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AEC RESEARCH AND DEVELOPMENT REPORT

EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD FOR 1959

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MAY 9, 1960

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EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD FOR 1959

By

The Radiological Evaluation Staff

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Radiation Protection Operation

May 9, 1960

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD FOR 1959

I. INTRODUCTION

During operation of the plutonium production and research facilities at Hanford, * controlled amounts of radioactive wastes are released to the atmosphere, ground, and to the Columbia River. These wastes contribute to the radiation exposure of persons living in the neighborhood of the controlled area. The protection of these persons from undue radiation exposure attributable to Hanford sources is one of the attendant responsibilities in the operation of the Hanford facilities.

The recommendations of the NCRP and ICRP, and the results of a continuous research program,[(1)] form the basis of the standards used in assessing the degree of protection needed and attained. The effectiveness of waste control and radiation protection practices is determined by comparison of the results of an extensive program of sampling and measurement of radionuclide abundance in the Hanford environs with the reference standards.

The release of radioactive wastes and environmental radiation protection results through 1958 are summarized in the transcribed proceedings of the Joint Committee on Atomic Energy - Congressional Hearings held in 1959.[(2)]

Hanford's experience in the field of environmental radiation protection for the year 1959 is the subject of this report. The results of Hanford's environmental monitoring for 1958 are reported in "Hanford Environmental Monitoring Annual Report", HW-61676, Unclassified, August 27, 1959, by B. V. Andersen.

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* Operated for the Atomic Energy Commission by the General Electric Company under contract number AT(45-1)-1350.

II. SUMMARY

A large fraction of exposure to persons residing in the neighborhood of the Hanford controlled area is through drinking treated Columbia River water. The source of this exposure is identified with the neutron-induced radionuclides generated in the cooling water of the production reactors. However, other sources and paths of exposure contribute to the total dose estimate.

The environmental radiation exposure is estimated for each of the critical organs of major interest, i.e., the gastrointestinal tract, bone and the total body. In each case, multiple sources and paths of intake contribute in varying degrees to the estimated dose. There is a general lack of detailed information on the variation of diet within a population group. Because of these and other uncertainties the environmental radiation exposure cannot be stated precisely. However, the exposure to persons in the neighborhood of the Hanford controlled area is estimated to be about 10 per cent-15 per cent of that permitted by the recommendations of the NCRP.

The estimated dose consists primarily of the dose due to ingestion of drinking water and foodstuffs which have been irrigated by river water containing diluted reactor cooling water. Hanford's contribution to environmental exposure through atmospheric paths is considerably less than that due to fallout from nuclear detonations. Atmospheric contributions are small compared to the contribution through water effluents.

It is possible that for exceptional cases where unusual amounts of local fish are included in the diet, the exposure would be greater than the preceding estimate. This larger estimate appears to be contained within the range of 40 per cent-60 per cent of the appropriate maximum permissible limit.

III. DISCUSSION OF ENVIRONMENTAL SAMPLING RESULTS

A brief discussion of the analytical methods for determining radionuclide concentrations in the various types of samples is contained in Appendix A. The results and interpretation thereof as discussed in this section are categorized according to method of waste release and potential path of intake.

A. Concentrations of Radionuclides in the Columbia River

The eight production reactors located as shown in Figure 1 create radionuclides in that portion of the Columbia River water used as reactor coolant. More than 60 radionuclides have been measured in reactor effluent water, and their relative abundance is illustrated in Figure 2. Other Hanford facilities do not contribute measurably to the quantity of radionuclides in the river.

Many of the radionuclides in the reactor effluent water are short-lived and decay rapidly after formation in the reactors. A gross decay curve, which illustrates this property, is reproduced as Figure 3. In addition to radioactive decay, a quantity of the radionuclides is removed from the river water by such mechanisms as silting and uptake by river biota.[3]

There are several ways by which radionuclides in the river water may result in exposure to humans. Among these paths of exposure are: 1) irrigated agriculture products (discussed in Section C), 2) sanitary water derived from treating river water, 3) edible fish and waterfowl which inhabit the river, and 4) external exposure from use of the river for recreational purposes.

Sanitary Water Concentrations

Pasco and Kennewick are the nearest cities downstream from the Plant which treat Columbia River water for use as sanitary water. Sanitary water from each of the water treatment plants was sampled weekly and analyzed for individual radionuclides or in some cases groups of radionuclides

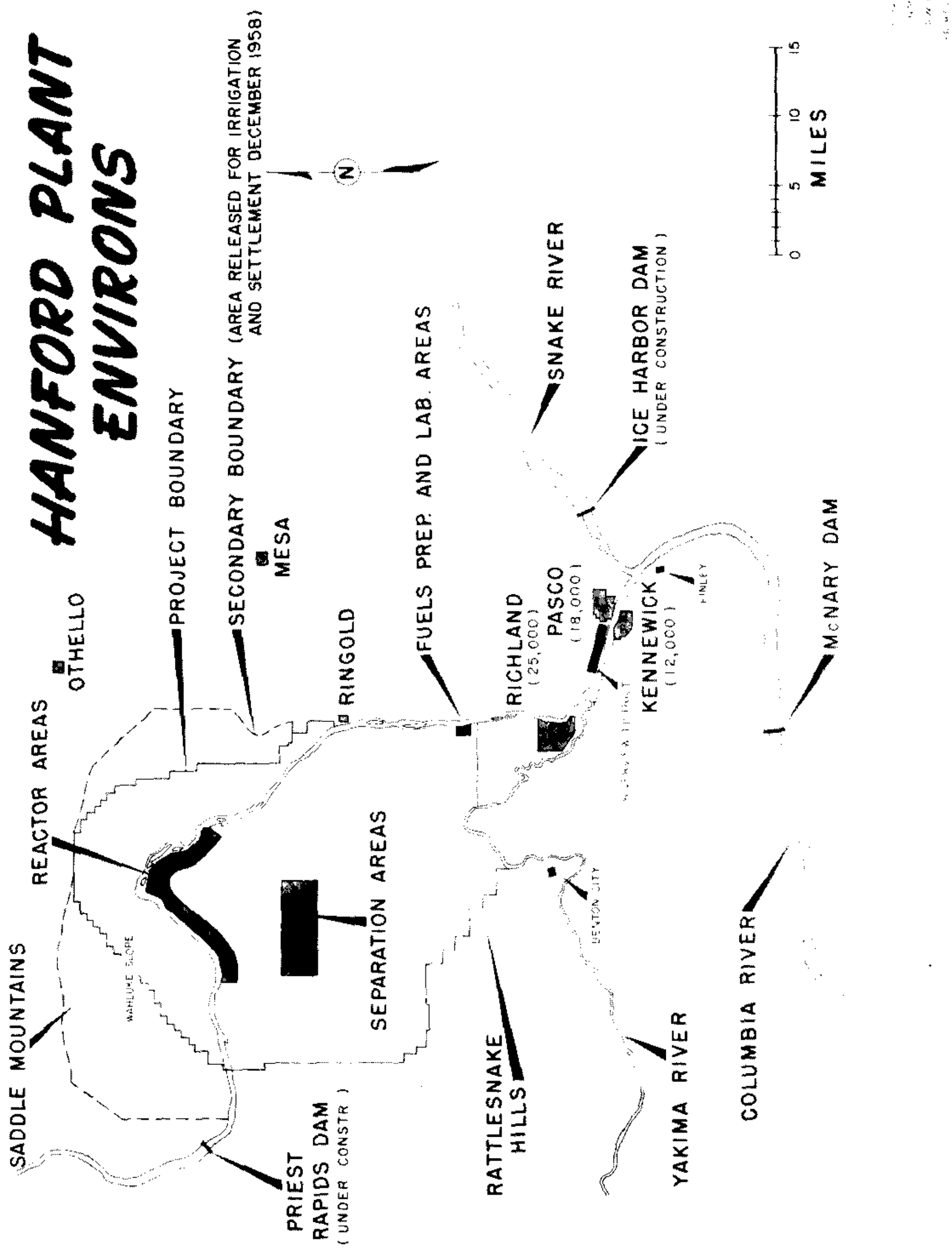
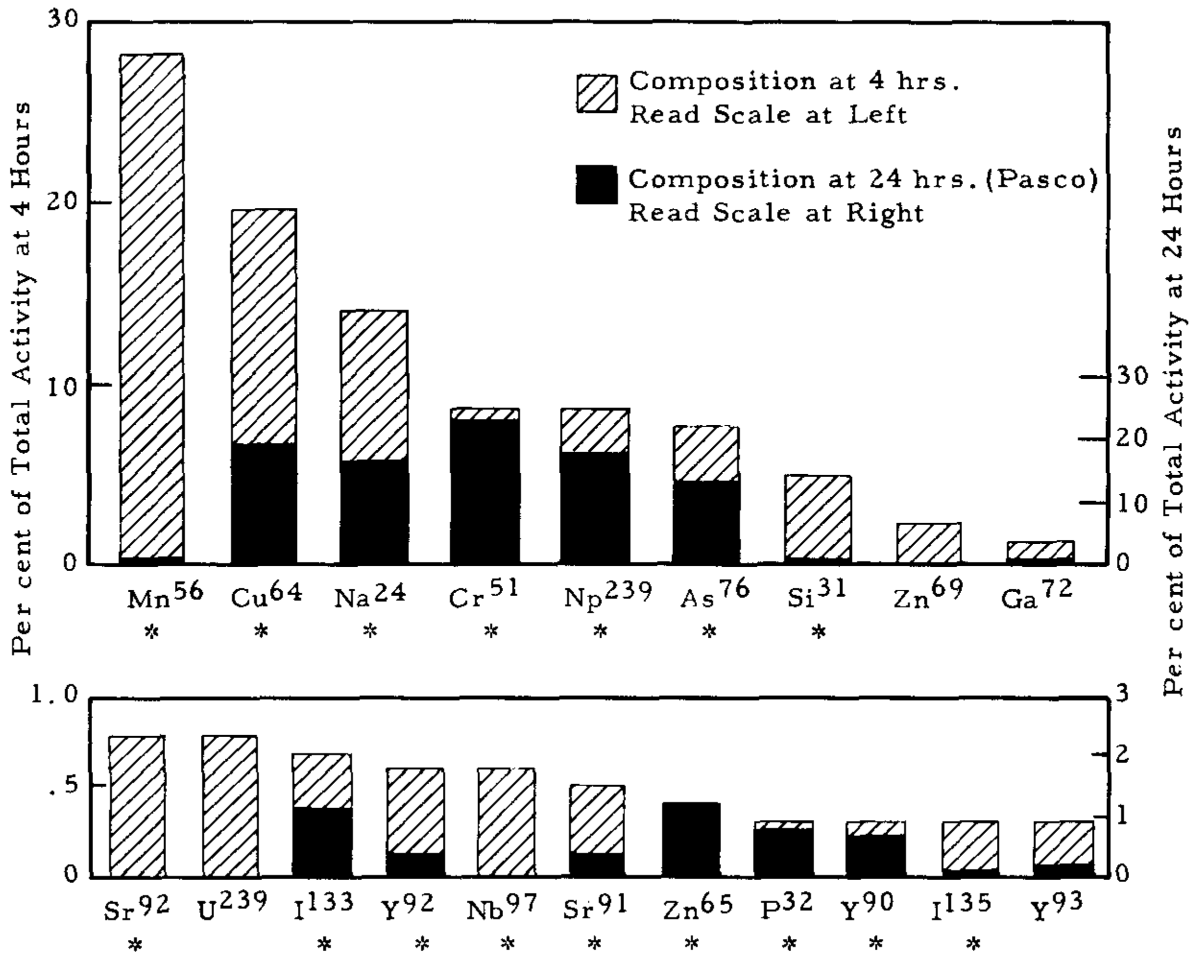


FIGURE 1

AEC-GE RICHLAND, WASH.



In addition to the isotopes shown above, which contribute about 98 per cent of the activity 4 hours after irradiation, trace amounts of the following have also been found.

Eu-152	Eu-157	I-131*	Y-91	Pr-145	Cs-137
Sm-153	Ba-140*	Ce-141	Fe-59*	Pm-151	Sr-85
W-187	Mo-99	Pr-142	Sr-89*	Co-60	U-238*
La-141	Sm-156	C-14	Mn-54	Pr-143	Pu-239*
Nd-149	Sc-46*	Nd-147	Zr-95	Ru-103	Ac-227
La-140	Cd-115	Ca-45*	Pm-149	Sc-47	Po-210*
I-132*	Ce-143	Ag-111	Eu-156	Sr-90*	

* Routine measurements are made on these isotopes.

FIGURE 2

Isotopic Composition of Reactor Effluent
4 Hours and 24 Hours after Irradiation

REDUCTION IN RADIOACTIVITY OF REACTOR EFFLUENT WITH TIME

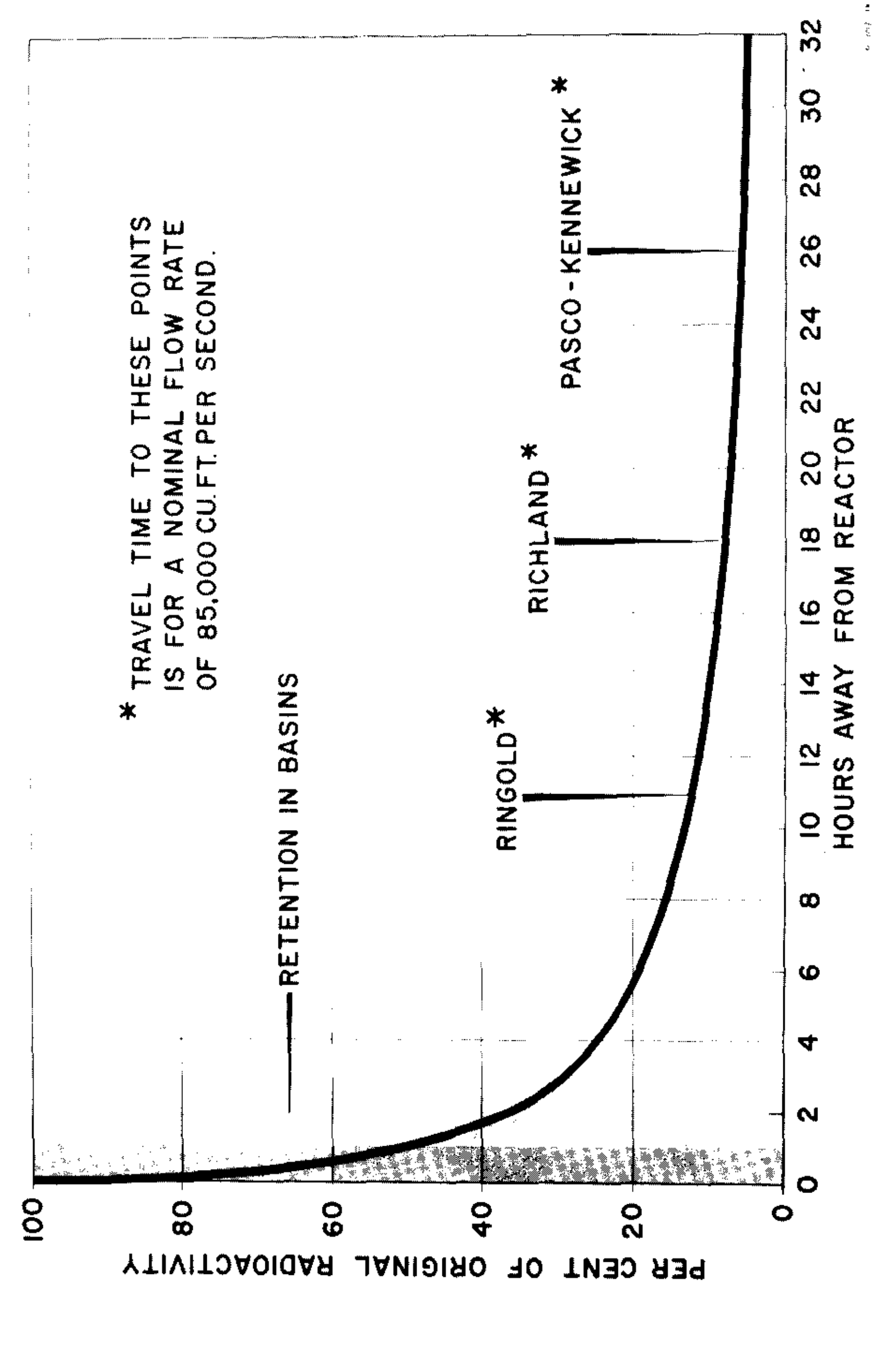


FIGURE 3

AEC-GE RICHLAND, WASH.

such as the rare earths. Untreated river water at the Pasco pumping plant inlet was also sampled and analyzed weekly. The data are included in Appendices B-1, -2, and -3.

