Westinghouse
Savannah River Company

P.O. Box 616
Aiken. SC 29802

CC: File(WSRC-RP-89-1093
BSF-TIM-89-0225)

November 28, 1989

Ms. W. F. Perrin, Technical Information Officer
U. S. Department of Energy
Savannah River Operations Office
Aiken, SC 29801

Dear Ms. Perrin:

REQUEST FOR APPROVAL TO RELEASE SCIENTIFIC/TECHNICAL INFORMATION

The attached document is submitted for approval for external release. Please complete Part II of this letter and return the letter to the undersigned by 12/13/89. Patent clearance is requested and received via direct communication between DOE Patent Counsel and Patent Reviewer. The document has been reviewed for classification by the WSRC Classification Officer and a designated WSRC Derivative Classifier and has been determined to be unclassified/[illegible].

J. A. Duschinski WSRC Technical Information Manager

I. DETAILS OF REQUEST FOR RELEASE

WSRC-RP-89-1093, "RADIOLOGICAL EFFECTS OF SRS OPERATIONS IN 1988," By L. R. Bauer.

A paper being sent to OSTI for release to the general public.

Technical questions pertaining to the contents of this document should be addressed to the author(s) or

A. L. Boni, Manager
Environmental Technology
Savannah River Site

Questions concerning processing of this document should be addressed to the WSRC Technical Information Manager, 5-3992 or 5-2646.

II. DOE-SR ACTION

DATE RECEIVED BY TIO 11-28-89

X Approved as written.
___Remarks.

___Not approved as written; ___revise and resubmit to DOE.
___Approved upon completion of changes marked on document.

for W. F. Perrin, Technical Information Officer, DOE-SR

Date 12/26/89

DOE F 1332.15 (5-88)

U.S. DEPARTMENT OF ENERGY

OMB Control No. 1910—1400

DOE AND MAJOR CONTRACTOR RECOMMENDATIONS FOR ANNOUNCEMENT AND DISTRIBUTION OF DOCUMENTS

1. DOE Report No.	2. DOE Contract No.	3. DOE B and R code(s)	4. OSTI UC or C Category No.
WSRC-RP-89-1093	DE-AC09-89SR18035		UC 702

5. Title

RADIOLOGICAL EFFECTS OF SRS OPERATIONS IN 1988, LR BAUER

6. Type of Document ("x" one)

a. Scientific and technical report: ☐ monthly ☐ quarterly ☐ annual ☐ final ☐ topical ☒ other

b. Conference paper: Name of conference (no abbreviations) _____

Location (city/st/ctry) _____

Date (mo/day/yr) _____ Sponsor _____

Contents: ☐ proceedings ☐ viewgraphs ☒ paper ☐ poster sessions

c. Computer Media:

Document is accompanied by ☐ magnetic tape(s) _____

☐ diskette(s) _____

☐ other (specify) _____

d. Other (e.g., journal article, manuscript, manual, etc.) (specify) _____

7. Copies Transmitted to OSTI ("x" one or more)

☐ a. Copies transmitted for unclassified distribution.

☐ b. Copies transmitted for special distribution.

☒ c. Two reproducible copies transmitted.

☐ d. Ten copies transmitted for OSTI processing and NTIS sales.

☐ e. Copies transmitted for classified distribution as defined in M-3679.

☐ f. One copy transmitted for OSTI classified processing.

8. Document contains information pertaining to any of the following:

☐ Yes ("x" one or more) ☒ No (if no, unlimited distribution may be made within the U.S. In addition, copies may be made available to Foreign requestors through exchange agreements or NTIS sales.)

☐ a. Classified
(Announce to addresses in M-3679)

☐ b. Official Use Only (OUO)

☐ c. Export Control/ITAR/EAR

☐ d. Proprietary Information

☐ e. Small Business Innovation Research (SBIR)

☐ f. Unclassified Controlled Nuclear Information (UCNI)

☐ g. Patent Sensitivity

☐ h. Translations of copyrighted material
(Boxes b–h will be announced to Government agencies and their contractors)

☐ i. Other (explain) _____
(This designation must be in accordance with written DOE Program Office guidance)

Upon demand, OSTI will make distribution of these documents in accordance with existing laws, regulations, and/or written program office guidance.

9. Patent and Copyrighted Information

a. ("x" one) ☐ 1. DOE patent clearance has been granted by responsible DOE patent group.

☐ 2. Document has been sent to responsible DOE patent group for clearance.

☒ 3. Patent clearance not required.

b. Does this material contain copyrighted information? ☒ No ☐ Yes

If yes, has release been obtained for DOE reproduction? ☐ No ☐ Yes
(attach release)

10. Additional information, remarks, and special handling instructions. (*Do not* identify Sigma categories for Nuclear Weapon Data reports, and *do not* provide additional instructions which are inconsistent with item 8 above.) (Continue on separate sheet, if necessary)

11. Submitted by (Name and Position) (Please print or type)

J. A. DUSCHINSKI, TECHNICAL INFORMATION MANAGEMENT

Phone: FTS 239-3992

(Organization) WESTINGHOUSE SAVANNAH RIVER COMPANY

Signature: J. A. Duschinski

Date: 12-7-90

WSRC-RP-89-1093

SAVANNAH RIVER LABORATORY
WESTINGHOUSE SAVANNAH RIVER COMPANY

Key words: offsite doses,
1988 operations,
radiological effects

October 25, 1989

To: A.L. Boni
From: L.R. Bauer LRB

RADIOLOGICAL EFFECTS OF SRS OPERATIONS - 1988 (u)

A review of the offsite impact from SRS atmospheric and liquid releases in 1988 has been completed. The results of that study are described in this report. The data for 1988 and the period 1979 - 1988 are discussed.

Distribution:

J.S. Moore, 703-A
A.L. Schwallie, 703-A
J.N. Herrman, 703-A
T.M. Anderson, 703-A
R.T. Begley, 773-A
J.L. Gallagher, 703-A
C.W. Thiessen, Hitchcock
S.A. Weber, 703-A
T.V. Crawford, 773-A
F.F. Cadek, Woodside
H.D. Harmon, 773-A
R. Maher, 703-A
D.L. McIntosh, 773-A
D.A. Orth, 773-A
W.C. Reining, 703-A
J.D. Spencer, 773-A
W.H. Carlton, 735-15A
J.E. Haywood, 703-H
E.W. Holtzscheiter, 773-A
J.R. Knight, 773-A
W.P. Mayson, Jr., 235-H
D.B. Moore, 773-A
J.F. Ortaldo, 707-H
L.W. Papouchado, 703-A
J.S. Roberts, 703-A
D.A. Stevenson, 735-15A
M.F. Sujka, 703-A
G.T. Wright, 773-A
R.P. Addis, 773-A
J.B. Gladden, 773-42A
D.E. Gordon, 703-52A
C. Gurosik, 233-5H
D.D. Hoel, 735-A
W.L. Marter, 742-A
J.C. McKibben, S-1
C.W. Mettlen, 704-M
D.C. Nichols, 704-35S
D.M. Hamby, 773-A
R.A. Moyer, 773-42A

RADIOLOGICAL EFFECTS OF SRS OPERATIONS IN 1988

SUMMARY

Atmospheric Releases

Releases of radioactivity to the atmosphere were generally lower in 1988 than in 1987. No major unplanned tritium releases were recorded during the year. There were, however, three inadvertent releases of Pu-238 from F Area in January, March and October of 160, 32 and 83 uCi, respectively. These releases did not significantly impact the offsite population.

As in previous years, SRS atmospheric releases were minor contributors to offsite individual and population doses.

Liquid Releases

Radioactive releases to onsite streams from direct discharges and seepage basin migration decreased in 1988. However, the average Savannah River flow rate for 1988 was 5670 ft^3/sec, the lowest annual average since plant start-up. As a result of this decrease in dilution volume, higher offsite population doses were reported in 1988. The maximum individual dose, conversely, was down from 1987. This decrease reflected the fact that the maximum individual dose is most significantly affected by the cesium concentration in fish. In 1988, though overall cesium releases were up, measured Cs-137 concentrations in fish were down. This reduction in the offsite transport of cesium in the Savannah River may have been attributable in part to the lower flow rates of the river and the onsite streams in 1988.

