931	.933	.936	.944	.950
1020	BA-140	.315	.320	.328	.343	.357	.376	.428	.465
1030	BA-140D	.698	.734	.793	.907	1.01	1.16	1.58	1.89
1040	BA-141	1.10	1.11	1.12	1.16	1.19	1.23	1.36	1.44
1050	BA-142	.601	.622	.656	.722	.783	.869	1.10	1.28
1060	LA-140	.698	.734	.793	.907	1.01	1.16	1.58	1.89
1070	LA-141	.966	.967	.967	.969	.970	.972	.977	.981
1080	LA-142	.937	.973	1.03	1.14	1.25	1.40	1.82	2.14
1090	CE-141	.173	.174	.175	.179	.182	.187	.199	.209
1100	CE-143	.420	.426	.435	.453	.470	.493	.555	.601
1110	CE-144+D	1.32	1.32	1.32	1.33	1.33	1.33	1.34	1.35
1120	PR-143	.314	.314	.314	.314	.314	.314	.314	.314
1130	PR-144	1.23	1.23	1.23	1.24	1.24	1.24	1.24	1.25
1140	ND-147	.257	.259	.264	.272	.280	.291	.320	.342
1150	PM-147	.0620	.0620	.0620	.0620	.0620	.0620	.0620	.0620
1160	PM-148	.727	.737	.755	.788	.819	.862	.982	1.07
1170	PM-149	.366	.367	.367	.367	.368	.368	.370	.371
1180	PM-151	.327	.332	.340	.356	.370	.390	.445	.484
1190	SM-153	.270	.271	.272	.273	.275	.277	.283	.288
1200	EU-156	.471	.490	.521	.580	.636	.714	.930	1.09
1210	W-181	.00316	.00316	.00317	.00318	.00320	.00322	.00327	.00331
1220	W-185	.144	.144	.144	.144	.144	.144	.144	.144
1230	W-187	.331	.339	.353	.379	.403	.437	.529	.595
1240	U-237	.142	.146	.151	.158	.165	.174	.200	.223
1250	NP-238	.263	.270	.282	.306	.327	.357	.440	.513
1260	NP-239	.203	.205	.208	.212	.217	.223	.240	.260
1270	PU-238	5.51	5.51	5.51	5.51	5.51	5.51	5.51	55.0
1280	PU-239	5.15	5.15	5.15	5.15	5.15	5.15	5.15	51.5
1290	PU-240	5.16	5.16	5.16	5.16	5.16	5.16	5.16	51.6
1300	PU241+D	.00535	.00535	.00535	.00535	.00535	.00535	.00535	.00636
1310	PU-242	4.90	4.90	4.90	4.90	4.90	4.90	4.90	48.9
1320	AM-241	5.51	5.51	5.51	5.52	5.52	5.52	5.52	54.8
1330	AM-243+D	5.28	5.28	5.28	5.29	5.29	5.29	5.30	52.7
1340	CM-242	6.11	6.11	6.11	6.11	6.11	6.11	6.11	61.1
1350	CM-244	5.80	5.80	5.80	5.80	5.80	5.80	5.80	58.0
1360	CF-252	12.2	12.2	12.2	12.2	12.2	12.2	12.2	165.

10.7 Program GRONK - CSTS Version

```
100 'THIS PROGRAM CALCULATES THE DOSE RESULTING FROM AN AIR RELEASE OF RADIOACTIVE ISOTOPES, 13 JUNE 1973
110 'FOR HELP CONTACT NORM ROBINSON,  509 942-3754
120 DIM L(52),T(52),S(52),E(8,8),P(17,10),A(16,10),B(16,10),H(16,10),N(10),U(10),V(10)
130 DIM Y(10),X(20),K(20),O(24),Z(8,35),M(17),W(16),F(16,1),Q(1,7),C(1,8)
140 DIM U(10)$(5),D(64)$(6),S(12)$(17),C(2)$(1),T(4)$(47),N(52)$(14),L(20)$(166),A$(124),B$(34),C$(107),K$(104),T$(72),$(22)
150 DEF FNX(A,B)=(A+B+ABS(A-B))/2        'FNX(A,B)=MAX(A,B)
160 PRINT "REACTOR NAME";
170 GET R$
180 RESTORE
190 '-----GET OPTION WORD AND DECODE
200 MAT O(24)=ZER
210 A$="EFNHLGSRPWTA0123456789XM"
220 PRINT
230 PRINT "OPTION WORD";
240 GET B$
250 FOR A=1 TO 24
260  FOR B=1 TO LEN(B$)
270   IF B$(B,1)<>A$(A,1) GOTO 300
280   O(A)=1
290   B$(B,1)=" "
300  NEXT B
310 NEXT A
320 A$=A$(LEN(B$)+1,0)=""
330 IF B$=A$ GOTO 360
340 PRINT "**BAD OPTION: "B$
350 GOTO 190
360 IF O(1)+O(2)+O(3)>0 GOTO 8650
370 IF O(7)+O(8)<2 GOTO 400
380 PRINT "**CONFLICTING OPTIONS R AND S"
390 GOTO 190
400 M$="PASQUILL"
410 IF O(4)=0 GOTO 430
420 M$="HANFORD"
430 K=K+1
440 IF K=1 GOTO 540
450 IF M$<>L$ GOTO 510
460 PRINT "ENTER COMMENTS FOR THIS CASE";
470 GET K$
480 OUTPUT#4, STR(K,"0CASE##:  ");K$
490 OUTPUT#4, TAB(11)M$;" MODEL";
500 GOTO 3150
510 FILE #1=G$
520 GOTO 1520
530
540 '****************************************************************************FIRST CASE OF RUN
550 '-----READ INITIAL PORTION OF FILE
560 G$="G"
570 G$(2,4)=R$
580 DISABLE ALL
590 ON ERROR GOTO 1070
600 FILE #1=G$
610 GET#1, T$
620 ON ERROR GOTO 1110
630 INPUT#1, B$
640 IF B$<>"RELEASE" GOTO 660
```

10.7 Program GRONK - CSTS Version (contd)

```
650 R=R+1
660 IF B$<>"RANGES" GOTO 630
670 ENABLE
680 ON ERROR GOTO 1320
690 MAT INPUT#1, Y(10)
700 X1=Y(0)=NUM
710 MAT Y=Y*(1609.344)
720 MAT X(X1)=Y
730 INPUT#1, A$,P$,A$
740 FOR D=1 TO 64
750  READ D(D)$
760 NEXT D
770 FOR D8=1 TO 32
780  IF D(D8+2)$=A$ GOTO 800
790 NEXT D8
800 READ D1,D$,C(0)$,C(2)$,S(1)$,S(2)$,S(3)$,S(4)$,S(5)$,S(6)$,S(7)$
810 READ S(8)$,S(9)$,S(10)$,S(11)$,S(12)$,T(0)$,T(1)$,T(2)$,T(3)$,T(4)$
820 MAT INPUT#1, P(16,X1)
830 ON ERROR
840 '-----OPEN PRINT FILE "TEMPG" AND COMMENT FILE "#"
850 FILE SCRATCH WIDTH (144,144) #2=TEMPG, SCRATCH WIDTH (144,144) #4=#
860 A$=TIM
870 OUTPUT#2, " GRONK ** GRONK ** GRONK ** GRONK ** GRONK";TAB(54)DAT:TAB(67)A$(1,5);TAB(83)"GRONK ** GRONK ** GRONK ** GRONK ** GRO
900 '-----PRINT POPULATION TABLE
910 MAT A(16,X1)=P
920 I$="#,###,### "
930 GOSUB 7850
940 FOR F=2 TO 1-O(13) STEP -2
950  OUTPUT#F, C(F)$
960  OUTPUT#F, C(F)$;TAB( FNX(5*X1-3-LEN(P$),2) );
970  FOR C=1 TO LEN(P$)
980   OUTPUT#F, P$(C,1);" ";
990  NEXT C
1000  OUTPUT#F, "  P O P U L A T I O N   T A B L E"
1010  GOSUB 8020
1020 NEXT F
1030 C$=L(18)$
1040 GOTO 1520
1050
1060 '*****************************************************************************DO ERROR HANDLING
1070 PRINT "**THERE IS NO MASTER FILE '"G$;"' FOR REACTOR "R$
1080 FILE
1090 REMOVE G$
1100 GOTO 8850
1110 PRINT "**THE WORD 'RANGES' IS MISSING OR MISSPELLED IN "G$
1120 GOTO 8850
1130 PRINT "**RELEASE LIST '"I$;"' IS MISSING OR MISSPELLED IN "G$
1140 GOTO 1330
1150 IF ESM<>48 GOTO 1180
1160 PRINT "**RELEASE LIST MUST HAVE 136 ISOTOPES, NOT"I
1170 GOTO 1330
1180 IF ESM<>36 GOTO 1210
1190 PRINT "**MAXIMUM NUMBER OF NONZERO RELEASES=52"
1200 GOTO 1330
1210 IF EST<>18 GOTO 8850
1220 PRINT "**FILE "G$;" HAS BAD RELEASE "A$
1230 GOTO 1330
1240 PRINT "**THE TITLE '"M$;"' IS MISSING OR MISSPELLED OR ON THE WRONG LINE IN "G$
```

10.7 Program GRONK - CSTS Version (contd)

```
1250 GOTO 1330
1260 PRINT "**NUMBER OF "M$;" MODEL DIRECTIONS CANNOT BE"D1
1270 GOTO 1330
1280 PRINT "**INCOMPATIBLE INITIAL DIRECTIONS FOR POPULATION AND METEOROLOGY TABLES"
1290 GOTO 1330
1300 PRINT "**WRONG NUMBER OF STABILITY CATEGORIES FOR "M$;" MODEL"
1310 GOTO 1330
1320 PRINT "**ERROR WAS ON OR BEFORE LINE"PNO(1);"OF "G$
1330 IF K>1 GOTO 1380
1340 DISABLE
1350 FILE SCRATCH#1=TEMPG
1360 REMOVE TEMPG
1370 GOTO 8850
1380 PRINT "PREVIOUS CASES SUBMITTED FOR PRINTING"
1390 GOTO 8690
1400 C=ESL-10
1410 PRINT "**TILT**    ";
1420 ON ERROR GOTO 1400
1430 JUMP C
1440
1450 DATA WSW,WSW-W,W,W-WNW,WNW,WNW-NW,NW,NW-NNW,NNW,NNW-N,N,N-NNE,NNE,NNE-NE,NE,NE-ENE,ENE,ENE-E,E,E-ESE,ESE,ESE-SE
1460 DATA SE,SE-SSE,SSE,SSE-S,S,S-SSW,SSW,SSW-SW,SW,SW-WSW,WSW,WSW-W,W,W-WNW,WNW,WNW-NW,NW,NW-NNW,NNW,NNW-N,N,N-NNE
1470 DATA NNE,NNE-NE,NE,NE-ENE,ENE,ENE-E,E,E-ESE,ESE,ESE-SE,SE,SE-SSE,SSE,SSE-S,S,S-SSW,SSW,SSW-SW,SW,SW-WSW
1480 DATA 16,"  ---------------"," ","0","VERY STABLE","MODERATELY STABLE",NEUTRAL,UNSTABLE,  A,B,C,D,E,F,G,G+
1490 DATA "T A B L E   O F   C H I / Q","SKIN DOSE TO INDIVIDUAL, MREM/YEAR","TOTAL BODY DOSE TO INDIVIDUAL, MREM/YEAR"
1500 DATA "TOTAL BODY DOSE TO POPULATION, MAN-REM/YEAR","T H Y R O I D   D O S E"
1510
1520 '**********************************************************************INPUT METEOROLOGY TABLES
1530 ON ERROR GOTO 1240
1540 INPUT#1, L$
1550 IF L$<>M$ GOTO 1540
1560 ON ERROR GOTO 1320
1570 INPUT#1, D1,B$,Y,H
1580 FOR D9=-1 TO 30
1590  IF D(D9+2)$=B$ GOTO 1610
1600 NEXT D9
1610 IF D1<>16 GOTO 1260
1620 IF ABS(D8-D9)>1 GOTO 1280
1630 L(0)$=L(1)$=L(2)$=L(3)$=""
1640 MAT INPUT#1, N(10)
1650 U1=NUM
1660 FOR U=1 TO U1
1670  N(U)=.44704*N(U)
1680  INPUT#1, U(U)$
1690  L(3)$(7*U+3,5)=L(3)$(7*(U1+U)+13,5)=U(U)$
1700 NEXT U
1710 '-----INPUT AND OUTPUT METEOROLOGY
1720 A=B=S1=K6=K7=0
1730 GOTO 2700
1740 S1=S1+1
1750 INPUT#1, M
1760 IF S1>1 GOTO 1960
1770 PRINT "ENTER COMMENTS FOR THIS CASE";
1780 GET K$
1790 OUTPUT#4, STR(K,"0CASE##:  ");K$
1800 OUTPUT#4, TAB(11)M$;" MODEL";
1810 FILE SCRATCH #5=#
1820 L1=U1
```

10.7 Program GRONK - CSTS Version (contd)

```
1830 L5=3
1840 L(3)$(7*U1+11,6)=L(3)$(14*U1+21,6)=L(D1+4)$="TOTALS"
1850 FOR D=1 TO D1
1860  L(D+3)$=D(D9+U+D)$
1870 NEXT D
1880 L(1)$(FNX(3.5*U1-6,1),30)="METEOROLOGY AS INPUT FROM FILE"
1890 L(1)$(10.5*U1+6,28)="METEOROLOGY IN STANDARD FORM"
1900 L(2)$(10.5*U1+6.5,25)="PERCENT OF ALL OCCURRENCES"
1910 L(2)$(3.5*U1-2,22)="NUMBER OF OBSERVATIONS"
1920 IF M=0 OR M>100 GOTO 1960
1930 L(2)$(3.5*U1-4.5,26)="PERCENT OF ALL OCCURRENCES"
1940 IF M=100 GOTO 1960
1950 L(2)$(3.5*U1-7.5,33)="PERCENT OCCURENCE WITHIN CATEGORY"
1960 K2=1
1970 IF M=0 GOTO 2030
1980 I$=J$=" ###.##"
1990 IF M=100 GOTO 2040
2000 K2=.01*M
2010 IF M<100 GOTO 2040
2020 K2=100/M
2030 I$=J$="###,###"
2040 K5=0
2050 FOR U=1 TO U1
2060  INPUT#1, V(U)
2070  K5=K5+V(U)
2080  A$(7*U-6,7)=STR(V(U),I$)
2090  V(U)=V(U)/D1
2100 NEXT U
2110 A$(7*U1+4,7)=STR(K5,I$)
2120 INPUT#1, C
2130 V(1)=V(1)+C/D1
2140 MAT INPUT#I, A(DI,U1)
2150 L3=7
2160 GOSUB 8130
2170 FOR U=1 TO U1
2180  FOR D=1 TO D1
2190   A(D,U)=K2*(A(D,U)+V(U))
2200   WRITE#5, A(D,U)
2210  NEXT D
2220 NEXT U
2230 K5=M(D1+1)
2240 IF M=0 GOTO 2280
2250 L3=7*U1+17
2260 I$=" ###.##"
2270 GOSUB 8130
2280 B$=M$
2290 L(0)$=""
2300 B$(LEN(B$)+2,LEN(S(4-4*O(4)+S1)$))=S(4-4*O(4)+S1)$
2310 B$(LEN(B$)+2,6)="CATEGORY"
2320 L(0)$(3.5*U1+9-LEN(B$)/2,LEN(B$))=L(0)$(10.5*U1+19-LEN(B$)/2,LEN(B$))=B$
2330 F=2
2340 OUTPUT#2, "1"T$;TAB(114)DAT
2350 OUTPUT#2, "0"
2360 K3=1
2370 IF 38+14*U1>125 OR M=0 GOTO 2390
2380 K3=0
2390 GOSUB 8400
2400 IF K3=0 OR M=0 GOTO 2440
```

