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UC-41

Battelle
Pacific Northwest Laboratories
Richland, Washington 99352

AEC Research and Development Report

ENVIRONMENTAL SURVEILLANCE AT HANFORD FOR CY-1971

AUGUST 1972

BNWL-1683

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3 October 1972

HOLDERS OF BNWL-1683, ENVIRONMENTAL SURVEILLANCE AT HANFORD for CY-1971

Subject: Errata

Page 13 — Table 3, under column labeled Vernita Min: the value for alpha should read 0.46 and the value for ^{3}H should read *0.0. The column labeled Richland Min. should read as follows: 0.54, *0.0, *0.0, *0.0, *-20.0, *-7.4, *0.32, *0.0, *-0.40, 3.4

Page 30 — Replacement Table 12 attached.

Page 31 — Units of the ^{131}I concentration are 10^{-9} μCi/ml.

Page 32 — Line 9: ....analytical limit of 20×10^{-9} μCi/ml

Page 38 — Table 13: add the line caption "Analytical Limit" to the line reading 0.6, 1.0, 0.2, 0.1.

Page 43 — Table 17: the title of the last column of the table should read:

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ENVIRONMENTAL SURVEILLANCE AT HANFORD FOR CY-1971

By

P. E. Bramson and J. P. Corley
Occupational and Environmental Safety Department

August 1972

BATTELLE
PACIFIC NORTHWEST LABORATORIES
RICHLAND, WASHINGTON 99352

During 1971, Hanford facilities were operated for the Atomic Energy Commission by: Atlantic Richfield Hanford Company, Pacific Northwest Laboratories of Battelle Memorial Institute, Douglas United Nuclear, Incorporated, ITT Federal Support Services, Incorporated, Westinghouse Hanford Company, and Hanford Environmental Health Foundation.

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INTRODUCTION

The Hanford site of the Atomic Energy Commission has had the primary mission of plutonium production. Activities have included nuclear fuel fabrication, plutonium production and test reactor operation, chemical separations for irradiated fuels, laboratory support and research, waste storage and disposal, and plant support operations. In recent years, privately-owned facilities have been located within the Hanford site boundaries, including a power generating station, office buildings, and a radioactive waste burial site.

The Hanford site is in a semi-arid region of southeastern Washington State (Figure 1) where the annual average rainfall is about 16 cm (6 inches). This section of the state has a sparse covering of natural vegetation primarily suited for grazing, although large areas near the site have gradually been put under irrigation during the past few years. The plant site (Figure 2) covers an area of about 1300 km^2 (500 mi^2). The Columbia River flows through the northern edge of the Hanford site and forms part of the eastern boundary. As indicated by the wind roses shown in Figure 2, prevailing winds near the plant production sites are from the northwest, with strong drainage and cross winds causing distorted flow patterns. The meteorology of the region is typical of desert areas, with frequent strong inversions occurring at night but breaking during the day to provide unstable and turbulent conditions.

The populated area of primary interest is the Tri-Cities area (Richland, Pasco, and Kennewick) situated on the Columbia River directly downstream from the plant. Smaller communities in the vicinity include Benton City, West Richland, Mesa and Othello. The population of the communities near the plant, together with the surrounding agricultural area, is about 100,000.

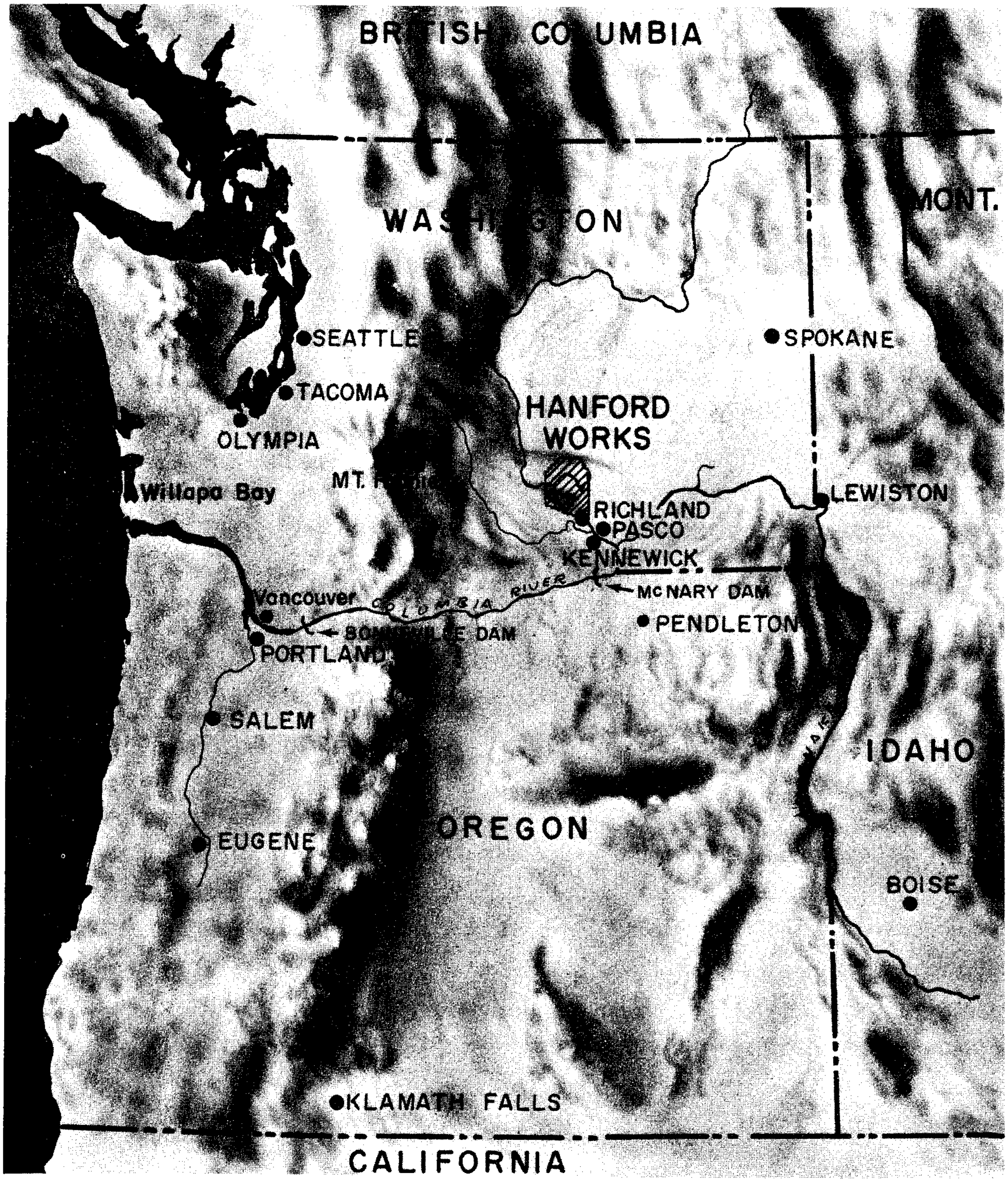

FIGURE 1. Geographical Relationship of Hanford to the Pacific Northwest

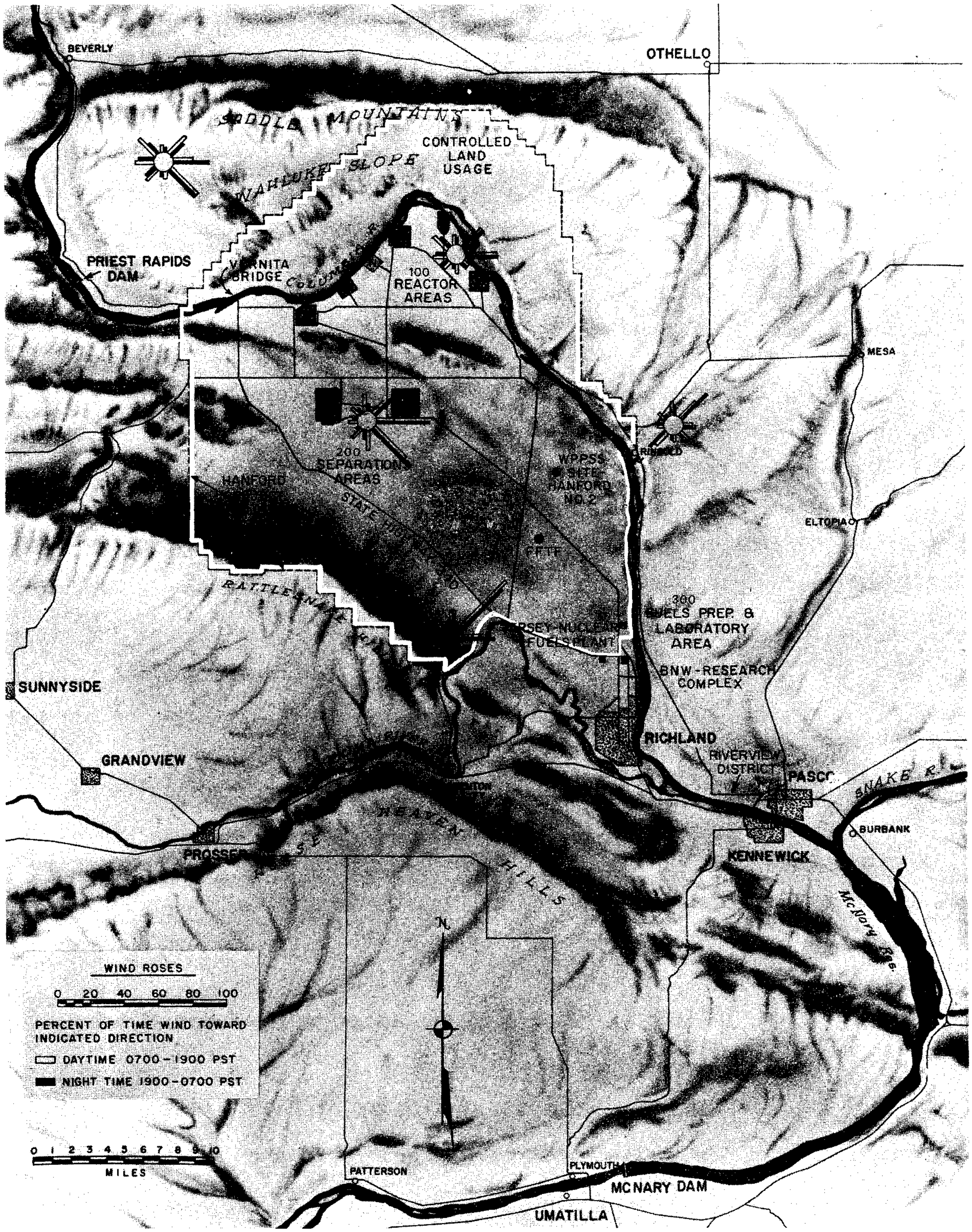

FIGURE 2. Features of Hanford Project and Vicinity

The farming area closest to the separations facilities is at Ringold, about 20 km (13 miles) away, but much of the land east and south of the project boundary is under cultivation and may be in the path of airborne releases. Most irrigated farms near the Hanford plant obtain water from the Yakima River or from the Columbia River above the plant. However, two small irrigated areas using Columbia River water taken downstream from the reactors are the Ringold farms and the Riverview district west of Pasco. These are about 40 km (25 miles) and 70 km (45 miles), respectively, downstream from the operating reactors. The principal products from the larger farm plots are hay, fruit, beef, and dairy products.

Radioactive wastes continued to be generated during 1971 by the Hanford production reactors, chemical separations plants, and laboratories. High level wastes were concentrated and retained in storage in the Chemical Separations areas. Controlled releases of low-level wastes, for which concentration and storage were not feasible, were made to the ground, to the atmosphere, and to the Columbia River.

The most significant Hanford contributions to off-plant radioactivity and population doses have in recent years usually originated with reactor once-through cooling water released to the Columbia River.[1] At one time, nine production reactors, eight with once-through cooling, were in operation at Hanford. Beginning in December, 1964, the older reactors with once-through cooling have been deactivated until only two production reactors remained in operation, N and KE. In January, 1971, the last production reactor with once-through cooling by river water, KE, was shut down. As a result, the amount of radioactivity released to the Hanford environment, other than to soil within the plant reservation, decreased to relative insignificance. N Reactor has a closed primary cooling loop and releases only minor quantities of radioactivity to the river.

Construction of a new reactor, the Fast Flux Test Facility and associated engineering facilities, was well underway in 1971. The reactor location is shown in Figure 2. This reactor will use cooling towers for heat dissipation rather than the Columbia River.

The purpose of this annual report is to present a summary and evaluation of the combined offsite effects of effluents released to uncontrolled areas by all Hanford contractors during 1971 in compliance with AECM-0513.[2] Detailed analytical data on which this evaluation is based have been published as a separate report (BNWL-1683 ADD).[3]

SUMMARY

The 1971 Hanford Environmental Surveillance Program showed continued compliance of the Hanford contractors and their operations with applicable environmental standards. The shutdown of the last of the single-pass cooled production reactors (KE) in January, 1971, eliminated the major remaining source of radioactivity released off-site and of population exposure from Hanford operations. No unusual releases occurred causing Concentration Guides, as given in AEC Manual Chapter 0524, Appendix, Table II, to be exceeded. All measurements of radioactivity outside the plant boundaries were less than 15% of the applicable Concentration Guides. Radiation dose estimates for population groups in the plant environs for 1971 were all less than 1% of applicable standards for plant operations. Off-site measurements of other air and water quality parameters were also well within applicable criteria and showed no significant evidence of plant operations.

SURVEILLANCE PROGRAM

Table 1 summarized those samples and measurements obtained routinely at or beyond the plant boundaries. A detailed listing is given in Appendix C. During January and February, 1971, a number of additional analyses were obtained routinely for dose estimates. These included: (a) weekly analyses of Columbia River water at Richland for P-32 and I-131; (b) monthly analyses of Columbia River water at Richland for the short-lived nuclides Na-24, Mn-56, Cu-64, As-76, Sb-122, Np-239, plus a group analysis for rare earths plus yttrium; (c) analyses of Richland sanitary water for Na-24, P-32, Zn-65, and I-131; (d) analyses for P-32 in local

TABLE 1. Routine Environmental Surveillance Schedule CY-1971

Type of Sample	Type of Analysis	Cont	D	SW	W	SM	M	SQ	Q	SA	A	Annual Total Samples
						WATER						
Columbia River Water	Radioactivity	1			1		3		1			352
	Dose Rate						7					84
	Chemical		1		3							416
	Biological						4					48
Sanitary Water	Radioactivity				3		1					168
	Chemical				2*							104
Waste Water	Radioactivity				1		10					172
	Biological						1					12
Groundwater Wells	Radioactivity						2	114	83	13		1066
	Chemical									7		14
						AIR						
Filters	Radioactivity				12	25						1274
Scrubbers	Radioactivity				2	1						130
Charcoal Cartridge	Radioactivity				4	16						624
						OTHER						
Radiation Level	Dose Rate		1	4		18	37					1588
Shoreline Survey	Dose Rate				1	1	24					366
Ground Control Plot	Radioactivity		1			16	26	12	8			1092
Road Survey	Radioactivity						10		3			132
Aerial Survey	Radioactivity									5		10
Railroad Survey	Radioactivity										1	1
Milk	Radioactivity					6	1					168
Fish Columbia River	Radioactivity					1						26
Wild Fowl	Radioactivity								9		120	156
Mammals	Radioactivity						1		3		7	31
Soil	Radioactivity										66	66
Vegetation	Radioactivity										23	23
Foodstuffs:												
Meat	Radioactivity						1		1			16
Eggs	Radioactivity						1					12
Chicken	Radioactivity								1			4
Produce	Radioactivity										14	11
Oysters	Radioactivity						1					12
												8181

* Samples routinely analyzed and reported by the Hanford Environmental Health Foundation.

farm milk and foodstuffs and in gamebirds; and, (e) sampling and isotopic analyses of other fish species important in the local fisherman's diet. From April to August, when no reactors were operating, no analyses were made for P-32 or I-131 in water or associated exposure pathways.