Report Description

A discussion of the offsite effective dose equivalents reported for 1988 SRS releases serves as the basis for this report. Detailed analyses of atmospheric and liquid release trends and their consequences in terms of relative importance among facilities, radionuclides, and exposure pathways have also been included.

Doses from SRS releases.

	1988	1987	1986
Atmospheric			
Average individual, mrem	0.18	0.26	0.25
Maximum individual, mrem	0.46	0.64	0.60
80-km population, per-rem	21.0	29.3	25.7
Liquid			
Maximum individual, mrem	0.79	0.93	0.74
Offsite population, per-rem	6.2	5.9	6.9

Annual Natural Radiation Background Dose.

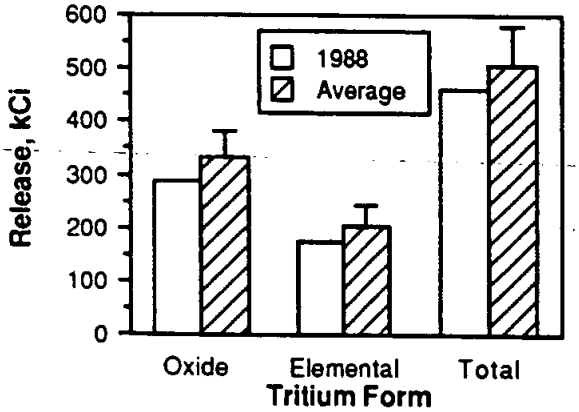
Average individual in the CSRA 295 mrem

ATMOSPHERIC RELEASES

The quantities of radionuclides released to the atmosphere by the SRS in 1988 are shown in Table 1. As in previous years, the primary sources of radioactivity were the reactors and the separations facilities. In terms of largest contributors to dose, the releases were dominated by H-3, Ar-41, and I-129.

Tritium. In 1988 approximately 38% and 62% of the atmospheric tritium oxide emissions from the SRS originated in the reactor and separations areas, respectively. All of the elemental tritium, conversely, came from the separations facilities. Because elemental tritium is biologically inert, the impact of tritium on the offsite environment is primarily dependent upon how much tritium is released in the oxide form.

Tritium releases in 1988 were slightly lower than the 10-yr average reported in Figure 1. This is partially attributable to smaller unplanned tritium releases during the past year. The single largest unplanned tritium release in 1988 was an emission of 20,000 Ci (85% elemental, 15% oxide) which occurred in March.



(Oxide and elemental averages based on 1985 - 1988. Total tritium average based on 1979 - 1988.)

Figure 1. Comparison of 1988 atmospheric tritium releases with average release values (+ 1 std. dev.).

Measured data reflecting the relative contributions of elemental and oxide tritium to total tritium release values have been routinely available since 1985. Of primary interest are the tritium oxide release values. As shown in Figure 2, tritium oxide releases have remained in the 300,000 Ci range over the past three years. The somewhat higher oxide value for 1985 was due to leakage of moderator from the C reactor vessel.

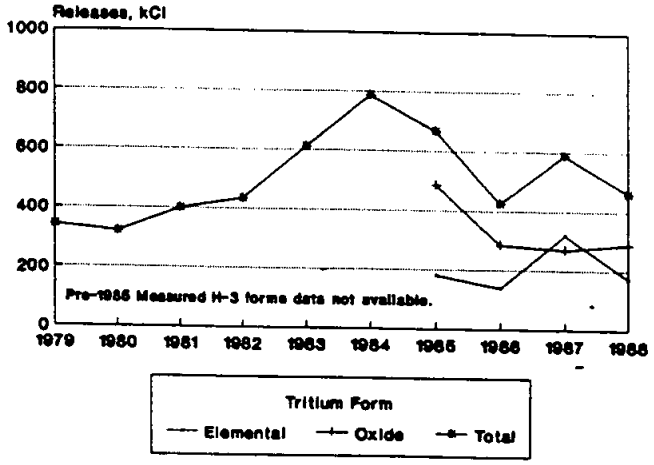


Figure 2. Atmospheric tritium releases, 1979 - 1988.

Ar-41 and other short-lived gases. Reactor releases of argon-41 decreased significantly in 1988 due to the stand-by status of K, L and P reactors throughout the second half of the year (Figure 3). Other reactor-produced short-lived gaseous radionuclides (isotopes of xenon and krypton) did not show comparable decreases because they are released in much smaller amounts. Furthermore, they are less sensitive to, and respond more slowly to, changes in reactor power level.

As seen in Figure 4, argon-41 release rates have varied widely over the period from 1979 to 1988. The 1988 release value represented a 66% decrease from 1987. Also apparent in Figure 4, however, is the relative insensitivity of the xenon and

Table 1. 1988 ATMOSPHERIC Releases, Ci.

Nuclide	Reactors	Sepns	Raw Mat.	H.Water	SRL	Total
		GASES AND VAPORS				
H-3 (oxide)	1.09E+05	1.79E+05	-	3.29E+02	-	2.88E+05
H-3 (elem.)	-	1.74E+05	-	-	-	1.74E+05
H-3 Total	1.09E+05	3.53E+05	-	3.29E+02	-	4.62E+05
C-14	1.10E+01	1.30E+01	-	-	-	2.40E+01
Ar-41	2.95E+04	-	-	-	-	2.95E+04
Kr-85m	1.02E+03	-	-	-	-	1.02E+03
Kr-85	-	2.40E+05	-	-	-	2.40E+05
Kr-87	1.36E+03	-	-	-	-	1.36E+03
Kr-88	1.61E+03	-	-	-	-	1.61E+03
Xe-131m	-	-	-	-	-	0.00E+00
Xe-133	6.97E+03	-	-	-	-	6.97E+03
Xe-135	2.98E+03	-	-	-	-	2.98E+03
I-129	-	6.30E-02	-	-	-	6.30E-02
I-131	4.96E-04	-	-	-	-	4.96E-04
		PARTICULATES				
Co-60	-	3.00E-06	-	-	-	3.00E-06
Se-75	-	2.00E-05	-	-	-	2.00E-05
Sr-89,90(a)	1.90E-03	1.08E-03	-	-	3.40E-05	3.01E-03
Zr-95	-	7.60E-04	-	-	-	7.60E-04
Nb-95	-	2.22E-03	-	-	-	2.22E-03
Ru-103	-	4.61E-04	-	-	-	4.61E-04
Ru-106	-	3.02E-02	-	-	-	3.02E-02
Cs-134	-	1.00E-04	-	-	-	1.00E-04
Cs-137	-	1.78E-03	-	-	-	1.78E-03
Ce-141	-	1.60E-05	-	-	-	1.60E-05
Ce-144	-	4.56E-03	-	-	-	4.56E-03
Os-185	-	3.00E-05	-	-	-	3.00E-05
U-235,238	-	1.47E-03	2.79E-06	-	-	1.47E-03
Pu-238	-	6.16E-04	-	-	-	6.16E-04
Pu-239(b)	-	6.75E-04	2.32E-06	-	1.00E-05	6.87E-04
Am-241,243	-	1.18E-04	-	-	-	1.18E-04
Cm-242,244	-	6.70E-05	-	-	-	6.70E-05
					Total	7.46E+05

a. Includes unidentified beta-gamma.

b. Includes unidentified alpha.

krypton release rates to year-to-year variations in reactor utilization.

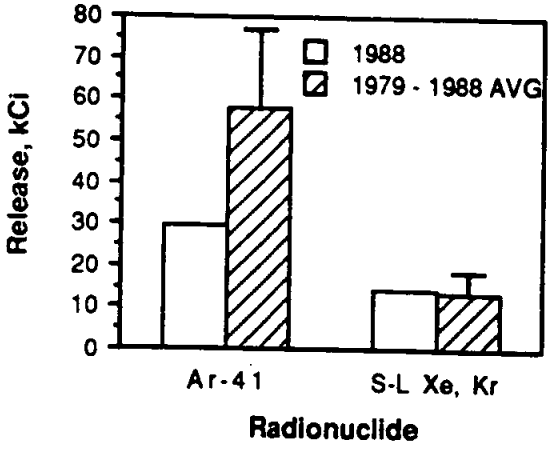


Figure 3. Comparison of reactor atmospheric releases of short-lived radionuclides with 1979 - 1988 averages (+ 1 std. dev.).