10.7 Program GRONK - CSTS Version (contd)

```
2410 OUTPUT#2, "1"T$;TAB(114)DAT
2420 OUTPUT#2, "0"
2430 GOSUB 8570
2440 F=0
2450 A=A+M(D1+1)
2460 K7=K7+K5
2470 IF M=0 OR M>=100 OR (K5>99.75 AND K5<100.25) GOTO 2600
2480 OUTPUT#2, "0"D$(3,10);" TABLE DOES NOT TOTAL 100%"D$(2,11)
2490 PRINT "**"G$;" WIND TABLE ERROR: TOTAL="K5;"%"
2500 IF K6<>0 GOTO 2600
2510 K6=1
2520 IF O(14)=1 GOTO 2600
2530 PRINT "SHALL I TYPE THE FAULTY METEOROLOGY HERE";
2540 GET B$
2550 IF B$(1,1)="Y" GOTO 2600
2560 IF B$(1,1)="N" GOTO 2590
2570 PRINT "**TILT**   ";
2580 GOTO 2530
2590 K6=-1
2600 IF K6<>0 OR O(14)=0 OR O(15)=0 OR 39+14*U1>132 OR M=0 GOTO 2640
2610 K3=0
2620 GOSUB 8400
2630 GOTO 2690
2640 IF K6<1 AND O(14)=0 GOTO 2670
2650 K3=1
2660 GOSUB 8400
2670 IF K6<>0 OR O(15)=0 OR M=0 GOTO 2690
2680 GOSUB 8570
2690 IF END#1 GOTO 2730
2700 INPUT#1, A$
2710 IF (O(4)=1 AND S1<4) OR (O(4)=0 AND S1<9 AND A$<>"NOTES") GOTO 1740
2720 IF A$<>"NOTES" AND (O(4)=0 OR A$<>"PASQUILL") GOTO 1320
2730 ON ERROR
2740 IF (O(4)=0 AND (S1<5 OR S1>8)) OR (O(4)=1 AND S1<>4) GOTO 1300
2750 IF M=0 OR (M>100 AND M=K7) GOTO 2920
2760 IF M<=100 GOTO 2790
2770 PRINT "**"M$;" WIND TABLE ERROR: GRAND TOTAL="K7;"NOT"M
2780 GOTO 2830
2790 IF A>99 AND A<101 GOTO 2820
2800 PRINT "**"M$;" WIND TABLE ERROR: GRAND TOTAL="A;"%"
2810 GOTO 2830
2820 IF K6=0 GOTO 2930
2830 OUTPUT#4, "  **METEOROLOGY ERROR";
2840 PRINT "SHALL I HALT RUN (BUT SUBMIT OUTPUT ACCUMULATED SO FAR TO MAIN PRINTER)";
2850 GET B$
2860 IF B$(1,1)="Y" GOTO 2900
2870 IF B$(1,1)="N" GOTO 2930
2880 PRINT "**TILT**   ";
2890 GOTO 2840
2900 OUTPUT#4, "***ABORTED***"
2910 GOTO 8670
2920 PRINT "TOTAL NUMBER OF OCCURRENCES="A;",  ALTER FILE '"G$;"' ACCORDINGLY."
2930 '-----AVERAGE ADJACENT POPULATION SECTORS IF NECESSARY
2940 IF D8=D9 GOTO 3060
2950 C=D9-D8
2960 B=8.5+7.5*C
2970 FOR X=1 TO X1
2980  P(B+C,X)=P(17-B,X)
```

10.7 Program GRONK - CSTS Version (contd)

```
2990 NEXT X
3000 FOR D=17-B TO B STEP C
3010  FOR X=1 TO X1
3020   P(D,X)=.5*(P(D,X)+P(D+C,X))
3030  NEXT X
3040 NEXT D
3050 D8=D9
3060 '-----INPUT PASQUILL CONSTANTS IF NECESSARY
3070 K6=SQR(2/&PI)/(A*&PI/8)
3080 IF O(4)=1 OR Z(1,1)>0 GOTO 3150
3090 FILE #1=TONIC
3100 FOR B=1 TO 35
3110  READ#1, Z(0,B)
3120 NEXT B
3130 MAT READ#1, Z(8,35)
3140
3150 '*****************************************************GET USER INPUT FROM TELETYPE, PRINT INPUT
3160 ON ERROR GOTO 1400
3170 DISABLE ALL
3180 IF (O(5)=0 AND O(6)=1) OR (K=1 AND O(5)+O(6)=0) GOTO 3340
3190 IF O(5)+O(6)=0 GOTO 3360
3200 PRINT "RELEASE HEIGHT+UNITS=";
3210 GET A$
3220 IF A$(LEN(A$))="M" GOTO 3260
3230 IF A$(LEN(A$))="F" GOTO 3300
3240 PRINT "**FOLLOW RELEASE HEIGHT WITH UNITS LETTER:  'M' FOR METERS, 'F' FOR FEET"
3250 GOTO 3200
3260 Z=VAL(A$(1,LEN(A$)-1))
3270 Z$=STR(Z)
3280 Z$(LEN(Z$)+2,13)="METER RELEASE"
3290 GOTO 3330
3300 Z$=STR(VAL(A$(1,LEN(A$)-1)))
3310 Z=.3048*VAL(Z$)
3320 Z$(LEN(Z$)+2,12)="FOOT RELEASE"
3330 IF Z>0 GOTO 3360
3340 Z=0
3350 Z$=" GROUND RELEASE"
3360 Z1=Z+P
3370 Z2=-.5*Z*Z
3380 K$(96-LEN(T$)-LEN(Z$),9)=""
3390 K$(97-LEN(T$)-LEN(Z$))=DAT
3400 OUTPUT#2, STR(K,"ICASE##:  ");T$;"   "Z$;"    "K$
3410 '-----INPUT RELEASES AND PRINT
3420 ON ERROR GOTO 1150
3430 I=I1=I2=0
3440 MAT M(8)=ZER
3450 FILE #1=G$, #3=GIN
3460 GET#1, T$
3470 IF R=0 GOTO 3560
3480 IF R=1 GOTO 3550
3490 PRINT "RELEASE LIST NAME=";
3500 GET I$
3510 INPUT#1, A$
3520 IF A$=I$ GOTO 3560
3530 IF A$<>"RANGES" GOTO 3510
3540 GOTO 1130
3550 INPUT#1, B$,I$
3560 H=41+58*O(11)
```

10.7 Program GRONK - CSTS Version (contd)

```
3570 FOR A=1 TO 6
3580  GET#3, A$(1,B+25)
3590  OUTPUT#2, A$(1,B+25)
3600  IF O(16)=0 GOTO 3620
3610  PRINT A$(1,B+25)
3620 NEXT A
3630 INPUT#1, B$
3640 IF B$="RANGES" OR B$="RELEASE" GOTO 3970
3650 IF B$(LEN(B$))<>"Z" GOTO 3700
3660 FOR I=I TO I-1+VAL(B$(1,LEN(B$)-1))
3670  GET#3, A$
3680 NEXT I
3690 GOTO 3630
3700 GET#3, A$(1,124)
3710 I=I+1
3720 K5=VAL(B$)*K6
3730 IF K5=0 GOTO 3630
3740 I1=I1+1
3750 N(I1)$=A$
3760 C=277777777*K5
3770 L(I1)=VAL(A$(29,8))
3780 T(I1)=C*VAL(A$(44,7))
3790 M(7)=M(7)+T(I1)
3800 S(I1)=C*VAL(A$(56,7))
3810 M(8)=M(8)+S(I1)
3820 IF A$(19,1)=" " GOTO 3930
3830 I2=I2+1
3840 E(I2,0)=31688*K5
3850 E(I2,7)=VAL(A$(19,1))
3860 E(I2,8)=-L(I1)
3870 FOR A=1 TO 6
3880  E(I2,A)=VAL(A$(63+9*A,7))
3890  M(A)=M(A)+E(I2,A)
3900 NEXT A
3910 IF O(11)=0 GOTO 3930
3920 N(I1)$(14,1)=STR(I2,"#")
3930 OUTPUT#2, A$(1,18);B$;TAB(26)A$(26,B)
3940 IF O(16)=0 GOTO 3630
3950 PRINT A$(1,18);B$;TAB(26)A$(26,B)
3960 GOTO 3630
3970 IF I<>136 GOTO 1160
3980 '-----FINISH PROCESSING OF OPTION LIST
3990 ON ERROR GOTO 1400
4000 OUTPUT#2, "0"
4010 OUTPUT#2, "0"M$;" MODEL"
4020 OUTPUT#2, Z$
4030 OUTPUT#4, "  "Z$;
4040 IF R=0 GOTO 4070
4050 OUTPUT#2, " "I$;" RELEASE LIST"
4060 OUTPUT#4, "   "I$;" LIST";
4070 IF O(7)=1 AND K>1 GOTO 4230
4080 O(0)=O(8)
4090 IF O(8)=1 GOTO 4140
4100 X1=X(0)=Y(0)
4110 MAT X(X1)=Y
4120 OUTPUT#2, " BUILT-IN TOTAL BODY/SKIN RANGES"
4130 GOTO 4240
4140 PRINT "ENTER NEW TOTAL BODY/SKIN RANGES IN MILES.  END THE SET WITH A BLANK LINE"
```

10.7 Program GRONK - CSTS Version (contd)

```
4150 MAT INPUT X(20)
4160 IF NUM>0 AND NUM<11 GOTO 4190
4170 PRINT "**MAXIMUM NUMBER OF RANGES=10"
4180 GOTO 4140
4190 X1=X(0)=NUM
4200 MAT X=X*(1609.344)
4210 OUTPUT#2, " NEW TOTAL BODY/SKIN RANGES"
4220 GOTO 4240
4230 OUTPUT#2, " SAME TOTAL BODY/SKIN RANGES"
4240 IF O(9)=0 GOTO 4270
4250 PRINT "PLUME RISE CONSTANT=";
4260 INPUT P
4270 IF P=0 GOTO 4300
4280 OUTPUT#2, " PLUME RISE CONSTANT="P;"METER-SQ/SEC"
4290 OUTPUT#4, "   PLUME RISE="P;
4300 IF O(10)=0 GOTO 4390
4310 IF H=0 GOTO 4370
4320 OUTPUT#2, " BUILDING WAKE FACTOR APPLIED.  BUILDING HEIGHT="H;"METERS"
4330 OUTPUT#4, "   WAKE FACTOR";
4340 K1=.25*H*H/&PI
4350 K0=K1+K1
4360 GOTO 4390
4370 PRINT "BUILDING HEIGHT IS ZERO; REQUEST FOR BUILDING WAKE FACTOR IGNORED"
4380 O(10)=0
4390 IF O(24)=1 GOTO 4420
4400 MAT U(U1)=N(U1)
4410 GOTO 4490
4420 IF Y=0 GOTO 4470
4430 OUTPUT#2, " WIND SPEEDS CORRECTED FROM"Y;"METERS TO"FNX(Z,10);"METERS"
4440 OUTPUT#4, "   WINDSPEED";
4450 MAT U(U1)=N(U1)*( (FNX(Z,10)/Y)↑(.5-O(4)/4) )
4460 GOTO 4490
4470 PRINT "WIND SENSOR HEIGHT IS ZERO; REQUEST FOR METEOROLOGY HEIGHT CORRECTION IGNORED"
4480 O(24)=0
4490 IF O(11)=0 GOTO 4750
4500 PRINT "ENTER GRAZING PERIOD, VEGETABLE CONSUMPTION PERIOD (MO/YR)";
4510 INPUT A,B
4520 PRINT "ENTER 2-YEAR-OLD VEG CONSUMPTION, ADULT VEG CONSUMPTION (KG/YR)";
4530 INPUT C,K5
4540 F1=A/12
4550 F2=B/12*C/18
4560 F3=B/12*K5/72
4570 OUTPUT#2, " PERFORM THYROID CALCULATION"
4580 OUTPUT#2, "   GRAZING PERIOD="A;"MONTHS/YEAR"
4590 OUTPUT#2, "   VEGETABLE CONSUMPTION PERIOD="B;"MONTHS/YEAR"
4600 OUTPUT#2, "   2-YEAR-OLD VEGETABLE CONSUMPTION="C;"KILOGRAMS/YEAR"
4610 OUTPUT#2, "   ADULT VEGETABLE CONSUMPTION="K5;"KILOGRAMS/YEAR"
4620 OUTPUT#4, "   THY";
4630 PRINT "ENTER THYROID RANGES IN MILES.  END THE SET WITH A BLANK LINE"
4640 ON ATTENTION GOTO 4730
4650 MAT INPUT K(20)
4660 IF NUM>0 AND NUM<11 GOTO 4690
4670 PRINT "**MAXIMUM NUMBER OF RANGES=10"
4680 GOTO 4630
4690 ON ATTENTION
4700 K(0)=NUM
4710 MAT K=K*(1609.344)
4720 GOTO 4750
```

