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ENVIRONMENTAL SURVEILLANCE AT HANFORD FOR CY-1972

P.E. Bramson and J.P. Corley

Battelle
Pacific Northwest Laboratories
Richland, Washington 99352

APRIL 1973

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Occupational and Environmental Safety Department

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During 1972, 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, Westinghouse Hanford Company, and Hanford Environmental Health Foundation.

AEC-RL RICHLAND, WASH.

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ENVIRONMENTAL SURVEILLANCE AT HANFORD FOR CY-1972

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INTRODUCTION

Production of plutonium has been the primary mission of the Hanford site of the Atomic Energy Commission. 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 nearest population center 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.

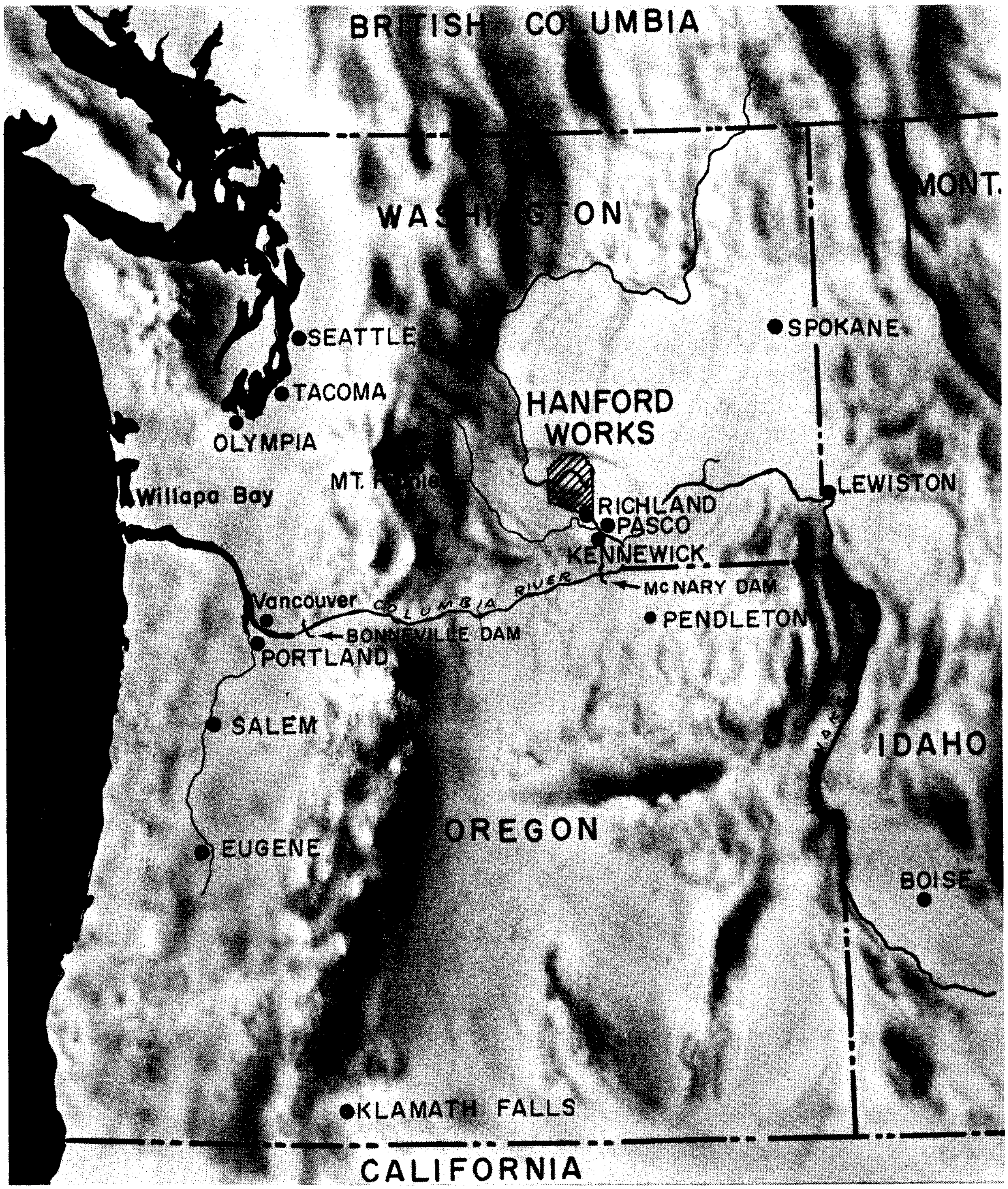

FIGURE 1: Geographical Relationship of Hanford to the Pacific Northwest

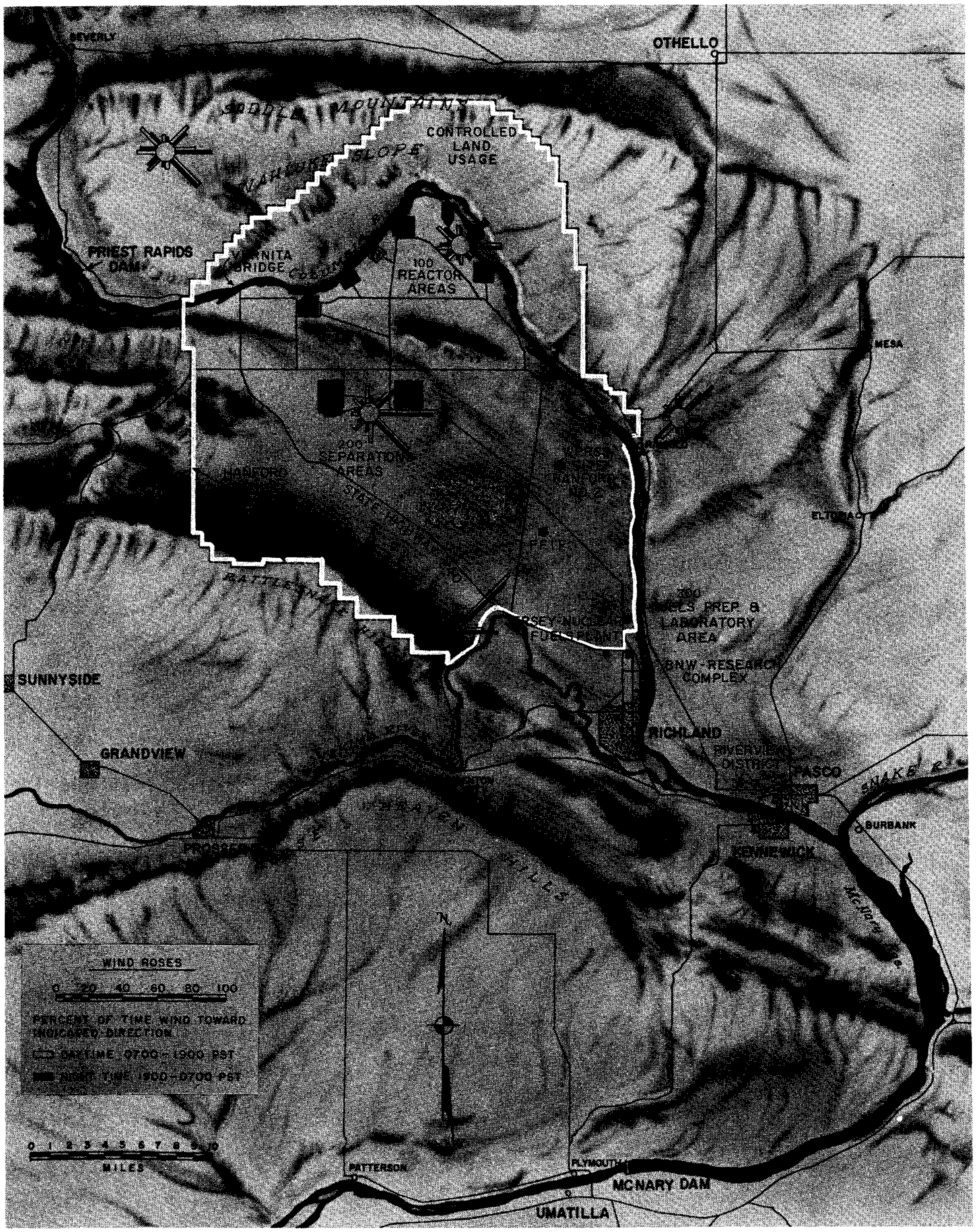

FIGURE 2: Features of Hanford Project and Vicinity

INTRODUCTION (Continued)

The farming area closest to Hanford is on Wahluke Slope, about 11 km (7 miles) from N-Reactor but much of the land east and south of the project boundary is under cultivation and could 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 reactor 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 N-Reactor. The principal products from the larger farm plots are hay, fruit, beef, and dairy products.

Radioactive wastes continued to be generated during 1972 by the N-production reactor, chemical separations plants, and laboratories. High level wastes were concentrated and retained in storage in the irradiated fuel processing 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. Between December, 1964, and January, 1971, all reactors with once-through cooling were deactivated. The only production reactor remaining in operation at Hanford is N-Reactor. N-Reactor has a closed primary cooling loop and releases only minor quantities of radioactivity to the river. As a result, the amount of radioactivity released to the Hanford environment, other than to soil within the plant reservation, decreased to relative insignificance.

Construction of a new reactor, the Fast Flux Test Facility, and associated engineering facilities, began in 1971 and continued through 1972. The reactor location is shown in Figure 2. This reactor will use dry cooling towers for heat dissipation rather than the Columbia River.

INTRODUCTION (Continued)

The purpose of this annual report is to present a summary and evaluation of the combined off-site effects of effluents released to uncontrolled areas by all Hanford contractors during 1972 in compliance with AECM-0513.[2] Detailed analytical data on which this evaluation is based have been published as a separate report (BNWL-1727 ADD).[3]

SUMMARY

The 1972 Hanford Environmental Surveillance Program showed continued compliance of the Hanford contractors and their operations with applicable environmental standards. Samples of surface water, groundwater, air, foodstuffs, soil and vegetation were collected and analyzed for radioactivity. Columbia River water also received chemical and biological analysis. Additionally, measurements were made of river immersion exposure rate, surface exposure rate (1 meter above soil surface) and radionuclide deposition on soil surfaces and highways open to public access.

The shutdown of the last of the single-pass cooled production reactors (KE) in January of 1971 eliminated the major remaining source of population exposure from Hanford operations. In 1972 the average river radionuclide concentrations were less than 1% of the Concentration Guides for all identified radionuclides. Unidentified alpha emitters were 2.2% of which about 0.4% was due to Hanford operations. Biological and chemical measurements indicated an addition of coliform organisms (7% of standard) and BOD (no standard) between measurement points which was due to non-plant sources. There was no measurable contribution to nitrate. Maximum river temperature was 19.6°C (less than the 20°C standard) and there was a net decrease in river temperature, on the average, between Priest Rapids and Richland.

Average radionuclide concentrations in Richland sanitary water were less than 1% of the Concentration Guides except for unidentified alpha emitters, which was about 2.4%. As indicated above, most of the alpha activity does not originate from Hanford operations. Nitrate and fluorides in Richland sanitary water were 3 and 12% of the standards, respectively.

SUMMARY (Continued)

Tritium and nitrate concentrations in four off-site wells were less than 0.1 and 1%, respectively, of the applicable standards.

Airborne radioactivity concentrations at the Hanford boundary were, on the average, the same as the more distant sampling locations, indicating that Hanford operations did not contribute detectably to off-site airborne radioactivity. Average airborne beta, alpha, and I-131 concentrations were 0.3, 6.6 and 0.1%, respectively, of the Concentration Guides for 1972. Airborne NO_2 and SO_2 were 14% and less than 20% of the standards, respectively.

A number of foodstuffs were sampled and analyzed for radioactive content. Average concentrations of Zn-65, Sr-90, I-131 and Cs-137 in local milk were less than 1% of the Concentration Guide for water. Trace radionuclides were also measured in local meat, poultry, eggs, produce, gamebirds, white fish and Willapa Bay oysters. There are no applicable Concentration Guides for these foods. Zn-65 concentration in the oysters decreased through 1972 at a rate closely corresponding to its radioactive decay rate and averaged 1.7×10^{-6} μCi/gm in 9 samples.