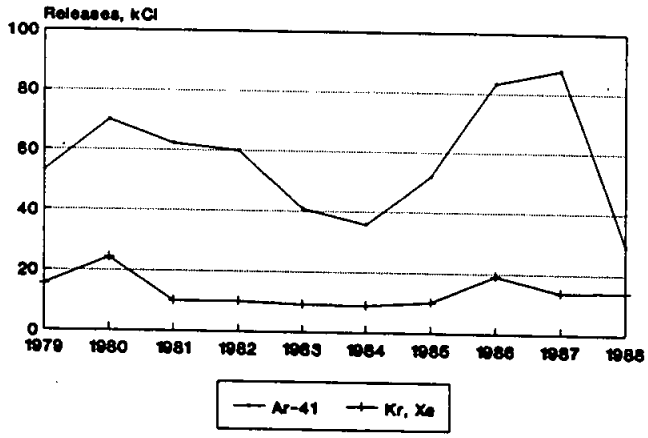


Figure 4. Atmospheric releases of short-lived radionuclides from the reactor areas, 1979 - 1988.

Radiolodines. Small quantities of the isotopes iodine-129 and iodine-131 are periodically released to the atmosphere from SRS operations. The separations and the reactor facilities are responsible for most of the I-129 and the I-131 emissions, respectively.

As indicated in Figure 5, iodine releases in 1988 were down markedly from previous years. I-129 releases were 28% lower than the ten-year average, and the I-131 releases were essentially eliminated by reactor shutdowns.

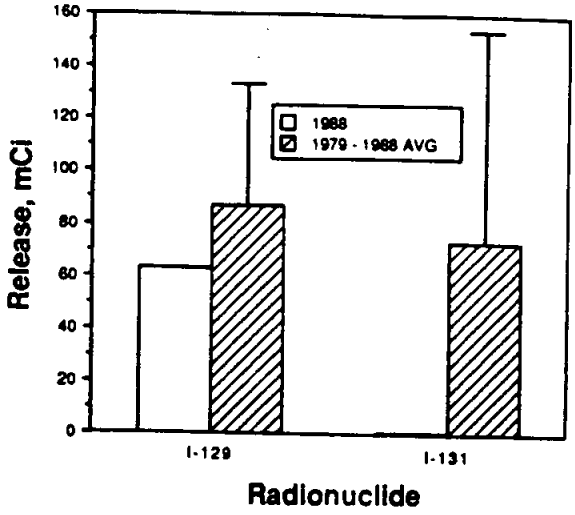


Figure 5. Comparison of atmospheric releases of radiolodines with 1979 - 1988 averages (+ 1 std. dev.).

Iodine-131 is a minor contributor to the offsite dose from atmospheric SRS releases due to its rather short half-life (8 days). Iodine-129, conversely, typically represents about 10% of the offsite atmospheric dose because of its persistence in the environment (half-life = 1.57 x 10^7 years), its ability to move through the food chain, and its radiological effectiveness (dose per unit activity ingested).

The combined factors of the long half-life and low release rate of iodine-129 make its detection quite difficult. The measurement of I-129 depends on ultra low-level detection techniques which have been developed at SRS over the past ten years and are not always available. Consequently, I-129 release data have historically been based on estimated values. A general profile of these values is provided in Figure 6.

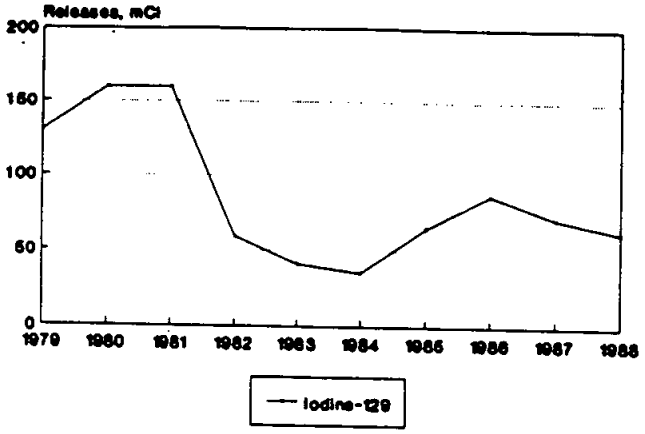


Figure 6. Atmospheric Iodine-129 releases, 1979 - 1988.

Transuranics. Releases of transuranics (TRUs) represent only 2% of the offsite atmospheric doses from SRS, but warrant discussion because they are frequently perceived as being much larger contributors to dose and are sometimes used as gross indicators of F Area performance.

Though TRU release values (especially for plutonium isotopes) vary widely, the data in Figure 7 suggest that TRU releases in 1988 were generally below the ten-year averages. As shown in Figure 8 (expanded below to show greater detail), each TRU release reported was less than 1 uCi. Three minor unplanned Pu-238 releases recorded during the year did not significantly affect the 1988 release numbers. All three releases occurred during maintenance activities, and in each case the contamination was confined onsite.

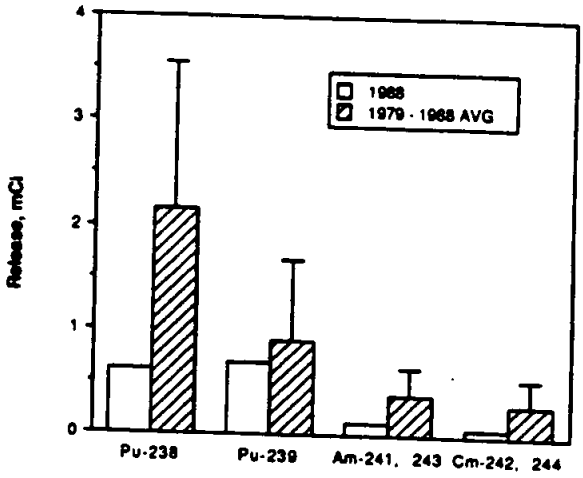


Figure 7. Comparison of atmospheric releases of TRUs with 1979 - 1988 averages (+ 1 std. dev.).

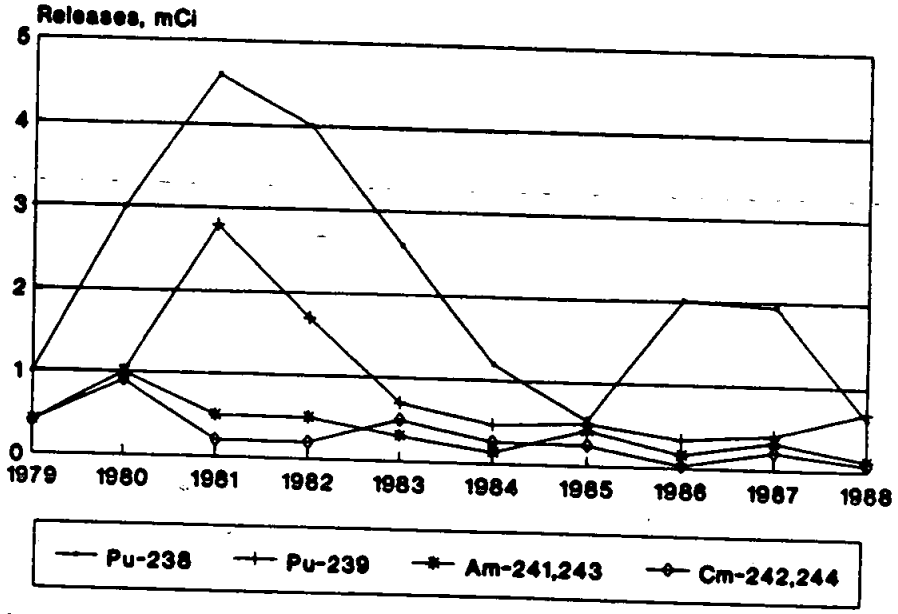


Figure 8. Separations area atmospheric TRU releases, 1979 - 1988.