Air is sampled with constant volume air pumps, operating at 40 l/min (1.5 cfm), with a particulate filter and iodine sampling device in series. Particulate filter media for off-site samples is 47 mm diameter HV-70,* an asbestos fiber mat filter. In addition to the individual filter analyses, all filters are composited in one of four groups for monthly gamma scan and quarterly measurement for plutonium and strontium-90. Radioiodines are routinely sampled with a KI-impregnated charcoal in a 15 cm (6-inch) long cartridge; caustic scrubber (bubbler) samplers were used in earlier years. Charcoal cartridges for most locations are analyzed only when other data indicates the presence of radioiodine in the atmosphere.

Containers for collection of weekly integrated water samples for radiochemical analysis are pre-dosed with concentrated H_2SO_4 to minimize wall deposition and biological activity in the collected sample.

Table 2 gives brief descriptions of the methods used for routine analyses. Routine radioanalyses are by U.S. Testing Company, Richland, Washington. Chemical measurements in Columbia River water are by Battelle-Northwest Laboratories; those in sanitary water and in air are made by the Hanford Environmental Health Foundation, Richland, Washington.

Basic regulations governing radiological criteria for the Hanford environment are embodied in AEC Manual Chapter 0524,[4] with Appendix, which specifies radioactivity release limits, Concentration Guides, and Population Dose Criteria. Federal Air Quality[5] and Washington State water quality standards[6] are also complied with. The routine surveillance program is basically designed to demonstrate compliance with these various standards, although other purposes are also served including emergency preparedness and trend detection.

* Trade name by Hollingsworth-Vose Company.

TABLE 2. Routine Analytical Procedures

Air

Alpha - Direct count of filter on gas flow alpha proportional counter.

Beta - Direct count of filter on gas flow beta proportional counter.

Sr-90 - Leach with HCl, fuming nitric precipitation, barium scavenge, carbonate precipitation, count with gas flow beta proportional counter.

Plutonium - Leach with HCl, precipitation with hydrofluoric acid, extraction with TTA in presence of aluminum nitrate and sodium nitrite, electrodeposition and alpha track counting on NTA film.

Gamma Emitters - Direct count of filter with sodium iodide well crystal. Routine radionuclides: Zr-Nb-95, Cs-134, Cs-137, Ru-Rh-106, Ce-Pr-144.

Iodine-131 - (a) Direct gamma count for iodine-131 on charcoal sample in sodium iodide well crystal.

(b) Precipitation with silver iodide from caustic solution. Direct count with beta proportional counter.

Nitrogen Dioxide - Collection with alkaline solution bubbler. Colorometric determination as azo dye, using sulfanilimide method.(8)

Sulfur Dioxide - Collection with bubbler solution of sodium tetrachloromercurate, with colorometric determination.(9)

Particulates - Collection on Gelman Type A glass fiber filter, with direct weighing for particulate loading.

Water

Alpha - Extraction with diethylether. Count dried residue with gas flow alpha proportional count.

Beta - Count dried residue with gas flow beta proportional counter.

Tritium - After distillation, direct count with liquid scintillation spectrometer.

Phosphorus-32 - Ammonium phosphomolybdate precipitate and gas flow beta proportional counter.

Strontium-90 - Same as for air filters.

TABLE 2. (contd)

(Water)

Iodine-131 - Same as for Air, Iodine-131 (b).

Uranium - Direct fluorometric measurement

Plutonium - Same as for air filters.

Gamma-Emitters - Same as for air filters. Routine radionuclides: Sc-46, Cr-51, Co-60, Zn-65, Cs-137.

Coliforms - (a) Membrane filter method,[7] (b) Multiple tube fermentation method - 48-hour test.[7]

Enterococci - Membrane filter method.[10]

B.O.D. - 5-Day B.O.D. procedure[7]

pH - Direct pH meter measurement.

Turbidity - Direct turbidimeter measurement

Dissolved Oxygen - Direct measurement with polarographic probe.

Nitrate Ion - Phenyldisulfonic method.[7]

Hexavalent Chromium - Continuous automated analyzer measurement (Technicon Autoanalyzer), based on diphenylcarbazide colorimetric method.[7]

Milk

Phosphorus-32 - Ashed, precipitated as ammonium phosphomolybdate, reprecipitated as magnesium ammonium phosphate, beta counted with gas flow beta proportional counter.

Strontium-90 - Ashed, then same as for air filters.

Iodine-131 - Ion exchange whole milk sample. Resin direct gamma counted in sodium iodide well crystal.

Gamma Emitters - Same as for air. Routine radionuclides: K-40, Zn-65, Cs-137, I-131

Solid Foodstuffs and Vegetation

Phosphorus-32 - Same as for milk.

Strontium-90 - Same as for milk.

Plutonium - Ashed, HCl leach, ion exchange, TTA extraction in presence of aluminum nitrate and sodium nitrite, alpha spectroscopy.

Gamma Emitters - Same as for air filters. Routine radionuclides: Co-60, K-40, Zn-65, Co-58, Mn-54, Cs-137, I-131.

TABLE 2. (contd)

Soil

Strontium-90 - HCl leach, then same as for air filters.

Plutonium - HCl leach, then same as for Solid Foodstuffs and Vegetation.

Gamma Emitters - Same as for air filters. Routine radionuclides: K-40, Cs-137

WATER DATA

Radioactivity in the Columbia River

N Reactor, the only production reactor remaining in operation at Hanford after January, 1971, uses recirculating, demineralized water as a primary coolant. Waste water containing some radioactive material is discharged to the ground. Many of the radionuclides are shortlived and disappear quickly due to radioactive decay before reaching the river; others are largely absorbed on soil particles and retained in the soil. The small quantities of nuclides reaching the river from N Reactor have usually been diluted well below detection level in the river.

Seasonal fluctuations in the flow rate of the Columbia River affect radionuclide concentrations by varying the quantity of water available for dilution of reactor effluent released to the river. In addition, scouring by high river flows of sediments deposited in reservoirs behind each dam causes seasonal fluctuations in transport rates of those longer-lived nuclides associated with the sediments. This has been notably true for Sc-46 and Zn-65. Also affected by the river flow rate is the time required for a specific volume of water to move downstream, which in turn affects the extent of decay of shorter-lived nuclides.

Figure 3 shows the weekly average flow rates of the Columbia River at Priest Rapids and Bonneville Dams determined from daily average flow rates published by the U.S. Geological Survey.[11] For 1971, the average river flow rate at Priest Rapids was 3820 m^3/sec (135,000 ft^3/sec) which was slightly above the 1948-1962 annual average of 3770 m^3/sec (133,000 ft^3/sec).

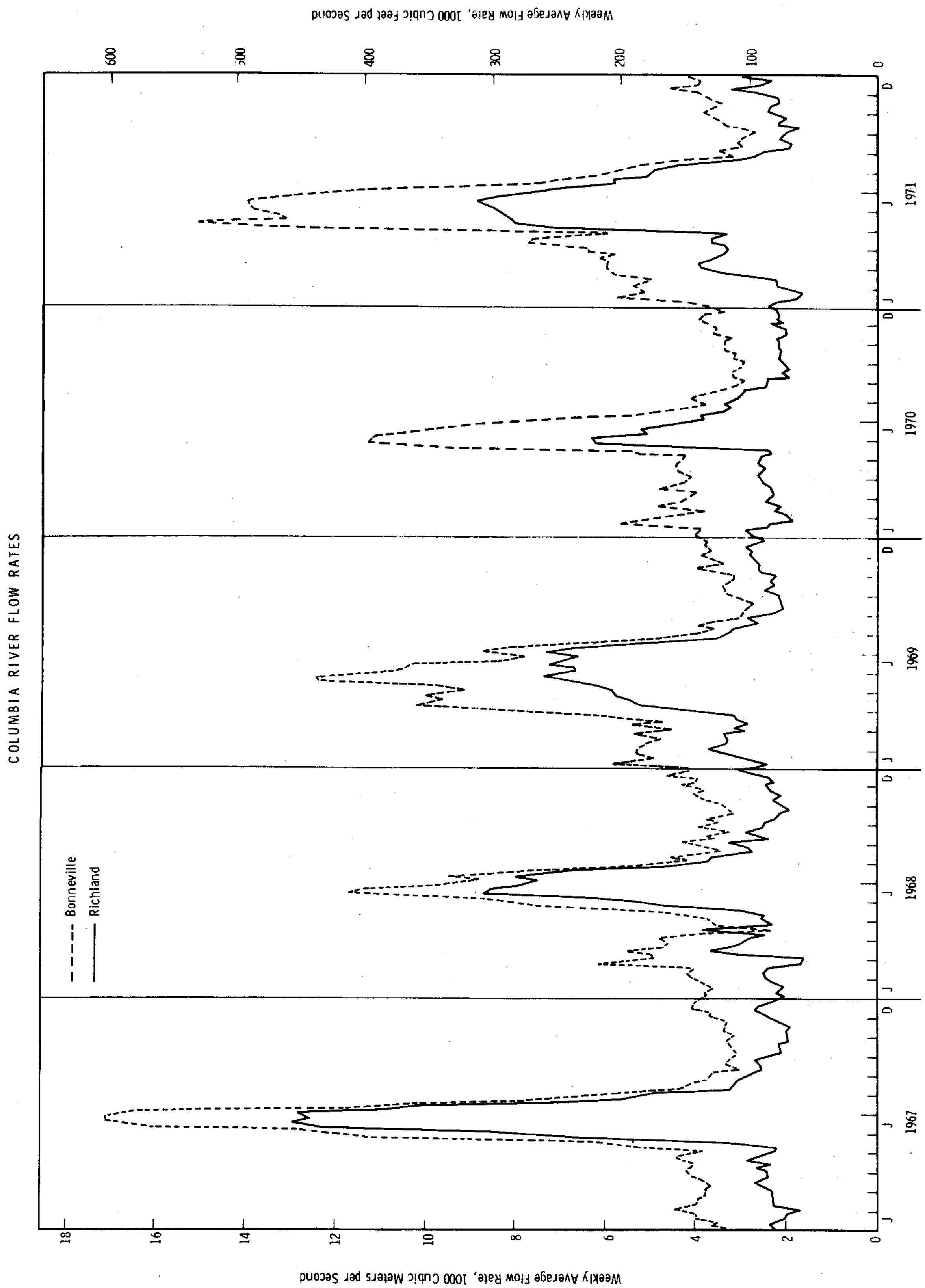

FIGURE 3. Columbia River Flow Rates

During 1971, samples of Columbia River water were collected at Vernita Toll Bridge near the upstream Hanford boundary and at the Richland water plant intake, near the downstream boundary, as well as at McNary Dam and Bonneville Dam. Where possible, cumulative sampling equipment was used to provide a more representative sample than periodic "grab" samples. Concentrations of radionuclides with relatively short half-lives were measured in monthly "grab" samples.

Sampling traverses across the Columbia River at Richland have indicated a slightly nonuniform distribution of the longer-lived radionuclides at this cross section. Entries of the Yakima River just below Richland and of the Snake River just below Pasco influence the distribution of radionuclides in the Columbia below these two points. The magnitude of the influence varies with seasonal changes in the flow rate of the tributaries.

Table 3 shows the maximum, minimum, and annual average radionuclide concentration in Columbia River water at Vernita and Richland for 1971. Possible Hanford contribution to the average river radionuclide concentrations is less than 1% of the Concentration Guides (C.G.) for water for all the radioisotopes in Table 3, except for alpha which is 3.4% of the Concentration Guide for an unknown mixture of alpha-emitters. Past analyses have shown the nautral uranium in the river water to account for at least 90% of the total alpha. Figures 4 and 5 show the river transport rates of five radionuclides past Richland. The transport rates at Richland in 1971 for the five radionuclides show the disappearance of the shorter-lived radionuclides following the KE Reactor shutdown. Some intermittent transport of previously deposited nuclide-bearing sediments continued to give occasional positive transport values.

Bonneville Dam, approximately 490 km (240 miles) below the N Reactor, is the farthest downstream location where river water is routinely sampled as part of the Hanford environmental surveillance program. Measurements at this location provide an upper limit to the annual transport of specific nuclides into the Pacific Ocean (Table 4).

TABLE 3. Average Concentration of Radionuclides in Columbia River Water for 1971 (10^{-9} μCi/ml)

Radionuclide	(a) Analytical Limit	# Of Samples	Vernita Max.	Vernita Min.	Vernita Avg.	% Of C.G.	# Of Samples	Richland Max.	Richland Min.	Richland Avg.	% Of C. G.	C. G.
Alpha	0.3	12	1.2	•0.46	0.84	2.8	12	1.8	0.54	1.01	3.4	30
^{3}H	600.0	12	4300	*0.0	1100	.04	12	1500	*0.0	780	.03	3,000,000
^{32}P	6.0						5	50.0	*0.0	2.5	.003	20,000
^{46}Sc	8.0						21	50.0	*0.0	5.2	.01	40,000
^{51}Cr	40.0						51	590.	*-20.0	85.0	.004	2,000,000
^{65}Zn	10.						21	35.0	*-7.4	4.5	.005	100,000
^{90}Sr	0.06	12	0.54	0.16	0.36	.12	12	3.8	*0.32	0.85	.28	300
^{131}I	2.0						47	4.0	*0.0	0.41	.01	300
^{137}Cs	3.0	3	1.2	*-0.007	0.41	.002	50	28.0	*0.40	5.9	.03	20,000
$U_{nat.}$	3.4						5	4.1	3.4	3.4	.02	20,000

(a) See Appendix A.
* Less than analytical limit. See Appendix A.

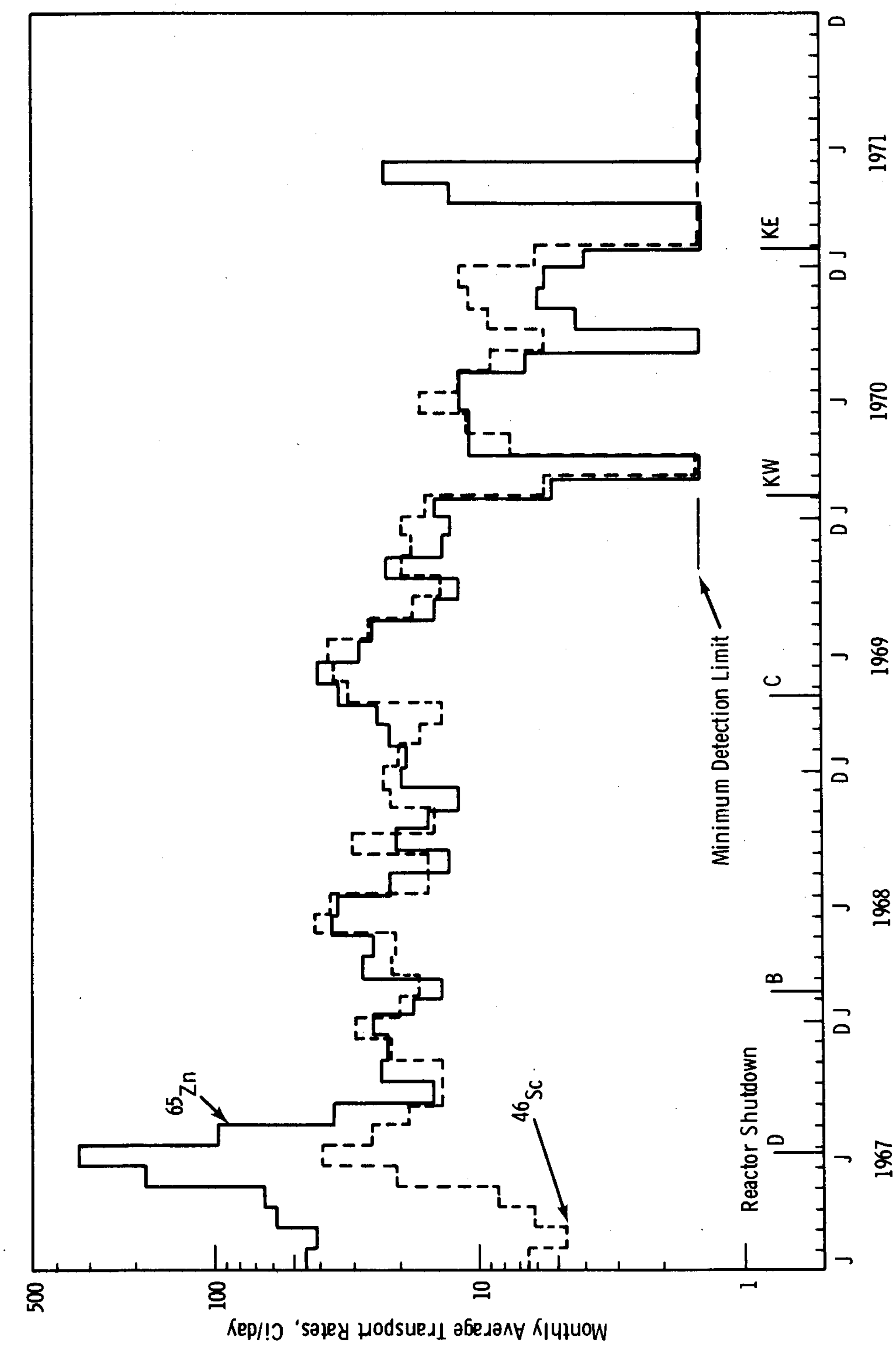

FIGURE 4. Sc-46 and Zn-65 Transport Rates in the Columbia River at Richland (Ci/day)