Soil and vegetation samples were analyzed for plutonium, uranium, Sr-90 and gamma emitters. Individual results showed no particular geographical pattern and the concentrations are believed to be the result of natural occurrence and regional fallout. Local plutonium concentrations are typical of arid western states.

The average external radiation exposure rate in the vicinity of Hanford was about 0.22 mR/day. The immersion exposure rate in the Columbia River at Richland averaged 0.14 mR/day, and the Columbia River shoreline exposure rate averaged 0.24 mR/day at Richland, both lower than measured upstream.

Estimated 1972 dose to the average Richland resident from Hanford sources was less than 1 mrem (0.6% of the standard), about the same as for 1971.

SURVEILLANCE PROGRAM

Environmental surveillance at Hanford includes measurement of environmental exposure rates and sampling of air, surface water, groundwater, soil, vegetation, locally produced foodstuffs, wild game and fish. Table 1 and Appendix C lists those samples and measurements obtained routinely at or beyond the plant boundaries.

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 potassium-iodide 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.

Water is sampled by integrating samplers and/or periodic one-liter grab samples with analysis for biological, chemical and radioactive content. 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. Groundwater is sampled at four off-site wells and analyzed for tritium and nitrate ion.

Annual sampling of soil and vegetation is conducted at a number of Hanford boundary and public access locations. Analyses for uranium, plutonium, strontium and gamma emitting radionuclides are performed.

Foodstuffs (meat, milk, eggs, chicken, produce and oysters) and potential foodstuffs (gamebirds, fish and deer) are sampled for radioactivity on varying schedules from weekly to annually.

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* Trade name by Hollingsworth-Vose Company.

TABLE 1: Routine Environmental Surveillance Schedule CY-1971

Type of Sample	Type of Analysis	Cont	D	SW	W	SM	M	SQ	Q	SA	A
			Frequency								
WATER											
Columbia River Water	Radioactivity	1			2		5		1		
	Dose Rate						7				
	Chemical		1		3						
	Biological						4				
Sanitary Water	Radioactivity				3		1				
	Chemical				2*						
Waste Water	Radioactivity				1		10				
	Biological						1				
Groundwater Wells	Radioactivity						3	131	82	15	
	Chemical									7	
AIR											
Filters	Radioactivity				14	22					
Scrubbers	Radioactivity				2	1					
Charcoal Cartridge	Radioactivity				3	7					
OTHER											
Surveillance Waste Disposal Sites	Radioactivity								24	71	1
Radiation Level	Dose Rate		1	3		18	37				
Shoreline Survey	Dose Rate				1	1	25				
Ground Control Plot	Radioactivity		1			16	26	14	8		
Road Survey	Radioactivity						11		3		
Aerial Survey	Radioactivity									5	
Railroad Survey	Radioactivity										1
Milk	Radioactivity					6	1				
Fish Columbia River	Radioactivity					1					
Wild Fowl	Radioactivity								10		100
Mammals	Radioactivity						1		3		7
Soil	Radioactivity										46
Vegetation	Radioactivity										23
Foodstuffs:											
Meat	Radioactivity						1			1	
Eggs	Radioactivity						1				
Chicken	Radioactivity								1		
Produce	Radioactivity										14
Oysters	Radioactivity						1				

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

SURVEILLANCE PROGRAM (Continued)

Appendix B gives brief descriptions of the methods used for routine analyses. Routine radioanalyses are by U. S. Testing Company, Richland, Washington. Chemical and biological 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.

WATER DATA

Radioactivity in the Columbia River

N-Reactor, the only production reactor remaining in operation at Hanford during 1972, 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 in soil particles and retained in the soil. A small stream (approximately 100 gpm) of single-pass cooling water was discharged into the Columbia River after dilution in the large volume secondary cooling water discharge. The small quantities of nuclides reaching the river from N-Reactor have usually been diluted well below detection level in the river and have normally not been detectable at the downstream plant boundary.

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

WATER DATA (Continued)

nuclides associated with the sediments. 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 1972, the average river flow rate at Priest Rapids was 4520 m^3/sec (159,500 ft^3/sec), which was well above the 1948-1962 annual average of 3770 m^3/sec (133,000 ft^3/sec).

During 1972, 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 non-uniform 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 and concentrations of radionuclides in the Columbia River below these two points. The magnitude of the influence varies with seasonal changes in the flow rate of the tributaries.

Table 2 shows the maximum, minimum, and annual average radionuclide concentration in Columbia River water at Vernita and Richland for 1972. The average river radionuclide concentrations were less than 1% of the Concentration Guides (C.G.) for water for all the radioisotopes in Table 2, except for alpha which was 2.2% of the Concentration Guide for an unknown mixture of alpha-emitters. About 0.4%, the difference between Vernita and Richland, could be attributed to Hanford operations. Table 3 shows the river transport rates of five radionuclides past Richland. The reduced transport rates at Richland in 1972 for the five radionuclides reflect the disappearance of the shorter-lived radionuclides following the

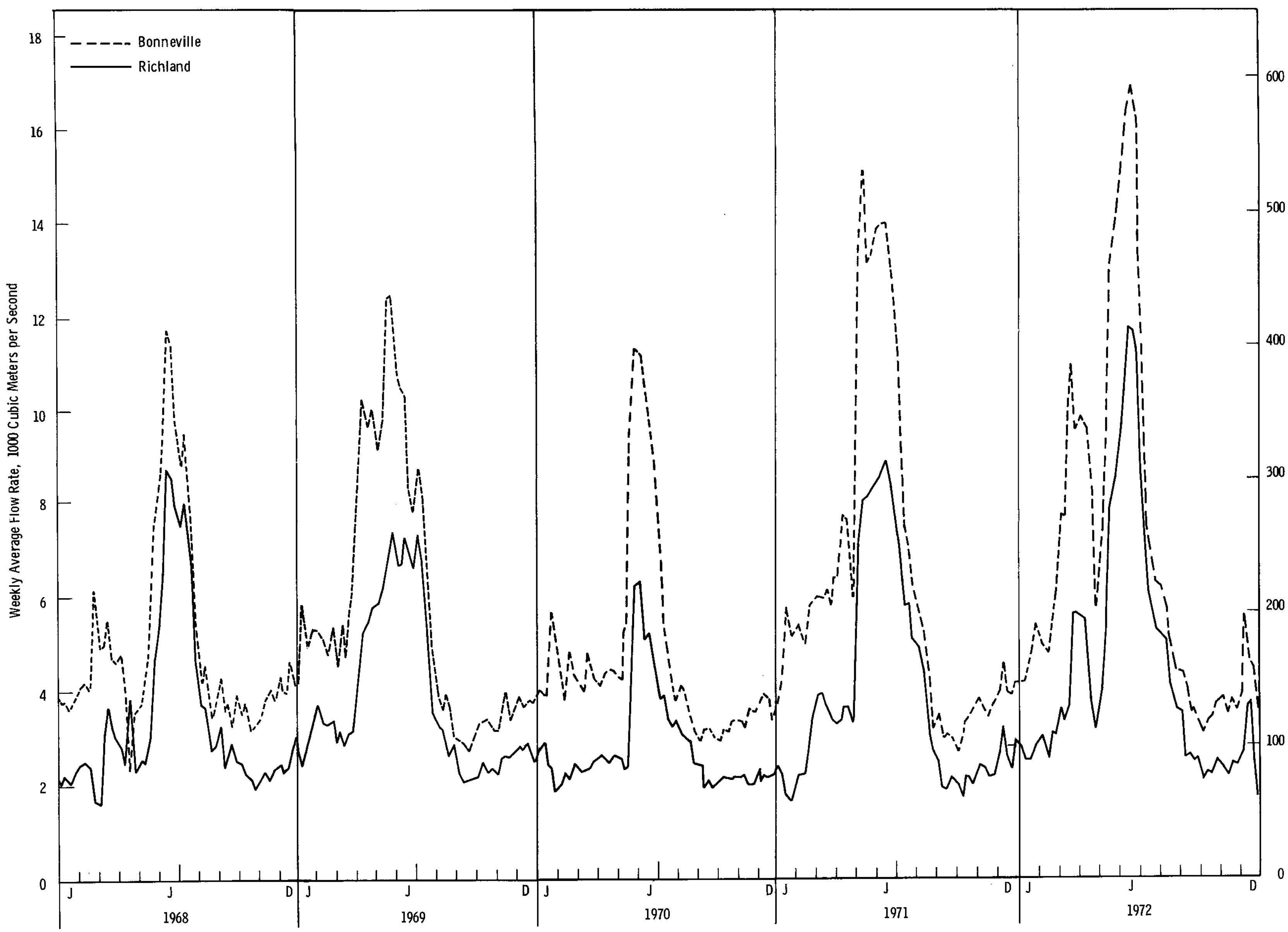

FIGURE 3: Columbia River Flow Rates

WATER DATA (Continued)

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 2: Concentrations of Radionuclides in Columbia River Water for 1972

(10^{-9} μCi/ml)

Radionuclide	[a]Analy. Limit	# Of Samples	Vernita Max.	Vernita Min.	Vernita Avg.	% Of C.G.	Analy. Limit	# Of Samples	Richland Max.	Richland Min.	Richland Avg.	% Of C.G.	C.G.
Alpha	0.3	12	0.74	0.30	0.54	1.8	0.3	12	0.92	0.48	0.67	2.2	30
^{3}H	220.	12	1400	*	110.	0.003	220.	12	1300	*	110	0.003	3,000,000
^{32}P	6.						6.0	11	*	*	*	<0.02	20,000
^{46}Sc	25.	5	*	*	*	<0.01	25.	53	*	*	*	<0.01	40,000
^{51}Cr	20.	5	20.	*	*	<0.01	300.	53	700	*	94.	0.005	2,000,000
^{60}Co	15.	5	0.30	*	*	<0.01	15.	53	42.	*	*	<0.02	17,000
^{65}Zn	2.	5	2.0	*	*	<0.01	2.0	4	2.0	*	*	<0.01	100,000
^{90}Sr	0.5	12	2.8	*	0.50	0.17	0.5	13	0.55	0.12	0.35	0.12	300
^{131}I	1.0	5	5.2	*	1.2	0.67	6.0	26	6.4	*	*	<0.03	300
^{137}Cs-^{137m}Ba	3.0	8	*	*	*	<0.01	3.0	7	*	*	*	<0.01	20,000
^{239}Pu	0.01	4	0.03	*	0.008	0.0005	0.01	4	0.06	*	0.02	0.001	1700

(a) See Appendix D.

* Less than the analytical limit shown. See Appendix D.

No entry indicates no specific analysis was made.

TABLE 3: Annual Average Transport Rates of Selected Radionuclides in the Columbia River at Richland

(Ci/day)

	1968			1969			1970			1971			1972		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
^{32}P	54.	7.7	21.	48.	8.7	21.	18.	0	6.6	7.6	0	0.42	(1)	(1)	(1)
^{46}Sc	150.	9.8	27.	97.	10.	23.	24.	<0.77	9.9	29.	0	<2.5	<15.	0	<1.7
^{51}Cr	550.	180.	360.	480.	48.	210.	170.	0	64.	300	0	<25.	340.	0	<36.
^{65}Zn	50.	8.2	22.	72.	8.0	23.	21.	<1.3	7.8	63.	0	<5.3	28.	0	<3.1
^{131}I	4.9	0.56	1.8	2.5	0.36	1.2	1.1	0	0.42	0.60	<0.07	<0.23	1.7	<0.04	<0.35

TABLE 4: Annual Average Transport Rate of Selected Radionuclides Past Bonneville Dam, 1968 - 1972

(Ci/day)

Radionuclide	1968	1969	1970	1971	1972
P-32	6.2	7.1	<2.3	(1)	(1)
Sc-46	7.6	<7	<2.5	<1.5	<0.1
Cr-51	200.	100.	<40.	(1)	(1)
Zn-65	<13.	<15.	<4.7	<3.7	<1

(1) Analysis discontinued.

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[12] applicable to the local river reaches are abstracted in Appendix C. 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 quantitative criteria are given. These are pH, turbidity, dissolved oxygen, coliform organisms, BOD, and temperature (Tables 5-7). 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 Priest Rapids and Vernita, and downstream at Richland. These are temperature and nitrate ion.