DOSES FROM ATMOSPHERIC RELEASES

The impacts of radioactive releases are highly dependent upon the definition of the "at risk" individuals or populations and the human parameters (e.g., breathing rates, food consumption, etc.) assigned to these groups. It is possible, however, to draw general conclusions about the characteristics of the Site's radiological impacts.

Key radionuclides. For the maximum and average offsite individuals, and for the offsite population, the 1988 atmospheric doses were dominated by H-3, Ar-41, and I-129. Ar-41's role was diminished in 1988 due to the change in the status of the reactors. Excluding H-3, Ar-41 and I-129, all other radionuclide releases accounted for only 6-13 % of the total atmospheric dose.

Major exposure pathways. When evaluated on a pathway-specific basis, the vegetation, inhalation, and plume exposure routes are the most important -- independent of whether the dose refers to an offsite maximum or average individual or to the 80-km population. The contributions to dose from vegetation and inhalation in 1988 ranged from 25-34% and from 38-42%, respectively, for the various "at risk" groups. Plume dose contributions varied more significantly (8% for the population -- 22% for the maximum individual) because they result from exposure to short-lived noble gases which decay rapidly as a plume travels away from a release point.

1988 Dose data. The dose data for atmospheric releases in 1988 have been reproduced in Tables 2, 3 and 4 for the offsite maximum individual, average individual, and the 80-km population, respectively. Brief discussions of the general trends in atmospheric doses to these groups for the period 1979 - 1988 are presented below. During this 10-yr period, however, three generations of dose codes have been used. (See the Appendix for a complete listing.) Detailed comparisons of these codes have been previously reported (Marter 1984, Marter 1988), and are not included here. This report places special emphasis on the 1986 - 1988 dose data which are based on current transport and dosimetric methodologies.

Dose trends. The trends in offsite atmospheric doses are roughly discernible from Figures 9, 10 and 11. Primarily, the figures serve as indicators of code sensitivity to year-to-year variations in release rates. For this reason, the dose data have been plotted against H-3 and Ar-41 release values. (Atmospheric doses appear to be most strongly correlated with these two radionuclides.) It is important to note when examining the figures that differences in the codes make quantifying long-term dose trends impractical. For example, a range in values from 1.0 to 0.1 mrem is not truly an indication of a ten-fold difference in dose.

Maximum individual. Dose estimates for the "maximum" offsite individual are performed with MAXIGASP, an SRL version of the NRC codes XOQDOQ and GASPAR. MAXIGASP uses conservative estimates of inhalation, intake, and plume exposure rates to establish a bounding dose received by a hypothetical individual living year-round at the Site perimeter.

The estimated dose from all atmospheric pathways for the maximum individual in 1988 was 0.456 mrem, which is approximately 0.15% of the annual dose received from natural sources of radioactivity. As seen in Table 5, the 1988 value reflects a decline in doses over the three-year period of directly comparable data. This decrease in doses generally follows the decrease in releases evident in Figure 9.

Table 2. MAXIMUM Individual Dose Commitment at Site Perimeter
– ATMOSPHERIC RELEASES –

By Pathway

	Average Consumption		Maximum Consumption	
Pathway	Max.Individual Dose, mrem (a)	Percent of Total Dose	Max.Individual Dose, mrem (a)	Percent of Total Dose
Plume	6.38E-02	21.77	6.38E-02	13.99
Ground	3.32E-04	0.11	3.32E-04	0.07
Inhalation	1.13E-01	38.57	1.13E-01	24.78
Vegetation	7.37E-02	25.15	1.96E-01	42.98
Milk	2.05E-02	7.00	5.77E-02	12.65
Meat	2.22E-02	7.58	2.57E-02	5.64
Total	2.93E-01		4.56E-01	

By Radionuclide

	Average Consumption		Maximum Consumption	
Radionuclide	Max.Individual Dose, mrem (a)	Percent of Total Dose	Max.Individual Dose, mrem (a)	Percent of Total Dose
GASES AND VAPORS				
H-3	1.91E-01	65.17	3.04E-01	66.71
C-14	6.64E-03	2.27	1.40E-02	3.07
Ar-41	5.27E-02	17.98	5.27E-02	11.56
Kr,Xe Isotopes	1.12E-02	3.81	1.12E-02	2.45
I-129	2.52E-02	8.60	6.46E-02	14.18
I-131	2.29E-06	0.00	5.11E-06	0.00
PARTICULATES				
Ru-106	1.60E-03	0.55	2.03E-03	0.45
Cs-137	7.69E-05	0.03	1.23E-04	0.03
U-235,238	7.59E-04	0.26	9.00E-04	0.20
Pu-238	1.55E-03	0.53	2.43E-03	0.53
Pu-239	1.94E-03	0.66	3.04E-03	0.67
Am-241,243	3.43E-04	0.12	5.41E-04	0.12
Cm-242,244	1.00E-04	0.03	1.58E-04	0.03
Total	2.93E-01		4.56E-01	

a. Committed effective dose equivalent.

Table 3. 1988 AVERAGE Individual Dose Commitment at Site Perimeter
– ATMOSPHERIC RELEASES –

By Pathway

Pathway	Avg.Individual Dose, mrem (a)	Percent of Total Dose
Plume	3.59E-02	20.56
Ground	2.03E-04	0.12
Inhalation	6.80E-02	38.95
Vegetation	4.47E-02	25.60
Milk	1.24E-02	7.10
Meat	1.34E-02	7.67
Total	1.75E-01	

By Radionuclide

Radionuclide	Avg.Individual Dose, mrem (a)	Percent of Total Dose
GASES AND VAPORS		
H-3	1.15E-01	65.71
C-14	4.01E-03	2.29
Ar-41	2.94E-02	16.80
Kr, Xe isotopes	6.46E-03	3.69
I-129	1.54E-02	8.80
I-131	1.40E-06	0.00
PARTICULATES		
Ru-106	9.73E-04	0.56
Cs-137	4.69E-05	0.03
U-235,238	4.59E-04	0.26
Pu-238	9.42E-04	0.54
Pu-239	1.17E-03	0.67
Am-241,243	2.08E-04	0.12
Cm-242,244	6.09E-05	0.03
Total	1.75E-01	

a. Committed effective dose equivalent.

Table 4. 80-KM POPULATION Dose Commitment
-- ATMOSPHERIC RELEASES --

By Pathway

Pathway	Pop. Dose, person-rem (a)	Percent of Total Dose
Plume	1.65E+00	7.87
Ground	8.47E-02	0.40
Inhalation	8.76E+00	41.76
Vegetation	7.20E+00	34.33
Milk	1.74E+00	8.30
Meat	1.54E+00	7.34
Total	2.10E+01	

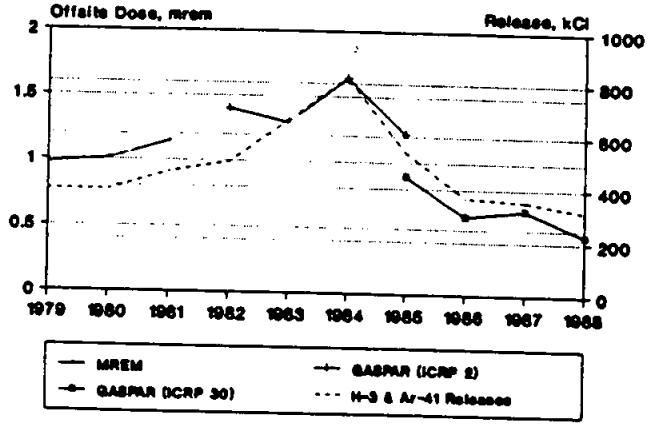
By Radionuclide

Radionuclide	Pop. Dose, person-rem (a)	Percent of Total Dose
GASES AND VAPORS		
H-3	1.60E+01	76.23
C-14	5.73E-01	2.73
Ar-41	1.22E+00	5.81
Kr,Xe isotopes	4.28E-01	2.04
I-129	2.29E+00	10.91
I-131	3.37E-04	0.00
PARTICULATES		
Ru-106	9.48E-02	0.45
Cs-137	9.24E-03	0.04
U-235,238	6.59E-02	0.31
Pu-238	1.22E-01	0.58
Pu-239	1.52E-01	0.72
Am-241,243	2.69E-02	0.13
Cm-242,244	7.89E-03	0.04
Total	2.10E+01	

a. Committed effective dose equivalent.

