

ENVIRONMENTAL STATUS  
OF THE HANFORD RESERVATION  
FOR CY-1973



**Battelle**

Pacific Northwest Laboratories  
Richland, Washington 99352

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FOR CY-1973

By

W. L. Nees and J. P. Corley  
Occupational and Environmental Safety Department

January 1975

*On January 19, 1975, research and development programs of the U.S. Atomic Energy Commission (AEC) became part of the newly formed Energy Research and Development Administration (ERDA). In this report, since it refers to work done in 1974, most references are to AEC programs.*

NOTICE

This document contains data obtained within the Hanford reservation for the use of the Atomic Energy Commission and its contractors. The evaluation of the offsite radiological impact of Hanford operations is documented separately in BNWL-1811.(1)

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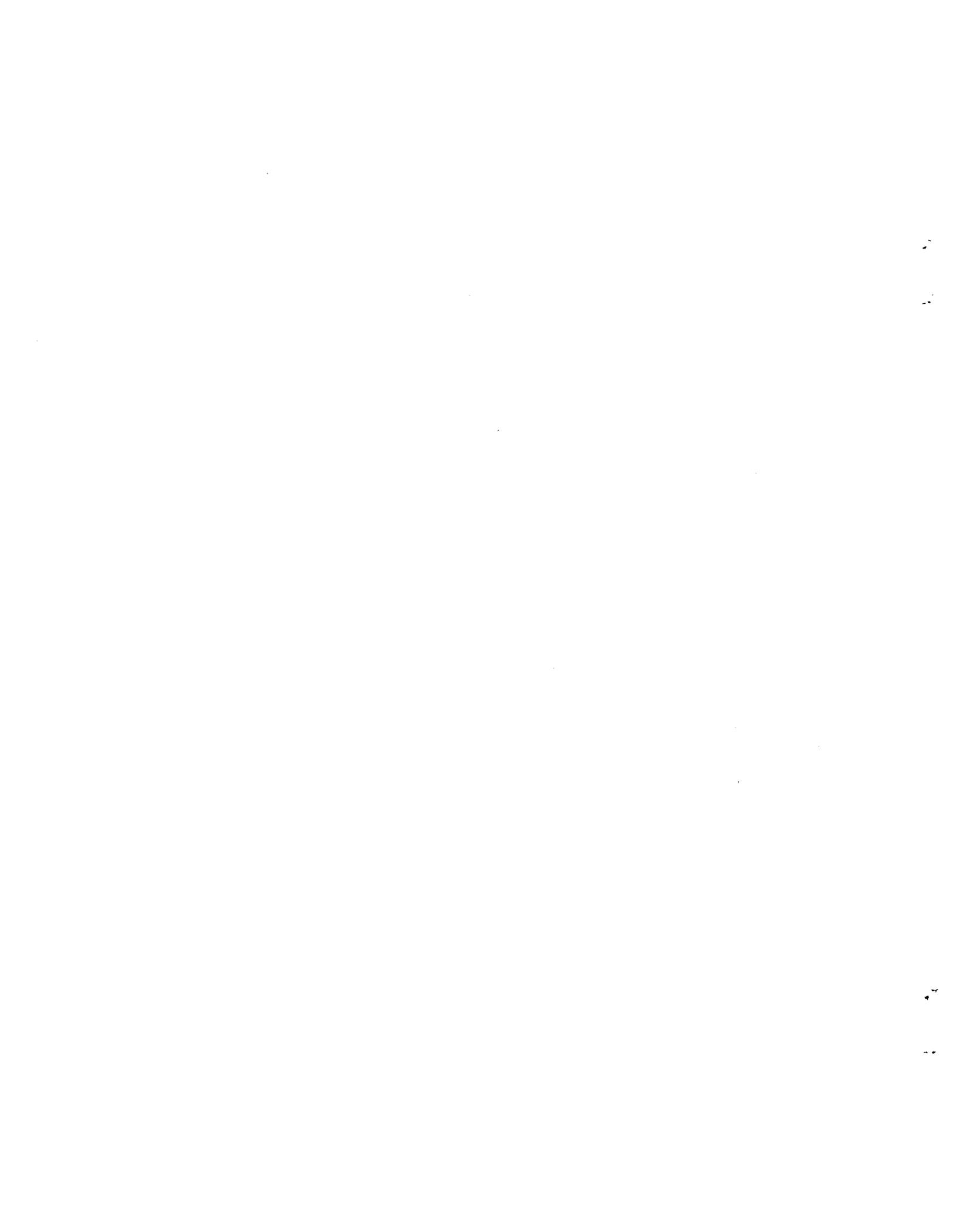
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ENVIRONMENTAL STATUS OF THE HANFORD RESERVATION FOR 1973I. INTRODUCTION

This report summarizes data collected during 1973 from locations within the Hanford plant boundaries (but generally outside areas under the control of individual contractors) for the environmental surveillance program, under the direction of the Environmental Evaluations staff. These environmental data are reported here for the information and use of the Richland Operations Office of the Atomic Energy Commission and its contractors.

The previous report in this series is BNWL-B-278<sup>(2)</sup>, "Environmental Status of the Hanford Reservation for 1972." Graphs in this report show 14 months of data--the subject 12 months and the preceding two. Ground-water data are not included in this report but are presented for the year 1973 in BNWL-1860<sup>(3)</sup>. Data from offsite sampling locations for 1973 are given in BNWL-1811<sup>(1)</sup>, although some data from offsite locations are included in this report for comparison with similar measurements made onsite.

The routine radiochemical analyses reported here were performed by the U.S. Testing Company, Inc. on samples collected by Battelle-Northwest; the 300 Area water quality analyses were performed by Westinghouse Hanford Co. or United Nuclear, Inc., and the remainder of the data by Battelle-Northwest staff.

The term "analytical limit," as used herein, is the concentration at which the laboratory can measure a radionuclide with a precision of  $\pm 100$  percent at the 90 percent confidence level. The detection limit for a specific radionuclide varies with sample type, sample size, counting time, and the amounts of interfering radionuclides present. The "analytical limits" represent upper bounds to these fluctuating detection limits.

## II. SURVEILLANCE HIGHLIGHTS

### Columbia River Water

During 1973, N Reactor was the only remaining plutonium-producing reactor and did not use river water for once-through primary cooling. Some low-level radioactive waste continued to be discharged to the ground at 100-N and thence to the river during the year.

Measured concentrations of  $^{90}\text{Sr}$  and total alpha activity in river water averaged, respectively,  $6.6 \times 10^{-10}$  and  $5.1 \times 10^{-10}$   $\mu\text{Ci/ml}$  at Vernita/100-B and  $3.3 \times 10^{-10}$  and  $4.9 \times 10^{-10}$   $\mu\text{Ci/ml}$  at Richland during the year. Tritium concentrations averaged  $5.1 \times 10^{-7}$   $\mu\text{Ci/ml}$  at Vernita and  $6.1 \times 10^{-7}$   $\mu\text{Ci/ml}$  at Richland.

The estimated annual GI tract dose for employees drinking 100-N Area sanitary water was  $<1$  mrem, a decrease from 1972. Average concentrations of coliform bacteria in Columbia River water were about the same as 1972 averages. These and other water quality measurements--pH, turbidity and dissolved oxygen--indicated continued compliance with Washington State Water Quality Standards.

### Ditches, Ponds, and Trenches

Radionuclide concentrations in samples collected from open waters on the Hanford project during 1973 were, in general, within their expected range of variation and were well below the plant working limit of  $5 \times 10^{-5}$   $\mu\text{Ci/ml}$ . The source of low-level uranium concentrations in West Lake was not identified.

Results of radiological, chemical, and biological analyses of samples collected from 300 Area ponds and trenches were generally within the expected range. Coliform and enterococci concentrations in the 300 Area leach trench were about the same as for 1972.

Concentrations of radionuclides in gamebirds and mammals sampled on or near Hanford waste sites were generally the same as those recorded in 1972.

### Airborne Radioactivity

Concentrations of  $^{131}\text{I}$  in the atmosphere, measured in charcoal samplers, were below  $2 \times 10^{-14}$   $\mu\text{Ci/ml}$ , the detection limit.

At most locations, both onsite and offsite, the average total beta activity was down from 1972. The maximum measured beta activity,  $8 \times 10^{-13}$   $\mu\text{Ci/ml}$ , occurred in February at a 200 East Area location. Annual average activity ranged from  $3 \times 10^{-14}$   $\mu\text{Ci/ml}$  and  $8 \times 10^{-14}$   $\mu\text{Ci/ml}$  in the 100 and 200 Areas, respectively. Offsite beta activity ranged from  $4 \times 10^{-14}$  to  $6 \times 10^{-14}$   $\mu\text{Ci/ml}$  and averaged about  $4.5 \times 10^{-14}$   $\mu\text{Ci/ml}$ .

Total alpha concentrations in air during 1973 averaged about  $2 \times 10^{-15}$   $\mu\text{Ci/ml}$  at most locations. Analyses of composite samples all showed less than  $1 \times 10^{-16}$   $\mu\text{Ci/ml}$  plutonium.

### Soil and Vegetation

Plutonium concentrations in soil and vegetation at perimeter sampling locations were the same as in 1972 and probably typical of general levels for the arid western states. Slightly higher plutonium concentrations were detected at several sampling sites near the 200 Areas. In several onsite soil and vegetation samples from near the 200 Areas  $^{95}\text{Zr-Nb}$  and  $^{137}\text{Cs}$  were present at somewhat higher concentrations than at perimeter sites. Concentrations of gamma-emitting radionuclides and  $^{90}\text{Sr}$  at perimeter sites are believed to be the result of regional fallout.

### Radiation Surveys

Twice during the monthly road surveys, several radioactive particles were found on Hanford roadways. The most active was a particle reading 35,000 c/m. Occurrences were attributed to waste hauling operations between Areas.

There was a downturn in the external exposure rates at most locations this year. The maximum average exposure rate measured was 1.2 mR/day at 200 East Area. On the basis of exposure rate measurements offsite and at 100-N, the total-body dose to WPPSS personnel from Hanford sources of external radiation at 100-N during 1973 was estimated to be 8 mrem.

The waste disposal sites audited were generally in good condition except for a few isolated low-level contaminated spots found at 100-H.

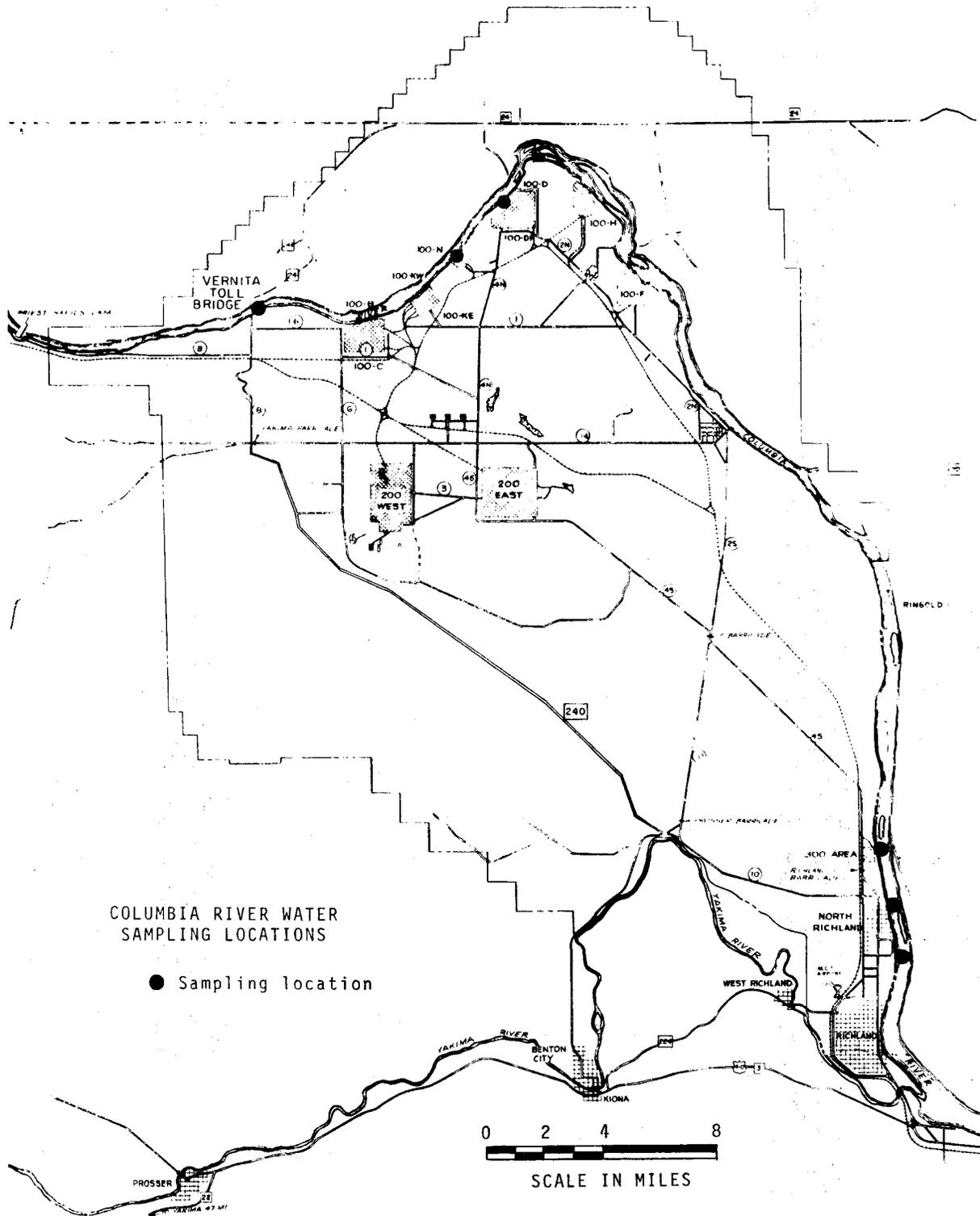
A special aerial survey detected several areas on the rivershore near the reactors and on river islands where the dose rate, apparently from  $^{60}\text{Co}$  deposited during reactor operation in earlier years, was up to 0.04 mR/hr vs. a background of about 0.01 mR/hr.

### III. COLUMBIA RIVER WATER

Columbia River water sampled upstream of the Hanford project at Vernita is analyzed for comparison with samples collected downstream of the project at Richland to determine overall plant effects on Columbia River water. These results are reported in the annual offsite environmental surveillance report.<sup>(1)</sup> In addition, sampling is done at intermediate locations to detect localized influences on plant drinking water or river water quality (Section IV). Sampling locations for raw Columbia River water are shown in Map 1.

Fallout radionuclides  $^3\text{H}$  and  $^{90}\text{Sr}$ , as well as total alpha activity, were measured in monthly composites of weekly grab samples at Vernita or 100-B and in monthly composites of weekly integrated samples at Richland. The measured concentrations of  $^{90}\text{Sr}$  and total alpha activity in river water averaged, respectively,  $6.6 \times 10^{-10}$  and  $5.1 \times 10^{-10}$   $\mu\text{Ci/ml}$  at Vernita/100-B, and  $3.3 \times 10^{-10}$  and  $4.9 \times 10^{-10}$   $\mu\text{Ci/ml}$  at Richland during the year. Measured tritium concentrations averaged  $5.1 \times 10^{-7}$   $\mu\text{Ci/ml}$  at Vernita and  $6.1 \times 10^{-7}$  at Richland. Averages were based on the actual sample results, which in many instances were less than the analytical limits.

From the Washington-Oregon border to Grand Coulee Dam, the Columbia is considered a Class A river, according to the Washington State Water Quality Standards.<sup>(4)</sup> These standards state that for Class A rivers, total coliform organisms shall not exceed median values of 240 per 100 ml, with less than 20% of the samples exceeding 1000 per 100 ml when associated with a fecal source. In addition to coliform, enterococci is measured to indicate contaminants of fecal origin. Biological measurements of Columbia River water samples collected monthly from Vernita, 100-F, 300 Area, and North Richland appear in Table 1. Normal seasonal peaking was observed during the summer months. Standards do not appear to have been exceeded during the year. Riverbank spring sampling indicates that the increase in the average coliform count between Vernita and North Richland (from 54 to 85) is not related to Hanford operations and was not of fecal origin.



COLUMBIA RIVER WATER  
SAMPLING LOCATIONS

● Sampling location

MAP 1. Columbia River Water Sampling Locations

TABLE 1  
COLUMBIA RIVER BIOLOGICAL ANALYSES FOR 1973

	Coliform (N/100 ml)			Enterococci (N/100 ml)			BOD (ppm)		
	<u>Vernita</u>	<u>% Std.</u>	<u>240</u>	<u>Vernita</u>	<u>% Std.</u>	<u>240</u>	<u>Vernita</u>	<u>% Std.</u>	<u>240</u>
No. Samples	12		12	12		12	11		11
Maximum	220		240	100		200	4.2		4.0
Minimum	2.5		6.0	2.0		4.0	0.6		0.95
Average	54	22	87	33	35	67	2.0	2.1	2.1

TABLE 2  
COLUMBIA RIVER CHEMICAL ANALYSES FOR 1973

Standard	NO <sub>3</sub> (ppm)		p <sup>H</sup>		Turbidity (JTU)		Dissolved O <sub>2</sub> (ppm)	
	Vernita	Richland	Vernita	300 Area	Vernita	300 Area	Vernita	300 Area
	45	45	6.5 to 8.5	6.5 to 8.5	5 + Bg	5 + Bg	8.0 min.	8.0 min.
Analy. Limit	0.1	0.1						
No. of Samples	50	51	48	23	43	208	36	176
Maximum	0.85	0.84	9.1	9.1	4.3	5.0	14.1	14.1
Minimum	*	*	7.6	7.5	0.5	0.6	9.0	8.0
Average	0.32	0.71	0.30	0.67	8.4	8.1	1.5	1.4
							10.5	10.2

\*Less than the analytical limit

BOD and nitrate analysis was also performed on the weekly samples of river water from Vernita and Richland. Turbidity, pH, and dissolved oxygen measurements obtained at Vernita and 300 Area were generally in compliance with Washington State Water Quality Standards (Table 2 and Figure 1).