The sanitary water of other communities near the plant which have sources of water supply other than the Columbia River was periodically sampled and analyzed. Richland, Benton City, Ringold and Riverview farms are examples of this portion of the program. A higher concentration of natural uranium has been noted in the water from Benton City wells, than in the water from wells of other local communities throughout a ten year sampling period. See Appendices B-4 and -5. However, there is no evidence that this condition is attributable to Hanford facilities. Sampling and analyses of the river and sanitary water in the Pasco system and sanitary water in Kennewick provided data which were used to estimate the radiation exposure from this source to the local residents. In both cities, the sanitary water samples were collected near the water treatment plants. Because there is an unknown, but significant flow time between sampling locations and most consumers, the concentration in sanitary water at the time it is consumed is overestimated. This is due to radioactive decay which reduces the concentrations of some of the nuclides substantially before they reach the majority of the consumers.

The actual decay time available varies from hours to days depending upon water usage rates, particular location of the consumer, and other influences.(4) Figures 4 and 5 show the efficiency of the water treatment plant at Pasco for the removal of various radionuclides. These data include the radioactive decay of the radionuclides during travel through the water treatment plant.

For the mixture of nuclides present in the river water and sanitary water, the gastrointestinal (GI) tract is an organ of major interest. During 1959, the calculated average dose to the GI tract for the Pasco population was equivalent to ~5 per cent of the maximum permissible concentration in water (MPC_w) for persons in the neighborhood of controlled areas.(5) The average monthly results for 1959 are summarized in Table I.

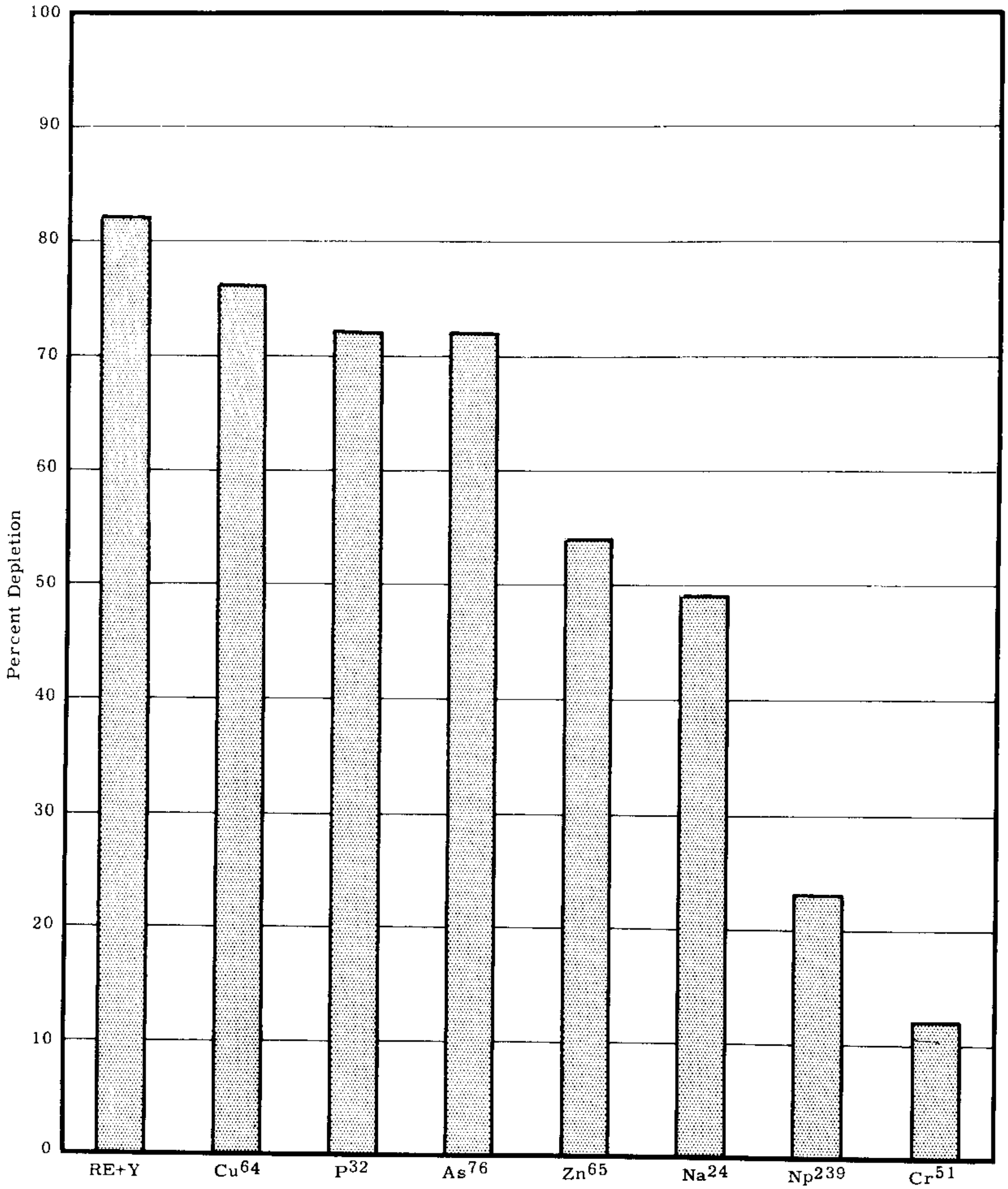


FIGURE 4

Depletion of Several Radionuclides in Columbia River Water During Treatment at Pasco, Washington Water Plant (1959 Averages)

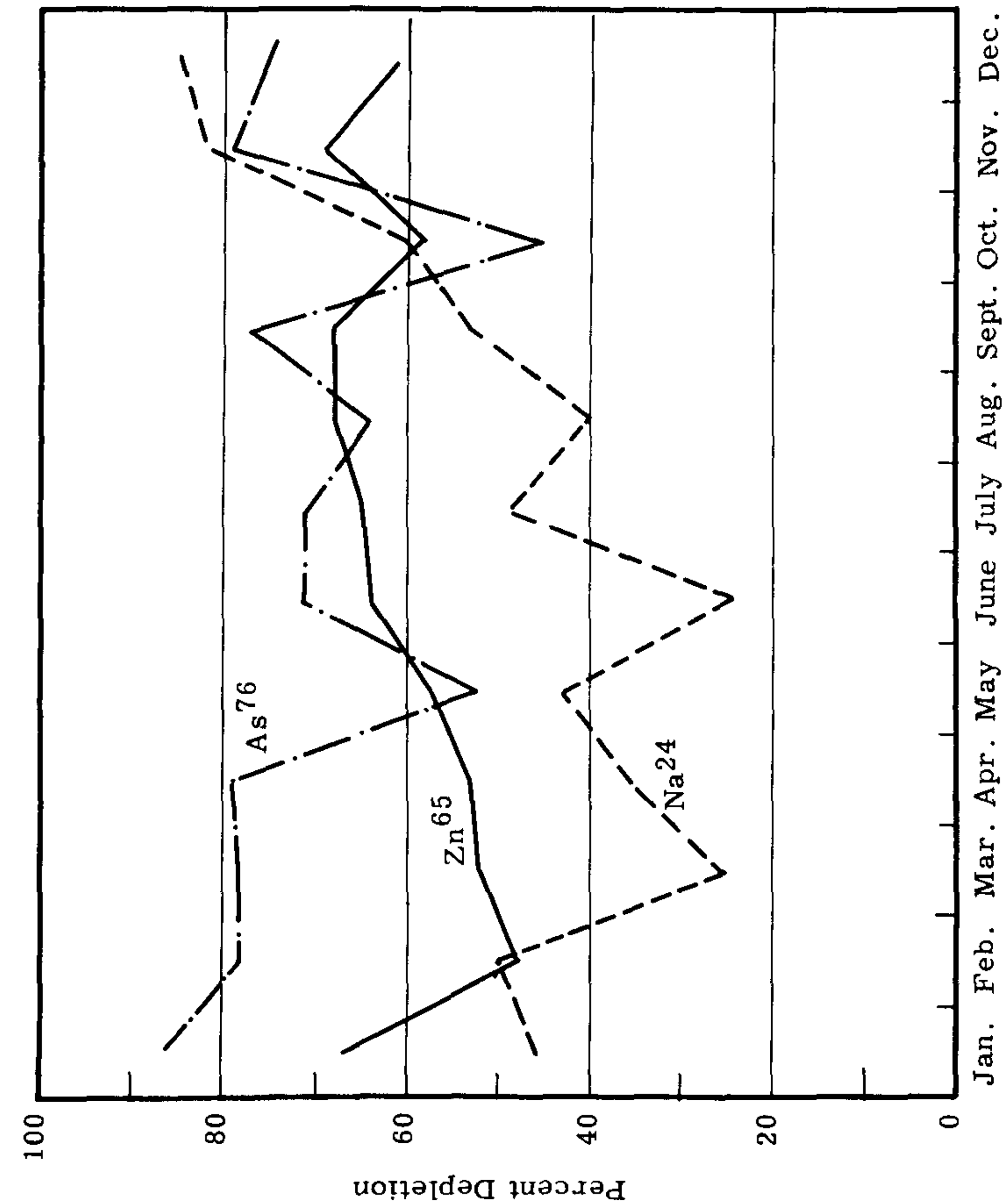


FIGURE 5

Depletion of Selected Radionuclides in Columbia River Water During Treatment at Pasco, Washington Water Plant (1959 Monthly Averages)

TABLE I

AVERAGE PERCENTAGES OF NBS HANDBOOK 69 MPC_W - GI TRACT IN SANITARY WATER AT PASCO, WASHINGTON 1959

Month	% MPC_W*
January	5.8
February	5.3
March	5.4
April	5.2
May	3.7
June	2.1
July	2.0
August	4.3
September	4.0
October	6.2
November	3.3
December	4.5

* The MPC_W for the GI tract was taken as that given for continuous occupational exposure from NBS Handbook 69 and multiplied by 0.1 for persons residing in the neighborhood of a controlled area. Solubility in GI tract and body fluids is assumed.

The calculated per cent for Kennewick residents averaged ~2 per cent of the MPC_W for the GI tract. Although there was no known routine consumption of the untreated river water, such a source of drinking water throughout the year would have resulted in radiation exposure equivalent to ~15 per cent of the MPC_W for the GI tract. The average contribution of several radionuclides to the dose to the GI tract would be as illustrated in Figure 6. Figure 7 illustrates the seasonal variation in concentration of radionuclides. This variation is influenced by the river flow variation shown in Figure 8, and, in the case of sanitary water, the treatment plant throughput [4] illustrated in Figure 9.

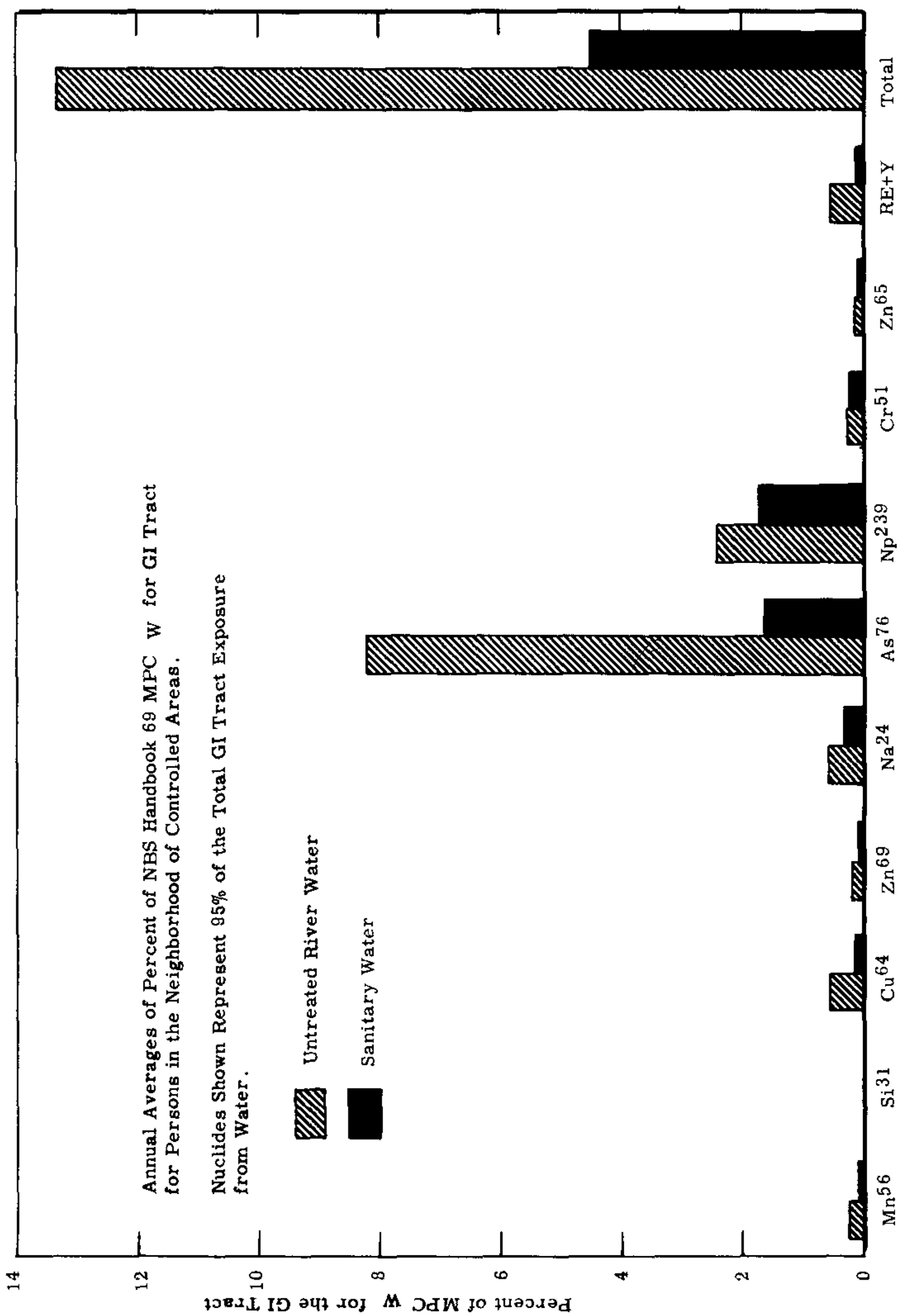


FIGURE 6

Per Cent of MPC_W for the GI Tract for Selected Radionuclides in Columbia River Water and Sanitary Water at Pasco, Washington - 1959

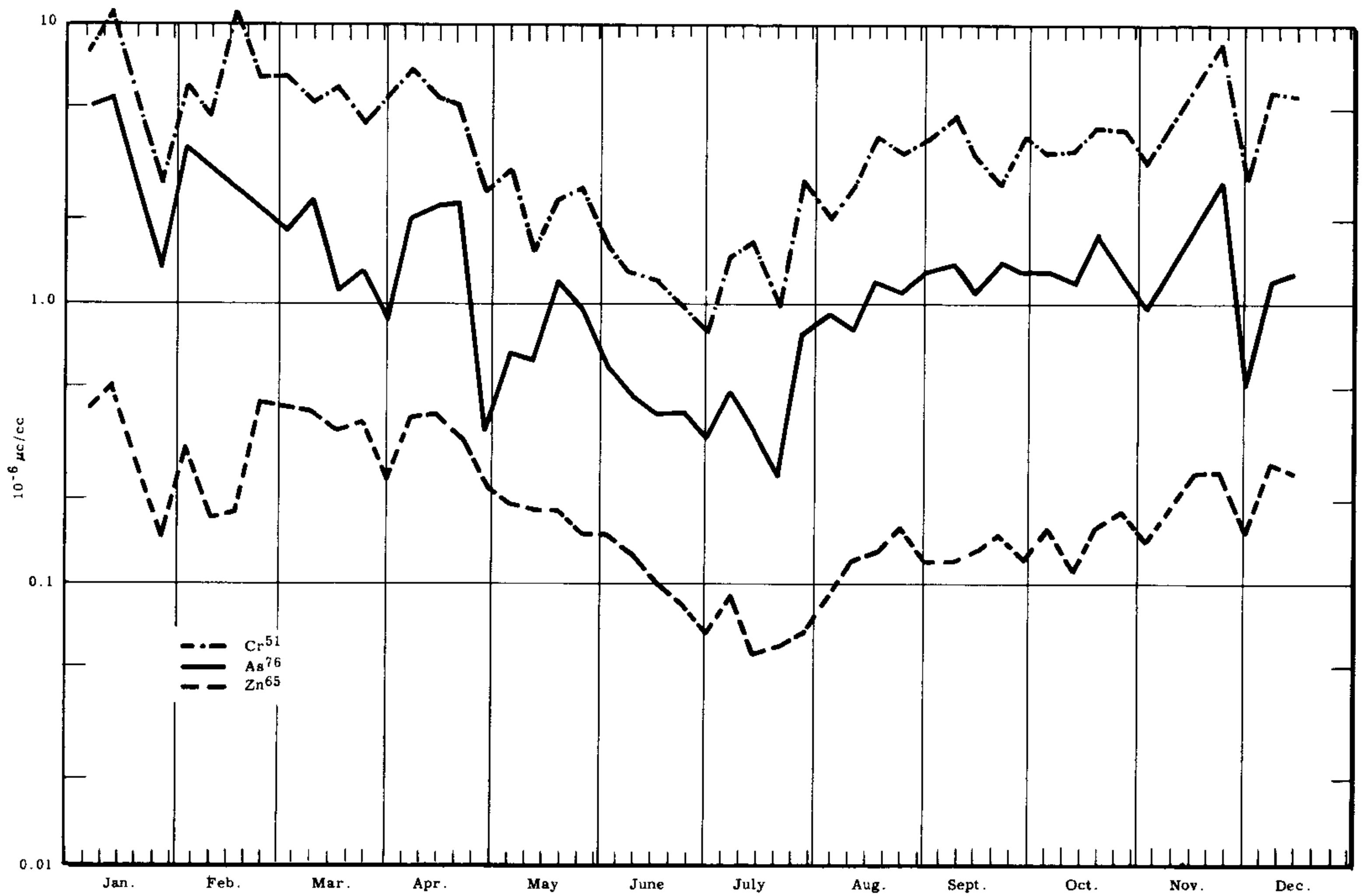


FIGURE 7

Variations in Concentrations of Selected Radionuclides in Columbia River Water at Pasco, Washington for 1959

AEC-GE RICHLAND, WASH.

