BN-SA--3673-HEDR

DE93 006309

Pre-Decisional Draft

DETERMINATION OF RADIONUCLIDES AND PATHWAYS CONTRIBUTING TO CUMULATIVE DOSE

Hanford Environmental Dose
Reconstruction Project
Dose Code Recovery Activities
- Calculation 004

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December 1992

Prepared for the
Technical Steering Panel
and the Centers for Disease Control
Under Contract 200-92-0503 (CDC)/18620 (BNW)

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PREFACE

This report documents one of a series of scoping calculations performed as part of the dose code recovery activities for the Hanford Environmental Dose Reconstruction Project. These scoping calculations form a mutually-dependent set that build upon each other, and each is best read in the context of the others. The complete list of scoping reports is given below.

Title	Calculation Number
Scoping Calculation for Components of the Cow-Milk Dose Pathway for Evaluating the Dose Contribution from Iodine-131	001
Determination of the Contribution of Livestock Water Ingestion to Dose from the Cow-Milk Pathway	002
Determination of Radionuclides and Pathways Contributing to Dose in 1945	003
Determination of Radionuclides and Pathways Contributing to Cumulative Dose	004
Determination of Dose Distributions and Parameter Sensitivity	005
Determination of the Feasibility of Reducing the Spatial Domain of the HEDR Dose Code	006
Determination of the Spatial Resolution Required for the HEDR Dose Code	007
Determination of the Temporal Resolution Required for the HEDR Dose Code	008

Additional scoping calculations are in progress or planned, and each will be documented in similar project reports.

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1.0 INTRODUCTION

A series of scoping calculations has been undertaken to evaluate the absolute and relative contributions of different radionuclides and exposure pathways to doses that may have been received by individuals living in the vicinity of the Hanford Site. These scoping calculations may include some radionuclides and pathways that were included in the Phase I air-pathway dose evaluations, as well as other potential exposure pathways being evaluated for possible inclusion in future Hanford Environmental Dose Reconstruction Project (HEDR) modeling efforts. Calculations of this type were not possible until the declassification of the radionuclide production information (Gydesen 1992a; 1992b) and the recent development of the source term model (Heeb 1992).

This scoping calculation (Calculation 004) examined the contributions of numerous radionuclides to cumulative dose via environmental exposures and accumulation in foods. This calculation builds on the work initiated in the first and second scoping studies (Ikenberry and Napier 1992, Napier 1992). Addressed in this calculation were the contributions to organ and effective dose of infants and adults from 1) air submersion and groundshine external dose, 2) inhalation, 3) ingestion of soil by humans, 4) ingestion of leafy vegetables, 5) ingestion of other vegetables and fruits, 6) ingestion of meat, 7) ingestion of eggs, and 8) ingestion of cows' milk from Feeding Regime 1, as described in calculation 002. This calculation specifically addresses cumulative radiation doses to infants and adults resulting from releases occurring over the period 1945 through 1972.

Recommendations determined from scoping calculations are provided to the HEDR Technical Steering Panel (TSP) with the intent of providing a definitive technical basis to assist in deciding whether specific radionuclides should or should not be included in the main computer code for the HEDR dose-estimation process for individuals.

2.0 TECHNICAL METHODS

Effective doses and critical-organ doses were calculated for a representative, highly exposed infant and adult in a highly exposed area for the time period of 1945 through 1972. Parameters in the calculations were selected to be approximate average, median, or best-estimate values, rather than conservative, upper- bound values. Individuals were assumed to have a rural lifestyle, with milk supplied by a backyard cow supported on Feeding Regime 1 (HEDR staff 1991, page 2.17). Infants were not assumed to age (thus maximizing the cumulative dose to infants).

Calculations used are based on individual-radionuclide results presented in Napier (1992). Doses are calculated on an annual basis, using the derived "dose per unit release" from scoping calculation 002.

The location of exposure selected was the region of Franklin County included as part of Census District 4 (Figure 1). This area lies directly east of the Hanford Site, and was shown in the Phase I air-pathway report (HEDR staff 1991, Appendix C) to be one of the most highly affected regions. The time period selected was the period 1945 through 1972, during which all of the original Hanford plutonium production reactors and all of the separations plants operated.

Normalized surface deposition and integrated air concentration parameters used were estimated during scoping calculation 002 (Napier 1992) based upon the RATCHET atmospheric dispersion code (Ramsdell and Burk 1992). For computational simplicity, monthly surface deposition and integrated air concentrations from a single realization were used in these scoping calculations (J. V. Ramsdell Jr., personal communication, October, 1992). Recent results from Ramsdell indicate that the particular realization used is well within a factor of two for all months of the maximums of the 100 realizations ultimately planned to be used for this particular location, and therefore this realization is considered to be a conservative, but reasonable, representation of this location (J.V Ramsdell, personal communication, November 1992). The Ramsdell data were used to calculate a total dose from the year 1945 at a node within Franklin County Census District 4. This was used to prepare a "dose per unit release" that was applied to all other years.

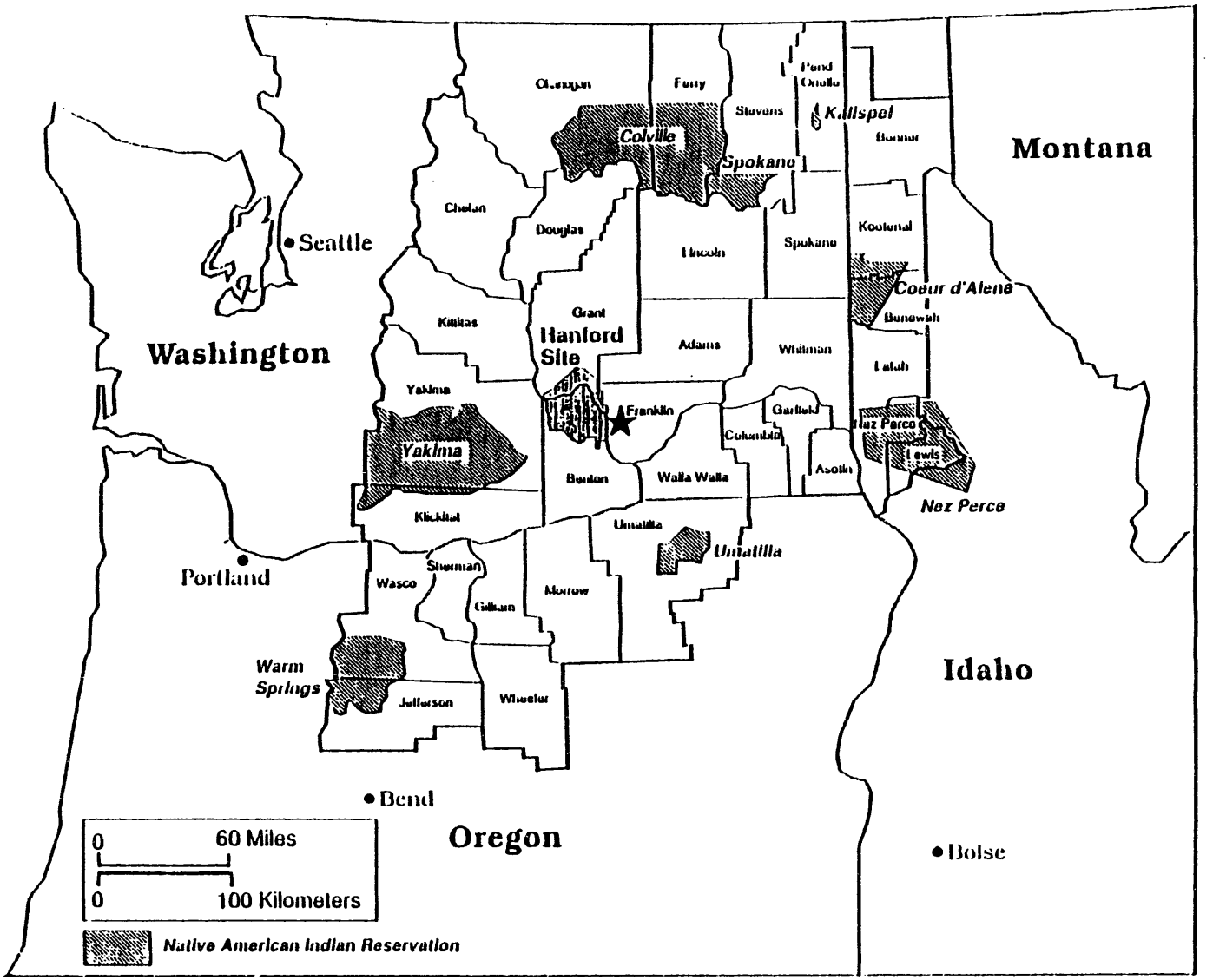

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FIGURE 1. Approximate Location (★) Within the HEDR Study Area Selected for Scoping Calculations

2.1 RADIONUCLIDE INVENTORY ESTIMATES

For all radionuclides, estimates had to be made of the quantity processed through the Hanford separations plants between 1945 and 1972. Heeb (C. Heeb, personal communication, November 1992) provided total annual throughput, annual mass-weighted cooling times, and average fuel burnups, based on a single source (Gydesen 1992c). These are presented in Table 1. A calculation was performed using the ORIGEN2 computer code to estimate the representative content of one ton of fuel discharged from a Hanford production reactor operating at conditions typical of 1945 (C. Heeb and U. Jenquin, personal communication, October 1992) and of the later years (Napier 1991). The quantities of radioactivity of 14 radionuclides identified as being the highest contributors to dose in Phase I (Napier 1991), or as being of identified public interest, are given in Table 2. The contents are provided for three burnups-two representing low-power reactor conditions in the early years and one representing higher power in the later years; it is evident that the burnup and power levels are important to the total fuel contents. The annual amounts processed through the separations facilities were estimated for each year using logarithmic interpolation of the values in this table for the annual-average cooling time.

TABLE 1. 1. FUEL REPROCESSED AT HANFORD (FROM PRELIMINARY SOURCE TERM SPREADSHEET)

Summation of Reprocessing Plant Operations from Gydesen (1992)

	T Plant			B Plant			REDOX			PUREX			Hanford Total
Year	Tons N	MWD/ton	Days	Tons N	MWD/ton	Days	Tons N	Tons E	Total Tns	Days	Tons	Days	Tons
1945	325	159	43	302	189	42			0	0	0	0	627
1946	291	241	73	873	202	59			0	0	0	0	1164
1947	306	203	78	345	203	78			0	0	0	0	651
1948	388	203	102	398	210	101			0	0	0	0	786
1949	393	284	95	356	282	94			0	0	0	0	749
1950	424	401	89	460	398	90			0	0	0	0	884
1951	560	482	55	508	494	55			0	0	0	0	1068
1952	295	594	65	118	588	58	822	0	822	82	0	0	1235
1953	246	503	73	0		0	2851	0	2851	82	0	0	3097
1954	1011	302	92	0		0	1579	0	1579	104	0	0	2590
1955	1266	236	108	0		0	3926	0	3926	137	0	0	5192
1956	45	260	190	0		0	2335	0	2335	128	2520	130	4901
1957	0		0	0		0	1829	0	1829	116	4397	116	6226
1958	0		0	0		0	1318	65	1383	128	5260	100	6643
1959	0		0	0		0	248	675	923	205	4988	104	5911
1960	0		0	0		0	275	546	821	189	6244	118	7065
1961	0		0	0		0	0	1253	1253	167	5947	122	7200
1962	0		0	0		0	0	972	972	188	6040	134	7013
1963	0		0	0		0	0	1150	1150	209	5414	159	6564
1964	0		0	0		0	0	1768	1768	211	5739	151	7527
1965	0		0	0		0	0	1668	1668	182	5781	164	7449
1966	0		0	0		0	37	1315	1352	208	3109	223	4461
1967	0		0	0		0			0	0	4505	211	4505
1968	0		0	0		0			0	0	4308	244	4308
1969	0		0	0		0			0	0	3025	273	3025
1970	0		0	0		0			0	0	1160	560	1160
1971	0		0	0		0			0	0	3550	549	3550
1972	0		0	0		0			0	0	1141	518	1141
Totals	5550			3360			15220	9412	24632		73148		106690

TABLE 2. Curies/Ton of Representative Hanford Fuel at Various Burnups and Cooling Times

NUCLIDE	LAMDA R (1/DAY)	200 MWD/T, 1 MW/T used 1945-1949		300MWD/T, 1 MW/T used 1950-1957		600 MWD/T, 10MW/T used 1958-1972	
		30 DAYS	50 DAYS	60 DAYS	100 DAYS	110 DAYS	190 DAYS
I 131	0.086	1984	354	150	4.78	21	0.0212
RU/RH106	0.00188	2011	1937	2880	2670	9330	8020
RU/RH103	0.0176	17310	12160	10800	5330	32100	7820
CO60	0.000361	12.6	12.5	1818.1	17.8	50.3	48.9
TE/I 132	7.23	65	0.9	0.0011	2.22E-05	2.74E-05	1.11E-12
XE133	0.132	1328	95	25.2	0.127	0.327	8.39E-06
CE/PR144	0.00244	15600	14860	19400	17600	43100	35500
PU239	7.87E-08	15.5	15.5	22.3	22.3	69.3	69.3
SR/Y90	6.66E-05	573	572	844	842	1560	1550
CS/BAm137	6.3E-05	636	635	950	948	1900	1890
I 129	1.21E-10	0.00017	0.00017	0.000257	0.000258	0.000569	0.000573
KR85	0.000177	74	74	108	107	204	201
ZR/NB95	0.0108	33240	26770	25800	16800	72700	30600
SR89	0.0137	22910	17410	15600	8990	41600	13900

2.2 RADIOACTIVE DECAY AND DAUGHTER INGROWTH

Several of the radionuclides listed in Table 2 are members of decay chains, and have either precursors or successors in these chains. Fortunately for this scoping calculation, the behavior and impact of these radionuclides could be described with simple one-member exponential decay with a few assumptions. In the radionuclide chains Ru-106/Rh-106, Ru-103/Rh-103, Ce-144/Pr-144, Cs-137/Ba-137m, and Zr-95/Nb-95, the parent is sufficiently long lived, and the daughters sufficiently short lived, that the chains could be considered to be in secular equilibrium at all times in the environment. The effective decay energies were summed, and the ingestion and inhalation dose factors adjusted to account for these chains. The chain Te-132/I-132 was considered in estimating the amount of I-132 remaining in the fuel, and thus releasable, but the release fractions (described below) were sufficiently disparate that the I-132 could be considered in isolation in the environment.

2.3 RADIONUCLIDE RELEASE FRACTIONS

Key to the determination of relative importance of the radionuclides in the fuel is the fraction of the separation plant throughput emitted to the atmosphere. Assessments commonly assume that the release fraction for noble gasses (Xe and Kr) is 1.0. Heeb demonstrated that, until installation of the

silver reactors, the release fraction for iodine (I-131, I-132, and I-129) is 0.9 (Heeb 1992). In Phase I scoping, a relatively large value was also given to ruthenium isotopes for the years 1945-1949 (Ru-103 and Ru-106). This was done to compensate for the initial impression that relatively large amounts of ruthenium were emitted in periodic events. Later research has indicated that problems originally described in terms of "hot particles" were, in fact, manifestations of a much more general release of "mists" from the dissolver vessels. Greager and MacReady (January 1948, page 2) state that "the amount of radioactivity associated with the rust particles is only a small portion of the total activity carried by the airstream. The bulk of this entrained activity is presumed to be in the form of liquid droplets which constitute a 'mist' given off from the processing tanks during normal operations." Parker (March 1948, page 28) continues, "It is concluded that the main picture of fission product deposition" (other than iodine-131) "approaches a continuous distribution rather than a particulate one. To summarize the inferences from old data, the emission of active droplets has been known from the start of operations." Furthermore, Healy (August 1948, page 7) shows that radiochemical analysis for non-iodine fission products on sage from the 200-West Area results in a radionuclide spectrum very much like that presented in Table 2; this analysis specifically reports on both ruthenium isotopes. Analysis of data in these reports, as well as later reports describing the efficiencies of filters applied afterwards, leads to an upper-bound release fraction for the first few years of operation for all other radionuclides of $1x10^{-5}$ (i.e., 1 part in 100,000 escaping from the dissolvers).

The particulate release fraction for the first five years may also be estimated from early vegetation-monitoring data. Parker (March 1948, page 27) describes vegetation contamination after one year of operations as being mostly iodine-131 with 0.05% other fission products. Healy (August 1948, pp. 7 - 9) also provides such information for 1945, 1946, and 1947. The activity ratios of deposited particulate radionuclides to deposited iodine-131 support release fractions of less than $1x10^{-5}$ for all non-volatile radionuclides from 1945 through 1949.

Sand filters and chemically-reactive devices to capture radioiodine (called silver reactors) were installed on the separations plants beginning in

the late 1940s. Documents at the time indicate that the sand filters were better than 99% efficient at removing fission product mists from the plant discharge airstream (REF). Measurements made at that time support reduction of the fractional release by two orders of magnitude. Measurements of releases made during the 1950s (Anderson 1959, page 5) and 1960s (e.g., Wilson 1965, page 22) indicate that throughout the many years of operation, the release fraction remained at or well below $1x10^{-7}$. This value was used as an upper bound for the entire period for particulate materials.

The silver reactors were not as successful in reducing the releases of iodine isotopes, but they were sufficient to allow continued operations of the facilities. Measurements made in the mid-1960s, of both stack gases and vegetation, indicate that at that time only about 1% of the iodine-131 was emitted (Wilson 1965, page 22). This was the upper bound of expected plant capabilities (DOE 1982, page A.7). There were two instances of failures of the silver reactors, both in 1951 (Roberts 1958, page 6). The separations plants continued operations during these silver reactor outages, resulting in greatly elevated releases of iodine-131 during two quarters of 1951 (Roberts 1958, page 6). This was used in the calculations as a release fraction of 0.9 in the early years, dropping to 0.01 for later years, with a single-year value of 0.10 to account for the portion of 1951 during which these filtering devices failed.

Emissions from the startup period of the REDOX plant require special consideration. As implied by the acronym, the REDOX plant used combinations of strong reducing and oxidizing chemical conditions to effect separation of radionuclides following dissolution of the fuel. Troubles with one of the strong oxidation steps lead to creation of volatile ruthenium compounds and enhanced ruthenium releases to the air. This same set of processes lead to deposition of ruthenium nitrate layers on the inside of some exhaust lines. Occasionally, these deposits would flake off and be emitted from the REDOX stack. A quarterly summary of the REDOX ruthenium releases is presented in Appendix A. A set of release fractions derived from this data was used to estimate the upper bound of releases (C.M. Heeb, personal communication, December 1992). Values of $1x10^{-4}$ for the period 1952 through 1955 and $1x10^{-5}$ for years thereafter for REDOX are felt to be reasonable yet conservative.

The total ruthenium inventories emitted as large particles are included in the ruthenium release fractions (i.e., the total number of curies emitted is included in the estimate), but the doses are estimated as if all of the ruthenium were mircometer-sized particulates; the doses from the particles themselves are not specifically addressed.

3.0 RESULTS/DISCUSSION

The results of calculations for each of the radionuclides for the years 1945 through 1972 in Census District 4 of Franklin County are presented in Tables 3 and 4 for infants and in Tables 5 and 6 for adults. These tables present effective dose equivalent (whole-body dose) and critical-organ dose (the dose to the organ receiving the highest dose).