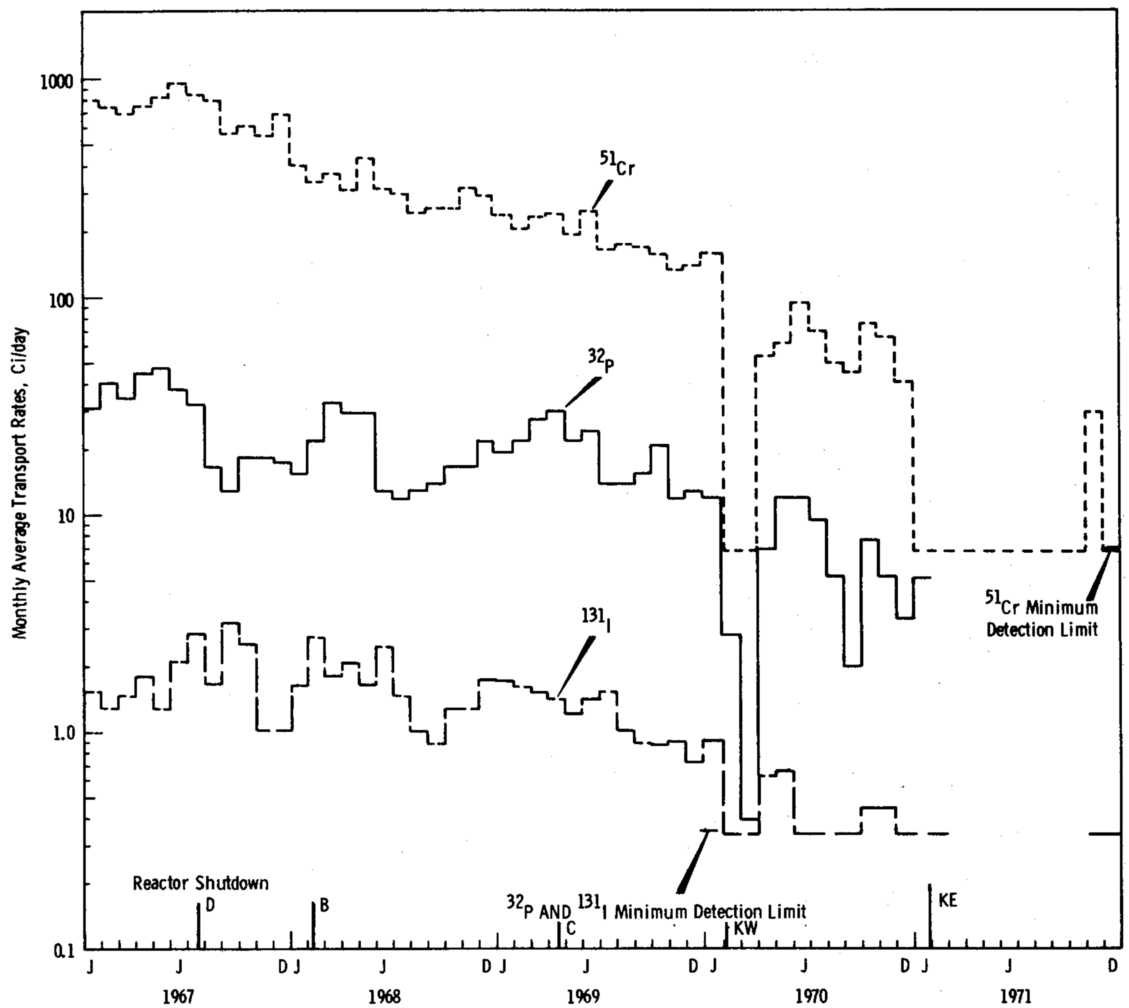

FIGURE 5. Transport Rates in the Columbia River at Richland (Ci/day)

TABLE 4. Annual Average Transport Rate of Selected Radionuclides Past Bonneville Dam, 1967 - 1971 (Ci/day)

Radionuclide	1967	1968	1969	1970	1971
^{32}P	12	6.2	7.1	< 2.3	- -
^{46}Sc	10	7.5	- -	- -	< 1.5
^{51}Cr	610	200	100	< 40	- -
^{65}Zn	40	< 13	< 15	< 4.7	< 3.7

NOTE: The (- -) indicates no routine analysis was made.

Columbia River Water Quality

Measurements of water quality parameters other than radioactivity are routinely made on Columbia River water in order to:

(a) Detect any impact of Hanford waste disposal practices on river water quality.

(b) Demonstrate continued compliance with Washington State water quality standards for the Columbia River and Public Health Service recommendation for sources of drinking water.

Standards[6] applicable to the local river reaches are extracted in Appendix B. In accordance with these, routine measurements are made either at Richland or the Laboratory (300) Area, approximately 8 km (5 miles) upstream from the Richland waterplant, for the parameters for which quantative criteria are given. These are pH, turbidity, dissolved oxygen, coliform organisms, BOD, and temperature. Enterococci measurements are made to clarify the types of coliforms present. In addition, those parameters which are most likely to be affected by Hanford operations are measured both upstream at Vernita and downstream at Richland. These are temperature, hexavalent chromium ion, and nitrate ion.

Temperature increases in the river may reflect the discharge of reactor cooling water to the river, as does the presence of hexavalent chromium, added as a corrosion preventative to the single pass coolant. Nitrate ion increases in the river could reflect the transport by groundwater of nitrate ion discharged with low-level liquid wastes to ground disposal sites within the reservation, as well as influx of groundwater draining from agricultural areas.

Tables 5 - 7 show the annual summaries for 1971 for the above parameters. Table 7 includes temperature data for several previous years for comparison.

Trace element concentrations in the Columbia River have been measured in previous years, but not in 1971. For the years 1968-1969, the data have been published separately.

TABLE 5. Columbia River Biological Analyses for 1971

	Coliform (N/100 ml)		Enterococci (N/100 ml)		BOD (ppm)	
	Vernita	Richland	Vernita	Richland	Vernita	Richland
# Samples	11	11	11	11	11	11
Max.	74.0	195	97.0	112	4.5	5.0
Min.	4.0	13	1.0	1.0	1.4	1.4
Average	34.0	65	22.0	28	3.0	3.0

TABLE 6. Columbia River Chemical Analyses for 1971

	NO_3^- (ppm)	NO_3^- (ppm)	Cr^{+6} (ppm)	pH	Turbidity (J.T.U.)	Dissolved O_2 (ppm)
	Vernita	Richland	300 Area	300 Area	300 Area	300 Area
# Samples	52	51	36	194	181	188
Max.	0.7	4.8	0.0018	9.0	12.0	13.0
Min.	0.1	0.1	0.0	7.2	0.1	8.7
Average	0.28	0.47	- -*	8.1	2.4	11.0

* Discontinued during 1971

TABLE 7. Temperature of Columbia River Water, 1967-1971, Degrees C

# Samples	Priest Rapids Daily			Richland Daily		
Year	Avg.	Max.	Min.	Avg.	Max.	Min.
1967	11.0	19.7	4.6	12.4	22.2	5.4
1968	10.5	19.1	2.5	11.7	20.6	2.0 (est.)
1969	10.7	19.7	0.3	11.2	20.6	1.0
1970	11.0	20.7	3.4	11.6	21.6	3.8
1971	10.4	19.7	2.6	10.7	20.9	2.2

For 1971, biological and chemical measurements of Columbia River water showed compliance with water quality criteria. Temperatures in excess of 68°F (20°C) at Richland were not the result of Hanford operations, since they occurred at a time when no reactors were operating. Increases in river temperature between Vernita and Richland can occur during the summer months from solar heat.

Radioactivity in Drinking Water

The City of Richland, about 75 km (45 miles) downstream from N Reactor is the first community below the project that uses the Columbia River as a source of drinking water. Pasco and Kennewick, a few miles further downstream, also use the Columbia River as a source of drinking water. The Richland and Pasco water plants use a modern flocculation-filtration treatment method; water for Kennewick is pumped from Raney well collectors (infiltration pipes) laid in the riverbed. During 1971, cumulative and grab drinking water samples were collected at the Richland water plant and were analyzed for selected individual radionuclides and gross beta activity (Table 8).

The concentrations of short-lived radionuclides in the water at the time it is consumed are less than shown in Table 8 because there can be a significant transport time between the water plant and most consumers. The transport time may vary from hours to days depending upon the location of the customers on the distribution system and the water demand. Average radionuclide concentrations in Richland drinking water samples were much less than 1% of the Concentration Guides for water except for alpha, which was about 4% of the Concentration Guide for an unknown mixture of alpha-emitters. As stated earlier, most of the alpha activity in the Columbia River, and therefore Richland drinking water, does not result from Hanford operations.

Richland Drinking Water Quality

The Hanford Environmental Health Foundation, as contractor to the Atomic Energy Commission, makes routine measurements for coliform bacteria,

TABLE 8. Average Concentrations of Several Radionuclides in Richland Drinking Water - 1971 (10^{-9} $\mu Ci/ml$)

Radionuclide	[a] Analytical Limit	# Of Samples	Concentration Max.	Concentration Min.	Concentration Avg.	% Of C. G.
Alpha	0.3	9	2.15	*0.16	1.2 (1)	4
Beta (3)	0.02	45	0.056	*0.0	<0.016	
^{32}P	6.0	6	27.2	*3.1	9.5 (2)	0.05
^{46}Sc	8.0	46	38.3	*-6.3	4.1	0.01
^{51}Cr	40.0	46	716.	*-9.7	110.	0.006
^{60}Co (C.G. 50,000)	2.0	46	24.1	0.0	1.8	0.006
^{65}Zn	10.0	52	186.	*-7.4	12.0	0.01
^{90}Sr	0.06	2	0.401	0.35	0.380 (1)	0.01
^{131}I	2.0	6	2.03	*0.51	<0.89 (2)	0.30

(1) November and December only.

(2) January and 1st week of February only.

(3) Counts per minute per milliliter.

(a) See Appendix A.

* Less than analytical limit. See Appendix A

hexavalent chromium, and nitrate ions at all sources used for plant drinking water, including the City of Richland municipal water supply. The objective of the program is to monitor the bacteriological and chemical quality of the plant drinking water, in part obtained from the City of Richland.

During 1971, all bacteriological and chemical measurements were within applicable limits. Annual average concentrations in the Richland water treatment plant were less than 0.001 ppm for hexavalent chromium, and 0.83 ppm for the nitrate ion. The first five months of the year, mercury was also measured and was consistently less than 0.2 ppb. For the last quarter of the year, the average fluoride concentration, also measured at the Richland water treatment plant, was 0.12 ppm.

Groundwater Data

An extensive groundwater monitoring program continued to show little, if any, measurable effect on Columbia River quality from low-level wastes released to ground disposal sites within the Hanford plant boundaries. The data from this program continued to be documented separately, the most recent report in this series being BNWL-1649.(13) A remote possibility exists that radioactive or process materials could penetrate to confined aquifers which generally underlie the Pasco Basin. Several farm wells on the east side of the Columbia River, which are believed to penetrate to these confined aquifers, are routinely sampled for tritium and nitrate ion. The data are not definitive, since contamination from the surface by nitrate from fertilizers and tritium from recent precipitation can also occur. Table 9 shows data from these wells for 1971. The high value for the White Bluffs Association well resulted from one positive sample of 5300×10^{-9} μCi/ml (less than 0.2% of the applicable Concentration Guide), which is not believed to be of Hanford origin since other data from this well and the data from other deep wells closer to plant facilities continued to give negative results.

TABLE 9. Groundwater Analyses from Wells in the Vicinity of Hanford Plant for 1971 (10^{-9} μCi/ml)

Analysis		Webber	Vail	W-15	White Bluffs Association
^3H	# Samples	2	2	2	3
	Max.	<940	<780	<730	5300
	Min.	<520	<520	<680	<510
	Avg.	<730	<650	<700	<2200
	% C.G.	<.02	<.02	<.02	<.07
NO_3^-	Max.	.8	.7	.8	.9
	Min.	<.5	<.5	<.5	<.5
	Avg.	<.65	<.6	<.65	<.7

AIR DATA

Radioactivity in the Atmosphere

Gaseous effluents from the Hanford chemical separations facilities are released to the atmosphere through tall stacks after passage through high efficiency filters. Laboratory stacks, reactor-building stacks, and stacks from waste storage facilities may also release small amounts of radioactive materials after high efficiency filtration.

During 1971, measurements of airborne I-131, total beta, and total alpha were made (as of the end of 1971) at 23 locations around the Hanford reservation. Figure 6 shows the locations of off-site air sampling stations. Figures 7 and 8 show the monthly average I-131 and particulate beta radioactivity in the atmosphere from both nearby locations in the direction of the prevailing wind (Eastern Quadrant) and from more distant perimeter communities.