Analysis of Columbia River water for biological quality indicated an increase of coliform organisms and slight increase in BOD between the Vernita and Richland measurement points. These additions are believed to be related to drainage from farming and animal husbandry activities not associated with Hanford operations. Additionally, this section of the river is heavily populated by waterfowl which may contribute to the biological load. However, essentially identical values for Enterococci at both upstream and downstream locations indicated that coliform increases were not of fecal origin. These data showed compliance with the water quality standards. Nitrate was on the average the same at upstream and downstream measurement points. pH, turbidity, and dissolved oxygen measurements were made only at 300 Area during 1972. The range of these measurements is believed to be of natural origin not associated with Hanford operations. There was a net decrease in average Columbia River temperature between Priest Rapids and Richland for 1972, as indicated in Table 7.

Columbia River Water Quality (Continued)

Maximum river temperature was below the 20°C standard for that portion of the river. Figure 4 illustrates the natural annual river temperature cycle.

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 1972, 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). Average radionuclide concentrations in Richland drinking water samples were much less than 1% of the Concentration Guides for water except alpha, which was about 2.4% of the Concentration Guide for an unknown mixture of alpha-emitters. Most of the alpha activity is not the result of Hanford operations as discussed in the river water section.

Richland Drinking Water Quality

The Hanford Environmental Health Foundation, as a contractor to the Atomic Energy Commission, makes routine measurements for coliform bacteria and specific chemical ions at the 300 Area treatment plant and the City of Richland municipal treatment plant. 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.

Annual average concentrations of nitrate (Table 9) in the 300 Area and Richland water treatment plants were 0.5 and 1.42 ppm, 1% and 3% of the standard, respectively. Annual average fluoride concentrations were 0.13 and 0.14 ppm, about 12% of the standard, respectively. The increase in nitrate between 300 Area and Richland is due in large part to nitrate in groundwater entering that portion of the river rather than to 300 Area Laboratory activities.

TABLE 5: Columbia River Biological Analyses for 1972

	Coliform (N/100 ml)		Enterococci (N/100 ml)		BOD (ppm)	
	Vernita	Richland	Vernita	Richland	Vernita	Richland
# Samples	14	11	14	11	14	11
Max.	210.	460.	280.	88.	4.1	4.2
Min.	1.0	2.0	1.0	2.0	1.0	1.2
Avg.	49.	88.	37.	34.	2.6	2.9

TABLE 6: Columbia River Chemical Analyses for 1972

	NO_3 (ppm)		pH		Turbidity (JTU)		Dissolved O_2 (ppm)	
Standard	45		6.5 to 8.5		5 + Bg		8.0 min.	
	Vernita	Richland	Vernita	300 Area	Vernita	300 Area	Vernita	300 Area
# Samples	51	52	47	224	48	219	34	181
Max.	1.3	1.0	9.2	9.4	28.	30.	13.6	14.7
Min.	*	0.14	7.4	7.2	0.6	0.05	4.0	8.1
Avg.	0.36	0.37	8.1	8.0	5.0	4.6	11.0	10.

* Less than the analvtical limit. See Appendix D.

TABLE 7: Temperature of Columbia River Water-1972
(^{o}C)

# Samples	Priest Rapids Daily			Richland Daily		
Year	Max.	Min.	Avg.	Max.	Min.	Avg.
1971	19.2	2.6	10.4	20.1	2.6	10.7
1972	19.3	1.0	10.9	19.0	-0.3	10.1

No entry indicates no data available.

TABLE 8: Concentrations of Several Radionuclides in Richland Drinking Water - 1972

(10^{-9} μCi/ml)

Radionuclide	(3) Analytical Limit	# Of Samples	Concentration Max.	Concentration Min.	Concentration Avg.	% of Concentration Guide (4)
Alpha	0.67 (1)	53	3.9	*	0.71	2.4 (1)
Beta (2)	0.220	53	0.360	*	*	<0.01
^{46}Sc	23.	53	37.	*	*	<0.01
^{51}Cr	300.	53	420	*	*	<0.01
^{60}Co	20.	53	39.	*	*	<0.01
^{65}Zn	35.	53	84.	*	*	<0.01
^{90}Sr	0.4	12	0.38	*	0.22	<0.7
^{137}Cs-^{137m}Ba	0.6	53	49.	*	*	<0.01

(1) Concentration Guide for an unknown mixture not including plutonium.
(2) Concentration Guide 2,000,000
(3) See Appendix D
(4) Concentration Guides presented in Table 2, page 13.
* Less than the analytical limit. See Appendix D.

TABLE 9: Nitrates and Fluorides at Water Treatment Plants

	Nitrates (ppm)					Fluorides (ppm)[1]				
Analytical Limit		0.05					0.01			
Location	# Samples	Max.	Min.	Avg.	% Std.	# Samples	Max.	Min.	Avg.	% Std.
300 Area Treatment Plant	48	0.98	0.42	0.50	1.1	40	0.18	0.13	0.13	10.8
Richland Treatment Plant	48	15.2	0.24	1.42	3.2	40	0.21	0.13	0.14	11.7

(1) Measurements for January-October only.

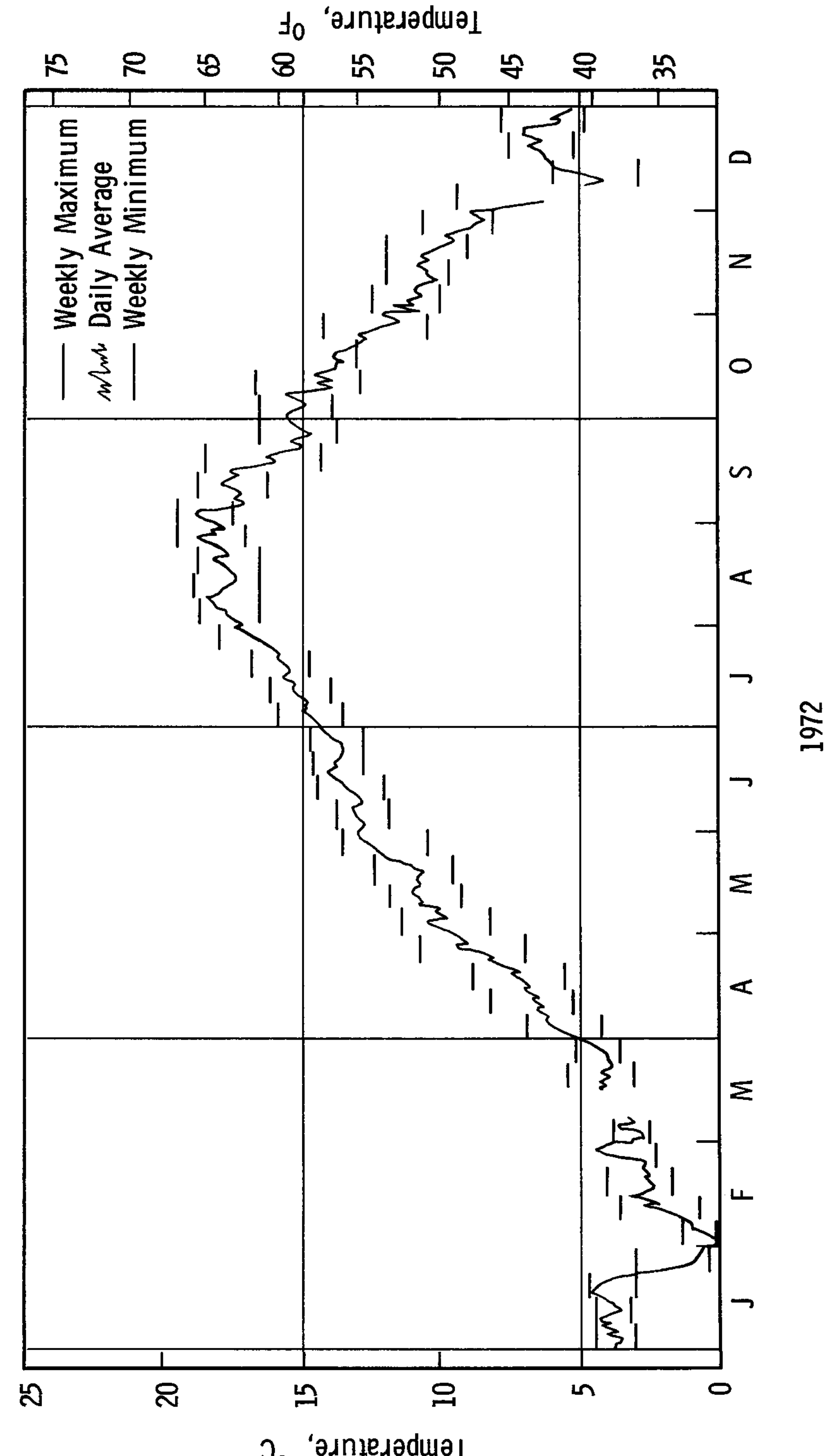

FIGURE 4: Temperature of the Columbia River at Richland

Groundwater

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 is documented separately, the most recent report in this series being BNWL-1737.[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 10 shows data from these wells for 1972. The value for the White Bluffs Association well resulted from one positive sample of 2900×10^{-9} μCi/ml (less than 0.1% 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 be negative.

TABLE 10: Groundwater Analyses from Wells in the Vicinity of Hanford - 1972
(10^{-9} μCi/ml)

		^3H (10^{-9} μCi/ml)				NO_3^- (ppm)			
Analytical Limit		520				0.5			
Location	No. of Samples	Max.	Min.	Avg.	% CG	Max.	Min.	Avg.	% Std.
Webber	2	*	*	*	<.02	*	*	*	<1
Vail	2	*	*	*	<.02	*	*	*	<1
W-15	2	*	*	*	<.02	*	*	*	<1
White Bluffs Association	2	2900	*	*	<.05	*	*	*	<1

* Less than the analytical limit. See Appendix D.

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 particulate radioactive materials after high efficiency filtration. N-Reactor releases noble gases to the atmosphere under normal operating conditions, due to activation of the reactor atmosphere.

During 1972, measurements of airborne I-131, total beta, and total alpha were made at 23 locations around the Hanford reservation. Figure 5 shows the locations of off-site air sampling stations. Figure 6 shows the monthly average 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.

Airborne beta concentrations followed the annual cycle observed in previous years and showed about the same maximum and minimum values as for 1971. Tables 11 and 12 present a more detailed review of the 1972 airborne radioactivity data for 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 analyzed when radioiodine was suspected in the atmosphere. The few such analyses were less than the analytical level.

Analyses for Sr-90 and plutonium were made quarterly on composited filters covering several locations. The results are given in Table 12, with average gross alpha and beta concentrations for comparison. Locations within each group are given in Table 11. The data show that plutonium accounted for about 1% of the gross alpha activity and Sr-90 for less than 1% of the gross beta activity. The radioactivity measured is believed to be essentially all of natural origin or from regional fallout.

Concentration Guides shown in Tables 11 and 12 were calculated from those given for unknown mixtures in AECM Chapter 0524, Appendix, Annex A, allowing for the specific nuclide data shown in Table 12 and adjusting for

Radioactivity in the Atmosphere (Continued)

population averages. Through the first half of 1972, the average airborne gross beta 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.

During the latter half of 1972, the Eastern Quadrant locations were noticeably higher in particulate activity then the more distant locations. This difference is possibly the result of Hanford operations, although no specific plant sources could be identified. Average airborne particulate activity was generally less than 0.3% of the Concentration Guide at all off-site locations.

Air Quality

Small atmospheric releases of oxides 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 C).

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 several off-site locations in the vicinity of Hanford. This data, reported in quarterly summary reports by the Hanford Environmental Health Foundation, has been summarized for 1972 in Table 13.

NO_2 and SO_2 samples were collected using 24-hour sequential samplers operated at ground level monitoring stations. The results are shown in Table 13. The highest average NO_2 concentration for any location was 0.007 ppm, 14% of the Federal Air Quality Standard. All SO_2 sample results were less than the detection level of 0.005 ppm, 20% of the Washington State standard. Suspended particulates, measured at Richland, varied over a wide range due to heavy dust storms typical of the area. Fluctuations of nitrogen dioxide and particulates were attributed to non-plant sources.