Although not the maximum doses that could be calculated, the doses in Tables 3 through 6 are for individuals in a highly impacted location, who live a lifestyle that would tend to maximize doses. The author believes it unlikely that median or mean doses calculated with more detailed models would exceed those presented here, for any radionuclide. A separate scoping calculation is underway to confirm that the position of this deterministic result is near the mean of the overall range of possible dose results (Calculation 0C5).

The results presented here support those drawn by Napier (1991) that I-131 is the most important to the HEDR study. Iodine-131 alone provides over 99.9% of the dose to both the infant and the adult. With the revision of the release fraction for ruthenium isotopes, the ruthenium isotopes fall to the general level of the other fission products. The major difference between the two studies is that this one deals with absolute magnitudes, rather than relative ratios. This type of comparison was not possible until the declassification of the radionuclide production information (Gydesen 1992a; 1992b) and the recent development of the source term model (Heeb 1992).

The dose decision levels provided by the TSP (Shleien 1992) require a two-part analysis of doses-an annual dose and a cumulative dose over the period of Hanford operations. This scoping calculation addresses the cumulative doses. A separate scoping calculation has been prepared to provide details of the pathways of exposure for all of the radionuclides in the year of maximum releases, i.e., 1945 (Calculation 003). Iodine dominates the dose to both infants and adults until the early 1960s. After that time, other radionuclides via the air pathway provide a larger percentage of the dose, but by that time, the total annual doses are all less than one millirem, even to

TABLE 3. Annual Effective Doses to Infants by Radionuclide

Year	I-131	Ru/Rh106	Ru/Rh103	Co60	Te/I-132	Xe133	Ce/Pr144	Pu239	Sr/Y90	Cs/Ba137mI-129	Kr85	Zr/Nb95	Sr89	
1945	1.62E+01	1.93E-05	1.24E-05	1.28E-07	1.06E-04	1.74E-05	1.20E-04	2.49E-05	1.41E-04	9.46E-06	1.30E-05	2.23E-07	8.73E-05	1.16E-04
1946	5.87E+00	3.46E-05	1.63E-05	2.36E-07	4.17E-06	2.81E-06	2.12E-04	4.62E-05	2.61E-04	1.75E-05	2.41E-05	4.14E-07	1.31E-04	1.64E-04
1947	7.83E-01	1.88E-05	6.89E-06	1.31E-07	5.43E-08	1.66E-07	1.14E-04	2.58E-05	1.46E-04	9.79E-06	1.35E-05	2.32E-07	6.17E-05	7.38E-05
1948	1.21E-01	2.17E-05	5.46E-06	1.57E-07	3.96E-10	8.57E-09	1.30E-04	3.12E-05	1.76E-04	1.18E-05	1.63E-05	2.80E-07	5.75E-05	6.42E-05
1949	1.81E-01	2.09E-05	5.70E-06	1.50E-07	1.22E-09	1.66E-08	1.26E-04	2.97E-05	1.68E-04	1.12E-05	1.55E-05	2.67E-07	5.79E-05	6.56E-05
1950	5.15E-02	3.41E-07	1.13E-07	8.04E-09	2.31E-08	2.97E-06	1.91E-06	4.49E-07	2.58E-06	1.75E-07	2.70E-07	4.05E-07	9.52E-07	1.14E-06
1951	1.05E+00	4.87E-07	1.80E-07	5.74E-07	7.86E-09	5.66E-06	2.65E-06	6.09E-07	3.54E-06	2.41E-07	3.72E-06	5.55E-07	1.39E-06	1.71E-06
1952	2.92E-02	3.57E-04	8.59E-05	1.16E-07	1.92E-10	9.77E-07	2.92E-06	7.05E-07	4.09E-06	2.78E-07	4.31E-07	6.39E-07	1.30E-06	1.50E-06
1953	3.08E-02	1.23E-03	2.95E-04	7.85E-08	1.72E-10	5.05E-07	7.21E-06	1.77E-06	1.02E-05	6.97E-07	1.08E-06	1.60E-06	3.03E-06	3.42E-06
1954	6.14E-03	6.57E-04	1.11E-04	9.99E-09	2.87E-11	5.02E-08	5.78E-06	1.48E-06	8.56E-06	5.83E-07	9.06E-07	1.33E-06	2.10E-06	2.24E-06
1955	1.57E-03	1.53E-03	1.54E-04	1.58E-09	6.04E-12	6.18E-09	1.07E-05	2.96E-06	1.71E-05	1.17E-06	1.82E-06	2.65E-06	3.05E-06	2.98E-06
1956	7.83E-04	9.38E-05	1.09E-05	4.80E-10	2.52E-12	1.38E-09	1.01E-05	2.80E-06	1.62E-05	1.10E-06	1.72E-06	2.50E-06	2.87E-06	2.80E-06
1957	3.23E-03	7.61E-05	1.07E-05	2.95E-09	1.21E-11	1.06E-08	1.33E-05	3.55E-06	2.06E-05	1.40E-06	2.18E-06	3.19E-06	4.23E-06	4.31E-06
1958	1.14E-01	2.04E-04	4.90E-05	5.45E-08	5.08E-10	7.06E-07	3.66E-05	1.18E-05	4.07E-05	3.00E-06	5.12E-06	6.52E-06	2.44E-05	2.83E-05
1959	7.10E-02	1.20E-04	1.04E-05	4.83E-08	1.81E-10	3.63E-07	3.16E-05	1.05E-05	3.62E-05	2.66E-06	4.56E-06	5.79E-06	1.96E-05	2.24E-05
1960	2.81E-02	1.13E-04	1.19E-05	5.76E-08	1.33E-11	7.80E-08	3.71E-05	1.25E-05	4.32E-05	3.18E-06	5.45E-06	6.91E-06	2.12E-05	2.34E-05
1961	1.91E-02	1.67E-04	1.71E-05	5.86E-08	5.51E-12	4.43E-08	3.72E-05	1.28E-05	4.40E-05	3.24E-06	5.56E-06	7.03E-06	2.02E-05	2.19E-05
1962	1.16E-03	1.31E-04	1.26E-05	5.65E-08	5.27E-15	5.95E-10	3.40E-05	1.24E-05	4.28E-05	3.15E-06	5.43E-06	6.82E-06	1.45E-05	1.44E-05
1963	6.71E-04	1.47E-04	1.02E-05	5.27E-08	1.62E-15	2.74E-10	3.11E-05	1.16E-05	4.00E-05	2.95E-06	5.09E-06	6.37E-06	1.24E-05	1.21E-05
1964	1.52E-03	2.22E-04	1.49E-05	6.05E-08	1.12E-14	9.29E-10	3.60E-05	1.33E-05	4.59E-05	3.38E-06	5.83E-06	7.31E-06	1.50E-05	1.49E-05
1965	5.01E-04	2.21E-04	2.25E-05	5.98E-08	6.23E-16	1.59E-10	3.53E-05	1.32E-05	4.54E-05	3.35E-06	5.77E-06	7.23E-06	1.39E-05	1.34E-05
1966	4.11E-06	1.68E-04	1.11E-05	3.52E-08	1.41E-20	1.45E-13	1.87E-05	7.91E-06	2.71E-05	2.00E-06	3.47E-06	4.29E-06	4.81E-06	4.02E-06
1967	6.40E-06	5.44E-06	3.45E-07	3.56E-08	2.20E-20	2.43E-13	1.92E-05	7.99E-06	2.74E-05	2.02E-06	3.50E-06	4.34E-06	5.24E-06	4.47E-06
1968	3.53E-07	4.89E-06	1.84E-07	3.37E-08	1.85E-23	2.93E-15	1.70E-05	7.64E-06	2.61E-05	1.93E-06	3.36E-06	4.12E-06	3.51E-06	2.72E-06
1969	2.02E-08	3.25E-06	7.74E-08	2.34E-08	2.66E-26	4.41E-17	1.11E-05	5.36E-06	1.83E-05	1.35E-06	2.37E-06	2.88E-06	1.80E-06	1.28E-06
1970	1.40E-19	7.25E-07	1.88E-10	8.12E-09	3.16E-53	5.83E-34	2.12E-06	2.06E-06	6.85E-06	5.08E-07	9.31E-07	1.05E-06	3.10E-08	9.64E-09
1971	1.09E-18	2.26E-06	6.95E-10	2.49E-08	9.73E-52	7.48E-33	6.67E-06	6.30E-06	2.10E-05	1.56E-06	2.84E-06	3.21E-06	1.07E-07	3.42E-08
1972	5.43E-18	7.72E-07	3.91E-10	8.10E-09	2.70E-49	1.60E-31	2.32E-06	2.02E-06	6.76E-06	5.01E-07	9.12E-07	1.04E-06	4.83E-08	1.70E-08
SUMS	24.51	5.58E-03	8.76E-04	2.21E-06	1.11E-04	3.17E-05	1.11E-03	3.10E-04	1.45E-03	1.00E-04	1.55E-04	8.92E-05	5.70E-04	6.66E-04	24.51774

TABLE 4. Annual Critical-Organ Doses to Infants by Radionuclide

Year	I-131	Ru/Rh106	Ru/Rh103	Co60	Te/I-132	Xe133	Ce/Pr144	Pu239	Sr/Y90	Cs/Ba137mI-129	Kr85	Zr/Nb95	Sr89	
1945	5.89E+02	1.54E-04	4.56E-05	4.27E-07	1.08E-03	1.74E-05	1.01E-03	2.98E-04	1.09E-03	1.24E-05	4.44E-04	2.23E-07	1.86E-04	1.08E-03
1946	2.14E+02	2.75E-04	5.97E-05	7.86E-07	4.25E-05	2.81E-06	1.78E-03	5.52E-04	2.01E-03	2.30E-05	8.24E-04	4.15E-07	2.79E-04	1.53E-03
1947	2.85E+01	1.49E-04	2.53E-05	4.37E-07	5.53E-07	1.66E-07	9.60E-04	3.09E-04	1.12E-03	1.28E-05	4.61E-04	2.32E-07	1.32E-04	6.91E-04
1948	4.40E+00	1.72E-04	2.00E-05	5.23E-07	4.04E-09	8.59E-09	1.09E-03	3.73E-04	1.35E-03	1.55E-05	5.56E-04	2.80E-07	1.23E-04	6.01E-04
1949	6.60E+00	1.66E-04	2.09E-05	4.99E-07	1.25E-08	1.66E-08	1.05E-03	3.55E-04	1.29E-03	1.47E-05	5.30E-04	2.67E-07	1.24E-04	6.14E-04
1950	1.88E+00	2.71E-06	4.15E-07	2.68E-08	2.36E-07	2.97E-06	1.60E-05	5.37E-06	1.99E-05	2.30E-07	9.23E-06	4.06E-07	2.03E-06	1.07E-05
1951	3.81E+01	3.87E-06	6.61E-07	1.91E-06	8.02E-08	5.67E-06	2.23E-05	7.29E-06	2.73E-05	3.16E-07	1.27E-04	5.56E-07	2.98E-06	1.60E-05
1952	1.06E+00	2.83E-03	3.15E-04	3.86E-07	1.96E-09	9.79E-07	2.45E-05	8.43E-06	3.15E-05	3.65E-07	1.47E-05	6.40E-07	2.77E-06	1.40E-05
1953	1.12E+00	9.81E-03	1.08E-03	2.62E-07	1.75E-09	5.06E-07	6.05E-05	2.11E-05	7.90E-05	9.14E-07	3.69E-05	1.60E-06	6.47E-06	3.20E-05
1954	2.24E-01	5.22E-03	4.09E-04	3.33E-08	2.93E-10	5.03E-08	4.85E-05	1.77E-05	6.60E-05	7.64E-07	3.09E-05	1.33E-06	4.48E-06	2.10E-05
1955	5.71E-02	1.22E-02	5.66E-04	5.26E-09	6.16E-11	6.20E-09	9.02E-05	3.54E-05	1.32E-04	1.53E-06	6.21E-05	2.66E-06	6.51E-06	2.79E-05
1956	2.85E-02	7.45E-04	4.01E-05	1.60E-09	2.57E-11	1.38E-09	8.52E-05	3.35E-05	1.25E-04	1.44E-06	5.87E-05	2.51E-06	6.12E-06	2.62E-05
1957	1.18E-01	6.05E-04	3.93E-05	9.83E-09	1.24E-10	1.06E-08	1.12E-04	4.25E-05	1.59E-04	1.83E-06	7.44E-05	3.20E-06	9.04E-06	4.03E-05
1958	4.14E+00	1.62E-03	1.80E-04	1.82E-07	5.18E-09	7.07E-07	3.07E-04	1.41E-04	3.14E-04	3.93E-06	1.75E-04	6.53E-06	5.21E-05	2.65E-04
1959	2.59E+00	9.56E-04	3.81E-05	1.61E-07	1.85E-09	3.64E-07	2.65E-04	1.25E-04	2.79E-04	3.49E-06	1.56E-04	5.80E-06	4.18E-05	2.10E-04
1960	1.03E+00	8.94E-04	4.35E-05	1.92E-07	1.36E-10	7.82E-08	3.11E-04	1.50E-04	3.33E-04	4.17E-06	1.86E-04	6.92E-06	4.53E-05	2.19E-04
1961	6.97E-01	1.33E-03	6.26E-05	1.95E-07	5.62E-11	4.44E-08	3.12E-04	1.53E-04	3.39E-04	4.25E-06	1.90E-04	7.04E-06	4.30E-05	2.05E-04
1962	4.24E-02	1.04E-03	4.62E-05	1.88E-07	5.37E-14	5.96E-10	2.85E-04	1.49E-04	3.30E-04	4.13E-06	1.85E-04	6.83E-06	3.09E-05	1.35E-04
1963	2.45E-02	1.17E-03	3.73E-05	1.76E-07	1.65E-14	2.74E-10	2.61E-04	1.39E-04	3.09E-04	3.86E-06	1.74E-04	6.38E-06	2.65E-05	1.13E-04
1964	5.55E-02	1.76E-03	5.47E-05	2.02E-07	1.14E-13	9.31E-10	3.02E-04	1.60E-04	3.54E-04	4.43E-06	1.99E-04	7.32E-06	3.20E-05	1.39E-04
1965	1.83E-02	1.75E-03	8.25E-05	1.99E-07	6.36E-15	1.59E-10	2.96E-04	1.58E-04	3.50E-04	4.39E-06	1.97E-04	7.24E-06	2.96E-05	1.25E-04
1966	1.50E-04	1.34E-03	4.09E-05	1.17E-07	1.44E-19	1.46E-13	1.57E-04	9.46E-05	2.09E-04	2.62E-06	1.19E-04	4.29E-06	1.03E-05	3.77E-05
1967	2.33E-04	4.33E-05	1.27E-06	1.19E-07	2.24E-19	2.43E-13	1.61E-04	9.56E-05	2.11E-04	2.64E-06	1.20E-04	4.34E-06	1.12E-05	4.18E-05
1968	1.29E-05	3.89E-05	6.76E-07	1.12E-07	1.88E-22	2.94E-15	1.42E-04	9.14E-05	2.01E-04	2.52E-06	1.15E-04	4.13E-06	7.49E-06	2.54E-05
1969	7.36E-07	2.58E-05	2.84E-07	7.80E-08	2.71E-25	4.42E-17	9.31E-05	6.42E-05	1.41E-04	1.77E-06	8.08E-05	2.88E-06	3.84E-06	1.20E-05
1970	5.10E-18	5.76E-06	6.88E-10	2.70E-08	3.22E-52	5.84E-34	1.78E-05	2.46E-05	5.28E-05	6.66E-07	3.18E-05	1.05E-06	6.61E-08	9.02E-08
1971	3.98E-17	1.80E-05	2.55E-09	8.30E-08	9.93E-51	7.50E-33	5.60E-05	7.53E-05	1.62E-04	2.04E-06	9.71E-05	3.21E-06	2.28E-07	3.20E-07
1972	1.98E-16	6.14E-06	1.44E-09	2.70E-08	2.76E-48	1.61E-31	1.94E-05	2.42E-05	5.21E-05	6.56E-07	3.11E-05	1.04E-06	1.03E-07	1.59E-07
SUMS	893.17	4.43E-02	3.21E-03	7.37E-06	1.13E-03	3.18E-05	9.34E-03	3.70E-03	1.11E-02	1.31E-04	5.28E-03	8.93E-05	1.22E-03	6.24E-03	893.2515