In mid-1970, caustic scrubbers for radioiodine sampling were replaced with activated charcoal cartridges. The activated charcoal has a much greater collection efficiency than the caustic solution for organic-bound radioiodines. Therefore, the apparently increased radioiodine concentrations noted after June 1970 only reflect this increased

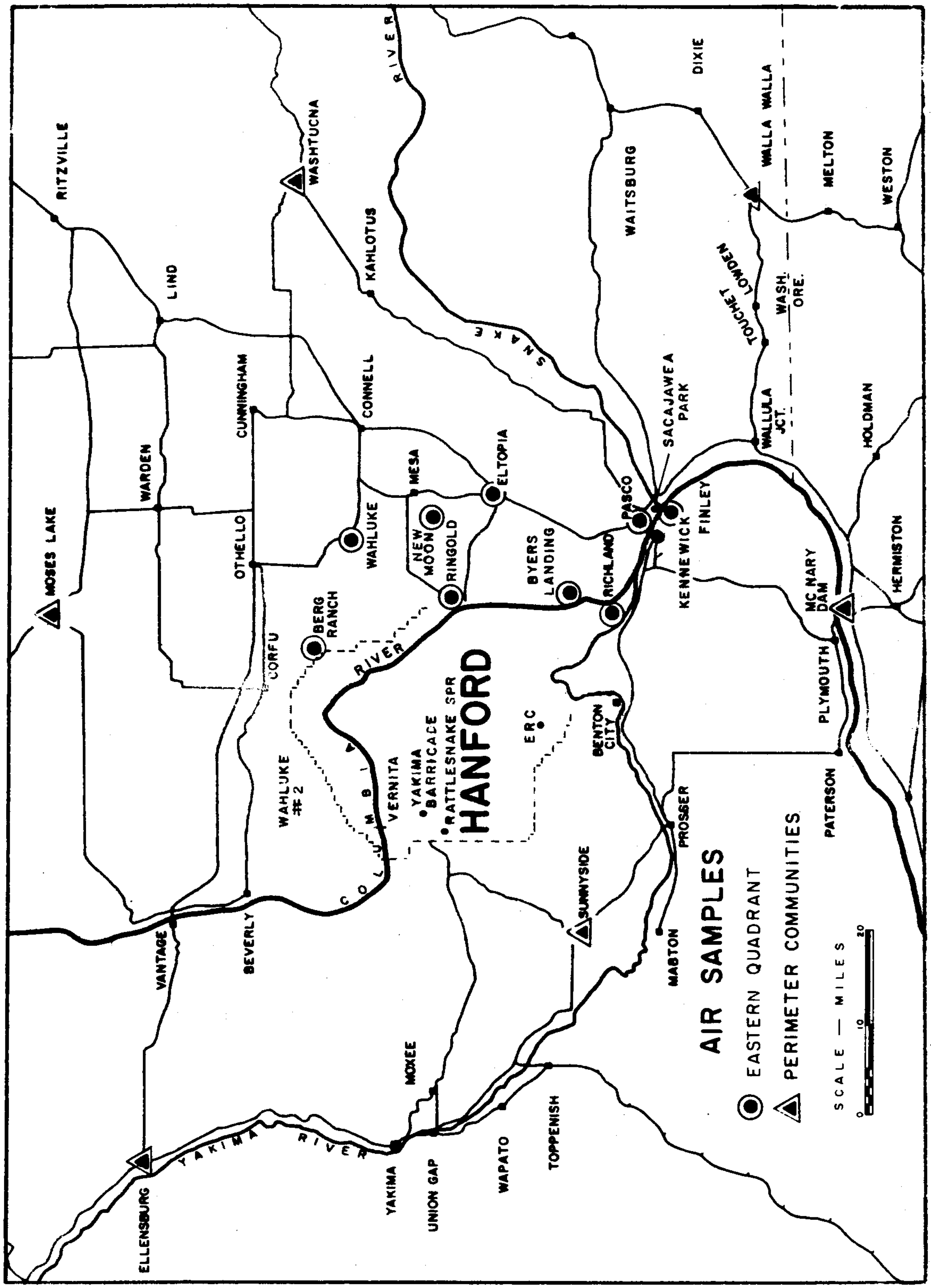

FIGURE 6. Offsite Air Sampling Locations

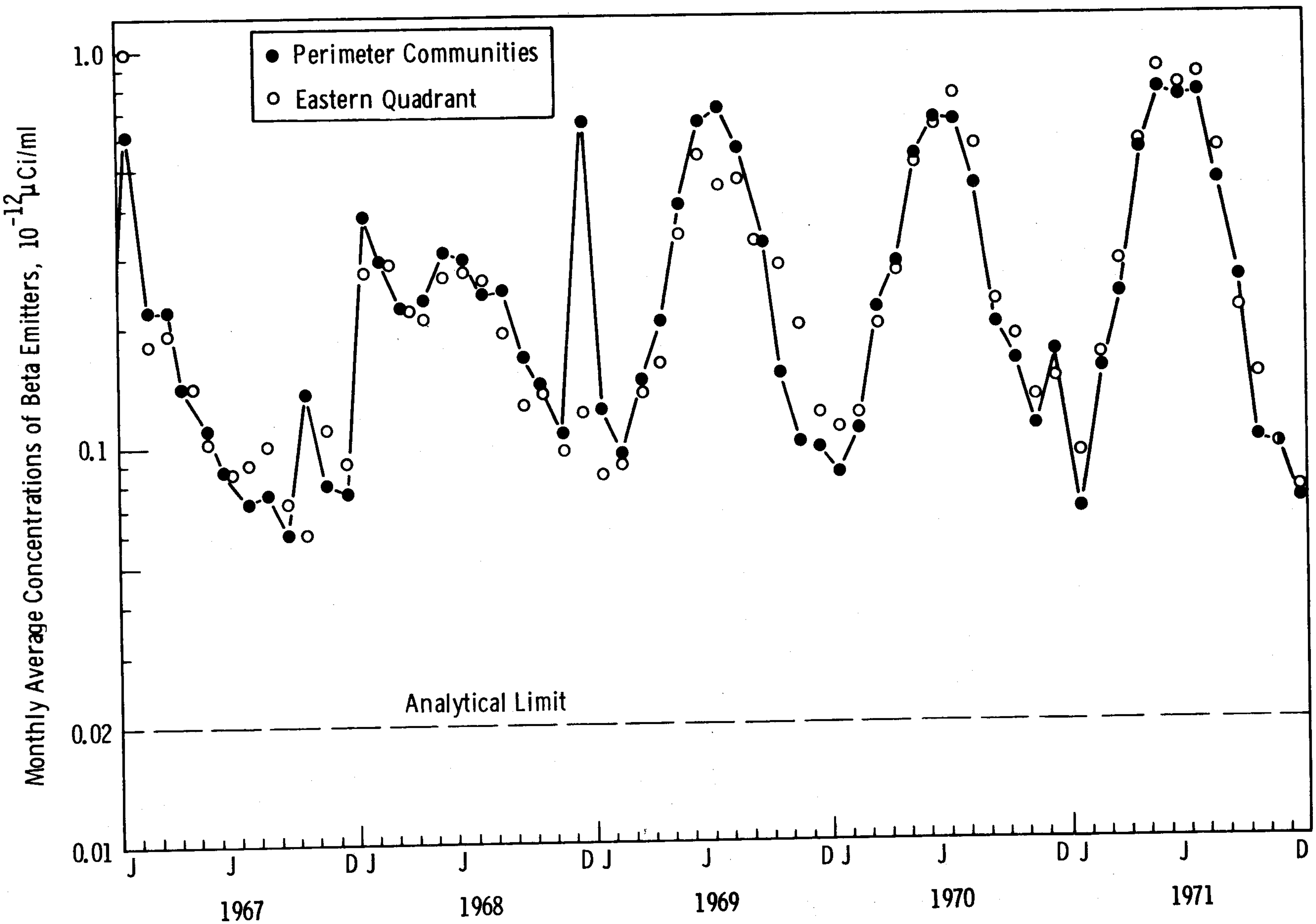

FIGURE 7. Monthly Average Particulate Total Beta Concentrations in the Air of Hanford Environs

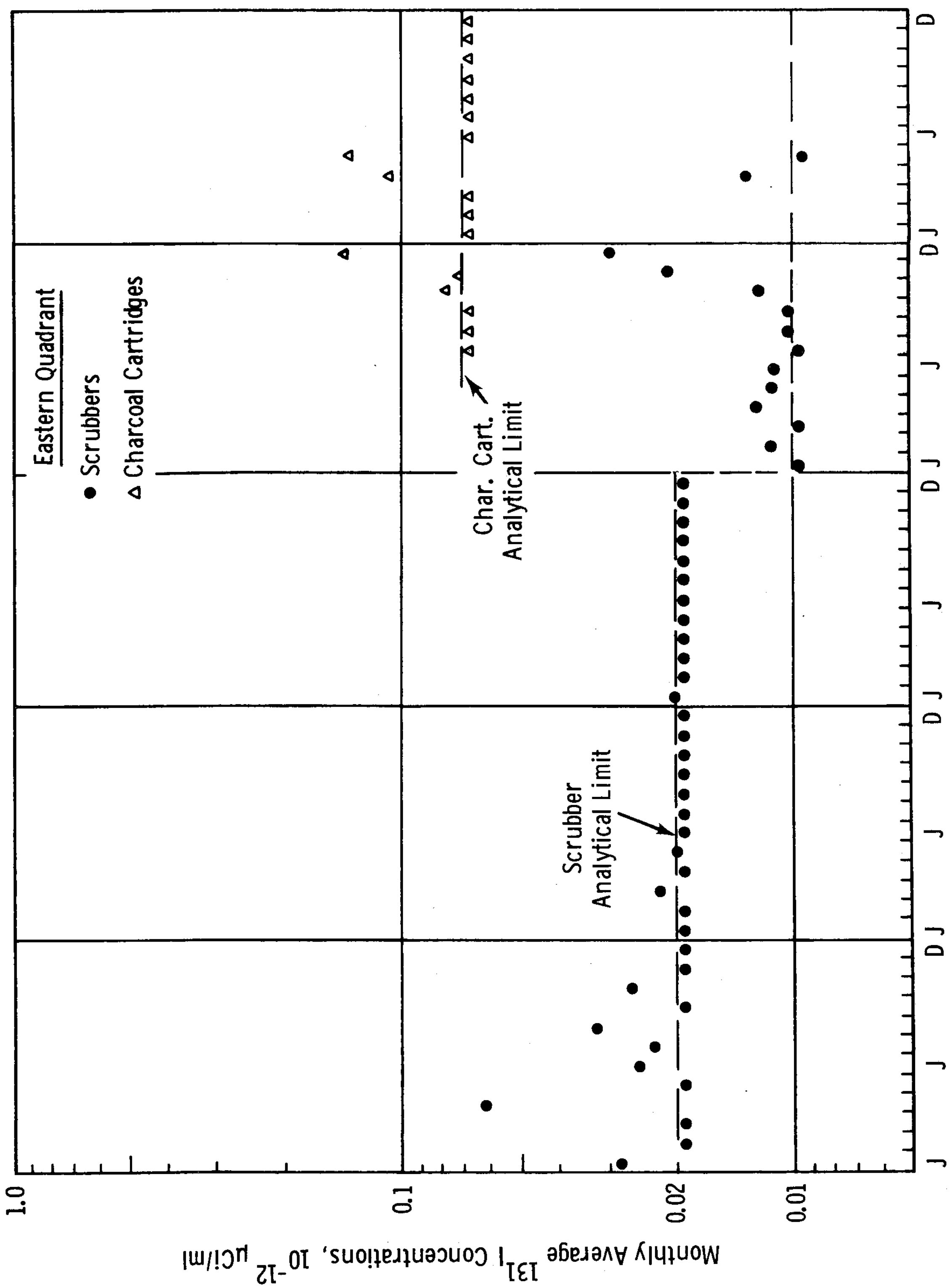

FIGURE 8. Monthly Average I-131 Concentrations in the Air of Hanford Environs

collection efficiency and not an actual change in airborne radionuclide concentrations. Airborne beta concentrations followed the annual cycle observed in previous years and showed about the same maximum and minimum values. Table 10 presents a more detailed review of the 1971 airborne radioactivity data and includes data from the sampling locations on or near the plant boundary. Activated charcoal sampling for I-131 was performed at the perimeter community locations but the samples were only occasionally analyzed when radioiodine was detected in other samples. Concentration Guides shown in Table 10 are taken from AECM-0524, Appendix, for unknown mixtures. Special analyses generally showed Sr-90 to account for less than 10% of the total beta radioactivity, which would raise the actual Concentration Guide to 100×10^{-12} μCi/ml. Average beta concentrations were less than 5% of the more restrictive Concentration Guides. Airborne alpha concentrations averaged less than 15% of the Concentration Guides for air and average I-131 concentrations were less than 0.1% of the Concentration Guides for air. Generally, the average airborne radioactivity concentrations at the Hanford boundary were the same as the more distant sampling locations, indicating that Hanford operations were not contributing significantly to off-site airborne radioactivity.

Air Quality Data

Small atmospheric releases of oxide of nitrogen occur intermittently from Hanford process facilities, and coal-fired steam plants on the project release oxides of sulfur and particulates, within the constraints of the Federal Air Quality Standards (See Appendix B).

The Hanford Environmental Health Foundation, as a contractor to the Atomic Energy Commission, routinely measures the concentrations of nitrogen dioxide, sulfur dioxide, and suspended particulates in the atmosphere at Richland and several other off-site locations. This data, reported in quarterly summary reports by the Hanford Environmental Health Foundation, has been summarized for 1971 in Table 11.

TABLE 10. Radioactivity in Air for 1971 in Units of 10^{-12} µCi/ml

	# Of Samples			Alpha Emitters				Beta Emitters				Iodine-131			
Analytical Limit				0.001				0.02				0.07			
Concentration Guide				0.02				10				100			
Plant Boundary Sampling Points				Max.	Min.	Avg.	% C.G.	Max.	Min.	Avg.	% C.G.	Max.	Min.	Avg.	% C.G.
Yakima Barricade	25	25	26	.012	*.001	.003	15	1.4	.07	.42	4.2	.16	*.006	.004	.004
Vernita	-	26	-	-	-	-	-	2.1	.07	.47	4.7	-	-	-	-
Wahluke #2	-	27	-	-	-	-	-	1.2	.06	.42	4.2	-	-	-	-
Berg Ranch	27	27	27	.015	*.001	.002	10	1.3	.06	.44	4.4	.19	*.015	.019	.019
Ringold	26	26	27	.015	*.001	.003	15	1.3	.04	.39	3.9	.24	*.0005	.023	.023
Byers Landing	25	25	26	.010	*.001	.003	15	1.1	.06	.39	3.9	.15	*.0003	.031	.031
Richland	26	26	27	.010	*.001	.001	5	1.2	.06	.42	4.2	.34	*.007	.037	.037
ECC	-	25	-	-	-	-	-	1.0	.07	.40	4.0	-	-	-	-
Rattlesnake Spr	-	25	-	-	-	-	-	1.4	.08	.46	4.6	-	-	-	-
Benton City	26	26	27	.014	*.001	.001	5	1.4	.07	.42	4.2	.11	*.004	.021	.021
Intermediate Sampling Points															
Othello	24	27	27	.003	*.001	.001	5	1.0	.05	.38	3.8	.19	*.003	.032	.032
Wahluke Watermaster		24	26	-	-	-	-	1.0	.03	.38	3.8	.20	*.001	.012	.012
Connell	-	27	27	-	-	-	-	1.3	.03	.44	4.4	.68	*.004	.065	.065
New Moon	18	26	27	.002	*.001	.001	5	.89	.03	.30	3.0	.18	*.003	.023	.023
Eltopia	-	27	-	-	-	-	-	1.1	.04	.39	3.9	-	-	-	-
Pasco	26	26	26	.016	*.001	.003	15	1.2	.05	.42	4.2	.28	*.002	.031	.031
Kennewick	-	25	-	-	-	-	-	.90	.06	.38	3.8	-	-	-	-
Distant Sampling Points															
Sunnyside	-	26	-	-	-	-	-	1.0	.05	.34	3.4	-	-	-	-
Ellensburg	-	23	-	-	-	-	-	1.1	.04	.31	3.1	-	-	-	-
Moses Lake	-	25	-	-	-	-	-	1.3	.06	.40	4.0	-	-	-	-
Washtucna	-	24	-	-	-	-	-	1.1	.04	.37	3.7	-	-	-	-
Walla Walla	21	26	-	.003	*.001	.001	5	1.0	.05	.35	3.5	-	-	-	-
McNary Dam	18	25	-	.002	*.001	.002	10	1.0	.07	.41	4.1	-	-	-	-

* Less than Analytical Limit. See Appendix A.

For 1971, atmospheric sulfur dioxide measurements within the city of Richland averaged less than 0.02 ppm, and all other off-site measurements were less than the detection limit of 0.01 ppm. Fluctuations of nitrogen dioxide and particulates were attributed to non-plant sources.

TABLE 11. Air Quality Measurements - Annual Averages for 1971

	NO_2 (ppm)				Suspended Particulate ($\mu g/m^3$)			
Location	# Of Samples	Max.	Min.	Avg.	# Of Samples	Max.	Min.	Avg.
Richland (747 Bldg)	49	6.8	.06	.86	42	440	25	120
Opposite Richland (Hobkirk Ranch)	170	0.019	<.001	.005	-	-	-	-
Opposite N. Richland (Gilliam Ranch)	157	3.0	<.001	.024	-	-	-	-
Opposite 300 Area (Sullivan Ranch)	170	0.025	.001	.005	-	-	-	-
Ringold (Keys Ranch)	166	0.028	.001	.006	-	-	-	-
White Bluffs (McLane Ranch)	149	0.028	.001	.006	-	-	-	-

(-) Indicates no measurement was made.

MILK, FOODS, AND BIOTA

Radionuclides in Milk

Irrigation with river water containing radionuclides can contribute radioactivity to local milk and locally grown farm produce, as can deposition of airborne materials from Hanford sources and from weapons test fallout. Chemical separations facilities would generally be the principal local source of airborne radionuclides other than fallout, although unusual radioactivity releases from ventilation stacks of reactor or laboratory facilities could be of interest.