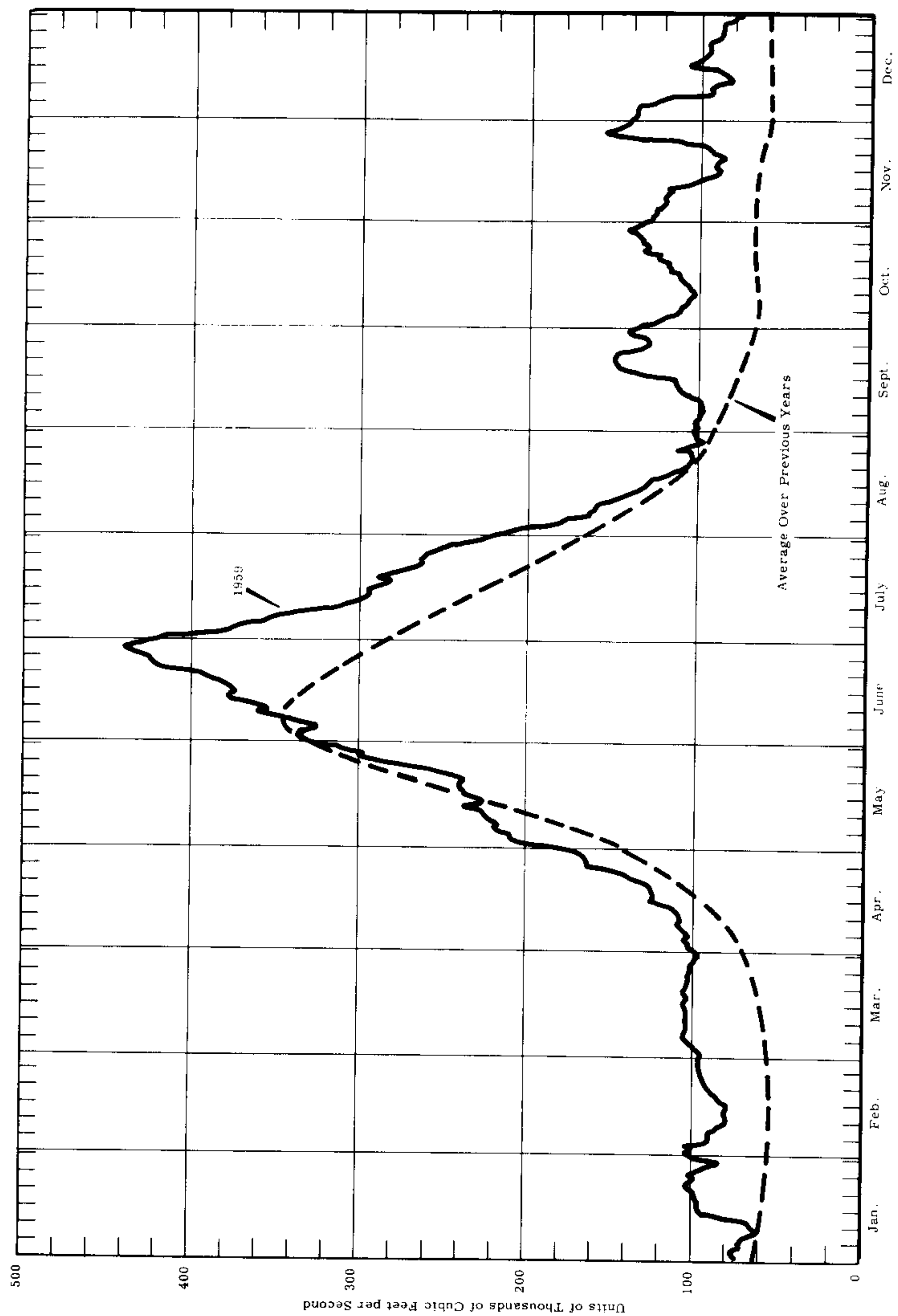


FIGURE 8

Flow Rate of Columbia River at Pasco, Washington
(From Data Published by the U. S. Geological Survey)

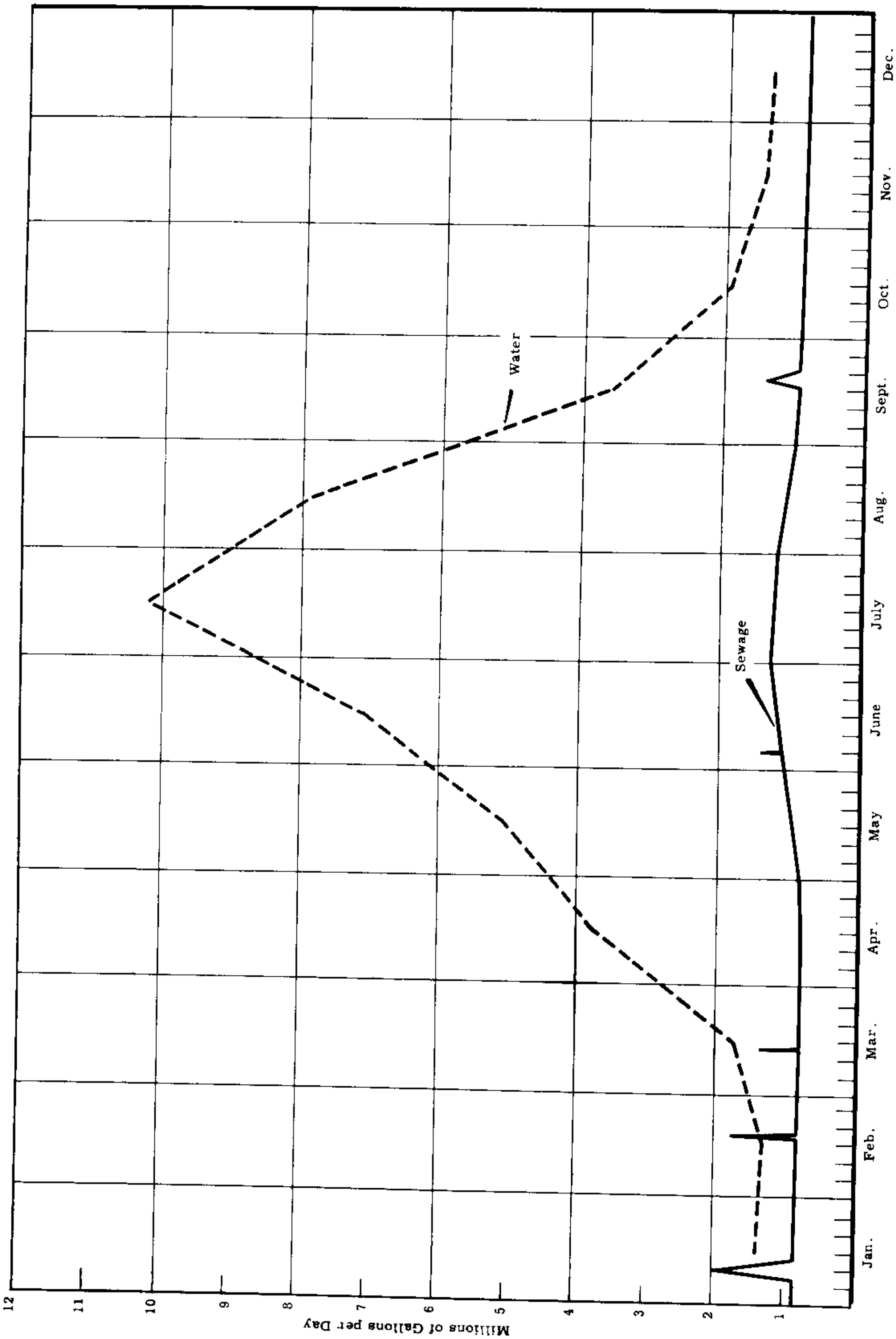


FIGURE 9

Volumes of Water and Sewage Processed at Pasco, Washington Water and Sewage Plants
1959 Monthly Averages

In calculating the percentage MPC_W for the GI tract from drinking water, the rare earth elements are included as a group; a maximum permissible limit for which was derived from measured concentrations in reactor effluent water[6] and the individual MPC_W's.[5]

The estimated dose to other organs through water intake is substantially less than that for the GI tract. Some indicative values are compared with the GI tract exposure in Table II.

TABLE II

1959 AVERAGE PERCENTAGE MPC_W* FOR ORGANS OF INTEREST

	% MPC_W		
	Bone	Total Body	GI
Pasco, Inlet Water (Columbia River Water)	1.6	0.9	15
Pasco, Sanitary Water	0.9	0.5	5
Kennewick, Sanitary Water	0.6	0.2	2
Vancouver, Columbia River Water**	0.7	0.2	-

* NBS Handbook 69, See footnote Table I.

** Last six months of 1959.

Several radionuclides which contribute to the exposure to these organs are present in amounts below the analytical detection limits. In this case and where analytical data permit, the concentrations in the reactor effluent, river depletion rates and river flow data are used to estimate the concentration at a given location. If insufficient data are available for this computation, it is then assumed that the radionuclide was present in the concentration represented by the detection limit. Thus the values in Table II are believed to be upper bounds of the estimated exposure.

The percentage of MPC_W for other organs was less than those listed in the preceding table.

The filter backwash solids and sediments accumulated in settling basins in Pasco water plant were sampled intermittently throughout the year and analyzed for gross beta emitters. These solids are dispersed into the Columbia

River along with waste water. Measurements[4] made during 1959 indicate this path of exposure to downstream communities to be negligible.

A study was made of distribution of radionuclides in the Pasco sewage plant, particularly the digested solids. In all of these samples the long-lived radionuclides predominated; Zn^{65} and Cr^{51} were the most abundant. Shorter-lived radionuclides decayed to below detectable concentrations during the process period. In the dried solids from the digested sewage, the Zn^{65} concentration was $\sim 5 \times 10^{-5}$ μc Zn^{65}/g. Chromium-51 was the second most abundant nuclide but was an order of magnitude less in concentration.

It is of interest to estimate the uptake of Zn^{65} and Cr^{51} by plants should such plants be fertilized by these solids. This estimate assumes: 1) the concentration remains the same from the time of production to the time of actual use, 2) that 10^{-5} grams of this fertilizer are used per gram of soil available to the plant (about twice average application)[7], and 3) rates of uptake equivalent to 1 μc Zn^{65}/g dry soil results in 0.01 μc Zn^{65}/g dry leaf and 1 μc Cr^{51}/g dry soil yields 0.2 μc Cr^{51}/g dry leaf.[7] The estimated concentrations in leaves of vegetation is : $\sim 5 \times 10^{-12}$ μc Zn^{65}/g dry leaf and $\sim 10^{-11}$ μc Cr^{51}/g dry leaf. Both of these concentrations are sufficiently small to make detection difficult and they are negligible in terms of exposure.

Concentrations in Edible Fish and Waterfowl

The Ringold vicinity is the first downstream area accessible to the public. It is a sportsfishing area where whitefish are taken, particularly during the fall and winter months. Waterfowl inhabit this section of the river; and some of these are harvested by local hunters. The amount of radiation exposure received by persons who regularly harvest ducks and whitefish was recently estimated by Foster and Junkins.[8] The following excerpt from the referenced document describes the present situation:

"The whitefish is currently considered to be the species which may contribute most to human exposure because of its relatively high accumulation of radionuclides (only slightly less than suckers), and because it is easily caught during the fall at a time when its content of radioactive materials is maximum.

"The maximum permissible concentration for P^{32} in drinking water 'for persons in the neighborhood of controlled areas' derived from NBS Handbook 69 is 2×10^{-5} $\mu c/cc$ which is equivalent to a daily intake of 4.4×10^{-2} $\mu c/day$. This amounts to about 0.3 μc per week or about 16 μc per year.

"On the basis of the stated assumptions and with averaging over a year's period, this quantity of P^{32} could be obtained from the consumption of about one pound of whitefish flesh each week in years when the average concentration of P^{32} in the fish reaches about 2×10^{-3} $\mu c/g$ of flesh during the late summer or early fall months.

"The concentration of Zn^{65} in the whitefish during the last summer is only about 1/20 of the observed level for P^{32} (in August, 1957). Further, the maximum permissible intake rate for Zn^{65} is 5-fold greater than for P^{32}. The Zn^{65} thus contributes only a relatively small fraction of the exposure received from the consumption of fish.

"The P^{32} content of the flesh of some ducks which are killed along the river within the Hanford reservation is similar to that found in the fish. A comparatively few ducks remain on the river throughout the year so that the accumulation of P^{32} and a few other nuclides builds up to a level which is in equilibrium with their environment. These ducks are not available to off-project hunters until the fall hunting season at which time their number is diluted 200 to 1,000 fold by flocks of ducks which are migrating through the region."

Results of the 1959 biological monitoring program, conducted by Radioecology Operation, indicated lower concentrations of nuclides in fish and waterfowl than were observed in 1957 and 1958.[9, 10, 11] The data are contained in Appendix B-6. Measurements made during the past four years on fish sampled at Ringold are summarized in Figure 10.