TABLE 5. Annual Effective Doses to Adults by Radionuclide

Year	I-131	Ru/Rh106	Ru/Rh103	Co60	Te/I-132	Xe133	Ce/Pr144	Pu239	Sr/Y90	Cs/Ba137mI-129	Kr85	Zr/Nb95	Sr89	
1945	1.55E+00	2.07E-05	1.06E-05	1.28E-07	6.55E-05	1.74E-05	1.23E-04	1.70E-04	8.09E-04	8.48E-06	7.82E-06	2.23E-07	7.89E-05	1.16E-04
1946	5.62E-01	3.69E-05	1.38E-05	2.36E-07	2.57E-06	2.81E-06	2.18E-04	3.16E-04	1.50E-03	1.57E-05	1.45E-05	4.14E-07	1.18E-04	1.64E-04
1947	7.50E-02	2.01E-05	5.87E-06	1.31E-07	3.34E-08	1.66E-07	1.17E-04	1.77E-04	8.38E-04	8.78E-06	8.12E-06	2.32E-07	5.57E-05	7.38E-05
1948	1.16E-02	2.32E-05	4.65E-06	1.57E-07	2.44E-10	8.57E-09	1.34E-04	2.13E-04	1.01E-03	1.06E-05	9.80E-06	2.80E-07	5.20E-05	6.42E-05
1949	1.74E-02	2.23E-05	4.85E-06	1.50E-07	7.53E-10	1.66E-08	1.29E-04	2.03E-04	9.62E-04	1.01E-05	9.34E-06	2.67E-07	5.23E-05	6.56E-05
1950	4.94E-03	3.64E-07	9.63E-08	8.03E-09	1.42E-08	2.97E-06	1.96E-06	3.07E-06	1.48E-05	1.57E-07	1.63E-07	4.05E-07	8.60E-07	1.14E-06
1951	1.00E-01	5.21E-07	1.53E-07	5.74E-07	4.84E-09	5.66E-06	2.72E-06	4.17E-06	2.03E-05	2.16E-07	2.24E-06	5.55E-07	1.26E-06	1.71E-06
1952	2.80E-03	3.81E-04	7.31E-05	1.16E-07	1.18E-10	9.77E-07	2.99E-06	4.82E-06	2.35E-05	2.50E-07	2.59E-07	6.39E-07	1.17E-06	1.50E-06
1953	2.95E-03	1.32E-03	2.51E-04	7.84E-08	1.06E-10	5.05E-07	7.39E-06	1.21E-05	5.89E-05	6.26E-07	6.50E-07	1.60E-06	2.74E-06	3.42E-06
1954	5.88E-04	7.02E-04	9.49E-05	9.98E-09	1.77E-11	5.02E-08	5.92E-06	1.01E-05	4.92E-05	5.23E-07	5.45E-07	1.33E-06	1.90E-06	2.25E-06
1955	1.50E-04	1.64E-03	1.31E-04	1.58E-09	3.72E-12	6.18E-09	1.10E-05	2.03E-05	9.84E-05	1.05E-06	1.10E-06	2.65E-06	2.75E-06	2.98E-06
1956	7.50E-05	1.00E-04	9.30E-06	4.80E-10	1.55E-12	1.38E-09	1.04E-05	1.91E-05	9.29E-05	9.87E-07	1.03E-06	2.50E-06	2.59E-06	2.80E-06
1957	3.09E-04	8.13E-05	9.12E-06	2.95E-09	7.47E-12	1.06E-08	1.37E-05	2.43E-05	1.18E-04	1.26E-06	1.31E-06	3.19E-06	3.83E-06	4.31E-06
1958	1.09E-02	2.17E-04	4.17E-05	5.45E-08	3.13E-10	7.06E-07	3.76E-05	8.06E-05	2.34E-04	2.69E-06	3.08E-06	6.52E-06	2.20E-05	2.83E-05
1959	6.80E-03	1.28E-04	8.84E-06	4.82E-08	1.12E-10	3.63E-07	3.24E-05	7.17E-05	2.08E-04	2.39E-06	2.74E-06	5.79E-06	1.77E-05	2.24E-05
1960	2.70E-03	1.20E-04	1.01E-05	5.75E-08	8.20E-12	7.80E-08	3.81E-05	8.57E-05	2.48E-04	2.85E-06	3.28E-06	6.91E-06	1.92E-05	2.34E-05
1961	1.83E-03	1.79E-04	1.45E-05	5.85E-08	3.39E-12	4.43E-08	3.81E-05	8.74E-05	2.53E-04	2.91E-06	3.35E-06	7.03E-06	1.82E-05	2.19E-05
1962	1.11E-04	1.40E-04	1.07E-05	5.65E-08	3.25E-15	5.95E-10	3.48E-05	8.51E-05	2.46E-04	2.83E-06	3.27E-06	6.82E-06	1.31E-05	1.44E-05
1963	6.43E-05	1.57E-04	8.64E-06	5.27E-08	9.96E-16	2.74E-10	3.19E-05	7.97E-05	2.30E-04	2.64E-06	3.06E-06	6.37E-06	1.12E-05	1.21E-05
1964	1.46E-04	2.37E-04	1.27E-05	6.05E-08	6.87E-15	9.29E-10	3.69E-05	9.14E-05	2.64E-04	3.03E-06	3.51E-06	7.31E-06	1.35E-05	1.49E-05
1965	4.80E-05	2.36E-04	1.91E-05	5.98E-08	3.84E-16	1.59E-10	3.62E-05	9.04E-05	2.61E-04	3.00E-06	3.47E-06	7.23E-06	1.25E-05	1.34E-05
1966	3.94E-07	1.80E-04	9.49E-06	3.52E-08	8.71E-21	1.45E-13	1.92E-05	5.41E-05	1.56E-04	1.79E-06	2.09E-06	4.29E-06	4.35E-06	4.02E-06
1967	6.13E-07	5.82E-06	2.94E-07	3.56E-08	1.36E-20	2.43E-13	1.97E-05	5.47E-05	1.57E-04	1.81E-06	2.11E-06	4.34E-06	4.74E-06	4.47E-06
1968	3.38E-08	5.23E-06	1.57E-07	3.37E-08	1.14E-23	2.93E-15	1.74E-05	5.23E-05	1.50E-04	1.73E-06	2.02E-06	4.12E-06	3.17E-06	2.72E-06
1969	1.93E-09	3.47E-06	6.58E-08	2.34E-08	1.64E-26	4.41E-17	1.14E-05	3.67E-05	1.05E-04	1.21E-06	1.42E-06	2.88E-06	1.62E-06	1.28E-06
1970	1.34E-20	7.74E-07	1.60E-10	8.11E-09	1.95E-53	5.83E-34	2.18E-06	1.41E-05	3.94E-05	4.56E-07	5.60E-07	1.05E-06	2.80E-08	9.64E-09
1971	1.04E-19	2.42E-06	5.92E-10	2.49E-08	5.99E-52	7.48E-33	6.94E-06	4.31E-05	1.21E-04	1.39E-06	1.71E-06	3.21E-06	9.63E-08	3.42E-08
1972	5.20E-19	8.25E-07	3.33E-10	8.09E-09	1.66E-49	1.60E-31	2.37E-06	1.38E-05	3.88E-05	4.49E-07	5.48E-07	1.04E-06	4.36E-08	1.70E-08
SUMS	2.35	5.96E-03	7.46E-04	2.21E-06	6.81E-05	3.17E-05	1.14E-03	2.12E-03	8.31E-03	8.99E-05	9.31E-05	8.92E-05	5.15E-04	6.66E-04	2.367152

TABLE 6. Annual Critical-Organ Doses to Adults by Radionuclide

Year	I-131	Ru/Rh106	Ru/Rh103	Co60	Te/I-132	Xe133	Ce/Pr144	Pu239	Sr/Y90	Cs/Ba137m	I-129	Kr85	Zr/Nb95	Sr89	
1945	4.97E+01	1.71E-04	3.21E-05	4.27E-07	6.68E-05	1.74E-05	1.04E-03	3.10E-03	9.94E-04	8.79E-06	2.59E-04	2.23E-07	3.09E-04	1.08E-03	
1946	1.81E+01	3.06E-04	4.19E-05	7.86E-07	2.62E-06	2.81E-06	1.84E-03	5.76E-03	1.84E-03	1.63E-05	4.81E-04	4.15E-07	4.63E-04	1.53E-03	
1947	2.41E+00	1.66E-04	1.78E-05	4.37E-07	3.41E-08	1.66E-07	9.91E-04	3.22E-03	1.03E-03	9.10E-06	2.69E-04	2.32E-07	2.19E-04	6.91E-04	
1948	3.71E-01	1.92E-04	1.41E-05	5.22E-07	2.49E-10	8.59E-09	1.13E-03	3.89E-03	1.24E-03	1.10E-05	3.25E-04	2.80E-07	2.04E-04	6.01E-04	
1949	5.58E-01	1.84E-04	1.47E-05	4.99E-07	7.68E-10	1.66E-08	1.09E-03	3.71E-03	1.18E-03	1.04E-05	3.09E-04	2.67E-07	2.05E-04	6.14E-04	
1950	1.59E-01	3.01E-06	2.92E-07	2.68E-08	1.45E-08	2.97E-06	1.65E-05	5.60E-05	1.82E-05	1.63E-07	5.39E-06	4.06E-07	3.37E-06	1.07E-05	
1951	3.22E+00	4.31E-06	4.64E-07	1.91E-06	4.94E-09	5.67E-06	2.30E-05	7.61E-05	2.50E-05	2.24E-07	7.41E-05	5.56E-07	4.94E-06	1.60E-05	
1952	8.99E-02	3.15E-03	2.22E-04	3.86E-07	1.21E-10	9.79E-07	2.53E-05	8.80E-05	2.88E-05	2.59E-07	8.58E-06	6.40E-07	4.60E-06	1.40E-05	
1953	9.47E-02	1.09E-02	7.62E-04	2.61E-07	1.08E-10	5.06E-07	6.24E-05	2.21E-04	7.23E-05	6.48E-07	2.15E-05	1.60E-06	1.07E-05	3.20E-05	
1954	1.89E-02	5.81E-03	2.87E-04	3.33E-08	1.81E-11	5.03E-08	5.00E-05	1.84E-04	6.04E-05	5.42E-07	1.80E-05	1.33E-06	7.43E-06	2.10E-05	
1955	4.82E-03	1.36E-02	3.98E-04	5.26E-09	3.80E-12	6.20E-09	9.31E-05	3.70E-04	1.21E-04	1.08E-06	3.63E-05	2.66E-06	1.08E-05	2.79E-05	
1956	2.41E-03	8.29E-04	2.82E-05	1.60E-09	1.58E-12	1.38E-09	8.79E-05	3.49E-04	1.14E-04	1.02E-06	3.42E-05	2.51E-06	1.02E-05	2.62E-05	
1957	9.94E-03	6.73E-04	2.76E-05	9.82E-09	7.62E-12	1.06E-08	1.16E-04	4.43E-04	1.45E-04	1.30E-06	4.34E-05	3.20E-06	1.50E-05	4.03E-05	
1958	3.50E-01	1.80E-03	1.26E-04	1.82E-07	3.19E-10	7.07E-07	3.17E-04	1.47E-03	2.87E-04	2.78E-06	1.02E-04	6.53E-06	8.65E-05	2.65E-04	
1959	2.18E-01	1.06E-03	2.68E-05	1.61E-07	1.14E-10	3.64E-07	2.73E-04	1.31E-03	2.55E-04	2.47E-06	9.09E-05	5.80E-06	6.94E-05	2.10E-04	
1960	8.67E-02	9.95E-04	3.06E-05	1.92E-07	8.37E-12	7.82E-08	3.21E-04	1.56E-03	3.05E-04	2.96E-06	1.09E-04	6.92E-06	7.52E-05	2.19E-04	
1961	5.89E-02	1.48E-03	4.40E-05	1.95E-07	3.46E-12	4.44E-08	3.22E-04	1.59E-03	3.11E-04	3.01E-06	1.11E-04	7.04E-06	7.14E-05	2.05E-04	
1962	3.58E-03	1.16E-03	3.25E-05	1.88E-07	3.31E-15	5.96E-10	2.94E-04	1.55E-03	3.02E-04	2.93E-06	1.08E-04	6.83E-06	5.13E-05	1.35E-04	
1963	2.07E-03	1.30E-03	2.62E-05	1.76E-07	1.02E-15	2.74E-10	2.70E-04	1.45E-03	2.82E-04	2.74E-06	1.01E-04	6.38E-06	4.40E-05	1.13E-04	
1964	4.68E-03	1.96E-03	3.85E-05	2.02E-07	7.01E-15	9.31E-10	3.12E-04	1.67E-03	3.24E-04	3.14E-06	1.16E-04	7.32E-06	5.31E-05	1.39E-04	
1965	1.54E-03	1.95E-03	5.80E-05	1.99E-07	3.92E-16	1.59E-10	3.06E-04	1.65E-03	3.20E-04	3.11E-06	1.15E-04	7.24E-06	4.91E-05	1.25E-04	
1966	1.27E-05	1.49E-03	2.87E-05	1.17E-07	8.89E-21	1.46E-13	1.62E-04	9.87E-04	1.91E-04	1.86E-06	6.92E-05	4.29E-06	1.71E-05	3.77E-05	
1967	1.97E-05	4.81E-05	8.90E-07	1.19E-07	1.38E-20	2.43E-13	1.66E-04	9.97E-04	1.93E-04	1.87E-06	6.98E-05	4.34E-06	1.86E-05	4.18E-05	
1968	1.09E-06	4.33E-05	4.75E-07	1.12E-07	1.16E-23	2.94E-15	1.47E-04	9.54E-04	1.84E-04	1.79E-06	6.70E-05	4.13E-06	1.24E-05	2.54E-05	
1969	6.21E-08	2.87E-05	1.99E-07	7.79E-08	1.67E-26	4.42E-17	9.61E-05	6.69E-04	1.29E-04	1.25E-06	4.71E-05	2.88E-06	6.37E-06	1.20E-05	
1970	4.30E-19	6.41E-06	4.84E-10	2.70E-08	1.99E-53	5.84E-34	1.84E-05	2.57E-04	4.84E-05	4.72E-07	1.85E-05	1.05E-06	1.10E-07	9.02E-08	
1971	3.36E-18	2.00E-05	1.79E-09	8.30E-08	6.12E-52	7.50E-33	5.78E-05	7.86E-04	1.48E-04	1.44E-06	5.67E-05	3.21E-06	3.78E-07	3.20E-07	
1972	1.67E-17	6.83E-06	1.01E-09	2.70E-08	1.70E-49	1.61E-31	2.01E-05	2.52E-04	4.77E-05	4.65E-07	1.82E-05	1.04E-06	1.71E-07	1.59E-07	
SUMS	75.44	4.93E-02	2.26E-03	7.36E-06	6.95E-05	3.18E-05	9.64E-03	3.86E-02	1.02E-02	9.31E-05	3.08E-03	8.93E-05	2.02E-03	6.24E-03	75.56094

critical organs. This is much below the TSP dose decision level for annual and cumulative doses, which calls into question the need to estimate doses from these radionuclides with the same detail as that used for the iodine-131.

The addition of the doses from 13 radionuclide decay chains to the dose from iodine-131 had the largest impact to the doses to adults. To emphasize the minor nature of this addition, a table of percent contributions to the adult effective dose is presented as Table 7. It is apparent from this table that the iodine-131 produces well over 99% of the dose to the individual at this high-exposure location over the entire period. It is also apparent that most of the dose occurs in the first few years of Hanford Site operations.

Because this scoping calculation addressed only the single, highly exposed, location immediately east of the Hanford Site, it cannot be used to judge the entire domain of the HEDR study. However, the normalized dose-per-unit-release factors employed are being used in a companion scoping calculation to address the overall scale of the project. That work will be reported separately to the TSP.

TABLE 7. Percentage Contribution of Each Radionuclide for Each Year to Cumulative Effective Dose to Adults

Year	I-131	Ru/Rh106	Ru/Rh103	Co60	Te/I-132	Xe133	Ce/Pr144	Pu239	Sr/Y90	Cs/Ba137m	I-129	Kr85	Zr/Nb95	Sr89	
1945	65.36%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	
1946	23.73%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.06%	0.00%	0.00%	0.00%	0.00%	0.01%	
1947	3.17%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	
1948	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	
1949	0.73%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	
1950	0.21%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
1951	4.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
1952	0.12%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
1953	0.12%	0.06%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
1954	0.02%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
1955	0.01%	0.07%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
1956	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
1957	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
1958	0.46%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1959	0.29%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1960	0.11%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1961	0.08%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1962	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1963	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1964	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1965	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1966	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1967	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1968	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1969	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
1970	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
1971	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	
1972	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
SUMS	99.16%	0.25%	0.03%	0.00%	0.00%	0.00%	0.05%	0.09%	0.35%	0.00%	0.00%	0.00%	0.02%	0.03%	100.00%

4.0 RECOMMENDATIONS

Scoping calculations were performed for that portion of Franklin County considered to be the most exposed area in the HEDR study region. Based on the results of this scoping calculation, and the companion study on pathways for each radionuclide, the following recommendations are made regarding exposure pathways, calculational methods, and the radionuclides included in calculating individual doses for the HEDR project:

EXPOSURE PATHWAYS

Although external dose, inhalation dose, and dose from ingestion of soil by humans all contribute less than one percent of the total dose, each individually has the potential to contribute a sizable fraction of the TSP's dose decision level in the first few years. Each of these pathways also shares the characteristic of being simple to calculate from information that will be available. For each of these reasons, and because their inclusion would enhance the face validity of the estimated doses, it is recommended that they be retained in the model. Each of the remaining pathways evaluated has the potential to contribute some multiples of the TSP dose decision level, even if only for a very limited geographical area or for a limited target population. Thus, they should also be retained.

CALCULATIONAL METHODS

While developing this spreadsheet scoping study, the authors noted that there are currently only very limited data available for the holdup time from slaughter to consumption of meat. The distribution of holdups (all foods consumed relatively fresh, or after long holdups in freezer lockers) will have a significant impact on the magnitude of this value. Additional information is required from the Demography and Food Habits Task to help better define this value. A study of the secondary literature will be requested of Task 06.

A second observation is that uptake through the roots of plants of radionuclides deposited on soil contributes only a very small percentage of the dose as compared with direct foliar deposition. Therefore, if only

iodine-131 is investigated in depth, the detailed structure of the soil components of the proposed model may not be required.

INCLUDED RADIONUCLIDES

The results indicate very plainly that the radionuclide of greatest interest is iodine-131. The doses, either to adults or infants and from any pathway, are four to seven orders-of-magnitude smaller from any other radionuclide than they are from iodine-131. None of the other radionuclides, separately or in combination, provides a cumulative dose greater than 20 mrem effective dose equivalent, or greater than 50 mrem to any organ, over the entire period from 1945 through 1972. The capability to estimate doses from other nuclides was retained on the possibility that they could contribute significantly to the cumulative dose. It is apparent from this analysis that they do not and, therefore, need not be included.

The HEDR staff recommends that the detailed analysis be limited to the doses from iodine-131 from the air pathways. Doses from other radionuclides should be performed with different tools or in a less detailed fashion. Options include additional spreadsheets, such as the one used for this analysis; deterministic calculations with the larger dose code (i.e., using the same code but with only one realization of source, dispersion, uptake, and dose); or scaling from the more completely calculated iodine doses. Any of these options would greatly reduce the computational complexity required of the main dose code, while reducing the effort needed to obtain adequate data to support the main dose code. Even if only upper-bound dose estimates were made for the other radionuclides, their addition to the dose estimate for iodine-131 would not significantly change the estimated uncertainty range of the overall estimate.

5.0 QUALITY ASSURANCE

Quality assurance was undertaken in accordance with PNL-MA-70, Volume 1, Procedures for Quality Assurance Program, under PNL administrative procedure PAP-70-301, "Hand Calculations, General." The senior author documented the calculation completely, prepared the spreadsheets, and independently performed the spreadsheet calculations. The researcher who developed the earlier spreadsheets upon which the current ones are based performed a thorough independent review. Spreadsheet documentation is on file and available for review.

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APPENDIX A

DETAILS OF RELEASE FRACTION ESTIMATION

DETAILS OF RELEASE FRACTION ESTIMATION

This appendix presents the result of a simple spreadsheet calculation to estimate the release fractions of various radionulcides at various times during separations plant operations. The release fractions are estimated using reported release rates and the estimated separations plant throughput.

The throughputs are calculated as described in Section 2.1. Because of limited availability to the author of information on radionuclide content as a function of fuel burnup, these should be considered to be order-of-magnitude estiamtes.

The release ratess are from several references. The earliest non-iodine value is from a document by Healy (1948, page 7). The series for ruthenium is based on REDOX quarterly reported values in Roberts (1958) and Ebright (1954). Various radionuclides were reported in the Hanford Site 1964 annual environmental monitoring report (Anderson 1965).

The release fractions are calculated as the published release rate divided by the estimated throughput, with annual and daily time units corrected.