The milk surveillance program maintained during 1971 included samples from local farms and dairies and from commercial supplies available to people in the Tri-Cities. Milk from local farms irrigated with water drawn from the river downstream from the reactors contained Zn-65 and I-131, as well as fission products of fallout origin. Prior to February, 1971 (no single-pass reactors operated after January 1971), milk from these farms contained detectable P-32. However, commercial milk distributed in the Tri-Cities usually did not contain detectable P-32 and Zn-65 because only a small fraction of this milk was produced on farms irrigated with water drawn from the Columbia River below the Hanford reactors.

Figure 9 shows the monthly average concentration of P-32 and Zn-65 in milk from river-irrigated farms in the Ringold and Riverview area for 1967 - 1971. P-32 analysis was discontinued after February 1971. Seasonal fluctuations in radionuclide concentrations, caused primarily by irrigation and feeding practices, followed expected trends. Average P-32 and Zn-65 concentrations in milk for 1971, as shown in Table 12, were less than 0.1% of the Concentration Guides. Even so, such concentrations would have been available only to a few local families.

Figure 10 shows the monthly average concentrations of I-131 in locally available milk. During 1971, I-131 concentrations in both farm milk and commercial milk were generally near or below the analytical limit (2×10^{-9} µCi/ml). The maximum I-131 concentration for the period

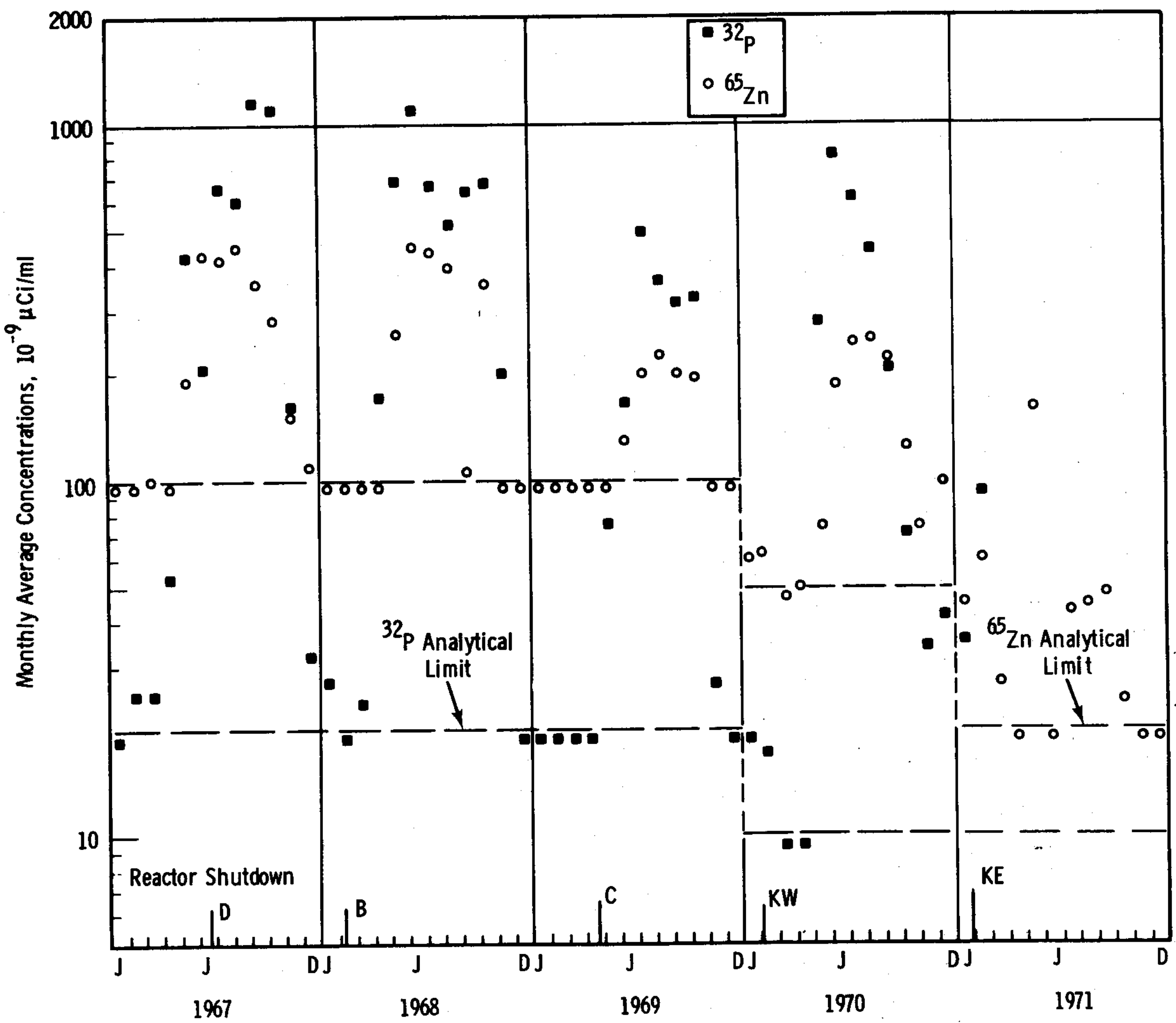

FIGURE 9. Monthly Average P-32 and Zn-65 Concentrations in Milk from River-Irrigated Farms

(25×10^{-9} µCi/ml) was measured in a single sample of farm milk collected on December 2. The average I-131 concentrations locally available in farm milk for 1971 (Table 12) were less than 0.5% of the Concentration Guides for water. Increases of I-131 concentrations in milk, attributed to fallout from atmospheric nuclear weapons testing, were observed the latter part of 1971.

TABLE 12: RADIONUCLIDE CONCENTRATIONS IN LOCALLY PURCHASED MILK AND FOOD

A. Milk (Units of 10^{-6} μCi/ml)

Sample	No. of Samples	^{32}P Max.	^{32}P Avg.	^{65}Zn Max.	^{65}Zn Avg.	^{90}Sr Max.	^{90}Sr Avg.	^{131}I Max.	^{131}I Avg.	^{137}Cs Max.	^{137}Cs Avg.
Concentration Guide (Water)		20		100		0.3		0.3		20	
Analytical Limit		.020		.020		0.002		0.002		.020	
Riverview	1	.10	.015*	.22	.054	.005	.002	.002	.001*	.028	.018*
Benton City & West Richland Composite	52	*	*	.21	.022	.003	.002	.025	.001*	.092	.016*
Col. Basin Composite	52	*	*	.20	.025	.002	.001*	.003	.001*	.081	.018*
Commercial	2	*	*	.17	.028	.006	.004	.003	.001*	.050	.026

B. Foodstuffs (Units of 10^{-6} μCi/gm)

Sample	No. of Samples	^{32}P Max.	^{32}P Avg.	^{65}Zn Max.	^{65}Zn Avg.	^{90}Sr Max.	^{90}Sr Avg.	$^{95}ZrNb$ Max.	$^{95}ZrNb$ Avg.	^{106}Ru Max.	^{106}Ru Avg.	^{131}I Max.	^{131}I Avg.	^{137}Cs Max.	^{137}Cs Avg.	$^{144}CePr$ Max.	$^{144}CePr$ Avg.
Analytical Limit		1.0		.030		.002		.010		.370		.025		.017		.350	
Commercial Meat	12	*	*	*	*	.013	.003	*	*	*	*	*	*	.194	.053	*	*
Poultry	2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Eggs	10	*	*	.93	.23	.012	.007	*	*	*	*	*	*	.036	.015*	*	*
Local Produce	3	*	*	.023*	.014*	*	*	.13	.021	*	*	*	*	.046	.016*	*	*
Commercial Produce	5	*	*	*	*	.039	.008	.242	.046	3.3	.82	*	*	.18	.047	5.3	1.5

NOTE: Mininum detected activities were all below the analytical limit and therefore not included in this table.
* Less than analytical limit. See Appendix A.

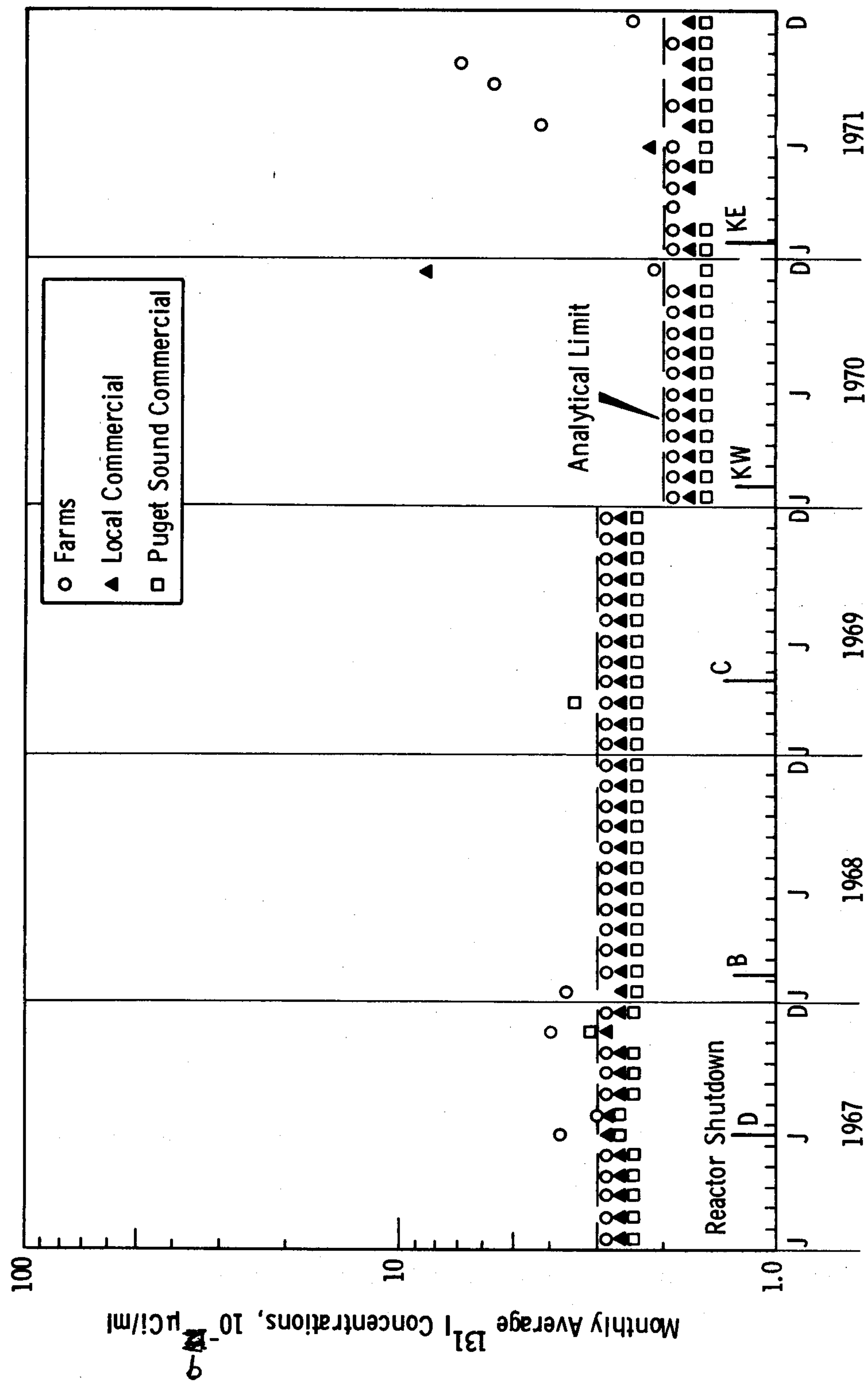

FIGURE 10. Monthly Average I-131 Concentrations in Locally Available Milk

The concentrations of other fallout nuclides, Sr-90 and Cs-137, in the local environs are usually below the national average because of the low rainfall. Measurements of fallout, like measurements of natural background radiation, help to put the radionuclide concentrations resulting from Hanford operations in proper perspective.

Concentration of Sr-90 in locally produced farm and commercial milk (Figure 11) are similar to those in commercial milk produced in other areas of low rainfall remote from the Hanford plant. Concentrations of Cs-137 (Figure 12) averaged near the analytical limit of 20x 10^{-9} μCi/ml. Regional fallout from nuclear weapons testing is the source of Sr-90 and Cs-137 in milk.