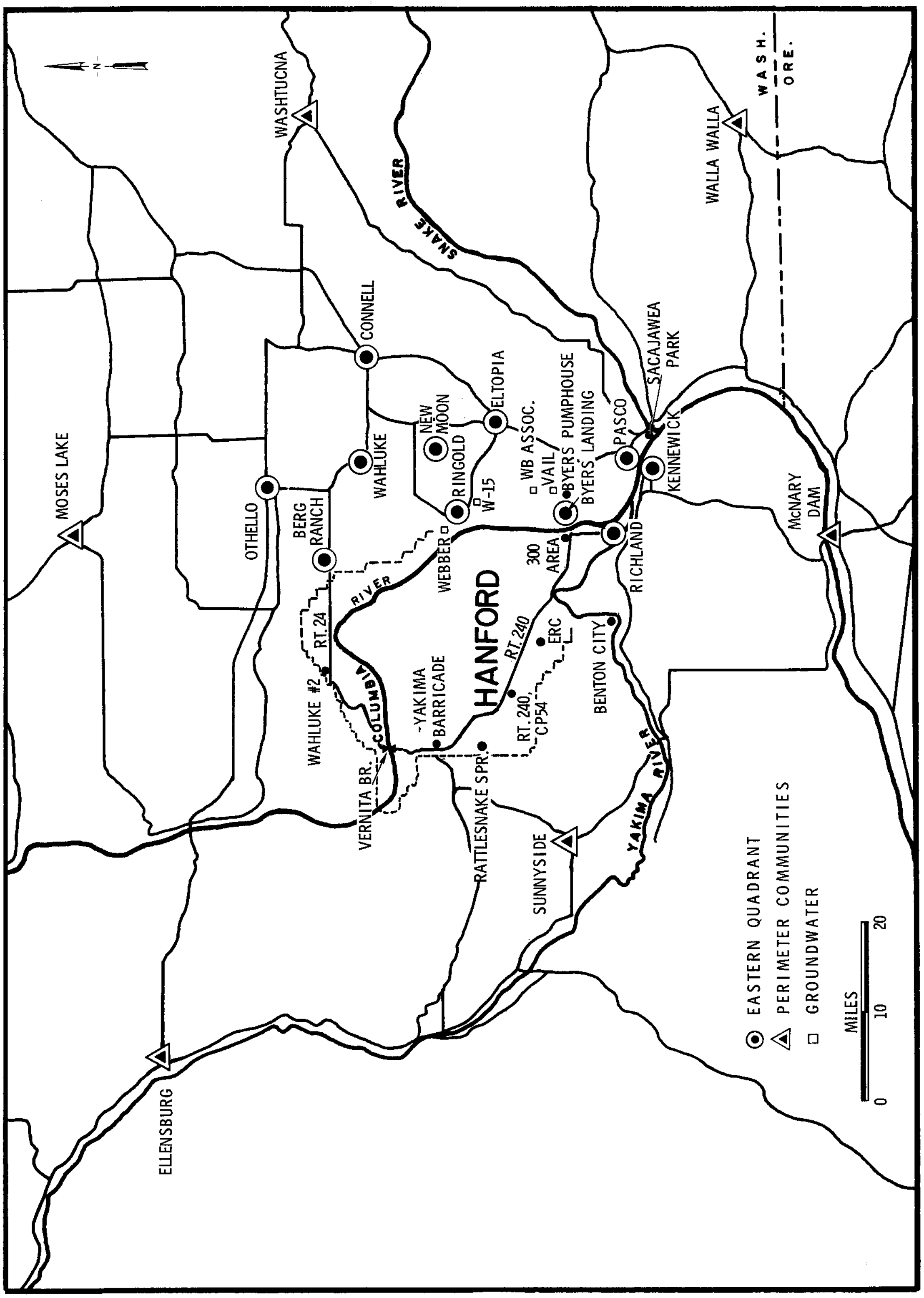

FIGURE 5: Off-Site Air Sampling Locations

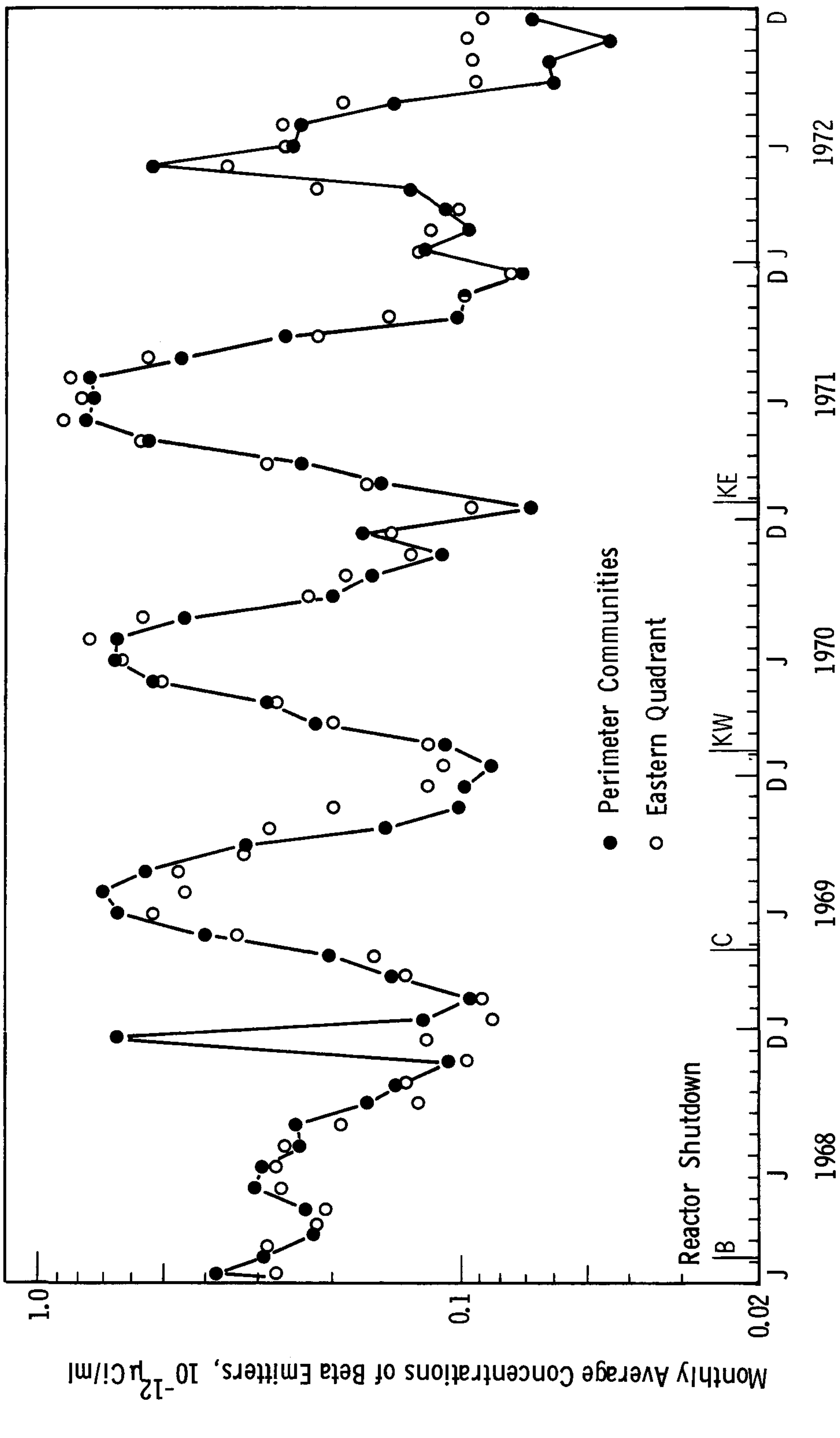

FIGURE 6: Monthly Average Total Beta Concentrations in Airborne Particulates

TABLE 11: Radioactivity in Air - 1972
(10^{-12} μCi/ml)

	Gross Alpha				Gross Beta				Iodine-131			
Analytical Limit	0.001				0.02				0.07			
Concentration Guide	0.03				100				100			
Eastern Quad.	Max.	Min.	Avg.	% CG	Max.	Min.	Avg.	% CG	Max.	Min.	Avg.	% C.G.
Othello	.006	*	.002	6.6	.44	.03	.18	.18	*	*	*	<7
Wahluke W.M.					.50	.01	.14	.14	*	*	*	<7
Connell					.58	.01	.16	.16	*	*	*	<7
New Moon		*			.46	.03	.16	.16	.043	*	*	<7
Eltopia					.40	.04	.15	.15				
Pasco	.005	*	.002	6.6	.35	.03	.17	.17	*	*	*	<7
Kennewick					.44	.03	.16	.16				
Richland	.005	.001	.002	6.6	.43	.04	.17	.17	*	*	*	<7
Berg Ranch	.006	*	.002	6.6	.92	.03	.22	.22	.056	*	*	<7
Ringold	.006	.001	.002	6.6	.57	.03	.18	.18	*	*	*	<7
Byers Landing	.006	.001	.002	6.6	.45	.05	.16	.16	.071	*	*	<7
Perimeter Communities												
Sunnyside					.37	.01	.12	.12				
Ellensburg					.20	.02	.10	.10				
Moses Lake					.35	.03	.14	.14				
Washtucna					.42	.06	.16	.16				
Walla Walla	.004	*	.001	3.3	.45	.02	.15	.15				
McNary Dam	.006	.001	.002	6.6	3.6	.04	.29	.29				
Western Quad.												
Yakima Barr.	.005	.001	.002	6.6	.62	.07	.19	.19	*	*	*	<7
Vernita					.36	.01	.16	.16				
Wahluke #2					.43	.02	.16	.16				
ERC					.41	.05	.16	.16				
Rattlesnake Spr.					.66	.06	.19	.19				
Benton City	.005	*	.002	6.6	.41	.04	.17	.17	*	*	*	<7

* Less than the analytical limit. See Appendix D.
No entry indicates no analysis was made.

TABLE 12: Airborne Radionuclides, Quarterly Averages-1972
(10^{-12} μCi/ml)

	Average Gross Beta	Sr-90	% C.G.	Average Total Alpha	Pu Alpha	% C.G.
Concentration Guide	100	10		.03	.02	
Eastern Quad.						
Jan-March	.115	.001	.01	.002	.000005	.025
April-June	.281	.001	.01	.001	.000015	.075
July-Sept.	.181	.002	.02	.001	.000045	.225
Oct.-Dec.	.092	.0001	.001	.003	.000006	.03
Perimeter Communities						
Jan-March	.109	.001	.01	.002	.000006	.03
April-June	.309	.001	.01	.002	.00002	.1
July-Sept.	.146	.002	.02	.001	.00003	.15
Oct.-Dec.	.059	.001	.01	.002	.000025	.125

TABLE 13: Air Quality Measurements
Annual Averages - 1972

	NO_2 (ppm)				Suspended Particulates (μg/m³)			
Location	No. of Samples	Max.	Min.	Avg.	No. of Samples	Max.	Min.	Avg.
Richland (747 Bldg)					70	938	28	174
Opposite Richland (Hobkirk Ranch)	109	.034	<.0008	.006				
Opposite N. Richland (Gillum Ranch)	109	.014	<.0008	.004				
Opposite 300 Area (Sullivan Ranch)	109	.019	<.0008	.004				
Ringold (Keys Ranch)	103	.010	<.0008	.004				

No entry indicates no specific measurement was made.
* Less than the analytical limit. See Appendix D.

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 could occur from ventilation stacks of reactor or laboratory facilities.

The milk surveillance program maintained during 1972 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, as well as fission products of fallout origin. Prior to February, 1971 (no single pass cooling 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. P-32 analysis was discontinued after the January 1971 shutdown of KE Reactor. Zn-65, which collected in the river sediments, is subject to resuspension in the water by changes in river flow rate and elevation, and could still be detected in river water after KE shutdown. Figure 7 shows the monthly average concentrations of Zn-65 in milk from river-irrigated farms in the Ringold and riverview area for 1968-1972. Seasonal fluctuations in radionuclide concentrations, caused primarily by irrigation and feeding practices, followed expected trends. Average Zn-65 concentration in milk for 1972 (Table 14) was less than 0.1% of the Concentration Guide. Even so, such concentrations would have been available only to a few local families.