ESTIMATION OF RELEASE FRACTIONS BASED ON VARIOUS REFERENCES

1. TOTAL THROUGHPUT FOR ALL SEPARATIONS PLANTS (CI/YEAR)

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm137	I 129	KR85	ZR/NB95	SR89	TOTAL NON-I-131
1945	8.00E+06	1.23E+06	8.72E+06	7.86E+03	4.00E+03	2.29E+06	9.40E+06	9.72E+03	3.59E+06	3.98E+06	1.07E-01	4.64E+04	1.82E+07	1.21E+07	5.04E+07
1946	2.10E+05	2.20E+06	1.14E+07	1.45E+04	1.60E+02	3.70E+04	1.68E+07	1.00E+04	6.05E+05	7.30E+06	1.98E-01	8.61E+04	2.73E+07	1.71E+07	7.53E+07
1947	2.81E+04	1.20E+06	4.64E+06	8.08E+03	2.00E+00	2.18E+03	9.04E+06	1.01E+04	3.71E+05	4.12E+06	2.11E-01	4.82E+04	1.29E+07	7.73E+06	3.05E+07
1948	4.40E+03	1.30E+06	3.83E+06	9.82E+03	1.52E-02	1.13E+02	1.03E+07	1.22E+04	4.40E+05	4.97E+06	1.34E-01	5.82E+04	1.20E+07	8.72E+06	3.53E+07
1949	6.73E+03	1.33E+06	4.00E+06	9.19E+03	4.70E-02	2.18E+02	9.94E+06	1.18E+04	4.27E+05	4.74E+06	1.27E-01	5.64E+04	1.21E+07	8.87E+06	3.52E+07
1950	1.72E+05	2.17E+06	7.94E+06	4.93E+04	7.99E+01	3.90E+04	1.51E+07	1.75E+04	6.58E+05	7.30E+06	2.00E-01	8.43E+04	1.89E+07	1.19E+07	5.06E+07
1951	3.50E+05	3.11E+06	1.28E+07	3.52E+06	2.72E+00	7.45E+04	2.10E+07	2.30E+04	9.02E+05	1.01E+06	2.74E-01	1.15E+06	2.91E+07	1.79E+07	6.94E+07
1952	9.77E+04	3.46E+06	1.03E+07	7.11E+06	6.64E-01	1.29E+04	2.31E+07	2.75E+04	1.04E+06	1.17E+06	3.10E-01	1.33E+06	2.71E+07	1.57E+07	6.27E+07
1953	1.03E+05	6.50E+06	2.28E+07	4.82E+05	5.94E-01	6.05E+03	5.70E+07	6.91E+04	2.01E+06	2.94E+06	7.98E-01	3.23E+06	6.33E+07	3.50E+07	1.94E+08
1954	2.05E+04	6.92E+06	1.40E+07	6.13E+04	9.94E-02	8.61E+02	4.66E+07	5.70E+04	2.18E+06	2.40E+06	6.60E-01	2.77E+06	4.30E+07	2.36E+07	1.39E+08
1955	5.1[illegible]E+03	1.31E+07	1.86E+07	9.80E+03	2.08E-02	6.14E+01	8.49E+07	1.16E+05	4.30E+06	4.01E+06	1.34E+00	5.52E+06	6.30E+07	3.12E+07	2.19E+08
1956	2.0[illegible]E+03	1.24E+07	1.55E+07	2.95E+03	8.71E-03	1.01E+01	8.02E+07	1.09E+05	4.12E+06	4.64E+06	1.27E+00	5.21E+06	5.99E+07	2.83E+07	2.07E+08
1957	1.00E+04	1.81E+07	2.52E+07	1.01E+04	4.19E-02	1.39E+02	1.06E+08	1.30E+05	5.24E+06	5.90E+06	1.61E+00	6.64E+06	8.04E+07	4.51E+07	2.92E+08
1958	3.00E+05	6.25E+07	2.34E+08	3.36E+05	1.70E+00	9.29E+03	2.00E+08	4.00E+05	1.04E+07	1.20E+07	3.70E+00	1.30E+06	5.10E+08	2.96E+08	1.42E+09
1959	2.37E+05	5.42E+07	1.62E+08	2.90E+05	6.20E-01	4.77E+03	2.40E+08	4.10E+05	8.21E+06	1.12E+07	3.37E+00	1.20E+06	4.00E+08	2.34E+08	1.15E+09
1960	9.41E+04	6.40E+07	1.81E+08	3.53E+05	4.00E-02	1.03E+03	2.93E+08	4.90E+05	1.19E+07	1.34E+07	4.03E+00	1.44E+06	4.43E+08	2.46E+08	1.25E+09
1961	6.40E+04	8.44E+07	1.86E+08	3.99E+05	1.81E-02	5.83E+02	2.94E+08	4.09E+05	1.12E+07	1.37E+07	4.10E+00	1.46E+06	4.21E+08	2.29E+08	1.20E+09
1962	3.00E+03	5.90E+07	9.05E+07	3.47E+05	1.82E-06	7.83E+00	2.69E+08	4.60E+05	1.00E+07	1.33E+07	4.01E+00	1.42E+06	3.02E+08	1.51E+08	9.04E+08
1963	2.24E+03	5.40E+07	7.90E+07	3.23E+05	5.59E-06	3.00E+00	2.40E+08	4.59E+05	1.02E+07	1.24E+07	3.75E+00	1.32E+06	2.59E+08	1.27E+08	7.90E+08
1964	6.00E+03	6.34E+07	9.07E+07	3.71E+05	3.30E-06	1.22E+01	2.86E+08	5.22E+05	1.17E+07	1.42E+07	4.30E+00	1.52E+06	3.13E+08	1.50E+08	9.45E+08
1965	1.60E+03	6.23E+07	8.62E+07	3.67E+05	2.10E-06	2.09E+00	2.79E+08	5.18E+05	1.18E+07	1.41E+07	4.20E+00	1.50E+06	2.09E+08	1.40E+08	8.85E+08
1966	1.37E+0[illegible]	3.30E+07	2.12E+07	2.18E+05	4.00E-11	1.01E-[illegible]	1.40E+08	3.09E+05	6.90E+06	8.41E+06	2.56E+00	8.82E+05	1.01E+08	4.21E+07	3.82E+08
1967	2.14E+[illegible]	3.47E+07	2.42E+07	2.19E+05	7.61E-11	3.19E-03	1.52E+08	3.12E+05	6.97E+06	8.50E+06	2.59E+00	9.02E+05	1.10E+08	4.60E+07	3.84E+08
1968	1.18E+[illegible]	3.12E+07	1.29E+07	2.07E+05	6.30E-14	3.00E-06	1.74E+08	2.09E+05	6.06E+06	8.11E+06	2.48E+00	8.57E+05	7.32E+07	2.84E+07	2.90E+08
1969	6.75E-02	2.07E+07	5.42E+06	1.44E+05	9.20E-17	5.00E-07	8.77E+07	2.10E+05	4.65E+06	5.00E+06	1.75E+00	5.99E+05	3.79E+07	1.34E+07	1.76E+08
1970	4.60E-13	4.62E+06	1.32E+04	4.98E+04	1.00E-43	7.07E-24	1.60E+07	6.04E+04	1.75E+06	2.14E+06	6.07E-01	2.10E+05	6.47E+06	1.01E+06	2.64E+07
1971	3.08E-12	1.44E+07	4.87E+04	1.53[illegible]	3.37E-42	9.05E-23	5.27E+07	2.40E+05	5.36E+06	6.55E+06	2.10E+00	6.60E+05	2.23E+06	5.50E+06	6.27E+07
1972	1.82E-11	4.92E+06	2.74E+04	4.97[illegible]	9.34E-40	2.11E-21	1.83E+07	7.91E+04	1.72E+06	2.11E+06	6.73E-01	2.10E+05	1.01E+06	1.70E+06	2.06E+07

2. REPORTED RELEASE RATES (CI/DAY)

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm137	I 129	KR85	ZR/NB95	SR89	TOTAL NON-I-131	REFERENCES
1948															0.4	HW-10758, P. 7 (REF IS FOR T PLANT, MULTIPLIED BY 2
1952		0.112329 (see notes)														HW-55569, P. 6
1953		0.964384 (see notes)														HW-55569, P. 6
1954		1.010959 (see notes)														HW-55569, P. 6
1955		0.021918														HW-55569, P. 6
1956		0.010959														HW-55569, P. 6
1957		0.019178														HW-55509, P. 8
1958	1.2	0.002	0.004						0.0006				0.004	0.0036	0.02	HW-61076, P. 5
1961	0.7	0.005	0.003				0.01						0.001			BNWL-90, P. 22
1962	0.36	0.0036	0.0009				0.015						0.0024			"
1963	0.19															" MINUS 80 CI FOR ACCIDENT
1964	0.22								0.002							"

3. CALCULATED RELEASE FRACTIONS

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm137	I 129	KR85	ZR/NB95	SR89	TOTAL NON-I-131
1948															4.14E-06
1952		1.19E-08													
1953		4.11E-06													
1954		9.55E-06													
1955		6.11E-07													
1956		3.23E-07													
1957		4.34E-07													
1958	1.15E-03	1.17E-08	6.23E-09						1.76E-08				2.86E-10	4.31E-09	5.15E-09
1961	3.99E-03	2.03E-08	6.60E-09				1.24E-08						4.34E-10		
1962	3.26E-02	2.20E-08	3.41E-09				2.04E-08						2.90E-10		
1963	3.00E-02														
1964	1.50E-02								6.24E-08						

NOTES ON QUARTERLY RUTHENIUM RELEASES FROM REDOX (EBRIGHT 1954)

Year	Quarter	
52	1	Failure of H-5 caustic scrubber 3/8/52. Building contamination est. 2 E-8 uc /cc.
	2	4/29/52 particle releases due to air sparging of Redox 1A column. 6/24/52: releases of entrained Ru particles on ammonium nitrate snow flakes first mentioned.
	3	9/52: glass wool frame samplers indicated a release of 0.5 Ci from Ru. The monthly average of 0.1 Ci/d was estimated.
	4	
53	1	
	2	
	3	8/14/53: More flakes several inches width and length and up to 3/4 inches thick. More seen on 8/18/53. Stack mon. ind. 35 Ci on 8/5 and 80 Ci on 8/6.
	4	
54	1	Jan 2 & 3, est. 260 Ci released. 1/5 est. 70 Ci. First caused by failure of H5 caustic scrubber. Last due to stack flushing attempt to get rid of ammonium nitrate flakes inside the stack. Failed to connect scrubber off-gas line to sand filter. 1/25 - 3/54 wide-spread Ru contamination.
	2	5/22/54 100-B area contaminated 80,000 c/m particles found. Found on Wahluke slope too.
	3	By 7/16/54 an additional caustic scrubber was installed and the scrubber of gas was connected to the sand filter. Ammonium nitrate formation reduced by scheduling changes which prohibited clad removal (which released ammonia to stack) and slug dissolving operations (which releases nitric oxide which combines with the ammonia to make ammonium nitrate) from being done at the same time. Also a paper strip air sampler added to stack monitoring system to measure particulate releases from stack.

APPENDIX B

CALCULATION OF ANNUAL RELEASE RATES AND EFFECTIVE DOSES FOR SELECTED RADIONUCLIDES

CALCULATION OF ANNUAL RELEASE RATES AND EFFECTIVE DOSES FOR SELECTED RADIONUCLIDES

This appendix presents the full spreadsheet calculation of cumulative effective dose equivalent to infants and adults. The spreadsheet contains sections dealing with radionuclide inventory, release fractions, dose factors, releases from T-Plant, B-Plant, REDOX, and PUREX, and the dose estimates.

CUMULATIVE SUMMARY OF EFFECTIVE DOSES

SUMMARY OF ANNUAL EFFECTIVE DOSES

THIS DOES NOT INCLUDE "LARGE" HOT PARTICLES OR RUTHENIUM SNOW

1. FUEL REPROCESSED AT HANFORD (FROM PRELIMINARY SOURCE TERM SPREADSHEET)

Summation of Reprocessing Plant Operations from HW-89085

	T Plant			B Plant			REDOX			PUREX		Hanford
Year	Tons N	MWD/ton	Days	Tons N	MWD/ton	Days	Tons N	Tons E	Total Tns	Days	Tons	Days	Total Tons
1945	325	159	43	302	189	42			0	0	0	0	627
1946	291	241	73	873	202	59			0	0	0	0	1164
1947	306	203	78	345	203	78			0	0	0	0	651
1948	388	203	102	398	210	101			0	0	0	0	786
1949	393	264	95	356	282	99			0	0	0	0	749
1950	424	401	89	460	398	90			0	0	0	0	884
1951	560	482	55	508	494	55			0	0	0	0	1068
1952	295	594	65	118	580	58	822	0	822	82	0	0	1235
1953	246	503	73	0		0	2851	0	2851	82	0	0	3097
1954	1011	302	92	0		0	1579	0	1579	104	0	0	2590
1955	1266	236	108	0		0	3928	0	3928	137	0	0	5192
1956	45	260	190	0		0	2335	0	2335	128	2520	130	4901
1957	0		0	0		0	1829	0	1829	116	4397	116	6226
1958	0		0	0		0	1318	65	1383	128	5260	100	6643
1959	0		0	0		0	248	675	923	205	4988	104	5911
1960	0		0	0		0	275	546	821	189	6244	118	7065
1961	0		0	0		0	0	1253	1253	187	5947	122	7200
1962	0		0	0		0	0	972	972	188	6040	154	7013
1963	0		0	0		0	0	1150	1150	209	5414	159	6564
1964	0		0	0		0	0	1768	1768	211	5759	151	7527
1965	0		0	0		0	0	1668	1668	182	5781	164	7449
1966	0		0	0		0	37	1315	1352	208	3109	223	4461
1967	0		0	0		0			0	0	4505	211	4505
1968	0		0	0		0			0	0	4308	244	4308
1969	0		0	0		0			0	0	3025	273	3025
1970	0		0	0		0			0	0	1160	560	1160
1971	0		0	0		0			0	0	3550	549	3550
1972	0		0	0		0			0	0	1141	516	1141
Totals	5550			3360			15220	9412	24632		73148		106690
											Check Sum		106690

Notes: Cooling times are non-mass-weighted monthly averages.
Burnup is supplied where available. These are non-mass-weighted monthly averages.

CUMULATIVE SUMMARY OF EFFECTIVE DOSES

2. APPROXIMATE ANNUAL DOSE FACTORS (REM/CI RELEASED)

NUCLIDE	LAMDA R (1/DAY)	INFANT 1945 dose	ADULT 1945 dose	CI release in 1945	INFANT DFs	Adult DFs
I 131	0.086	1.66E+01	1.59E+00	555089	2.99E-05	2.86E-06
RU/RH106	0.00188	1.90E-05	2.03E-05	12	1.57E-06	1.68E-06
RU/RH103	0.0176	1.21E-05	1.03E-05	85	1.43E-07	1.21E-07
CO60	0.000361	0.00E+00	1.26E-07	0.08	0.00E+00	1.63E-06
Te/I 132	7.23	1.50E-04	9.24E-05	5188.55	2.89E-08	1.78E-08
XE133	0.132	1.94E-05	1.94E-05	254835	7.60E-11	7.60E-11
CE/PR144	0.00244	1.18E-04	1.21E-04	93	1.27E-06	1.30E-06
PU239	7.87E-08	2.45E-05	1.68E-04	0.10	2.56E-04	1.75E-03
SR/Y90	6.66E-05	1.39E-04	7.97E-04	4	3.93E-05	2.25E-04
CS/BAm13	6.3E-05	9.31E-06	8.35E-06	4	2.37E-06	2.13E-06
I 129	1.21E-10	1.28E-05	7.70E-06	9E-02	1.36E-04	8.15E-05
KR85	0.000177	2.20E-07	2.20E-07	45668	4.81E-12	4.81E-12
ZR/NB95	0.0108	8.52E-05	7.70E-05	178	4.79E-07	4.33E-07
SR89	0.0137	0.00E+00	1.13E-04	118	0.00E+00	9.55E-07

COLUMN VALUES

INFANT	2.99E-05	2.86E-06	2.99E-05	1.57E-06	1.43E-07	1.63E-06	2.89E-08	7.60E-11
ADULT	1.57E-06	1.68E-06	2.86E-06	1.68E-06	1.21E-07	1.63E-06	1.78E-08	7.60E-11
	1.43E-07	1.21E-07						
	0.00E+00	1.63E-06						
	2.89E-08	1.78E-08						
	7.60E-11	7.60E-11						
	1.27E-06	1.30E-06						
	2.56E-04	1.75E-03						
	3.93E-05	2.25E-04						
	2.37E-06	2.13E-06						
	1.36E-04	8.15E-05						
	4.81E-12	4.81E-12						
	4.79E-07	4.33E-07						
	0.00E+00	9.55E-07						

COLUMNS TRANSPOSED

(ADULT VALUES USED FOR INFANTS FOR CO60 AND SR89)

Notes: Derived from individual radionuclide monthly dose calculation worksheets, SUMMARIZED IN SUM-PATH.WQ1

3. FUEL CONTENTS OF RADIONUCLIDES

TAKEN FROM ORIGEN2 RUNS BY C. HEEB AND U.JENQUIN

NUCLIDE	LAMDA R (1/DAY)	200 MWD/T, 1 MW/T use 1945-1949 30 DAYS	50 DAYS	300MWD/T, 1 MW/T use 1950-1957 60 DAYS	100 DAYS	600 MWD/T, 10MW/T use 1958... 110 DAYS	190 DAYS
I 131	0.086	1984	354	150	4.78	21	0.0212
RU/RH106	0.00188	2011	1937	2880	2670	9330	8020
RU/RH103	0.0176	17310	12160	10800	5330	32100	7820
CO60	0.000361	12.6	12.5	1818.1	17.8	50.3	48.9
Te/I 132	7.23	65	0.9	0.0011	2.22E-05	2.74E-05	1.11E-12
XE133	0.132	1328	95	25.2	0.127	0.327	8.39E-06
CE/PR144	0.00244	15600	14860	19400	17600	43100	35500
PU239	7.87E-08	15.5	15.5	22.3	22.3	69.3	69.3
SR/Y90	6.66E-05	573	572	844	842	1560	1550
CS/BAm13	6.3E-05	636	635	950	948	1900	1890
I 129	1.21E-10	0.00017	0.00017	0.000257	0.000256	0.000569	0.000573
KR85	0.000177	74	74	106	107	204	201
ZR/NB95	0.0108	33240	28770	25800	16800	72700	30600
SR89	0.0137	22910	17410	15600	6990	41600	13900

4. RELEASE FRACTIONS

Assumptions of installation of sand filters and silver reactors

	1945-49	1950-72 (Except REDOX)		1951 silver reactor failure REDOX T 1955	REDOX
NOBLE GASES	1	1	1	1	1
IODINES	0.9	0.01	0.1	0.01	0.01
RUTHENIUMS	1E-05	1E-07	1E-07	0.0001	1E-05
ALL OTHERS	1E-05	1E-07	1E-07	1E-07	1E-07

10% USED FOR 1951 IODINE BECAUSE OF SILVER REACTOR FAILURES
1% USED FOR SILVER REACTORS BECAUSE OF PUREX EIS, 1964 MONITORING RPT
1E-5 USED FOR PARTICULATES EARLY YEARS BECAUSE OF MONITORING DATA
1E-5 USED FOR REDOX RU MOST OF TIME, 1E-4 STARTUP TO 1955

PEAKING FACTORS FOR SHORT-LIVED RADIONUCLIDES

1.4 (FROM OTHER SPREAD SHEETS)

1

CUMULATIVE SUMMARY OF EFFECTIVE DOSES

5. RELEASE ESTIMATES, NUCLIDE BY YEAR

A. T-PLANT

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89
1945	2.61E+05	6.38E+00	4.46E+01	4.07E-02	1.59E+03	1.06E+05	4.91E+01	5.04E-02	1.86E+00	2.06E+00	4.97E-02	2.41E+04	9.37E+01	6.21E+01
1946	1.61E+04	5.40E+00	2.36E+01	3.60E-02	2.49E+00	1.91E+03	4.09E+01	4.51E-02	1.66E+00	1.84E+00	4.45E-02	2.15E+04	6.08E+01	3.70E+01
1947	1.24E+04	5.63E+00	2.28E+01	3.78E-02	6.99E-01	1.04E+03	4.25E+01	4.74E-02	1.75E+00	1.94E+00	4.68E-02	2.26E+04	6.06E+01	3.64E+01
1948	1.89E+03	6.61E+00	1.87E+01	4.75E-02	5.92E-03	5.14E+01	5.08E+01	6.01E-02	2.21E+00	2.45E+00	5.94E-02	2.87E+04	5.89E+01	3.29E+01
1949	3.68E+03	7.00E+00	2.17E+01	4.63E-02	3.04E-02	1.41E+02	5.24E+01	6.09E-02	2.24E+00	2.49E+00	6.01E-02	2.91E+04	6.48E+01	3.70E+01
1950	1.65E+03	9.19E-02	4.99E-01	2.17E-03	7.99E-01	3.87E+04	6.80E-01	7.29E-04	2.71E-02	3.02E-02	8.10E-04	3.49E+04	1.12E+00	7.16E-01
1951	1.89E+04	1.63E-01	6.66E-01	1.92E-01	1.47E-01	4.09E+04	1.10E+00	1.25E-03	4.73E-02	5.32E-02	1.44E-02	6.06E+04	1.53E+00	9.42E-01
1952	4.14E+02	8.42E-02	2.93E-01	3.13E-02	2.68E-03	5.61E+03	5.66E-01	6.58E-04	2.49E-02	2.80E-02	7.58E-04	3.18E+04	7.24E-01	4.32E-01
1953	1.64E+02	6.91E-02	2.10E-01	9.57E-03	1.03E-03	1.49E+03	4.82E-01	5.49E-04	2.07E-02	2.34E-02	6.33E-04	2.65E+04	5.50E-01	3.19E-01
1954	1.32E+02	2.74E-01	6.18E-01	4.41E-03	6.69E-04	5.01E+02	1.81E+00	2.25E-03	8.52E-02	9.59E-02	2.61E-03	1.08E+05	1.85E+00	1.01E+00
1955	4.19E+01	3.33E-01	5.84E-01	8.76E-04	1.77E-04	7.64E+01	2.18E+00	2.82E-03	1.07E-01	1.20E-01	3.27E-03	1.35E+05	1.95E+00	1.02E+00
1956	1.29E-03	1.01E-02	4.90E-03	2.42E-09	2.15E-09	5.41E-05	6.36E-02	1.00E-04	3.77E-03	4.25E-03	1.17E-04	4.72E+03	2.66E-02	1.17E-02
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CUMULATIVE SUMMARY OF EFFECTIVE DOSES