Table 5. Maximum offsite individual doses from atmospheric releases, 1986 - 1988.

Year	Dose, mrem
1988	0.456
1987	0.644
1986	0.597



H-3 dose component >1985 = HTO only.

Figure 9. Maximum individual doses from atmospheric releases, 1979 - 1988.

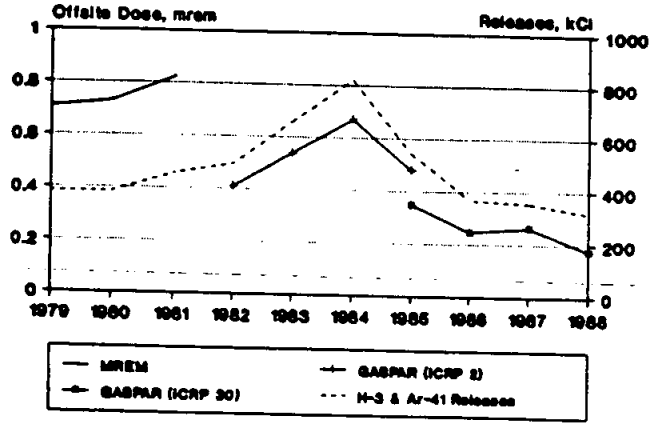
Average individual. Dose estimates for the "average" offsite individual are also performed using MAXIGASP, but in this case more realistic intake and exposure rate estimates are used. The actual dose reported is an average of the doses calculated for an individual located at a number of points along the Site boundary covering all compass sectors. The result is that lower doses following the same general trends seen for maximum individuals are generated.

The 1988 average offsite individual dose was 0.175 mrem -- 0.06% of the average annual dose from natural sources of radioactivity. The values presented in Table 6 show that the contributions from SRS atmospheric releases are essentially imperceptible additions to an average individual's dose from natural radiation sources in the CSRA.

Table 6. Average offsite individual doses from atmospheric releases, 1986 - 1988.

Year	Dose, mrem
1988	0.175
1987	0.263
1986	0.246

As with the doses for the maximum individual, excellent correlation with the tritium and argon-41 release levels (Figure 10) is seen in the values for the average individual. Most notable in the figure is the overall decline in release rates, and therefore doses, from 1984 to 1988.



H-3 dose component >1985 = HTO only.

Figure 10. Average individual doses from atmospheric releases, 1979 - 1988.

80-km population. These dose estimates are based on calculations made with POPGASP, an SRL

version of the XOQDOQ and GASPAR codes designed for population dose assessments.

Population doses are expressed as pooled or collective dose equivalents (person-rem) which may then be used to estimate the number of health effects anticipated in a given population from a given dose. A risk factor commonly applied in this case is the EPA's central risk estimate of 400 fatal cancers per 1,000,000 person-rem (EPA, 1989). If this risk factor is applied to the population dose data for 1988 (Table 7), it suggests that 0.008 excess fatal cancers may be expected in the 555,100-member population within 80 km of the SRS. Conversely, within the projected lifetimes of that population, approximately 94,370 fatal cancers will arise from all other sources.

The offsite population dose profile from atmospheric releases is shown in Figure 11. If the EPA risk factor is applied to the cumulative value in the figure, 698 person-rem, an estimated 0.28 additional cancers might be expected in the population. Therefore, no observable impacts to the offsite population are believed to be associated with the 1979 - 1988 atmospheric releases from the SRS.

Table 7. 80-km population doses from atmospheric releases, 1986 - 1988.

Year	Dose, person-rem
1988	21.0
1987	29.3
1986	25.7

(Based on 555,100 people.)

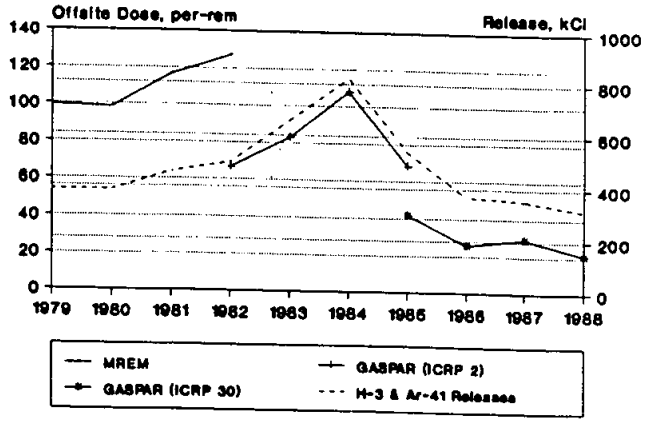


Figure 11. 80-km population doses from atmospheric releases, 1979 - 1988.

LIQUID RELEASES

The quantities of radionuclides released in 1988 to onsite streams are shown in Table 8. As in previous years, the reactors and the separations facilities were the primary sources of radioactivity. In terms of largest contributors to dose, the releases were dominated by tritium, cesium-137 and to a much lesser extent strontium-90.

Tritium. Tritium releases to the Savannah River have two primary sources: direct releases to onsite streams and migration from seepage basins. In 1988, direct releases and seepage basin migration accounted for 28% and 72% of the liquid tritium releases, respectively.

A comparison of the 1988 total tritium release value with the 10-yr average is shown below (Figure 12). From the figure it is evident that tritium releases in 1988 were much lower than the 10-yr average.

Nevertheless, significantly higher than average tritium release rates may be anticipated over the next few years as a result of full-scale

operation of the Effluent Treatment Facility (ETF). The ETF is expected to increase tritium discharges to Upper Three Runs by approximately 30,000 Ci/yr. This increase, however, will be gradually compensated for by a decrease in migration to Upper Three Runs and Four Mile Creek as the tritium inventory in the F- and H-Area seepage basins is exhausted. (The ETF eliminates the need for the separations areas seepage basins.)

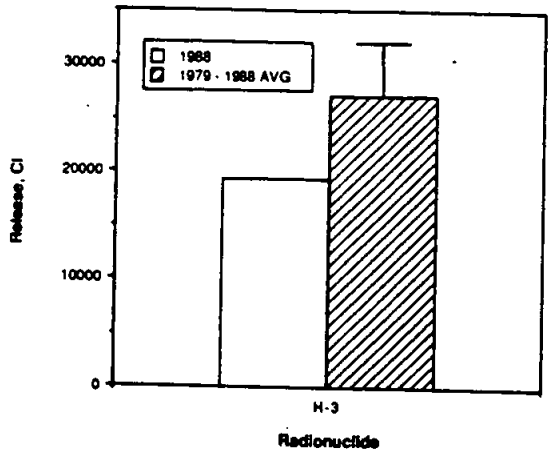


Figure 12. Comparison of 1988 liquid tritium release level with the 1979 - 1988 average (+ 1 std. dev.).

The pattern of liquid tritium releases from the SRS for 1979-1988 is profiled in Figure 13. A comparison of the relative contributions of direct releases and seepage basin migration shows that seepage basin releases have exceeded direct releases over the last decade. The trend shown in the figure may, however, be reversed by the full-scale operation of the ETF.

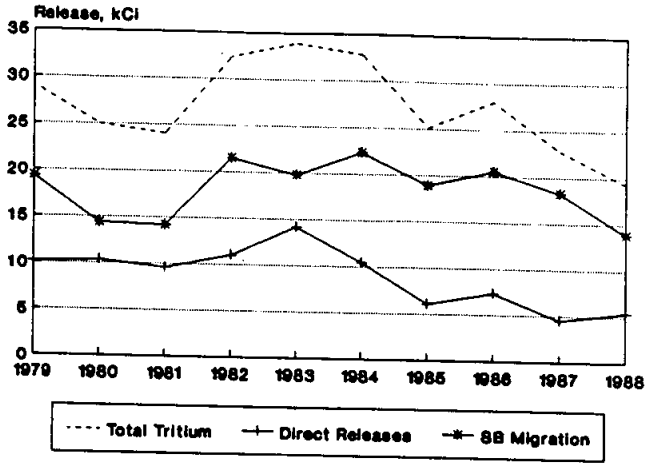


Figure 13. Liquid tritium releases, 1979 - 1988.