10.7 Program GRONK - CSTS Version (contd)

```
4730 K(0)=X1
4740 MAT K(X1)=X(X1)
4750 IF O(12)=0 GOTO 4620
4760 OUTPUT#2, " ADD THESE RESULTS TO RESULTS OF NEXT CASE"
4770 OUTPUT#4, "   ADD TABLES";
4780 A1=1+A1*SGN(A1)
4790 FILE SCRATCH#1=STR(A1-2*INT(A1/2),"ADD#")
4800 IF A1=1 GOTO 4850
4810 GOTO 4840
4820 IF A1=0 GOTO 4850
4830 A1=-A1-1
4840 FILE #3=STR(1-A1+2*INT(A1/2),"ADD#")
4850 OUTPUT#4
4860 GOSUB 7150
4870 PRINT
4880
4890 '*********************************************************************PRINT CALCULATED TABLES
4900 '------CALCULATE AND PRINT CHI/Q TABLE
4910 ON ERROR
4920 K5=L=0
4930 MAT A(16,X1)=ZER
4940 MAT B(16,X1)=ZER
4950 MAT H(16,X1)=ZER
4960 GOSUB 5640
4970 MAT A=A*(K6)
4980 GOSUB 7860
4990 I$=" #.##!!!! "
5000 GOSUB 7410
5010 '------PRINT SKIN DOSE TO INDIVIDUAL
5020 MAT A=H
5030 GOSUB 7410
5040 '------PRINT TOTAL BODY DOSE TO INDIVIDUAL
5050 MAT A=B
5060 GOSUB 7410
5070 '------CALCULATE AND PRINT TOTAL BODY DOSE TO POPULATION
5080 IF O(0)=1 GOTO 5350
5090 FOR D=1 TO 16
5100  FOR X=1 TO X1
5110   A(D,X)=B(D,X)*P(D,X)*.001
5120  NEXT X
5130 NEXT D
5140 GOSUB 7410
5150 OUTPUT#2, STR(K,"1CASE##:  ");T$;"   "Z$;"    "K$
5160 OUTPUT#2, "0"
5170 FOR F=2 TO 1-O(23) STEP -2
5180  A$="   RADIUS                        DOSE        ANNUAL DOSE"
5190  A$(21-LEN(P$)/2,LEN(P$))=P$
5200  OUTPUT#F, C(F)$
5210  OUTPUT#F, " CUMULATIVE    CUMULATIVE    CUMULATIVE      AVERAGE"
5220  OUTPUT#F, A$
5230  OUTPUT#F, "  (MILES)       POPULATION   (MAN-REM/YR)    (MREM/YR)"
5240  OUTPUT#F
5250  FOR X=1 TO X1
5260   A=VAL(C$(10*X-1,1))*1E6 +VAL(C$(10*X+1,3))*1000 +VAL(C$(10*X+5,3))
5270   B=VAL(L(18)$(10*X,9))
5280   OUTPUT#F, C(F)$;STR(3+INT(X(X)/1609.344+2.5*SGN(X(X)/1609.344-7.5)),"######");TAB(16)C$(10*X-1,9);TAB(32);
5290   IF A=0 GOTO 5320
5300   OUTPUT#F, VAL(STR(B,".##!!!!"));TAB(46)VAL(STR(1000*B/A,".##!!!!"))
```

10.7 Program GRONK - CSTS Version (contd)

```
5310   GOTO 5330
5320   OUTPUT#F, VAL(STR(B,".##!!!!"))
5330  NEXT X
5340 NEXT F
5350 IF O(11)=0 OR (I2=0 AND A1<2) GOTO 5620
5360 '-----CALCULATE AND PRINT THYROID AND TRITIUM DOSE TO INDIVIDUAL
5370 K8=X(1)
5380 X1=1
5390 Q(1,7)=K6
5400 FOR K7=1 TO K(0)
5410  X(1)=K(K7)
5420  IF I2=0 GOTO 5500
5430  L=1
5440 MAT A(16,12)=ZER
5450 MAT B(16,7)=ZER
5460 GOSUB 5640
5470  K5=4
5480  GOSUB 7410
5490  GOTO 5530
5500  IF END#3 GOTO 5530
5510  MAT READ#3, B(16,7)
5520  MAT WRITE#1, B(16,7)
5530 NEXT K7
5540 X(1)=K8
5550 X1=X(0)
5560 IF A1>=0 GOTO 5620
5570 FILE #3
5580 REMOVE ADD1
5590 IF A=-2 GOTO 5610
5600 REMOVE ADD0
5610 A1=0
5620 GOTO 180
5630
5640'BEGIN SUBR *********************************************************PERFORM CHI/Q CALCULATION
5650 DISABLE
5660 RESTORE #5
5670 IF O(4)=0 GOTO 6190
5680 '-----HANFORD CHI/Q
5690 FOR S=1 TO 4
5700  IF S>2 GOTO 5800
5710  IF S=2 GOTO 5760
5720  L2=34
5730  L3=-8.8E-4
5740  L4=.025
5750  GOTO 5930
5760  L2=97
5770  L3=-2.5E-4
5780  L4=.33
5790  GOTO 5930
5800  FOR X=1 TO X1
5810   M(X)=X(X)!(.8+.025*S)
5820  NEXT X
5830  IF S=4 GOTO 5900
5840  IF O(24)=0 GOTO 5860
5850  MAT U=N*( (FNX(Z,10)/Y)!.25 )
5860  L2=.106066   '=.15/SQR(2)
5870  L3=.0848528  '=.12/SQR(2)
5880  L4=.0777817  '=.11/SQR(2)
```

10.7 Program GRONK - CSTS Version (contd)

```
5890  GOTO 5930
5900  L2=.212132   '=.30/SQR(2)
5910  L3=.183848   '=.26/SQR(2)
5920  L4=.169706   '=.24/SQR(2)
5930  FOR U=1 TO U1
5940   IF Z1=0 GOTO 6000
5950   IF P=0 GOTO 5990
5960   L1=Z+P/U(U)
5970   K2=-.5*L1*L1
5980   GOTO 6000
5990   K2=Z2
6000   MAT READ#5, W(16)
6010   IF U(U)<8 GOTO 6040
6020   K3=L4
6030   GOTO 6080
6040   IF U(U)<3 GOTO 6070
6050   K3=L3
6060   GOTO 6080
6070   K3=L2
6080   FOR X=1 TO X1
6090    T=X(X)/U(U)
6100    IF S>2 GOTO 6130
6110    C=SQR(L2-L2*EXP(L3*T*T)+L4*T)
6120    GOTO 6140
6130    C=K3*M(X)
6140    GOSUB 6480
6150   NEXT X
6160  NEXT U
6170 NEXT S
6180 GOTO 6450
6190 '-----PASQUILL CHI/Q
6200 FOR S=1 TO S1
6210  IF O(24)=0 OR S<>5 GOTO 6230
6220  MAT U=N*( (FNX(Z,10)/Y)|.5 )
6230  K3=1
6240  FOR X=1 TO X1
6250   IF X(X)<Z(0,K3+1) GOTO 6280
6260   K3=K3+1
6270   GOTO 6250
6280   V(X)=Z(S,K3)+(X(X)-Z(0,K3))*(Z(S,K3+1)-Z(S,K3))/(Z(0,K3+1)-Z(0,K3))
6290  NEXT X
6300  FOR U=1 TO U1
6310   IF Z1=0 GOTO 6370
6320   IF P=0 GOTO 6360
6330   L1=Z+P/U(U)
6340   K2=-.5*L1*L1
6350   GOTO 6370
6360   K2=Z2
6370   MAT READ#5, W(16)
6380   FOR X=1 TO X1
6390    T=X(X)/U(U)
6400    C=V(X)
6410    GOSUB 6480
6420   NEXT X
6430  NEXT U
6440 NEXT S
6450 ENABLE
6460RETURN
```

10.7 Program GRONK - CSTS Version (contd)

```
6470
6480'BEGIN SUBR ****************************************PERFORM INNERMOST LOOPS IN CHI/Q CALCULATION
6490 IF Z1=0 GOTO 6590
6500 IF O(10)=0 GOTO 6570
6510 IF K1>C GOTO 6550
6520 K4=C*C+K0
6530 K4=EXP(K2/K4)/(SQR(K4)*X(X)*U(U))
6540 GOTO 6660
6550 K4=EXP(K2/(3*C*C))/(1.732*C*X(X)*U(U))
6560 GOTO 6660
6570 K4=EXP(K2/(C*C))/(C*X(X)*U(U))
6580 GOTO 6660
6590 IF O(10)=0 GOTO 6650
6600 IF K1>C GOTO 6630
6610 K4=1/(SQR(C*C+K0)*X(X)*U(U))
6620 GOTO 6660
6630 K4=1/(1.732*C*X(X)*U(U))
6640 GOTO 6660
6650 K4=1/(C*X(X)*U(U))
6660 IF L=0 GOTO 6800
6670 '-----THYROID SECTION
6680 FOR I=1 TO I2
6690  C(1,I)=E(I,0)*EXP(E(1,8)*T)
6700 NEXT I
6710 MAT Q(1,6)=C(1,I2)*E(12,6)
6720 FOR D=1 TO 16
6730  F(D,1)=K4*W(D)
6740 NEXT D
6750 MAT H(16,I2)=F(16,1)*C(1,I2)
6760 MAT A=A+H
6770 MAT H(16,7)=F(16,1)*Q(1,7)
6780 MAT B=B+H
6790RETURN
6800 '-----TOTAL BODY/SKIN SECTION
6810 B=C=0
6820 FOR I=1 TO I1
6830  A=EXP(-L(1)*T)
6840  B=B+A*T(I)
6850  C=C+A*S(I)
6860 NEXT I
6870 FOR D=1 TO 16
6880  A=K4*W(D)
6890  A(D,X)=A(D,X)+A
6900  B(D,X)=B(D,X)+A*B
6910  H(D,X)=H(D,X)+A*C
6920 NEXT D
6930RETURN
6940
6950'BEGIN SUBR *****************************************************************PRINT THYROID TABLE
6960 OUTPUT#F, C(F)$
6970 OUTPUT#F, TAB(11)"CHI/Q"$TAB(28)"NUCLIDE CONCENTRATION, PCI/CUBIC METER"$TAB(76)"D O S E   F R O M   P A T H W A Y   M R E M /
6980 OUTPUT#F, TAB(9)"SEC/M**3"D$$D$(3)$D$(3)$D$(8)$"     INHALATION           MILK        LEAFY VEGETABLES"
6990 OUTPUT#F, TAB(74)D$$D$$D$
7000 OUTPUT#F, TAB(19)"TE-132D  I-129    I-130    I-131    I-132    I-133    I-135    2 YR     ADULT     2 YR     ADULT     2 YR     ADULT"
7010 OUTPUT#F
7020 FOR D=1 TO 16
7030  OUTPUT#F USING " #####   #.#!!!!", D(D9+D+D)$,B(D,7)$
7040  A$=A$(58,0)=""
```

10.7 Program GRONK - CSTS Version (contd)

```
7050  FOR I=1 TO 12
7060   A$(8*E(I,7)-5,7)=STR(A(D,1),"#.#!!!!")
7070  NEXT I
7080  OUTPUT#F USING A$(1,57);
7090  OUTPUT#F USING "  #.#!!!! #.#!!!!", B(D,1),B(D,2);B(D,3)*F1,B(D,4)*F1;B(D,5)*F2,B(D,6)*F3
7100  IF D<>4 AND D<>8 AND D<>12 GOTO 7120
7110  OUTPUT#F
7120 NEXT D
7130RETURN
7140
7150'BEGIN SUBR *****************************************************************PRINT PERCENT BY ISOTOPE
7160 OUTPUT#2, STR(K,"1CASE##:  ");T$;"   "Z$;"    "K$
7170 FOR F=2 TO 1-O(17) STEP -2
7180  OUTPUT#F, C(F)$
7190  OUTPUT#F, C(F)$;TAB(18)"CONTRIBUTION TO DOSE AT RELEASE POINT"
7200  OUTPUT#F, C(F)$;" ISOTOPE        TOTAL  SKIN    INHALATION    ---MILK----    VEGETABLES"
7210  OUTPUT#F, TAB(18)"BODY";TAB(32)"2 YR  ADULT   2 YR  ADULT   2 YR  ADULT"
7220 NEXT F
7230 FOR I=1 TO 11
7240  A$=N(I)$(1,13)
7250  IF T(I)<.05*M(7) GOTO 7270
7260  A$(17,5)=STR(100*T(I)/M(7),"### %")
7270  IF S(I)<.05*M(8) GOTO 7290
7280  A$(23,5)=STR(100*S(I)/M(8),"### %")
7290  IF N(I)$(14)=" " GOTO 7340
7300  FOR A=1 TO 6
7310   IF E(VAL(N(I)$(14)),A)<.05*M(A) GOTO 7330
7320   A$(24+7*A,5)=STR(100*E(VAL(N(I)$(14)),A)/M(A),"### %")
7330  NEXT A
7340  IF LEN(A$)=13 GOTO 7380
7350  OUTPUT#2, A$
7360  IF O(17)=0 GOTO 7380
7370  PRINT A$
7380 NEXT I
7390RETURN
7400
7410'BEGIN SUBR ******************************************************SET UP PRINTING OF RESULT TABLES
7420 K2=0
7430 OUTPUT#2, STR(K,"1CASE##:  ");T$;"   "Z$;"    "K$
7440 FOR F=2 TO 1-O(K5+18) STEP -2
7450  OUTPUT#F, C(F)$
7460  IF A1=0 OR A1=1 OR K2=0 OR F=0 GOTO 7620
7470  IF K5=4 GOTO 7550
7480  FOR D=1 TO 16
7490   FOR X=1 TO X1
7500    READ#3, A  ''
7510    A(D,X)=A(D,X)+A
7520   NEXT X
7530  NEXT D
7540  GOTO 7590
7550  MAT A=ZER
7560  IF END#3 GOTO 7590
7570  MAT READ#3, H(16,7)
7580  MAT B=B(16,7)+H
7590  OUTPUT#2, "0";TAB(43)"*****SUM OF RESULTS FOR LAST"ABS(A1);"CASES*****"
7600  IF O(K5+18)=0 GOTO 7620
7610  PRINT "----------SUM OF RESULTS FOR LAST"ABS(A1);"CASES"
7620  IF K5=4 GOTO 7680
```

10.7 Program GRONK - CSTS Version (contd)

```
7630  OUTPUT#F, C(F)$;TAB(FNX(5*X1+13.5-LEN(T(K5)$)/2,2))T(K5)$;TAB(116-LEN(M$))M$;" MODEL"
7640  GOSUB 8020
7650  IF (A1<>1 OR K2=1) AND (A1<2 OR K2=0) OR F=0 GOTO 7730
7660  MAT WRITE#1, A(16,X1)
7670  GOTO 7730
7680  OUTPUT#F, C(F)$;TAB(180-32*K5)T(K5)$;TAB(116-LEN(M$))M$;" MODEL"
7690  OUTPUT#F, TAB(58)X(1)/1609.344;"MILES"
7700  GOSUB 6950
7710  IF ((A1<>1 OR K2=1) AND (A1<2 OR K2=0)) OR F=0 GOTO 7730
7720  MAT WRITE#1, B(16,7)
7730 NEXT F
7740 IF K5<>3 OR K2=1 OR O(19)=1 GOTO 7760
7750 PRINT "POPULATION TOTAL BODY DOSE="INT(M(D1+1)*100+.5)/100;"MANREM/YEAR"
7760 IF A1=0 OR A1=1 OR K2=1 GOTO 7790
7770 K2=1
7780 GOTO 7430
7790 K5=K5+1
7800RETURN
7810
7820'BEGIN SUBR ************************************************************PRINT RESULT MATRICES
7830 'MAXIMUM OF 11 RANGES CAN FIT ON ONE PRINT LINE
7840 'TO CENTER TITLE:   TAB(FNX(5*X1+13.5-LEN/2, 2));
7850'**INITIALIZE TABLE HEADINGS FOR MATRIX A(D1,X1)
7860 L1=X1
7870 L3=9
7880 L5=0
7890 L(0)$="   RANGE"
7900 L(0)$(14+10*X1,6)=L(D1+1)$="TOTALS"
7910 L(D1+2)$="CUM TOTL"
7920 FOR X=1 TO X1
7930  A$=STR(VAL(STR(X(X)/1609.344,".###!!!!")))
7940  L(0)$(4-LEN(A$)+10*X,LEN(A$))=A$
7950  L(0)$(4+10*X,3)=" MI"
7960 NEXT X
7970 FOR D=1 TO D1
7980  L(D)$=D(D8+D+D)$
7990 NEXT D
8000RETURN
8010
8020'**OUTPUT THE MATRIX A(D1,X1)
8030 IF F=0 GOTO 8050
8040 GOSUB 8130
8050 OUTPUT#F, C(F)$
8060 FOR D=0 TO D1+2
8070  OUTPUT#F, " "L(D)$
8080  IF D<>0 AND D<>4 AND D<>8 AND D<>12 AND D<>16 AND D<>D1+1 GOTO 8100
8090  OUTPUT#F
8100 NEXT D
8110RETURN
8120
8130'**PUT TABLE INFORMATION INTO L()$
8140 MAT M(D1+1)=ZER
8150 L2=LEN(I$)
8160 L4=L3
8170 FOR L=1 TO L1
8180  K4=0
8190  FOR D=1 TO D1
8200   L(D+L5)$(L4,L2)=STR(A(D,L),I$)
```