B. B-PLANT

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89
1945	2.79E+05	5.94E+00	4.26E+01	3.79E-02	2.09E+03	1.22E+05	4.58E+01	4.68E-02	1.73E+00	1.92E+00	4.62E-02	2.23E+04	8.86E+01	5.90E+01
1946	1.78E+05	1.66E+01	9.04E+01	1.09E-01	1.42E+02	3.50E+04	1.27E+02	1.35E-01	4.99E+00	5.54E+00	1.34E-01	6.46E+04	2.12E+02	1.34E+02
1947	1.38E+04	6.34E+00	2.56E+01	4.26E-02	9.78E-01	1.14E+03	4.79E+01	5.35E-02	1.97E+00	2.19E+00	5.28E-02	2.55E+04	6.82E+01	4.09E+01
1948	2.14E+03	7.00E+00	1.96E+01	4.87E-02	7.79E-03	6.14E+01	5.22E+01	6.17E-02	2.27E+00	2.52E+00	6.09E-02	2.95E+04	6.12E+01	3.43E+01
1949	2.38E+03	6.29E+00	1.83E+01	4.36E-02	1.19E-02	7.64E+01	4.70E+01	5.52E-02	2.03E+00	2.25E+00	5.45E-02	2.63E+04	5.62E+01	3.17E+01
1950	7.61E+01	1.25E-01	2.95E-01	2.76E-03	3.98E-04	3.28E+02	8.31E-01	1.03E-03	3.88E-02	4.36E-02	1.19E-03	4.93E+04	8.65E-01	4.78E-01
1951	1.61E+04	1.48E-01	5.97E-01	1.60E-01	1.24E-01	3.38E+04	9.97E-01	1.13E-03	4.29E-02	4.83E-02	1.30E-02	5.49E+04	1.38E+00	8.46E-01
1952	3.03E+02	3.41E-02	1.33E-01	2.81E-02	2.28E-03	5.67E+03	2.30E-01	2.63E-04	9.96E-03	1.12E-02	3.03E-04	1.28E+04	3.12E-01	1.90E-01
1953	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1954	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1955	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1956	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CUMULATIVE SUMMARY OF EFFECTIVE DOSES

C. REDOX

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89
1945	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	2.59E+02	2.27E+02	6.02E+02	1.17E-02	1.48E-03	1.58E+03	1.51E+00	1.83E-03	6.93E-02	7.80E-02	2.12E-03	8.83E+04	1.68E+00	9.47E-01
1953	8.65E+02	7.87E+02	2.07E+03	3.86E-02	4.91E-03	5.16E+03	5.24E+00	6.36E-03	2.40E-01	2.70E-01	7.34E-03	3.06E+05	5.78E+00	3.26E+00
1954	7.33E+01	4.16E+02	7.81E+02	1.72E-03	3.24E-04	1.60E+02	2.75E+00	3.52E-03	1.33E-01	1.50E-01	4.08E-03	1.69E+05	2.54E+00	1.34E+00
1955	1.05E+01	9.76E+02	1.08E+03	9.22E-05	3.17E-05	4.95E+00	6.31E+00	8.75E-03	3.30E-01	3.71E-01	1.02E-02	4.16E+05	4.42E+00	2.11E+00
1956	1.39E+01	5.91E+01	7.58E+01	1.61E-04	4.69E-05	1.01E+01	3.84E+00	5.21E-03	1.96E-01	2.21E-01	6.04E-03	2.46E+05	2.90E+00	1.43E+00
1957	3.06E+01	4.74E+01	7.34E+01	5.07E-04	1.16E-04	3.87E+01	3.09E+00	4.08E-03	1.54E-01	1.73E-01	4.72E-03	1.95E+05	2.59E+00	1.32E+00
1958	8.61E+01	1.25E+02	3.23E+02	6.91E-03	1.15E-05	5.87E+01	5.71E+00	9.59E-03	2.15E-01	2.62E-01	7.88E-03	2.81E+05	3.28E+00	4.50E+00
1959	7.36E-02	7.19E+01	5.52E+01	4.49E-03	5.59E-13	1.45E-03	3.16E+00	6.40E-03	1.43E-01	1.74E-01	5.30E-03	1.85E+05	2.40E+00	1.04E+00
1960	2.73E-01	6.60E+01	6.57E+01	4.02E-03	1.69E-11	1.15E-02	2.92E+00	5.69E-03	1.27E-01	1.55E-01	4.70E-03	1.65E+05	2.55E+00	1.16E+00
1961	5.03E-01	1.01E+02	1.04E+02	6.13E-03	4.10E-11	2.34E-02	4.48E+00	8.68E-03	1.94E-01	2.37E-01	7.17E-03	2.52E+05	3.98E+00	1.83E+00
1962	3.58E-01	7.84E+01	7.95E+01	4.76E-03	2.57E-11	1.59E-02	3.47E+00	6.74E-03	1.51E-01	1.84E-01	5.57E-03	1.96E+05	3.06E+00	1.40E+00
1963	6.44E-02	8.89E+01	6.39E+01	5.59E-03	2.92E-13	1.05E-03	3.90E+00	7.97E-03	1.78E-01	2.17E-01	6.60E-03	2.30E+05	2.86E+00	1.23E+00
1964	8.64E-02	1.36E+02	9.56E+01	8.58E-03	3.21E-13	1.31E-03	5.97E+00	1.23E-02	2.74E-01	3.34E-01	1.01E-02	3.54E+05	4.31E+00	1.85E+00
1965	9.95E-01	1.36E+02	1.50E+02	8.18E-03	1.45E-10	5.71E-02	6.04E+00	1.16E-02	2.59E-01	3.15E-01	9.55E-03	3.36E+05	5.57E+00	2.59E+00
1966	8.42E-02	1.05E+02	7.68E+01	6.57E-03	4.47E-13	1.45E-03	4.59E+00	9.37E-03	2.09E-01	2.55E-01	7.76E-03	2.71E+05	3.40E+00	1.47E+00
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CUMULATIVE SUMMARY OF EFFECTIVE DOSES

D. PUREX

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89
1945	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1953	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1954	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1955	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1956	1.23E+01	6.35E-01	7.85E-01	1.33E-04	4.03E-05	8.02E+00	4.12E+00	5.62E-03	2.12E-01	2.39E-01	6.52E-03	2.68E+05	3.06E+00	1.49E+00
1957	7.74E+01	1.14E+00	1.78E+00	1.30E-03	3.01E-04	1.01E+02	7.45E+00	9.81E-03	3.70E-01	4.17E-01	1.14E-02	4.69E+05	6.26E+00	3.19E+00
1958	3.72E+03	5.00E+00	2.02E+01	2.66E-02	1.76E-02	9.23E+03	2.32E+01	3.65E-02	8.21E-01	1.00E+00	2.99E-02	1.08E+06	4.27E+01	2.52E+01
1959	2.37E+03	4.70E+00	1.77E+01	2.51E-02	6.28E-03	4.77E+03	2.18E+01	3.46E-02	7.78E-01	9.48E-01	2.84E-02	1.02E+06	3.65E+01	2.24E+01
1960	9.41E+02	5.74E+00	1.75E+01	3.13E-02	4.60E-04	1.03E+03	2.64E+01	4.33E-02	9.73E-01	1.19E+00	3.56E-02	1.27E+06	4.17E+01	2.34E+01
1961	6.39E+02	5.43E+00	1.55E+01	2.98E-02	1.91E-04	5.83E+02	2.49E+01	4.12E-02	9.27E-01	1.13E+00	3.39E-02	1.21E+06	3.81E+01	2.11E+01
1962	3.86E+01	5.18E+00	8.85E+00	2.99E-02	1.82E-07	7.81E+00	2.34E+01	4.19E-02	9.39E-01	1.14E+00	3.45E-02	1.22E+06	2.72E+01	1.37E+01
1963	2.24E+01	4.60E+00	7.28E+00	2.68E-02	5.59E-08	3.60E+00	2.07E+01	3.75E-02	8.41E-01	1.03E+00	3.09E-02	1.09E+06	2.31E+01	1.14E+01
1964	5.08E+01	4.98E+00	9.02E+00	2.86E-02	3.86E-07	1.22E+01	2.25E+01	3.99E-02	8.96E-01	1.09E+00	3.29E-02	1.17E+06	2.70E+01	1.37E+01
1965	1.58E+01	4.87E+00	7.12E+00	2.85E-02	2.14E-08	2.03E+00	2.18E+01	4.01E-02	8.98E-01	1.09E+00	3.30E-02	1.17E+06	2.34E+01	1.14E+01
1966	5.32E-02	2.34E+00	1.36E+00	1.50E-02	4.24E-14	4.61E-04	1.02E+01	2.15E-02	4.81E-01	5.86E-01	1.79E-02	6.21E+05	6.65E+00	2.75E+00
1967	2.14E-01	3.47E+00	2.42E+00	2.19E-02	7.61E-13	3.19E-03	1.52E+01	3.12E-02	6.97E-01	8.50E-01	2.59E-02	9.02E+05	1.10E+01	4.68E+00
1968	1.16E-02	3.12E+00	1.29E+00	2.07E-02	6.38E-16	3.86E-05	1.34E+01	2.99E-02	6.65E-01	8.11E-01	2.48E-02	8.57E+05	7.32E+00	2.84E+00
1969	6.75E-04	2.07E+00	5.42E-01	1.44E-02	9.20E-19	5.80E-07	8.77E+00	2.10E-02	4.66E-01	5.69E-01	1.75E-02	5.99E+05	3.75E+00	1.34E+00
1970	4.68E-15	4.62E-01	1.32E-03	4.98E-03	1.09E-45	7.67E-24	1.68E+00	8.04E-03	1.75E-01	2.14E-01	6.87E-03	2.18E+05	6.47E-02	1.01E-02
1971	3.65E-14	1.44E+00	4.67E-03	1.53E-02	3.37E-44	9.85E-23	5.27E+00	2.48E-02	5.35E-01	6.55E-01	2.10E-02	6.68E+05	2.23E-01	3.58E-02
1972	1.82E-13	4.92E-01	2.74E-03	4.97E-03	9.34E-42	2.11E-21	1.83E+00	7.91E-03	1.72E-01	2.11E-01	6.73E-03	2.16E+05	1.01E-01	1.78E-02

CUMULATIVE SUMMARY OF EFFECTIVE DOSES

6. TOTAL RELEASES FROM ALL SEPARATIONS PLANTS

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89
1945	5.40E+05	1.23E+01	8.72E+01	7.86E-02	3.68E+03	2.29E+05	9.49E+01	9.72E-02	3.59E+00	3.98E+00	9.59E-02	4.64E+04	1.82E+02	1.21E+02
1946	1.96E+05	2.20E+01	1.14E+02	1.45E-01	1.44E+02	3.70E+04	1.68E+02	1.80E-01	6.65E+00	7.38E+00	1.78E-01	8.61E+04	2.73E+02	1.71E+02
1947	2.62E+04	1.20E+01	4.84E+01	8.05E-02	1.88E+00	2.18E+03	9.04E+01	1.01E-01	3.71E+00	4.12E+00	9.96E-02	4.82E+04	1.29E+02	7.73E+01
1948	4.03E+03	1.38E+01	3.83E+01	9.62E-02	1.37E-02	1.13E+02	1.03E+02	1.22E-01	4.48E+00	4.97E+00	1.20E-01	5.82E+04	1.20E+02	6.72E+01
1949	6.06E+03	1.33E+01	4.00E+01	9.19E-02	4.23E-02	2.18E+02	9.94E+01	1.16E-01	4.27E+00	4.74E+00	1.15E-01	5.54E+04	1.21E+02	6.87E+01
1950	1.72E+03	2.17E-01	7.94E-01	4.93E-03	7.99E-01	3.90E+04	1.51E+00	1.75E-03	6.58E-02	7.38E-02	2.00E-03	8.43E+04	1.99E+00	1.19E+00
1951	3.50E+04	3.11E-01	1.26E+00	3.52E-01	2.72E-01	7.45E+04	2.10E+00	2.38E-03	9.02E-02	1.01E-01	2.74E-02	1.15E+05	2.91E+00	1.79E+00
1952	9.77E+02	2.27E+02	6.03E+02	7.11E-02	6.64E-03	1.29E+04	2.31E+00	2.75E-03	1.04E-01	1.17E-01	3.18E-03	1.33E+05	2.71E+00	1.57E+00
1953	1.03E+03	7.67E+02	2.07E+03	4.82E-02	5.94E-03	6.65E+03	5.70E+00	6.91E-03	2.61E-01	2.94E-01	7.98E-03	3.33E+05	6.33E+00	3.58E+00
1954	2.05E+02	4.19E+02	7.62E+02	6.13E-03	9.94E-04	6.61E+02	4.56E+00	5.78E-03	2.16E-01	2.46E-01	6.68E-03	2.77E+05	4.38E+00	2.35E+00
1955	5.24E+01	9.77E+02	1.08E+03	9.69E-04	2.09E-04	6.14E+01	6.49E+00	1.16E-02	4.36E-01	4.91E-01	1.34E-02	5.52E+05	6.36E+00	3.12E+00
1956	2.62E+01	5.98E+01	7.66E+01	2.95E-04	8.71E-05	1.81E+01	8.02E+00	1.09E-02	4.12E-01	4.64E-01	1.27E-02	5.21E+05	5.99E+00	2.93E+00
1957	1.08E+02	4.85E+01	7.52E+01	1.81E-03	4.19E-04	1.39E+02	1.05E+01	1.39E-02	5.24E-01	5.90E-01	1.61E-02	6.64E+05	6.84E+00	4.51E+00
1958	3.80E+03	1.30E+02	3.43E+02	3.35E-02	1.78E-02	9.29E+03	2.69E+01	4.60E-02	1.04E+00	1.26E+00	3.78E-02	1.36E+06	5.10E+01	2.96E+01
1959	2.37E+03	7.66E+01	7.28E+01	2.96E-02	6.28E-03	4.77E+03	2.49E+01	4.10E-02	9.21E-01	1.12E+00	3.37E-02	1.20E+06	4.09E+01	2.34E+01
1960	9.41E+02	7.17E+01	8.32E+01	3.53E-02	4.60E-04	1.03E+03	2.93E+01	4.90E-02	1.10E+00	1.34E+00	4.03E-02	1.44E+06	4.43E+01	2.45E+01
1961	6.40E+02	1.07E+02	1.20E+02	3.59E-02	1.91E-04	5.83E+02	2.94E+01	4.99E-02	1.12E+00	1.37E+00	4.10E-02	1.46E+06	4.21E+01	2.29E+01
1962	3.89E+01	8.35E+01	8.83E+01	3.47E-02	1.82E-07	7.83E+00	2.68E+01	4.86E-02	1.09E+00	1.33E+00	4.01E-02	1.42E+06	3.82E+01	1.51E+01
1963	2.24E+01	9.35E+01	7.12E+01	3.23E-02	5.59E-08	3.60E+00	2.46E+01	4.55E-02	1.02E+00	1.24E+00	3.75E-02	1.32E+06	2.59E+01	1.27E+01
1964	5.09E+01	1.41E+02	1.05E+02	3.71E-02	3.86E-07	1.22E+01	2.65E+01	5.22E-02	1.17E+00	1.43E+00	4.30E-02	1.52E+06	3.13E+01	1.56E+01
1965	1.68E+01	1.41E+02	1.58E+02	3.67E-02	2.16E-06	2.09E+00	2.79E+01	5.16E-02	1.16E+00	1.41E+00	4.26E-02	1.50E+06	2.89E+01	1.40E+01
1966	1.37E-01	1.07E+02	7.82E+01	2.16E-02	4.89E-13	1.91E-03	1.48E+01	3.09E-02	6.90E-01	8.41E-01	2.56E-02	8.92E+05	1.01E+01	4.21E+00
1967	2.14E-01	3.47E+00	2.42E+00	2.19E-02	7.61E-13	3.19E-03	1.52E+01	3.12E-02	6.97E-01	8.50E-01	2.59E-02	9.02E+05	1.10E+01	4.68E+00
1968	1.18E-02	3.12E+00	1.29E+00	2.07E-02	6.38E-16	3.86E-05	1.34E+01	2.99E-02	6.65E-01	8.11E-01	2.46E-02	8.57E+05	7.32E+00	2.84E+00
1969	6.75E-04	2.07E+00	5.42E-01	1.44E-02	9.20E-19	5.80E-07	8.77E+00	2.10E-02	4.66E-01	5.69E-01	1.75E-02	5.99E+05	3.75E+00	1.34E+00
1970	4.68E-15	4.62E-01	1.32E-03	4.98E-03	1.09E-45	7.67E-24	1.68E+00	8.04E-03	1.75E-01	2.14E-01	6.87E-03	2.18E+05	6.47E-02	1.01E-02
1971	3.65E-14	1.44E+00	4.67E-03	1.53E-02	3.37E-44	9.85E-23	5.27E+00	2.46E-02	5.35E-01	6.55E-01	2.10E-02	6.68E+05	2.23E-01	3.58E-02
1972	1.82E-13	4.92E-01	2.74E-03	4.97E-03	9.34E-42	2.11E-21	1.83E+00	7.91E-03	1.72E-01	2.11E-01	6.73E-03	2.16E+05	1.01E-01	1.78E-02
SUMS	8.19E+05	3.55E+03	6.14E+03	1.36E+00	3.82E+03	4.18E+05	8.80E+02	1.21E+00	3.68E+01	4.22E+01	1.14E+00	1.85E+07	1.19E+03	6.98E+02