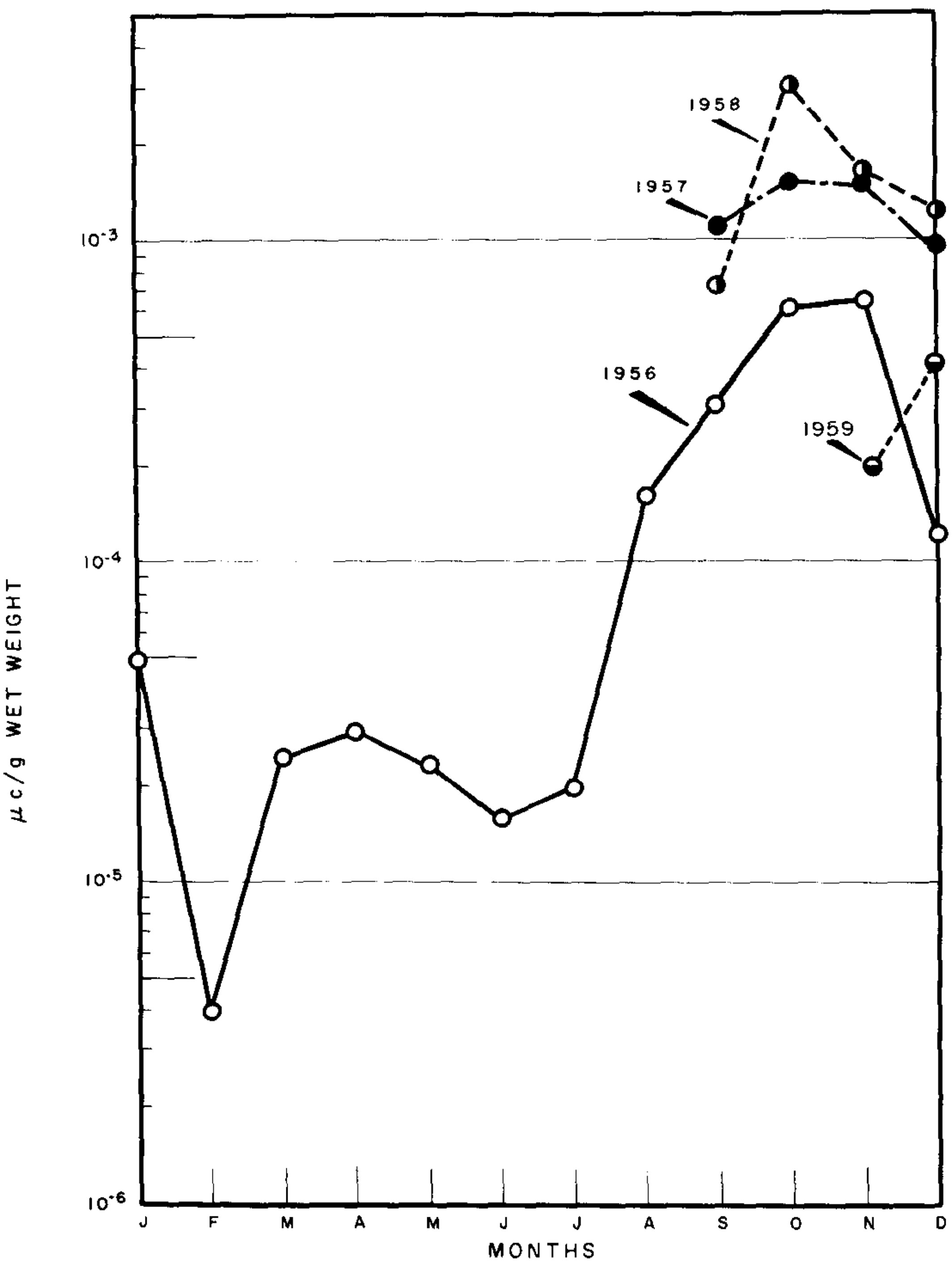


FIGURE 10

Concentrations of Beta Emitters in Muscle of Whitefish at Ringold

Recreational Use of Columbia River

In the vicinity of Richland, Pasco and Kennewick, ionization chambers were used to measure the penetrating radiation in the river. Such measurements indicated an annual exposure of about 60 mr, excluding background, for the operators of a ferry boat just upstream from the City of Richland, assuming they spent one-third of their time in the boat. Since the major contributors to the dose, such as Na^{24}, are short-lived, the exposure from recreational boating further downstream is less. Swimmers would have received about 6 mr from this source, if they were in the river as much as 240 hours during the year.

Concentrations in Columbia River Water at Vancouver

Most of the radionuclides present in the river water which contribute to the GI tract dose have decayed to concentrations too small to be measured at Vancouver, Washington. Radionuclides which contribute to the dose to bone and total body have decayed to a lesser extent and the calculated percentage of the respective MPC_W's in river water at Vancouver were all of the same order of magnitude; i.e., < 1 per cent of the applicable MPC_W. The measurements at Vancouver are reported in Appendix B-7 and are summarized in Table III.

TABLE III

1959 AVERAGE PERCENTAGE MPC_W* FOR SELECTED ORGANS FROM DRINKING COLUMBIA RIVER WATER AT VANCOUVER, WASHINGTON

	% MPC_W		
	GI	Bone	Total Body
P^{32}	0.034	0.15	0.034
Cr^{51}	0.11	--	0.011
Zn^{65}	0.014	0.0029	0.029
Np^{239}	0.018	~0	~0

* NBS Handbook 69 (See * Table I)

There is considerable uncertainty in the related estimates because of the low concentrations of the radionuclides; however, the results are consistent with those calculated from upstream measurements of higher concentrations.

Samples of river water and mud were collected in several locations downstream from Pasco and are reported in Appendices B-8, -9 and 10. These samples were analyzed for gross alpha and beta emitters and the data used as an indicator of unusual conditions. During 1959, analyses for individual radionuclides were initiated on the samples collected at Vancouver.

Results Related to the Pacific Ocean

The analytical measurements together with information on the river flow, Figure 11, can be used to estimate the total quantities of the various radionuclides transported to the Pacific Ocean by the river. Such estimates are included in Appendices B-11 and -12. Chromium-51, Np^{239}, Zn^{65}, and P^{32} persisted in measurable amounts at Vancouver. Although the half-lives of some of these radionuclides are long by comparison with most of the others in the mixture, they are not so long that the total quantities in the North Pacific Ocean will continue to increase indefinitely. On the basis of the Vancouver measurements, the total quantity of these radionuclides in the Ocean, attributable to the Hanford reactors may be estimated. If a constant rate of entry into the ocean, over a period of years, equivalent to that indicated by the Vancouver data is assumed, then the equilibrium value amounts to: ~400 curies of P^{32}, ~400 curies of Np^{239}, ~40,000 curies of Cr^{51} and ~7,000 curies of Zn^{65}. An equilibrium exists for these radionuclides where the rate of addition through the river system corresponds to the rate of decay of the radionuclides which have previously entered the Ocean.

Vancouver, Washington was selected as the farthest downriver location for routine sampling for several reasons: The salt content of

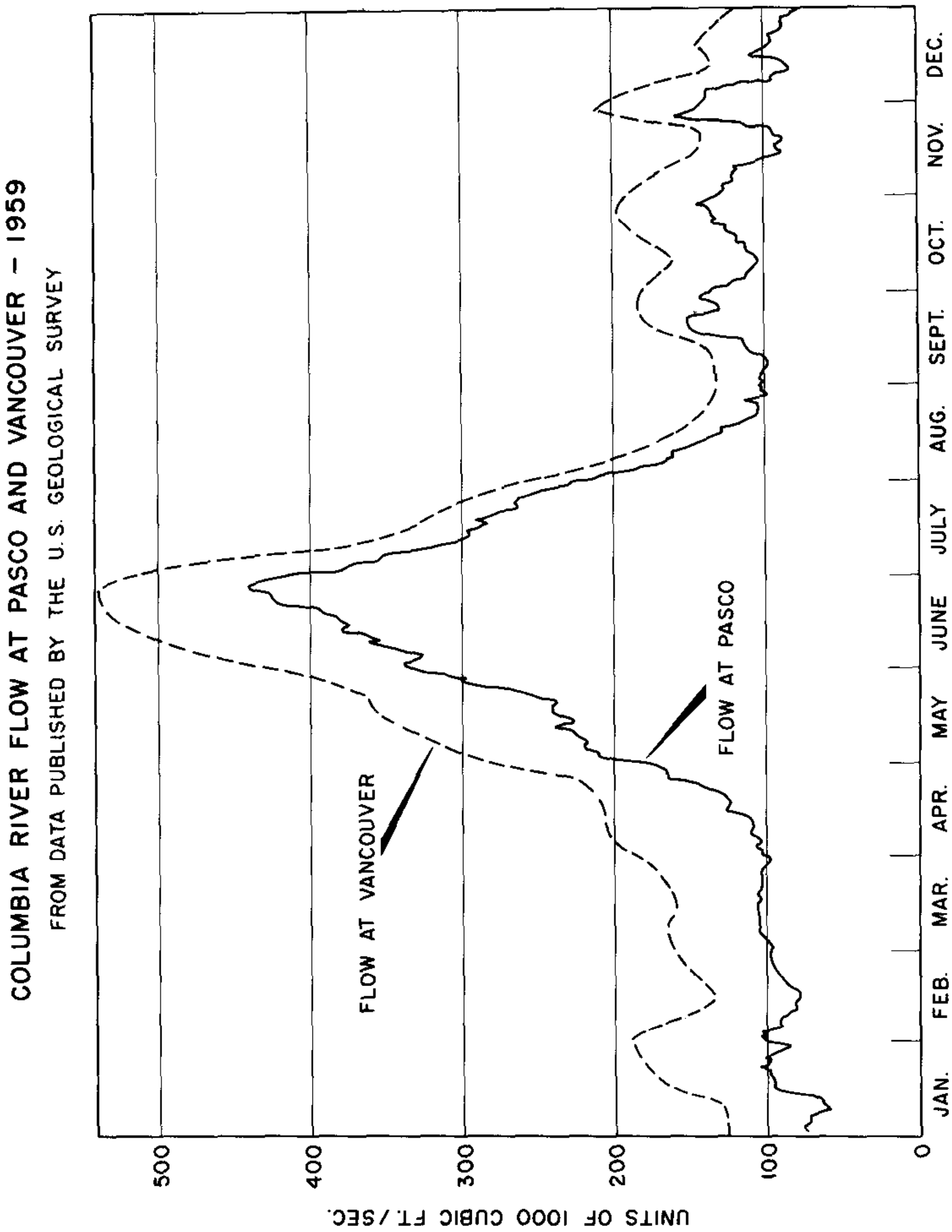

COLUMBIA RIVER FLOW AT PASCO AND VANCOUVER - 1959
FROM DATA PUBLISHED BY THE U.S. GEOLOGICAL SURVEY
FLOW AT VANCOUVER
FLOW AT PASCO
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
0
100
200
300
400
500
UNITS OF 1000 CUBIC FT./SEC.

FIGURE 11

water nearer the mouth of the river complicates quantitative measurement of the radionuclides; tidal movement near the mouth increases variability of results and interpretation of flow times; and, since the very short-lived radionuclides have decayed to small concentrations, radioactive decay of the remainder decreases the total radioactivity at much slower rate than is typical for upriver locations.

The most probable way in which these radionuclides can contribute to human exposure is through concentration in edible marine organisms taken from the Ocean.

Concentrations of the radionuclides in fish, shell fish, and other biota were measured in samples collected along the coasts of Oregon and Washington.

The measurement of Zn^{65} in people has been reported previously.[13] Since Zn^{65} was known to exist in some foodstuffs grown in the Riverview District, it was suspected that people whose diets included these foods would also contain measurable amounts of Zn^{65}. This was confirmed in 1958.[14] However, in the course of calibrating and refining Hanford's whole body counter facility, it became apparent that there was yet another source of Zn^{65} intake.[15] This source has since been identified as sea food, primarily oysters, grown in the Pacific Ocean.

Results of sea food sampling and analyses are contained in Appendix B-13, -14 and -15. The data indicate that the oysters, particularly those from the vicinity of Willapa Bay, Washington, were higher in Zn^{65} content than were other sea foods. These oysters contained on the order of 3.0 to 7.0×10^{-5} μc Zn^{65}~g of edible meat. Measured body burdens of those whose diets are known to include these oysters were 0.01 μc Zn^{65} or less, which is <0.2 per cent of the maximum permissible body burden.

Since the Columbia River transports Zn^{65} to the Ocean, it might be expected that Zn^{65} concentrations in marine organisms would vary along the coast, relative to the mouth of the river. Due to the unavailability of some organisms at various locations, it is difficult to establish such a pattern.

However, it is interesting to note that the Zn^{65} content of oysters from Sequim, Washington, which is on the Straits of Juan de Fuca, is about one order of magnitude less than those of Willapa Bay, Washington.

B. Concentration of Radionuclides in Gaseous Effluents and Vegetation

Any discussion of concentrations of radionuclides in the atmosphere or on vegetation during 1959 must include consideration of the contribution of fallout of debris from nuclear detonations. In the United States, the testing of nuclear devices by detonation was terminated for an indefinite period during the latter part of 1958. However, the fallout of debris from prior detonations continued to be measurable throughout the early months of 1959. During these early months of 1959, the contribution from fallout was sufficient to make the detection of any contribution normally associated with operation of Hanford's facilities difficult.

Atmospheric Concentrations

The filter papers from air sampling stations were changed daily by cooperating agencies. These filter papers were analyzed both for number of radioactive particles and for total beta activity. The average weekly particle concentrations measured in number of particles per cubic meter of filtered air are contained in Appendix C-1 and illustrated in Figure 12. The results for total beta emitters are reported in Appendix C-2 and illustrated in Figure 13. The trend throughout the year in both Figures 12 and 13 is apparent. It is indicated by a decrease in the average weekly concentration and the average weekly beta activity beginning in April. The decrease is logarithmic over the next four to five months, and reaches an apparent "background" in October.

During the period from October through December, 1959 measurements of filter papers indicated a measurable contribution from Hanford Operations.

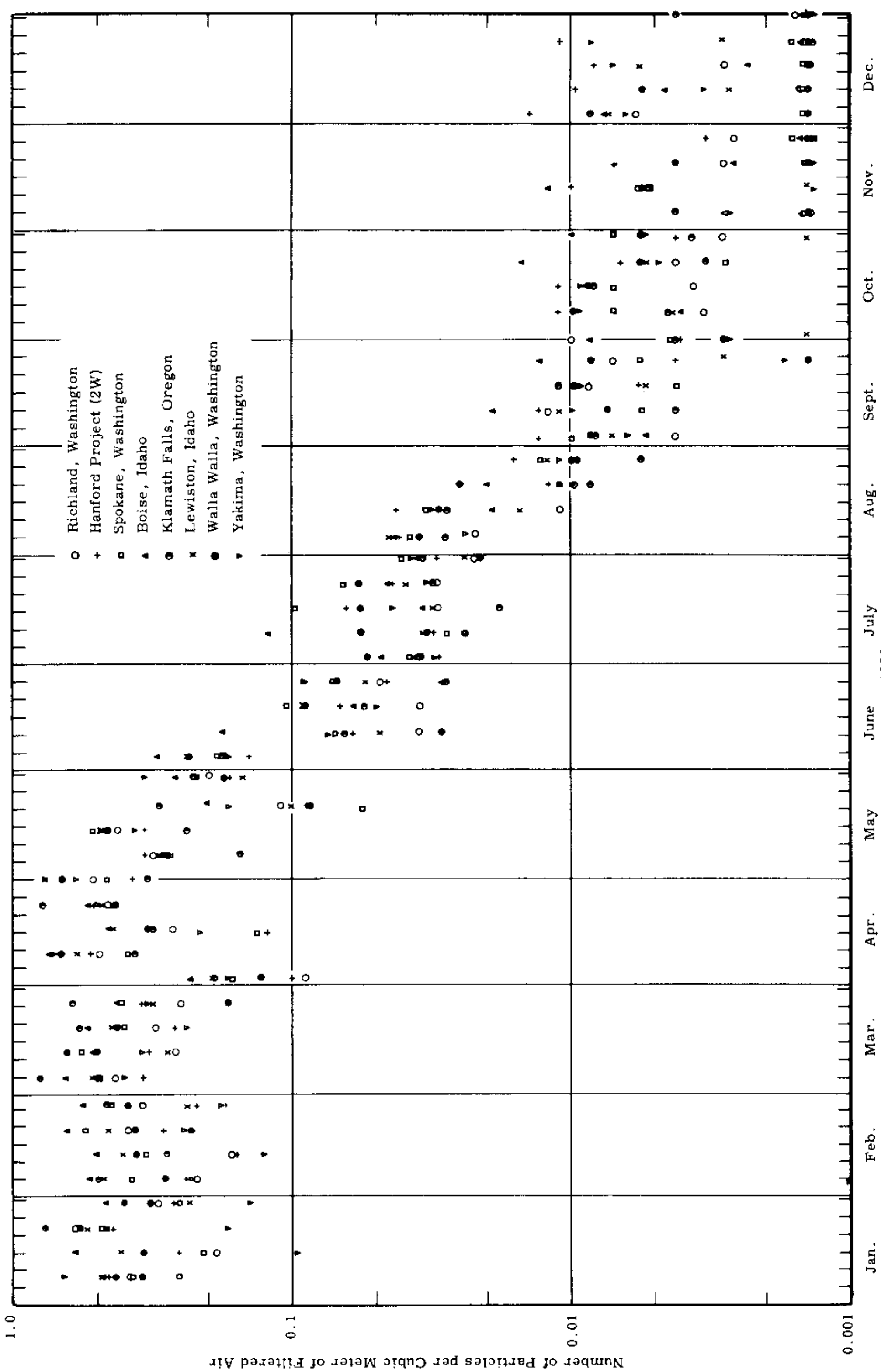


FIGURE 12

Radioactive Particle Concentrations at Selected Northwestern United States Sampling Locations - 1959