Table 8. 1988 LIQUID Releases, Ci

Nuclide	Reactors	Sepns	Raw Mat.	H.Water	SRL	Total
H-3 (a)	6.49E+03	1.11E+04	-	1.74E+03	-	1.93E+04
Co-58,60	-	-	-	-	-	-
Sr-90 (b)	1.38E-01	2.38E-01	-	-	8.23E-04	3.77E-01
I-129	-	2.20E-02	-	-	-	2.20E-02
Cs-137	4.44E-01	1.21E-01	-	-	-	5.65E-01
U-235,238	-	-	5.49E-03	-	1.90E-05	5.51E-03
Pu-239 (c)	1.20E-05	5.32E-03	-	-	2.06E-04	5.54E-03

(a) Direct releases + seepage basin migration .
(b) Unidentified beta releases included as Sr-90.
(c) Unidentified alpha releases included as Pu-239.

Cesium-137. Cesium releases in 1988 were up 49% over 1987 and were 142% higher than the 10-yr average (Figure 14). The reactor and separations facilities were responsible for 79% and 21% of the 1988 liquid cesium releases, respectively. Although cesium release rates from both areas were significantly higher in 1988, no major unplanned releases were recorded and actual release levels remained very low.

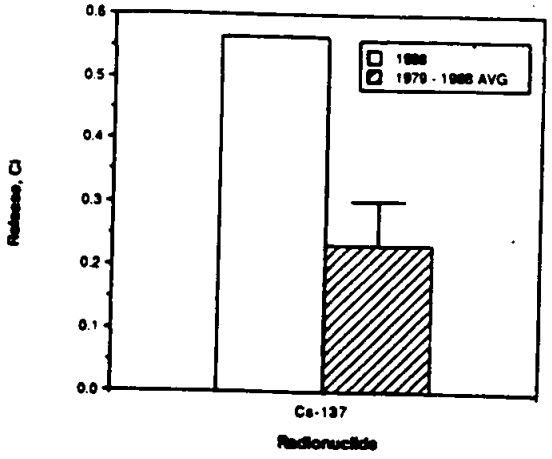


Figure 14. Comparison of 1988 liquid cesium-137 releases with the 1979 - 1988 average (+ 1 std. dev.).

Figure 15 shows the cesium release rates over the period 1979 - 1988. However, the correlation between release ra.. and cesium concentration in the Savannah River (and its biota) is typically very poor. The influence of variations in stream and river flow rates, coupled with the complexity of the other mechanisms affecting cesium transport and sorption, dictates that measured cesium concentrations be used as much as possible when assessing offsite impact.

Strontium-90. Direct discharges of strontium-90 in 1988 were principally released from the reactor areas (36%) and the separations areas (63%), with

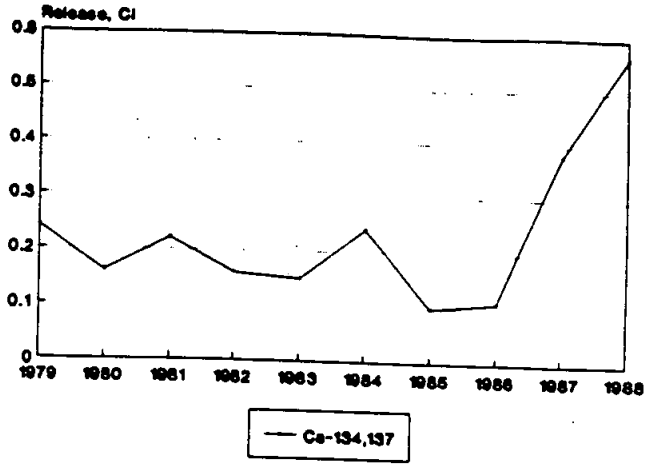


Figure 15. Liquid cesium releases, 1979 - 1988.

a minor contribution (< 1%) from SRL. A secondary source of strontium in onsite streams was seepage basin migration which accounted for an estimated 0.2 Ci in 1988.

It is important to note that the release values reported for strontium-90 include unidentified beta-gamma releases. This is a necessary assumption for dose calculations. With that in mind, the 1988 release value (Figure 16) appears to be only slightly higher than the 10-yr average. The trend data of Figure 17, however, exhibit considerable year-to-year variations due to fluctuations in strontium and unidentified beta-gamma releases from the separations areas.

DOSES FROM LIQUID RELEASES

The impacts of liquid releases from SRS sources are typically evaluated for both a "maximum" individual and a number of downstream population groups. The relative contributions of various radionuclides to these two types of dose assessments are radically different and may vary considerably from year to year. As seen in Figure 18, the dose to the maximum

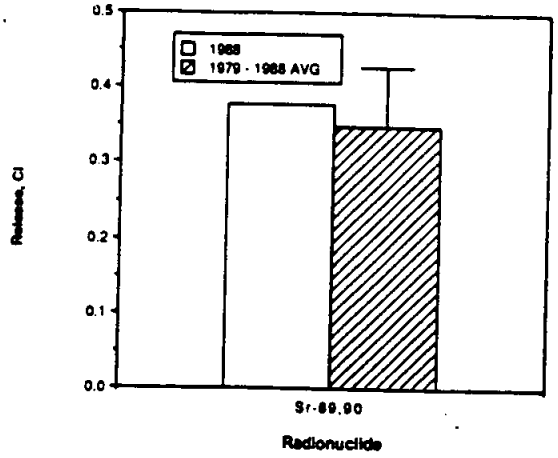


Figure 16. Comparison of 1988 liquid strontium releases with the 1979 - 1988 average (+ 1 std. dev.).

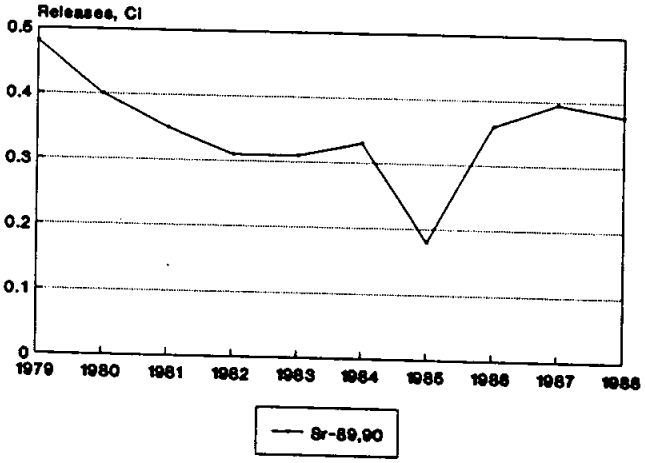


Figure 17. Liquid strontium releases, 1988.

individual in 1988 was principally attributable to cesium-137. This reflects the fact that most of the dose results from the consumption of Savannah River fish in which, based on measured data, cesium accumulates.

For the Beaufort-Jasper and Port Wentworth populations (Figure 19), the doses are calculated base on the radioactivity levels in their drinking water supplies. Because tritium is neither appreciably sorbed on river sediments nor removed by

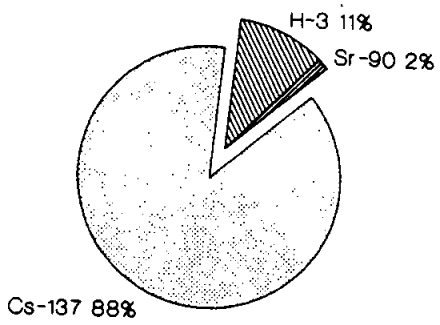


Figure 18. Relative contributions to maximum individual dose from liquid releases, 1988.

conventional water treatment processes, it is responsible for almost all of the dose via the drinking water pathway.