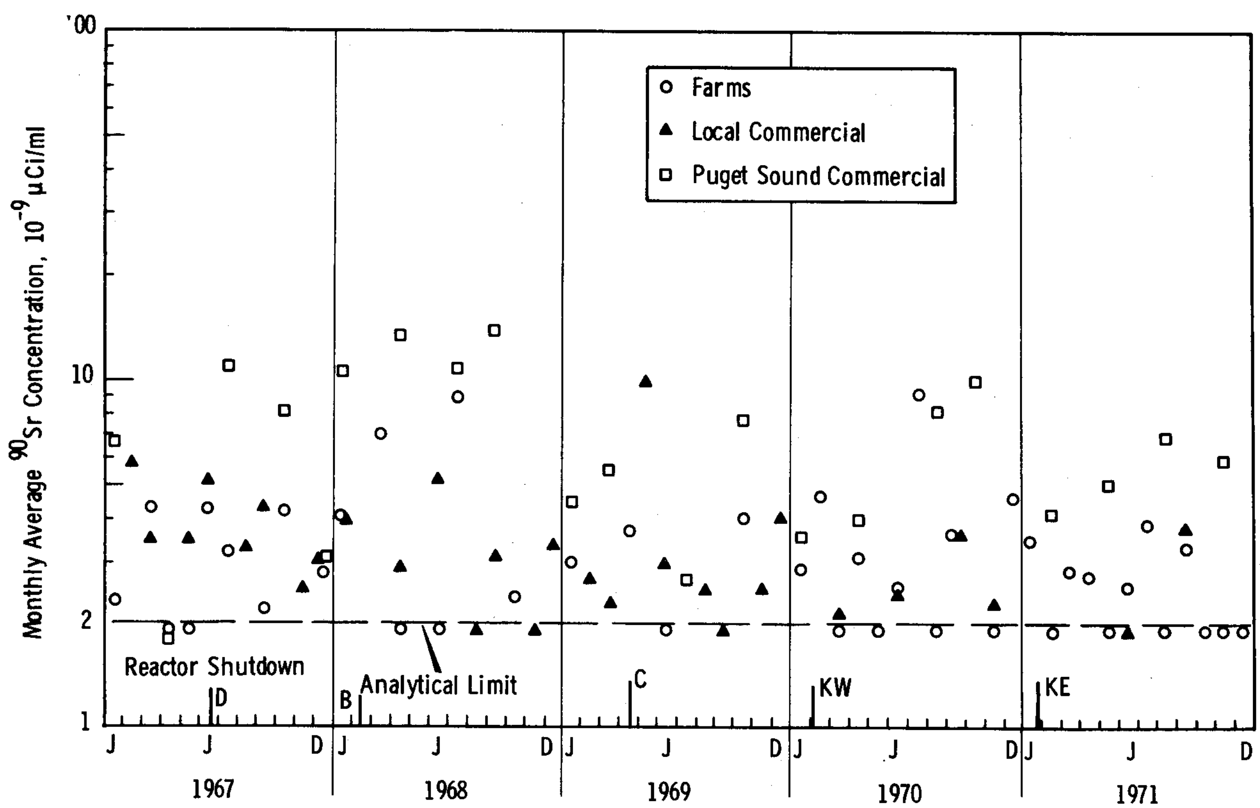

FIGURE 11. Monthly Average Sr-90 Concentrations in Locally Available Milk

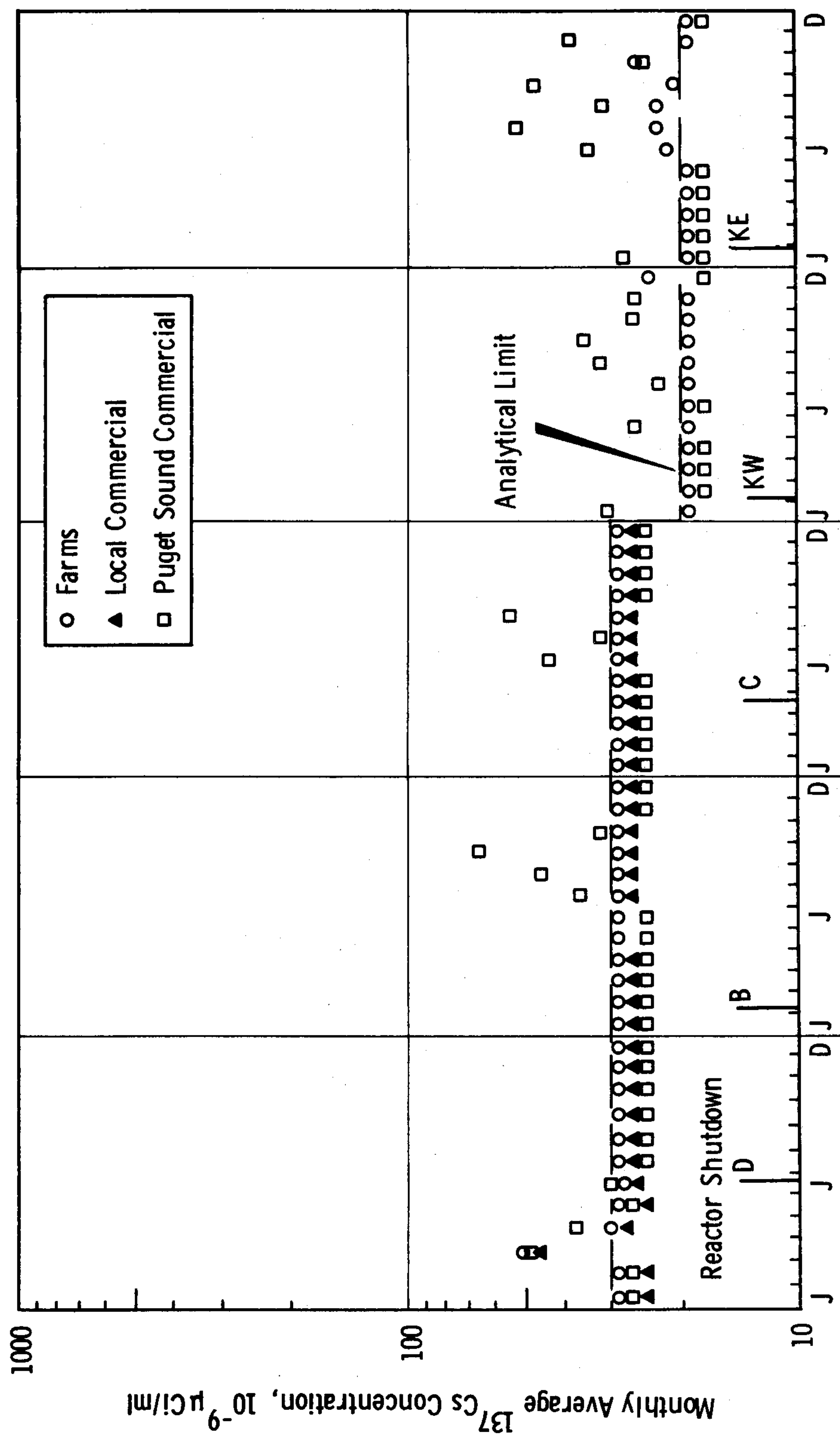

FIGURE 12. Monthly Average Cs-137 Concentrations in Locally Available Milk

Concentrations of Sr-90 and Cs-137 in locally available milk averaged less than 1.4% and 0.3% of the respective Concentration Guides[4] for water.

Radionuclides in Foods

A program of sampling meat and produce of local farms and stores was conducted throughout 1971. Sampling schedules were geared to local foodstuff production schedules. Meat was obtained from Riverview farms and local stores. Leafy vegetables were obtained from Riverview farms in July, August, and September, and from local stores in May through October. Table 12 shows that, on the average, concentrations of reactor-produced Zn-65 were higher in local farm foodstuffs than in locally available commercial products. Conversely, the concentrations of fallout radionuclides Sr-90, Cs-137, CePr-144, ZrNb-95, and Ru-106 were higher in the commercial foodstuffs.

Although concentration or daily intake guides for other than Sr-90 and Cs-137 are not specifically available for foods, it is common practice and provides an appropriate perspective to compare radionuclide concentrations in foods with Concentration Guides for water, keeping in mind that such a comparison implies continued daily intake of foodstuffs. These Guides have been listed in Table 12 for comparison.

Radionuclides in Fish, Shellfish, and Gamebirds

Fish in the Columbia River downstream from the single-pass Hanford reactors acquired radionuclides originating with reactor effluent. Historically, whitefish were the fish species caught and consumed locally that usually contained the greatest concentrations of radioactive material, although pan fish species were of greater significance as a source of human exposure due to the difference in quantities consumed.[14] Figure 13 shows the concentrations of Zn-65 in whitefish samples taken downstream of the Hanford reactors during the period of 1967-1971. P-32 concentrations in whitefish dropped to less than the analytical limit of 10^{-6} μCi/gm within a month after shutdown of the KE reactor. Radionuclide concentrations of other nuclides and other fish species would have been of even less significance as a source of human exposure.

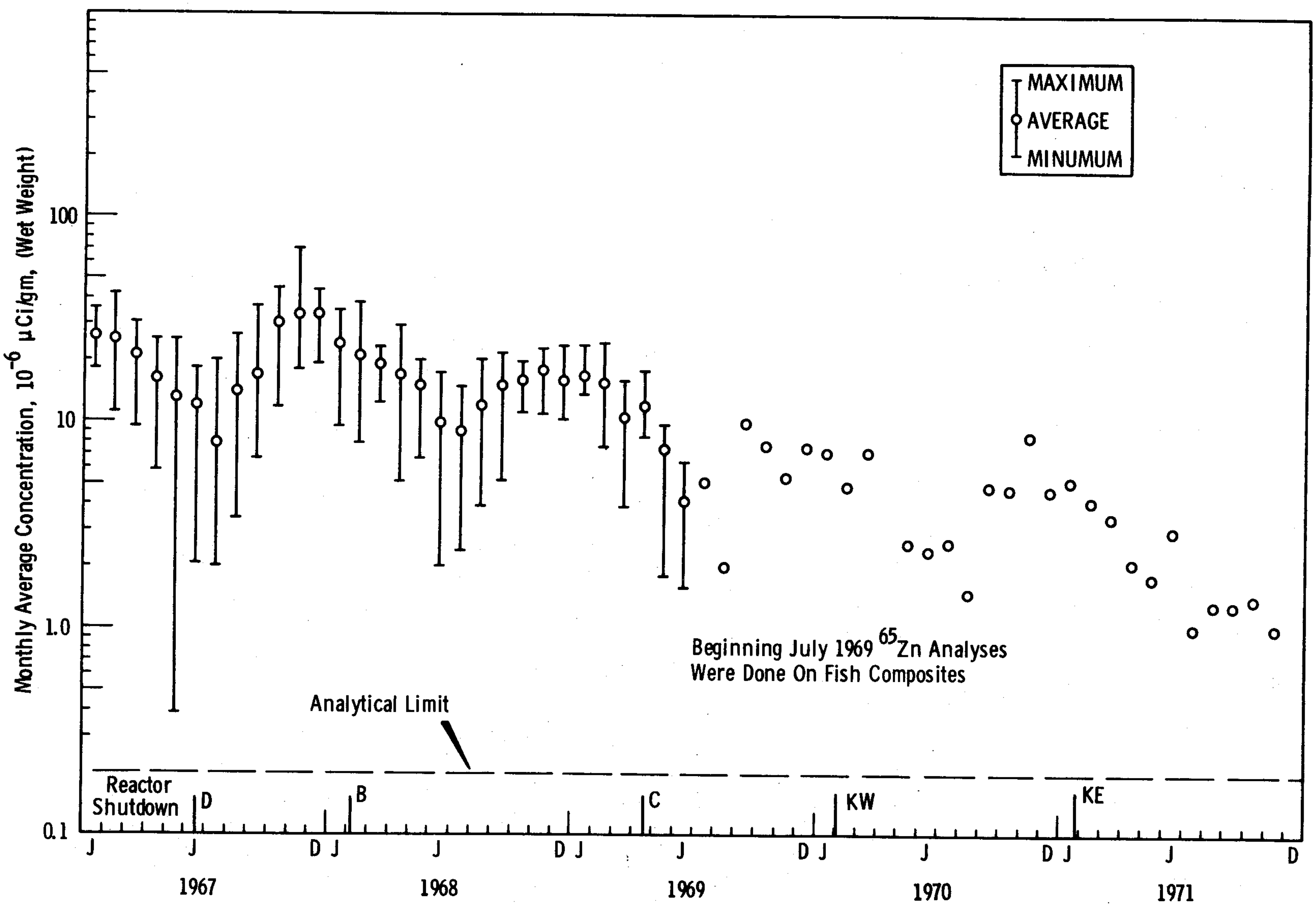

FIGURE 13. Monthly Average Zn-65 Concentrations in Flesh of Whitefish Caught in the Columbia River Between Ringold and Richland

Zn-65 and P-32 are the only radionuclides from Hanford reactor effluents that have been found in sufficient abundance in food organisms beyond the mouth of the Columbia River to be of significance to human radiation exposure. Oysters have been found to contain higher concentrations of Zn-65 than other common seafoods.[15] Monthly average concentrations of Zn-65 and P-32, periodically measured in oysters grown commercially in the Willapa Bay area, are shown in Figure 14 for the years of 1967-1971. A normal seasonal minimum for P-32 occurs in the late summer, due to seasonal changes of ocean currents. For 1971, the concentrations of P-32 were so low that negligible quantities of P-32 were found in Willapa Bay oysters. Concentrations of Zn-65 decreased at a rate closely corresponding to its radioactive decay.

Waterfowl and other gamebirds utilizing the river downstream from the reactors may acquire radionuclides as a result of ingestion of insects, algae, vegetation, and water containing these radionuclides. Some water fowl remain in this general area throughout the year. The concentrations of radionuclides in game birds are dependent upon the bird species, the geographical locations of the birds, and their current feeding habits. Data from a dietary survey of Hanford employees and from a special survey of local hunters[17] indicate that about 30% of the game bird meals consumed by local hunters were reported to be birds shot within about 5 km (3 miles) of the Columbia River between Ringold and McNary Dam. The same studies showed that about 30% of all gamebirds taken locally were ducks and geese, and that the average Richland resident consumed 1.4 kg/yr of gamebirds.

The average concentrations of several radionuclides in the muscle (the edible portion) of 89 waterfowl samples collected on the river within the Hanford boundaries for the environmental monitoring program during hunting seasons in 1971 are shown in Table 13. Average radionuclide concentrations in muscle for 16 pheasants collected at the Hanford site also appear Table 13.

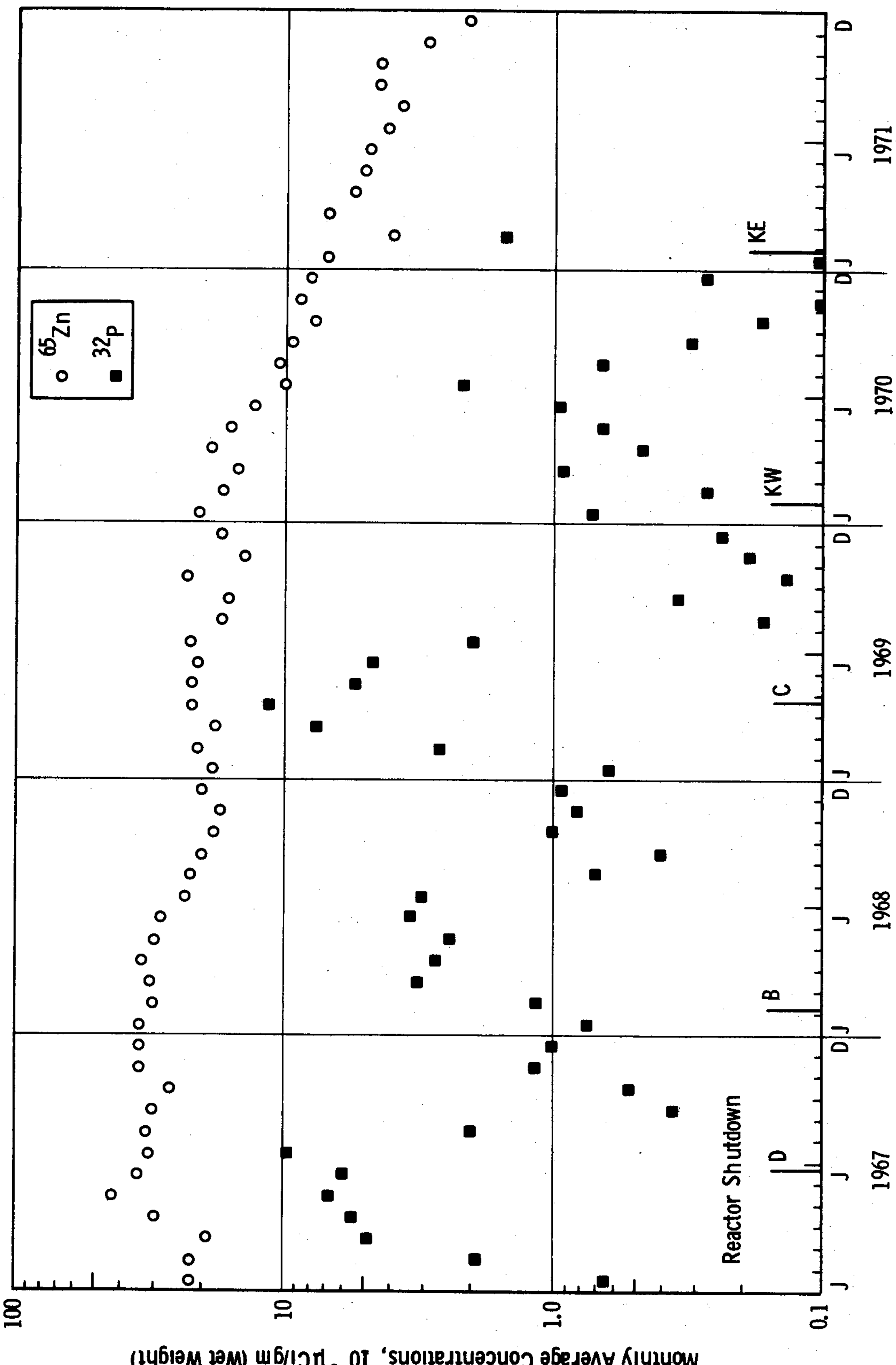

FIGURE 14. P-32 and Zn-65 Concentrations in Willapa Bay Oysters

TABLE 13. Average Radionuclide Concentrations in Muscle of Gamebirds - 1971, Units of 10^{-6} $\mu Ci/gm$

	^{24}Na				^{32}P				^{65}Zn				^{137}Cs			
Analytical Limit	0.6				1.0				0.2				0.1			
Species	# Of Sample	Max.	Min.	Avg.	# Of Sample	Max.	Min.	Avg.	# Of Sample	Max.	Min.	Avg.	# Of Sample	Max.	Min.	Avg.
Geese (River)[a]	10	*	*	*	10	1.2	*-2.9	*.24	10	1.4	*	0.57	10	0.55	*-.02	0.097
Duck (River)[a]	79	5.2	*	0.97	31	170.0	*-2.8	19	79	15.0	*-.06	0.63	79	0.28	*-.28	0.046
Pheasant[b]	-	-	-	-	-	-	-	-	16	0.35	*-.05	*	16	0.13	*.002	0.08

(a) Collected in January 1971 on the Columbia River within the Hanford boundary.

(b) Collected in November and December 1971 within 3 miles (5 km) of the Columbia River and within the Hanford boundary.

* Less than analytical detection limit. See Appendix A.

Radionuclide concentrations in gamebirds in 1971 were generally below the levels recorded in 1970. Geese were generally lower in radionuclide concentrations than ducks taken from the same areas. Only Zn-65 was consistently above detectable limits after the KE reactor shut down.

There are no appropriate Concentration Guides with which to compare the gamebird radionuclide concentrations because of the limited period of the year during which hunting is permitted and consumption usually occurs.