CUMULATIVE SUMMARY OF EFFECTIVE DOSES

7. INFANT DOSES

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89	
1945	1.62E+01	1.93E-05	1.24E-05	1.28E-07	1.06E-04	1.74E-05	1.20E-04	2.49E-05	1.41E-04	9.46E-06	1.30E-05	2.23E-07	8.73E-05	1.16E-04	
1946	5.87E+00	3.46E-05	1.63E-05	2.36E-07	4.17E-06	2.81E-06	2.12E-04	4.62E-05	2.61E-04	1.75E-05	2.41E-05	4.14E-07	1.31E-04	1.64E-04	
1947	7.83E-01	1.88E-05	6.89E-06	1.31E-07	5.43E-08	1.66E-07	1.14E-04	2.58E-05	1.46E-04	9.79E-06	1.35E-05	2.32E-07	6.17E-05	7.38E-05	
1948	1.21E-01	2.17E-05	5.46E-06	1.57E-07	3.96E-10	8.57E-09	1.30E-04	3.12E-05	1.76E-04	1.18E-05	1.63E-05	2.80E-07	5.75E-05	6.42E-05	
1949	1.81E-01	2.09E-05	5.70E-06	1.50E-07	1.22E-09	1.66E-08	1.26E-04	2.97E-05	1.68E-04	1.12E-05	1.55E-05	2.67E-07	5.79E-05	6.56E-05	
1950	5.15E-02	3.41E-07	1.13E-07	8.04E-09	2.31E-08	2.97E-06	1.91E-06	4.49E-07	2.58E-06	1.75E-07	2.70E-07	4.05E-07	9.52E-07	1.14E-06	
1951	1.05E+00	4.87E-07	1.80E-07	5.74E-07	7.86E-09	5.66E-06	2.65E-06	6.09E-07	3.54E-06	2.41E-07	3.72E-06	5.55E-07	1.39E-06	1.71E-06	
1952	2.92E-02	3.57E-04	8.59E-05	1.16E-07	1.92E-10	9.77E-07	2.92E-06	7.05E-07	4.09E-06	2.78E-07	4.31E-07	6.39E-07	1.30E-06	1.50E-06	
1953	3.06E-02	1.23E-03	2.95E-04	7.85E-06	1.72E-10	5.05E-07	7.21E-06	1.77E-06	1.02E-05	6.97E-07	1.08E-06	1.60E-06	3.03E-06	3.42E-06	
1954	6.14E-03	6.57E-04	1.11E-04	9.99E-09	2.87E-11	5.02E-08	5.78E-06	1.48E-06	8.56E-06	5.83E-07	9.06E-07	1.33E-06	2.10E-06	2.24E-06	
1955	1.57E-03	1.53E-03	1.54E-04	1.58E-09	6.04E-12	6.18E-09	1.07E-05	2.96E-06	1.71E-05	1.17E-06	1.82E-06	2.65E-06	3.05E-06	2.96E-06	
1956	7.83E-04	9.38E-05	1.09E-05	4.80E-10	2.52E-12	1.38E-09	1.01E-05	2.80E-06	1.62E-05	1.10E-06	1.72E-06	2.50E-06	2.87E-06	2.80E-06	
1957	3.23E-03	7.81E-05	1.07E-05	2.95E-09	1.21E-11	1.06E-08	1.33E-05	3.55E-06	2.06E-05	1.40E-06	2.18E-06	3.19E-06	4.23E-06	4.31E-06	
1958	1.14E-01	2.04E-04	4.90E-05	5.45E-06	5.08E-10	7.06E-07	3.66E-05	1.18E-05	4.07E-05	3.00E-06	5.12E-06	6.52E-06	2.44E-05	2.63E-05	
1959	7.10E-02	1.20E-04	1.04E-05	4.83E-06	1.81E-10	3.63E-07	3.16E-05	1.05E-05	3.62E-05	2.66E-06	4.56E-06	5.79E-06	1.96E-05	2.24E-05	
1960	2.81E-02	1.13E-04	1.19E-05	5.76E-06	1.33E-11	7.80E-08	3.71E-05	1.25E-05	4.32E-05	3.18E-06	5.45E-06	6.91E-06	2.12E-05	2.34E-05	
1961	1.91E-02	1.67E-04	1.71E-05	5.86E-06	5.51E-12	4.43E-08	3.72E-05	1.28E-05	4.40E-05	3.24E-06	5.56E-06	7.03E-06	2.02E-05	2.19E-05	
1962	1.16E-03	1.31E-04	1.26E-05	5.65E-06	5.27E-15	5.95E-10	3.40E-05	1.24E-05	4.28E-05	3.15E-06	5.43E-06	6.82E-06	1.45E-05	1.44E-05	
1963	6.71E-04	1.47E-04	1.02E-05	5.27E-06	1.62E-15	2.74E-10	3.11E-05	1.16E-05	4.00E-05	2.95E-06	5.09E-06	6.37E-06	1.24E-05	1.21E-05	
1964	1.52E-03	2.22E-04	1.49E-05	6.05E-06	1.12E-14	9.29E-10	3.60E-05	1.33E-05	4.59E-05	3.38E-06	5.83E-06	7.31E-06	1.50E-05	1.49E-05	
1965	5.01E-04	2.21E-04	2.25E-05	5.98E-06	6.23E-16	1.59E-10	3.53E-05	1.32E-05	4.54E-05	3.35E-06	5.77E-06	7.23E-06	1.39E-05	1.34E-05	
1966	4.11E-06	1.66E-04	1.11E-05	3.52E-06	1.41E-20	1.45E-13	1.67E-05	7.91E-06	2.71E-05	2.00E-06	3.47E-06	4.29E-06	4.81E-06	4.02E-06	
1967	6.40E-06	5.44E-06	3.45E-07	3.56E-06	2.20E-20	2.43E-13	1.92E-05	7.99E-06	2.74E-05	2.02E-06	3.50E-06	4.34E-06	5.24E-06	4.47E-06	
1968	3.53E-07	4.89E-06	1.84E-07	3.37E-06	1.85E-23	2.93E-15	1.70E-05	7.64E-06	2.61E-05	1.93E-06	3.36E-06	4.12E-06	3.51E-06	2.72E-06	
1969	2.02E-06	3.25E-06	7.74E-06	2.34E-06	2.66E-26	4.41E-17	1.11E-05	5.36E-06	1.83E-05	1.35E-06	2.37E-06	2.88E-06	1.80E-06	1.28E-06	
1970	1.40E-19	7.25E-07	1.88E-10	6.12E-09	3.16E-53	5.83E-34	2.12E-06	2.06E-06	6.85E-06	5.08E-07	9.31E-07	1.05E-06	3.10E-06	9.64E-09	
1971	1.09E-18	2.26E-06	6.95E-10	2.49E-06	9.73E-52	7.46E-33	6.67E-06	6.30E-06	2.10E-05	1.56E-06	2.84E-06	3.21E-06	1.07E-07	3.42E-06	
1972	5.43E-18	7.72E-07	3.91E-10	8.10E-09	2.70E-49	1.60E-31	2.32E-06	2.02E-06	6.76E-06	5.01E-07	9.12E-07	1.04E-06	4.83E-06	1.70E-06	
SUMS	24.51	5.58E-03	8.76E-04	2.21E-06	1.11E-04	3.17E-05	1.11E-03	3.10E-04	1.45E-03	1.00E-04	1.55E-04	8.92E-05	5.70E-04	6.86E-04	24.51774

CUMULATIVE SUMMARY OF EFFECTIVE DOSES

8. ADULT DOSES

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89	
1945	1.55E+00	2.07E-05	1.06E-05	1.28E-07	6.55E-05	1.74E-05	1.23E-04	1.70E-04	6.09E-04	6.46E-06	7.82E-06	2.23E-07	7.89E-05	1.16E-04	
1946	5.62E-01	3.69E-05	1.38E-05	2.36E-07	2.57E-06	2.81E-06	2.18E-04	3.16E-04	1.50E-03	1.57E-05	1.45E-05	4.14E-07	1.18E-04	1.64E-04	
1947	7.50E-02	2.01E-05	5.87E-06	1.31E-07	3.34E-06	1.66E-07	1.17E-04	1.77E-04	8.38E-04	8.78E-06	8.12E-06	2.32E-07	5.57E-05	7.38E-05	
1948	1.16E-02	2.32E-05	4.65E-06	1.57E-07	2.44E-10	8.57E-09	1.34E-04	2.13E-04	1.01E-03	1.06E-05	9.80E-06	2.80E-07	5.20E-05	6.42E-05	
1949	1.74E-02	2.23E-05	4.85E-06	1.50E-07	7.53E-10	1.66E-08	1.29E-04	2.03E-04	9.62E-04	1.01E-05	9.34E-06	2.67E-07	5.23E-05	6.56E-05	
1950	4.94E-03	3.64E-07	9.63E-08	8.03E-09	1.42E-08	2.97E-06	1.96E-06	3.07E-06	1.46E-05	1.57E-07	1.63E-07	4.05E-07	6.60E-07	1.14E-06	
1951	1.00E-01	5.21E-07	1.53E-07	5.74E-07	4.84E-09	5.66E-06	2.72E-06	4.17E-06	2.03E-05	2.16E-07	2.24E-06	5.55E-07	1.26E-06	1.71E-06	
1952	2.80E-03	3.81E-04	7.31E-05	1.16E-07	1.18E-10	9.77E-07	2.99E-06	4.82E-06	2.35E-05	2.50E-07	2.59E-07	6.39E-07	1.17E-06	1.50E-06	
1953	2.95E-03	1.32E-03	2.51E-04	7.84E-08	1.06E-10	5.05E-07	7.39E-06	1.21E-05	5.89E-05	6.26E-07	6.50E-07	1.60E-06	2.74E-06	3.42E-06	
1954	5.88E-04	7.02E-04	9.49E-05	9.98E-09	1.77E-11	5.02E-08	5.92E-06	1.01E-05	4.92E-05	5.23E-07	5.45E-07	1.33E-06	1.90E-06	2.25E-06	
1955	1.50E-04	1.64E-03	1.31E-04	1.58E-09	3.72E-12	6.16E-09	1.10E-05	2.03E-05	9.84E-05	1.05E-06	1.10E-06	2.65E-06	2.75E-06	2.98E-06	
1956	7.50E-05	1.00E-04	9.30E-06	4.60E-10	1.55E-12	1.38E-09	1.04E-05	1.91E-05	9.29E-05	9.87E-07	1.03E-06	2.50E-06	2.59E-06	2.80E-06	
1957	3.09E-04	6.13E-05	9.12E-06	2.95E-09	7.47E-12	1.06E-08	1.37E-05	2.43E-05	1.18E-04	1.26E-06	1.31E-06	3.19E-06	3.63E-06	4.31E-06	
1958	1.09E-02	2.17E-04	4.17E-05	5.45E-08	3.13E-10	7.06E-07	3.76E-05	6.06E-05	2.34E-04	2.69E-06	3.08E-06	6.52E-06	2.20E-05	2.63E-05	
1959	6.80E-03	1.38E-04	8.84E-06	4.82E-08	1.12E-10	3.63E-07	3.24E-05	7.17E-05	2.08E-04	2.39E-06	2.74E-06	5.79E-06	1.77E-05	2.24E-05	
1960	2.70E-03	1.20E-04	1.01E-05	5.75E-08	8.20E-12	7.80E-08	3.81E-05	8.57E-05	2.48E-04	2.85E-06	3.26E-06	6.91E-06	1.92E-05	2.34E-05	
1961	1.83E-03	1.79E-04	1.45E-05	5.85E-08	3.39E-12	4.43E-08	3.81E-05	8.74E-05	2.53E-04	2.91E-06	3.35E-06	7.03E-06	1.82E-05	2.19E-05	
1962	1.11E-04	1.40E-04	1.07E-05	5.65E-08	3.25E-15	5.95E-10	3.48E-05	8.51E-05	2.46E-04	2.83E-06	3.27E-06	6.82E-06	1.31E-05	1.44E-05	
1963	6.43E-05	1.57E-04	8.64E-06	5.27E-08	9.96E-16	2.74E-10	3.19E-05	7.97E-05	2.30E-04	2.64E-06	3.06E-06	6.37E-06	1.12E-05	1.21E-05	
1964	1.46E-04	2.37E-04	1.27E-05	6.05E-08	6.87E-15	9.29E-10	3.69E-05	9.14E-05	2.64E-04	3.03E-06	3.51E-06	7.31E-06	1.35E-05	1.49E-05	
1965	4.80E-05	2.36E-04	1.91E-05	5.98E-08	3.84E-16	1.59E-10	3.62E-05	9.04E-05	2.61E-04	3.00E-06	3.47E-06	7.23E-06	1.25E-05	1.34E-05	
1966	3.94E-07	1.80E-04	9.49E-06	3.52E-08	8.71E-21	1.45E-13	1.92E-05	5.41E-05	1.56E-04	1.79E-06	2.09E-06	4.29E-06	4.35E-06	4.02E-06	
1967	6.13E-07	5.82E-06	2.94E-07	3.56E-08	1.36E-20	2.43E-13	1.97E-05	5.47E-05	1.57E-04	1.81E-06	2.11E-06	4.34E-06	4.74E-06	4.47E-06	
1968	3.38E-08	5.23E-06	1.57E-07	3.37E-08	1.14E-23	2.93E-15	1.74E-05	5.23E-05	1.50E-04	1.73E-06	2.02E-06	4.12E-06	3.17E-06	2.72E-06	
1969	1.93E-09	3.47E-06	8.58E-08	2.34E-08	1.64E-26	4.41E-17	1.14E-05	3.67E-05	1.05E-04	1.21E-06	1.42E-06	2.88E-06	1.62E-06	1.28E-06	
1970	1.34E-20	7.74E-07	1.60E-10	8.11E-09	1.95E-53	5.83E-34	2.18E-06	1.41E-05	3.94E-05	4.56E-07	5.60E-07	1.05E-06	2.80E-08	9.64E-09	
1971	1.04E-19	2.42E-06	5.92E-10	2.49E-08	5.99E-52	7.48E-33	6.84E-06	4.31E-05	1.21E-04	1.39E-06	1.71E-06	3.21E-06	9.63E-08	3.42E-08	
1972	5.20E-19	8.25E-07	3.33E-10	8.09E-09	1.66E-49	1.60E-31	2.37E-06	1.38E-05	3.88E-05	4.49E-07	5.48E-07	1.04E-06	4.36E-08	1.70E-08	
SUMS	2.35	5.96E-03	7.46E-04	2.21E-06	6.81E-05	3.17E-05	1.14E-03	2.12E-03	8.31E-03	8.99E-05	9.31E-05	8.92E-05	5.15E-04	6.66E-04	2.367152

APPENDIX C

CALCULATION OF ANNUAL RELEASE RATES AND CRITICAL-ORGAN DOSES FOR SELECTED RADIONUCLIDES

CALCULATION OF ANNUAL RELEASE RATES AND CRITICAL-ORGAN DOSES FOR SELECTED RADIONUCLIDES

This appendix presents the full spreadsheet calculation of cumulative organ doses to infants and adults. The spreadsheet contains sections dealing with radionuclide inventory, release fractions, dose factors, releases from T-Plant, B-Plant, REDOX, and PUREX, and the dose estimates. The format is identical to that of the spreadsheet in Appendix B.

It should be noted that the critical organ for each radionuclide may differ (e.g., thyroid for iodine radioisotopes, lung for ruthenium isotopes, bone for plutonium and strontium). Because the doses are so dominated by iodine in thyroid, no effort has been made to separate them. However, the "sums" across radionuclides must be interpreted as upper-bound estimates of cumulative dose rather than as actual doses to any particular organ.

CUMULATIVE SUMMARY OF ORGAN DOSES

SUMMARY OF ANNUAL LARGEST ORGAN DOSES

THIS DOES NOT INCLUDE "LARGE" HOT PARTICLES OR RUTHENIUM SNOW

1. FUEL REPROCESSED AT HANFORD (FROM PRELIMINARY SOURCE TERM SPREADSHEET)

Summation of Reprocessing Plant Operations from HW-69085

	T Plant			B Plant			REDOX			PUREX		Hanford
Year	Tons N	MWD/ton	Days	Tons N	MWD/ton	Days	Tons N	Tons E	Total Tns	Days	Tons	Days	Total Tons
1945	325	159	43	302	189	42			0	0	0	0	627
1946	291	241	73	873	202	59			0	0	0	0	1164
1947	306	203	76	345	203	76			0	0	0	0	651
1948	358	203	102	398	210	101			0	0	0	0	756
1949	393	284	95	356	282	99			0	0	0	0	749
1950	424	401	89	460	398	90			0	0	0	0	884
1951	560	482	55	508	494	55			0	0	0	0	1068
1952	295	594	65	118	588	58	822	0	822	82	0	0	1235
1953	246	503	73	0		0	2851	0	2851	82	0	0	3097
1954	1011	302	92	0		0	1579	0	1579	104	0	0	2590
1955	1266	236	106	0		0	3926	0	3926	137	0	0	5192
1956	45	260	190	0		0	2335	0	2335	128	2520	130	4901
1957	0		0	0		0	1829	0	1829	116	4397	116	6226
1958	0		0	0		0	1318	65	1383	128	5260	100	6643
1959	0		0	0		0	248	675	923	205	4988	104	5911
1960	0		0	0		0	275	546	821	189	6244	118	7065
1961	0		0	0		0	0	1253	1253	187	5947	122	7200
1962	0		0	0		0	0	972	972	188	6040	154	7013
1963	0		0	0		0	0	1150	1150	209	5414	159	6564
1964	0		0	0		0	0	1768	1768	211	5759	151	7527
1965	0		0	0		0	0	1668	1668	182	5781	164	7449
1966	0		0	0		0	37	1315	1352	208	3109	223	4461
1967	0		0	0		0			0	0	4505	211	4505
1968	0		0	0		0			0	0	4308	244	4308
1969	0		0	0		0			0	0	3025	273	3025
1970	0		0	0		0			0	0	1160	560	1160
1971	0		0	0		0			0	0	3550	549	3550
1972	0		0	0		0			0	0	1141	518	1141
Totals	5550			3360			15220	9412	24632		73148		106690
											Check Sum		106690

Notes: Cooling times are non-mass-weighted monthly averages.
Burnup is supplied where available. These are non-mass-weighted monthly averages.