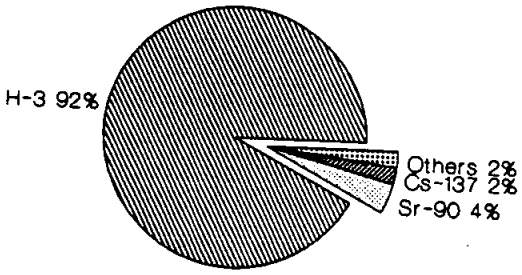


Figure 19. Relative contributions to offsite population drinking water doses from liquid releases, 1988.

Complete dose data for the 1988 liquid releases have been reproduced in Tables 9 and 10 for the offsite maximum individual and the downstream populations, respectively.

Table 9. MAXIMUM Individual Dose Commitment
– LIQUID RELEASES –

By Pathway

Pathway	Max.Indiv. (a) Dose, mrem (b)	Percent of Total Dose
Fish	7.00E-01	89.02
Water	8.56E-02	10.89
Shoreline	7.13E-04	0.09
Swimming	1.34E-06	0.00
Boating	4.03E-06	0.00
Total	7.86E-01	

By Radionuclide

Radionuclide	Max.Indiv. (a) Dose, mrem (b)	Percent of Total Dose
H-3	8.44E-02	10.74
Sr-90	1.18E-02	1.50
I-129	9.41E-04	0.12
Cs-137	6.86E-01	87.28
Pm-147	3.96E-06	0.00
U-235,238	9.63E-06	0.00
Pu-239	2.02E-03	0.26
Total	7.86E-01	

a. Hypothetical person just downstream of SRS. There are no known persons who meet the hypothetical situation.
b. Committed effective dose equivalent.

Table 10. Offsite POPULATION Dose Commitments
– LIQUID RELEASES –

BY PATHWAY

Pathway	Pop. Dose, person-rem (a)	Percent of Total Dose
Sport Fish	1.83E+00	29.51
Comml. Fish	7.74E-02	1.25
Beaufort-Jasp.	3.03E+00	48.86
Port Went.	1.26E+00	20.32
Salt Water Invert.	1.77E-04	0.00
Recreation-River	3.88E-03	0.06
Total	6.20E+00	

BY RADIONUCLIDE

Radionuclide	Pop. Dose, person-rem (a)	Percent of Total Dose
H-3	3.96E+00	63.81
Sr-90	1.82E-01	2.94
I-129	2.13E-02	0.34
Cs-137	1.95E+00	31.53
Pm-147	6.77E-05	0.00
U-235,238	4.15E-03	0.07
Pu-239	1.31E-01	2.12
Total	6.20E+00	

a. Committed effective dose equivalent.

As with the atmospheric releases, the liquid pathway dose codes used at the SRS have been revised over the past ten years. (See listing in the Appendix.) Emphasis here has been placed on the current dose data (1986 - 1988) which use ICRP 30 dose factors.

Although the dose codes have varied over the period 1979 - 1988, dose profiles for the maximum individual and the downstream populations have been included in Figures 20 and 22. The doses were not plotted against release rates because they are also strongly dependent on a number of other variables (e.g., flow rates, desorption rates).

Maximum individual. Maximum offsite individual dose estimates are calculated for SRS liquid releases with LADTAP (Liquid Annual Doses To All Persons), an NRC computer code specifically designed for such applications. As used in LADTAP, a maximum individual is a person who consumes an average amount of water (assumed to be untreated river water) and a maximum amount of fish from the Savannah River at a point just below the SRS. This person also spends many hours of recreational activities (fishing, boating, and swimming) at that location. No such individual is known to exist.

The 1988 effective dose equivalent for the maximum individual was 0.786 mrem (Table 11.) This dose, though unlikely to be received by any individual, would represent 0.3% of the average annual dose typically observed for an individual living in the CSRA from natural sources of radioactivity.

The pattern of maximum individual doses over the 1979 - 1988 period is shown in Figure 20. It is interesting to note that the higher release rate and lower river flow rate of 1988 did not produce a higher dose estimate relative to 1987. This is a reflection of the dependence of maximum individual dose on the concentration of cesium in fish, rather than on the absolute release value. Measured cesium concentrations in fish were lower in 1988 than in 1987, and therefore a smaller dose resulted.

Table 11. Maximum offsite individual doses from liquid releases, 1986 - 1988.

Year	Dose, mrem
1988	0.786
1987	0.932
1986	0.738

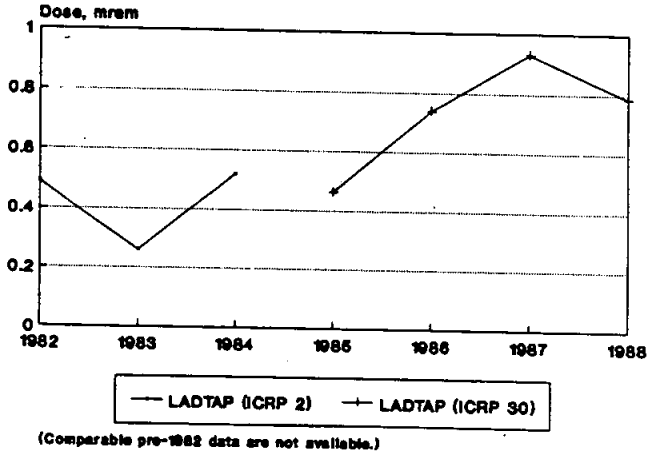


Figure 20. Maximum individual doses from liquid releases, 1979 - 1988.

Offsite population. Population doses from liquid releases are also calculated with the LADTAP code. The nearest known users of Savannah River water below the SRS are two water treatment plants located about 160 km downstream at Port Wentworth, GA, and Beaufort-Jasper, SC. In addition to those two

consumers of commercial and sports fish and for consumers of salt water invertebrates are routinely performed.

Population doses are principally attributable to tritium releases and are based on measured rather than predicted tritium concentrations. Average tritium concentrations in the Savannah River for the period 1979 - 1988 are shown in Figure 21. Data have been presented for sampling locations above and below the SRS and at the Port Wentworth (PW) and Beaufort-Jasper (BJ) water treatment plants (WTPs). The data have been plotted on a scale that indicates how the concentrations compare to the EPA drinking water standard (DWS) for tritium (20 pCi/mL). As seen in the figure, no concentration exceeded 25% of the DWS, and WTP values were typically in the range of 10 - 15% of the standard.

The 1988 population dose reported for liquid releases is 6.2 person-rem (Table 12). Included in this dose are the Port Wentworth (1.26 person-rem) and Beaufort-Jasper (3.03 person-rem) components which account for nearly 70% of the dose (Table 10).

Table 12. Offsite population doses from liquid releases, 1986 - 1988.

Year	Dose, person-rem
1988	6.20
1987	5.96
1986	6.86

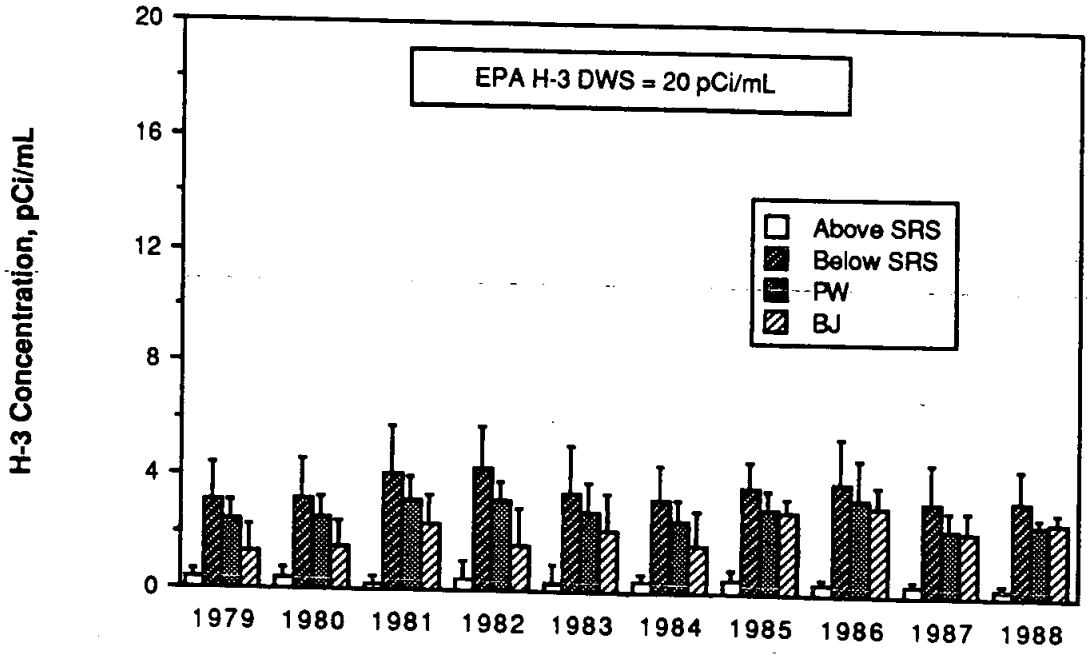


Figure 21. Annual average tritium concentrations in the Savannah River, 1979 - 1988 (+ 1 std. dev.).