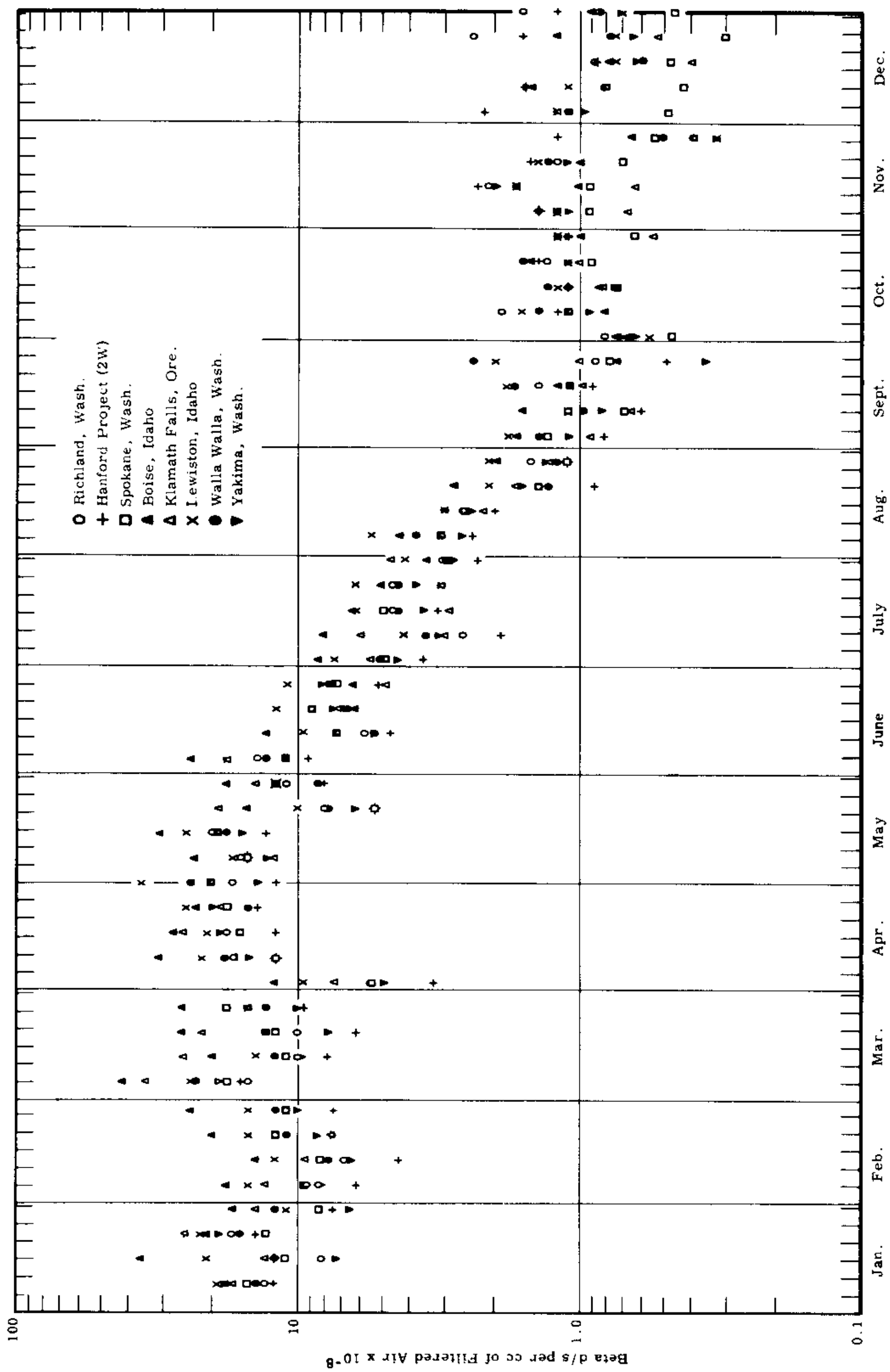


FIGURE 13

Activity on Filters from Selected Northwestern United States Sampling Locations - 1959

This contribution was primarily limited to the Hanford controlled area as demonstrated by the plots of the particle frequency distribution. Only those filters through which equal volumes of air (i.e., $\sim 120\ m^3$) have been passed are considered. Figure 14b shows such a distribution for the location within the controlled area identified as "Hanford" and Figure 14a is a plot for all off-site locations. The distribution for "Hanford" is very nearly described by a Poisson distribution with a mean of about one particle per 24-hour sampling period. Air sample filters for locations distant from Hanford had a particle distribution, which again could be described by a Poisson distribution but with a mean of 0.4 particles per 24-hour sampling period. The discrepancy, as indicated by marginal χ^2 test results can be explained by noting that the observer, in counting the radiographic images, either tends to find no images (particles) or, once he has found one, he tends to find more. Thus, the distribtuion shows a tendency to be high at zero as well as at the larger numbers of particles counted; such distributions have been described by a negative binomial distribution.[16] This effect has been observed by other investigators in dealing with the counting of a very small number of events per unit area (or time) by human observers.

The analysis of filter papers for individual radionuclides is not a routine procedure. However, such an analysis was performed[17] in 1959. During the third calendar quarter of 1959, filter papers from each of 13 locations were grouped for this analysis. Table IV is a summary of the results corrected for radioactive decay to July 15, 1959 and converted to μc per cc of filtered air. The fact that the concentrations in Table IV are very nearly the same for all locations is further evidence that the radionuclides are from fallout.

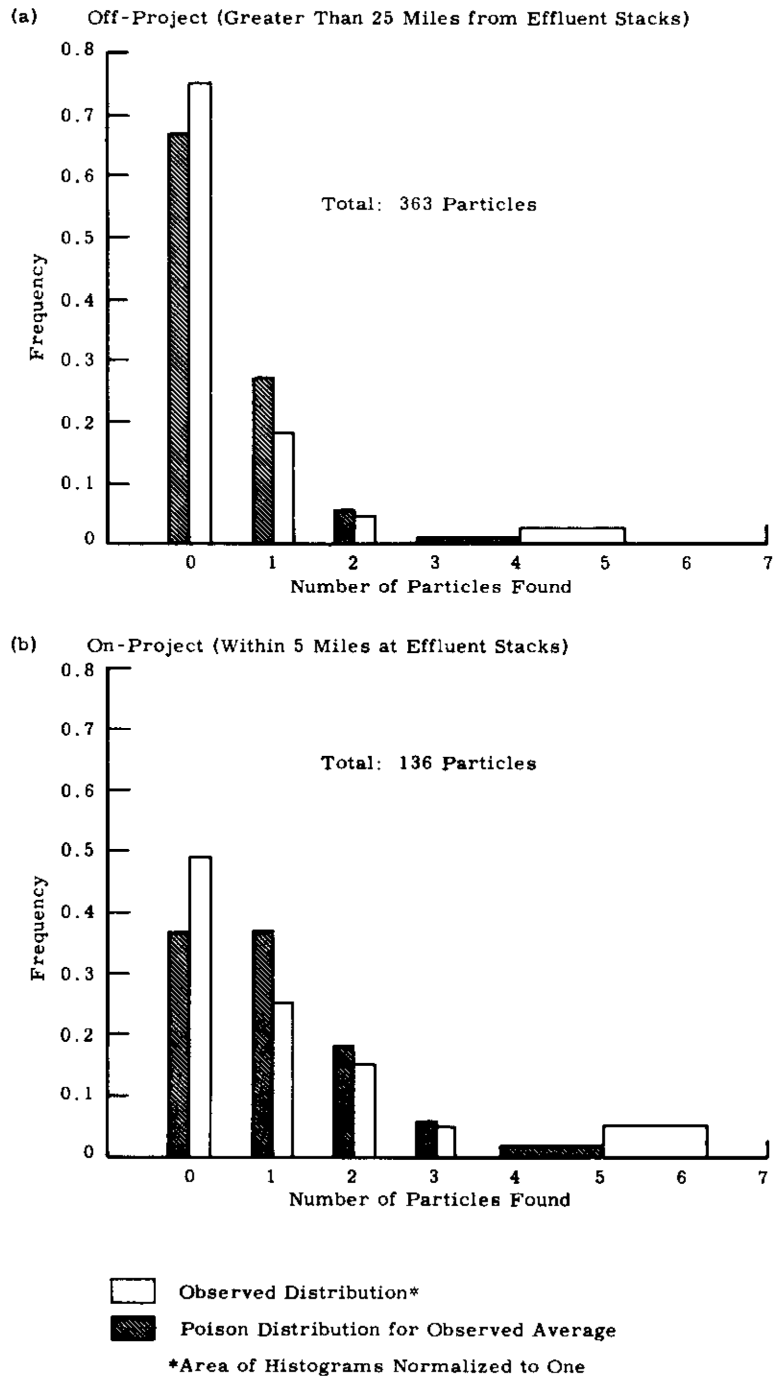


FIGURE 14

Comparison of Particle Distribution Found on Filter Paper
4th Quarter - 1959

TABLE IV

CONCENTRATION OF RADIONUCLIDES ON FILTER PAPERS THIRD QUARTER - 1959 (Units of 10^{-13} $\mu c/cc$)

	Zr^{95}-Nb^{95}	Cs^{137}	Ru^{106}	Ce^{144}-Pr^{144}	Zn^{65}
Benton City, Wash. *	1.4	0.47	1.6	2.9	--
Richland, Wash.	1.3	0.29	1.7	2.5	--
Kennewick, Wash*	1.9	0.54	2.1	3.8	--
Pasco, Wash. *	1.7	0.53	2.3	3.4	0.11
Yakima, Wash.	1.7	0.27	1.5	2.7	--
Walla Walla, Wash.	1.4	0.29	1.5	2.9	--
Meacham, Ore. *	0.97	0.31	1.1	2.6	0.09
Lewiston, Idaho	1.6	0.35	2.7	3.7	--
Spokane, Wash.	1.4	0.29	1.6	3.1	--
Boise, Idaho	2.0	0.44	2.7	5.0	--
Seattle, Wash. *	0.90	0.25	0.88	1.8	0.06
Klamath Falls, Ore.	1.4	0.32	2.2	3.0	--
Great Falls, Mont. *	1.4	0.37	1.5	2.5	0.11
Average Concentration	1.47	0.363	1.80	3.07	0.09
Per Cent MPC_{air} for Critical Organ **	0.001	0.002	0.004	0.01	(0.0002)***

* Not routinely analyzed for particle concentration.

** Based on NCRP recommendations

*** Based on four locations with reported results.

Radiodine has characteristically predominated in gaseous effluents from Hanford separations facilities. Therefore, air sampling for I^{131} in the atmosphere is a routine procedure for several nearby communities. The sampling results are given in Appendix C-3 and the annual average results are summarized in Table V.

TABLE V

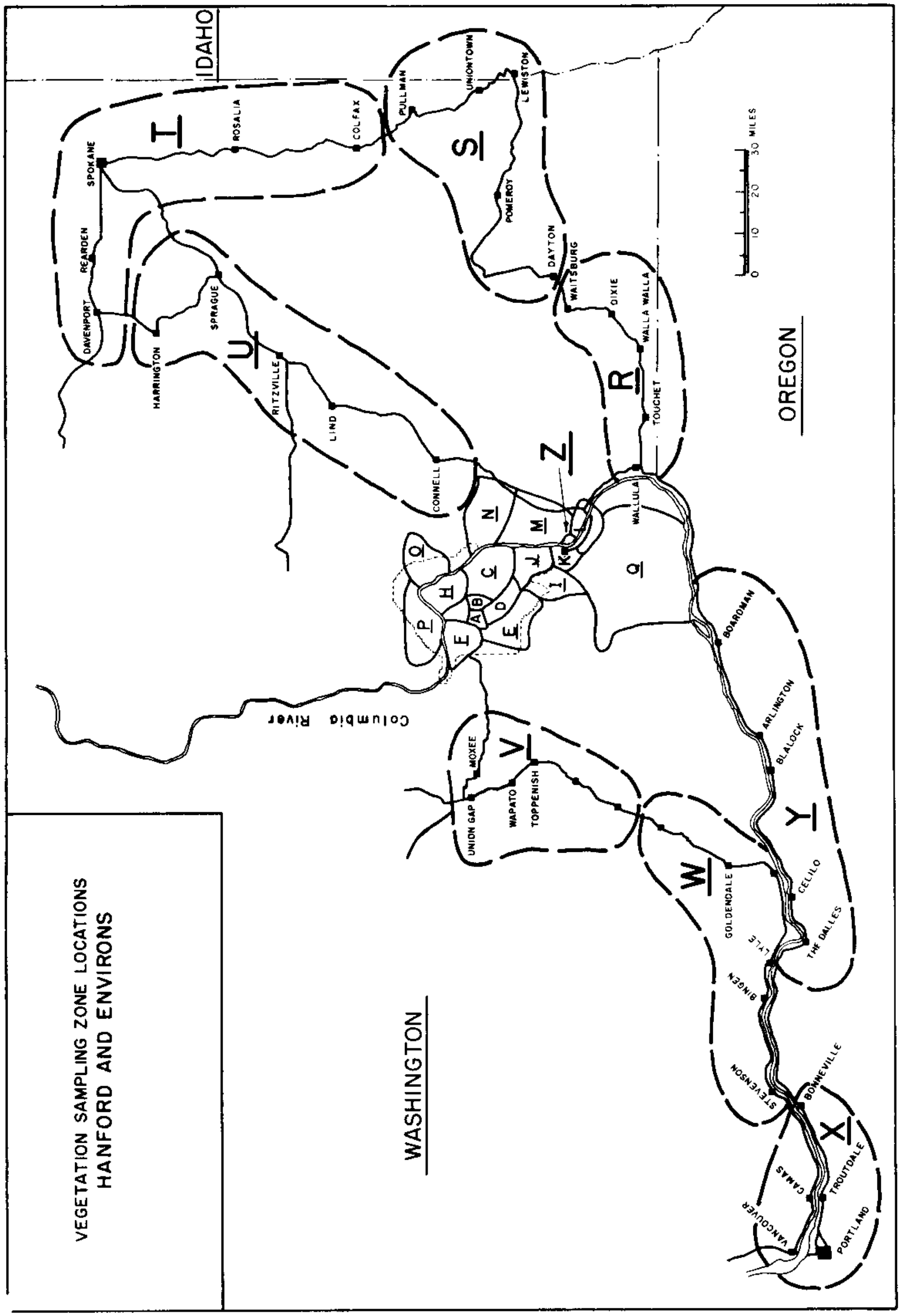
AVERAGE I^{131} CONCENTRATIONS IN ATMOSPHERE - 1959

	$\mu c\ I^{131}/cc$	% MPC_{air}-Thyroid*
Benton City, Wash.	15.4×10^{-14}	0.05
North Richland, Wash.	6.4×10^{-14}	0.02
Richland, Wash.	7.9×10^{-14}	0.03
Pasco, Wash.	13.2×10^{-14}	0.04

* Based on NCRP recommendations

Concentrations in Vegetation

Atmospheric concentrations generally result in the uptake of radionuclides by plant life. Therefore, the sampling program at Hanford includes sampling of native grasses from several locations throughout the Pacific Northwest. These locations are identified as zones as shown in Figure 15. The sampling procedure consisted of collecting 15 grams of grass at each of ten sites throughout a zone. The samples within zones were composited and analyzed by use of a gamma energy spectrometer. Radionuclides observed included Zr^{95}-Nb^{95}, $Ce^{141+144}$, $Ru^{103+106}$, I^{131} and Ba^{140}-La^{140}. The results for all off-site zones are contained in Appendices C-4 through C-20. Figures 16, 17, 18, and 19 illustrate the variation in concentration observed during 1959. Figures 17, 18, and 19 show a similar pattern throughout the year. There is a significant difference in Figure 16 which is representative of zones located within approximately 15 miles of Hanford's chemical separations facility stacks. Measurably higher concentrations prevailed in those zones near the stacks than in the more distant zones during November and December.