CUMULATIVE SUMMARY OF ORGAN DOSES

2. APPROXIMATE ANNUAL DOSE FACTORS (REM/CI RELEASED)

NUCLIDE	LAMDA R (1/DAY)	INFANT 1945 dose	ADULT 1945 dose	CI released In 1945	INFANT DFs	Adult DFs	COLUMN VALUES			COLUMNS TRANSPOSED					
I 131	0.086	6.05E+02	5.11E+01	555089	1.09E-03	9.21E-05	INFANT	1.09E-03	9.21E-05	1.09E-03	1.25E-05	5.23E-07	5.43E-06	2.95E-07	7.61E-11
RU/RH106	0.00188	1.51E-04	1.68E-04	12	1.25E-05	1.39E-05	ADULT	1.25E-05	1.39E-05	9.21E-05	1.39E-05	3.68E-07	5.43E-06	1.82E-08	7.61E-11
RU/RH103	0.0176	4.44E-05	3.12E-05	85	5.23E-07	3.68E-07		5.23E-07	3.68E-07						
CO60	0.000361	0.00E+00	4.20E-07	0.08	0.00E+00	5.43E-06		0.00E+00	5.43E-06		(ADULT VALUES USED FOR INFANTS				
Te/I 132	7.23	1.53E-03	9.43E-05	5188.55	2.95E-07	1.82E-08		2.95E-07	1.82E-08		FOR CO60 AND SR89)				
XE133	0.132	1.94E-05	1.94E-05	254835	7.61E-11	7.61E-11		7.61E-11	7.61E-11						
CE/PR144	0.00244	9.90E-04	1.02E-03	93	1.06E-05	1.10E-05		1.06E-05	1.10E-05						
PU239	7.87E-08	2.93E-04	3.06E-03	0.10	3.06E-03	3.19E-02		3.06E-03	3.19E-02						
SR/Y90	6.66E-05	1.07E-03	9.79E-04	4	3.03E-04	2.77E-04		3.03E-04	2.77E-04						
CS/BAm13	6.3E-05	1.22E-05	8.65E-06	4	3.11E-06	2.21E-06		3.11E-06	2.21E-06						
I 129	1.21E-10	4.37E-04	2.55E-04	9E-02	4.83E-03	2.70E-03		4.83E-03	2.70E-03						
KR85	0.000177	2.20E-07	2.20E-07	45688	4.82E-12	4.82E-12		4.82E-12	4.82E-12						
ZR/NB95	0.0108	1.82E-04	3.02E-04	178	1.02E-06	1.70E-06		1.02E-06	1.70E-06						
SR89	0.0137	0.00E+00	1.06E-03	118	0.00E+00	8.94E-06		0.00E+00	8.94E-06						

Notes: Derived from individual radionuclide monthly dose calculation worksheets, SUMMARIZED IN SUM-PATH.WQ1

3. FUEL CONTENTS OF RADIONUCLIDES

TAKEN FROM ORIGEN2 RUNS BY C. HEEB AND U. JENQUIN

NUCLIDE	LAMDA R (1/DAY)	200 MWD/T, 1 MW/T use 1945-1949 30 DAYS	50 DAYS	300MWD/T, 1 MW/T use 1950-1957 60 DAYS	100 DAYS	600 MWD/T, 10MW/T use 1958... 110 DAYS	190 DAYS
I 131	0.086	1984	354	150	4.78	21	0.0212
RU/RH106	0.00188	2011	1937	2680	2670	9330	8020
RU/RH103	0.0176	17310	12160	10800	5330	32100	7820
CO60	0.000361	12.6	12.5	1818.1	17.8	50.3	48.9
Te/I 132	7.23	65	0.9	0.0011	2.22E-05	2.74E-05	1.11E-12
XE133	0.132	1328	95	25.2	0.127	0.327	8.39E-06
CE/PR144	0.00244	15600	14860	19400	17600	43100	35500
PU239	7.87E-08	15.5	15.5	22.3	22.3	69.3	69.3
SR/Y90	6.66E-05	573	572	844	842	1560	1550
CS/BAm13	6.3E-05	636	635	950	948	1900	1890
I 129	1.21E-10	0.00017	0.00017	0.000257	0.000258	0.000569	0.000573
KR85	0.000177	74	74	108	107	204	201
ZR/NB95	0.0108	33240	26770	25800	16800	72700	30800
SR89	0.0137	22910	17410	15800	8990	41600	13900

4. RELEASE FRACTIONS

Assumptions of installation of sand filters and silver reactors

	1945-49	1950-72	1951 silver reactor failure	REDOX TO 1955	REDOX AFTER 1955
NOBLE GASES	1	1	1	1	1
IODINES	0.9	0.01	0.1	0.01	0.01
RUTHENIUMS	1E-05	1E-07	1E-07	0.0001	1E-05
ALL OTHERS	1E-05	1E-07	1E-07	1E-07	1E-07

10% USED FOR 1951 IODINE BECAUSE OF SILVER REACTOR FAILURES

1% USED FOR SILVER REACTORS BECAUSE OF PUREX EIS, 1964 MONITORING RPT

1E-5 USED FOR PARTICULATES EARLY YEARS BECAUSE OF MONITORING DATA

1E-5 USED FOR REDOX RU MOST OF TIME, 1E-4 1952-1955

PEAKING FACTORS FOR SHORT-LIVED RADIONUCLIDES

I131, I132,	1.4	(FROM OTHER SPREAD SHEETS)
ALL OTHE	1	

CUMULATIVE SUMMARY OF ORGAN DOSES

5. RELEASE ESTIMATES, NUCLIDE BY YEAR

A. T-PLANT

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89
1945	2.61E+05	6.38E+00	4.46E+01	4.07E-02	1.59E+03	1.08E+05	4.91E+01	5.04E-02	1.86E+00	2.06E+00	4.97E-02	2.41E+04	9.37E+01	6.21E+01
1946	1.81E+04	5.40E+00	2.36E+01	3.60E-02	2.49E+00	1.91E+03	4.09E+01	4.51E-02	1.66E+00	1.84E+00	4.45E-02	2.15E+04	8.08E+01	3.70E+01
1947	1.24E+04	5.63E+00	2.28E+01	3.78E-02	8.99E-01	1.04E+03	4.25E+01	4.74E-02	1.75E+00	1.94E+00	4.68E-02	2.26E+04	8.06E+01	3.64E+01
1948	1.89E+03	6.81E+00	1.67E+01	4.75E-02	5.92E-03	5.14E+01	5.08E+01	6.01E-02	2.21E+00	2.45E+00	5.94E-02	2.87E+04	5.89E+01	3.29E+01
1949	3.68E+03	7.00E+00	2.17E+01	4.83E-02	3.04E-02	1.41E+02	5.24E+01	6.09E-02	2.24E+00	2.49E+00	6.01E-02	2.91E+04	6.48E+01	3.70E+01
1950	1.65E+03	9.19E-02	4.99E-01	2.17E-03	7.99E-01	3.87E+04	6.80E-01	7.29E-04	2.71E-02	3.02E-02	6.10E-04	3.49E+04	1.12E+00	7.16E-01
1951	1.59E+04	1.63E-01	6.66E-01	1.92E-01	1.47E-01	4.09E+04	1.10E+00	1.25E-03	4.73E-02	5.32E-02	1.44E-02	6.06E+04	1.53E+00	9.42E-01
1952	4.14E+02	8.42E-02	2.93E-01	3.13E-02	2.88E-03	5.61E+03	5.66E-01	6.58E-04	2.49E-02	2.80E-02	7.58E-04	3.18E+04	7.24E-01	4.32E-01
1953	1.64E+02	6.91E-02	2.10E-01	9.57E-03	1.03E-03	1.49E+03	4.62E-01	5.49E-04	2.07E-02	2.34E-02	6.33E-04	2.65E+04	5.50E-01	3.19E-01
1954	1.32E+02	2.74E-01	6.18E-01	4.41E-03	6.69E-04	5.01E+02	1.81E+00	2.25E-03	8.52E-02	9.59E-02	2.61E-03	1.08E+05	1.85E+00	1.01E+00
1955	4.19E+01	3.33E-01	5.84E-01	5.76E-04	1.77E-04	7.84E+01	2.18E+00	2.82E-03	1.07E-01	1.20E-01	3.27E-03	1.35E+05	1.95E+00	1.02E+00
1956	1.29E-03	1.01E-02	4.90E-03	2.42E-09	2.15E-09	5.41E-05	6.36E-02	1.00E-04	3.77E-03	4.25E-03	1.17E-04	4.72E+03	2.68E-02	1.17E-02
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CUMULATIVE SUMMARY OF ORGAN DOSES

B. B-PLANT

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89
1945	2.79E+05	5.94E+00	4.26E+01	3.79E-02	2.09E+03	1.22E+05	4.58E+01	4.68E-02	1.73E+00	1.92E+00	4.62E-02	2.23E+04	8.86E+01	5.90E+01
1946	1.78E+05	1.66E+01	9.04E+01	1.09E-01	1.42E+02	3.50E+04	1.27E+02	1.35E-01	4.99E+00	5.54E+00	1.34E-01	6.46E+04	2.12E+02	1.34E+02
1947	1.38E+04	6.34E+00	2.56E+01	4.26E-02	9.78E-01	1.14E+03	4.79E+01	5.35E-02	1.97E+00	2.19E+00	5.28E-02	2.55E+04	6.82E+01	4.09E+01
1948	2.14E+03	7.00E+00	1.96E+01	4.87E-02	7.79E-03	6.14E+01	5.22E+01	6.17E-02	2.27E+00	2.52E+00	6.09E-02	2.95E+04	6.12E+01	3.43E+01
1949	2.38E+03	6.29E+00	1.83E+01	4.36E-02	1.19E-02	7.64E+01	4.70E+01	5.52E-02	2.03E+00	2.25E+00	5.45E-02	2.63E+04	5.62E+01	3.17E+01
1950	7.61E+01	1.25E-01	2.95E-01	2.76E-03	3.98E-04	3.28E+02	8.31E-01	1.03E-03	3.88E-02	4.36E-02	1.19E-03	4.93E+04	8.65E-01	4.78E-01
1951	1.61E+04	1.48E-01	5.97E-01	1.60E-01	1.24E-01	3.36E+04	9.97E-01	1.13E-03	4.29E-02	4.83E-02	1.30E-02	5.49E+04	1.38E+00	8.46E-01
1952	3.03E+02	3.41E-02	1.33E-01	2.61E-02	2.26E-03	5.67E+03	2.30E-01	2.63E-04	9.96E-03	1.12E-02	3.03E-04	1.26E+04	3.12E-01	1.90E-01
1953	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1954	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1955	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1956	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1957	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1958	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1959	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1960	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1961	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1962	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1963	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1964	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1965	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1966	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CUMULATIVE SUMMARY OF ORGAN DOSES

C. REDOX

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89
1945	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	2.59E+02	2.27E+02	6.02E+02	1.17E-02	1.48E-03	1.58E+03	1.51E+00	1.83E-03	6.93E-02	7.80E-02	2.12E-03	8.83E+04	1.68E+00	9.47E-01
1953	8.65E+02	7.87E+02	2.07E+03	3.88E-02	4.91E-03	5.16E+03	5.24E+00	6.36E-03	2.40E-01	2.70E-01	7.34E-03	3.06E+05	5.78E+00	3.26E+00
1954	7.33E+01	4.18E+02	7.81E+02	1.72E-03	3.24E-04	1.60E+02	2.75E+00	3.52E-03	1.33E-01	1.50E-01	4.06E-03	1.69E+05	2.54E+00	1.34E+00
1955	1.05E+01	9.76E+02	1.08E+03	9.22E-05	3.17E-05	4.95E+00	6.31E+00	8.75E-03	3.30E-01	3.71E-01	1.02E-02	4.16E+05	4.42E+00	2.11E+00
1956	1.39E+01	5.91E+01	7.58E+01	1.61E-04	4.69E-05	1.01E+01	3.84E+00	5.21E-03	1.96E-01	2.21E-01	6.04E-03	2.48E+05	2.90E+00	1.43E+00
1957	3.06E+01	4.74E+01	7.34E+01	5.07E-04	1.18E-04	3.87E+01	3.09E+00	4.06E-03	1.54E-01	1.73E-01	4.72E-03	1.95E+05	2.59E+00	1.32E+00
1958	8.61E+01	1.25E+02	3.23E+02	6.91E-03	1.15E-05	5.67E+01	5.71E+00	9.59E-03	2.15E-01	2.62E-01	7.68E-03	2.81E+05	6.28E+00	4.50E+00
1959	7.36E-02	7.19E+01	5.52E+01	4.49E-03	5.59E-13	1.45E-03	3.16E+00	6.40E-03	1.43E-01	1.74E-01	5.30E-03	1.85E+05	2.40E+00	1.04E+00
1960	2.73E-01	6.60E+01	6.57E+01	4.02E-03	1.69E-11	1.15E-02	2.92E+00	5.69E-03	1.27E-01	1.55E-01	4.70E-03	1.65E+05	2.55E+00	1.16E+00
1961	5.03E-01	1.01E+02	1.04E+02	6.13E-03	4.10E-11	2.34E-02	4.48E+00	8.68E-03	1.94E-01	2.37E-01	7.17E-03	2.52E+05	3.98E+00	1.83E+00
1962	3.58E-01	7.84E+01	7.95E+01	4.76E-03	2.57E-11	1.59E-02	3.47E+00	6.74E-03	1.51E-01	1.84E-01	5.57E-03	1.96E+05	3.06E+00	1.40E+00
1963	6.44E-02	8.89E+01	6.39E+01	5.59E-03	2.92E-13	1.05E-03	3.90E+00	7.97E-03	1.78E-01	2.17E-01	6.60E-03	2.30E+05	2.86E+00	1.23E+00
1964	8.64E-02	1.36E+02	9.58E+01	8.58E-03	3.21E-13	1.31E-03	5.97E+00	1.23E-02	2.74E-01	3.34E-01	1.01E-02	3.54E+05	4.31E+00	1.85E+00
1965	9.95E-01	1.36E+02	1.50E+02	8.18E-03	1.45E-10	5.71E-02	6.04E+00	1.16E-02	2.59E-01	3.15E-01	9.55E-03	3.36E+05	5.57E+00	2.59E+00
1966	8.42E-02	1.05E+02	7.68E+01	6.57E-03	4.47E-13	1.45E-03	4.59E+00	9.37E-03	2.09E-01	2.55E-01	7.76E-03	2.71E+05	3.40E+00	1.47E+00
1967	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1968	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1969	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1970	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1971	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1972	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

CUMULATIVE SUMMARY OF ORGAN DOSES

D. PUREX

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89
1945	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1946	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1947	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1948	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1949	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1950	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1951	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1952	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1953	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1954	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1955	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1956	1.23E+01	6.35E-01	7.85E-01	1.33E-04	4.03E-05	6.02E+00	4.12E+00	5.62E-03	2.12E-01	2.39E-01	6.52E-03	2.68E+05	3.06E+00	1.49E+00
1957	7.74E+01	1.14E+00	1.78E+00	1.30E-03	3.01E-04	1.01E+02	7.45E+00	9.81E-03	3.70E-01	4.17E-01	1.14E-02	4.69E+05	5.26E+00	3.19E+00
1958	3.72E+03	5.00E+00	2.02E+01	2.68E-02	1.76E-02	9.23E+03	2.32E+01	3.65E-02	6.21E-01	1.00E+00	2.99E-02	1.08E+06	4.27E+01	2.52E+01
1959	2.37E+03	4.70E+00	1.77E+01	2.51E-02	6.28E-03	4.77E+03	2.18E+01	3.46E-02	7.78E-01	9.48E-01	2.84E-02	1.02E+06	3.85E+01	2.24E+01
1960	9.41E+02	5.74E+00	1.75E+01	3.13E-02	4.60E-04	1.03E+03	2.64E+01	4.33E-02	9.73E-01	1.19E+00	3.56E-02	1.27E+06	4.17E+01	2.34E+01
1961	6.39E+02	5.43E+00	1.55E+01	2.98E-02	1.91E-04	5.83E+02	2.49E+01	4.12E-02	9.27E-01	1.13E+00	3.39E-02	1.21E+06	3.61E+01	2.11E+01
1962	3.66E+01	5.16E+00	6.85E+00	2.99E-02	1.82E-07	7.61E+00	2.34E+01	4.19E-02	9.39E-01	1.14E+00	3.45E-02	1.22E+06	2.72E+01	1.37E+01
1963	2.24E+01	4.60E+00	7.26E+00	2.68E-02	5.59E-08	3.60E+00	2.07E+01	3.75E-02	8.41E-01	1.03E+00	3.09E-02	1.09E+06	2.31E+01	1.14E+01
1964	5.08E+01	4.98E+00	9.02E+00	2.66E-02	3.66E-07	1.22E+01	2.25E+01	3.99E-02	8.96E-01	1.09E+00	3.29E-02	1.17E+06	2.70E+01	1.37E+01
1965	1.58E+01	4.87E+00	7.12E+00	2.65E-02	2.14E-06	2.03E+00	2.16E+01	4.01E-02	8.96E-01	1.09E+00	3.30E-02	1.17E+06	2.34E+01	1.14E+01
1966	5.32E-02	2.34E+00	1.36E+00	1.50E-02	4.24E-14	4.61E-04	1.02E+01	2.15E-02	4.81E-01	5.66E-01	1.79E-02	6.21E+05	6.65E+00	2.75E+00
1967	2.14E-01	3.47E+00	2.42E+00	2.19E-02	7.61E-13	3.19E-03	1.52E+01	3.12E-02	6.97E-01	8.50E-01	2.59E-02	9.02E+05	1.10E+01	4.68E+00
1968	1.18E-02	3.12E+00	1.29E+00	2.07E-02	6.36E-16	3.66E-05	1.34E+01	2.99E-02	6.65E-01	8.11E-01	2.48E-02	8.57E+05	7.32E+00	2.84E+00
1969	6.75E-04	2.07E+00	5.42E-01	1.44E-02	9.20E-19	5.80E-07	8.77E+00	2.10E-02	4.66E-01	5.69E-01	1.75E-02	5.99E+05	3.75E+00	1.34E+00
1970	4.68E-15	4.62E-01	1.32E-03	4.96E-03	1.09E-45	7.67E-24	1.68E+00	8.04E-03	1.75E-01	2.14E-01	6.67E-03	2.18E+05	6.47E-02	1.01E-02
1971	3.65E-14	1.44E+00	4.87E-03	1.53E-02	3.37E-44	9.85E-23	5.27E+00	2.46E-02	5.35E-01	6.55E-01	2.10E-02	6.68E+05	2.23E-01	3.56E-02
1972	1.82E-13	4.92E-01	2.74E-03	4.97E-03	9.34E-42	2.11E-21	1.83E+00	7.91E-03	1.72E-01	2.11E-01	6.73E-03	2.16E+05	1.01E-01	1.78E-02