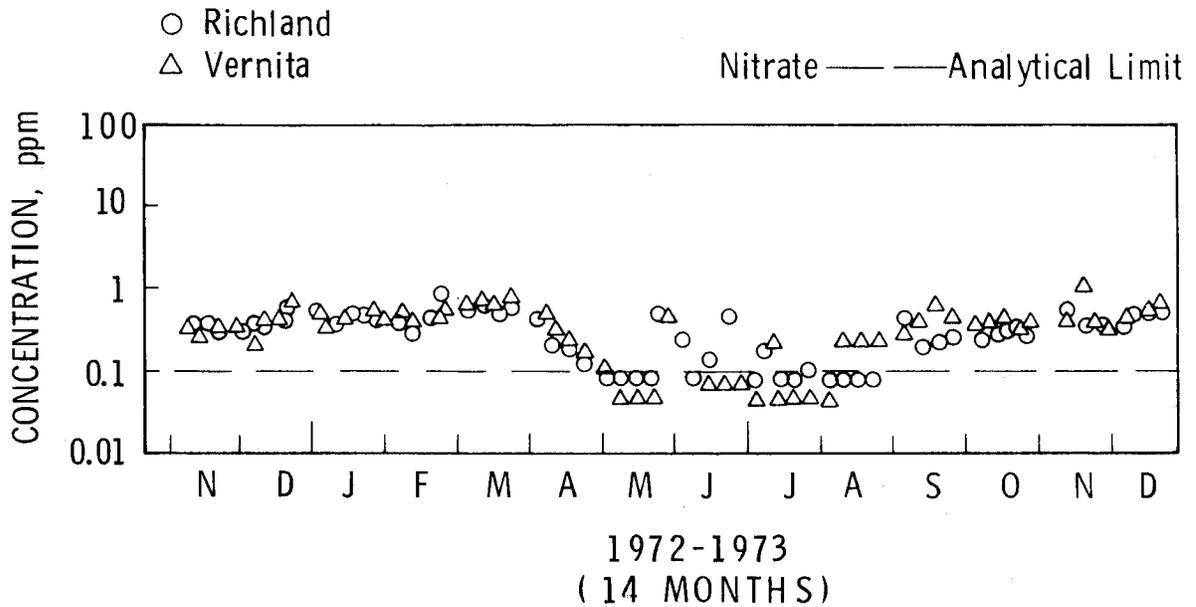
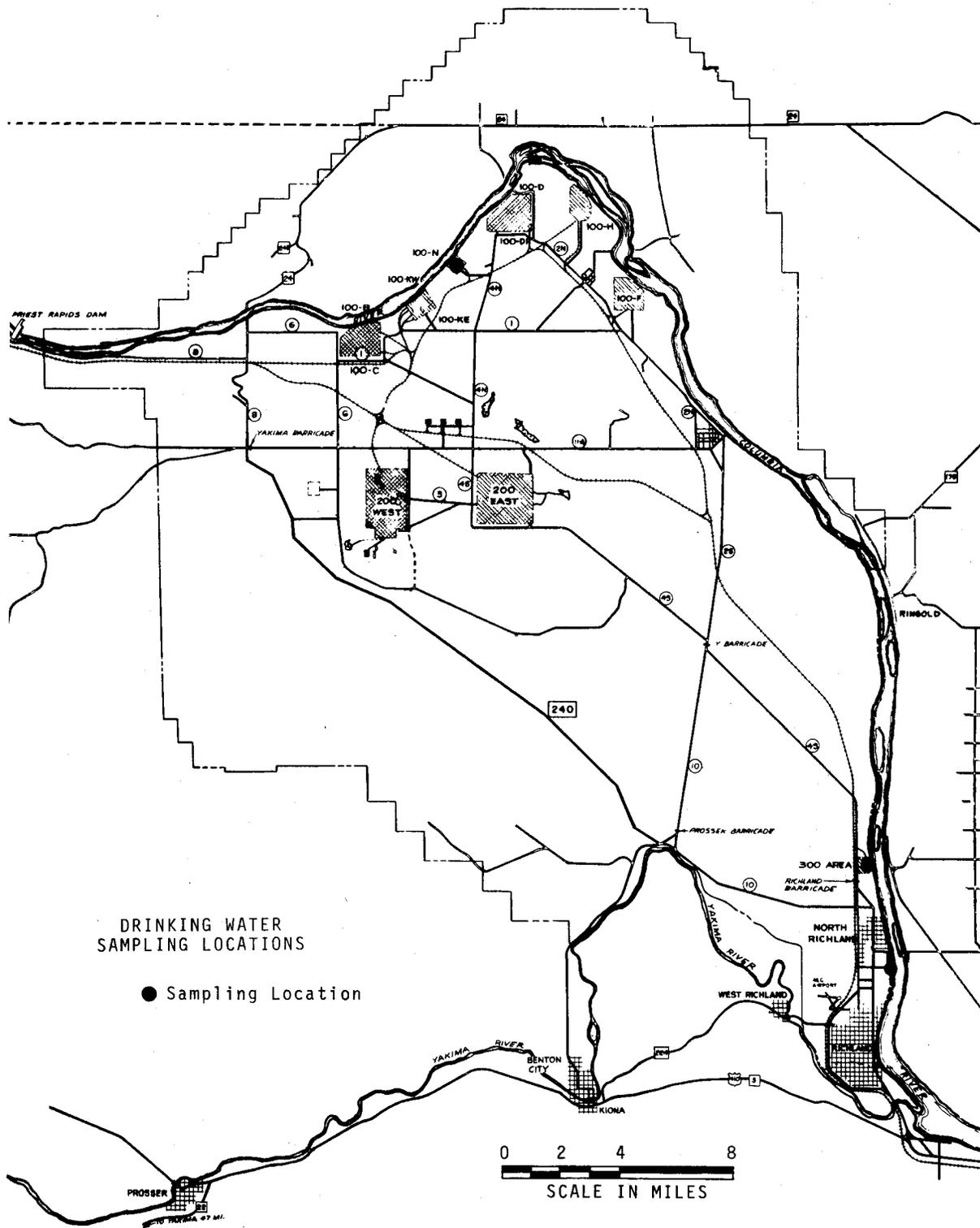


FIGURE 1. Nitrate Concentrations in Columbia River Water

#### IV. DRINKING WATER

Drinking water was sampled at the three locations shown in Map 2. The GI tract dose from drinking 100-N water (Table 3) was estimated from monthly isotopic and more frequent total beta analyses. The assumed water intake rate was 1.2 liters per day, five days a week, 50 weeks per year, as reported previously. The GI tract dose from drinking 100-N water was less than 1 mrem during 1973, compared with 1.6 mrem during 1972 and 2.8 mrem during 1971. These GI tract doses represented 0.2 and 0.6 percent, respectively, of the 1500 mrem per year dose standard for non-occupationally exposed individuals, or 0.02 and 0.06 percent of the yearly dose standard for occupationally exposed individuals (15,000 mrem/year).



MAP 2. Drinking Water Sampling Locations

TABLE 3  
CONCENTRATIONS OF RADIONUCLIDES IN COLUMBIA RIVER WATER FOR 1973

Units of  $10^{-9}$   $\mu\text{Ci/ml}$

Columbia River Water at Vernita							
Radionuclide	C.G.	Analytical Limit	Number of Samples	Max	Min	Avg	% C.G.
Alpha	30	0.2	3	0.80	0.24	0.51	1.7
Beta	30	0.005					
$^3\text{H}$	3,000,000	250	12	1,100	*	*	0.02
$^{46}\text{Sc}$	40,000	25	3	*	*	*	<0.004
$^{51}\text{Cr}$	2,000,000	250	3	*	*	*	<0.001
$^{60}\text{Co}$	30,000	20	3	*	*	*	<0.003
$^{65}\text{Zn}$	100,000	40	3	*	*	*	<0.001
$^{90}\text{Si}$	300	0.06	3	1.4	0.27	0.66	0.22
$^{131}\text{I}$	300	1.5	4	*	*	*	<0.2
$^{137}\text{Cs}$	20,000	1.0	3	*	*	*	<0.001
$^{239}\text{Pu}$	5,000	0.01	1	*	*	*	<0.001

Columbia River Water at 100-N							
			Number of Samples	Max	Min	Avg	% C.G.
Alpha							
Beta							
$^3\text{H}$			4	310,000	1,900	81,000	2.7
$^{46}\text{Sc}$			1	*	*	*	<0.001
$^{51}\text{Cr}$			1	*	*	*	<0.001
$^{60}\text{Co}$			1	38	38	38	0.13
$^{65}\text{Zn}$							
$^{90}\text{Si}$							
$^{131}\text{I}$			1	140	140	140	47.
$^{137}\text{Cs}$			1	*	*	*	<0.001
$^{239}\text{Pu}$							

Drinking Water at 100-N							
			Number of Samples	Max	Min	Avg	% C.G.
Alpha							
Beta			51	0.01	*	*	<0.01
$^3\text{H}$							
$^{46}\text{Sc}$							
$^{51}\text{Cr}$							
$^{60}\text{Co}$							
$^{65}\text{Zn}$							
$^{90}\text{Si}$							
$^{131}\text{I}$							
$^{137}\text{Cs}$							
$^{239}\text{Pu}$							

\* Less than the analytical limit shown.

No entry indicates no specific analysis was made.

## V. DITCHES, PONDS, AND TRENCHES

Open waters, primarily for disposal of cooling water, were sampled routinely at the locations discussed below and shown in Map 3. Grab samples were collected monthly except that an integrated sample was collected weekly from the 300 Area Process Pond inlet. The sampling is not conducted for inventory purposes but rather serves as surveillance of the radioactive contamination level in these waters. Total alpha and total beta concentrations were well below  $5 \times 10^{-5}$   $\mu\text{Ci/ml}$ , the limit for open waters on the Hanford Reservation.<sup>(5)</sup>

300 Area Process Pond samples received both radionuclide and chemical analyses. Biological measurements were also obtained on samples from the 300 Area Sanitary Waste Leach Trench and its associated river shoreline seepage area.

### 200 Area Waste Waters

The waste waters sampled in the 200 Areas are primarily cooling water from chemical processes and waste tanks. Monthly grab samples were collected from 222-S Pond (216-S-19), T Pond (216-T-4), U Pond (216-U-10), Redox Pond (216-S-16), Gable Pond (216-A-25), B Pond (216-B-3), Chemical Sewer Emergency Ditch (216-B-63), 331 Pond, and West Lake. Analytical results are presented in Figures 2, 3, 4, and 5, as well as Table 4. Alpha and beta activity in all ponds was within normal range of fluctuation. Due to ice, no samples could be obtained during January.

Pond samples received a quarterly gamma-emitter analysis (Table 4). Samples from ponds occasionally contained fallout radionuclides at similar concentrations to those typically found in Columbia River water. This is to be expected since the Columbia River is the major source of process and cooling waters for the 200 Areas.

The source of the alpha activity in West Lake has not been identified. There was no apparent surface water flow between West Lake and Gable Pond. Furthermore, Gable Pond alpha activity is an order of magnitude less than West Lake. Sampling of groundwater and soil surfaces in the vicinity of