10.7 Program GRONK - CSTS Version (contd)

```
8210   K4=K4+A(D,L)
8220   M(D)=M(D)+A(D,L)
8230  NEXT D
8240  IF L5>0 GOTO 8270
8250  L(D1+2+L5)$(L4,L2)=STR(M(D1+1)+K4,I$)
8260  GOTO 8290
8270  IF L3>7 GOTO 8290
8280  K4=K4+D1*V(L)
8290  M(D1+1)=M(D1+1)+K4
8300  L(D1+1+L5)$(L4,L2)=STR(K4,I$)
8310  L4=L4+L2
8320 NEXT L
8330 FOR D=1 TO D1+1
8340  L(D+L5)$(L4+3,L2)=STR(M(D),I$)
8350 NEXT D
8360 IF L5>0 GOTO 8380
8370 L(D1+2+L5)$(L4+3,L2)=L(D1+2+L5)$(L4-L2)
8380RETURN
8390
8400 '**PRINT METEOROLOGY TABLE
8410 FOR D=0 TO D1+4
8420  IF K3=0 GOTO 8450
8430  OUTPUT#F, " "L(D)$(1,7*U1+16)
8440  GOTO 8460
8450  OUTPUT#F, " "L(D)$(1,7*U1+16);"        "L(D)$(1,6);L(D)$(7*U1+17)
8460  IF D<>2 AND D<>3 AND D<>7 AND D<>11 AND D<>15 AND D<>D1+3 GOTO 8520
8470  IF D<>D1+3 GOTO 8510
8480  OUTPUT#F
8490  OUTPUT#F, " VARBL "A$
8500  OUTPUT#F, " CALM  "STR(C,J$);TAB(7*U1+11)STR(C,J$)
8510  OUTPUT#F
8520 NEXT D
8530 IF M=0 OR M>=100 GOTO 8550
8540 OUTPUT#F, TAB(7*U1+12-LEN(STR(M)))"TIMES"STR(M);"%"
8550RETURN
8560
8570 '**PRINT METEOROLOGY TABLE (LAST HALF ONLY)
8580 FOR D=0 TO D1+4
8590  OUTPUT#F, " "L(D)$(1,6);L(D)$(7*U1+17)
8600  IF D<>2 AND D<>3 AND D<>7 AND D<>11 AND D<>15 AND D<>D1+3 GOTO 8620
8610  OUTPUT#F
8620 NEXT D
8630RETURN
8640
8650 '*************************************************************COMPLETE FILES, SUBMIT FOR LISTING
8660 IF LI=0 GOTO 8800
8670 OUTPUT#1, #1S U M M A R Y   O F   R U N           #R$
8680 D.SABLE
8690 RESTORE #4
8700 IF END#4 GOTO 8740
8710 GET#4, A$
8720 OUTPUT#2, A$
8730 GOTO 8700
8740 A$=TIM
8750 OUTPUT#2, "-GRONK ** GRONK ** GRONK ** GRONK ** GRONK";TAB(54)DAT;TAB(67)A$(1,5);TAB(83)"GRONK ** GRONK ** GRONK ** GRONK ** GR
8760 OUTPUT#2, "1MAIL TO:  NM ROBINSON, BATTELLE-NORTHWEST, 3717 BLDG, 300 AREA, RICHLAND, WASHINGTON  99352"
8770 FILE
8780 SUBMIT TEMPG,A=LISTBCC
```

10.7 Program GRONK - CSTS Version (contd)

```
8790 REMOVE TEMPG
8800 IF O(2)=0 GOTO 8820
8810 OFF
8820 IF O(3)=0 GOTO 8850
8830 PRINT "NEW RUN:"
8840 RUN
8850 ENABLE
```

10.8 Program GRONK - CSCX Version

```
100 'THIS PROGRAM CALCULATES THE DOSE RESULTING FROM AN AIR RELEASE OF RADIOACTIVE ISOTOPES, 12 JUNE 1973
110 'FOR HELP CONTACT NORM ROBINSON,   509 942-3754
120 DIM L(52),T(52),S(52),E(8,8),P(17,10),A(16,10),B(16,10),H(16,10),N(10),U(10),V(10)
130 DIM Y(10),X(20),K(20),O(24),Z(8,35),M(17),W(16),F(16,1),Q(1,7),C(1,8)
140 DIM U(10)$(5),D(64)$(6),S(12)$(17),C(2)$(1),T(4)$(47),N(52)$(15),L(20)$(166),A$(124),B$(34),C$(107),K$(83),T$(72),$(22)
150 DEF FNX(A,B)=(A+B+ABS(A-B))/2        'FNX(A,B)=MAX(A,B)
160 PRINT ¤REACTOR NAME¤;
170 GET R$
180 RESTORE
190 WIDTH 132
200 '-----GET OPTION WORD AND DECODE
210 MAT O(24)=ZER
220 A$=¤EFNHLGSRPWTA0123456789XM¤
230 PRINT
240 PRINT ¤OPTION WORD¤;
250 GET B$
260 FOR A=1 TO 24
270  FOR B=1 TO LEN(B$)
280   IF B$(B,1)<>A$(A,1) GOTO 310
290   O(A)=1
300   B$(B,1)=¤ ¤
310  NEXT B
320 NEXT A
330 A$=A$(LEN(B$)+1,0)=¤¤
340 IF B$=A$ GOTO 370
350 PRINT ¤**BAD OPTION: ¤B$
360 GOTO 200
370 IF O(1)+O(2)+O(3)>0 GOTO 8790
380 IF O(7)+O(8)<2 GOTO 410
390 PRINT ¤**CONFLICTING OPTIONS R AND S¤
400 GOTO 200
410 M$=¤PASQUILL¤
420 IF O(4)=0 GOTO 440
430 M$=¤HANFORD¤
440 K=K+1
450 IF K=1 GOTO 550
460 IF M$<>L$ GOTO 520
470 PRINT ¤ENTER COMMENTS FOR THIS CASE¤;
480 GET K$
490 OUTPUT#4, STR(K,¤ @N MSG   CASE##:  ¤);K$
500 OUTPUT#4, ¤ @N MSG¤;TAB(13)M$;¤ MODEL¤;
510 GOTO 3310
520 FILE #1=G$
530 GOTO 1690
540
550 '*********************************************************************************FIRST CASE OF RUN
560 '-----READ INITIAL PORTION OF FILE
570 G$=¤G¤
```

10.8 Program GRONK - CSCX Version (contd)

```
580 G$(2,4)=R$
590 DISABLE ALL
600 ON ERROR GOTO 1240
610 FILE #1=G$
620 GET#1, T$
630 ON ERROR GOTO 1280
640 INPUT#1, B$
650 IF B$<>¤RELEASE¤ GOTO 670
660 R=R+1
670 IF B$<>¤RANGES¤ GOTO 640
680 ENABLE
690 ON ERROR GOTO 1490
700 MAT INPUT#1, Y(10)
710 X1=Y(0)=NUM
720 MAT Y=Y*(1609.344)
730 MAT X(X1)=Y
740 INPUT#1, A$,P$,A$
750 FOR D=1 TO 64
760  READ D(D)$
770 NEXT D
780 FOR D8=1 TO 32
790  IF D(D8+2)$=A$ GOTO 810
800 NEXT D8
810 READ D1,D$,C(0)$,C(2)$,S(1)$,S(2)$,S(3)$,S(4)$,S(5)$,S(6)$,S(7)$
820 READ S(8)$,S(9)$,S(10)$,S(11)$,S(12)$,T(0)$,T(1)$,T(2)$,T(3)$,T(4)$
830 MAT INPUT#1, P(16,X1)
840 ON ERROR
850 '-----OPEN PRINT FILE AND CRJE FILE
860 FOR C=0 TO 9
870  F$=EDT(STR(C),¤TEMP#¤)
880  FILE #2=F$
890  IF END#2 GOTO 950
900  GET#2, A$(1,121)
910  IF A$(114)<>DAT GOTO 950
920 NEXT C
930 PRINT ¤**TOO MANY WAITING RUNS - TRY AGAIN LATER¤
940 GOTO 8940
950 U$=EDT(F$(5),¤SUB#¤)
960 W$=EDT(F$(5),¤WEATH#¤)
970 FILE SCRATCH#2=F$,SCRATCH#4=U$
980 OUTPUT#2, TAB(114)DAT
990 DISABLE
1000 FILE SCRATCH#2=F$
1010 ENABLE
1020 A$=TIM
1030 OUTPUT#4, ¤ @ RUN,S GRONK¤U$(4);¤,¤UID;¤,,¤PID;¤,30,5000¤;TAB(42)¤DL HAGGARD¤;TAB(62)¤3717 BLDG  942-5282¤
1040 OUTPUT#4, ¤ @PRL TEL CUB600¤;TAB(32)DAT;¤  ¤A$(1,5)
1050 OUTPUT#4, ¤ @N MSG  ¤T$
1060 OUTPUT#2, ¤1¤T$;TAB(114)DAT
1070 '-----PRINT POPULATION TABLE
1080 MAT A(16,X1)=P
1090 I$=¤#,###,### ¤
1100 GOSUB 8010
1110 FOR F=2 TO 1-O(13) STEP -2
1120  OUTPUT#F, C(F)$
1130  OUTPUT#F, C(F)$;TAB( FNX(5*X1-3-LEN(P$),2) );
1140  FOR C=1 TO LEN(P$)
1150   OUTPUT#F, P$(C,1);¤ ¤;
1160  NEXT C
```

10.8 Program GRONK - CSCX Version (contd)

```
1170  OUTPUT#F, ¤  P O P U L A T I O N   T A B L E¤
1180  GOSUB 8180
1190 NEXT F
1200 C$=L(18)$
1210 GOTO 1690
1220
1230 '**************************************************************************DO ERROR HANDLING
1240 PRINT ¤**THERE IS NO MASTER FILE '¤G$;¤' FOR REACTOR ¤R$
1250 FILE
1260 REMOVE G$
1270 GOTO 8940
1280 PRINT ¤**THE WORD 'RANGES' IS MISSING OR MISSPELLED IN ¤G$
1290 GOTO 8940
1300 PRINT ¤**RELEASE LIST '¤I$;¤' IS MISSING OR MISSPELLED IN ¤G$
1310 GOTO 1500
1320 IF ESM<>48 GOTO 1350
1330 PRINT ¤**RELEASE LIST MUST HAVE 136 ISOTOPES, NOT¤I
1340 GOTO 1500
1350 IF ESM<>36 GOTO 1380
1360 PRINT ¤**MAXIMUM NUMBER OF NONZERO RELEASES=52¤
1370 GOTO 1500
1380 IF EST<>18 GOTO 8940
1390 PRINT ¤**FILE ¤G$;¤ HAS BAD RELEASE ¤R$
1400 GOTO 1500
1410 PRINT ¤**THE TITLE '¤M$;¤' IS MISSING OR MISSPELLED OR ON THE WRONG LINE IN ¤G$
1420 GOTO 1500
1430 PRINT ¤**NUMBER OF ¤M$;¤ MODEL DIRECTIONS CANNOT BE¤D1
1440 GOTO 1500
1450 PRINT ¤**INCOMPATIBLE INITIAL DIRECTIONS FOR POPULATION AND METEOROLOGY TABLES¤
1460 GOTO 1500
1470 PRINT ¤**WRONG NUMBER OF STABILITY CATEGORIES FOR ¤M$;¤ MODEL¤
1480 GOTO 1500
1490 PRINT ¤**ERROR WAS ON OR BEFORE LINE¤PNO(1);¤OF ¤G$
1500 IF K>1 GOTO 1550
1510 DISABLE
1520 FILE
1530 REMOVE F$,U$
1540 GOTO 8940
1550 PRINT ¤PREVIOUS CASES SUBMITTED FOR PRINTING¤
1560 GOTO 8820
1570 C=ESL-10
1580 PRINT ¤**TILT**   ¤;
1590 ON ERROR GOTO 1570
1600 JUMP C
1610
1620 DATA WSW,WSW-W,W,W-WNW,WNW,WNW-NW,NW,NW-NNW,NNW,NNW-N,N,N-NNE,NNE,NNE-NE,NE,NE-ENE,ENE,ENE-E,E,E-ESE,ESE,ESE-SE
1630 DATA SE,SE-SSE,SSE,SSE-S,S,S-SSW,SSW,SSW-SW,SW,SW-WSW,WSW,WSW-W,W,W-WNW,WNW,WNW-NW,NW,NW-NNW,NNW,NNW-N,N,N-NNE
1640 DATA NNE,NNE-NE,NE,NE-ENE,ENE,ENE-E,E,E-ESE,ESE,ESE-SE,SE,SE-SSE,SSE,SSE-S,S,S-SSW,SSW,SSW-SW,SW,SW-WSW
1650 DATA 16,¤  ---------------¤,¤ ¤,¤G¤,¤VERY STABLE¤,¤MODERATELY STABLE¤,NEUTRAL,UNSTABLE,  A,B,C,D,E,F,G,G+
1660 DATA ¤T A B L E   O F   C H I / Q¤,¤SKIN DOSE TO INDIVIDUAL, MREM/YEAR¤,¤TOTAL BODY DOSE TO INDIVIDUAL, MREM/YEAR¤
1670 DATA ¤TOTAL BODY DOSE TO POPULATION, MAN-REM/YEAR¤,¤T H Y R O I D   D O S E¤
1680
1690 '*******************************************************************INPUT METEOROLOGY TABLES
1700 ON ERROR GOTO 1410
1710 INPUT#1, L$
1720 IF L$<>M$ GOTO 1710
1730 ON ERROR GOTO 1490
1740 INPUT#1, D1,B$,Y,H
1750 FOR D9=-1 TO 30
```