Figure 8 shows the monthly average concentrations of I-131 in locally available milk. During 1972, I-131 concentrations in both farm milk and commercial milk were generally below the analytical limit ($2x10^{-9}$ μCi/ml).

TABLE 14: Radionuclide Concentrations in Locally Purchased Milk and Food-1972

A. Milk (10^{-6} μCi/ml

Sample	# Samples	^{65}Zn Max.	^{65}Zn Avg.	^{65}Zn % CG	^{90}Sr Max.	^{90}Sr Avg.	^{90}Sr % CG.	^{131}I Max.	^{131}I Avg.	^{131}I % CG.	^{137}Cs Max.	^{137}Cs Avg.	^{137}Cs % CG.
Concentration Guide (Water)		100			0.3			0.3			20		
Analytical Limit		.050			0.002			0.002			.030		
Riverview	21	.092	.016	.02	.004	.003	1.0	*	*	.33	.049	.014	.07
Benton City & West Richland Composite	26	*	*					.004	.001	.33	.029	.009	.05
Col. Basin Composite	52	.067	*		.002	.002	.67	.005	.001	.33	.033	.012	.06
Commercial	37	.062	.016	.02	.007	.004	1.3	*	*	.33	.035	.016	.08

B. Foodstuffs (10^{-6} μCi/gm)

Sample	# Samples	^{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		.030		.002		.020		.370		.070		.040		.350	
Commercial Meat	12	.064	.016	.006	.001	*	*	*	*	*	*	.084	.034	*	*
Poultry	4	.13	.06	.004	.003	*	*	*	*	*	*	.035	.01	*	*
Eggs	10	.088	.038	.026	.013	*	*	*	*	*	*	.040	.009	*	*
Local Produce	3	*	*	.03	.03	.14	.095	*	*	*	*	.090	.043	*	*
Commercial Produce	5	*	*	.010	.009	.12	.034	1.0	.38	*	*	*	*	*	*

NOTE: Minimum concentrations reported were all below the analytical limit and therefore not listed in this Table.

* Less than the analytical limit. See Appendix D.

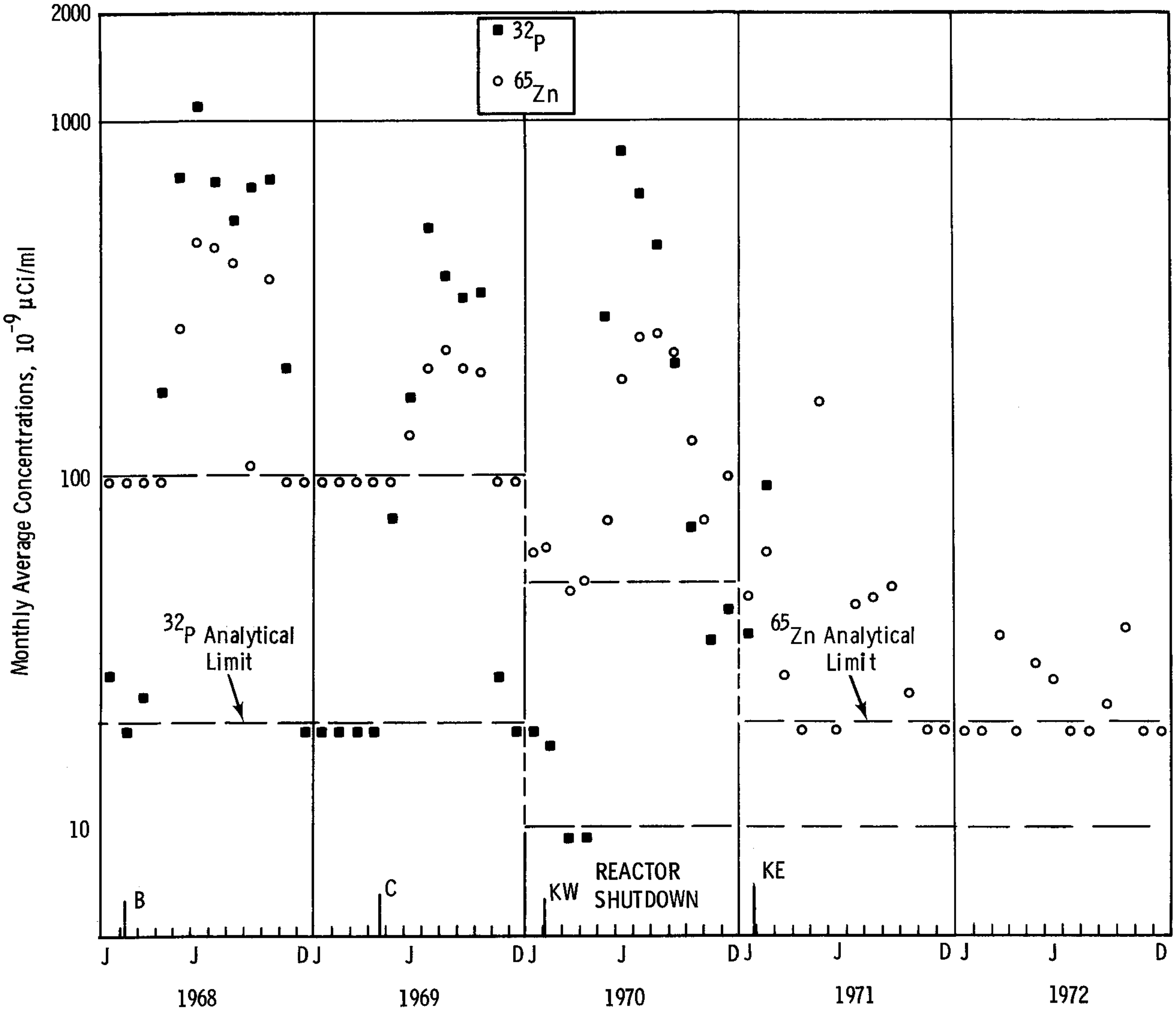

FIGURE 7: Monthly Average P-32 and Zn-65 Concentrations in Milk from River-Irrigated Farms

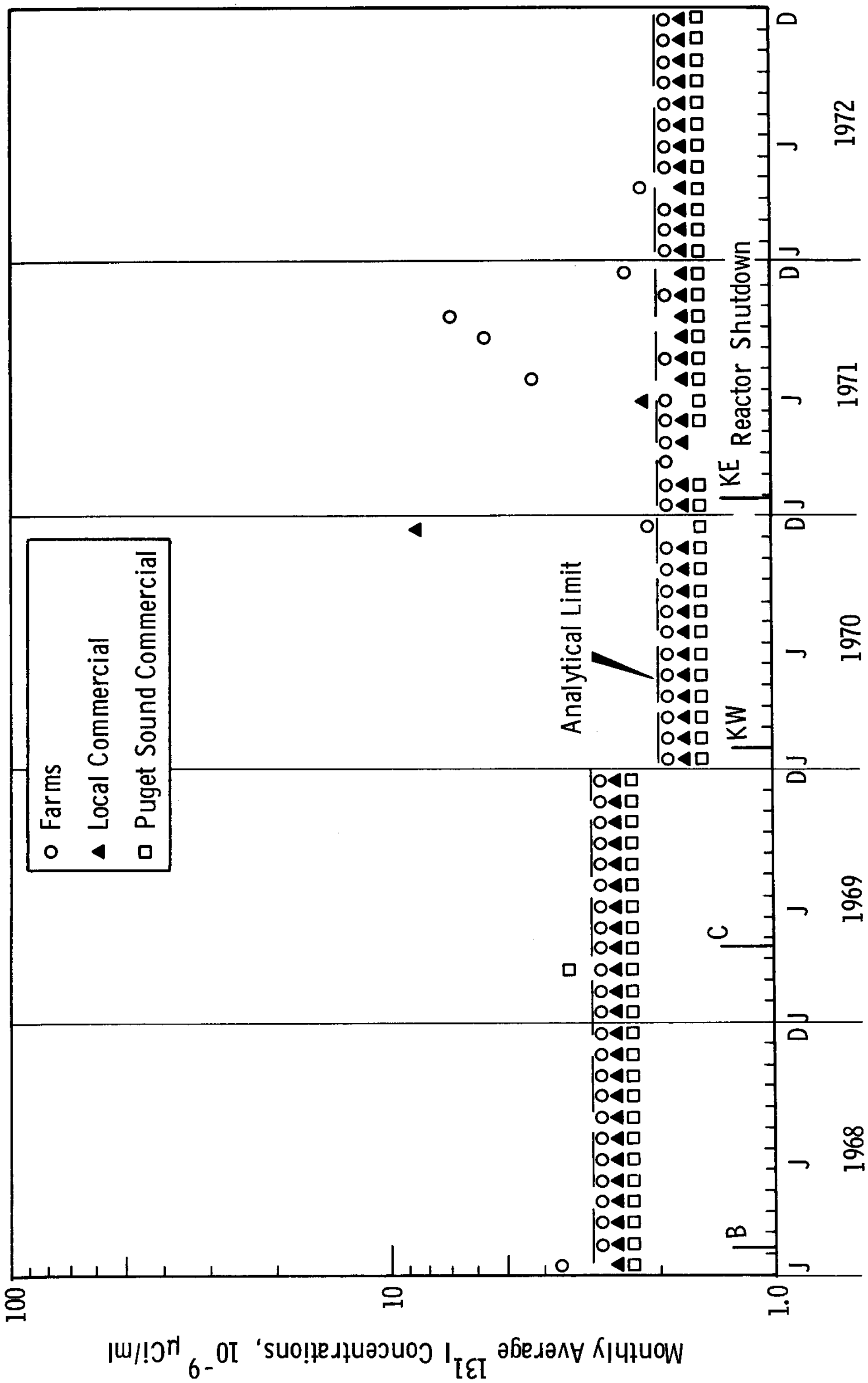

FIGURE 8: Monthly Average I-131 Concentrations in Locally Available Milk

Radionuclides in Milk (Continued)

Average I-131 concentrations locally available in farm milk for 1972 (Table 14) were less than 0.4% of the Concentration Guides for water. An increase of I-131 concentrations in milk, attributed to fallout from atmospheric nuclear weapons testing for lack of plant sources, was observed in April, 1972.

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, since regional fallout from nuclear weapons testing is the primary source of Sr-90 and Cs-137 in milk.

Concentrations of Sr-90 in locally produced farm and commercial milk (Figure 9) were similar in 1972 to those in commercial milk produced in other areas of low rainfall remote from the Hanford plant. The Puget Sound Commercial generally has a higher Sr-90 concentration due to higher rainfall in that milk production area. Sr-90 in local milk averaged 0.8% of the Concentration Guide for water compared to 1.3% in Puget Sound commercial milk. Concentrations of Cs-137 averaged below 0.2×10^{-9} μCi/ml, less than 0.1% of the Concentration Guide for water.

Radionuclides in Food

Sampling of meat and produce from local farms and stores continued throughout 1972 with sampling schedules geared to local foodstuff production. Meat was obtained from a local slaughter house, as well as local stores. Leafy vegetables were obtained from Riverview farms in July, August, and September, and from local stores in May through October. Average radionuclide concentrations in foodstuffs, shown in Table 14, were somewhat higher in local farm produce than in locally available commercial produce.

Concentration or daily intake guides for other than Sr-90 and Cs-137 are not specifically available for foods. Calculated doses from concentrations shown in Table 14 and standard diets would be less than 1 mrem to all body organs.