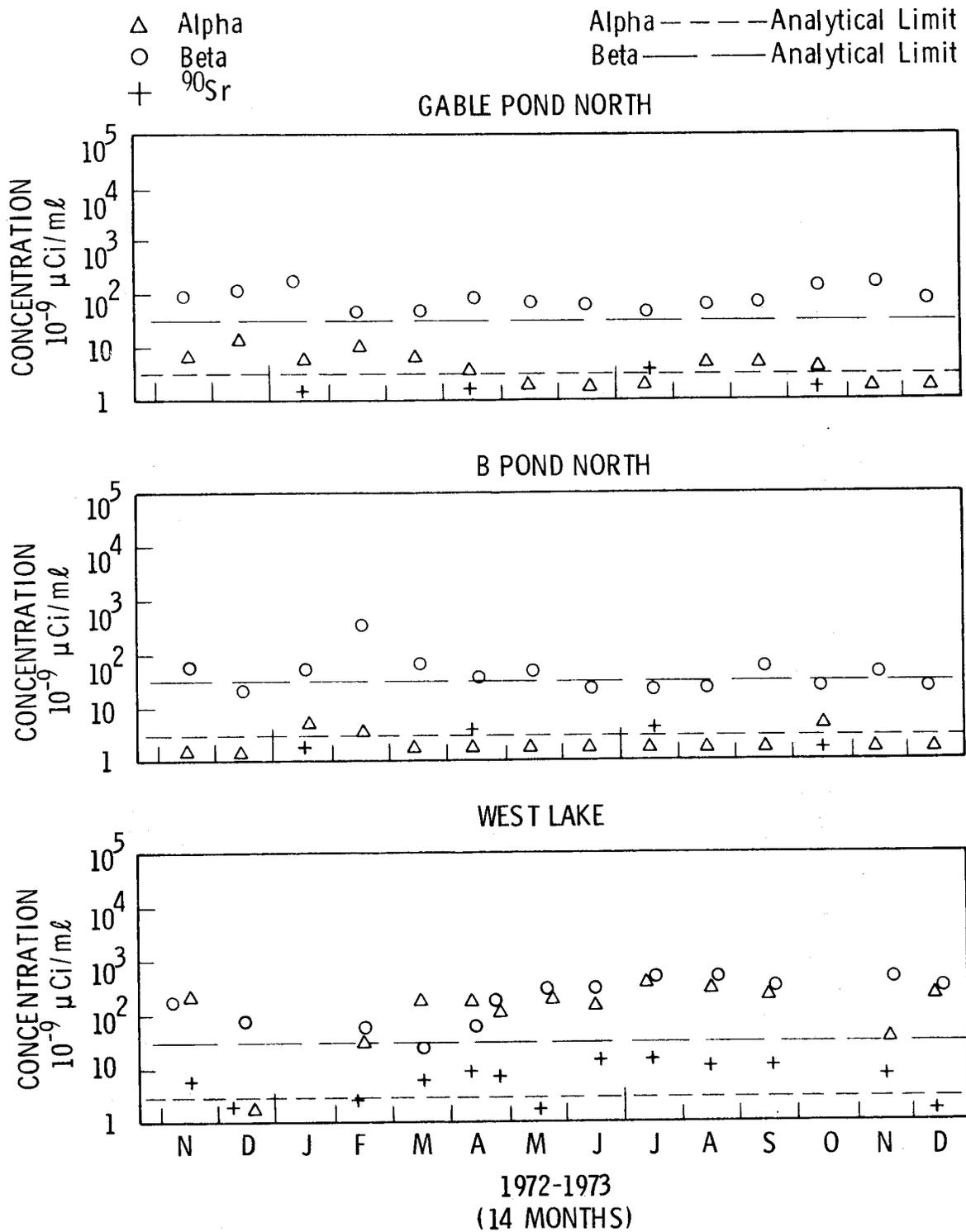


FIGURE 2. Radioactivity of Waste Water Samples 200 East Area

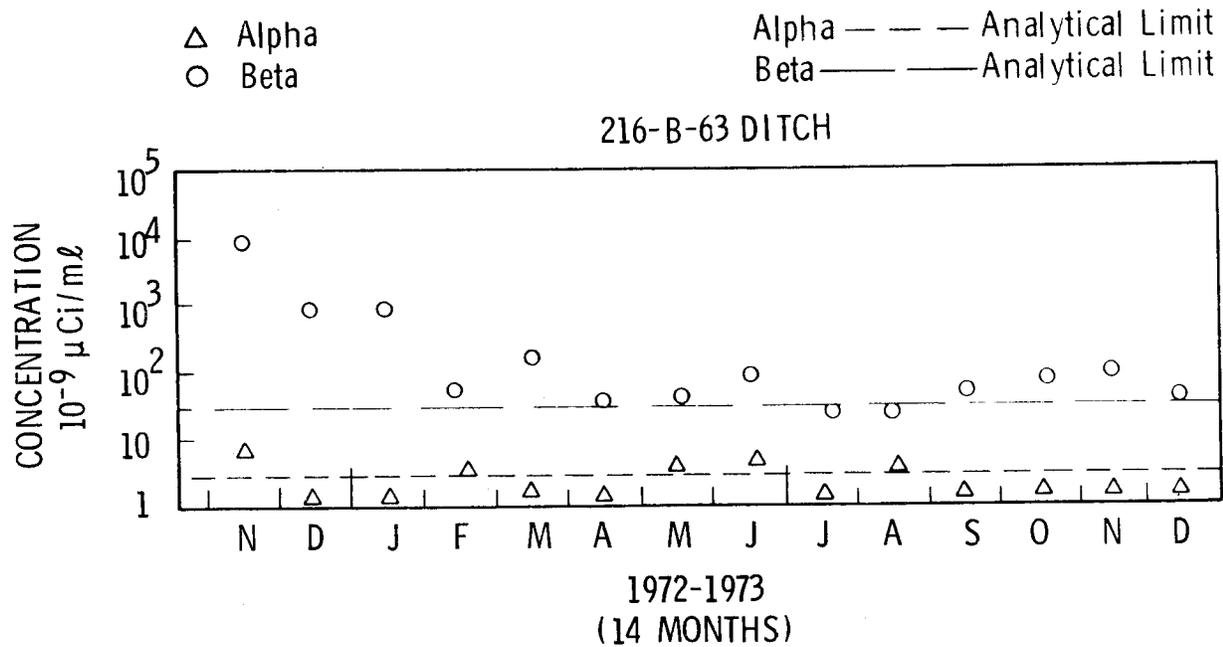


FIGURE 3. Radioactivity of Waste Water Samples 200 East Area

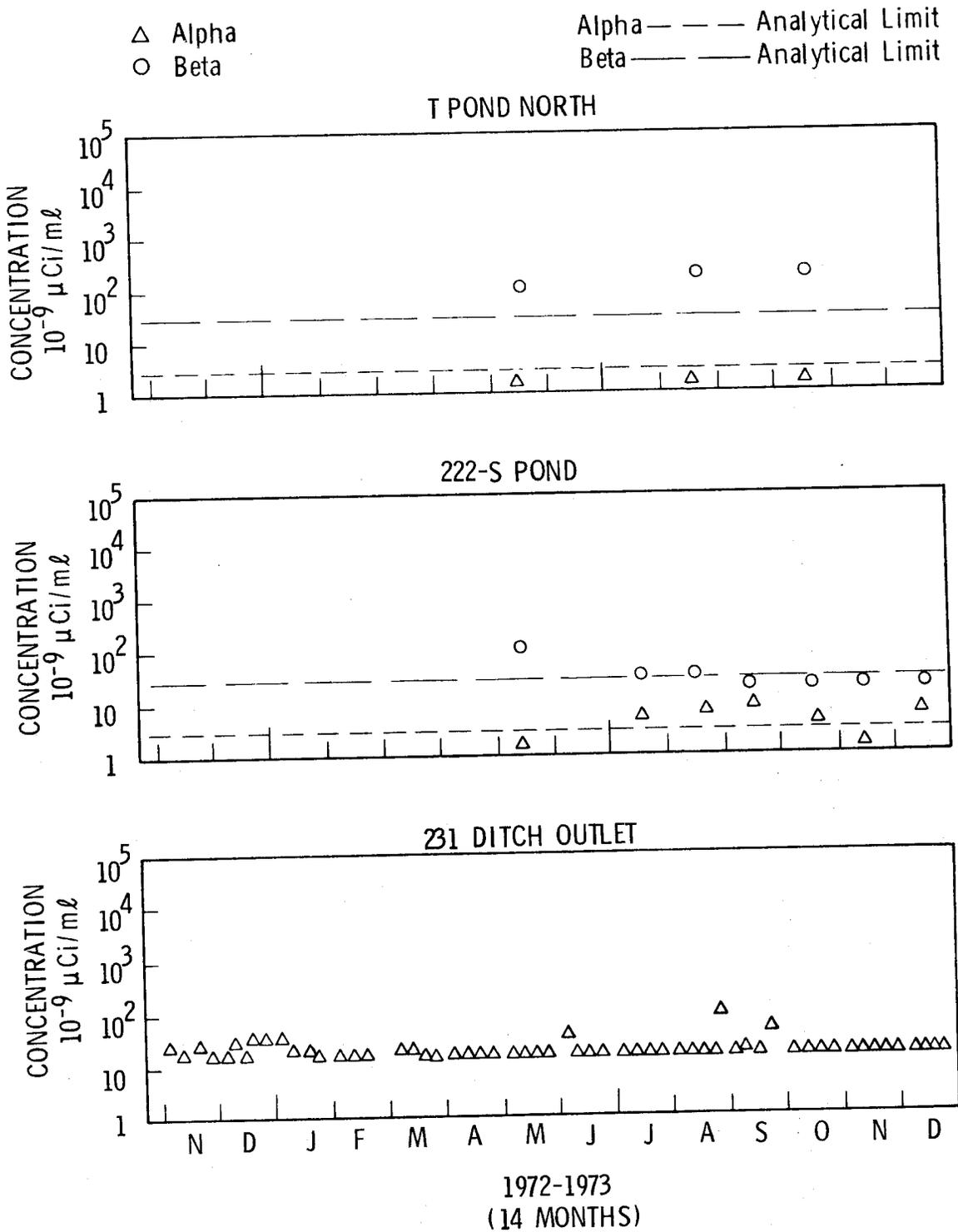


FIGURE 4. Radioactivity of Waste Water Samples 200 West Area

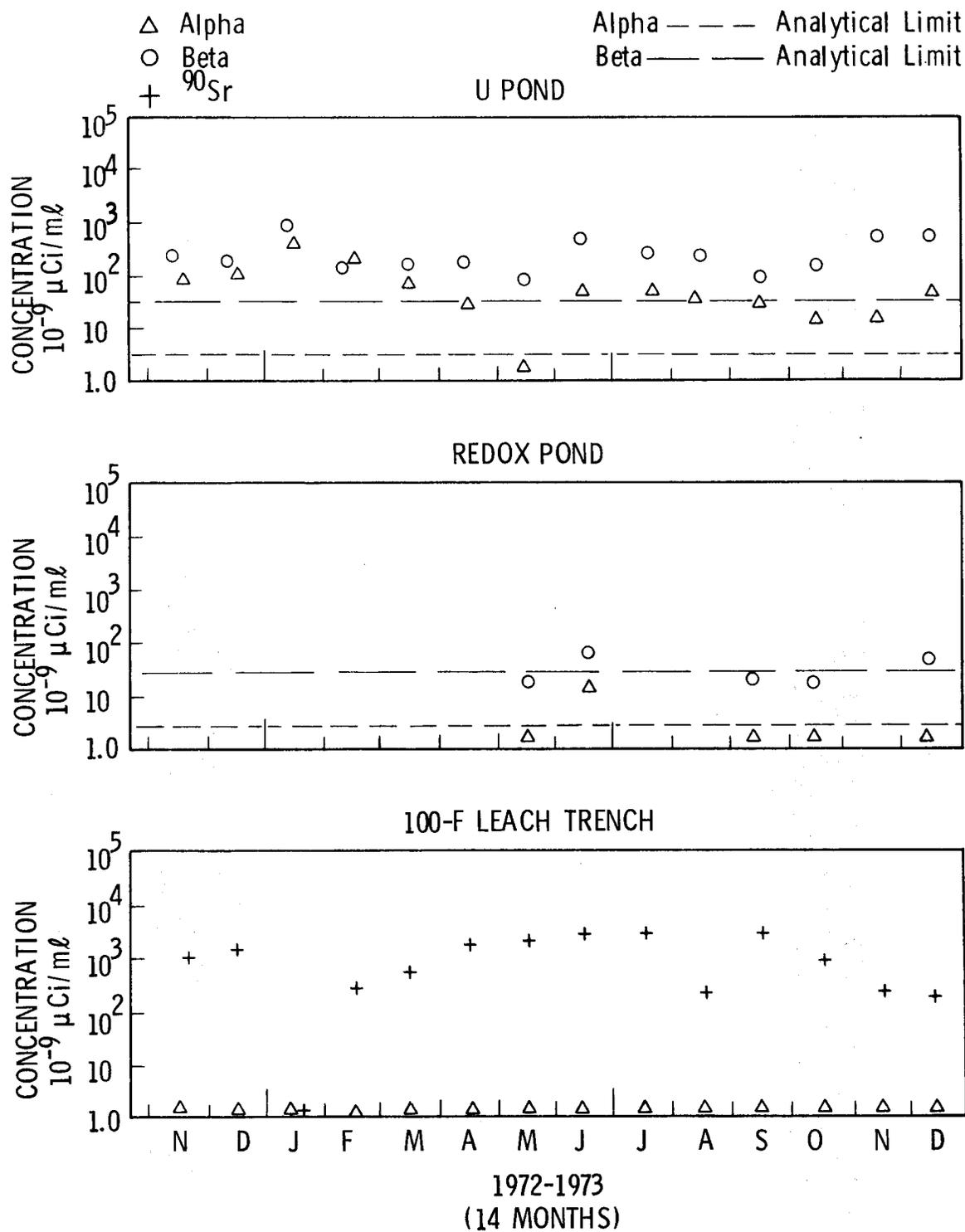


FIGURE 5. Radioactivity of Waste Water Samples 200W, 100F Areas

TABLE 4  
 GAMMA ACTIVITY IN WASTE WATER SAMPLES - 1973  
 Units of  $10^{-9}$   $\mu\text{Ci/ml}$

	<u>Date</u>	<u><math>^{46}\text{Sc}</math></u>	<u><math>^{51}\text{Cr}</math></u>	<u><math>^{60}\text{Co}</math></u>	<u><math>^{65}\text{Zn}</math></u>	<u><math>^{137}\text{Cs}</math></u>
<u>Analytical Limit</u>		40	400	32	55	29
<u>Location</u>						
West Lake	4/6	*	*	*	*	*
	7/6	*	*	*	*	*
Gable Pond	1/19	*	*	*	*	*
	4/6	*	*	*	*	35
	7/6	*	*	*	*	*
	10/12	*	*	*	*	76
B Pond	1/19	*	*	*	*	*
	4/6	*	*	*	*	*
	7/6	*	*	*	*	*
	10/12	*	*	*	*	*
T Pond	10/12	*	*	*	*	30
S Pond	7/6	*	*	*	*	*
	10/12	*	*	*	*	*
U Pond	1/19	*	*	*	*	*
	4/6	*	*	*	*	36
	7/6	*	*	*	*	110
	10/12	*	*	*	*	*
Redox	10/12	*	*	*	*	*
216-B-63 Ditch	1/12	*	*	*	*	*
	4/6	*	*	*	*	*
	7/6	*	*	*	*	*
	10/12	*	*	*	*	*
331 Pond	1/9	*	*	*	*	*
	4/24	*	*	*	*	*
	7/17	*	*	*	*	*
	10/9	*	*	*	*	*

\* Less than analytical limit

West Lake revealed no unusual alpha concentrations. Radioanalysis indicates that uranium is the source of the alpha activity detected in West Lake.

#### 100-F Leach Trench

The 100-F Leach Trench receives waste water runoff from the 100-F Biology animal pens.

Alpha and  $^{90}\text{Sr}$  analysis of monthly grab samples collected from 100-F Leach Trench are presented in Figure 5. Average  $^{90}\text{Sr}$  and alpha concentrations were  $12.3 \times 10^{-7}$  and  $1.0 \times 10^{-11}$   $\mu\text{Ci/ml}$ , respectively, for 100-F Leach Trench.

#### 300 Area Waste Waters

300 Area process pond receives manufacturing process and cooling water from fuel fabrication processes as well as cooling water and small amounts of laboratory waste waters from the laboratory operations.

Total beta, uranium, nitrate ion, and hexavalent chromium concentrations measured in weekly cumulative samples, collected near the inlet of the 300 Area processing pond, are presented in Figure 6. The concentration of uranium is based on a measurement of total alpha. Monthly average fluoride ion measurement results appear in Table 5. The average fluoride ion concentration for 1973 was 2.4 ppm, the same as for 1971.

300 Area Leach Trench receives sanitary waste from the laboratory office and manufacturing facilities in the 300 Area. Samples were collected monthly from the 300 Area Leach Trench and from the river shoreline seepage area. Analyses for coliform, enterococci (fecal bacteria), and BOD (biochemical oxygen demand) are summarized in Table 6.

331 Pond receives waste waters from the 331 Building laboratories and effluent liquor from the animal pen septic tanks. Monthly grab samples were collected from 331 Pond. Analytical results from alpha and beta are presented in Figure 7. Table 4 presents the results of quarterly gamma scans of 331 Pond water. Gamma-emitter concentrations were less than the analytical detection limit.

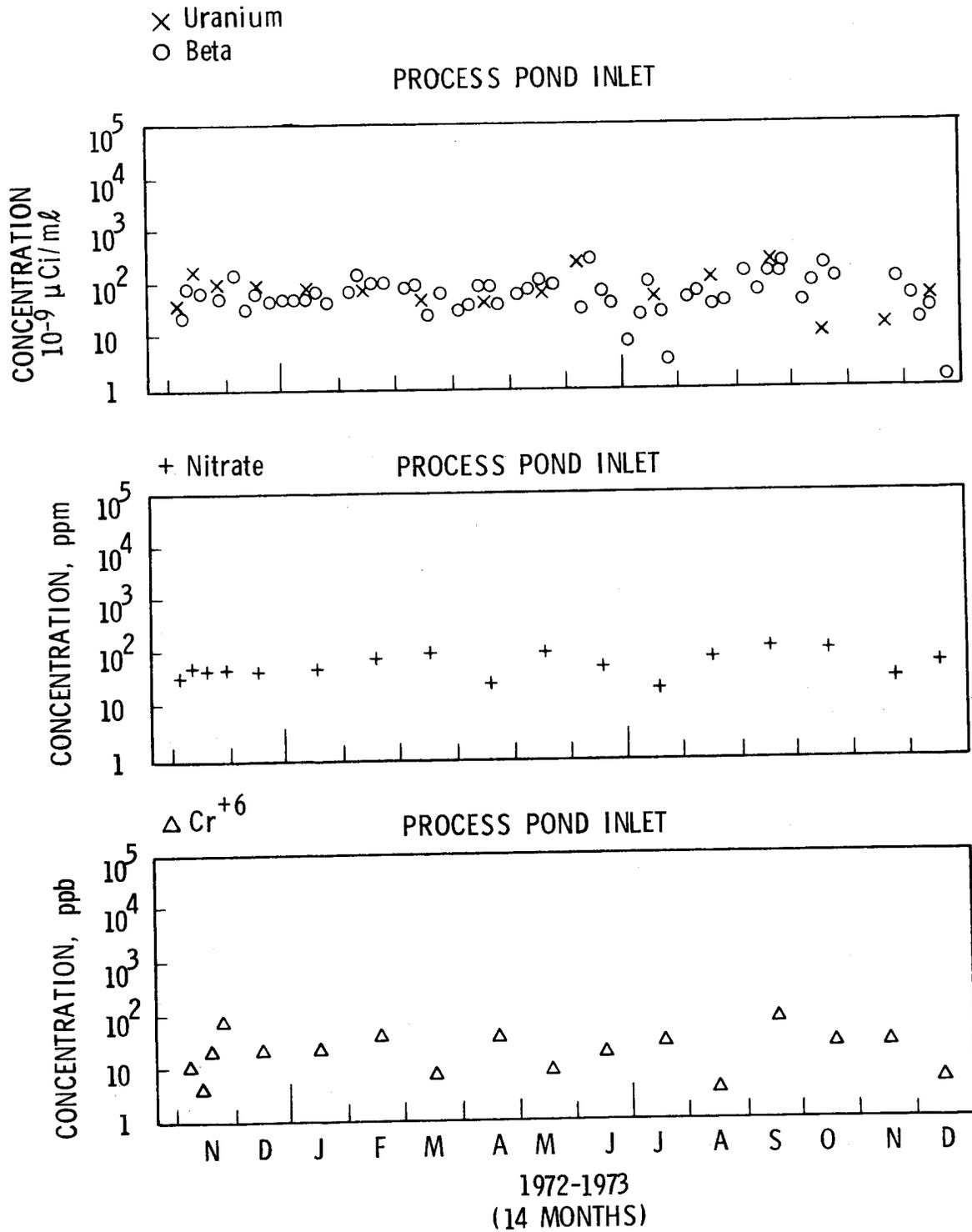


FIGURE 6. Waste Water Analyses 300 Area

TABLE 5

FLUORIDE ION CONCENTRATIONS IN THE 300 AREA PROCESS POND - 1973  
(Monthly Composites of Weekly Integrated Samples)

<u>Month</u>	<u>F- ppm</u>
January	2.5
February	2.9
March	3.0
April	0.48
May	3.6
June	1.8
July	0.76
August	3.6
September	5.7
October	2.7
November*	0.90
December	1.5
Average	2.4

---

\* No analyses were made for the period  
10/29-73 to 11/19/73.

TABLE 6

BIOLOGICAL MEASUREMENTS OF SAMPLES COLLECTED FROM THE 300 AREA LEACHING TRENCH AND ITS ASSOCIATED RIVER SHORELINE SEEPAGE AREA - 1973

## 300 LEACHING TRENCH

<u>Date</u>	<u>Coliform N/100 ml</u>	<u>Enterococci N/100 ml</u>	<u>BOD mg/ℓ</u>
1/9	60,000	22,000	
2/6	860,000	65,000	1.1
3/6	2,000	1,200	1.6
4/3	120,000	5,700	2.2
5/8	460,000	15,000	0.65
6/7	1,100,000	6,000	3.0
7/11	700,000	22,000	2.2
8/7	170,000	38,000	0.7
9/11	1,650,000	8,000	2.2
10/2	1,600,000	52,000	1.8
11/27	825,000	42,000	1.2
12/11	1,100,000	52,000	0.0
Average	770,000	33,000	1.5

## RIVER SHORELINE SEEPAGE AREA

<u>Date</u>	<u>Coliform N/100 ml</u>	<u>Enterococci N/100 ml</u>	<u>BOD mg/ℓ</u>
1/9	30	5	
2/6	5	5.5	2.0
3/6	8	3	1.5
4/3	37	13	3.5
5/8	10	40	1.9
6/7	70	30	1.1
7/11	100	30	3.2
8/7	80	70	3.0
9/11	180		1.2
10/2	205	160	2.2
11/27	70	10	2.0
12/11	23	8	1.7
Average	68	34	2.1

No entry indicates no analysis was made.