10.8 Program GRONK - CSCX Version (contd)

```
1760  IF D(D9+2)$=B$ GOTO 1780
1770 NEXT D9
1780 IF D1<>16 GOTO 1430
1790 IF ABS(D8-D9)>1 GOTO 1450
1800 L(0)$=L(1)$=L(2)$=L(3)$=¤¤
1810 MAT INPUT#1, N(10)
1820 U1=NUM
1830 FOR U=1 TO U1
1840  N(U)=.44704*N(U)
1850  INPUT#1, U(U)$
1860  L(3)$(7*U+3,5)=L(3)$(7*(U1+U)+13,5)=U(U)$
1870 NEXT U
1880 '-----INPUT AND OUTPUT METEOROLOGY
1890 A=B=S1=K6=K7=0
1900 GOTO 2890
1910 S1=S1+1
1920 INPUT#1, M
1930 IF S1>1 GOTO 2130
1940 PRINT ¤ENTER COMMENTS FOR THIS CASE¤;
1950 GET K$
1960 OUTPUT#4, STR(K,¤ @N MSG   CASE##:  ¤);K$
1970 OUTPUT#4, ¤ @N MSG¤;TAB(13)M$;¤ MODEL¤;
1980 FILE SCRATCH#3=W$
1990 L1=U1
2000 L5=3
2010 L(3)$(7*U1+11,6)=L(3)$(14*U1+21,6)=L(D1+4)$=¤TOTALS¤
2020 FOR D=1 TO D1
2030  L(D+3)$=D(D9+D+D)$
2040 NEXT D
2050 L(1)$(FNX(3.5*U1-6,1),30)=¤METEOROLOGY AS INPUT FROM FILE¤
2060 L(1)$(10.5*U1+6,28)=¤METEOROLOGY IN STANDARD FORM¤
2070 L(2)$(10.5*U1+6.5,25)=¤PERCENT OF ALL OCCURRENCES¤
2080 L(2)$(3.5*U1-2,22)=¤NUMBER OF OBSERVATIONS¤
2090 IF M=0 OR M>100 GOTO 2130
2100 L(2)$(3.5*U1-4.5,26)=¤PERCENT OF ALL OCCURRENCES¤
2110 IF M=100 GOTO 2130
2120 L(2)$(3.5*U1-7.5,33)=¤PERCENT OCCURENCE WITHIN CATEGORY¤
2130 K2=1
2140 IF M=0 GOTO 2200
2150 I$=J$=¤ ###.##¤
2160 IF M=100 GOTO 2210
2170 K2=.01*M
2180 IF M<100 GOTO 2210
2190 K2=100/M
2200 I$=J$=¤####,###¤
2210 K5=0
2220 FOR U=1 TO U1
2230  INPUT#1, V(U)
2240  K5=K5+V(U)
2250  A$(7*U-6,7)=STR(V(U),I$)
2260  V(U)=V(U)/D1
2270 NEXT U
2280 A$(7*U1+4,7)=STR(K5,I$)
2290 INPUT#1, C
2300 V(1)=V(1)+C/D1
2310 MAT INPUT#1, A(D1,U1)
2320 L3=7
2330 GOSUB 8290
2340 FOR U=1 TO U1
```

10.8 Program GRONK - CSCX Version (contd)

```
2350  FOR D=1 TO D1
2360   A(D,U)=K2*(A(D,U)+V(U))
2370   WRITE#3, A(D,U)
2380  NEXT D
2390 NEXT U
2400 K5=M(D1+1)
2410 IF M=0 GOTO 2460
2420 L3=7*U1+17
2430 I$=¤ ###.##¤
2440 GOSUB 8290
2450 L(0)$=¤¤
2460 B$=M$
2470 B$(LEN(B$)+2,LEN(S(4-4*O(4)+S1)$))=S(4-4*O(4)+S1)$
2480 B$(LEN(B$)+2,8)=¤CATEGORY¤
2490 L(0)$(3.5*U1+9-LEN(B$)/2,LEN(B$))=L(0)$(10.5*U1+19-LEN(B$)/2,LEN(B$))=B$
2500 F=2
2510 OUTPUT#2, ¤1¤T$;TAB(114)DAT
2520 OUTPUT#2, ¤0¤
2530 K3=1
2540 IF 38+14*U1>125 OR M=0 GOTO 2560
2550 K3=0
2560 GOSUB 8560
2570 IF K3=0 OR M=0 GOTO 2610
2580 OUTPUT#2, ¤1¤T$;TAB(114)DAT
2590 OUTPUT#2, ¤0¤
2600 GOSUB 8720
2610 F=0
2630 A=A+M(D1+1)
2650 K7=K7+K5
2660 IF M=0 OR M>=100 OR (K5>99.75 AND K5<100.25) GOTO 2790
2670 OUTPUT#2, ¤0¤D$(3,10);¤ TABLE DOES NOT TOTAL 100%¤D$(2,11)
2680 PRINT ¤**¤B$;¤ WIND TABLE ERROR: TOTAL=¤K5;¤%¤
2690 IF K6<>0 GOTO 2790
2700 K6=1
2710 IF O(14)=1 GOTO 2790
2720 PRINT ¤SHALL I TYPE THE FAULTY METEOROLOGY HERE¤;
2730 GET B$
2740 IF B$(1,1)=¤Y¤ GOTO 2790
2750 IF B$(1,1)=¤N¤ GOTO 2780
2760 PRINT ¤**TILT**   ¤;
2770 GOTO 2720
2780 K6=-1
2790 IF K6<>0 OR O(14)=0 OR O(15)=0 OR 39+14*U1>132 OR M=0 GOTO 2830
2800 K3=0
2810 GOSUB 8560
2820 GOTO 2880
2830 IF K6<1 AND O(14)=0 GOTO 2860
2840 K3=1
2850 GOSUB 8560
2860 IF K6<>0 OR O(15)=0 OR M=0 GOTO 2880
2870 GOSUB 8720
2880 IF END#1 GOTO 2920
2890 INPUT#1, A$
2900 IF (O(4)=1 AND S1<4) OR (O(4)=0 AND S1<9 AND A$<>¤NOTES¤) GOTO 1910
2910 IF A$<>¤NOTES¤ AND (O(4)=0 OR A$<>¤PASQUILL¤) GOTO 1490
2920 ON ERROR
2930 IF (O(4)=0 AND (S1<6 OR S1>8)) OR (O(4)=1 AND S1<>4) GOTO 1470
2940 IF M=0 OR (M>100 AND M=K7) GOTO 3080
2942 IF M<=100 GOTO 2950
```

10.8 Program GRONK - CSCX Version (contd)

```
2944 PRINT ¤**¤M$;¤ WIND TABLE ERROR: GRAND TOTAL=¤K7;¤NOT¤M
2946 GOTO 2990
2950 IF A>99 AND A<101 GOTO 2980
2960 PRINT ¤**¤M$;¤ WIND TABLE ERROR: GRAND TOTAL=¤A;¤%¤
2970 GOTO 2990
2980 IF K6=0 GOTO 3090
2990 OUTPUT#4, ¤  **METEOROLOGY ERROR¤;
3000 PRINT ¤SHALL I HALT RUN (BUT SUBMIT OUTPUT ACCUMULATED SO FAR TO MAIN PRINTER)¤;
3010 GET B$
3020 IF B$(1,1)=¤Y¤ GOTO 3060
3030 IF B$(1,1)=¤N¤ GOTO 3090
3040 PRINT ¤**TILT**   ¤;
3050 GOTO 3000
3060 OUTPUT#4, ¤***ABORTED***¤
3070 GOTO 8810
3080 PRINT ¤TOTAL NUMBER OF OCCURRENCES=¤A;¤,  ALTER FILE '¤G$;¤' ACCORDINGLY.¤
3090 '-----AVERAGE ADJACENT POPULATION SECTORS IF NECESSARY
3100 IF D8=D9 GOTO 3220
3110 C=D9-D8
3120 B=8.5+7.5*C
3130 FOR X=1 TO X1
3140  P(B+C,X)=P(17-B,X)
3150 NEXT X
3160 FOR D=17-B TO B STEP C
3170  FOR X=1 TO X1
3180   P(D,X)=.5*(P(D,X)+P(D+C,X))
3190  NEXT X
3200 NEXT D
3210 D8=D9
3220 '-----INPUT PASQUILL CONSTANTS IF NECESSARY
3230 K6=2/(A*SQR(2*&PI)*&PI/8)
3240 IF O(4)=1 OR Z(1,1)>0 GOTO 3310
3250 FILE #1=*TONIC
3260 FOR B=1 TO 35
3270  READ#1, Z(0,B)
3280 NEXT B
3290 MAT READ#1, Z(8,35)
3300
3310 '****************************************************GET USER INPUT FROM TELETYPE, PRINT INPUT
3320 ON ERROR GOTO 1570
3330 DISABLE ALL
3340 IF (O(5)=0 AND O(6)=1) OR (K=1 AND O(5)+O(6)=0) GOTO 3500
3350 IF O(5)+O(6)=0 GOTO 3520
3360 PRINT ¤RELEASE HEIGHT+UNITS=¤;
3370 GET A$
3380 IF A$(LEN(A$))=¤M¤ GOTO 3420
3390 IF A$(LEN(A$))=¤F¤ GOTO 3460
3400 PRINT ¤**FOLLOW RELEASE HEIGHT WITH UNITS LETTER:  'M' FOR METERS, 'F' FOR FEET¤
3410 GOTO 3360
3420 Z=VAL(A$(1,LEN(A$)-1))
3430 Z$=STR(Z)
3440 Z$(LEN(Z$)+2,13)=¤METER RELEASE¤
3450 GOTO 3490
3460 Z$=STR(VAL(A$(1,LEN(A$)-1)))
3470 Z=.3048*VAL(Z$)
3480 Z$(LEN(Z$)+2,12)=¤FOOT RELEASE¤
3490 IF Z>0 GOTO 3520
3500 Z=0
3510 Z$=¤ GROUND RELEASE¤
```

10.8 Program GRONK - CSCX Version (contd)

```
3520 Z1=Z+P
3530 Z2=-.5*Z*Z
3540 K$(96-LEN(T$)-LEN(Z$),9)=¤¤
3550 K$(97-LEN(T$)-LEN(Z$))=DAT
3560 OUTPUT#2, STR(K,¤1CASE##:  ¤);T$;¤    ¤Z$;¤     ¤K$
3570 '-----INPUT RELEASES AND PRINT
3580 ON ERROR GOTO 1320
3590 I=I1=I2=0
3600 MAT M(8)=ZER
3610 FILE #1=G$,#3=GIN
3620 GET#1, T$
3630 IF R=0 GOTO 3720
3640 IF R=1 GOTO 3710
3650 PRINT ¤RELEASE LIST NAME=¤;
3660 GET I$
3670 INPUT#1, A$
3680 IF A$=I$ GOTO 3720
3690 IF A$<>¤RANGES¤ GOTO 3670
3700 GOTO 1300
3710 INPUT#1, B$,I$
3720 B=41+58*O(11)
3730 FOR A=1 TO 6
3740  GET#3, A$(1,B+25)
3750  OUTPUT#2, A$(1,B+25)
3760  IF O(16)=0 GOTO 3780
3770  PRINT A$(1,B+25)
3780 NEXT A
3790 INPUT#1, B$
3800 IF B$=¤RANGES¤ OR B$=¤RELEASE¤ GOTO 4130
3810 IF B$(LEN(B$))<>¤Z¤ GOTO 3860
3820 FOR I=I TO I-1+VAL(B$(1,LEN(B$)-1))
3830  GET#3, A$
3840 NEXT I
3850 GOTO 3790
3860 GET#3, A$(1,124)
3870 I=I+1
3880 K5=VAL(B$)*K6
3890 IF K5=0 GOTO 3790
3900 I1=I1+1
3910 N(I1)$=A$
3920 C=277777777*K5
3930 L(I1)=VAL(A$(29,8))
3940 T(I1)=C*VAL(A$(44,7))
3950 M(7)=M(7)+T(I1)
3960 S(I1)=C*VAL(A$(56,7))
3970 M(8)=M(8)+S(I1)
3980 IF A$(19,1)=¤ ¤ GOTO 4090
3990 I2=I2+1
4000 E(I2,0)=31688*K5
4010 E(I2,7)=VAL(A$(19,1))
4020 E(I2,8)=-L(I1)
4030 FOR A=1 TO 6
4040  E(I2,A)=VAL(A$(63+9*A,7))
4050  M(A)=M(A)+E(I2,A)
4060 NEXT A
4070 IF O(11)=0 GOTO 4090
4080 N(I1)$(15,1)=STR(I2,¤#¤)
4090 OUTPUT#2, A$(1,18);B$;TAB(26)A$(26,B)
4100 IF O(16)=0 GOTO 3790
```

10.8 Program GRONK - CSCX Version (contd)

```
4110 PRINT A$(1,18);B$;TAB(26)A$(26,B)
4120 GOTO 3790
4130 IF I<>136 GOTO 1330
4140 '-----FINISH PROCESSING OF OPTION LIST
4150 ON ERROR GOTO 1570
4160 OUTPUT#2, ¤0¤
4170 OUTPUT#2, ¤0¤M$;¤ MODEL¤
4180 OUTPUT#2, Z$
4190 OUTPUT#4, ¤  ¤Z$;
4200 IF R=0 GOTO 4230
4210 OUTPUT#2, ¤ ¤I$;¤ RELEASE LIST¤
4220 OUTPUT#4, ¤    ¤I$;¤ LIST¤;
4230 IF O(7)=1 AND K>1 GOTO 4390
4240 O(0)=O(8)
4250 IF O(8)=1 GOTO 4300
4260 X1=X(0)=Y(0)
4270 MAT X(X1)=Y
4280 OUTPUT#2, ¤ BUILT-IN TOTAL BODY/SKIN RANGES¤
4290 GOTO 4400
4300 PRINT ¤ENTER NEW TOTAL BODY/SKIN RANGES IN MILES.  END THE SET WITH A BLANK LINE¤
4310 MAT INPUT X(20)
4320 IF NUM>0 AND NUM<11 GOTO 4350
4330 PRINT ¤**MAXIMUM NUMBER OF RANGES=10¤
4340 GOTO 4300
4350 X1=X(0)=NUM
4360 MAT X=X*(1609.344)
4370 OUTPUT#2, ¤ NEW TOTAL BODY/SKIN RANGES¤
4380 GOTO 4400
4390 OUTPUT#2, ¤ SAME TOTAL BODY/SKIN RANGES¤
4400 IF O(9)=0 GOTO 4430
4410 PRINT ¤PLUME RISE CONSTANT=¤;
4420 INPUT P
4430 IF P=0 GOTO 4460
4440 OUTPUT#2, ¤ PLUME RISE CONSTANT=¤P;¤METER-SQ/SEC¤
4450 OUTPUT#4, ¤    PLUME RISE=¤P;
4460 IF O(10)=0 GOTO 4550
4470 IF H=0 GOTO 4530
4480 OUTPUT#2, ¤ BUILDING WAKE FACTOR APPLIED.  BUILDING HEIGHT=¤H;¤METERS¤
4490 OUTPUT#4, ¤    WAKE FACTOR¤;
4500 K0=.5*H*H/&PI
4510 K1=SQR(.5*K0)
4520 GOTO 4550
4530 PRINT ¤BUILDING HEIGHT IS ZERO; REQUEST FOR BUILDING WAKE FACTOR IGNORED¤
4540 O(10)=0
4550 IF O(24)=1 GOTO 4580
4560 MAT U(U1)=N(U1)
4570 GOTO 4650
4580 IF Y=0 GOTO 4630
4590 OUTPUT#2, ¤ WIND SPEEDS CORRECTED FROM¤Y;¤METERS TO¤FNX(Z,10);¤METERS¤
4600 OUTPUT#4, ¤    WINDSPEED¤;
4610 MAT U(U1)=N(U1)*( (FNX(Z,10)/Y)Δ(.5-O(4)/4) )
4620 GOTO 4650
4630 PRINT ¤WIND SENSOR HEIGHT IS ZERO; REQUEST FOR METEOROLOGY HEIGHT CORRECTION IGNORED¤
4640 O(24)=0
4650 IF O(11)=0 GOTO 4910
4660 PRINT ¤ENTER GRAZING PERIOD, VEGETABLE CONSUMPTION PERIOD (MO/YR)¤;
4670 INPUT A,B
4680 PRINT ¤ENTER 2-YEAR-OLD VEG CONSUMPTION, ADULT VEG CONSUMPTION (KG/YR)¤;
4690 INPUT C,K5
```