VEGETATION SAMPLING ZONE LOCATIONS
HANFORD AND ENVIRONS

FIGURE 15

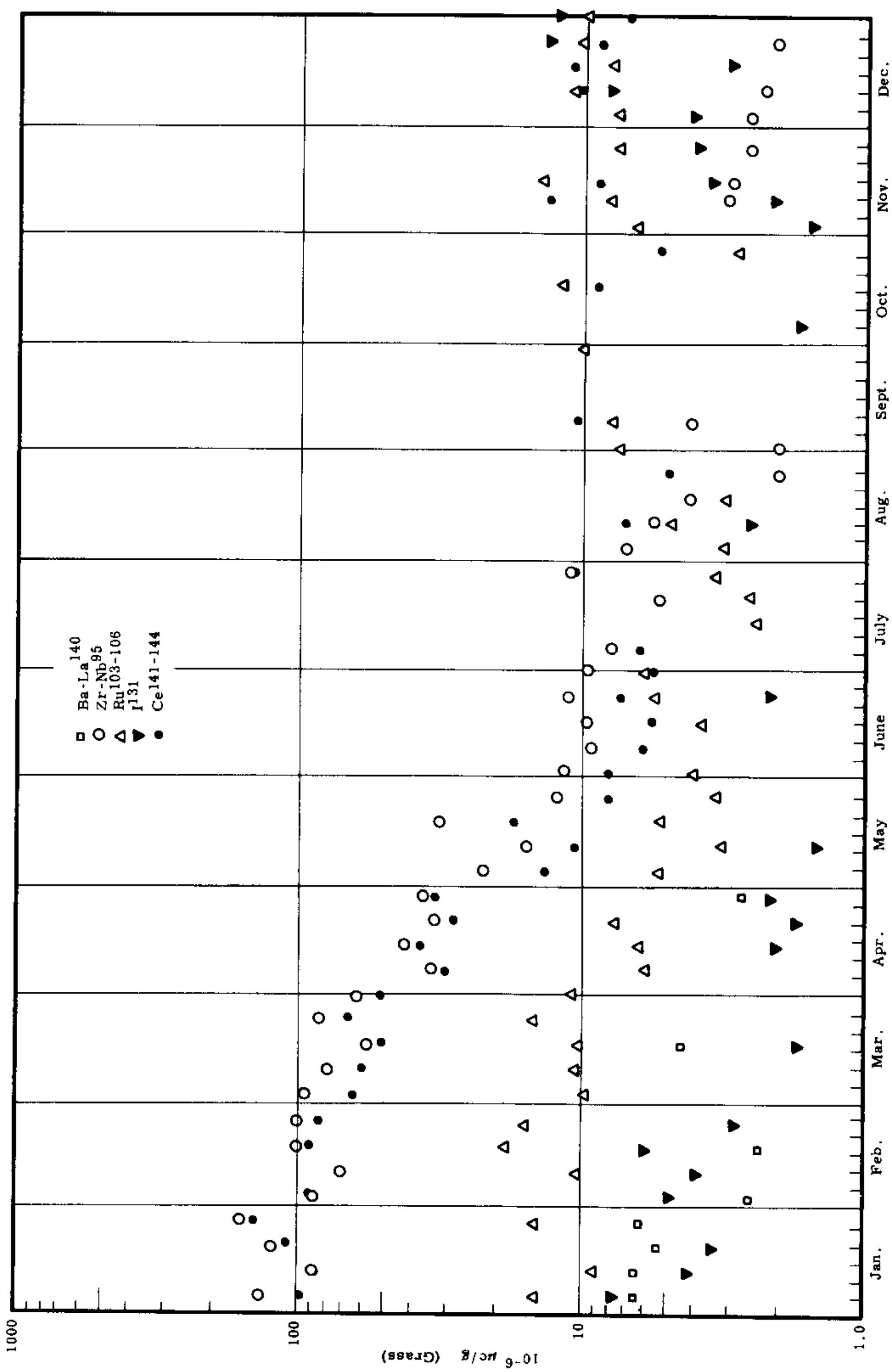


FIGURE 16

Radionuclide Concentration on Native Grasses - Zone C (1959)

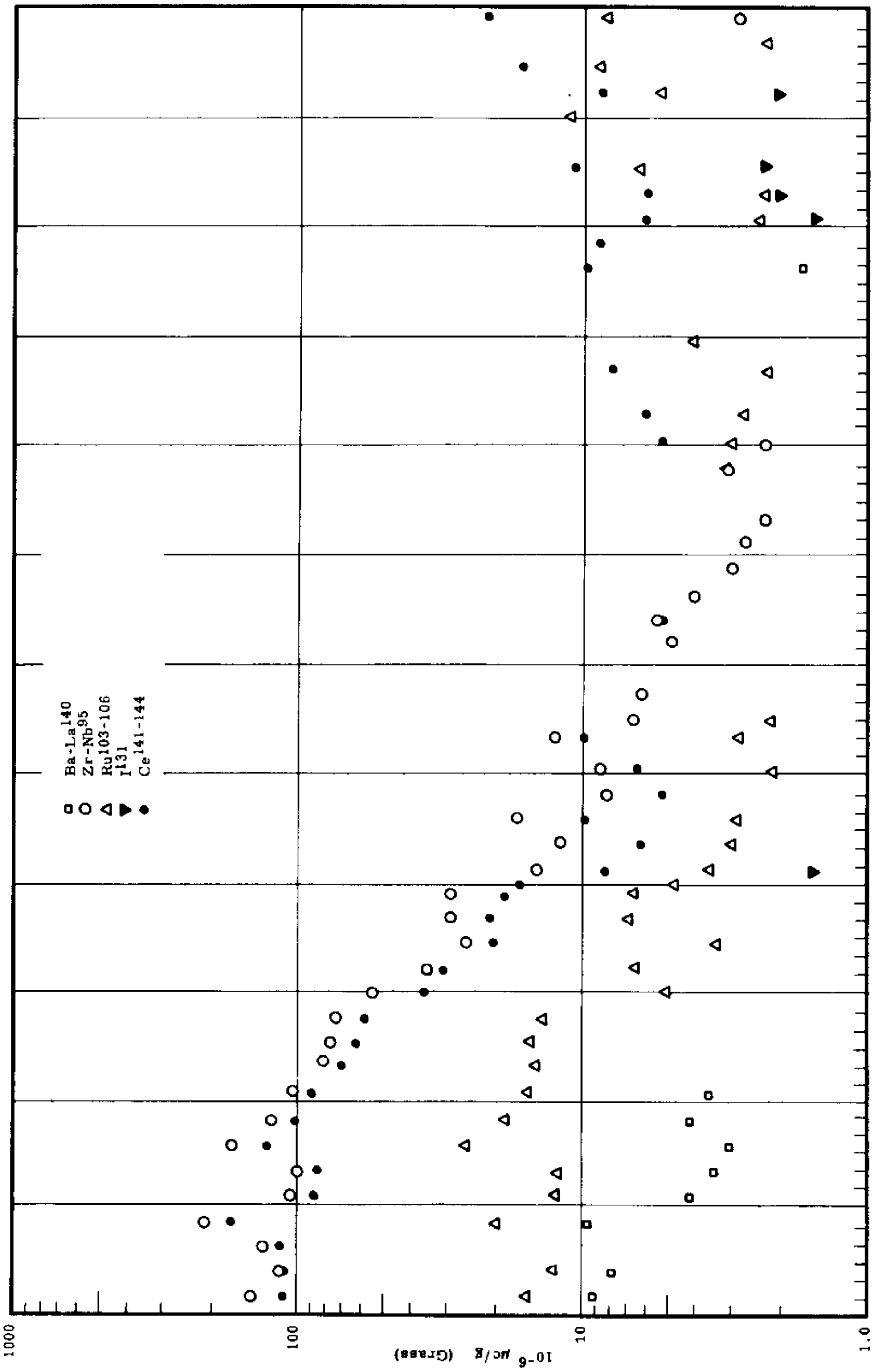


FIGURE 17

Radionuclide Concentration on Native Grasses - Zone O (1959)

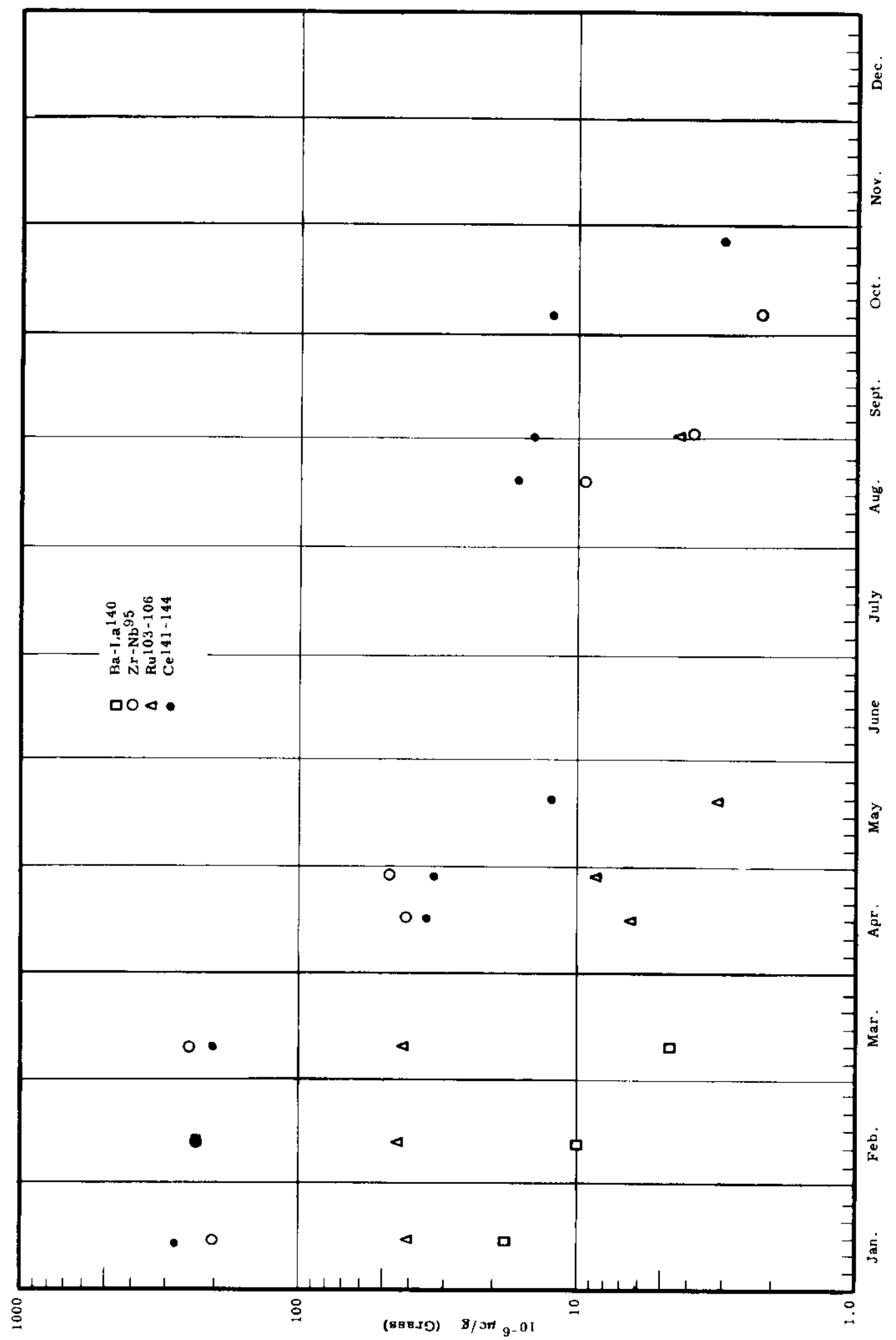


FIGURE 18

Radionuclide Concentration on Native Grasses - Spokane & Vicinity (1959)

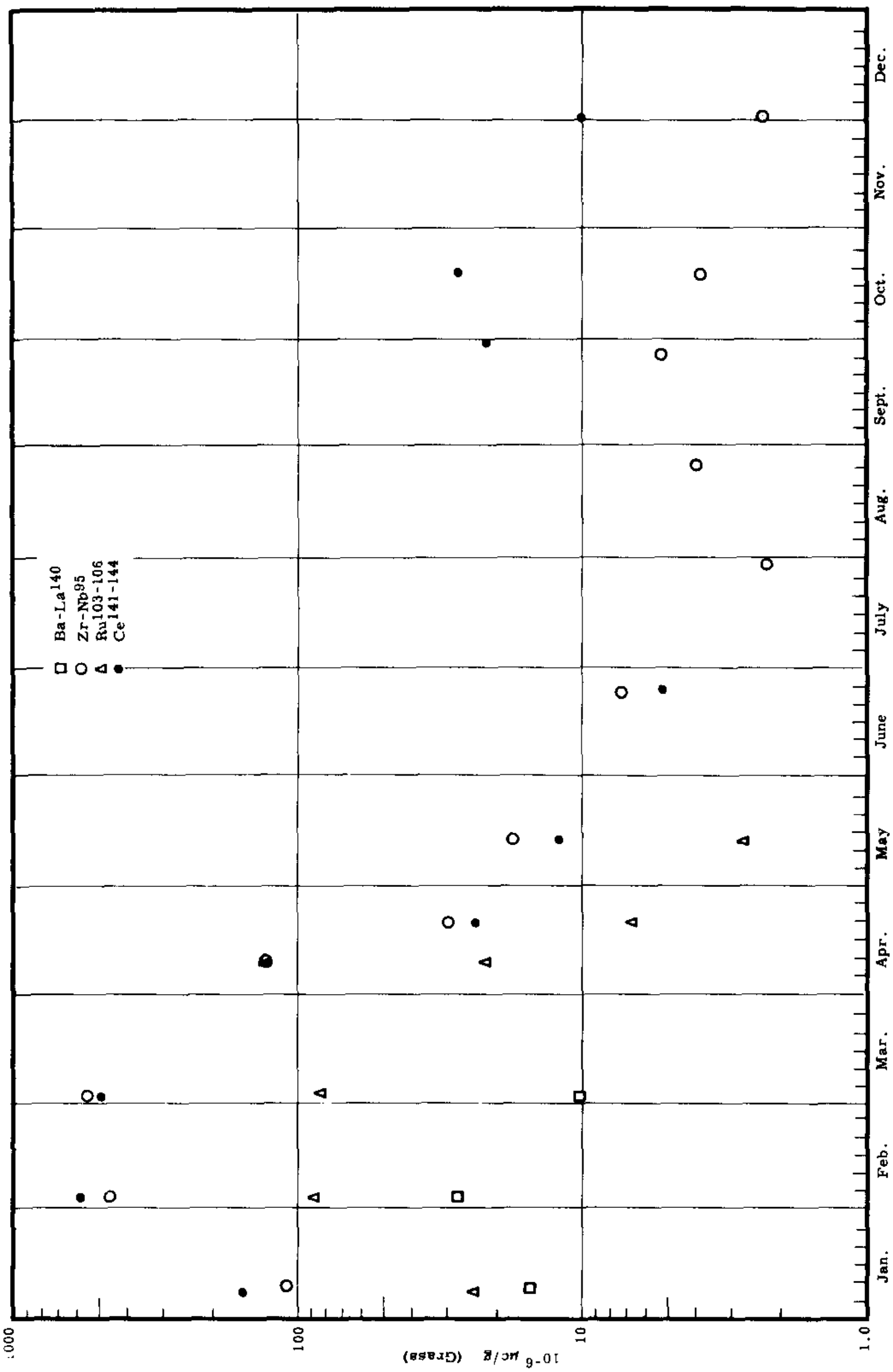


FIGURE 19

Radionuclide Concentration on Native Grasses - Portland & Vicinity (1959)

Figure 20 indicates that all sampling locations followed a similar trend throughout the year. Concentrations for Zr^{95}-Nb^{95} only are plotted because they were consistently abundant radionuclides.

Daily measurements of I^{131} emissions from chemical separations effluent stacks were made and are reported in Appendix C-21. In addition, all samples of native vegetation were analyzed for I^{131}. The criterion for release of I^{131} is based on uptake by vegetation and the subsequent ingestion by range animals as well as humans,[(18)] rather than the breathing air MPC recommended by the NCRP. The control limit derived in the reference is 1×10^{-5} $\mu c/g$ of vegetation. Since this control is based upon chronic ingestion, concentrations in excess of this limit for short periods of time are relatively unimportant and do not necessarily indicate excessive exposure.