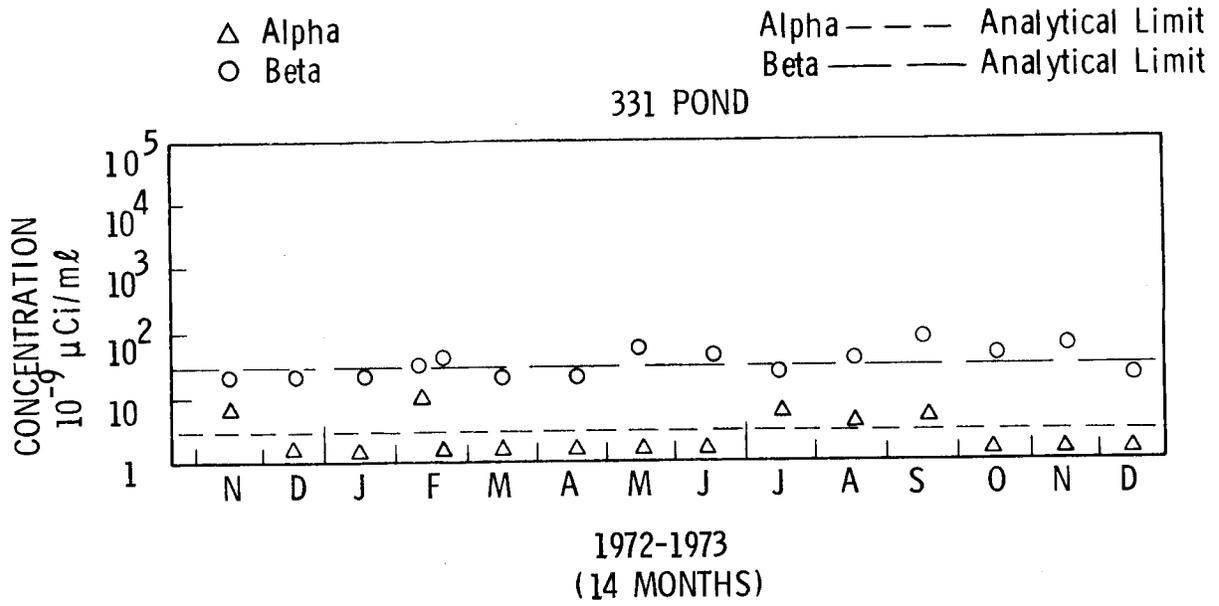


FIGURE 7. Radioactivity of Waste Water Samples 300 Area

VI. GROUNDWATER

Results of the groundwater surveillance program are published separately. The most recent report is BNWL-1860, "Radiological Status of the Groundwater Beneath the Hanford Project, 1973".<sup>(3)</sup>

## VII. BIRDS AND MAMMALS

Migratory waterfowl utilize, as nesting places, Hanford Reservation ponds which receive low-level radioactive waste. Ingestion of the waste water or waste-contaminated vegetation may result in measurable quantities of radionuclides in the waterfowl's tissues and organs. Some resident waterfowl, other gamebirds such as pheasants, and a variety of mammals also have access to the waste waters and potentially contaminated vegetation.

Gamma scan and  $^{90}\text{Sr}$  analyses were obtained on muscle samples of most gamebirds and mammals collected. At several locations the liver was sampled for  $^{239}\text{Pu}$  or uranium analysis. When several birds of the same species and location were collected on the same day, muscle from one to five birds was composited for a gamma scan. The gamma scan of the composite obviated the gamma scans of the individual birds.

### Waterfowl

Radionuclide concentrations in 22 waterfowl sampled from ponds in 1973 were generally the same as those recorded in 1972. Tables 7 and 8 present this data, as well as the average analytical results for ducks (38) and geese (23) sampled from the Columbia River in the vicinity of the reactor areas. The  $^{60}\text{Co}$  concentration in one duck collected at the 100-F Leach Trench is unexplained, since there is no indication of elevated  $^{60}\text{Co}$  in the Leach Trench or other bodies of water accessible to waterfowl. The average  $^{137}\text{Cs}$  was much lower in the river waterfowl than the 200 Area pond waterfowl, indicating that the river waterfowl, most subject to public hunting, do not frequent the 200 Area ponds. Even were the resident duck population on these ponds subject to public hunting, a member of the public would have to consume 25 meals of such ducks to get even 1% of the whole body dose limit for a member of the general public.

### Pheasants

No unusual radionuclide concentrations were detected in 16 pheasants.  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ , and  $^{65}\text{Zn}$  concentrations were similar to the values observed in river birds.

TABLE 7  
 AVERAGE RADIONUCLIDE CONCENTRATIONS IN MUSCLE OF GAMEBIRDS - 1973  
 Units of  $10^{-6}$   $\mu\text{Ci/gm}$  (wet weight)

<u>Location</u>	<u>Species</u>	<u>No. of Samples</u>	<u><math>^{58}\text{Co}</math></u>	<u><math>^{60}\text{Co}</math></u>	<u><math>^{65}\text{Zn}</math></u>	<u><math>^{90}\text{Sr}</math></u>	<u><math>^{137}\text{Cs}</math></u>
Analytical Limit			0.15	0.15	0.20	0.002	0.1
U Pond	Ducks	1	1.7	*	*	0.020	22
Redox Pond	Ducks	3	*	*	*	0.010	3.8
Gable Pond	Ducks	6	*	0.25	*	0.036	31
B Pond	Ducks	4	*	*	*	0.008	6.7
300 Pond	Ducks	3	*	*	*	0.017	0.23
100-F Trench	Ducks	3	*	6.3	*	0.008	*
West Lake	Ducks	4	*	*	*	0.007	0.46
Columbia River	Ducks	38	*	*	*	0.003	*
Columbia River	Geese	23	*	*	*		*
100 Areas	Pheasants	16	*	*	*	0.002	*

\* Less than analytical limit.

No entry indicates no analysis was made.

TABLE 8

AVERAGE CONCENTRATIONS OF SELECTED RADIONUCLIDES IN THE LIVERS  
OF WATERFOWL SAMPLES IN THE HANFORD ENVIRONS - 1973

Units of  $10^{-6}$   $\mu\text{Ci/gm}$  (wet weight)

<u>Location</u>	<u>No. of Samples</u>	<u>U</u>	<u><math>^{239}\text{Pu}</math></u>
Analytical Limit		0.001	0.0002
300 Pond	2	0.014	0.007
100-F Trench	2		0.0006
West Lake	1	0.001	
U Pond	1	0.001	
Gable Pond	1		0.003

No entry indicates no analysis was performed.

TABLE 9

CONCENTRATION OF SEVERAL RADIONUCLIDES IN DEER - 1973

Units of  $10^{-6}$   $\mu\text{Ci/gm}$  (wet weight)

<u>Location</u>	<u>Date</u>	<u>Tissue</u>	<u><math>^{65}\text{Zn}</math></u>	<u><math>^{90}\text{Sr}</math></u>	<u><math>^{137}\text{Cs}</math></u>	<u><math>^{239}\text{Pu}</math></u>
Analytical Limit			0.06	0.002	0.026	0.00001
100-K	1/23	Muscle	*	*	0.51	
100-K	1/23	Liver				0.00001
100-D	11/8	Muscle	0.097	*	0.046	
100-D	11/8	Liver				0.0002

\* Less than the analytical limit.

No entry indicates no analysis was performed.

### Deer

The deer population sampled is assumed to be resident on the Hanford Reservation. Relaxation of access control of sportsmen on Wahluke Slope increases the possibility of hunters bagging a deer living on the Hanford Reservation.

Deer were sampled as part of the environmental sampling program in January and November. Generally, the radionuclide concentrations detected in muscle tissue (Table 9) were comparable to 1972 samples.  $^{137}\text{Cs}$  concentration in the muscle of the January deer was slightly higher than any deer sample of 1972.  $^{90}\text{Sr}$  concentrations observed in the Hanford deer are similar to the concentrations in deer from other parts of the country and are attributed to fallout.

### Small Mammals

Sampling of mice and rabbits (Table 10) was conducted near liquid waste trenches and ponds in the 100, 200, and 300 Areas. The results serve as an indicator of potential transport of radioactivity away from waste sites by small mammals and predators even though no direct pathway to man of radiation exposure from such mammals is believed to exist. Radionuclide concentrations in mammals collected in 1973 were generally the same as in 1972. Mice collected from the vicinity of the 100-N trench continued to show radionuclide concentrations orders of magnitude above specimens from other Hanford locations, probably as a result of ingestion of water from 100-N trench.

Radionuclide concentrations in rabbits were about the same as 1972.

TABLE 10  
 CONCENTRATIONS OF SELECTED RADIONUCLIDES IN SMALL ANIMALS - 1973

Units of  $10^{-6}$   $\mu\text{Ci/gm}$

Date	Location	$^{40}\text{K}$	$^{51}\text{Cr}$	$^{54}\text{Mn}$	$^{59}\text{Fe}$	$^{60}\text{Co}$	$^{65}\text{Zn}$	$^{90}\text{Sr}$	$^{95}\text{ZrNb}$	
<u>Mice</u>										
	Analytical Limit	4.3	0.4	0.35	1.5	0.32	0.64	0.002	0.40	
1/4	200 West	*	*	*	*	0.55	*	0.65	*	
1/4	100-N Trench	*	*	5,000	*	16,000	960	84	*	
2/2	100-N Trench	*	*	9,200	7,300	31,000	*	130	3,300	
2/2	200 West	9.3	*	*	*	*	*	0.32	*	
2/28	100-N Trench	170	*	250	140	560	22	9.0	*	
3/20	100-N Trench	590	*	150	360	*	29	32	36	
3/27	200 West	*	*	*	*	0.76	*	0.31	*	
3/27	300 Area	*	*	*	*	*	*	0.05	*	
4/3	200 West	*	*	*	*	0.32	0.74	0.41	*	
4/3	100-N Trench	*	*	*	2,800	2,900	*	15	1,700	
4/3	300 Area	*	16.0	*	*	1.6	*	0.14	*	
5/3	200 West	5.6	*	*	*	1.3	1.1	0.32	*	
5/3	100-N Trench	*	*	40	48	140	*	6.1	5.0	
6/8	200 West	4.9	*	*	*	*	*	0.34	*	
<u>Rabbits</u>										
	Analytical Limit	$^{32}\text{P}$	$^{40}\text{K}$	$^{54}\text{Mn}$	$^{60}\text{Co}$	$^{65}\text{Zn}$	$^{90}\text{Sr}$	$^{137}\text{Cs}$	U	$^{239}\text{Pu}$
		7.6	1.2	0.05	0.073	0.13	0.002	0.075	0.001	0.0002
3/14	300-N BG	*	3.9	*	*	*	0.009	*	0.06(a)	0.001(a)
7/27	B. Pond	*	2.9	*	*	*	0.089	3.0	*	0.003(a)
9/5	300 Pond	*	3.5	*	*	0.15	0.008	0.13	*	*
<u>Raccoon</u>										
3/20	300 Area (muscle)	2.4	*	0.05	0.36	*	*	0.087	0.008	
	(bone)	*	*	*	*	*	0.05	*	0.067	
	(liver)						0.006			

(a) Concentration in liver tissue less than the analytical limit. \* entry indicates no analysis was performed.

TABLE 10 (Continued)  
 CONCENTRATIONS OF SELECTED RADIONUCLIDES IN SMALL ANIMALS - 1973  
 Units of  $10^{-6}$   $\mu\text{Ci/gm}$

Date	Location	$^{103}\text{Ru}$	$^{106}\text{Ru}$	$^{131}\text{I}$	$^{134}\text{Cs}$	$^{137}\text{Cs}$	$^{140}\text{BaLa}$	$^{144}\text{CePr}$	U	$^{239}\text{Pu}$
<u>Mice</u>										
Analytical Limit		7.2	7.2	0.6	0.36	0.36	0.15	5.3	0.001	0.0002
1/4	200 West	*	*	*	*	0.60	*	*		0.004
1/4	100-N Trench	*	5,000	*	5,300	120	*	10,000		
2/2	100-N Trench	*	1,900	*	*	52	420	*		
2/2	200 West	*	*	*	*	1.8	*	*	1.4	0.007
2/28	100-N Trench	*	*	*	*	47	*	*		
3/20	100-N Trench	*	*	*	*	39	480	160	0.028	0.84
3/27	200 West	*	*	*	*	1.0	*	*		
3/27	300 Area	*	*	*	*	*	*	*	0.014	
4/3	200 West	*	*	*	*	1.0	*	*	0.016	
4/3	100-N Trench	51	*	560	*	*	1,200	1,500		
4/3	300 Area	*	*	*	*	*	*	*	0.32	
5/3	200 West	*	*	*	*	1.3	*	*	0.016	
5/3	100-N Trench	*	150	*	*	27	*	170		
6/8	200 West	*	*	*	*	0.52	*	*	0.006	

\* Less than the analytical limit.  
 No entry indicates no analysis was performed.

## VIII. AIRBORNE RADIOACTIVITY

Results of routine sampling of the atmosphere for radioactivity at 18 locations within the Hanford Reservation (Map 4) are presented in Figures 8 through 18. For comparison, data from 18 offsite locations (Map 5) are included in the following discussion. Sampling for chemical pollutants and particulates in the atmosphere is conducted and reported by the Hanford Environmental Health Foundation.

The sampling equipment, sheltered in small buildings, draws air at a flow rate of  $2.5 \text{ m}^3/\text{hr}$  (1.5 cfm) through HV-70 or Acropor filter paper, and then through activated charcoal cartridges for radioiodine collection. The normal sampling period is one or two weeks depending on sampler location. The "total beta" activity is calculated from the gross beta count, using a Sr-Y-90 calibration, and "total alpha" from a  $^{239}\text{Pu}$  calibration for particulates collected on the filter paper during the sampling period.

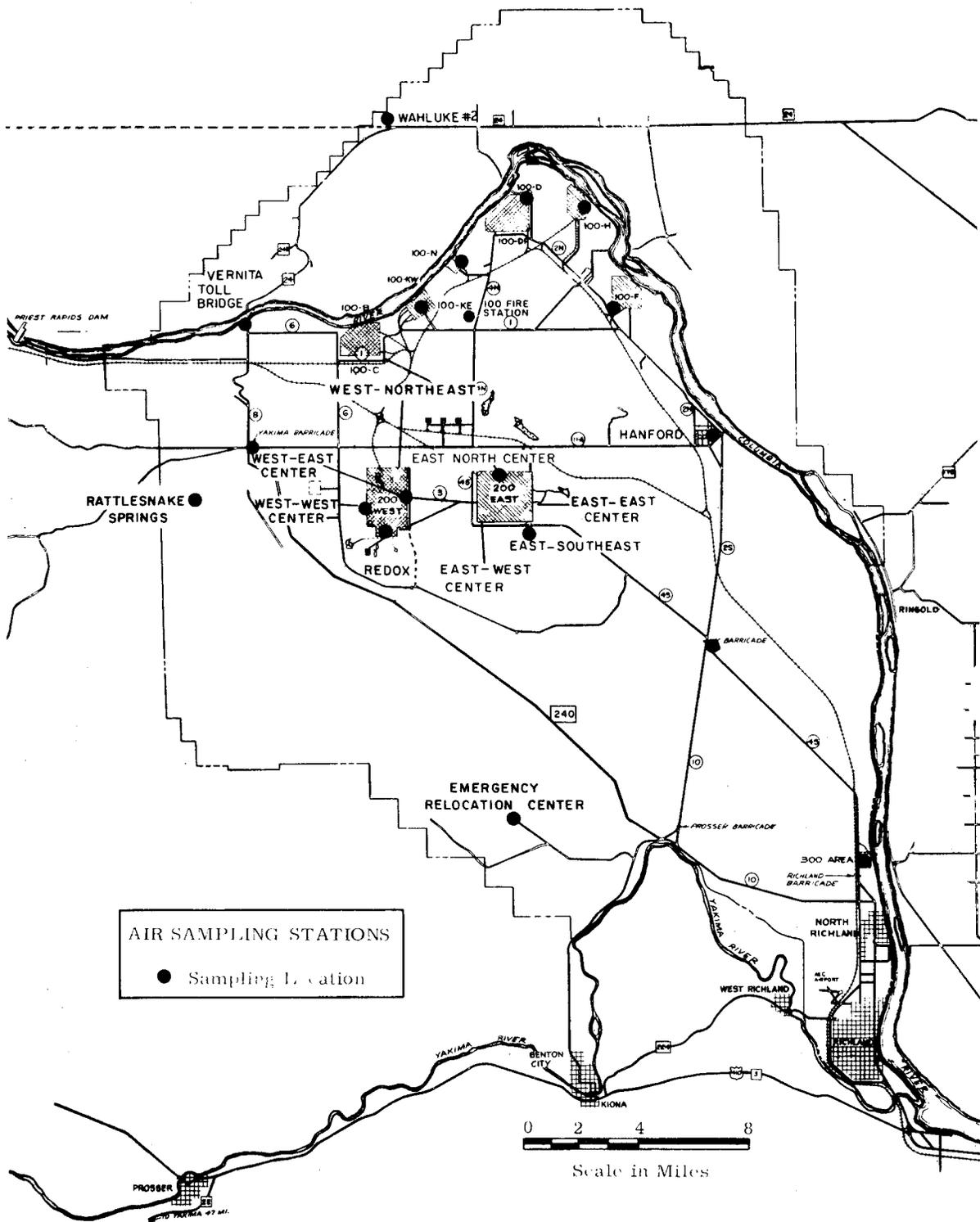
Table 11 gives a summary of the annual average  $^{131}\text{I}$ , particulate beta, and particulate total alpha activity in air at onsite locations for 1969-1973. Results of gamma scans, gross alpha, and gross beta analyses on selected environmental air filters for 1973 are presented in Tables 12 and 13. Concentration Guides shown are taken from AECM 0524, Annex A, Table II, Column 1<sup>(6)</sup>, and are applicable to individuals not occupationally exposed.