10.8 Program GRONK - CSCX Version (contd)

```
4700 F1=A/12
4710 F2=B/12*C/18
4720 F3=B/12*K5/72
4730 OUTPUT#2, ¤ PERFORM THYROID CALCULATION¤
4740 OUTPUT#2, ¤   GRAZING PERIOD=¤A;¤MONTHS/YEAR¤
4750 OUTPUT#2, ¤   VEGETABLE CONSUMPTION PERIOD=¤B;¤MONTHS/YEAR¤
4760 OUTPUT#2, ¤   2-YEAR-OLD VEGETABLE CONSUMPTION=¤C;¤KILOGRAMS/YEAR¤
4770 OUTPUT#2, ¤   ADULT VEGETABLE CONSUMPTION=¤K5;¤KILOGRAMS/YEAR¤
4780 OUTPUT#4, ¤   THY¤;
4790 PRINT ¤ENTER THYROID RANGES IN MILES.  END THE SET WITH A BLANK LINE¤
4800 ON ATTENTION GOTO 4890
4810 MAT INPUT K(20)
4820 IF NUM>0 AND NUM<11 GOTO 4850
4830 PRINT ¤**MAXIMUM NUMBER OF RANGES=10¤
4840 GOTO 4790
4850 ON ATTENTION
4860 K(0)=NUM
4870 MAT K=K*(1609.344)
4880 GOTO 4910
4890 K(0)=X1
4900 MAT K(X1)=X(X1)
4910 IF O(12)=0 GOTO 4980
4920 OUTPUT#2, ¤ ADD THESE RESULTS TO RESULTS OF NEXT CASE¤
4930 OUTPUT#4, ¤   ADD TABLES¤;
4940 A1=1+A1*SGN(A1)
4950 FILE SCRATCH#1=STR(A1-2*INT(A1/2),¤ADD#¤)
4960 IF A1=1 GOTO 5010
4970 GOTO 5000
4980 IF A1=0 GOTO 5010
4990 A1=-A1-1
5000 FILE #3=STR(1-A1+2*INT(A1/2),¤ADD#¤)
5010 OUTPUT#4
5020 GOSUB 7310
5030 PRINT
5040
5050 '********************************************************************PRINT CALCULATED TABLES
5060 '-----CALCULATE AND PRINT CHI/Q TABLE
5070 ON ERROR
5080 K5=L=0
5090 MAT A(16,X1)=ZER
5100 MAT B(16,X1)=ZER
5110 MAT H(16,X1)=ZER
5120 GOSUB 5800
5130 MAT A=A*(K6)
5140 GOSUB 8020
5150 I$=¤ #.##!!!! ¤
5160 GOSUB 7570
5170 '-----PRINT SKIN DOSE TO INDIVIDUAL
5180 MAT A=H
5190 GOSUB 7570
5200 '-----PRINT TOTAL BODY DOSE TO INDIVIDUAL
5210 MAT A=B
5220 GOSUB 7570
5230 '-----CALCULATE AND PRINT TOTAL BODY DOSE TO POPULATION
5240 IF O(0)=1 GOTO 5500
5250 FOR D=1 TO 16
5260  FOR X=1 TO X1
5270   A(D,X)=B(D,X)*P(D,X)*.001
5280  NEXT X
```

10.8 Program GRONK - CSCX Version (contd)

```
5290 NEXT D
5300 GOSUB 7570
5310 OUTPUT#2, STR(K,¤1CASE##:  ¤);T$;¤    ¤Z$;¤    ¤K$
5320 FOR F=2 TO 1-O(23) STEP -2
5330  A$=¤   RADIUS                         DOSE        ANNUAL DOSE¤
5340  A$(21-LEN(P$)/2,LEN(P$))=P$
5350  OUTPUT#F, C(F)$
5360  OUTPUT#F, ¤ CUMULATIVE    CUMULATIVE    CUMULATIVE       AVERAGE¤
5370  OUTPUT#F, A$
5380  OUTPUT#F, ¤  (MILES)      POPULATION   MAN-REM/YR)     (MREM/YR)¤
5390  OUTPUT#F
5400  FOR X=1 TO X1
5410   A=VAL(C$(10*X-1,1))*1E6 +VAL(C$(10*X+1,3))*1000 +VAL(C$(10*X+5,3))
5420   B=VAL(L(18)$(10*X,9))
5430   OUTPUT#F, C(F)$;STR(3+INT(X(X)/1609.344+2.5*SGN(X(X)/1609.344-7.5)),¤####F#¤);TAB(16)C$(10*X-1,9);TAB(32);
5440   IF A=0 GOTO 5470
5450   OUTPUT#F, VAL(STR(B,¤.##!!!!¤));TAB(46)VAL(STR(1000*B/A,¤.##!!!!¤))
5460   GOTO 5480
5470   OUTPUT#F, VAL(STR(B,¤.##!!!!¤))
5480  NEXT X
5490 NEXT F
5500 IF O(11)=0 OR (I2=0 AND A1<2) GOTO 5770
5510 '-----CALCULATE AND PRINT THYROID AND TRITIUM DOSE TO INDIVIDUAL
5520 K8=X(1)
5530 X1=1
5540 Q(1,7)=K6
5550 FOR K7=1 TO K(0)
5560  X(1)=K(K7)
5570  IF I2=0 GOTO 5650
5580  L=1
5590  MAT A(16,12)=ZER
5600  MAT B(16,7)=ZER
5610  GOSUB 5800
5620  K5=4
5630  GOSUB 7570
5640  GOTO 5680
5650  IF END#3 GOTO 5680
5660  MAT READ#3, B(16,7)
5670  MAT WRITE#1, B(16,7)
5680 NEXT K7
5690 X(1)=K8
5700 X1=X(0)
5710 IF A1>=0 GOTO 5770
5720 FILE #3
5730 REMOVE ADD1
5740 IF A1=-2 GOTO 5760
5750 REMOVE ADD0
5760 A1=0
5770 FILE APPEND#4=U$
5780 GOTO 180
5790
5800'BEGIN SUBR ************************************************************PERFORM CHI/Q CALCULATION
5810 DISABLE
5820 FILE#4=W$
5830 IF O(4)=0 GOTO 6350
5840 '-----HANFORD CHI/Q
5850 FOR S=1 TO 4
5860  IF S>2 GOTO 5960
5870  IF S=2 GOTO 5920
```

10.8 Program GRONK - CSCX Version (contd)

```
5880  L2=34
5890  L3=-8.8E-4
5900  L4=.025
5910  GOTO 6090
5920  L2=97
5930  L3=-2.5E-4
5940  L4=.33
5950  GOTO 6090
5960  FOR X=1 TO X1
5970   M(X)=X(X)Δ(.8+.025*S)
5980  NEXT X
5990  IF S=4 GOTO 6060
6000  IF O(24)=0 GOTO 6020
6010  MAT U=N*( (FNX(Z,10)/Y)Δ.25 )
6020  L2=.106066   '=.15/SQR(2)
6030  L3=.0848528  '=.12/SQR(2)
6040  L4=.0777817  '=.11/SQR(2)
6050  GOTO 6090
6060  L2=.212132   '=.30/SQR(2)
6070  L3=.183848   '=.26/SQR(2)
6080  L4=.169706   '=.24/SQR(2)
6090  FOR U=1 TO U1
6100   IF Z1=0 GOTO 6160
6110   IF P=0 GOTO 6150
6120   L1=Z+P/U(U)
6130   K2=-.5*L1*L1
6140   GOTO 6160
6150   K2=Z2
6160   MAT READ#4, W(16)
6170   IF U(U)<8 GOTO 6200
6180   K3=L4
6190   GOTO 6240
6200   IF U(U)<3 GOTO 6230
6210   K3=L3
6220   GOTO 6240
6230   K3=L2
6240   FOR X=1 TO X1
6250    T=X(X)/U(U)
6260    IF S>2 GOTO 6290
6270    C=SQR(L2-L2*EXP(L3*T*T)+L4*T)
6280    GOTO 6300
6290    C=K3*M(X)
6300    GOSUB 6640
6310   NEXT X
6320  NEXT U
6330 NEXT S
6340 GOTO 6610
6350 '-----PASQUILL CHI/Q
6360 FOR S=1 TO S1
6370  IF O(24)=0 OR S<>5 GOTO 6390
6380  MAT U=N*( (FNX(Z,10)/Y)Δ.5 )
6390  K3=1
6400  FOR X=1 TO X1
6410   IF X(X)<Z(0,K3+1) GOTO 6440
6420   K3=K3+1
6430   GOTO 6410
6440   V(X)=Z(S,K3)+(X(X)-Z(0,K3))*(Z(S,K3+1)-Z(S,K3))/(Z(0,K3+1)-Z(0,K3))
6450  NEXT X
6460  FOR U=1 TO U1
```

10.8 Program GRONK - CSCX Version (contd)

```
6470   IF Z1=0 GOTO 6530
6480   IF P=0 GOTO 6520
6490   L1=Z+P/U(U)
6500   K2=-.5*L1*L1
6510   GOTO 6530
6520   K2=Z2
6530   MAT READ#4, W(16)
6540   FOR X=1 TO X1
6550    T=X(X)/U(U)
6560    C=V(X)
6570    GOSUB 6640
6580   NEXT X
6590  NEXT U
6600 NEXT S
6610 ENABLE
6620RETURN
6630
6640'BEGIN SUBR *******************************.****PERFORM INNERMOST LOOPS IN CHI/Q CALCULATION
6650 IF Z1=0 GOTO 6750
6660 IF O(10)=0 GOTO 6730
6670 IF K1>C GOTO 6710
6680 K4=C*C+K0
6690 K4=EXP(K2/K4)/(SQR(K4)*X(X)*U(U))
6700 GOTO 6820
6710 K4=EXP(K2/(3*C*C))/(1.732*C*X(X)*U(U))
6720 GOTO 6820
6730 K4=EXP(K2/(C*C))/(C*X(X)*U(U))
6740 GOTO 6820
6750 IF O(10)=0 GOTO 6810
6760 IF K1>C GOTO 6790
6770 K4=1/(SQR(C*C+K0)*X(X)*U(U))
6780 GOTO 6820
6790 K4=1/(1.732*C*X(X)*U(U))
6800 GOTO 6820
6810 K4=1/(C*X(X)*U(U))
6820 IF L=0 GOTO 6960
6830 '-----THYROID SECTION
6840 FOR I=1 TO I2
6850  C(1,I)=E(I,0)*EXP(E(I,8)*T)
6860 NEXT I
6870 MAT Q(1,6)=C(1,I2)*E(I2,6)
6880 FOR D=1 TO 16
6890  F(D,1)=K4*W(D)
6900 NEXT D
6910 MAT H(16,I2)=F(16,1)*C(1,I2)
6920 MAT A=A+H
6930 MAT H(16,7)=F(16,1)*Q(1,7)
6940 MAT B=B+H
6950RETURN
6960 '-----TOTAL BODY/SKIN SECTION
6970 B=C=0
6980 FOR I=1 TO I1
6990  A=EXP(-L(I)*T)
7000  B=B+A*T(I)
7010  C=C+A*S(I)
7020 NEXT I
7030 FOR D=1 TO 16
7040  A=K4*W(D)
7050  A(D,X)=A(D,X)+A
```

10.8 Program GRONK - CSCX Version (contd)

```
7060  B(D,X)=B(D,X)+A*B
7070  H(D,X)=H(D,X)+A*C
7080 NEXT D
7090RETURN
7100
7110'BEGIN SUBR ********************************************************************PRINT THYROID TABLE
7120 OUTPUT#F, C(F)$
7130 OUTPUT#F, TAB(11)¤CHI/Q¤;TAB(28)¤NUCLIDE CONCENTRATION, PCI/CUBIC METER¤;TAB(76)¤D O S E   F R O M   P A T H W A Y   M
        R E M / Y R¤
7140 OUTPUT#F, TAB(9)¤SEC/M**3¤D$;D$(3);D$(3);D$(8);¤    INHALATION           MILK        LEAFY VEGETABLES¤
7150 OUTPUT#F, TAB(74)D$;D$;D$
7160 OUTPUT#F, TAB(19)¤TE-132D  I-129    I-130    I-131    I-132    I-133    I-135    2 YR     ADULT     2 YR     ADULT     2 YR     A
        DULT¤
7170 OUTPUT#F
7180 FOR D=1 TO 16
7190  OUTPUT#F USING ¤ #####   #.#!!!!¤, D(D9+D+D)$,B(D,7);
7200  A$=A$(58,0)=¤¤
7210  FOR I=1 TO I2
7220   A$(8*E(I,7)-5,7)=STR(A(D,I),¤#.#!!!!¤)
7230  NEXT I
7240  OUTPUT#F USING A$(1,57);
7250  OUTPUT#F USING ¤  #.#!!!! #.#!!!!¤, B(D,1),B(D,2);B(D,3)*F1,B(D,4)*F1;B(D,5)*F2,B(D,6)*F3
7260  IF D<>4 AND D<>8 AND D<>12 GOTO 7280
7270  OUTPUT#F
7280 NEXT D
7290RETURN
7300
7310'BEGIN SUBR ********************************************************************PRINT PERCENT BY ISOTOPE
7320 OUTPUT#2, STR(K,¤1CASE##:  ¤);T$;¤   ¤Z$;¤    ¤K$
7330 FOR F=2 TO 1-O(17) STEP -2
7340  OUTPUT#F, C(F)$
7350  OUTPUT#F, C(F)$;TAB(18)¤CONTRIBUTION TO DOSE AT RELEASE POINT¤
7360  OUTPUT#F, C(F)$;¤ ISOTOPE       TOTAL  SKIN    INHALATION    ---MILK----   VEGETABLES¤
7370  OUTPUT#F, TAB(18)¤BODY¤TAB(32)¤2 YR  ADULT   2 YR  ADULT   2 YR  ADULT¤
7380 NEXT F
7390 FOR I=1 TO I1
7400  A$=N(I)$(1,14)
7410  IF T(I)<=.005*M(7) GOTO 7430
7420  A$(17,5)=STR(100*T(I)/M(7),¤### %¤)
7430  IF S(I)<=.005*M(8) GOTO 7450
7440  A$(23,5)=STR(100*S(I)/M(8),¤### %¤)
7450  IF N(I)$(15)=¤ ¤ GOTO 7500
7460  FOR A=1 TO 6
7470   IF E(VAL(N(I)$(15)),A)<=.005*M(A) GOTO 7490
7480   A$(24+7*A,5)=STR(100*E(VAL(N(I)$(15)),A)/M(A),¤### %¤)
7490  NEXT A
7500  IF LEN(A$)=14 GOTO 7540
7510  OUTPUT#2, A$
7520  IF O(17)=0 GOTO 7540
7530  PRINT A$
7540 NEXT I
7550RETURN
7560
7570'BEGIN SUBR ****************************************************SET UP PRINTING OF RESULT TABLES
7580 K2=0
7590 OUTPUT#2, STR(K,¤1CASE##:  ¤);T$;¤   ¤Z$;¤    ¤K$
7600 FOR F=2 TO 1-O(K5+18) STEP -2
7610  OUTPUT#F, C(F)$
7620  IF A1=0 OR A1=1 OR K2=0 OR F=0 GOTO 7780
```