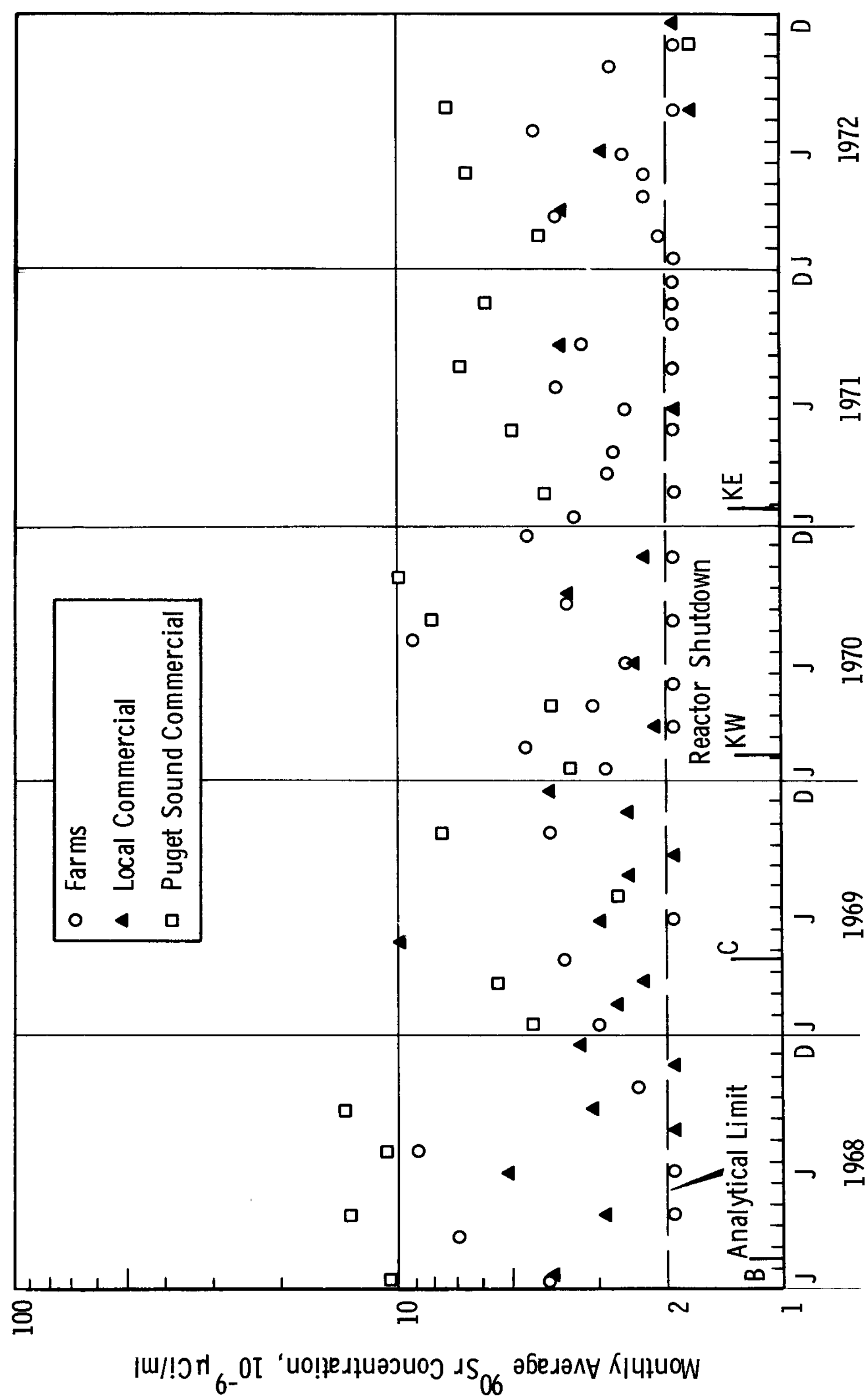

FIGURE 9: Monthly Average Sr-90 Concentrations in Locally Available Milk

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 10 and Table 15 show the concentrations of Zn-65 in whitefish samples taken downstream of the Hanford reactors during the period of 1968-1972. For 1972, the average Zn-65 concentration in 21 whitefish samples was 0.4×10^{-6} μCi/gm, and the average P-32 concentration was 0.62×10^{6} μCi/gm. The calculated dose to the maximum individual from the consumption of Columbia River fish was 1.5 mrem, not including any contribution from fallout nuclides Sr-90 and Cs-137. Dietary assumptions used in the calculations are given in Appendix E.

Zn-65 and P-32 are the only radionuclides from Hanford reactor effluents that have been found in sufficient abundance in seafoods collected 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, periodically measured in oysters grown commercially in the Willapa Bay area, are shown in Figure 11 for the years of 1968-1972. P-32 analysis was discontinued following shutdown of KE Reactor, the primary P-32 source. Concentrations of Zn-65 decreased at a rate closely corresponding to its radioactive decay and averaged 1.7×10^{-6} μCi/gm in nine samples for 1972 (Table 15).

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 waterfowl 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.

TABLE 15: Average Radionuclide Concentrations in Muscle of Gamebirds, Fish, and Shellfish-1972

(10^{-6} μCi/gm)

	^{32}P				^{60}Co				^{65}Zn				^{90}Sr				^{137}Cs			
Analytical Limit	1.0				0.15				0.2				0.002				0.1			
Species	# Sample	Max.	Min.	Avg.	# Sample	Max.	Min.	Avg.	# Samples	Max.	Min.	Avg.	# Samples	Max.	Min.	Avg.	# Samples	Max.	Min.	Avg.
Geese (river)[a]					32	0.12	*	*	32	0.37	*	0.079	10	0.017	*	0.003	32	0.97	*	0.10
Duck (river)[a]	1	*	*	*	71	0.24	*	*	71	0.77	*	0.096	58	0.014	*	0.003	71	1.2	*	0.070
Pheasant[b]					24	*	*	*	24	0.29	*	0.073	20	0.008	*	0.002	24	0.24	*	0.084
Whitefish	20	1.8	*	0.62	21	0.18	*	*	21	0.92	*	0.40	7	0.003	*	0.002	21	0.31	*	0.17
Oysters	9				9	*	*	*	9	2.5	1.0	1.7					9	*	*	*

(a) Collected in January 1972 on the Columbia River within the Hanford boundary.

(b) Collected in November and December 1972 within 5 km (3 miles) of the Columbia River and within the Hanford boundary.

* Less than the analytical detection limit. See Appendix D.

No entry indicates no analysis was made.

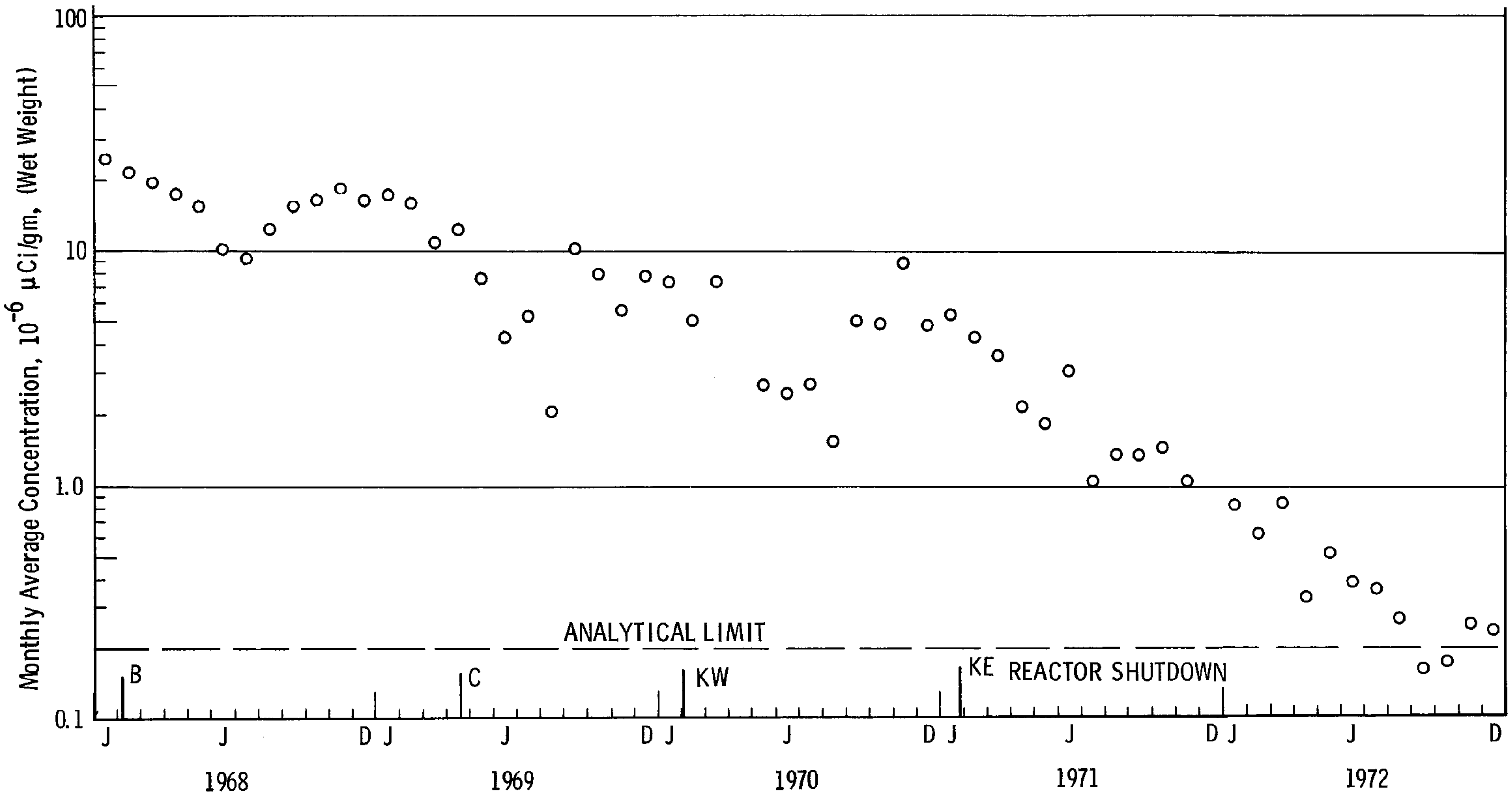

FIGURE 10: Monthly Average Zn-65 Concentrations in Whitefish from the Columbia River

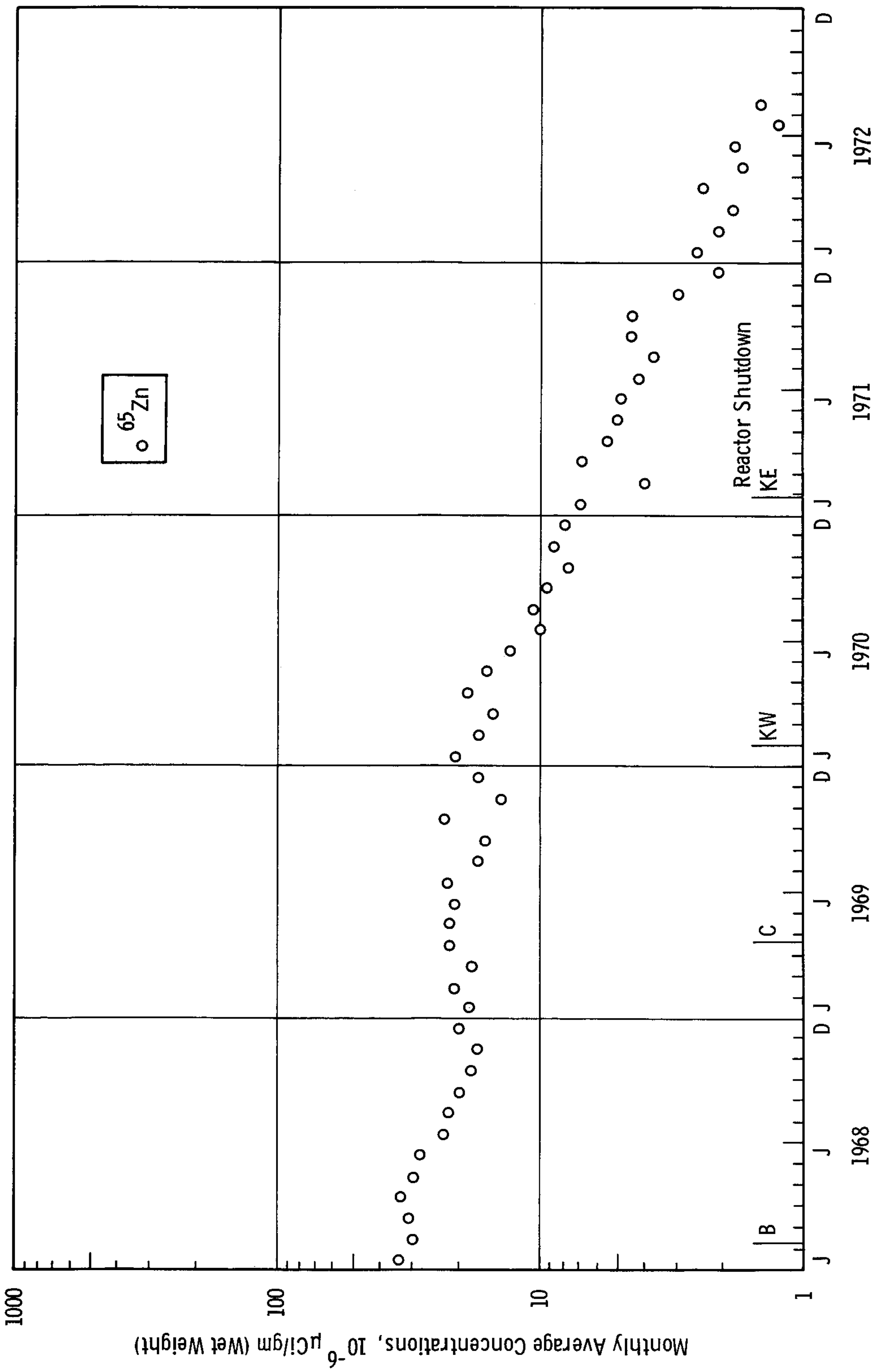

FIGURE 11: Zn-65 Concentrations in Willapa Bay Oysters

Radionuclides in Fish, Shellfish, and Gamebirds (Continued)

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 103 waterfowl samples collected on the river within the Hanford boundaries for the environmental monitoring program during hunting seasons in 1972 are shown in Table 15. Average radionuclide concentrations in muscle for 24 pheasants collected at the Hanford site also appear in Table 15.