CUMULATIVE SUMMARY OF ORGAN DOSES

6. TOTAL RELEASES FROM ALL SEPARATIONS PLANTS

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89
1945	5.40E+05	1.23E+01	8.72E+01	7.86E-02	3.68E+03	2.29E+05	9.49E+01	9.72E-02	3.59E+00	3.98E+00	9.59E-02	4.64E+04	1.82E+02	1.21E+02
1946	1.96E+05	2.20E+01	1.14E+02	1.45E-01	1.44E+02	3.70E+04	1.68E+02	1.60E-01	6.65E+00	7.38E+00	1.78E-01	8.61E+04	2.73E+02	1.71E+02
1947	2.62E+04	1.20E+01	4.84E+01	8.05E-02	1.88E+00	2.18E+03	9.04E+01	1.01E-01	3.71E+00	4.12E+00	9.96E-02	4.82E+04	1.29E+02	7.73E+01
1948	4.03E+03	1.38E+01	3.83E+01	9.62E-02	1.37E-02	1.13E+02	1.03E+02	1.22E-01	4.48E+00	4.97E+00	1.20E-01	5.82E+04	1.20E+02	6.72E+01
1949	6.06E+03	1.33E+01	4.00E+01	9.19E-02	4.23E-02	2.18E+02	9.94E+01	1.16E-01	4.27E+00	4.74E+00	1.15E-01	5.54E+04	1.21E+02	6.87E+01
1950	1.72E+03	2.17E-01	7.94E-01	4.93E-03	7.99E-01	3.90E+04	1.51E+00	1.75E-03	6.58E-02	7.38E-02	2.00E-03	8.43E+04	1.99E+00	1.19E+00
1951	3.50E+04	3.11E-01	1.26E+00	3.52E-01	2.72E-01	7.45E+04	2.10E+00	2.36E-03	9.02E-02	1.01E-01	2.74E-02	1.15E+05	2.91E+00	1.79E+00
1952	9.77E+02	2.27E+02	6.03E+02	7.11E-02	6.64E-03	1.29E+04	2.31E+00	2.75E-03	1.04E-01	1.17E-01	3.18E-03	1.33E+05	2.71E+00	1.57E+00
1953	1.03E+03	7.87E+02	2.07E+03	4.82E-02	5.94E-03	6.65E+03	5.70E+00	6.91E-03	2.61E-01	2.94E-01	7.98E-03	3.33E+05	6.33E+00	3.58E+00
1954	2.05E+02	4.19E+02	7.82E+02	6.13E-03	9.94E-04	6.61E+02	4.56E+00	5.78E-03	2.18E-01	2.46E-01	6.68E-03	2.77E+05	4.36E+00	2.35E+00
1955	5.24E+01	9.77E+02	1.08E+03	9.69E-04	2.09E-04	8.14E+01	8.49E+00	1.16E-02	4.36E-01	4.91E-01	1.34E-02	5.52E+05	6.36E+00	3.12E+00
1956	2.62E+01	5.98E+01	7.66E+01	2.95E-04	8.71E-05	1.81E+01	8.02E+00	1.09E-02	4.12E-01	4.64E-01	1.27E-02	5.21E+05	5.99E+00	2.93E+00
1957	1.08E+02	4.85E+01	7.52E+01	1.81E-03	4.19E-04	1.39E+02	1.05E+01	1.39E-02	5.24E-01	5.90E-01	1.61E-02	6.64E+05	8.84E+00	4.51E+00
1958	3.80E+03	1.30E+02	3.43E+02	3.35E-02	1.76E-02	9.29E+03	2.89E+01	4.60E-02	1.04E+00	1.26E+00	3.78E-02	1.36E+06	5.10E+01	2.98E+01
1959	2.37E+03	7.66E+01	7.28E+01	2.96E-02	6.26E-03	4.77E+03	2.49E+01	4.10E-02	9.21E-01	1.12E+00	3.37E-02	1.20E+06	4.09E+01	2.34E+01
1960	9.41E+02	7.17E+01	8.32E+01	3.53E-02	4.60E-04	1.03E+03	2.93E+01	4.90E-02	1.10E+00	1.34E+00	4.03E-02	1.44E+06	4.43E+01	2.45E+01
1961	6.40E+02	1.07E+02	1.20E+02	3.59E-02	1.91E-04	5.83E+02	2.94E+01	4.99E-02	1.12E+00	1.37E+00	4.10E-02	1.43E+06	4.21E+01	2.29E+01
1962	3.89E+01	8.35E+01	8.83E+01	3.47E-02	1.82E-07	7.83E+00	2.68E+01	4.86E-02	1.09E+00	1.33E+00	4.01E-02	1.42E+06	3.02E+01	1.51E+01
1963	2.24E+01	9.35E+01	7.12E+01	3.23E-02	5.59E-08	3.60E+00	2.46E+01	4.55E-02	1.02E+00	1.24E+00	3.75E-02	1.32E+06	2.59E+01	1.27E+01
1964	5.09E+01	1.41E+02	1.05E+02	3.71E-02	3.86E-07	1.22E+01	2.65E+01	5.22E-02	1.17E+00	1.43E+00	4.30E-02	1.52E+06	3.13E+01	1.56E+01
1965	1.68E+01	1.41E+02	1.58E+02	3.67E-02	2.16E-08	2.09E+00	2.79E+01	5.16E-02	1.16E+00	1.41E+00	4.26E-02	1.50E+06	2.89E+01	1.40E+01
1966	1.37E-01	1.07E+02	7.82E+01	2.16E-02	4.89E-13	1.91E-03	1.48E+01	3.09E-02	6.90E-01	8.41E-01	2.56E-02	8.92E+05	1.01E+01	4.21E+00
1967	2.14E-01	3.47E+00	2.42E+00	2.19E-02	7.61E-13	3.19E-03	1.52E+01	3.12E-02	6.97E-01	8.50E-01	2.59E-02	9.02E+05	1.10E+01	4.68E+00
1968	1.18E-02	3.12E+00	1.29E+00	2.07E-02	6.38E-16	3.86E-05	1.34E+01	2.99E-02	6.65E-01	8.11E-01	2.48E-02	8.57E+05	7.32E+00	2.84E+00
1969	6.75E-04	2.07E+00	5.42E-01	1.44E-02	9.20E-19	5.80E-07	8.77E+00	2.10E-02	4.68E-01	5.69E-01	1.75E-02	5.99E+05	3.75E+00	1.34E+00
1970	4.68E-15	4.62E-01	1.32E-03	4.98E-03	1.09E-45	7.67E-24	1.68E+00	8.04E-03	1.75E-01	2.14E-01	6.87E-03	2.18E+05	6.47E-02	1.01E-02
1971	3.65E-14	1.44E+00	4.87E-03	1.53E-02	3.37E-44	9.65E-23	5.27E+00	2.46E-02	5.35E-01	6.55E-01	2.10E-02	6.68E+05	2.23E-01	3.58E-02
1972	1.82E-13	4.92E-01	2.74E-03	4.97E-03	9.34E-42	2.11E-21	1.83E+00	7.91E-03	1.72E-01	2.11E-01	6.73E-03	2.16E+05	1.01E-01	1.78E-02
SUMS	5.19E+05	3.55E+03	6.14E+03	1.36E+00	3.82E+03	4.18E+05	5.80E+02	1.21E+00	3.68E+01	4.22E+01	1.14E+00	1.85E+07	1.19E+03	6.98E+02

CUMULATIVE SUMMARY OF ORGAN DOSES

7. INFANT DOSES

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89	
1945	5.89E+02	1.54E-04	4.56E-05	4.27E-07	1.08E-03	1.74E-05	1.01E-03	2.98E-04	1.09E-03	1.24E-05	4.44E-04	2.23E-07	1.86E-04	1.08E-03	
1946	2.14E+02	2.75E-04	5.97E-05	7.86E-07	4.25E-05	2.81E-06	1.78E-03	5.52E-04	2.01E-03	2.30E-05	8.24E-04	4.15E-07	2.79E-04	1.53E-03	
1947	2.85E+01	1.49E-04	2.53E-05	4.37E-07	5.53E-07	1.66E-07	9.60E-04	3.09E-04	1.12E-03	1.28E-05	4.61E-04	2.32E-07	1.32E-04	8.91E-04	
1948	4.40E+00	1.72E-04	2.00E-05	5.23E-07	4.04E-09	8.59E-09	1.09E-03	3.73E-04	1.35E-03	1.55E-05	5.56E-04	2.80E-07	1.23E-04	6.01E-04	
1949	6.60E+00	1.66E-04	2.09E-05	4.99E-07	1.25E-08	1.66E-08	1.05E-03	3.55E-04	1.29E-03	1.47E-05	5.30E-04	2.67E-07	1.24E-04	6.14E-04	
1950	1.98E+00	2.71E-06	4.15E-07	2.68E-08	2.36E-07	2.97E-06	1.60E-05	5.37E-06	1.99E-06	2.30E-07	9.23E-06	4.06E-07	2.03E-06	1.07E-05	
1951	3.81E+01	3.67E-06	6.61E-07	1.91E-06	8.02E-08	5.67E-06	2.23E-05	7.29E-06	2.73E-05	3.16E-07	1.27E-04	5.56E-07	2.98E-06	1.60E-05	
1952	1.06E+00	2.83E-03	3.15E-04	3.66E-07	1.96E-09	9.79E-07	2.45E-05	8.43E-06	3.15E-05	3.65E-07	1.47E-05	6.40E-07	2.77E-06	1.40E-05	
1953	1.12E+00	9.81E-03	1.08E-03	2.62E-07	1.75E-09	5.06E-07	8.05E-05	2.11E-05	7.90E-05	9.14E-07	3.69E-05	1.60E-06	6.47E-06	3.20E-05	
1954	2.24E-01	5.22E-03	4.09E-04	3.33E-08	2.93E-10	5.03E-08	4.85E-05	1.77E-05	6.60E-05	7.64E-07	3.09E-05	1.33E-06	4.48E-06	2.10E-05	
1955	5.71E-02	1.22E-02	5.66E-04	5.26E-09	6.16E-11	6.20E-09	9.02E-05	3.54E-05	1.32E-04	1.53E-06	6.21E-05	2.66E-06	6.51E-06	2.79E-05	
1956	2.85E-02	7.45E-04	4.01E-05	1.60E-09	2.57E-11	1.38E-09	8.52E-05	3.35E-05	1.25E-04	1.44E-06	5.87E-05	2.51E-06	6.12E-06	2.62E-05	
1957	1.18E-01	6.05E-04	3.93E-05	9.83E-09	1.24E-10	1.06E-08	1.12E-04	4.25E-05	1.59E-04	1.83E-06	7.44E-05	3.20E-06	9.04E-06	4.03E-05	
1958	4.14E+00	1.62E-03	1.60E-04	1.82E-07	5.18E-09	7.07E-07	3.07E-04	1.41E-04	3.14E-04	3.93E-06	1.75E-04	6.53E-06	5.21E-05	2.65E-04	
1959	2.59E+00	9.56E-04	3.81E-05	1.61E-07	1.65E-09	3.64E-07	2.65E-04	1.25E-04	2.79E-04	3.49E-06	1.56E-04	5.80E-06	4.18E-05	2.10E-04	
1960	1.03E+00	8.94E-04	4.35E-05	1.92E-07	1.36E-10	7.82E-08	3.11E-04	1.50E-04	3.33E-04	4.17E-06	1.86E-04	6.92E-06	4.53E-05	2.19E-04	
1961	6.97E-01	1.33E-03	6.26E-05	1.95E-07	5.62E-11	4.44E-08	3.12E-04	1.53E-04	3.39E-04	4.25E-06	1.90E-04	7.04E-06	4.30E-05	2.05E-04	
1962	4.24E-02	1.04E-03	4.62E-05	1.88E-07	5.37E-14	5.96E-10	2.85E-04	1.49E-04	3.30E-04	4.13E-06	1.85E-04	6.83E-06	3.09E-05	1.35E-04	
1963	2.45E-02	1.17E-03	3.73E-05	1.76E-07	1.65E-14	2.74E-10	2.61E-04	1.39E-04	3.09E-04	3.86E-06	1.74E-04	6.38E-06	2.65E-05	1.13E-04	
1964	5.55E-02	1.76E-03	5.47E-05	2.02E-07	1.14E-13	9.31E-10	3.02E-04	1.60E-04	3.54E-04	4.43E-06	1.99E-04	7.32E-06	3.20E-05	1.39E-04	
1965	1.83E-02	1.75E-03	8.25E-05	1.99E-07	6.36E-15	1.59E-10	2.96E-04	1.58E-04	3.50E-04	4.39E-06	1.97E-04	7.24E-06	2.96E-05	1.25E-04	
1966	1.50E-04	1.34E-03	4.09E-05	1.17E-07	1.44E-19	1.46E-13	1.57E-04	9.46E-05	2.09E-04	2.62E-06	1.19E-04	4.29E-06	1.03E-05	3.77E-05	
1967	2.33E-04	4.33E-05	1.27E-06	1.19E-07	2.24E-19	2.43E-13	1.61E-04	9.56E-05	2.11E-04	2.64E-06	1.20E-04	4.34E-06	1.12E-05	4.18E-05	
1968	1.29E-05	3.89E-05	6.76E-07	1.12E-07	1.88E-22	2.94E-15	1.42E-04	9.14E-05	2.01E-04	2.52E-06	1.15E-04	4.13E-06	7.49E-06	2.54E-05	
1969	7.36E-07	2.58E-05	2.84E-07	7.80E-08	2.71E-25	4.42E-17	9.31E-05	6.42E-05	1.41E-04	1.77E-06	8.08E-05	2.88E-06	3.84E-06	1.20E-05	
1970	5.10E-18	5.76E-06	6.88E-10	2.70E-08	3.22E-52	5.84E-34	1.78E-05	2.46E-05	5.28E-05	6.66E-07	3.18E-05	1.05E-06	6.61E-08	9.02E-08	
1971	3.98E-17	1.80E-05	2.55E-09	6.30E-08	9.93E-51	7.50E-33	5.60E-05	7.53E-05	1.62E-04	2.04E-06	9.71E-05	3.21E-06	2.28E-07	3.20E-07	
1972	1.98E-16	6.14E-06	1.44E-09	2.70E-08	2.76E-48	1.61E-31	1.94E-05	2.42E-05	5.21E-05	6.56E-07	3.11E-05	1.04E-06	1.03E-07	1.59E-07	
SUMS	893.17	4.43E-02	3.21E-03	7.37E-06	1.13E-03	3.18E-05	9.34E-03	3.70E-03	1.11E-02	1.31E-04	5.28E-03	6.93E-05	1.22E-03	6.24E-03	893.25151

CUMULATIVE SUMMARY OF ORGAN DOSES

8. ADULT DOSES

Year	I 131	RU/RH106	RU/RH103	CO60	Te/I 132	XE133	CE/PR144	PU239	SR/Y90	CS/BAm13	I 129	KR85	ZR/NB95	SR89	
1945	4.97E+01	1.71E-04	3.21E-05	4.27E-07	6.68E-05	1.74E-05	1.04E-03	3.10E-03	9.94E-04	8.79E-06	2.59E-04	2.23E-07	3.09E-04	1.08E-03	
1946	1.81E+01	3.06E-04	4.19E-05	7.86E-07	2.62E-06	2.81E-06	1.84E-03	5.76E-03	1.84E-03	1.63E-05	4.81E-04	4.15E-07	4.63E-04	1.53E-03	
1947	2.41E+00	1.66E-04	1.78E-05	4.37E-07	3.41E-08	1.66E-07	9.91E-04	3.22E-03	1.03E-03	9.10E-06	2.69E-04	2.32E-07	2.19E-04	6.91E-04	
1948	3.71E-01	1.92E-04	1.41E-05	5.22E-07	2.49E-10	8.59E-09	1.13E-03	3.89E-03	1.24E-03	1.10E-05	3.25E-04	2.80E-07	2.04E-04	6.01E-04	
1949	5.56E-01	1.84E-04	1.47E-05	4.99E-07	7.68E-10	1.66E-08	1.09E-03	3.71E-03	1.18E-03	1.04E-05	3.09E-04	2.67E-07	2.05E-04	6.14E-04	
1950	1.59E-01	3.01E-06	2.92E-07	2.66E-08	1.45E-08	2.97E-06	1.65E-05	5.60E-05	1.82E-05	1.63E-07	5.39E-06	4.06E-07	3.37E-06	1.07E-05	
1951	3.22E+00	4.31E-06	4.64E-07	1.91E-06	4.94E-09	5.67E-06	2.30E-05	7.81E-05	2.50E-05	2.24E-07	7.41E-05	5.56E-07	4.94E-06	1.60E-05	
1952	8.99E-02	3.15E-03	2.22E-04	3.86E-07	1.21E-10	9.79E-07	2.53E-05	8.60E-05	2.88E-05	2.59E-07	8.56E-06	6.40E-07	4.60E-06	1.40E-05	
1953	9.47E-02	1.09E-02	7.62E-04	2.61E-07	1.08E-10	5.06E-07	6.24E-05	2.21E-04	7.23E-05	6.48E-07	2.15E-05	1.60E-06	1.07E-05	3.20E-05	
1954	1.89E-02	5.81E-03	2.87E-04	3.33E-08	1.81E-11	5.03E-08	5.00E-05	1.84E-04	6.04E-05	5.42E-07	1.80E-05	1.33E-06	7.43E-06	2.10E-05	
1955	4.82E-03	1.36E-02	3.98E-04	5.26E-09	3.80E-12	6.20E-09	9.31E-05	3.70E-04	1.21E-04	1.08E-06	3.63E-05	2.66E-06	1.08E-05	2.79E-05	
1956	2.41E-03	8.29E-04	2.82E-05	1.60E-09	1.58E-12	1.38E-09	8.79E-05	3.49E-04	1.14E-04	1.02E-06	3.42E-05	2.51E-06	1.02E-05	2.62E-05	
1957	9.94E-03	6.73E-04	2.76E-05	9.82E-09	7.62E-12	1.06E-08	1.16E-04	4.43E-04	1.45E-04	1.30E-06	4.34E-05	3.20E-06	1.50E-05	4.03E-05	
1958	3.50E-01	1.80E-03	1.26E-04	1.62E-07	3.19E-10	7.07E-07	3.17E-04	1.47E-03	2.87E-04	2.78E-06	1.02E-04	6.53E-06	6.65E-05	2.65E-04	
1959	2.16E-01	1.06E-03	2.68E-05	1.61E-07	1.14E-10	3.64E-07	2.73E-04	1.31E-03	2.55E-04	2.47E-06	9.09E-05	5.80E-06	6.94E-05	2.10E-04	
1960	8.67E-02	9.95E-04	3.06E-05	1.92E-07	8.37E-12	7.82E-08	3.21E-04	1.56E-03	3.05E-04	2.96E-06	1.09E-04	6.92E-06	7.52E-05	2.19E-04	
1961	5.89E-02	1.48E-03	4.40E-05	1.95E-07	3.46E-12	4.44E-08	3.22E-04	1.59E-03	3.11E-04	3.01E-06	1.11E-04	7.04E-06	7.14E-05	2.05E-04	
1962	3.58E-03	1.16E-03	3.25E-05	1.88E-07	3.31E-15	5.96E-10	2.94E-04	1.55E-03	3.02E-04	2.93E-06	1.08E-04	6.83E-06	5.13E-05	1.35E-04	
1963	2.07E-03	1.30E-03	2.62E-05	1.76E-07	1.02E-15	2.74E-10	2.70E-04	1.45E-03	2.82E-04	2.74E-06	1.01E-04	6.38E-06	4.40E-05	1.13E-04	
1964	4.68E-03	1.96E-03	3.85E-05	2.02E-07	7.01E-15	9.31E-10	3.12E-04	1.67E-03	3.24E-04	3.14E-06	1.16E-04	7.32E-06	5.31E-05	1.39E-04	
1965	1.54E-03	1.95E-03	5.80E-05	1.99E-07	3.92E-16	1.59E-10	3.06E-04	1.65E-03	3.20E-04	3.11E-06	1.15E-04	7.24E-06	4.91E-05	1.25E-04	
1966	1.27E-05	1.49E-03	2.87E-05	1.17E-07	8.89E-21	1.46E-13	1.62E-04	9.67E-04	1.91E-04	1.86E-06	6.92E-05	4.29E-06	1.71E-05	3.77E-05	
1967	1.97E-05	4.81E-05	8.90E-07	1.19E-07	1.38E-20	2.43E-13	1.66E-04	9.97E-04	1.93E-04	1.87E-06	6.98E-05	4.34E-06	1.86E-05	4.18E-05	
1968	1.09E-06	4.33E-05	4.75E-07	1.12E-07	1.16E-23	2.94E-15	1.47E-04	9.54E-04	1.84E-04	1.79E-06	6.70E-05	4.13E-06	1.24E-05	2.54E-05	
1969	6.21E-08	2.87E-05	1.99E-07	7.79E-08	1.67E-26	4.42E-17	9.61E-05	6.69E-04	1.29E-04	1.25E-06	4.71E-05	2.88E-06	6.37E-06	1.20E-05	
1970	4.30E-19	6.41E-06	4.84E-10	2.70E-08	1.99E-53	5.84E-34	1.84E-05	2.57E-04	4.84E-05	4.72E-07	1.85E-05	1.05E-06	1.10E-07	9.02E-08	
1971	3.36E-18	2.00E-05	1.79E-09	8.30E-08	6.12E-52	7.50E-33	5.76E-05	7.66E-04	1.48E-04	1.44E-06	5.67E-05	3.21E-06	3.78E-07	3.20E-07	
1972	1.67E-17	6.83E-06	1.01E-09	2.70E-08	1.70E-49	1.61E-31	2.01E-05	2.52E-04	4.77E-05	4.65E-07	1.82E-05	1.04E-06	1.71E-07	1.59E-07	
SUMS	75.44	4.93E-02	2.26E-03	7.36E-06	6.95E-05	3.18E-05	9.64E-03	3.66E-02	1.02E-02	9.31E-05	3.08E-03	8.93E-05	2.02E-03	6.24E-03	75.560944

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