Dose estimates using the previously referenced dietary studies[14,16,17] combined with concentration data for the various species, indicated that the dose received by the average Richland resident (adult) from gamebird consumption was less than 1 mrem for 1971.

SOIL AND VEGETATION

Thirteen stations for routine soil and vegetation sampling were established around the perimeter of the Hanford reservation in 1971. Specific locations are given in Appendix C. Samples of the top two inches of soil and native vegetation (perennial) were taken at each of these stations at the end of September, and analyzed for plutonium, Sr-90, and gamma emitters. The averaged results from all stations are given in Table 14. Individual results, tabulated in BNWL-1683 ADD showed no particular geographical pattern, and the concentrations measured are believed to be the result of regional fallout.

Gamma emitters in soil samples were measured with a germanium crystal detector, in vegetation samples with a sodium iodide crystal. As a result, slight differences in the gamma spectra were reported. Since the bulk of the vegetation was perennial, no conclusions should be drawn as to uptake of radionuclides from the soil. The plutonium concentations are typical of general regional levels for the arid western states. No valid Concentration Guides exist for nuclides in soil and desert vegetation.

TABLE 14. Radionuclides in Soil and Vegetation in Units of 10^{-6} μCi/gm

	Soil			Vegetation		
	Max.	Min.	Avg.	Max.	Min.	Avg.
CO-58	0.08	*	0.017	*	*	*
Co-60	0.12	*	0.032	*	*	*
Zn-65	0.29	*	0.068	*	*	*
Sr-90	0.99	*	0.18	0.78	0.07	0.21
ZrNb-95	*	*	*	2.7	0.68	1.6
Ru-106	2.3	*	0.45	2.71	*	0.95
Cs-137	1.3	0.33	0.66	0.82	0.15	0.43
Ce-Pr-144	1.2	*	0.44	10.6	1.1	4.7
Pu-238	0.0067	*	0.0029	0.0038	*	*
Pu-239, 240	0.018	*	0.011	0.011	*	0.004

EXTERNAL RADIATION

Clusters of three ionization chambers* are maintained at selected locations within the plant boundary and at Richland and have been used to measure the gamma radiation exposure at 1 meter above ground level for many years (Table 15), although it was recognized that the results were conservatively high. Thermoluminescent dosimeters (TLD-200)** were introduced into the routine surveillance program in 1970, and were available for the full year of 1971. Although Table 14 is included as an indication of long-range trends, the more significant data for 1971 is a comparison of annual average exposure data from all monitored locations (the same as air sampling locations - See Figure 6). This shows the same value of

* Victoreen stray radiation chambers, 100-ml.
** Harshaw Chemical Company, CaF_2(Dy)

58 mR/yr for both Eastern Quadrant locations, adjacent to the Hanford plant, and the more remote perimeter communities locations.

TABLE 15. Radiation Exposure Rates at Richland, 1967-1971 from Ionization Chambers (mR/yr)

Location	1967	1968	1969	1970	1971
Hanford Test Location	0.35	0.36	0.37	0.39	0.40
Richland	0.26	0.28	0.30	0.34	0.34

Estimates of the external radiation dose received from recreational use of the Columbia River in the vicinity of the Hanford project have been based on routine measurements at the shoreline at Richland and Sacajawea Park (where the Snake River enters the Columbia) and below the surface of the river at Richland. The average exposure rates at the two shoreline locations (Figure 15) were taken from measurements with a large (40 liter) ionization chamber prior to July, 1971, and with a low-level dose rate meter* subsequently. Measurements were taken at 1 meter back from the water's edge and centered 1 meter above the ground, which approximates the dose rates to the gonads of a person on the riverbank. The exposure rates measured at the shoreline include components from radioactivity accumulated in sediment deposits and algae growths at the river's edge as well as from any radioactive material in the water. The same data, tabulated in Table 16, shows the effect of shutdown of the single-pass reactors. Averages for 1971 are not significantly different from local background measurements with the same instrument.

The immersion dose received by Tri-City swimmers is based on April through October exposure rates at Richland measured with thermoluminescent dosimeters positioned about 1 meter below the surface of the Columbia River. Measured immersion exposure rates were primarily due to the gamma emitters in the river. In the vicinity of Richland, the average measured immersion exposure rate from April through October 1971 was 0.15 mR/day, attributed to natural radioactivity.

* Nuclear Enterprises Model.

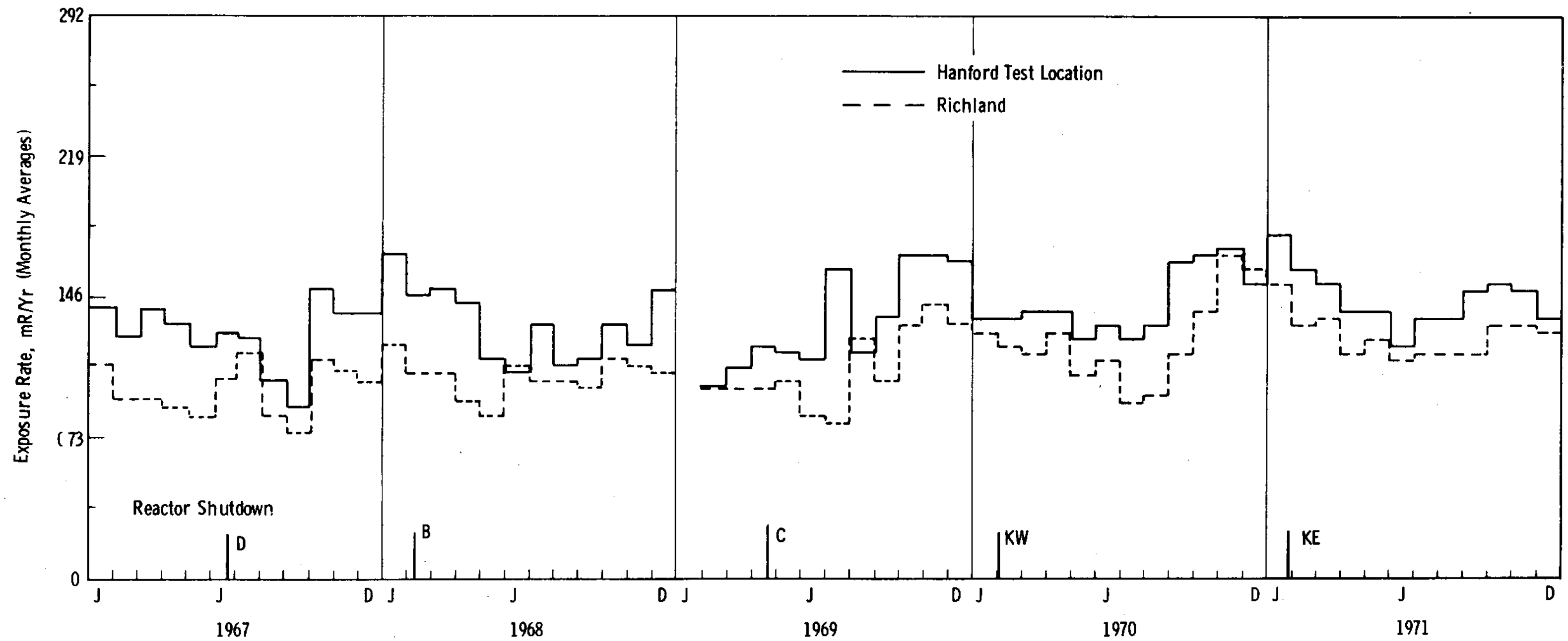

FIGURE 15. Monthly Average Gamma Exposure Rates at Hanford Test Location and at Richland

TABLE 16. Radiation Exposure Rates at the Columbia River Shoreline 1967-1971

Location	1968 (mR/day) Max.	1968 (mR/day) Min.	1968 (mR/day) Avg.	1968 (mR/yr) Avg.	1969 (mR/day) Max.	1969 (mR/day) Min.	1969 (mR/day) Avg.	1969 (mR/yr) Avg.	1970 (mR/day) Max.	1970 (mR/day) Min.	1970 (mR/day) Avg.	1970 (mR/yr) Avg.	1971 (mR/day) Max.	1971 (mR/day) Min.	1971 (mR/day) Avg.	1971 (mR/yr) Avg.
Richland	3.6	.12	1.1	400	1.5	.30	.71	260	1.1	.14	.44	160	.77	.12	.30	110
Sacajawea Park	1.5	.24	.67	240	1.5	.30	.60	220	1.3	.24	.52	190	.60	.12	.30	110

POPULATION DOSE IMPLICATIONS

Since 1958, a major part of the environmental surveillance effort at Hanford has been addressed to the estimation of radiation doses to the surrounding population, with methods detailed in References 1 and 18. The trend of these estimates with the step-wise shutdown of the single-pass production reactors is indicated by Table 17 and Figures 16 and 17. For comparison, estimates of radiation dose to the local population from nuclear weapons testing fallout are shown in Table 18.

TABLE 17. Comparable Dose Estimates[a] for Average Richland Resident, 1967 - 1971

	% of Standard					Standard
	1967	1968	1969	1970	1971	(mrem/yr)
Bone	3	3	3	2	<1	500
Whole Body	3	2	2	1	<1	170
GI Tract	6	5	4	2	<1	500
Thyroid (infant)	8	8	5	2	<1	500

(a) Not including contributions from fallout or natural background radiation.

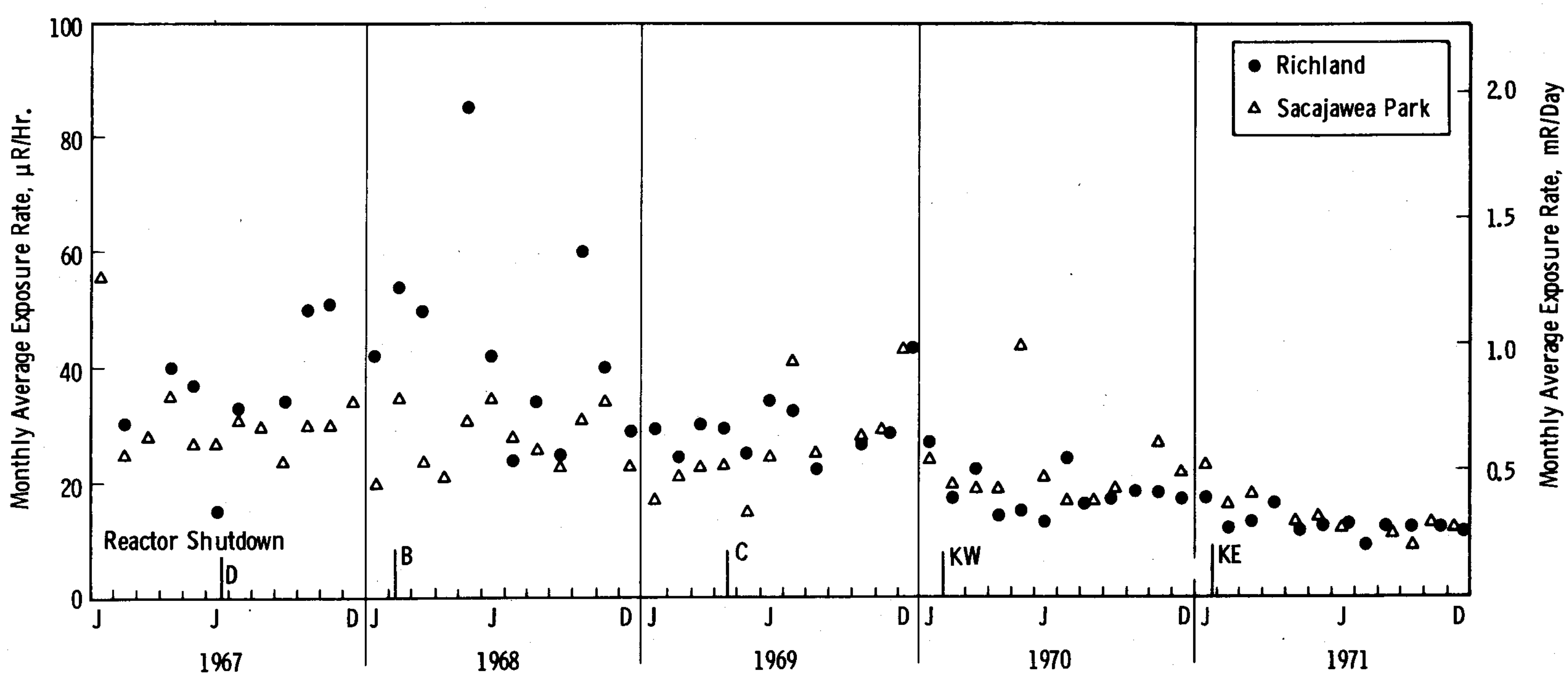

FIGURE 16. Monthly Average External Gamma Exposure Rates at the Columbia River Shoreline at Richland and Sacajawea Park

TABLE 18. Radiation Dose Commitments from Ingestion of Fallout Nuclides, and Comparison with Radiation Doses from Plant Sources, 1971[a] mrem

	^{3}H	^{90}Sr	^{137}Cs	Total from Fallout	Total Dose From Plant Sources
Maximum Individual					
Bone	-	30[b]	1	31	3
Whole Body	<1	3[b]	<1[c]	3	3
GI Tract	-	<1	<1	<1	3
Average Richland Resident					
Bone	-	15[b]	<1	15	<1
Whole Body	<1	1[b]	<1[c]	2	<1
GI Tract	-	<1	<1	<1	<1

(a) Not including natural radioactivity.

(b) The radiation dose commitments shown for bone and whole body represent the dose received over a period of 50 years based on ICRP methods. Only a few percent of the total dose commitment from Sr-90 intake is received during the first year for each of these organs.

(c) For the whole body dose commitment from ingestion of Cs-137 by an adult, the FRC dose conversion factor of 0.06 rem/μCi was used.

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As indicated in the text, sanitary water and air quality data for this report were provided by the Hanford Environmental Health Foundation. M. J. Schultz of that organization was especially helpful in the presentation of this data.