A plot of doses over the period 1979 - 1988, Figure 22, shows that the 1988 value is consistent with the range of doses observed over the past several years.

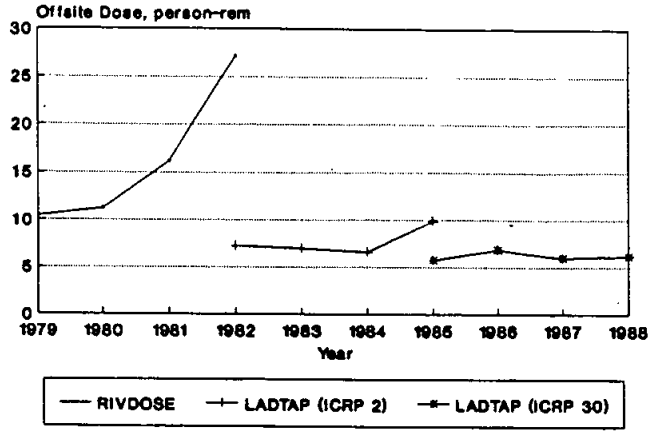


Figure 22. Offsite population doses from liquid releases, 1979 - 1988.

The impact of these doses may be assessed by using the EPA risk factor previously applied to the atmospheric releases. Based on the cumulative dose from liquid pathways for the 1979 - 1988 period, 83.2 person-rem, an additional 0.03 excess fatal cancers might be expected within the 626,150 people upon which the dose asessments are based. During the projected lifetime of that population, an estimated 106,000 fatal cancers attributable to other sources will arise. Therefore, it is unlikely that a relationship between any of the cancers deaths occurring in these population groups and the 1979 - 1988 liquid releases from the SRS will be encountered.

SUMMARY

For a "maximum" individual, the contributions to dose from SRS liquid releases have in recent years exceeded those from atmospheric releases. Overall doses for this hypothetical individual for all atmospheric and liquid SRS releases have remained in the 1.3 - 1.6 mrem range over the past three years. Such doses represent minor components of the doses received from other sources such as natural radioactivity in the terrestrial environment.

With respect to the offsite population, doses from atmospheric releases are generally higher than those from liquid releases, and this trend continued in 1988. Analyses of 1988 data and the data for the preceding decade suggest that radioactive releases from the SRS during this period have not significantly impacted the offsite population.

Acknowledgement. The author notes with appreciation the comments and suggestions of W.L. Marter and D.M. Hamby which were instrumental to the completion of this report.

REFERENCES

EPA (U.S. Environmental Protection Agency), 1989. 40 CFR Part 61 "National Emission Standards for Hazardous Air Pollutants; Regulation of Radionuclides"; Proposed Rule and Notice of Public Hearing, Federal Register, Vol. 54, No. 43.

Marter, W.L., 1984. "Recommended Environmental Dosimetry for Normal Operations at SRP", Savannah River Laboratory, DPST-83-270.

Marter, W.L., 1988. "Radiological Effect of SRP Operations - 1987",

Savannah River Laboratory, DPST-88-784.

Note: Release and dose data were extracted from the annual environmental reports (DPSPU-Year-30-1 series now superceded by the WSRC-RP-Year-59-1 series) for the period 1979 - 1988.

Appendix

Dose Codes Used at SRS 1979 - 1988

Atmospheric Releases

MREM ICRP 2 dose factors 1966 - 1968 meteorological data	1979 - 1981
GASPAR ICRP 2 dose factors 1975 - 1979 meteorological data	1982 - 1985
GASPAR ICRP 30 dose factors 1982 - 1986 meteorological data	1986 - 1988

Liquid Releases

RIVDOSE ICRP 2 dose factors measured dilution factors	1979 - 1981
LADTAP II ICRP 2 dose factors measured dilution factors	1982 - 1984
LADTAP II ICRP 30 dose factors measured dilution factors	1985 - 1988

OSR 14-357
(Rev 10-86)

Rec-11-22-89 ✓

EDITOR NOT NECESSARY...

SAVANNAH RIVER DOCUMENT APPROVAL SHEET

(See SRP Procedures Manual Item 101)

Document Number WSRC-RP-89-1093

UC or C Number UC-702

1. DESCRIPTION OF DOCUMENT (to be completed by author)

TITLE Radiological Effects of SRS Operations in 1988

AUTHOR(S) L. R. Bauer PHONE NO. 5-3280

TYPE: ☒ INTERNAL DOCUMENT ☒ EXTERNAL DOCUMENT

☒ DP Report (TECHNICAL REPORT)

☐ Paper (see below)

☐ Other

Additional Information for External Papers

PAPER FOR: Presentation Only ____ Publication Only XX Both ____

MEETING NAME ____

CITY ____ DATES ____

CHAIRMAN & ADDRESS ____

JOURNAL NAME ____

DEADLINES FOR PUBLICATION: Abstract ____ No. of Copies ____

Paper XX No. of Copies ____

I understand that for information in this paper intended for external distribution:

A. Approvals by both Du Pont and DOE-SR managements are required.

B. Distribution verbally, or by publication, must be in accordance with policies set forth in DOE-SR orders.

C. Content of the external distribution must be limited to that actually approved by DOE-SR.

AUTHOR'S SIGNATURE Linda L Bauer

2. APPROVAL BY AUTHOR'S ORGANIZATION (required for all technical documents)

SRP/SRL ORGANIZATION SRL/ETS

DERIVATIVE CLASSIFIER A. L. Boni A L Boni

Classification Unclassified Topic SRS Radiological Dose Assessments

DISTRIBUTION

____ Limit to List Attached. Reason: ____

____ Limit to SRP & SRL. Reason: ____

____ Limit to DOE-SR & Du Pont Contractual Family. Reason: ____

____ Site-Specific Procedure, Data Sheet, TA, etc.

X Unlimited To General Public

APPROVED BY RESEARCH MANAGER/SUPERINTENDENT A L Boni DATE 11-20-89

3. CLASSIFICATION & PATENT INFORMATION (to be completed by Patent & Classification Reviewer)

CLASSIFICATION (circle one for each)

Overall	S	C	UNCI	U
Abstract	S	C	UNCI	U
Title	S	C	UNCI	U
Cover Letter	S	C	UNCI	U

CLASSIFICATION GUIDE TOPICS

EG-DAR-1

Topic 2.2

PATENT CONSIDERATIONS

Possible Novel Features NA

Closest Prior Art ____

APPROVED BY AED PATENT & CLASSIFICATION OFFICER C J Bonnick DATE 11/22/89

4. PUBLICATIONS DIVISION PROCESSING

DATE RECEIVED ____ PUBLICATIONS SUPERVISOR ____

EDITOR ____ DATE ASSIGNED ____

DATE COPIES SUBMITTED FOR RELEASE ____

DOE-SR RELEASE DATES: Patent Branch ____ Tech. Info. Office 12/26/89

DATE COMPLETED ____ DATE SUBMITTED TO OSTI 12/7/90

(Rec'd 11/28/89 @ 1 P.M. JPS)