### Iodine-131

Concentrations of  $^{131}\text{I}$  in the atmosphere during 1973 were less than the analytical limit of  $7 \times 10^{-14} \text{ } \mu\text{Ci/ml}$  for onsite locations and offsite locations.

### Total Beta

During 1973 environmental air filters from 18 onsite locations and 18 offsite locations were examined weekly or biweekly for particulate beta activity. Tables 11 and 12 show the average particulate beta activity in air at various locations.



MAP 4. Onsite Air Sampling Stations



TABLE 11

AVERAGE  $^{131}\text{I}$ , PARTICULATE BETA, AND PARTICULATE TOTAL ALPHA  
CONCENTRATIONS IN THE ATMOSPHERE, 1969 - 1973

Units of  $10^{-12}$   $\mu\text{Ci/ml}$

Location	I-131 (a)					
	1969 <sup>(b)</sup>	Jan-June 1970 <sup>(b)</sup>	Jul-Dec 1970 <sup>(c)</sup>	1971 <sup>(c)</sup>	1972 <sup>(c)</sup>	1973 <sup>(c)</sup>
100 Areas (1)	0.01	0.007	0.06	0.03	*	*
200 Areas (1)	0.01	0.01	0.09	0.04	*	*
Other Onsite Locations (2)	0.02	0.02	0.08	0.04	*	*
Total Beta						
	<u>1969</u>	<u>1970</u>		<u>1971</u>	<u>1972</u>	<u>1973</u>
100 Areas (5)	0.33	0.43		0.30	0.13	0.03
200 Areas (5)	0.53	0.65		0.73	1.3	0.08
Other Onsite Locations (8)	0.28	0.35		0.49	0.18	0.04
Total Alpha						
	<u>1969</u>	<u>1970</u>		<u>1971</u>	<u>1972</u>	<u>1973</u>
100 Areas (1)	0.007	0.01		0.002	0.002	0.002
200 Areas (5)	0.01	0.02		0.009	0.003	0.001
Other Onsite Locations (4)	0.008	0.01		0.003	0.002	0.002

\* Less than the analytical limit.

(a) Most restrictive Concentration Guide -  $100 \times 10^{-12}$   $\mu\text{Ci/ml}$

(b) Scrubbers

(c) Charcoal Cartridges

( ) Number of locations included 1973

TABLE 12  
 $^{131}\text{I}$ , PARTICULATE BETA, AND PARTICULATE TOTAL ALPHA IN THE ATMOSPHERE - 1973  
 Units of  $10^{-12}$   $\mu\text{Ci}/\text{m}^3$

Analytical Limit Location	Onsite									
	Beta			$^{131}\text{I}$			Alpha			
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	
		0.02			0.07			0.0004		
200 ENC	1.2	*	0.18	*	*	*	0.006	*	0.001	0.001
200 ESE	0.18	0.02	0.04				0.004	*	0.001	0.001
200 WEC	0.15	0.02	0.06				0.003	*	0.001	0.001
Redox	0.33	0.02	0.08				0.006	*	0.001	0.001
200 WMC	0.27	*	0.06				0.005	*	0.001	0.001
300 Area	0.13	*	0.04				0.005	*	0.003	0.003
ACRMS	1.2	*	0.04							
300 SW Gate	0.77	0.016	0.04							
100-K	0.48	*	0.04							
100-N	0.40	0.023	0.04				0.006	*	0.002	0.002
100-D	0.46	0.018	0.04							
100-F Fire Station	0.13	*	0.04							
100-F	0.51	0.022	0.03							
Hanford	1.7	0.015	0.05							
Wye Barricade	0.55	0.089	0.05							
Rattlesnake	0.66	0.062	0.05				0.004	*	0.001	0.001
ERC	0.41	0.046	0.05				0.007	*	0.002	0.002
Yakima Barricade	0.62	0.069	0.04							
Vernita	0.36	0.013	0.05							
Wahluke #2	0.43	0.016	0.04				0.003	0.0005	0.001	0.001

\*Less than the analytical limit.  
 No entry indicates no analysis was performed.

TABLE 12 (Continued)

$^{131}\text{I}$ , PARTICULATE BETA, AND PARTICULATE TOTAL ALPHA IN THE ATMOSPHERE - 1973  
Units of  $10^{-12}$   $\mu\text{Ci}/\text{m}^3$

Location	Offsite					
	Beta		$^{131}\text{I}$		Alpha	
	Max.	Min.	Avg.	Max.	Min.	Avg.
Analytical Limit	0.02	0.02	0.07	0.0004	0.0004	0.0004
Byers Landing	0.07	*	0.05	0.002	0.0006	0.001
Ringold	0.21	0.02	0.05	0.004	*	0.001
Richland	0.76	*	0.05	0.005	0.0004	0.001(a)
Pasco	0.07	*	0.04	0.002	0.001	0.002
Walla Walla	0.50	0.03	0.06	0.005	*	0.001
McNary	0.66	0.02	0.06	0.003	*	0.001
Ellensburg	0.07	*	0.04	0.003	*	0.001
Sunnyside	0.09	*	0.04	0.003	0.0006	0.002(b)
Othello	0.09	*	0.04	0.003	0.0006	0.002(b)
Connell	0.07	0.02	0.04	0.003	*	0.001
Berg Ranch	0.11	0.03	0.05	0.003	*	0.001
Wahluke Wm.	0.10	0.02	0.04	0.003	*	0.001
Cooke Bros.	0.08	*	0.03	0.003	*	0.001
Moses Lake	0.08	0.02	0.04	0.003	*	0.001
Washtucna	0.11	0.02	0.05	0.003	*	0.001
Benton City	0.41	*	0.04	0.003	*	0.001

\*Less than the analytical limit.

No entry indicates no analysis was performed.

(a) January, February, and March

(b) January, February, March, and April

TABLE 13  
 AVERAGE CONCENTRATIONS OF GAMMA EMITTERS AND PLUTONIUM  
 ON SELECTED AIR FILTERS - 1973  
 Units of  $10^{-12}$   $\mu\text{Ci}/\text{m}^3$

	$^{60}\text{Co}$	$^{90}\text{Sr}$	$^{95}\text{ZrNb}$	$^{106}\text{RuRh}$	$^{134}\text{Cs}$	$^{137}\text{Cs}-^{137m}\text{Ba}$	Total Pu
Analytical Limit	0.003	0.000003	0.002	0.044	0.01	0.003	0.000001
Concentration Guides	300	200	1000	200	400	500	1
<u>Active Areas</u>							
Active Area #1	*	0.002	0.026	*	*	0.128	0.00008
Active Area #2	*	0.002					0.00007
Active Area #3	*	0.002	0.005	0.14	*	0.022	0.00006
Active Area #4	*	0.0006	*	0.15	*	*	0.00006
Active Area #5	*		*	0.12	*	*	
<u>Inner Ring</u>							
Inner SW Quadrant	*	0.0004	*	0.14	*	*	0.00002
Inner NW Quadrant	0.003	0.00004	*	0.15	*	*	0.00003
Inner East Quadrant	*	0.0004	*	0.12	*	*	0.00002
<u>Eastern Quadrant</u>							
Inner NE Quadrant	*	0.0004	*	0.12	*	*	0.00003
Inner SE Quadrant	*	0.0004	*	0.14	*	*	0.00005
<u>Perimeter Communities</u>							
Outer NE Quadrant	*	0.0004	*	0.12	*	*	0.00006
Outer SE Quadrant	*	0.0004	*	0.12	*	*	0.00002
Outer West Quadrant	*	0.0003	*	0.15	*	*	0.00005

\*Less than analytical limit.  
 No entry indicates no analysis was performed.

In the past, airborne beta activity has been characterized by seasonal peaking about mid-year. This was not apparent in 1972 or 1973 as it was in previous years, as shown in Figures 8-14. Concentrations in and near the 100 Areas were quite uniform during any given period, indicating the lack of a significant source at the Reactor Areas. This was not true of the 200 Areas, notably the East North Center (ENC) locations which are affected by a nearby 200 East Area waste disposal operation. The maximum measured beta concentrations,  $8 \times 10^{-13}$   $\mu\text{Ci/ml}$ , occurred in February at the 200 ENC location. Annual average concentrations were lower than in 1972, ranging from  $4 \times 10^{-14}$  to  $8 \times 10^{-14}$   $\mu\text{Ci/ml}$  except for 200 ENC which averaged  $1.8 \times 10^{-13}$   $\mu\text{Ci/ml}$ .

Annual average concentrations at offsite locations ranged from about  $4 \times 10^{-14}$  to  $6 \times 10^{-14}$   $\mu\text{Ci/ml}$ . The beta concentrations at all locations were significantly lower than recent years, both on and offsite.

#### Total Alpha

The weekly filters analyzed for beta-gamma emitting radionuclides were also analyzed for alpha activity. These data are presented in Tables 11 and 12. Alpha counting of the filters was normally performed after seven days to allow for the decay of short-lived activity from naturally-occurring radon daughters. Total alpha concentrations during 1973 averaged about  $1.5 \times 10^{-15}$   $\mu\text{Ci/ml}$  at most onsite locations as compared to  $2 \times 10^{-15}$  in 1972. The highest annual average was  $3 \times 10^{-15}$   $\mu\text{Ci/ml}$  at the 300 Area compared to  $4.0 \times 10^{-15}$   $\mu\text{Ci/ml}$  at ENC for 1972. Analysis of composite samples (Table 13) all showed less than  $1 \times 10^{-16}$   $\mu\text{Ci/ml}$  of plutonium.

#### Other Radionuclides

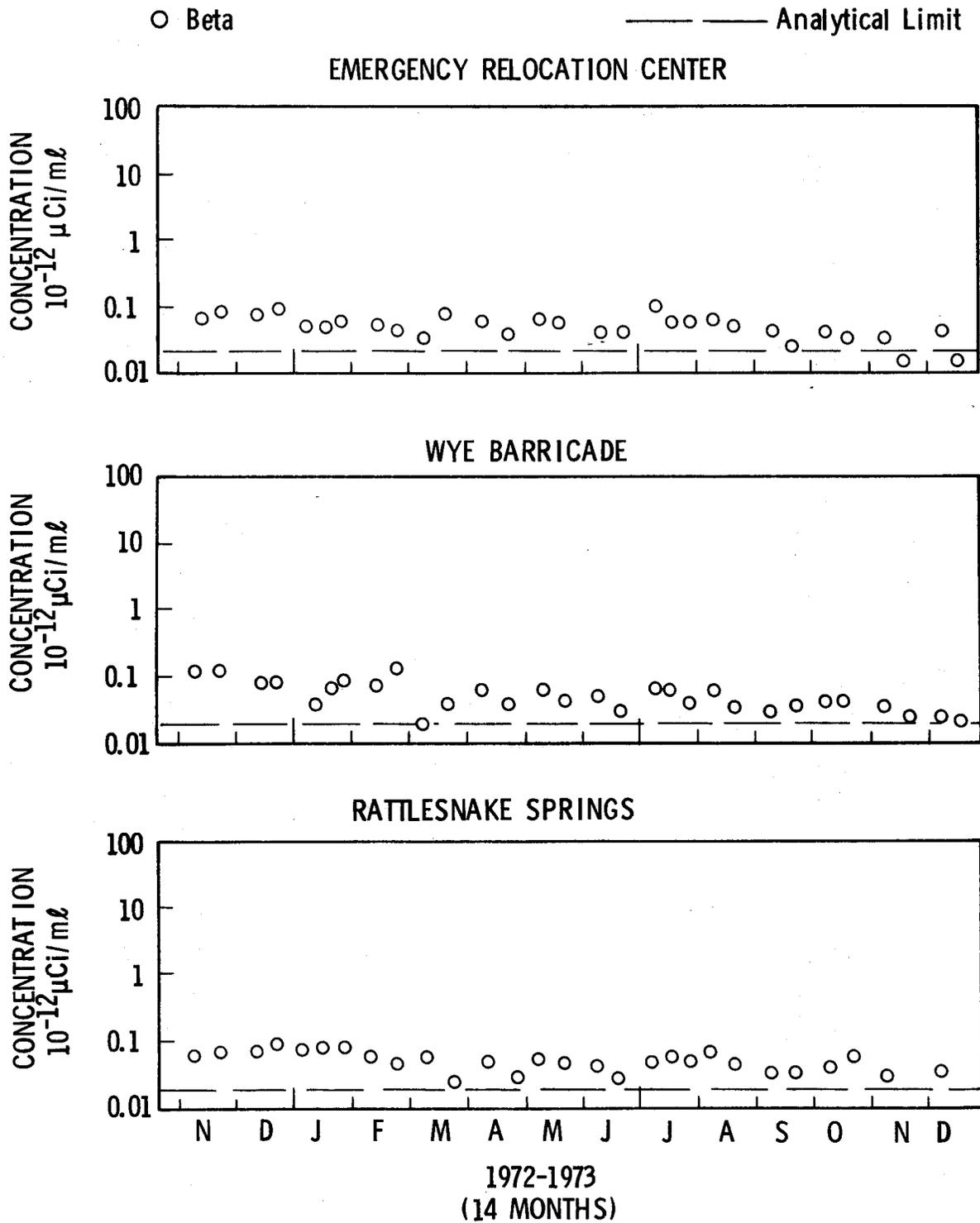
Gamma spectrum analysis was performed on a number of monthly composites of selected air filters. Quarterly analysis for  $^{90}\text{Sr}$  and  $^{239}\text{Pu}$  of the composites was also performed. Table 13 presents the results of these special analyses. At most sampling locations average concentrations of gamma emitters for 1973 were lower than 1972.