10.8 Program GRONK - CSCX Version (contd)

```
7630  IF K5=4 GOTO 7710
7640  FOR D=1 TO 16
7650   FOR X=1 TO X1
7660    READ#3, A ''
7670    A(D,X)=A(D,X)+A
7680   NEXT X
7690  NEXT D
7700  GOTO 7750
7710  MAT A=ZER
7720  IF END#3 GOTO 7750
7730  MAT READ#3, H(16,7)
7740  MAT B=B(16,7)+H
7750  OUTPUT#2, ¤0¤;TAB(43)¤*****SUM OF RESULTS FOR LAST¤ABS(A1);¤CASES*****¤
7760  IF O(K5+18)=0 GOTO 7780
7770  PRINT ¤----------SUM OF RESULTS FOR LAST¤ABS(A1);¤CASES¤
7780  IF K5=4 GOTO 7840
7790  OUTPUT#F, C(F)$;TAB(FNX(5*X1+13.5-LEN(T(K5)$)/2,2))T(K5)$;TAB(116-LEN(M$))M$;¤ MODEL¤
7800  GOSUB 8180
7810  IF (A1<>1 OR K2=1) AND (A1<2 OR K2=0) OR F=0 GOTO 7890
7820  MAT WRITE#1, A(16,X1)
7830  GOTO 7890
7840  OUTPUT#F, C(F)$;TAB(180-32*K5)T(K5)$;TAB(116-LEN(M$))M$;¤ MODEL¤
7850  OUTPUT#F, TAB(58)X(1)/1609.344;¤MILES¤
7860  GOSUB 7110
7870  IF ((A1<>1 OR K2=1) AND (A1<2 OR K2=0)) OR F=0 GOTO 7890
7880  MAT WRITE#1, B(16,7)
7890 NEXT F
7900 IF K5<>3 OR K2=1 OR O(19)=1 GOTO 7920
7910 PRINT ¤POPULATION TOTAL BODY DOSE=¤INT(M(D1+1)*100+.5)/100;¤MANREM/YEAR¤
7920 IF A1=0 OR A1=1 OR K2=1 GOTO 7950
7930 K2=1
7940 GOTO 7590
7950 K5=K5+1
7960RETURN
7970
7980'BEGIN SUBR ************************************************************PRINT RESULT MATRICES
7990 'MAXIMUM OF 11 RANGES CAN FIT ON ONE PRINT LINE
8000 'TO CENTER TITLE:   TAB(FNX(5*X1+13.5-LEN/2, 2));
8010'**INITIALIZE TABLE HEADINGS FOR MATRIX A(D1,X1)
8020 L1=X1
8030 L3=9
8040 L5=0
8050 L(0)$=¤   RANGE¤
8060 L(0)$(14+10*X1,6)=L(D1+1)$=¤TOTALS¤
8070 L(D1+2)$=¤CUM TOTL¤
8080 FOR X=1 TO X1
8090  A$=STR(VAL(STR(X(X)/1609.344,¤.###!!!!¤)))
8100  L(0)$(4-LEN(A$)+10*X,LEN(A$))=A$
8110  L(0)$(4+10*X,3)=¤ MI¤
8120 NEXT X
8130 FOR D=1 TO D1
8140  L(D)$=D(D8+D+D)$
8150 NEXT D
8160RETURN
8170
8180'**OUTPUT THE MATRIX A(D1,X1)
8190 IF F=0 GOTO 8210
8200 GOSUB 8290
8210 OUTPUT#F, C(F)$
```

10.8 Program GRONK - CSCX Version (contd)

```
8220 FOR D=0 TO D1+2
8230  OUTPUT#F, ¤ ¤L(D)$
8240  IF D<>0 AND D<>4 AND D<>8 AND D<>12 AND D<>16 AND D<>D1+1 GOTO 8260
8250  OUTPUT#F
8260 NEXT D
8270RETURN
8280
8290'**PUT TABLE INFORMATION INTO L()$
8300 MAT M(D1+1)=ZER
8310 L2=LEN(I$)
8320 L4=L3
8330 FOR L=1 TO L1
8340  K4=0
8350  FOR D=1 TO D1
8360   L(D+L5)$(L4,L2)=STR(A(D,L),I$)
8370   K4=K4+A(D,L)
8380   M(D)=M(D)+A(D,L)
8390  NEXT D
8400  IF L5>0 GOTO 8430
8410  L(D1+2+L5)$(L4,L2)=STR(M(D1+1)+K4,I$)
8420  GOTO 8450
8430  IF L3>7 GOTO 8450
8440  K4=K4+D1*V(L)
8450  M(D1+1)=M(D1+1)+K4
8460  L(D1+1+L5)$(L4,L2)=STR(K4,I$)
8470  L4=L4+L2
8480 NEXT L
8490 FOR D=1 TO D1+1
8500  L(D+L5)$(L4+3,L2)=STR(M(D),I$)
8510 NEXT D
8520 IF L5>0 GOTO 8540
8530 L(D1+2+L5)$(L4+3,L2)=L(D1+2+L5)$(L4-L2)
8540RETURN
8550
8560 FOR D=0 TO D1+4
8570  IF K3=0 GOTO 8600
8580  OUTPUT#F, ¤ ¤L(D)$(1,7*U1+16)
8590  GOTO 8610
8600  OUTPUT#F, ¤ ¤L(D)$(1,7*U1+16);¤       ¤L(D)$(1,6);L(D)$(7*U1+17)
8610  IF D<>2 AND D<>3 AND D<>7 AND D<>11 AND D<>15 AND D<>D1+3 GOTO 8670
8620  IF D<>D1+3 GOTO 8660
8630  OUTPUT#F
8640  OUTPUT#F, ¤ VARBL ¤A$
8650  OUTPUT#F, ¤ CALM  ¤STR(C,J$);TAB(7*U1+11)STR(C,J$)
8660  OUTPUT#F
8670 NEXT D
8680 IF M=0 OR M>=100 GOTO 8700
8690 OUTPUT#F, TAB(7*U1+12-LEN(STR(M)))¤TIMES¤STR(M);¤%¤
8700RETURN
8710
8720 FOR D=0 TO D1+4
8730  OUTPUT#F, ¤ ¤L(D)$(1,6);L(D)$(7*U1+17)
8740  IF D<>2 AND D<>3 AND D<>7 AND D<>11 AND D<>15 AND D<>D1+3 GOTO 8760
8750  OUTPUT#F
8760 NEXT D
8770RETURN
8780
8790 '*****************************************************************COMPLETE FILES, SUBMIT AS BATCH JOB
8800 IF F$=¤¤ GOTO 8890
```

10.8 Program GRONK - CSCX Version (contd)

```
8810 OUTPUT#2, ¤1¤
8820 OUTPUT#4, ¤ @IL CPY ¤UID;¤,¤G$
8830 OUTPUT#4, ¤ @DLN CPY ¤UID;¤,¤F$
8840 OUTPUT#4, ¤ @ APR ¤UID;¤//¤F$
8850 DISABLE
8860 FILE
8870 SUBMIT U$
8880 REMOVE U$,W$
8890 IF O(2)=0 GOTO 8910
8900 OFF
8910 IF O(3)=0 GOTO 8940
8920 PRINT ¤NEW RUN:¤
8930 RUN
8940 ENABLE
```

10.9 File GIN

	ISOTOPE	RELEASE CI/YEAR	LAMBDA 1/SEC	EXTERNAL DOSE FACTORS MREM/HR PER PCI/CUBIC METER		THYROID DOSE FACTORS -- MREM/YEAR PER PCI/CUBIC METER					
						---INHALATION---		----M I L K-----		LEAFY VEGETABLES	
				TOTAL BODY	SKIN	2 YEAR	ADULT	2 YEAR	ADULT	2 YEAR	ADULT
1000											
1001											
1002											
1003											
1004											
1005											
2001	1 H-3		1.79E-09	0	0						
2002	2 C-14		3.83E-12	1.4E-11	3.5E-09						
2003	3 N-13		1.16E-03	8.5E-07	1.4E-06						
2004	4 F-18		1.04E-04	8.2E-07	1.1E-06						
2005	5 NA-22		8.44E-09	1.8E-06	2.3E-06						
2006	6 NA-24		1.28E-05	3.5E-06	4.5E-06						
2007	7 P-32		5.61E-07	3.0E-09	6.2E-07						
2008	8 AR-39		8.17E-11	3.3E-10	1.2E-07						
2009	9 AR-41		1.05E-04	1.1E-06	1.6E-06						
2010	10 SC-46		9.56E-08	1.7E-06	2.0E-06						
2011	11 CR-51		2.89E-07	2.4E-08	2.9E-08						
2012	12 MN-54		2.65E-08	7.0E-07	8.1E-07						
2013	13 MN-56		7.47E-05	1.5E-06	2.4E-06						
2014	14 FE-55		8.44E-09	3.5E-11	1.6E-09						
2015	15 FE-59		1.78E-07	1.0E-06	1.2E-06						
2016	16 CO-57		2.97E-08	1.0E-07	1.2E-07						
2017	17 CO-58		1.12E-07	8.2E-07	1.1E-06						
2018	18 CO-60		4.17E-09	2.0E-06	2.5E-06						
2019	19 NI-63		2.39E-10	0	0						
2020	20 NI-65		7.53E-05	4.8E-07	1.1E-06						
2021	21 CU-64		1.51E-05	1.7E-07	2.8E-07						
2022	22 ZN-65		3.28E-08	4.9E-07	5.6E-07						
2023	23 ZN-69M+D		1.39E-05	3.4E-07	6.8E-07						
2024	24 ZN-69		2.02E-04	7.1E-10	2.5E-07						
2025	25 BR-82		5.44E-06	2.4E-06	2.9E-06						
2026	26 BR-83+D		8.03E-05	7.5E-09	2.7E-07						
2027	27 BR-84		3.64E-04	1.6E-06	3.0E-06						
2028	28 BR-85		3.86E-03	6.7E-09	9.7E-07						
2029	29 KR-83M		1.04E-04	0	7.6E-10						
2030	30 KR-85M		4.39E-05	1.3E-07	3.2E-07						
2031	31 KR-85		2.04E-09	2.2E-09	1.6E-07						
2032	32 KR-87		1.52E-04	1.3E-06	2.7E-06						
2033	33 KR-88		6.86E-05	1.5E-06	2.0E-06						
2034	34 RB-86		4.31E-07	8.0E-08	6.8E-07						
2035	35 RB-88		6.47E-04	5.6E-07	2.7E-06						
2036	36 RB-89		7.50E-04	2.1E-06	2.8E-06						
2037	37 SR-89		1.54E-07	2.1E-09	4.9E-07						
2038	38 SR-90		7.78E-10	2.4E-10	1.3E-07						
2039	39 SR-90D		7.78E-10	6.1E-09	8.6E-07						
2040	40 SR-91		1.99E-05	8.9E-07	1.6E-06						
2041	41 SR-92		7.11E-05	1.1E-06	1.3E-06						
2042	42 Y-90		3.00E-06	6.1E-09	8.6E-07						
2043	43 Y-91M		2.31E-04	4.6E-07	5.6E-07						
2044	44 Y-91		1.36E-07	3.1E-09	5.2E-07						
2045	45 Y-92		5.44E-05	2.1E-07	1.6E-06						
2046	46 Y-93		1.89E-06	8.7E-08	1.2E-06						
2047	47 ZR-95		1.23E-07	6.8E-07	8.4E-07						
2048	48 ZR-95D		1.23E-07	6.4E-07	7.5E-07						
2049	49 ZR-97		1.13E-05	6.9E-07	1.4E-06						