On the average, radionuclide concentrations were similar in ducks, geese, geese, and pheasants. Zn-65 averaged less than 0.1×10^{-6} Ci/gm. Co-60 averaged below the 0.15×10^{-6} Ci/gm analytical limit. P-32 was not routinely measured; as past experience indicated, it would have been less than its analytical limit.

There are no applicable Concentration Guides with which to compare the gamebird radionuclide concentrations. However, 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 1972.

SOIL AND VEGETATION

Routine soil and vegetation sampling was performed at 13 stations around the perimeter of the Hanford reservation in 1972. Specific locations are given in Appendix A and shown in Figure 5. Samples of the top two inches of soil and native vegetation (perennial) were taken at each of these stations in October, 1972, and analyzed for plutonium, uranium, Sr-90, and gamma emitters. The averaged results from all stations are given in Table 16. Individual results, tabulated in BNWL-1727 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 of the superior energy resolution of the germanium detector, slight differences in the gamma spectra were reported. The bulk of the vegetation was perennial, hence no conclusions should be drawn as to uptake of radionuclides from the soil. The plutonium concentrations are typical of general regional levels for the arid western states. No Concentration Guides exist for nuclides in soil and desert vegetation.

TABLE 16: Radionuclides in Soil and Vegetation - 1972
(10^{-6} μCi/gm)

	Soil				Vegetation			
	Analy. Limit	Max.	Min.	Avg.	Analy. Limit	Max.	Min.	Avg.
Co-58	0.03	0.11	*	0.01	0.05	*	*	*
Co-60	0.03	0.15	*	0.04	0.05	0.09	*	*
Zn-65	0.07	0.18	*	0.03	0.08	*	*	*
Sr-90	0.002	0.38	0.01	0.18	0.002	0.85	0.02	0.13
ZrNb-95	0.4	1.2	*	0.28	0.01	2.1	0.14	1.0
Ru-106	0.4	2.2	*	0.64	0.4	5.7	*	3.5
Cs-137	0.03	1.5	0.04	0.58	0.02	5.8	0.24	1.7
CePr-144	0.3	1.5	0.52	0.99	0.4	4.4	*	*
Pu-238	0.003	0.012	*	0.003	0.003	0.007	*	0.003
Pu-239	0.001	0.023	*	0.008	0.001	0.010	0.001	0.004
Uranium-Nat.					0.015	0.23	0.01	0.06

No entry indicates no analysis was made.

* Less than the analytical limit. See Appendix D.

EXTERNAL RADIATION

Eastern Quadrant/Perimeter Communities

Thermoluminescent dosimeters (TLD-200)* are maintained at selected locations to measure the gamma radiation exposure at one meter above ground level. Figure 12 and Table 17 present average gamma exposure rates at a number of downwind (Eastern Quadrant) locations, and for comparison the average of several distant perimeter communities. Fallout from foreign nuclear weapons tests in October 1971 and March 1972 resulted in an abrupt increase in measured exposures in early 1972. Comparison of the daily average on an annual basis shows nearly the same value for both Eastern Quadrant locations, adjacent to the Hanford plant (downwind), and the more remote perimeter community locations. However, during the period March through August, 1972, the Eastern Quadrant locations were somewhat higher than the perimeter communities as is apparent in Figure 12. This apparent difference could not be correlated to any radioactivity releases associated with Hanford operations and, in fact, occurred during the period when no reactors were in operation on the Hanford reservation.

TABLE 17: External Radiation Exposure Rates - 1972
(mR/day)

Location	Max.	Min.	Avg.
Perimeter Communities	0.24	0.17	0.21
Eastern Quadrant	0.23	0.19	0.22

Columbia River Shoreline

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 exposure rate measured at the shoreline may 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 average exposure rates at the two shoreline locations

* Harshaw Chemical Company, $CaF_2(Dy)$

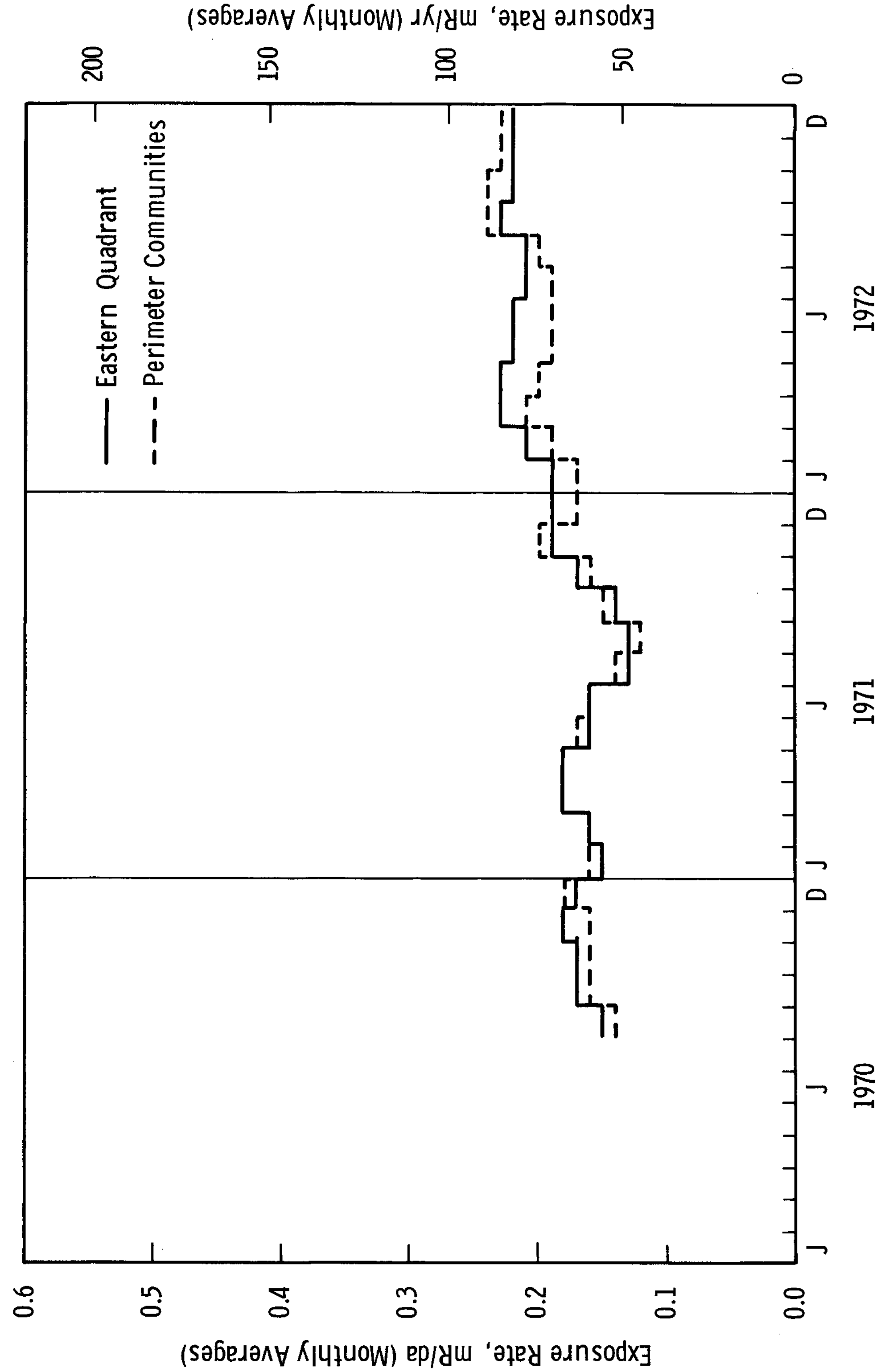

FIGURE 12: Monthly Average Gamma Exposure Rates

Columbia River Shoreline (Continued)

(Figure 13) were taken from measurements with a 40-liter ionization chamber prior to July, 1971, and with a low-level dose rate meter* subsequently. Measurements were taken one meter back from the water's edge and centered one meter above the ground, which approximates the dose rate to the gonads of a person on the riverbank. Average shoreline exposure rates (Table 18) at these two locations are essentially the same, 0.24 mR/day at Richland and 0.26 mR/day at Sacajawea Park or 88 and 95 mR/year, respectively. The average exposure rate at Vernita, upstream of the Hanford plant, was also 0.24 mR/day.

Immersion

The immersion dose received by Tri-City swimmers is based on April through October exposure rates at Richland (Table 19), and measured with thermo-luminescent dosimeters positioned about one meter below the surface of the Columbia River. Measured immersion exposure rates would be primarily due to the gamma emitters in the river. In the vicinity of Richland, the average measured immersion exposure rate for 1972 was 0.14 mR/day with a maximum of 0.17 mR/day. For comparison, the immersion dose measured upstream was 0.16 mR/day.

Surface Measurements

Roads and land surfaces in the vicinity of Hanford are periodically surveyed to detect possible radionuclide deposition resulting from Hanford operations and associated activities. Locations of control plots and routes of road and aerial surveys are described in Appendix C, Part IV.

Eleven small areas, called control plots, are located around the Hanford boundaries. These plots, measuring 3m x 3m (10' x 10') are surveyed monthly or semi-monthly with a GM survey meter for deposited radioactive material. Radioactive fallout resulting from a foreign nuclear weapons test was detected on all control plots in March. No surface radioactivity of Hanford origin was detected on the control plots or during road or aerial surveys.

Public highways 24 and 240, which traverse the Hanford reservation, are surveyed quarterly with a bioplastic scintillation detector attached to the bumper of a truck and positioned about 0.6 meters (2 ft.) above the edge of

* Nuclear Enterprises Model.

Surface Measurements (Continued)

the road surface. This road monitor has been described in BNWL-62.[21] During 1972, no radioactivity was detected.

Aerial surveys can be used to detect contamination which is spread over a large land area. Like road, rail, and control plot surveys, aerial surveys are only qualitative in nature, but through routine use of this technique a capability for rapid assessment of an emergency situation is maintained. Aerial surveys are conducted at an altitude of 150 meters (500 ft.) using a three-inch by five-inch thallium-activated sodium iodide scintillation crystal detector. Aerial survey flight patterns used during 1972 were:

(1) near the Hanford project perimeter
(2) 15-40 air miles beyond the project perimeter
(3) following the Columbia River from the Vernita Bridge (upstream of the Hanford reactors) downstream to McNary Dam.

During 1972, no significant changes were seen in previously observed patterns.