**FIGURE 12.** Total Beta Activity in the Atmosphere Intermediate Areas



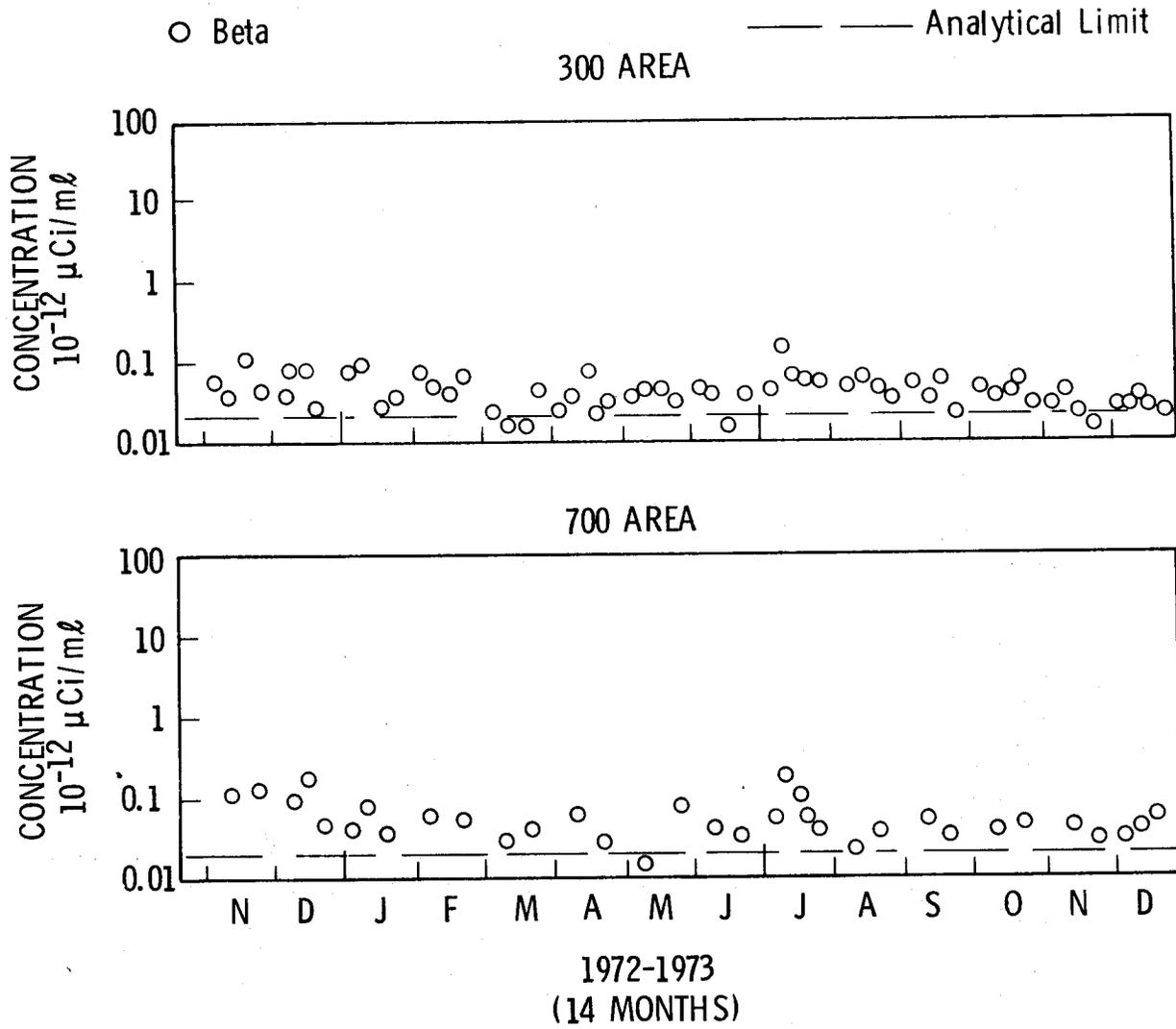
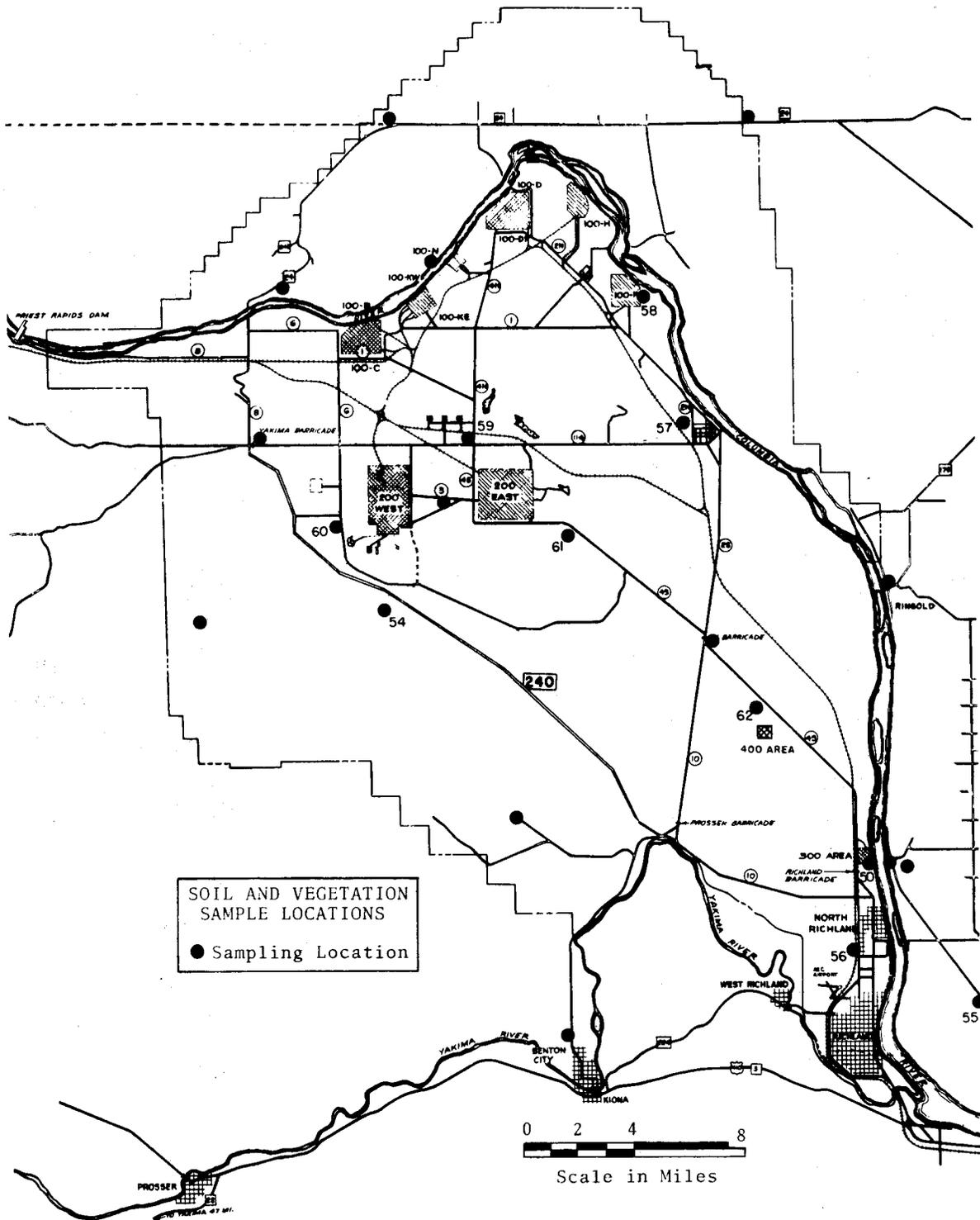


FIGURE 14. Total Beta Activity in the Atmosphere 300 and 700 Areas

## IX. SOIL AND VEGETATION

Twenty-three locations for routine soil and vegetation sampling were established on and around the Hanford Reservation in 1971. Specific locations are given in Map 6. Samples of the top two inches of soil and native vegetation (perennial) were taken at each of these locations at the end of October 1973 and analyzed for plutonium,  $^{90}\text{Sr}$ , and gamma emitters. Gamma emitters in soil samples were measured with a lithium-drifted germanium 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 soil and vegetation results from 13 perimeter and 10 onsite locations are given in Tables 14 and 15. Concentrations averaged about the same as for 1972;  $^{144}\text{Ce-Pr}$  was lower by a factor of ten from 1971 concentrations. Individual results showed no particular geographical pattern, and the concentrations measured are believed to be the result of regional fallout. The plutonium concentrations are believed to be typical of general regional levels for the arid western states. As in 1972, average concentrations of several radionuclides in soil were marginally higher in the onsite samples compared to the perimeter samples. Onsite  $^{238}\text{Pu}$  concentrations in soil and vegetation were statistically the same as the perimeter. As compared to offsite, the average  $^{239}\text{Pu}$  concentration appears to be slightly higher in the surface inch of soil for several onsite locations, notably Hanford (#57), 200 Area's Fire Station, 200 East Hill (#61), and Army Loop Road (#60). Soil profile samplings to a 12 inch depth were made at sampling locations: 200 East Hill (#61), Rts. 4 and 11A (#59), and Army Loop Road (#60). The results are shown in Table 14.



MAP 6. Soil and Vegetation Sample Locations

TABLE 14  
 CONCENTRATIONS OF RADIONUCLIDES IN SOIL SAMPLES - 1973  
 Units of  $10^{-6}$   $\mu\text{Ci/gm}$  of Soil

Location (0-1 inches)	40K	58Co	60Co	65Zn	90Sr	95ZrNb	106Ru	134Cs	137Cs	144CePr	224Ra	226Ra	238Pu	239+240Pu	U
Analytical Limit	0.5	0.03	0.03	0.07	0.002	0.2	0.4	0.03	0.03	0.3	0.04	0.06	0.003	0.001	0.015
W of 100-N	25	0.10	*	0.22	0.31	0.36	1.3	0.06	1.2	1.2	2.2	0.65	*	0.02	0.70
331	18	*	*	0.13	0.01	*	*	0.07	*	0.55	1.1	0.24	*	*	0.27
FFTF	18	*	0.15	0.13	0.08	*	*	0.18	0.26	*	1.3	0.50	*	0.003	0.35
Wye Barricade	15	*	0.04	*	0.13	*	1.1	0.05	0.71	*	1.6	0.34	*	0.01	0.12
Hanford	17	*	0.04	*	0.33	*	0.55	0.05	1.2	0.35	1.1	0.47	*	0.02	0.30
100-F	19	*	0.14	*	0.28	*	0.69	0.04	0.73	0.85	1.5	0.53	*	0.006	0.22
200 Fire Station	16	0.05	*	0.36	0.04	*	0.70	0.11	0.61	0.99	1.6	0.67	*	0.02	0.56
200-E Hill	16	0.04	0.19	*	0.47	*	0.94	0.04	2.2	1.4	1.2	0.61	*	0.04	0.54
Rt. 4 and 11A	15	*	0.18	0.30	0.12	*	0.80	*	2.4	*	1.2	0.65	0.008	0.01	0.51
Army Loop Road	17	*	0.18	0.30	0.07	*	0.80	*	2.4	0.65	1.2	0.50	*	0.04	0.72
Average Onsite	18	0.02	0.07	0.13	0.18	*0.10	0.68	0.06	0.97	0.66	1.4	0.52	*0.002	0.02	0.43
Perimeter															
Benton City	18	0.08	*	*	0.12	*	0.47	*	0.81	1.5	2.5	0.94	*	0.01	0.67
ERC	16	0.07	*	0.14	0.04	0.20	1.7	0.06	1.3	0.31	2.4	0.79	*	0.02	0.39
Rt. 240 CP 54	15	*	*	0.16	0.07	*	0.59	0.10	1.1	0.97	2.1	0.46	*	0.004	0.37
Rattlesnake Spr.	20	0.05	0.12	*	0.17	0.26	0.64	0.17	1.5	0.70	2.0	0.70	*	0.04	0.52
Yakima Barricade	18	0.04	0.06	0.07	0.13	*	0.46	0.09	0.59	0.35	1.8	0.76	*	0.01	0.30
Vernita	20	0.14	*	0.07	0.37	0.22	0.78	*	0.39	0.91	0.88	0.38	*	0.01	0.28
Wahiuke #2	18	*	0.14	0.10	0.32	*	0.46	0.07	1.0	1.2	2.1	0.51	*	0.02	0.53
Berg Ranch	18	0.04	*	0.13	0.04	*	1.4	0.10	0.82	1.0	1.6	0.62	*	0.02	0.36
Ringold	22	*	0.13	0.12	0.01	*	*	*	0.14	0.58	2.2	0.44	*	*	0.50
Byers P.H.	16	*	*	0.12	0.19	*	1.4	0.08	0.76	0.43	0.94	0.42	*	0.003	0.28
Byers Landing	21	*	0.09	*	0.06	*	*	*	0.84	0.83	1.8	0.58	*	0.005	0.18
Riverview	18	0.09	*	*	0.12	*	0.51	*	0.84	*	1.4	0.62	0.006	0.02	0.14
North Richland	17	0.09	*	*	0.12	*	0.51	*	0.84	*	1.1	0.57	*	0.02	0.35
Average Perimeter	18	0.04	0.04	*0.06	0.13	*0.11	0.72	0.05	0.70	0.71	1.8	0.60	*0.001	0.01	0.37
Onsite															
200-E Hill															
1-2 inches	15	*	0.04	0.12	0.22	*	0.67	*	0.46	*	1.8	0.49	*	0.02	0.21
2-4 inches	15	0.03	0.08	0.18	0.19	*	*	0.04	0.09	0.42	0.56	0.62	*	0.005	0.29
4-8 inches	16	*	*	0.14	0.009	*	*	0.05	0.10	0.83	1.6	0.61	*	*	0.24
8-12 inches	17	*	0.07	*	0.01	*	*	0.12	0.32	0.32	1.7	0.55	*	*	0.27
Rt. 4 and 11A															
1-2 inches	18	*	0.09	0.28	0.08	0.10	0.58	0.05	0.17	1.1	1.3	0.41	*	0.009	0.15
2-4 inches	17	0.08	0.05	0.08	0.02	0.27	*	0.12	0.04	0.60	1.4	0.34	0.008	0.004	0.41
4-8 inches	16	0.03	*	*	*	*	*	0.07	0.10	*	1.7	0.46	*	*	0.20
8-12 inches	16	0.06	*	*	0.02	*	*	*	0.10	*	1.6	0.70	0.004	0.01	0.28
Army Loop Road															
1-2 inches	15	*	*	0.40	0.13	*	0.69	*	0.44	*	0.90	0.46	*	0.01	0.35
2-4 inches	16	0.07	*	0.26	0.009	*	*	0.04	0.38	*	1.6	0.52	*	*	0.39
4-8 inches	17	*	*	0.37	0.005	*	0.43	0.08	0.04	0.38	1.3	0.55	*	*	0.35
8-12 inches	15	0.04	*	0.23	*	*	0.25	*	0.04	0.52	1.4	0.48	*	*	0.40

\* Less than the analytical limit.

TABLE 15  
 CONCENTRATION OF RADIONUCLIDES IN VEGETATION - 1973  
 Units of  $10^{-6}$   $\mu\text{Ci/gm}$  of Vegetation

Location	Onsite											
	$^{40}\text{K}$	$^{60}\text{Co}$	$^{65}\text{Zn}$	$^{90}\text{Sr}$	$^{95}\text{ZrNb}$	$^{106}\text{Ru}$	$^{137}\text{Cs}$	$^{140}\text{BaLa}$	$^{144}\text{CePr}$	$^{238}\text{Pu}$	$^{239-240}\text{Pu}$	U
Analytical Limit	0.5	0.03	0.07	0.002	0.2	0.4	0.03	0.2	0.3	0.003	0.001	0.015
W of 100-N	12.0	*	0.64	0.06	0.42	*	0.38	28.0	*	*	0.004	0.04
331	17.0	*	1.2	0.05	0.27	*	0.36	17.0	*	*	0.001	0.05
FFTF	11.0	*	0.64	0.02	0.25	*	0.26	9.2	*	*	*	*
Wye Barricade	7.3	*	0.34	0.04	0.48	*	0.97	8.0	*	*	0.003	*
Hanford	8.1	*	0.22	0.03	0.27	*	0.22	7.3	*	*	*	*
100-F	12.0	*	0.46	0.04	0.33	*	0.31	11.0	*	*	*	*
Rt 4 and 11A	9.2	*	*	0.04	0.25	*	0.31	14.0	*	*	*	*
Redox P.S.	15.0	*	4.0	0.23	9.5	*	27.0	47.0	*	0.01	0.01	*
200 Fire Station	8.9	*	0.63	0.06	0.95	*	2.2	18.0	*	0.004	0.004	*
200-E Hill	12.0	*	2.6	0.28	6.4	*	18.0	21.0	*	0.008	0.008	0.69
Average Onsite	11.0	*	1.1	0.08	1.9	*	5.0	18.0	*	*0.0007	0.003	0.089
<u>Perimeter</u>												
Benton City	13.0	*	0.77	0.03	0.16	*	0.24	18.0	*	*	0.001	0.05
ERC	9.9	*	0.54	0.06	0.40	*	0.44	18.0	*	*	*	*
Rt 240 CP 54	12.0	*	0.48	0.08	0.48	*	0.69	11.0	*	*	0.006	*
Rattlesnake Spr.	20.0	*	1.6	0.04	0.48	*	0.62	24.0	*	*	0.004	0.07
Yakima Barricade	12.0	*	1.2	0.04	0.32	*	0.50	16.0	*	*	*	*
Vernita	14.0	*	0.55	0.04	0.40	*	0.27	22.0	*	*	*	*
Wahlake #2	14.0	*	1.5	0.07	0.52	*	1.9	27.0	*	0.005	0.005	0.11
Berg Ranch	11.0	*	0.63	0.09	0.30	*	0.51	11.0	*	*	*	0.04
Ringold	15.0	*	*	0.05	*	*	*	19.0	*	*	*	0.05
Byers P.H.	16.0	*	0.76	0.04	0.17	*	0.27	13.0	*	*	*	*
Byers Landing	7.8	*	0.83	0.02	0.37	*	0.51	23.0	*	0.002	0.002	0.024
Riverview	15.0	*	1.4	0.02	0.22	*	0.25	19.0	*	0.002	0.002	0.04
North Richland	9.3	*	0.59	0.21	0.22	*	0.36	12.0	*	0.003	0.003	*
Average Perimeter	13.0	*	0.83	0.06	0.32	*	0.49	18.0	*	*0.009	0.002	0.04

\*Less than analytical limit.