10.9 File GIN (contd)

2050	50	ZR-97D		1.13E-05	5.6E-07	1.1E-06						
2051	51	NB-95		2.29E-07	6.4E-07	7.5E-07						
2052	52	NB-97		1.61E-04	5.6E-07	1.1E-06						
2053	53	MO-99+D		2.86E-06	2.2E-07	5.8E-07						
2054	54	MO-99D		2.86E-06	1.1E-07	1.3E-07						
2055	55	TC-99M		3.22E-05	1.1E-07	1.3E-07						
2056	56	TC-99		1.04E-13	5.8E-11	2.4E-08						
2057	57	TC-101		8.25E-04	3.6E-07	7.6E-07						
2058	58	RU-103+D		2.02E-07	4.1E-07	4.9E-07						
2059	59	RU-105+D		4.33E-05	5.4E-07	1.0E-06						
2060	60	RU-106+D		2.19E-08	1.7E-07	1.5E-06						
2061	61	RH-105		5.36E-06	7.8E-08	1.8E-07						
2062	62	PD-109+D		1.43E-05	4.3E-09	3.0E-07						
2063	63	AG-110M+D		3.17E-08	2.2E-06	2.4E-06						
2064	64	AG-111		1.07E-06	2.2E-08	3.2E-07						
2065	65	SN-125		8.53E-07	7.3E-08	9.1E-07						
2066	66	SB-124		1.34E-07	1.6E-06	2.2E-06						
2067	67	SB-125		8.14E-09	3.6E-07	4.5E-07						
2068	68	SB-127		2.07E-06	6.7E-07	9.0E-07						
2069	69	TE-125M		1.38E-07	1.7E-09	1.1E-08						
2070	70	TE-127M		7.36E-08	1.2E-10	1.6E-09						
2071	71	TE-127		2.05E-05	1.2E-09	1.6E-07						
2072	72	TE-129M+D		2.36E-07	9.4E-08	5.7E-07						
2073	73	TE-129		1.68E-04	8.7E-08	5.3E-07						
2074	74	TE-131M		6.42E-06	1.0E-06	1.3E-06						
2075	75	TE-131		4.61E-04	3.4E-07	1.1E-06						
2076	76	TE-132		2.47E-06	1.8E-07	2.3E-07						
2077	77	TE-132D	1	2.47E-06	2.0E-06	2.7E-06	0.	0.	126.	9.11	4.04	1.17
2078	78	TE-133M+D		2.31E-04	1.8E-06	2.4E-06						
2079	79	TE-134		2.75E-04	1.2E-07	1.9E-07						
2080	80	I-129	2	1.29E-15	1.1E-09	4.0E-09	5.74	34.3	3600.	3140.	1485.	5190.
2081	81	I-130	3	1.55E-05	1.8E-06	2.3E-06	2.88	1.57	83.	6.61	26.8	8.53
2082	82	I-131	4	9.97E-07	3.1E-07	4.9E-07	12.5	10.6	3620.	448.	1190.	589.
2083	83	I-132	5	8.36E-05	2.0E-06	2.7E-06	0.835	0.414	4.58	0.330	1.48	0.428
2084	84	I-133	6	9.17E-06	4.4E-07	8.8E-07	5.51	2.70	262.	18.7	84.1	24.1
2085	85	I-134	8	2.22E-04	2.0E-06	2.9E-06	0.424	0.209	0.911	0.0655	0.293	0.0844
2086	86	I-135	7	2.86E-05	1.5E-06	2.0E-06	2.00	0.985	31.2	2.28	10.0	2.94
2087	87	XE-131M		6.81E-07	2.8E-09	4.8E-08						
2088	88	XE-133M		3.56E-06	2.7E-08	6.0E-08						
2089	89	XE-133		1.52E-06	2.5E-08	6.9E-08						
2090	90	XE-135M		7.42E-04	3.5E-07	5.0E-07						
2091	91	XE-135		2.09E-05	2.1E-07	4.9E-07						
2092	92	XE-137		2.97E-03	1.2E-07	1.8E-06						
2093	93	XE-138		6.81E-04	1.2E-06	1.7E-06						
2094	94	CS-134M		6.64E-05	7.3E-08	9.1E-08						
2095	95	CS-134		1.07E-08	1.3E-06	1.7E-06						
2096	96	CS-135		7.33E-09	2.8E-11	8.8E-09						
2097	97	CS-136		6.17E-07	1.9E-06	2.2E-06						
2098	98	CS-137		7.31E-10	4.7E-07	7.0E-07						
2099	99	CS-138		3.58E-04	1.8E-06	3.1E-06						
2100	100	CS-139		1.22E-03	8.0E-07	2.1E-06						
2101	101	BA-139		1.39E-04	3.7E-08	8.9E-07						
2102	102	BA-140		6.28E-07	2.2E-07	4.4E-07						
2103	103	BA-140D		6.28E-07	1.9E-06	2.7E-06						
2104	104	BA-141		6.42E-04	5.2E-07	1.6E-06						
2105	105	BA-142		1.05E-03	1.0E-06	1.6E-06						
2106	106	LA-140		4.78E-06	1.9E-06	2.7E-06						
2107	107	LA-141		4.94E-05	2.3E-09	9.2E-07						

10.9 File GIN (contd)

2108	108	LA-142	1.26E-04	2.0E-06	3.1E-06
2109	109	CE-141	2.43E-07	5.9E-08	1.5E-07
2110	110	CE-143	5.81E-06	2.6E-07	6.3E-07
2111	111	CE-144+D	2.83E-08	4.0E-08	1.2E-06
2112	112	PR-143	5.89E-07	7.5E-10	2.5E-07
2113	113	PR-144	6.69E-04	2.6E-08	1.2E-06
2114	114	ND-147	7.22E-07	1.3E-07	3.1E-07
2115	115	PM-147	8.39E-09	3.3E-11	1.2E-08
2116	116	PM-148	1.49E-06	5.2E-07	1.2E-06
2117	117	PM-149	3.64E-06	6.9E-09	3.1E-07
2118	118	PM-151	6.86E-06	2.3E-07	5.0E-07
2119	119	SM-153	4.06E-06	3.0E-08	2.0E-07
2120	120	EU-156	5.36E-07	9.8E-07	1.5E-06
2121	121	W-181	5.72E-08	2.5E-10	3.2E-10
2122	122	W-185	1.07E-07	1.4E-10	7.2E-08
2123	123	W-187	8.06E-06	3.8E-07	6.3E-07
2124	124	U-237	1.19E-06	1.2E-07	1.6E-07
2125	125	NP-238	3.83E-06	3.5E-07	5.7E-07
2126	126	NP-239	3.42E-06	1.1E-07	2.1E-07
2127	127	PU-238	2.56E-10	6.8E-11	1.7E-09
2128	128	PU-239	9.03E-13	5.6E-11	7.6E-10
2129	129	PU-240	3.33E-12	6.5E-11	1.7E-09
2130	130	PU-241+D	1.66E-09	2.8E-11	4.2E-11
2131	131	PU-242	5.81E-14	5.1E-11	1.6E-09
2132	132	AM-241	4.81E-13	1.8E-08	2.7E-08
2133	133	AM-243+D	2.77E-12	1.4E-07	2.5E-07
2134	134	CM-242	4.92E-08	1.6E-10	2.1E-09
2135	135	CM-244	1.25E-09	1.2E-10	1.7E-09
2136	136	CF-252	8.31E-09	0	0

10.10 File TONIC

THE FILE TONIC IS A TABLE OF SIGMA-Z VERSUS RANGE USED BY GRONK. IT IS STORED IN INTERNAL FORMAT, HENCE IT CANNOT BE LISTED DIRECTLY. THE TABLE BELOW GIVES THE CONTENTS OF TONIC.

RANGE, METERS	PASQUILL A	PASQUILL B	PASQUILL C	PASQUILL D	PASQUILL E	PASQUILL F	PASQUILL G, G+
0	15.5	10.2	7.6	4.9	3.0	1.5	.9
100	15.5	10.2	7.6	4.9	3.0	1.5	.9
120	18.0	12.0	9.0	5.5	3.6	1.7	1.0
150	23.0	15.0	11.4	6.8	4.4	2.3	1.3
200	31.0	20.0	14.5	8.7	5.7	3.0	1.8
250	43.0	25.5	18.0	10.5	7.1	3.8	2.3
300	55.0	31.0	21.0	12.1	8.3	4.7	2.8
400	90.0	43.0	28.0	15.8	11.0	6.2	3.7
500	135.0	55.0	34.0	19.0	13.0	7.7	4.6
600	200.0	70.0	40.8	22.0	15.0	9.0	5.4
700	270.0	85.0	47.0	24.7	17.0	10.2	6.1
800	380.0	100.0	52.5	27.5	19.0	11.5	6.9
900	530.0	120.0	59.0	30.0	20.4	12.7	7.6
1000	740.0	140.0	64.0	32.0	22.0	13.5	8.1
1500	1000.0	243.0	93.0	44.0	30.0	18.3	11.0
2000	1000.0	400.0	116.0	53.5	37.0	21.7	13.0
3000	1000.0	900.0	165.0	70.0	46.5	27.6	16.6
4000	1000.0	1000.0	210.0	84.0	55.0	32.0	19.2
5000	1000.0	1000.0	249.0	96.0	61.0	35.5	21.3
6000	1000.0	1000.0	300.0	105.0	67.0	38.6	23.2
7000	1000.0	1000.0	340.0	118.0	71.0	41.2	24.7
8000	1000.0	1000.0	380.0	128.0	77.0	44.0	26.4
9000	1000.0	1000.0	405.0	135.0	80.0	46.0	27.6
10000	1000.0	1000.0	440.0	145.0	84.0	48.0	28.8
15000	1000.0	1000.0	618.0	175.0	98.0	56.0	33.6
20000	1000.0	1000.0	760.0	204.0	110.0	60.8	36.5
30000	1000.0	1000.0	1000.0	248.0	125.0	70.0	42.0
40000	1000.0	1000.0	1000.0	290.0	135.0	75.0	45.0
50000	1000.0	1000.0	1000.0	320.0	145.0	80.0	48.0
60000	1000.0	1000.0	1000.0	348.0	155.0	83.0	49.8
70000	1000.0	1000.0	1000.0	380.0	160.0	87.0	52.2
80000	1000.0	1000.0	1000.0	400.0	165.0	90.0	54.0
90000	1000.0	1000.0	1000.0	420.0	175.0	92.0	55.2
100000	1000.0	1000.0	1000.0	440.0	175.0	93.0	55.8
1E38	1000.0	1000.0	1000.0	440.0	175.0	93.0	55.8

10.11 Sample File Gxxxx

File Name: GMARC

```
100 MARC FOUR  2 UNITS
110 28Z 11.896 64.16 3186.8 34.616 111.12 0
120 0 0.546 45Z 0.170 0 0.130 0 0 80.04 123.48
130 10036 7.352 186.88 5.392 25.544 43Z
140 RANGES
150  .5 1.5 2.5 3.5 4.5 7.5 15 25 35 45
160
170 POPULATION 1980 N
180      0  0  29  21  67  575  37850  131050  18000  13200
190      0  3  67  218  80  831  7950  14450  15650  6850
200      0  15  0  70  33  2486  59950  55050  17800  12000
210      0  0  0  0  17  989  53250  52800  20950  11850
220      0  0  0  0  5  1804  7250  9900  7250  12950
230      0  0  0  0  17  3511  6000  4950  19100  14100
240      0  0  0  0  12  953  4900  15150  6100  6700
250      0  0  0  0  10  430  4500  12500  33750  23850
260      0  0  0  0  0  82  3250  12450  83850  88350
270      0  0  0  0  37  314  5650  5900  6450  11400
280      0  0  0  7  34  196  7900  10850  6250  16300
290      0  0  0  38  48  743  6750  6950  7500  9300
300      0  0  4  90  34  833  2150  4050  9500  31000
310      0  0  83  18  64  131  3800  3950  15350  17850
320      0  2  7  0  22  162  2150  7750  16250  72900
330      0  19  82  18  15  131  37650  13250  16750  15350
340 PASQUILL 16 N 36.576 56.3
350 2.06 5.758 9.789 15.546 21.88
360
370 0-3 4-7 8-12 13-18 19+
380 "PASQUILL A",100
390  0,0,0,0,0,0
400 .0537 .0692 .0346 0 0 .0276 .0462 .0231 .0115 0
410 .0813 .1154 .0577 0 0 .0075 .1154 .0462 0 0
420 .0835 .1500 .0346 0 0 .0329 .1269 .0462 0 0
430 .0620 .1961 .0346 .0115 0 .0552 .0923 .0231 .0115 0
440 .0790 .0808 .0231 0 0 .0391 .0346 .0115 0 0
450 .0299 .0808 .0692 0 0 .0299 .0808 .0462 0 0
460 .0459 .1385 .0231 0 0 .0176 .0808 .0115 0 0
470 .0276 .0462 .0231 0 0 .0198 .1154 0 0 0
480 "PASQUILL B",100
490  0,0,0,0,0,0
500 .1108 .2423 .0577 0 0 .0548 .0923 .0692 0 0
510 .1296 .3115 .3346 .0231 0 .0439 .3115 .3808 .0346 0
520 .0907 .2769 .2077 .0577 0 .0360 .1846 .1038 0 0
530 .0367 .1961 .2308 .0462 0 .0447 .1269 .0808 0 0
540 .1268 .2654 .1961 .0231 0 .0057 .0923 .1269 .0115 0
550 .0475 .1731 .2538 .0231 0 .0166 .0692 .1500 .0346 0
560 .0273 .2423 .1961 0 0 .0461 .1500 .0692 .0115 0
570 .0504 .2192 .0231 0 0 .0425 .0923 .06923 0 0
```

10.11 Sample File Gxxxx (contd)

```
580 "PASQUILL C",100
590  0,0,0,0,0,0
600 .0575 .2423 .1615 .0462 0 .0433 .1846 .3000 .0923 0
610 .0487 .3231 1.004 .3000 .0692 .0390 .3808 .9230 .2538 .0602
620 .1003 .4154 .4500 .2423 .0231 .0281 .1038 .2538 .1500 .0231
630 .0912 .1846 .2769 .1385 .0231 .0419 .1500 .1500 .0115 .0115
640 .1152 .1846 .3346 .1038 .0115 .0455 .2423 .2077 .0346 0
650 .0621 .3577 .7961 .2538 .0231 .0344 .2654 .5423 .1154 0
660 .0759 .4038 .5769 .0577 0 .0331 .2308 .3115 .0346 0
670 .0304 .1615 .1615 .0115 0 .0304 .1615 .1038 0 0
680 "PASQUILL D",100
690  0,0,0,0,0,0
700 .0998 .2423 .6115 .2192 .0346 .1004 .2538 .8538 .4731 .0231
710 .1527 .5192 2.169 .7615 .1038 .0692 .5538 1.073 .4154 .0692
720 .0842 .3923 .4731 .3577 .0923 .1262 .2769 .1961 .3346 .0923
730 .0781 .2884 .4384 .5423 .2539 .0604 .1961 .3346 .3000 .1385
740 .1215 .4038 .7615 .4269 .0692 .1100 .4154 1.061 .3692 .0231
750 .1704 .8192 2.077 .6577 .0923 .0733 .4154 1.281 .5423 .0346
760 .06583 .4961 .9577 .1154 0 .04819 .1961 .2769 .0577 0
770 .0814 .3461 .3231 .0808 0 .0584 .1615 .1615 .0692 .0115
780 "PASQUILL E",100
790  0,0,0,0,0,0
800 .1999 .4269 .5538 .0692 0 .07349 .3231 .75 .0923 0
810 .2094 .75 1.846 .1961 0 .1269 .4615 .5423 .0346 0
820 .1472 .5307 .2423 .03461 0 .1595 .1731 .1961 .0923 .01154
830 .2639 .4269 .7269 .3231 .1269  .2130 .3115 .6115 .3692 .05769
840 .1500 .4384 .9692 .3808 .05769 .1247 .3231 .6692 .1154 .0115
850 .1813 .7269 1.211 .1269 0 .0529 .3692 .45 .0462 0
860 .16 .5307 .4038 .0231 0 .076 .3461 .2308 .0115 0
870 .1206 .4038 .3577 .0115 0 .1525 .4615 .2423 .0462 0
880 "PASQUILL F",100
890  0,0,0,0,0,0
900 .2133 .7154 1.292 .03461 0 .1549 .6577 1.5 .0346 0
910 .2052 1.085 2.804 .04615 0 .2439 .8653 .9577 0 0
920 .2805 .7384 .4961 .04615 0 .1936 .4384 .3231 .0231 0
930 .1569 .5654 .7269 .06923 0 .1427 .5538 .5538 .1038 0
940 .2235 .6923 .8769 .0462 0 .2187 .5423 .7961 .0231 0
950 .1461 .6923 1.038 .03461 0 .1046 .45 .5307 .0115 0
960 .06932 .3692 .7730 0 0 .08902 .4269 .6000 .01154 0
970 .1963 .6807 1.027 .01154 0 .1535 .4269 .4615 .0231 0
980 NOTES  THIS PROGRAM USES MARC FOUR POPULATION (1980 - REVISED 5/5/73)
990  AND RTI METEOROLOGY TAKEN AT 120 FEET AS GIVEN IN VOL. 2, PSAR
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