TABLE 18: Gamma Exposure Rates at the Columbia River Shoreline -1972

Location	(mR/day) Max.	Min.	Avg.	(mR/yr) Avg.
Richland	0.60	0.096	0.24	88
Sacajawea Park	0.36	0.12	0.26	95

TABLE 19: Columbia River Immersion Exposure Rate-1972

Location	(mR/day) Max.	Min.	Avg.
Above N Area	0.24	0.11	0.16
Richland Pump House	0.17	0.11	0.14

POPULATION DOSE IMPLICATIONS

Since 1958, the major emphasis of the environmental surveillance effort at Hanford has been on the estimation of radiation doses to the surrounding population, with methods detailed in References 1 and 18. Although the major reductions in plant emissions, and especially the elimination of single-pass reactors, have made it more difficult to assess the small remaining dose potential, the significance of radiation dose to people as the basic criterion of environmental effects still holds.

Table 20 shows the trend in estimated doses as percent of the standard, for postulating the maximum and the average Richland resident for the period of 1968-1972.

For comparison, Table 21 presents estimates of the calculated radiation dose commitments to area residents resulting from ingestion of radionuclides from regional fallout. For bone dose especially, fallout continued to be much more significant in 1972 than plant sources. Figures 13 and 14 indicate the downward trend of plant origin dose estimates with the stepwise shutdown of the Hanford reactors.

TABLE 20: Comparable Dose Estimates[a] for Maximum Average Individual and Richland Resident, 1968-1972

	% of Standard					Standard
	1968	1969	1970	1971	1972	(mrem/yr)
Max. Individual						
Bone	17	9	6	<1	<1	1500
Whole Body	5	4	2	<1	<1	500
GI Tract	4	3	2	<1	<1	1500
Thyroid (infant)	7	4	2	<1	<1	1500
Average Richland Resident						
Bone	3	3	2	<1	<1	500
Whole Body	2	2	1	<1	<1	170
GI Tract	5	4	2	<1	<1	500
Thyroid (infant)	8	5	2	<1	<1	500

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

TABLE 21: Radiation Dose Commitments from Ingestion of Fallout Nuclides from Plant Sources-1972

(mrem/yr)

	^{3}H	^{90}Sr	^{137}Cs	Total from Fallout	Total from Plant Sources
Maximum Individual					
Bone	-	26	<1	27	3
Whole Body	<1	2	<1(b)	3	2
GI Tract	-	<1	<1	<1	2
Average Richland Resident					
Bone	-	10	<1	10	<1
Whole Body	<1	<1	<1(b)	1	<1
GI Tract	-	<1	<1	<1	<1

(a) Not including natural radioactivity

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.

(b) 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.

No entry indicates no calculation was made.

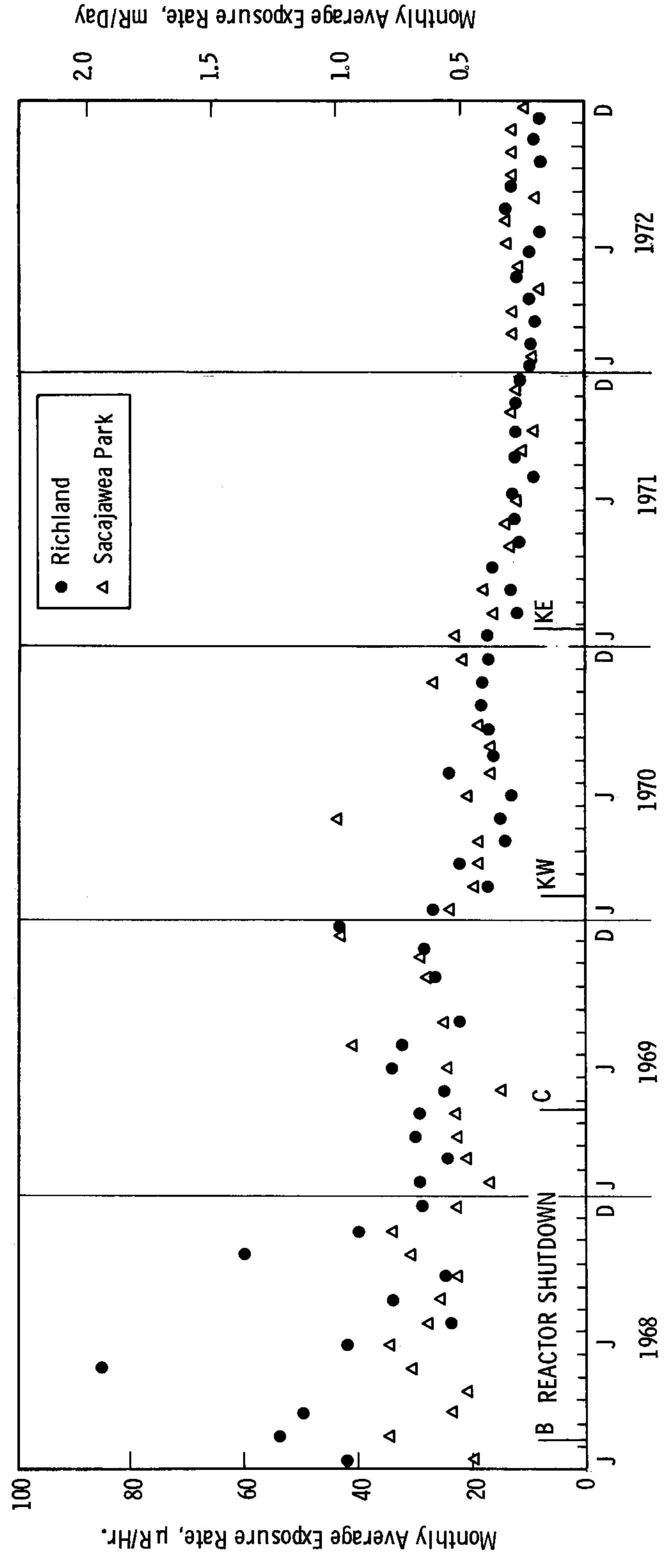

FIGURE 13: Monthly Average Gamma Exposure Rates at the Columbia River Shoreline

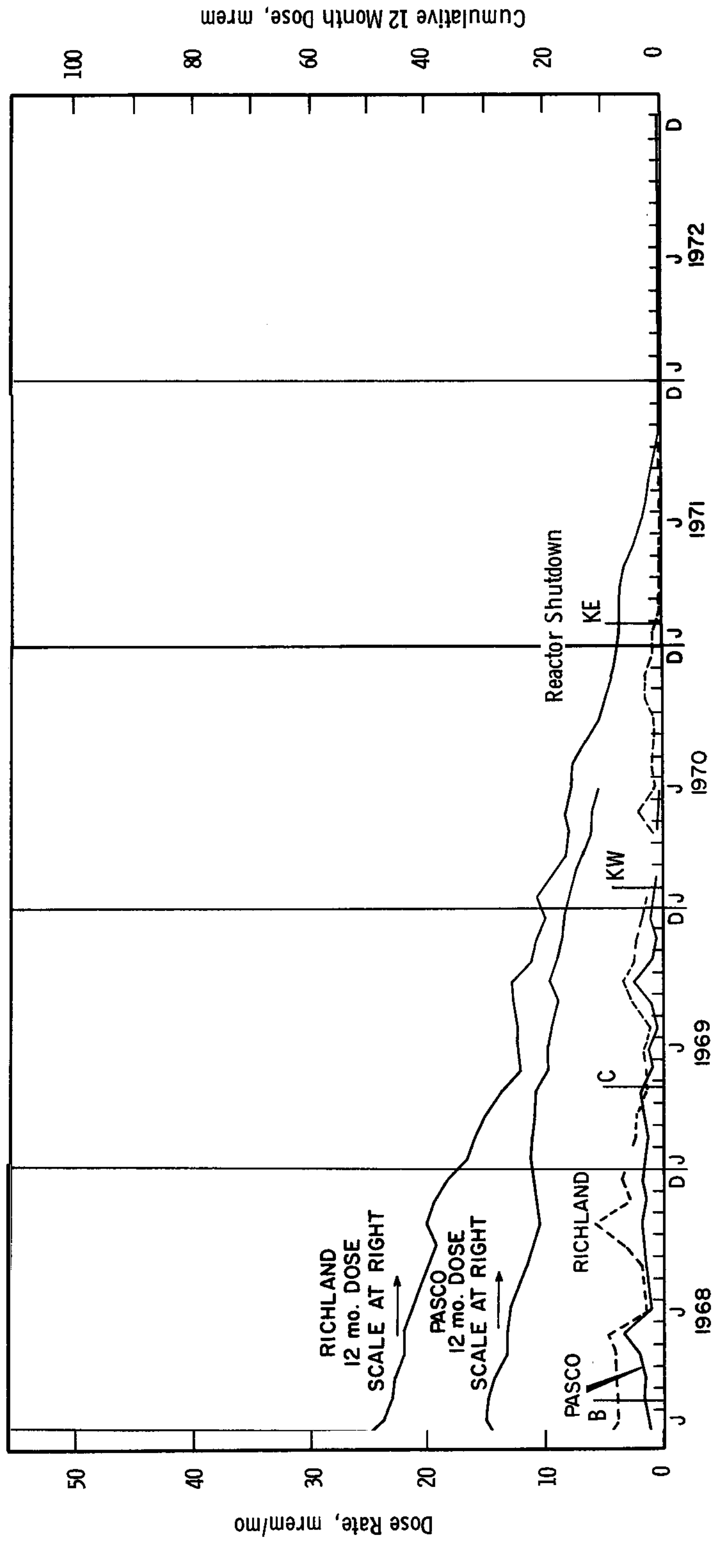

FIGURE 14: Doses to the GI Tract from Drinking Water

ACKNOWLEDGEMENT

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 these data.

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APPENDIX A

ROUTINE MONITORING SCHEDULE

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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. Pasco, 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

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. SURFACE CONTAMINATION

A. Control Plots

Wahluke Slope; nine between Vernita Bridge and Ringold	GM
Pasco - One	GM
State Highway 240 - One southwest of 200 Separations Area	GM

B. 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

C. Aerial Survey

Project Perimeter	SA
Richland - Ellensburg-Ritzville Triangle	SA
Columbia River, Vernita Bridge, McNary Dam	SA

APPENDIX B

ROUTINE ANALYTICAL PROCEDURES

APPENDIX B

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.

(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 colormetric 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.

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

APPENDIX C

APPLICABLE STANDARDS

APPENDIX C

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^oF (FRESH WATER) or 61^oF (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

   Washington-Oregon border (River Mile 309) to Grand Coulee Dam (River Mile 595)

   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 100 μg/m^3; 24 hour average - not to exceed 250 μg/m^3 more than once per year.

   Ref: Environmental Protection Agency[5]

3. Suspended particulates: annual 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.

Concentration Guides for air and water, given in Table II of the Appendix, also apply to maximum exposures to individuals.

APPENDIX D

ANALYTICAL LIMITS

APPENDIX D

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 ± 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 E

DIETARY ASSUMPTIONS

APPENDIX E

DIETARY ASSUMPTIONS

Foodstuffs	Maximum Individual	Average (Adult) Richland Resident
Water	730 ℓ/yr	680 ℓ/yr[a]
Milk	380 ℓ/yr	130 ℓ/yr[a]
Meat	80 kg/yr	74 kg/yr[a]
Chicken	8 kg/yr	5.4 kg/yr
Eggs	30 kg/yr	15 kg/yr
Seafood	0	1.4 kg/yr[a,b]
Col. River Fish	40 kg/yr	0.48 kg/yr
Game Birds	0	1.2 kg/yr[a]
Leafy Vegs.	73 kg/yr[c]	36.5 kg/yr
Other Vegs. & Fruits	530 kg/yr[c]	200 kg/yr

Foodstuffs	Maximum Individual	Average (Infant) Richland Resident
Water	0.8 ℓ/day	0.4 ℓ/day
Milk	1.0 ℓ/day	0.6 ℓ/day
Leafy Vegs.	50 g/day	25 g/day

(a) Based on dietary questionnaires of Richland residents employed at Hanford.

(b) One-tenth of the total is assumed to be Willapa Bay oysters, the remainder free of radionuclides of Hanford origin.

(c) Fresh produce from the Riverview area is assumed to be available only during five months of the year.

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