## X. RADIATION SURVEYS

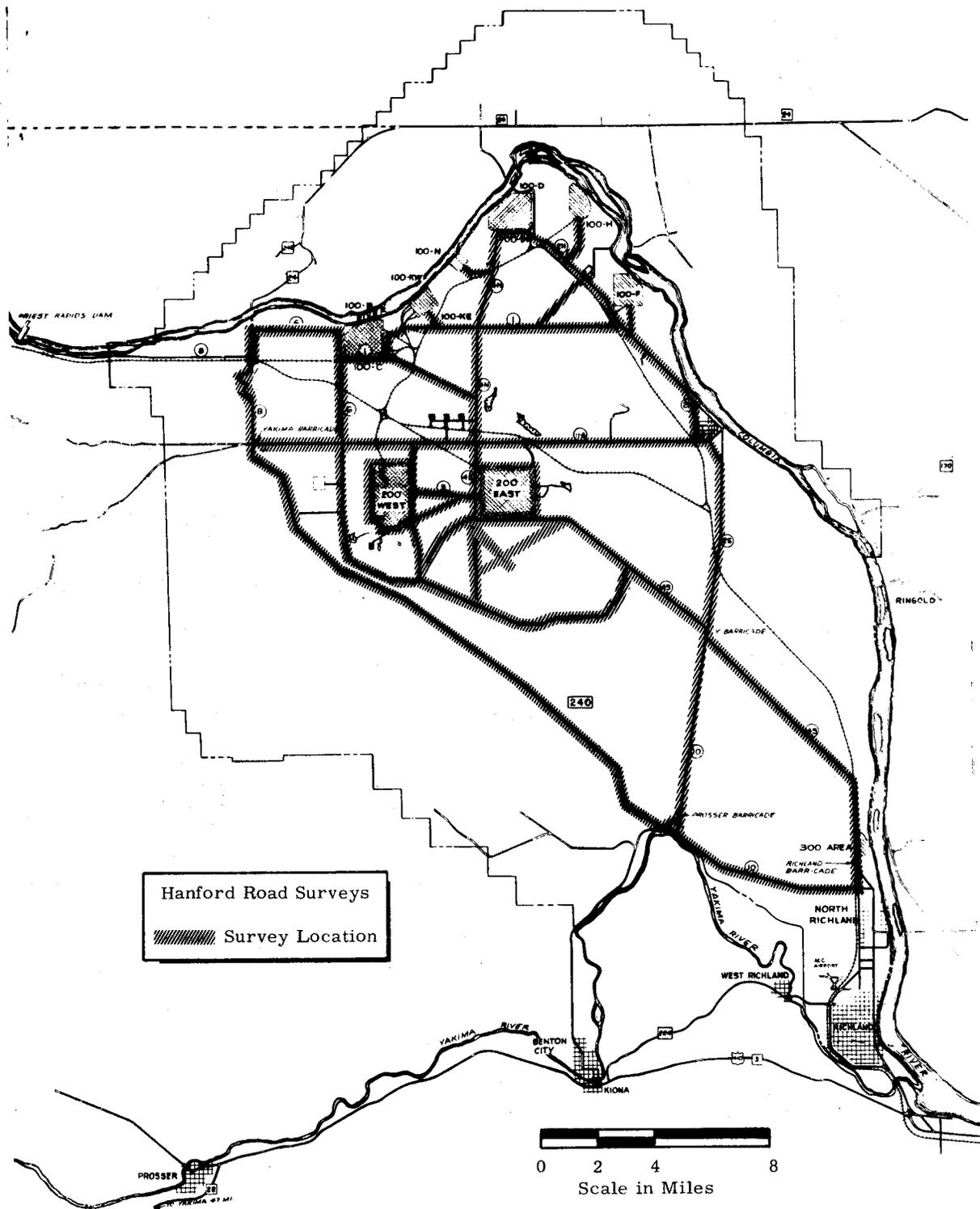
### Surface Contamination

Hanford Roads Survey. Hanford roads are routinely surveyed (Map 7) with a bioplastic scintillation detector attached to the front end of a truck and positioned about 0.6 meters (2 ft.) above the road surface. This road monitor has been described in BNWL-62.<sup>(7)</sup> Most traveled roads within the Hanford Reservation were surveyed monthly. During the year, several radioactive particles were found on or near Hanford roadways. All of these areas were decontaminated.

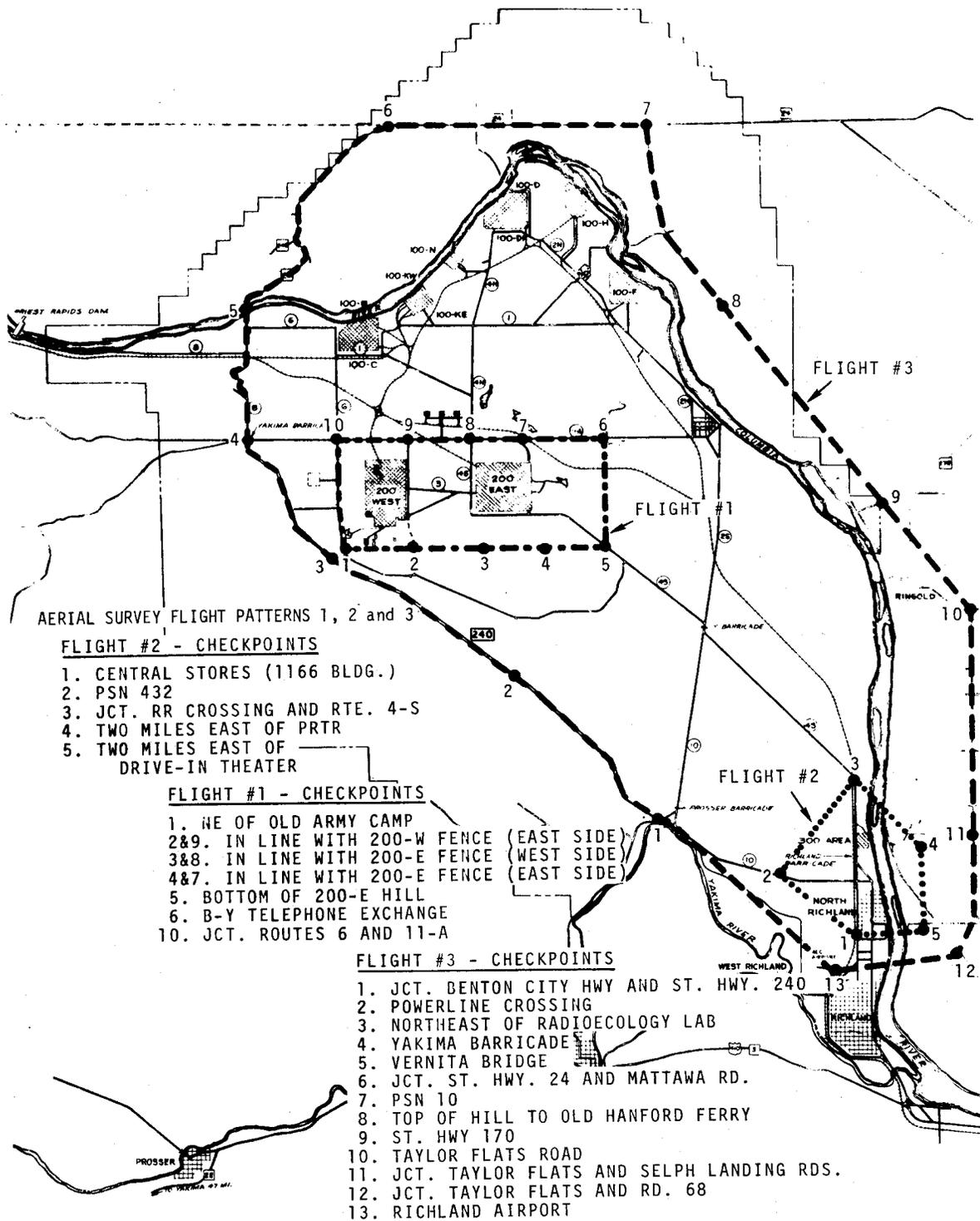
Six particles were found on August 14, 1973 and August 20, 1973 on the 100-N access road, between 0.4 and 0.6 miles from the main gate. They were identified as  $^{65}\text{Zn}$  and  $^{60}\text{Co}$  and were attributed to the waste hauling operations from 100-N. The particles measured from 5000 to 35,000 cpm on a GM meter. One other contaminated spot was found on the road near mile post 4N-mile 7 on September 6, 1973, and measured 25,000 cpm.

Railroad Survey. All Hanford railroad tracks outside area fences are surveyed annually with the previously described road survey detector attached to a railroad maintenance car. Nothing unusual was detected in 1973.

Aerial Surveys. Aerial surveys can be used to detect contamination which is spread over a large land area. Although Hanford aerial surveys have been only comparative, through routine use 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 3-inch by 5-inch NaI (Tl) scintillation crystal detector. Aerial survey flight patterns used during 1972 are shown on Maps 8 and 9. Flight patterns 1, 2, and 3 are located within and near the Hanford project perimeter. Flight pattern 4 follows the Columbia River from the Vernita Bridge (upstream of the Hanford reactors) downstream to Plymouth. Flight pattern 5 lies 15 to 40 air miles beyond the project perimeter. The aerial surveys were flown twice during 1973. No unusual radioactivity conditions were detected.



MAP 7. Hanford Road Surveys



**MAP 8. Aerial Survey Flight Patterns 1, 2 and 3.**



In addition to the regular aerial survey, EG & G, Inc., Las Vegas, NV performed a special low-altitude survey (30 to 50 meters) using its ARMS-II equipment, as part of its contractual services to the AEC. This work included low-altitude (30 to 50 meters) with a Navy SH-3 helicopter for some detailed surveys of each operating area and waste disposal site.

In general no unexpected radioactivity was located. Some low-level residual  $^{60}\text{Co}$  from the single pass reactors was detected (a maximum of 0.04 mR/hr vs. a background of 0.01 mR/hr) on some of the Columbia River islands and shorelines within the site boundaries by this aerial survey. Initial follow-up indicated these areas were not in general use by the public. Additional ARMS survey work was scheduled for 1974.

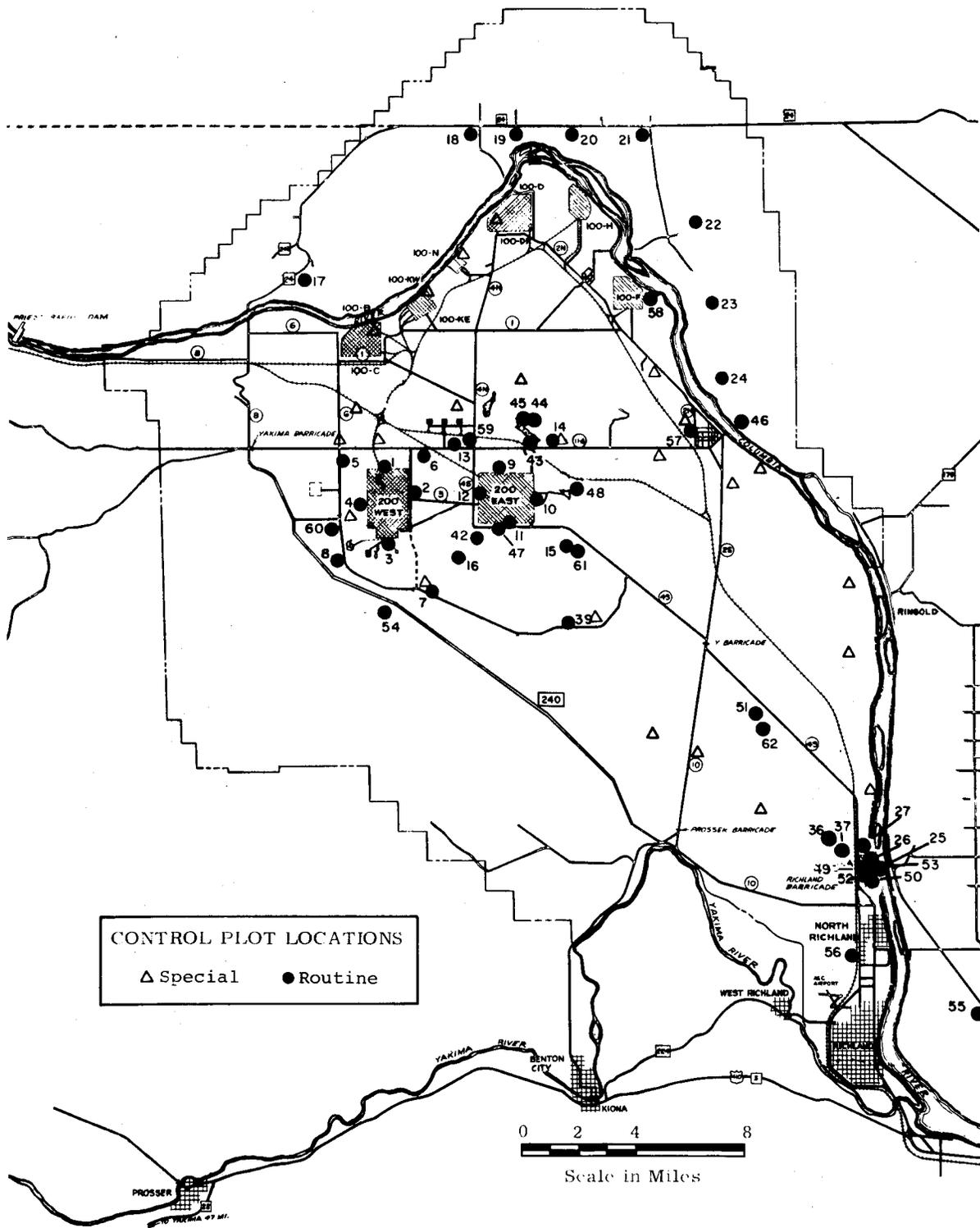
Control Plots. Small areas, called control plots, are located within the Hanford boundaries (Map 10). These plots, measuring 3.05 m by 3.05 m (10x10 ft.) are surveyed monthly or semi-monthly with a GM survey meter for deposited radioactive material. In addition, 22 special control plots located near test wells are surveyed on a semi-annual basis. All of the control plots were background for 1973.

Waste Disposal Sites. Active, inactive, and retired waste disposal sites were visited at least once during 1973 and inspected for general physical condition and evidence of disturbance. The locations of such sites outside plant areas were shown on Map 3. The sites were generally in good order, with the most recurring problem being housekeeping, such as signs falling down, chains not in place and vegetation growing inside the waste sites. Radiation levels were noted as follows and were reported to responsible contractor representatives for corrective action:

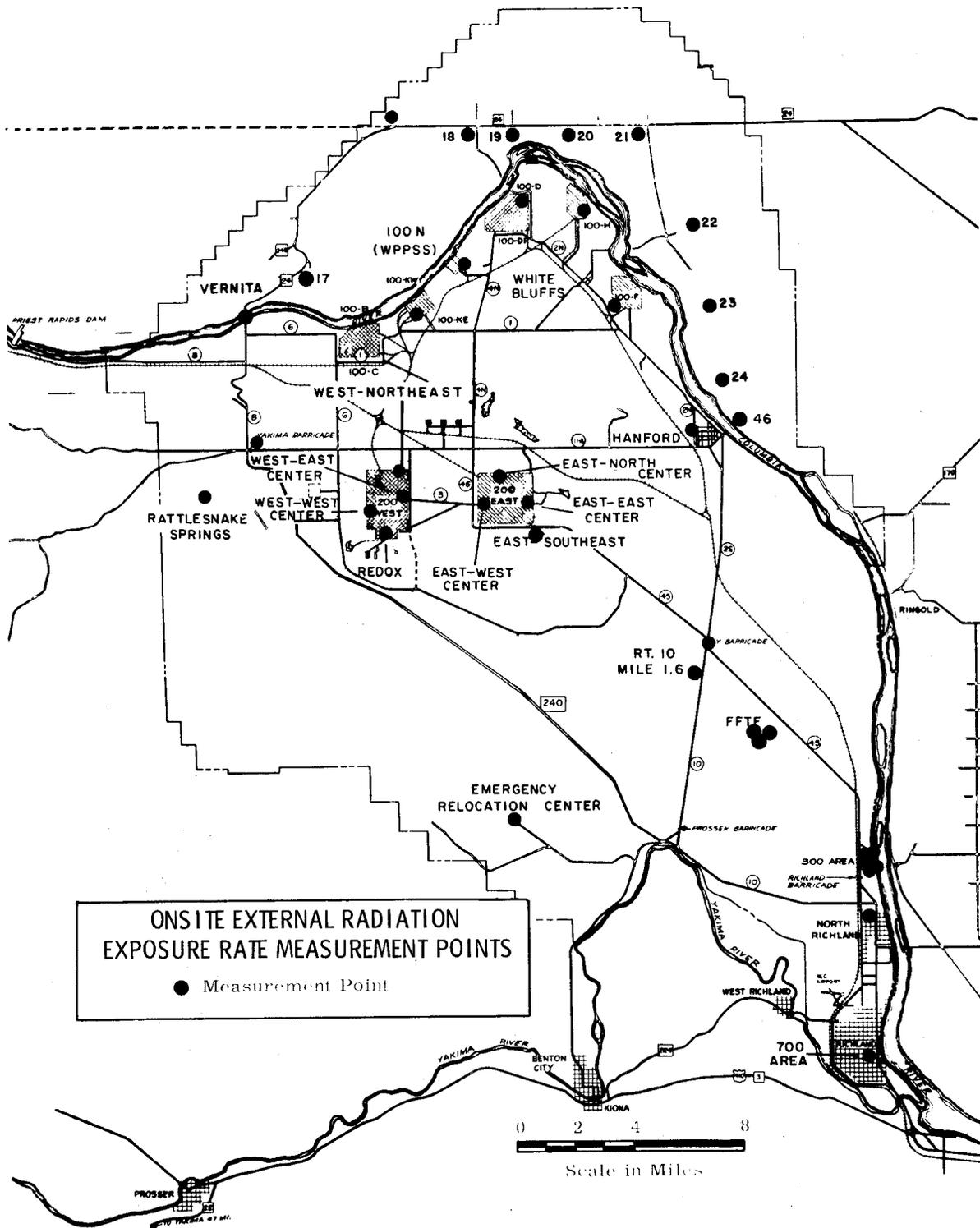
100-H Liquid Disposal Trench (Retired) - 3500 to 4500 cpm in several isolated spots.

#### External Exposure Rates

Exposure Rates Onsite. During 1973, trends in external radiation exposure rates were determined from Thermoluminescent Dosimeters (TLD) located near the air sampler shelters (Map 11) where air samples were also



MAP 10. Control Plot Locations



MAP 11. Onsite External Radiation Exposure Rate Measurement Points

collected. The dosimeters are mounted one meter from the ground on a wire suspended from a metal fence post. TLD measurements were also made at nine control plots on the Wahluke Slope and a number of offsite locations. At three locations (WPPSS at 100-N, Mile 1.6 on Rt. 10, and 700 Area), Victoreen stray radiation chambers were used in addition to the TLD. Prior to July 1970, the Victoreen stray radiation chambers were used at all locations where external radiation exposure rates were measured. Table 16 shows the average external radiation exposure for a number of onsite locations for 1972 and 1973. Offsite locations are not included in the table. The external exposure rates for 1973 were down from 1972 at most locations, in correlation with the lower concentrations of airborne radioactivity. The maximum six-month average exposure rate noted during 1973 was, as usual, 1.2 mR/day at the 200 East North Center (ENC) location. The average of the locations in Table 16 was 0.23 mR/day compared with 0.19 mR/day for a number of offsite locations. At most locations, the external exposure rate was relatively constant.