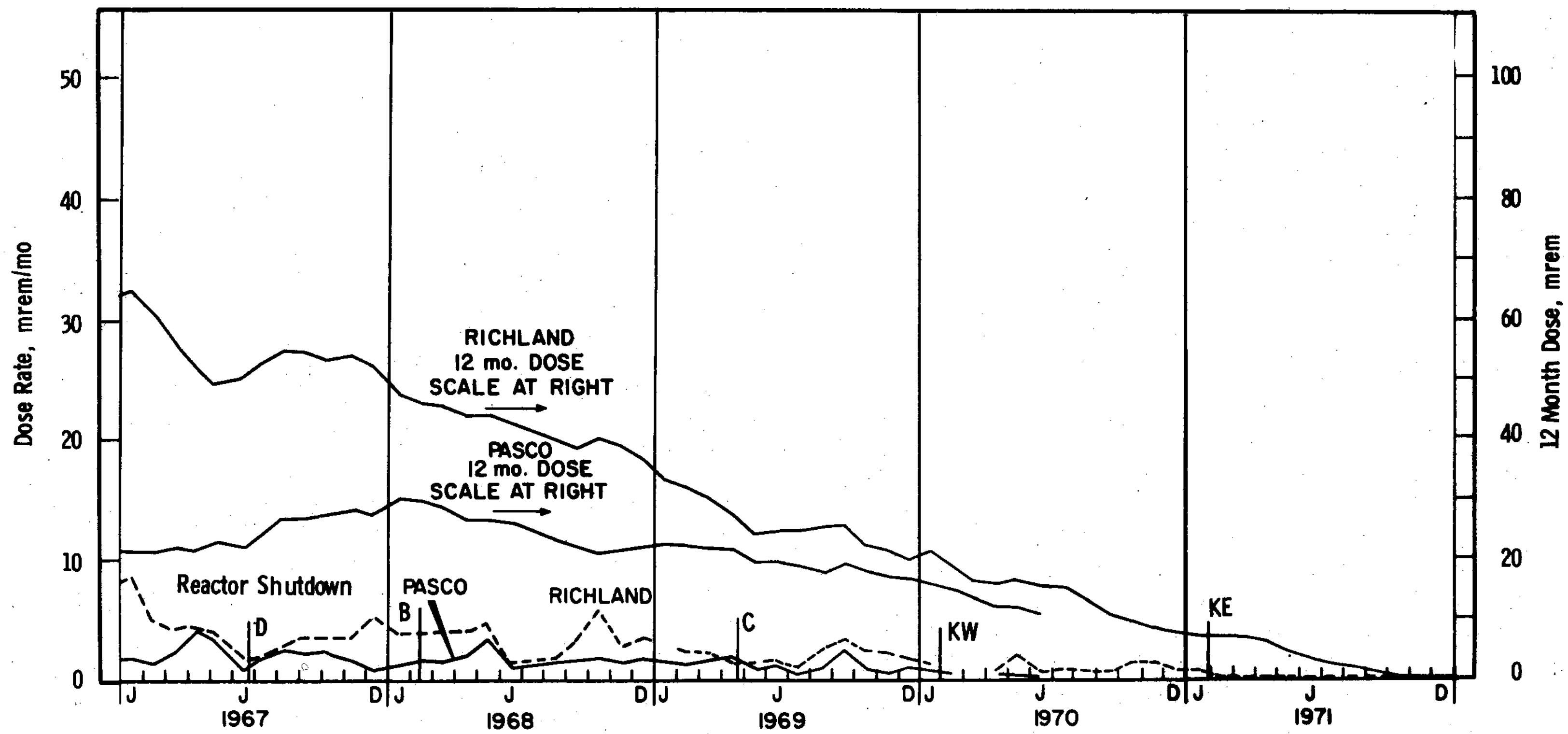

FIGURE 17. Doses to the GI Tract from Richland and Pasco Drinking Water (1.86 liter/day Intake Rate)

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APPENDIX A

ANALYTICAL LIMITS

APPENDIX A

ANALYTICAL LIMITS

Routine environmental radioanalyses for the Hanford program are performed by the U. S. Testing Company, Richland, Washington. Analytical limits are specified in a services contract between U. S. Testing and the Atomic Energy Commission. The term "analytical limit" is defined as the concentration at which the laboratory can measure a radionuclide with an accuracy (bias-precision composite) of $\pm$ 100% at the 90% confidence level. The detection limit for a specific radionuclide varies with sample type, sample size, counting time, and amounts of interfering radionuclides present. The "analytical limits" given represent upper bounds to these fluctuating detection limits.

The following rule has been applied for determining statistical detection levels for averaged data:

$$A.L._{ave} = \frac{A.L._i}{\sqrt{n}}$$

i.e., the laboratory analytical level is divided by the square root of the number of averaged results to obtain the estimated analytical level for the average, with the same confidence level and precision.

It is recognized that the value obtained will be approximate, since rigorously the variance of each result should be pooled. However, no simple method is available for estimating the variance of the average. The rule is applicable generally when, but only when, the actual net result is available for each sample including negative values. If the result is given only as less than some pre-determined value, it is not applicable.

APPENDIX B

APPLICABLE STANDARDS

APPENDIX B

APPLICABLE STANDARDS

I. Extracts from Washington State Water Quality Standards for Interstate Waters, 1967:[6]

" A. Water Quality Criteria

1. Class A Excellent

a. General Characteristics

Water quality of this class exceeds or meets the requirements for all or substantially all uses.

b. Characteristic uses

Characteristic uses include, but are not limited to, the following:

Water supply (domestic, industrial, agricultural)
Wildlife habitat, stock watering
General recreation and aesthetic enjoyment (picnicking, hiking, fishing, swimming, skiing and boating)
Commerce and navigation
Fish and shellfish reproduction, rearing and harvest

c. Water Quality Standards

Total Coliform Organisms shall not exceed median values of 240 (FRESH WATER) with less than 20% of samples exceeding 1,000 when associated with any fecal source or 70 (MARINE WATER) with less than 10% of samples exceeding 230 when associated with any fecal source.

Dissolved Oxygen shall exceed 8.0 mg/l (FRESH WATER) or 6.0 mg/l (MARINE WATER).

Temperature No measurable increases shall be permitted within the waters designated which result in water temperatures exceeding 65°F (FRESH WATER) or 61°F (MARINE WATER) nor shall the cumulative total of all such increases arising from nonnatural causes be permitted in excess of $t = 90/(T-19)$ (FRESH WATER) or $t = 40/(T-35)$ (MARINE WATER); for purposes hereof "t" represents the permissive increase and "T" represents the resulting water temperature.

1. Class A Excellent (Continued)

   c. Water Quality Standards (Continued)

      pH shall be within the range of 6.5 to 8.5 (FRESH WATER) or 7.8 to 8.5 (MARINE WATER) with an induced variation of less than 0.25 units.

      Turbidity shall not exceed 5 JTU (Jackson Turbidity Units - Standard Candle) over natural conditions

      Toxic, Radioactive or Deleterious Material Concentrations shall be below those of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.

      Aesthetic Values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.

B. Classification

Interstate and coastal waters of the State of Washington are classified as follows:

1. Columbia River Class A

   Mouth to the Washington-Oregon border (River Mile 309)

   Special Conditions

   Temperature No measurable increases shall be permitted within the waters designated which result in water temperatures exceeding 68°F nor shall the cumulative total of all such increases arising from nonnatural causes be permitted in excess of $t = 110/(T-15)$; for purposes hereof "t" represents the permissive increase and "T" represents the resulting water temperature.

II. Air and Sanitary Water Quality Standards

A. Air Quality Standards

1. Sulfur dioxide: 24-hour average: 0.10 ppm
   Annual Average: 0.02 ppm

   Ref: Washington State Department of Ecology[19]
   Chapter 18-56, Sulfur Oxide Standards, April 1970.

2. Nitrogen dioxide: Annual arithmetic mean (only standard available)

   Ref: Environmental Protection Agency[5]

3. Suspended particulates: annula mean - concentration not to exceed 60 micrograms per cubic meter of air (less background east of the Cascades).

   Ref: Washington State Department of Ecology[19]
   Chapter 18-40, Suspended Particulate Standards, April 1970.

B. Bacteriological and Chemical Quality Criteria for Sanitary Water

1. Bacteriological quality - no coliform organisms shall be present in any sanitary water samples.

   Ref: Hanford Standard HW-4966-S[20]

2. Chemical Quality

   a. Fluorides: with a mean average of maximum daily air temperatures = 64.8°F for this area, the recommended control limit is 1.2 mg/liter. A concentration of greater than 1.4 mg/liter shall constitute grounds for rejection of the water supply.

      Ref: Public Health Service[12]

   b. Nitrates: 45 mg/liter

      Ref: Public Health Service[12]

c. Mercury: No current standards exist for allowable mercury content in sanitary water. However, 5.0 ppb is an accepted limit pending revision of Public Health Service Drinking Water Standards.

III. RADIATION STANDARDS

The basic radiation standards for population dose in use at Hanford are given in the following extract from AEC Manual Chapter 0524, Appendix:[4]

" TABLE 2: Radiation Protection Standards for External and Internal Exposure[7]

Type of Exposure	Annual Dose or Dose Commitment, rem: Based on Dose to Critical Individuals at Points of Maximum Probable Exposure	Annual Dose or Dose Commitment, rem: Based on an Average Dose to a Suitable Sample of the Exposed Population[a]
Whole body, gonads, or bone marrow	0.5	0.17
Other organs[b]	1.5	0.5 "

(a) See Paragraph 5.4, FRC Report No. 1, for discussion on concept of suitable sample of exposed population.

APPENDIX C

ROUTINE MONITORING SCHEDULE

APPENDIX C

ROUTINE MONITORING SCHEDULE

Frequency Symbols Used

D - Daily
W - Weekly
BW - Bi-weekly
SW - Semi-weekly
M - Monthly
BM - Bi-monthly
SM - Semi-monthly
M Comp. - Monthly Composite
Q - Quarterly
A - Annually
SA - Semi-annually

I. WATER SAMPLES

A. Columbia River Raw Integrated

Location	Frequency	Measurement
Richland	W	Beta, gamma scan
	BW Comp.	I-131
	M Comp.	H-3, P-32, Sr-90, Alpha
	Q	Pu, Zn-65, Cs-137
Bonneville Dam	M Comp.	Zn-65, Sc-46

B. Columbia River Raw Grab

Location		
Vernita	W	pH, Diss. O_2, Turbidity
	M	Coliform, Enterococci, BOD
	W	NO_3^-
	M Comp.	H-3, Sr-90, Alpha
	Q	Pu, Cs-137
300 Area	D	pH, DO, Turbidity
	Continuous	Cr^{+6}
North Richland	M	Coliform, Enterococci, BOD
Richland	W	NO_3^-
	Continuous	Temperature

C. Sanitary Water Integrated

Location	Frequency	Measurement
Richland	W	Alpha, Beta, Gamma scan
	M Comp.	Sr-90
	W	Coliform, Cr^{+6}, NO_3^-

D. Groundwater

Location		
Webber Ranch	SA	NO_3^-, H-3
W-15	SA	NO_3^-, H-3
White Bluffs	SA	NO_3^-, H-3
Vail Ranch	SA	NO_3^-, H-3
Hildebrandt	SA	NO_3^-, H-3

II. Air Samples

A. Radioactivity

Location	Frequency	Measurement
Yakima Barricade	BW	Beta, alpha
Vernita Bridge	BW	Beta
ERC	BW	Beta
Rattlesnake Springs	BW	Beta
Benton City	BW	Beta, alpha
Wahluke Slope #2	BW	Beta
Berg Ranch	BW	Beta, alpha
Othello	BW	Beta, alpha
Connell	BW	Beta
New Moon	BW	Beta
Wahluke Water Master	BW	Beta
Eltopia	BW	Beta
Ringold	BW	Beta, alpha
Byers Landing	BW	Beta, alpha
Pasco	BW	Beta, alpha
Kennewick	BW	Beta
Richland	BW	Beta, alpha
Sunnyside	BW	Beta

A. Radioactivity (Continued)

Location	Frequency	Measurement
Ellensburg	BW	Beta
Moses Lake	BW	Beta
Washtucna	BW	Beta
Walla Walla	BW	Beta, alpha
Moses Lake	BW	Beta, alpha

B. Air Quality

Location	Frequency	Measurement
Richland	D BW	NO_2, SO_2 Particulate
Opposite Richland	D	NO_2, SO_2
Opposite N. Richland	D	NO_2, SO_2
Opposite 300 Area	D	NO_2, SO_2
Ringold	D	NO_2, SO_2

III. MILK AND HAY*

A. Commercial Sources

Milk	Location	Frequency	Measurement
Lucerne	Tri-City	M Q	I-131, gamma scan Sr-90
Darigold-Arden	Tri-City	SM Q	I-131 Sr-90

* Current cattle forage, hay, or pasture grass is routinely collected from all farms where milk is sampled, but analyses are made only on special request by Environmental Evaluation Section, BNW.

B. Farm Sources

Milk	Location	Frequency	Measurement
Rhoades (raw)	Benton City	BW Q	I-131, gamma scan Sr-90
Col. Basin Comp.	Esser, Ribison, Bleazard	BW Q	I-131, gamma scan Sr-90
Col. Basin #3 (raw)	Taylor, New Moon, Monson	BW	I-131, gamma scan
West Richland, Benton City Comp. (raw)	Dinneen, Atterberry	BW	I-131, gamma scan
River-Irrigated (Ditch)	Harris (Riverview)	BW Q	I-131, gamma scan Sr-89, Sr-90
River-Irrigated (Sprinkler)	Hall (Riverview)	BW Q	I-131, gamma scan Sr-89, Sr-90

IV. FISH AND GAMEBIRDS

A. Whitefish (Muscle)

	Location	Frequency	Measurement
Whitefish	Ringold to Richland		
(5 fish/sample)		SM Comp.	Gamma scan, P-32

B. River Ducks

80 birds/yr	100-K to Ringold	Oct - Jan.	Sr-90, gamma scan (muscle)

C. River Geese

20 birds/yr	100-K to Ringold	Oct - Jan.	Gamma scan (muscle)

D. Pheasant

20 birds/yr	100-K to 300 Area	Oct - Jan.	Sr-90, gamma scan (muscle)

V. FOODSTUFFS

A. Meat, Chicken, Eggs

	Location	Frequency	Measurement
Farm meat, lean beef	Riverview (river irr.)	M Q	Gamma scan Sr-90
Commercial meat, lean beef	Pasco Meat Packers	M	Sr-90, gamma scan
*Farm eggs	Harris (Riverview)	M Q	Gamma scan Sr-90
*Farm eggs	Olsen (Riverview)	M Q	Gamma scan Sr-90
*Farm eggs	Kinne (Ringold)	M Q	 Sr-90
*Farm Chicken	Harris (Riverview)	Q	Sr-90, gamma scan
*Farm Chicken	Kinne (Ringold)	Q	Sr-90, gamma scan

B. Produce

Produce	Location	Frequency**	Measurement
Commercial leafy veg. comp.	Tri-City	M Q	Gamma scan, Sr-89, Sr-90
Farm leafy veg. comp.	Riverview	M Q	Gamma scan, Sr-90
Farm leafy veg. comp.	Benton City	2 samples/yr	Gamma scan Sr-90

C. Oysters

	Location	Frequency	Measurement
	Willipa Bay	M	Gamma scan

* Sample from only one source in any one time period.

** During growing season, May - October only.

VI. SOIL AND VEGETATION

	Frequency	Measurement
A. Benton City	A	U, Sr-90, Gamma scan, Pu-239
B. ERC	A	U, Sr-90, Gamma scan. Pu-239
C. Rt. 240, CP #54	A	U, Sr-90, Gamma scan, Pu-239
D. Rattlesnake Springs	A	U, Sr-90, Gamma scan, Pu-239
E. Yakima Barricade	A	U, Sr-90, Gamma scan, Pu-239
F. Vernita Bridge, north end	A	U, Sr-90, Gamma scan, Pu-239
G. Wahluke Slope #2	A	U, Sr-90, Gamma scan, Pu-239
H. Berg Ranch	A	U, Sr-90, Gamma scan, Pu-239
I. Ringold	A	U, Sr-90, Gamma scan, Pu-239
J. Byers Pumphouse	A	U, Sr-90, Gamma scan, Pu-239
K. Byers Landing	A	U, Sr-90, Gamma scan, Pu-239
L. Riverview, CP #55	A	U, Sr-90, Gamma scan, Pu-239
M. North Richland, CP #56	A	U, Sr-90, Gamma scan, Pu-239

VII. RIVER MUD

Not currently in schedule. Data obtained from another source.

VIII. GAMMA EXPOSURE RATE

A. Columbia River	Frequency	Measurement
Vernita	M	Integrated gamma Immersion dose-TLD
Richland Pumphouse	M	Integrated gamma Immersion dose-TLD

B. Columbia River Shoreline	Frequency	Measurement
Vernita	M	Exposure rate contamination survey
Richland Pumphouse above water plant	W	Exposure rate contamination survey
Sacajawea	BW	Exposure rate contamination survey

C. Land

1. TLD

All air sample locations	M	Integrated gamma dose

2. Stray Radiation Chambers

700 Area	SW	Integrated gamma dose

D. Continuous Radiation Monitors

300 Area	Continuous	Gamma dose rate - Water surface
300 Area	Continuous	I-131 concentration in river

IX. ROAD SURVEY

Hanford Highway, Horn Rapids to Yakima Barricade & Rt. 240	Q	Radiation contamination Bioplastic crystal
300 Area to Prosser Barricade	Q	Radiation contamination Bioplastic crystal
North Richland	Q	Radiation contamination Bioplastic crystal

B. Columbia River Shoreline	Frequency	Measurement
Vernita	M	Exposure rate contamination survey
Richland Pumphouse above water plant	W	Exposure rate contamination survey
Sacajawea	BW	Exposure rate contamination survey
C. Land		
1. TLD		
All air sample locations	M	Integrated gamma dose
2. Stray Radiation Chambers		
700 Area	SW	Integrated gamma dose
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300 Area to Prosser Barricade	Q	Radiation contamination Bioplastic crystal
North Richland	Q	Radiation contamination Bioplastic crystal

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