During the year there was no indication that I^{131} concentrations in vegetation exceeded the control limit of 1×10^{-5} μc I^{131}/g in any off-site location and only rarely did the vegetation concentration exceed this level in zones within the Plant boundary. In Figure 21, the vegetation results are shown for the zone immediately surrounding one of the stacks. In this figure, the daily stack emission data have been summed, corrected for half-life, and plotted as "quantity available" according to the following equation:

$$C_o = \sum_{0}^{N} a_t \, e^{-\lambda t}$$

where: C_o = total quantity I^{131} available on the day of interest.

t = time in days previous to the day of interest.

a_t = the daily I^{131} emission on the t^{th} day previous to the day of interest.

λ = disintegration constant for I^{131} = 0.0845/day.

N = earliest previous day considered, 1 November 1958 in this case.

NOTE: Because of the relatively short half-life of I^{131}, it is not necessary to consider the amount emitted per day for more than about the 45th

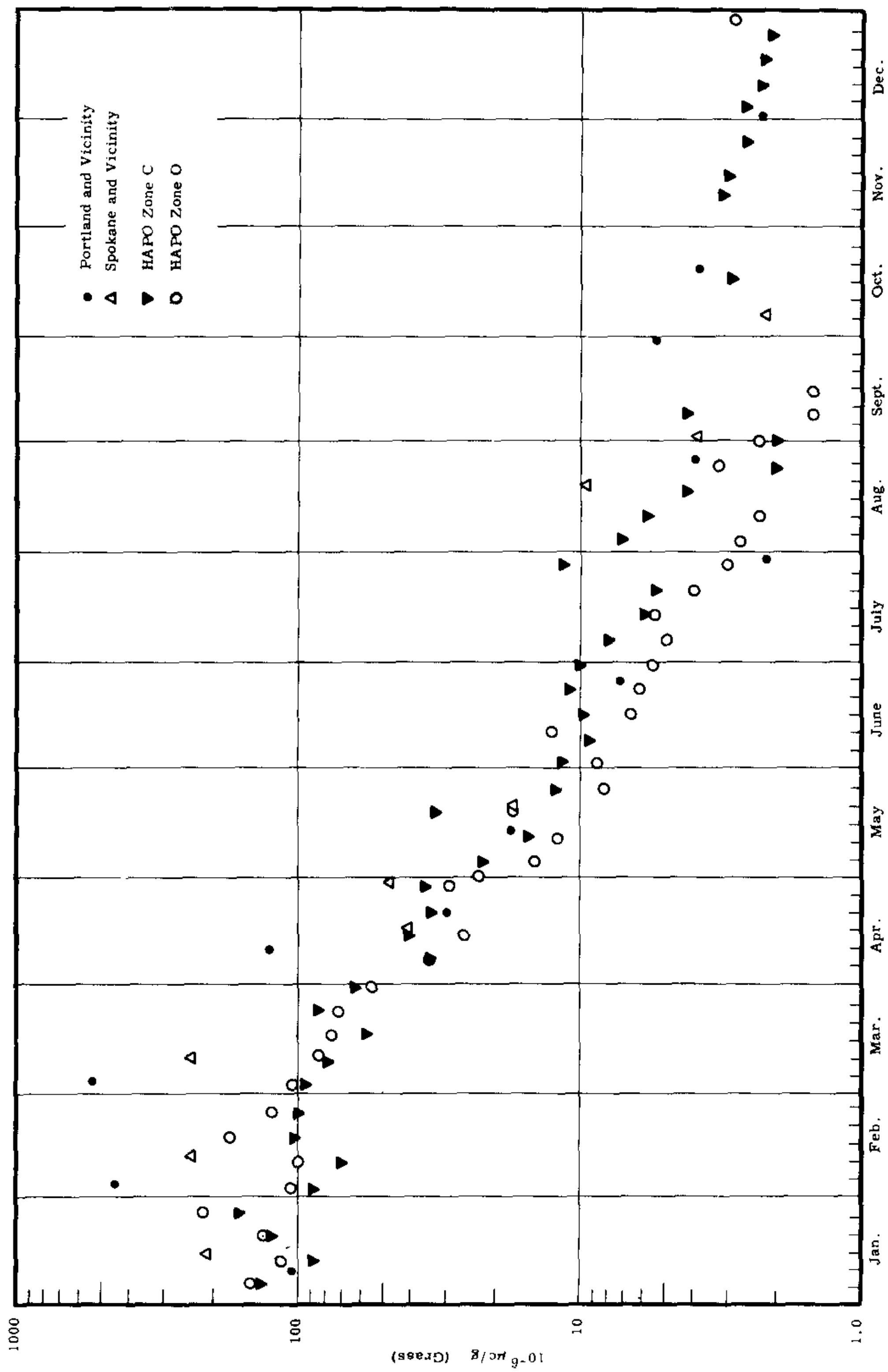


FIGURE 20

Zr^{95}-Nb^{95} Concentration on Native Grasses at Selected Sites (1959)

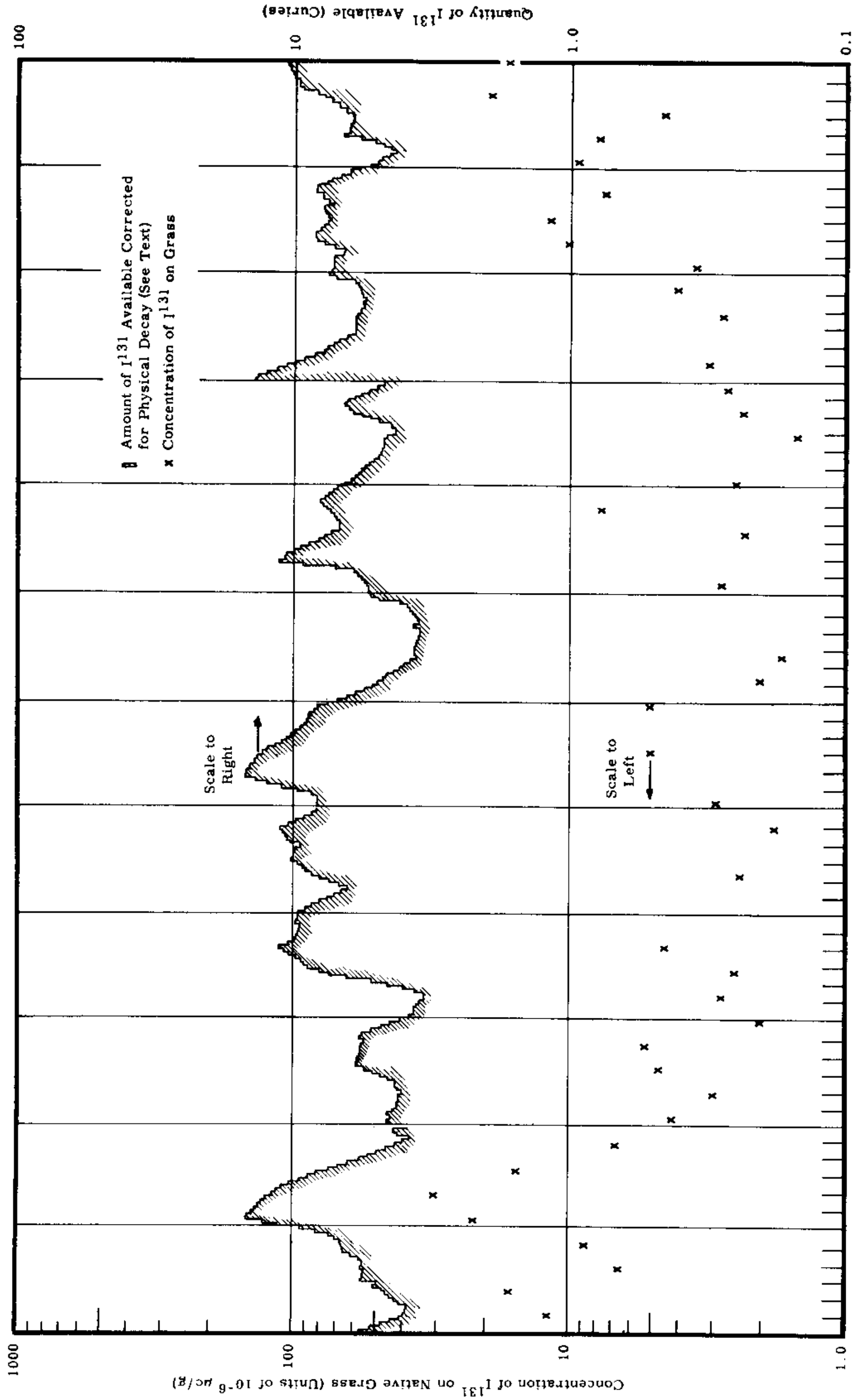


FIGURE 21

Comparison of I^{131} Deposition on Grasses with I^{131} Emitted in the Vicinity of a Separations Facility - 1959 previous day. However, the above equation is mathematically convenient in that the total I^{131} available from any previous day needs only to be decayed by one day and the current day's emission added to arrive at the current amount of I^{131} available.

Figure 21 indicates a tendency for grass concentrations to follow the "quantity I^{131} available" plot; however, the efficiency of "collection" of I^{131} by grass appeared to be considerably less in the summer than in the winter months.

The concentration of I^{131} in jack rabbit thyroids (Appendix C-22) followed the same pattern as the vegetation concentrations. Figure 22 compares the average jack rabbit thyroid concentrations with the average vegetation concentrations. The jack rabbits were obtained from three locations, and the data are plotted for each location. The vegetation concentration is the average concentration between dates for the area in the near vicinity of the two separations facilities' stacks. The quantity of I^{131} available was determined from the daily stack emissions; corrected for physical decay as described previously. The anomaly in thyroid and grass concentration values for October and November may be due to change in the rate of the jack rabbit's metabolism.[19]

C. Concentration of Radionuclides in Farm Products

The two farming areas located nearest downstream of the Hanford plant which use Columbia River water for irrigation are the Ringold farms and the Riverview Irrigation District. These farming areas are located about 15 and 30 miles downstream, respectively, from the nearest reactor. The farms in both areas are relatively small and so diversified that their harvests contribute only a small fraction of produce consumed in nearby communities. However, their locations with respect to the reactors should result in the maximum concentrations of radionuclides in produce for those radionuclides associated with irrigation water.

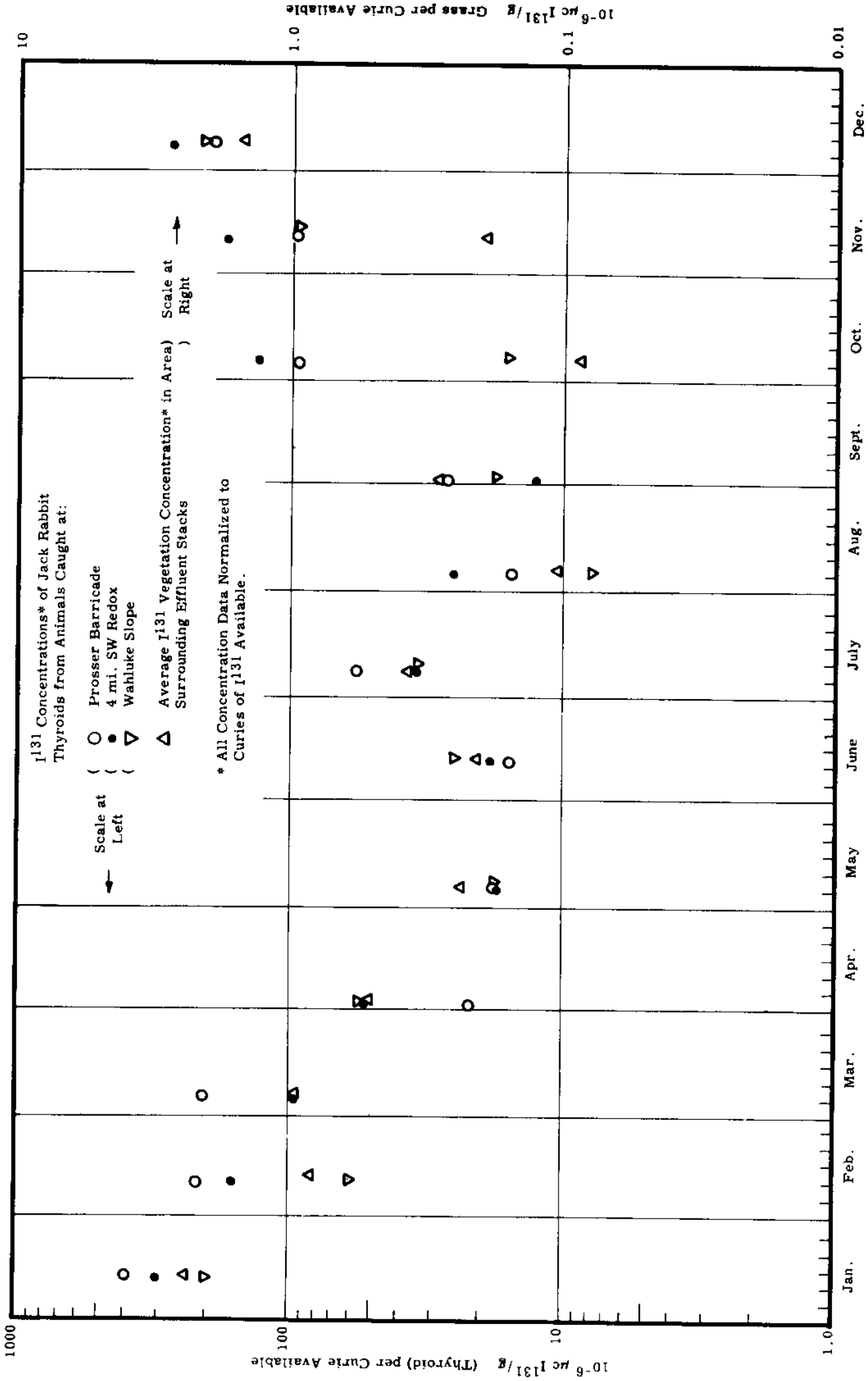


FIGURE 22

Comparison of Average I^{131} Concentrations - Jack Rabbit Thyroids and Native Grasses (1959)

The wind direction near Hanford's Separation Facilities is predominately from the northwest. Ringold is about 20 miles east and Riverview about 30 miles southeast of the chemical separations facilities, and hence are also subject to air-borne effluents. Therefore, sampling of produce was established for two additional localities which are subject to air-borne effluents but not to reactor effluent water. One location is about 20 miles south of the separations area in the vicinity of Benton City, Washington. The second location is about 40 miles southeast of the plant in the vicinity of Finley, Washington. The Yakima River is the source of irrigation water for both locations. These locations and other features of the Hanford environs are shown in Figure 1.

The foodstuffs sampled and analyzed have been categorized as to grain, vegetables, fruits, alfalfa, milk, and miscellaneous. The choice of categories and selection of samples was based on crop availability, importance to human diet, and the possibility of an unusual affinity for a particular radionuclide. For the most part, these foodstuffs were freshly harvested and were analyzed within a few days after acquisition. There was no culinary treatment given to the samples in preparation for analysis, although some depletion of radioactive contamination during washing, peeling, etc., might be expected if the produce was being prepared for human consumption.

Milk sampling consisted of samples from Ringold, Riverview and from all commercially available milk in the Richland-Pasco-Kennewick area.

Multichannel gamma energy spectrometry was used to analyze the samples for the following radionuclides: K^{40}, Sc^{46}, Cr^{51}, Zn^{65}, Zr^{95}-Nb^{95}, $Ru^{103+106}$, I^{131}, Cs^{137}, $Ce^{141+144}$. Analysis for P^{32}, Sr^{89} and Sr^{90} was accomplished through radiochemical separation and beta counting, as described in Appendix A.

The preceding radionuclides are not all of those potentially present in foodstuffs but are those which are either anticipated from Hanford's waste releases or fallout and are radiologically significant.

In tabulating the data, reference is often made to reporting limits. These reporting limits reflect some of the uncertainties of gamma energy spectra measurement of a radionuclide in the presence of other gamma emitters. Thus the reporting limit is generally higher for any particular radionuclide than the detection limit would be if the radionuclide were the only one present. The reporting limits bear no uniform mathematical relationship with detection limits but have been established through experience.

Concentrations in Milk

Small amounts of Zn^{65} occurred in milk originating from areas irrigated with Columbia River water. The concentrations of Zn^{65} found in milk are given in Appendix D-1 and summarized in Table VI.