100-N Area. TLDs were used at 100-N Area in order to estimate the potential exposure of WPPSS personnel. Measurements with the TLD during 1972 indicated an average exposure rate of 0.29 mR/day at 100-N compared with an offsite background of 0.19 mR/day. Based on the net exposure rate of 0.10 mR/day (0.29 minus 0.19) and assuming an exposure for 40 hours per week (50 weeks per year), the total-body dose to WPPSS personnel from Hanford sources of external radiation at 100-N during 1973 would be 8 mrem/yr (1.5% of the standards for individuals nonoccupationally exposed or 0.15% of the standards for individuals occupationally exposed). This was slightly higher than was measured in 1972.

Exposure Rates at the Columbia River Shoreline. Radiation exposure rates are measured at one meter (about 3 ft.) above the river shoreline, which approximates the exposure rate to the gonads of a person standing on the riverbank. Contamination is measured at the surface. Exposure

TABLE 16  
 AVERAGE EXTERNAL GAMMA EXPOSURE RATES - 1973  
 Units of mR/day

Location	1972	1972	1973	1973
	Jan-June	July-Dec	Jan-June	July-Dec
<u>100 Areas</u>				
Vernita	0.24	0.26	0.24	0.22
100-K	0.31	0.28	0.22	0.20
*100-N (WPPSS)	0.42*	0.49*	0.45*	0.49*
100-N (WPPSS)	0.28	0.30	0.29	0.29
100-D	0.22	0.20	0.22	0.21
100-F	0.23	0.23	0.22	0.22
Hanford	0.21	0.21	0.19	0.18
100-H	0.24	0.23		
100 Fire Station			0.19	0.20
<u>200-West Area</u>				
Redox	0.25	0.27	0.28	0.28
West-Center	0.30	0.31	0.29	0.33
East-Center	0.22	0.21	0.22	0.22
West-Northeast	0.24	0.26	0.23	0.23
<u>200-East Area</u>				
North-Center	0.56	0.78	1.2	0.97
West-Center	0.21	0.21	0.21	0.20
Southeast	0.28	0.27	0.22	0.22
East-Center	0.34	0.24	0.28	0.26
<u>Wahluke Slope</u>				
Wahluke #2			0.22	0.21
C.P. 17	0.25	0.25	0.22	0.21
C.P. 18	0.26	0.25	0.20	0.20
C.P. 19	0.24	0.23	0.21	0.20
C.P. 20	0.24	0.25	0.21	0.21
C.P. 21	0.27	0.24	0.21	0.20
C.P. 22	0.24	0.25	0.20	0.20
C.P. 23	0.24	0.24	0.20	0.20
C.P. 24	0.25	0.25	0.21	0.21
C.P. 46	0.24	0.25	0.22	0.22
<u>Richland Research Center</u>				
C.P. 63			0.22 <sup>(a)</sup>	0.21
C.P. 64			0.19 <sup>(a)</sup>	0.17
C.P. 65			0.21 <sup>(a)</sup>	0.19
C.P. 66			0.22 <sup>(a)</sup>	0.20
C.P. 67			0.18 <sup>(a)</sup>	0.17
<u>Other Onsite</u>				
Yakima Barricade	0.28	0.25	0.21	0.21
Rattlesnake Springs	0.20	0.22	0.19	0.19
Emergency Relocation Center	0.24	0.26	0.22	0.21
FFTF Site	0.23	0.23	0.20	0.20
FFTF North				0.20
FFTF Southeast				0.19
Prosser Barricade				0.20
WYE Barricade	0.19	0.20	0.19	0.20
*Rt. 10 Mile 1.6	0.38*	0.42*	0.40*	0.43*
Rt. 10 Mile 1.6	0.26	0.25	0.21	0.20
300 Area (3705 Bldg)	0.26	0.24	0.21	0.21
300 Area (320 Bldg)	0.26	0.25		
300 Area (331 Bldg)	0.22	0.23	0.19	0.18
300 Pond	0.40	0.25	0.24	0.24
ACRMS	0.24	0.24	0.24	0.24
300 SW Gate			0.22	0.20
300 S. Gate			0.20	0.20

\*Measurements with stray radiation chambers.  
 No entry indicates no measurement was performed.  
 (a) April through June.

rate was measured with a low-level dose rate monitor (LLM)\* calibrated in  $\mu\text{R/hr}$  (Radium gamma). Contamination level was measured with a GM survey instrument.

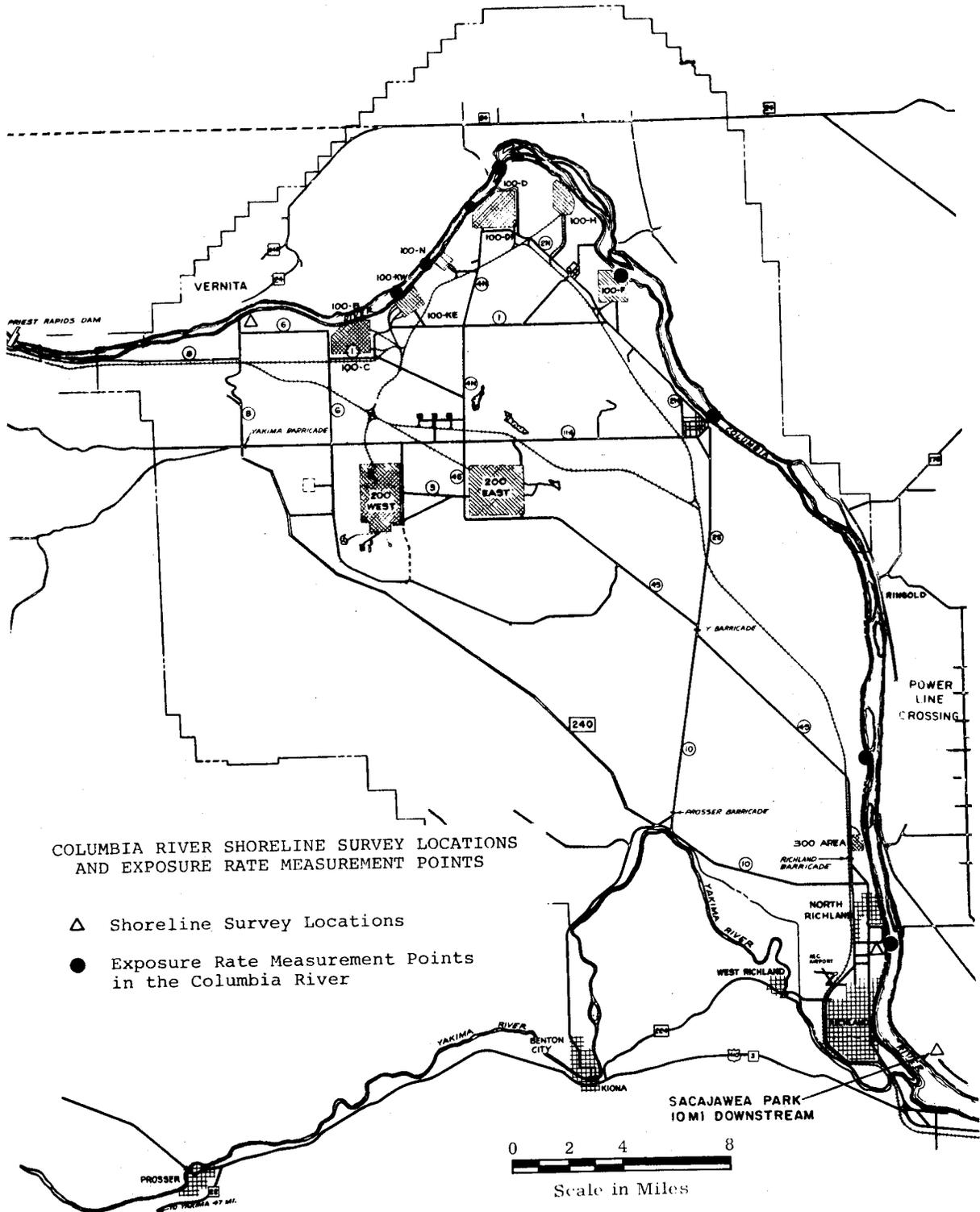
Monthly measurements of exposure rates made at 24 shoreline locations covering the reach of the river from the reactors to Richland include both the exposure rate at one meter and the levels of surface contamination measured with a portable GM survey meter. These data appear in Table 17. In addition, routine measurements of shoreline exposure rates are made at Vernita, Richland and at Sacajawea Park, ten miles downstream from Richland. Data from these locations, which are shown in Map 12 are included in the annual offsite environmental report.<sup>(1)</sup>

During 1973, exposure rates on the Columbia River shoreline were generally slightly lower than during 1972. However, the maximum shoreline exposure rate found during routine surveys in 1973 was  $65 \mu\text{R/hr}$ , measured in January just below 100-N Trench. For comparison, the maximum shoreline exposure rate measured during 1972 was  $28 \mu\text{R/hr}$  below 100-N Trench. The maximum level of surface shoreline contamination encountered during 1973, 600 cpm (GM), was also detected below 100-N Trench in November.

Exposure Rates Below the Surface of the Columbia River. During 1973, exposure rates in the river were determined from TLD contained within submerged plastic bottles at the locations shown in Map 12. Six-month averages for 1973 are shown in Table 18 with data from 1972 for comparison. Exposure rates in the river during 1973 were generally lower than 1972.

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\* Manufactured by Nuclear Enterprises Limited, Canada.



**MAP 12.** Columbia River Shoreline Survey Locations and Exposure Rate Measurement Points

TABLE 17  
 MAXIMUM READINGS (a) FROM MONTHLY SHORELINE SURVEYS FOR 1973  
 (μR/hr with c/m in Parentheses)

A. COLUMBIA RIVER PLANT SHORE		382.5 p(b)		381.5 P		379.4 P		378.6 P		369.7 P		368.3 P		362.6 P		350.4 P		343.3 P		340.5 P		
Date	Above 181-KW		Below 181-KE		100-N Trench		Below 100-N		White Bluff Ferry		100-F Slough		Hanford		PowerLine Cross.		Port of Benton		Richland			
	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)
1/18	10	(100)	11	(100)	65	(400)	25	(200)	12	(100)	18	(150)	22	(200)	14	(150)	11	(100)	12	(100)	12	(100)
1/24					22	(150)	11	(100)	12	(100)	12	(100)	14	(100)	13	(100)	12	(100)	12	(100)	10	(100)
2/21	10	(100)	12	(100)	50	(300)	15	(200)	13	(100)	17	(150)	17	(150)	13	(100)	13	(100)	13	(100)	12	(100)
3/16	12	(150)	13	(150)	25	(250)	15	(200)	15	(150)	12	(100)	12	(100)	12	(100)	10	(100)	10	(100)	10	(100)
4/23	12	(100)	13	(100)	26	(200)	14	(100)	12	(100)	12	(100)	13	(100)	13	(100)	14	(100)	11	(150)	12	(150)
5/18	9	(100)	10	(100)	40	(400)	13	(100)	13	(100)	13	(100)	13	(150)	14	(100)	10	(100)	10	(100)	9	(100)
6/14	9	(100)	9	(150)	21	(300)	12	(200)	9	(100)	10	(100)	10	(100)	11	(100)	10	(100)	10	(100)	10	(100)
7/13	12	(150)	10	(150)	45	(400)	12	(150)	12	(200)	10	(100)	10	(100)	12	(200)	10	(150)	12	(150)	10	(100)
8/13	10	(100)	13	(150)	15	(200)	13	(150)	20	(150)	10	(100)	10	(100)	13	(100)	16	(150)	14	(150)	14	(100)
9/7	9	(100)	10	(100)	42	(350)	14	(250)	9	(100)	9	(100)	9	(100)	8	(100)	11	(100)	10	(100)	12	(150)
10/11	8	(100)	8	(100)	35	(300)	10	(100)	8	(100)	10	(100)	10	(75)	15	(150)	8	(100)	10	(100)	8	(100)
11/8	12	(150)	12	(150)	58	(600)	14	(150)	17	(100)	12	(100)	11	(100)	11	(100)	12	(100)	12	(100)	12	(100)
12/7	14	(150)	13	(150)	35	(250)	12	(100)	12	(100)	22	(150)	17	(200)	15	(100)	13	(100)	13	(100)	13	(100)

B. COLUMBIA RIVER - ISLAND LOCATION		377.0 IF		375.8 IF		373.3 IP		371.0 IP		367.0 IF		355.7 I(c)	
Date	D Island		E Island		Locke Island		Locke Island		100-F Slough		Near Ringold		
	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	
1/18	20	(150)	17	(100)	10	(100)	15	(100)	13	(100)	15	(150)	
1/24	14	(100)	10	(100)	10	(100)	14	(100)	15	(150)	13	(100)	
2/21	17	(150)	18	(200)	12	(150)	12	(150)	13	(150)	11	(100)	
3/16	15	(200)	15	(100)	15	(100)	14	(100)	12	(100)	13	(100)	
4/23	13	(100)	13	(100)	14	(150)	13	(100)	12	(150)	13	(100)	
5/18	13	(100)	15	(100)	14	(150)	13	(100)	12	(100)	9	(100)	
6/14	12	(200)	9	(200)	9	(150)	8	(150)	12	(200)	12	(150)	
7/13	11	(100)	12	(150)	10	(150)	12	(150)	15	(150)	20	(150)	
8/13	11	(100)	15	(150)	20	(150)	13	(100)	14	(150)	12	(100)	
9/7	11	(100)	14	(200)	10	(150)	11	(150)	15	(150)	10	(100)	
10/11	13	(100)	10	(100)	10	(100)	10	(100)	14	(100)	10	(100)	
11/8	15	(200)	12	(100)	11	(100)	13	(150)	14	(150)	12	(100)	
12/7	18	(150)	14	(100)	16	(100)	17	(150)	18	(100)	18	(100)	

TABLE 17 (Continued)  
 MAXIMUM READINGS (a) FROM MONTHLY SHORELINE SURVEYS FOR 1973  
 ( $\mu$ R/hr with c/m in Parentheses)

Date	381.0 F		378.3 F		369.8 F		362.0 F (c)		359.0 F		354.7 F (d)		350.4 F		345.2 F	
	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)	LLM	(GM)
1/18	10	(100)	12	(100)	13	(100)	15	(150)	10	(100)	12	(100)	15	(150)	12	(100)
2/21	10	(100)	11	(100)	13	(100)	13	(100)	12	(100)	10	(100)	12	(100)	19	(150)
3/16	11	(100)	12	(100)	10	(150)	14	(100)	12	(100)	11	(100)	11	(100)	15	(200)
4/23	13	(100)	15	(100)	12	(100)	19	(100)	12	(100)	17	(100)	10	(100)	17	(100)
5/18	9	(100)	12	(100)	9	(100)	15	(100)	11	(100)	10	(100)	11	(100)	14	(100)
6/14	9	(150)	9	(100)	8	(100)	11	(100)	9	(100)	9	(100)	10	(100)	13	(100)
7/13	10	(150)	10	(150)	12	(150)	12	(200)	8	(100)	9	(100)	11	(150)	12	(150)
8/13	10	(100)	10	(100)	13	(100)	12	(100)	15	(100)	20	(150)	21	(150)	21	(150)
9/7	8	(100)	9	(100)	9	(100)	9	(100)	10	(100)	13	(150)	9	(100)	17	(250)
10/11	8	(100)	8	(100)	10	(100)	15	(150)	10	(100)	10	(100)	10	(100)	15	(100)
11/8	11	(100)	12	(100)	12	(100)	14	(150)	12	(100)	11	(100)	11	(100)	15	(200)
12/7	12	(100)	12	(100)	12	(100)	20	(150)	13	(100)	12	(100)	15	(100)	17	(150)

(a) Measurements reported in  $\mu$ R/hr are taken 1 meter above the ground and 1 meter back from the water's edge. Measurements reported in ( ) are the maximum c/m found with a GM in the immediate vicinity of the water's edge.

(b) River miles measured from the mouth of the Columbia. Plant shore, far shore, and island are designated by P, F, and I, respectively.

(c) Point only open to the general public on Wednesdays, Saturdays, and Sundays, during the hunting season.

(d) Point open to the general public during the entire year.

No entry indicates no measurement was performed.

TABLE 18  
 AVERAGE EXPOSURE RATES BELOW THE SURFACE OF THE COLUMBIA RIVER (1972-1973)  
 Units of mR/day

River Mile	1972		1973	
	Jan-June	July-Dec	Jan-June	July-Dec
Vernita			0.16	0.14
Coyote Rapids				
100-K Barge	0.14	0.18	0.14	0.16
D-Island	0.20	0.19	0.17	0.17
100-F Area	0.23(a)	0.17	0.14	0.10
S. Wooded Island	0.18	0.19(c)	0.12	0.10
Richland Pumphouse	0.14(b)	0.13	0.15	0.11
Above 100-D	0.15(a)	0.18	0.17	0.17
Below 100-N	0.16(a)	0.19	0.18	0.16
Hanford Powerline		0.29(d)		

(a) March-June

(b) Jan-April

(c) September, November, December

(d) October-December

No entry indicates no measurement was performed.

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