TABLE VI

AVERAGE CONCENTRATIONS OF Zn^{65} IN MILK

Location	Number of Samples	Concentration (Units of 10^{-6} μc Zn^{65}/g)
Ringold	1	0.42
Riverview 1	10	< 0.05
Riverview 2	3	0.53
Riverview 3	12	1.9

The variability of occurrence of Zn^{65} in milk on land irrigated with river water, as indicated by Table VI, may be influenced by the manner of irrigation of the animal's grazing food. Another possibility is the origin of the animal's drinking water which may be directly from the irrigation ditch or from a well.

Table VII shows the concentration of Zn^{65} in milk over several months from a representative area and indicates little variability with season.

TABLE VII

Zn^{65} IN MILK DURING THE SUMMER AND FALL OF 1959[17]

Riverview Irrigation District, Pasco, Washington
Location 3

Date	10^{-6} $\mu c/cc$
July 16	1.6
July 22	1.7
July 29	1.8
August 12	2.3
August 19	2.0
August 28	1.8
September 1	2.2
September 9	2.3
September 30	2.6
October 19	1.2
October 21	1.7
October 28	2.0
AVERAGE	1.93

In addition to sampling milk from local farms, milk purchased in local commercial establishments was sampled and analyzed. These results are reported in Appendix D-1 and compared with locally obtained milk in Table VIII. Small amounts of Cs^{137}, Sr^{89}, and Sr^{90} were present in most milk samples.

TABLE VIII

AVERAGE CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN MILK

(Units of 10^{-6} $\mu c/g$)

	No. Samples Analyzed for:	Cs^{137}	No. Samples Analyzed for:	Sr^{89}	Sr^{90}
Reporting Limits		0.02		0.004	0.002
Riverview 1	10	0.044	9	0.022	0.0032
Riverview 2	3	0.025	2	0.0087	0.0036
Ringold 1	1	<0.02	1	0.0060	0.0020
Commercial A	12	0.029	7	0.0098	0.0032
Commercial B	5	0.033	1	0.0087	0.0032
Commercial C	6	0.027	4	0.0048	0.0030
Commercial D	4	0.028	3	0.0071	0.0035
Commercial E	3	0.038	2	0.021	0.0046
Commercial F	5	<0.020	2	0.010	0.0013
Commercial G	6	0.028	5	0.0079	0.0034
Commercial H	9	0.067	6	0.024	0.0087

In both local and commercial milk samples many of the radionuclides other than Cs^{137} did not appear in concentrations above their respective reporting limits as shown in Appendix D-1. Such radionuclides were: Sc^{46}, Cr^{51}, Zn^{65}, Zr^{95}-Nb^{95}, $Ru^{103+106}$, I^{131}, and $Ce^{141+144}$.

With the exception of commercial brand H, the concentrations of Cs^{137}, Sr^{89} and Sr^{90} appear quite comparable. Commercial milk H is known to include milk imported from western Washington. The higher values observed for milk H are consistent with the assumptions; the origin of these radionuclides is debris from nuclear detonations, and increased rainfall increases the amount of these radionuclides on vegetation.

The absence of detectable quantities of Zn^{65} in commercial milk as indicated by the data in Appendix D-1 is probably due to the small fraction of milk contributed by the local farms to the total commercial milk supply.

Concentrations in Fresh Farm Produce

Phosphorus-32, Sc^{46}, Cr^{51} and Zn^{65} are predominately reactor effluent radionuclides and as such would be expected to appear in produce from downstream farms irrigated with Columbia River water. However, the analyses performed and reported in Appendices D-3 through D-6 did not exclude the measurement of radionuclides from other sources.

Average concentrations of Zn^{65} and Cr^{51} in produce are summarized in Tables IX and X, respectively.

TABLE IX

AVERAGE CONCENTRATIONS OF Zn^{65} IN PRODUCE AT VARIOUS LOCATIONS

(Units of 10^{-6} $\mu c/g$)

	Riverview	Ringold	Benton City	Finley
Grain	1.5	2.6	< 0.1	< 0.1
Vegetables	0.18	0.50	0.12	< 0.1
Fruit	0.13	<0.1	< 0.1	< 0.1
Alfalfa	1.3	0.68	< 0.1	< 0.1

TABLE X

AVERAGE CONCENTRATIONS OF Cr^{51} IN PRODUCE AT VARIOUS LOCATIONS

(Units of 10^{-6} $\mu c/g$)

	Riverview	Ringold	Benton City	Finley
Grain	0.7	<0.5	< 0.5	< 0.5
Vegetables	0.53	0.62	< 0.5	< 0.5
Fruit	0.66	<0.5	< 0.5	< 0.5
Alfalfa	6.6	3.4	0.64	0.58

Differences observed in results for similar kinds of produce from farms within the same district were theorized to be due to the method of irrigation. Table XI summarizes the results obtained for produce grown under the two general methods of irrigation.

TABLE XI

COMPARISON OF Zn^{65} IN PRODUCE BETWEEN DIFFERENT MODES OF IRRIGATION(17)

(Units of 10^{-6} $\mu c/g$)

Sample	Sprinkler Irrigated	Ditch Irrigated
Alfalfa	8.9	0.88
Corn	1.4	1.6
Green Beans	1.3	0.10
Carrots	0.36	0.17
Tomatoes	0.36	0.035
Cabbage	0.18	0.28
Irrigation Water	0.072	0.070

Table XII compares the occurrences of Zn^{65} and Cr^{51} in the Riverview district for several kinds of produces.

TABLE XII

COMPARISON OF Cr^{51} AND Zn^{65} IN FARM PRODUCE (17)

(10^{-6} $\mu c/g$)

Sample	Cr^{51}	Zn^{65}
Red Beets*	0.13	0.16
Wheat*	0.79	4.0
Carrots*	0.29	0.17
Pasture Grass*	8.0	36.0

TABLE XII (Contd.)

Sample	Cr^{51}	Zn^{65}
Hamburger**	<0.22	4.5
Milk**	<0.22	1.9
Cabbage***	0.76	0.18
Lettuce***	1.2	0.44
Boysenberries***	0.66	0.29
Pasture Grass***	6.9	3.9
Carrots***	1.0	0.36
Grapes***	0.86	0.18
Tomatoes***	0.82	0.36
Soil*** (to depth of two inches)	38.0	5.6
Irrigation Water	3.2	0.068

* Irrigated by ditch, or by flooding in the case of pasture grass and wheat.
** From cattle raised on sprinkler-irrigated pasture.
*** Sprinkler-irrigated.

Scandium-46 concentration in alfalfa from Riverview and Ringold districts averaged about 1.5×10^{-7} μc Sc^{46}/g and was less than 1×10^{-7} μc/g for other locations. Scandium-46 concentrations in other kinds of produce were also less than 1×10^{-7} μc/g.

The radionuclides; Sr^{89}, Sr^{90}, Zr^{95}-Nb^{95}, $Ru^{103+106}$, I^{131}, Cs^{137}, and $Ce^{141+144}$, result primarily from air-borne effluents, although they do exist in small amounts in the Columbia River water. The occurrences of these radionuclides are summarized by locality and particular kind of produce in Tables XIII through XVI.

TABLE XIII

AVERAGE CONCENTRATIONS OF SEVERAL RADIONUCLIDES AT VARIOUS LOCATIONS FOR GRAIN

(Units of 10^{-6} $\mu c/g$)

	Riverview	Ringold	Benton City	Finley
Sr^{89}	0.026	0.052	0.023	<0.01
Sr^{90}	0.012	<0.006	0.020	<0.006
Zr^{95}-Nb^{95}	0.33	0.52	0.33	0.15
$Ru^{103+106}$	0.60	0.77	<0.5	<0.5
I^{131}	<0.7	<0.7	<0.7	<0.7
Cs^{137}	<0.05	0.083	0.057	0.059
$Ce^{141+144}$	1.1	0.95	0.62	0.63

TABLE XIV

AVERAGE CONCENTRATIONS OF SEVERAL RADIONUCLIDES AT VARIOUS LOCATIONS FOR VEGETABLES

(Units of 10^{-6} $\mu c/g$)

	Riverview	Ringold	Benton City	Finley
Sr^{89}	0.014	<0.01	<0.01	0.013
Sr^{90}	0.0093	<0.006	0.0063	0.0094
Zr^{95}-Nb^{95}	0.1	<0.1	<0.1	0.12
$Ru^{103+106}$	<0.5	0.51	<0.5	<0.5
I^{131}	<0.1	0.18	<0.1	<0.1
Cs^{137}	0.052	<0.05	<0.05	<0.05
$Ce^{141+144}$	0.53	0.62	<0.5	<0.5

TABLE XV

AVERAGE CONCENTRATIONS OF SEVERAL RADIONUCLIDES AT VARIOUS LOCATIONS FOR FRUIT

(Units of 10^{-6} $\mu c/g$)

	Riverview	Ringold	Benton City	Finley
Sr^{89}	0.61	0.63	0.011	<0.01
Sr^{90}	0.0061	0.0074	0.0074	<0.006
$Zr^{95}-Nb^{95}$	0.12	<0.1	<0.1	0.14
$Ru^{103+106}$	<0.5	0.63	<0.5	<0.5
I^{131}	<0.1	<0.1	<0.1	0.11
Cs^{137}	<0.05	<0.05	<0.05	0.57
$Ce^{141+144}$	0.61	0.63	0.5	0.61

TABLE XVI

AVERAGE CONCENTRATIONS OF SEVERAL RADIONUCLIDES AT VARIOUS LOCATIONS FOR ALFALFA

(Units of 10^{-6} $\mu c/g$)

	Riverview	Ringold	Benton City	Finley
Sr^{89}	0.081	0.062	0.10	0.034
Sr^{90}	0.022	0.009	0.073	0.069
$Zr^{95}-Nb^{95}$	1.5	0.17	1.7	0.4
$Ru^{103+106}$	0.97	0.82	1.0	1.4
I^{131}	0.17	0.25	0.16	0.52
Cs^{137}	0.14	0.088	0.14	0.23
$Ce^{141+144}$	2.6	1.3	2.4	2.7

As evidenced in Tables 13 through 16, the concentrations of radionuclides in the several kinds of produce were quite erratic. Therefore, it is difficult to distinguish between the quantity of these radionuclides originating from releases from process stacks and those originating from reactor cooling water.

Radionuclides in Miscellaneous Foodstuffs

Four samples of ground beef were purchased from local markets and analyzed for the same radionuclides discussed in the vegetable produce samples. In addition to naturally-occurring K^{40}, the meat was found to contain a concentration of about 3×10^{-7} μc Zr^{95}-Nb^{95}/g. In one sample only, a Cs^{137} concentration of about 6×10^{-8} $\mu c/g$ was measured.

Five commercially canned baby food samples were collected and analyzed. Cesium-137 was the predominant radionuclide with a concentration of about 1×10^{-7} $\mu c/g$ in meats. The Cs^{137} concentration was less than 5×10^{-8} $\mu c/g$ in the canned vegetables.

Four samples of condensed or evaporated milk were purchased and analyzed. Cesium-137 ranged from 4.1×10^{-8} to 1.7×10^{-7} $\mu c/g$. One sample indicated $Ce^{141+144}$ was present in the amount of 4.6×10^{-6} $\mu c/g$.

Eleven samples of dry or powdered milk were analyzed. These samples covered five different brands. The sampling period was during the last quarter of 1959. The predominant radionuclide was again Cs^{137} which was present in similar amounts for all samples. The average concentration was about 4.4×10^{-7} μc Cs^{137}/g. In one sample, the $Ce^{141+144}$ concentration was 1.9×10^{-6} $\mu c/g$.

In all of the above miscellaneous foodstuffs, analysis for Sr^{90} and Sr^{89} was not completed.

IV. ESTIMATE OF RADIATION EXPOSURE - NONOCCUPATIONAL

Persons living in the neighborhood of the Hanford facilities receive radiation exposure from radionuclides through several paths of intake and from external radiations. In many cases it is not possible to differentiate the origins of radiation exposure among Plant operation, fallout from nuclear detonations, and natural background. However, multiple sources and paths of intake must be jointly considered in the estimate of radiation exposure.

There is a general lack of detailed information on variation of dietary habits of individuals within a population group. Because of this and other uncertainties, the radiation exposure to persons in the neighborhood of a controlled area cannot be stated precisely; although direct measurement of body burdens by whole body monitoring techniques promises improvement of the situation for some radionuclides in the future. Nevertheless, it is desirable to estimate the magnitude of exposure to man based on the data included in this report.

In summing radiation exposure from the various sources, the criteria used are those recommended by the NCRP(5) for persons in the neighborhood of controlled areas.

The calculations include the recommended practice of using one-tenth of the continuous occupational limits for persons in the neighborhood of a controlled area. In addition to the assumptions inherent in the derivation of maximum permissible limits, several additional assumptions have been made as follows:

1. The persons considered resided in Pasco and obtained drinking water from the city system, used the Columbia River for swimming and boating, obtained milk from commercial sources, obtained produce from Riverview Irrigation District, consumed oysters from Willapa Bay, and obtained fish and ducks from the Columbia River downstream of the project.

2. The continuous consumption rate of foods in kg/week consisted of: milk 6, vegetables 3, fruit 3, cereal grains 1.5, oysters 0.1 and whitefish or ducks 0.1.

3. The metabolic uptake of radionuclides ingested with foodstuffs is comparable to the uptake through drinking water.

4. For foodstuffs, and where the organ of interest is the GI tract, the more restrictive limit for the radionuclide, that is soluble or insoluble form, is used to estimate the dose to the GI tract.

5. Where two radionuclides are not routinely differentiated analytically, e.g., Zr^{95}-Nb^{95}, all of the radioactive material is assumed to be the radionuclide with the more restrictive limit.

6. Radionuclides present in drinking water are soluble in body fluids.

For the purpose of this estimate, consideration was given to the consumption of varying amounts of foods as compared to the rate of water intake as used by the NCRP. It is, therefore, convenient to define the maximum permissible rate of intake (MPRI) as the maximum permissible concentration in water (MPC_w) times the rate of water intake, as defined for the standard man.

The radiation exposure of the gastrointestinal tract reaches equilibrium promptly with the intake of radionuclides under condition of chronic exposure. The recommended annual limit for GI tract dose is 1500 mrem for persons in the vicinity of controlled areas. The particular mixture of radionuclides present in the sanitary water at Pasco, as indicated by the 1959 data, results in a calculated average of ~5 per cent of the MPC_w for the GI tract or a corresponding dose of ~75 mrem per year. About 40 per cent of the GI tract dose from drinking water is from As^{76}, another 40 per cent from Np^{239}, and the balance distributed among several radionuclides as illustrated previously in Figure 6.

The consumption of various foodstuffs adds to the dose to the GI tract, in mrem /yr, approximately as follows: milk 10-60, vegetables 15, fruit 15, cereal grains 25, oysters 10 and whitefish or ducks 45. Many measurements of radionuclides in milk were less than reporting limits, therefore the range given reflects alternate use of zero and reporting limit concentrations. For all other measurements the ranges are small and representative values are used. The total exposure to the GI tract from sanitary water and locally grown foodstuffs amounted to about 250 mrem/yr.*

The dose to bone does not necessarily reach equilibrium promptly with the rate of ingestion of radionuclides. Therefore, the total fraction of the MPRI for those radionuclides which contribute to the dose to organs other than the GI tract is perhaps more illustrative than the estimated dose.

The Pasco drinking water provided < 1 per cent of the MPRI for bone, mostly from P^{32} and Sr^{90}. Milk provided another 1.5 per cent, vegetables 1.5 per cent, fruit 1 per cent, cereal grains 1 per cent, oysters < 0.5 per cent and whitefish or ducks < 5 per cent. Sr^{90} is the radionuclide of major interest in all of the foregoing foodstuffs, except fish and waterfowl taken locally from the Columbia River, in which case P^{32} is of major concern. The percentage MPRI for bone, including all paths of intake assumed in the illustration, was ~10 per cent.

Again using the percent MPRI for radionuclides which contribute to total body exposure, a total of ~5 per cent was obtained. The distribution among the paths of intake was < 0.5 per cent from Pasco sanitary water, ~0.5 per cent from milk, ~0.5 per cent from vegetables, ~0.5 per cent from fruit, ~0.5 per cent from cereal grains, < 0.5 per cent from oysters and ~ 3 per cent from whitefish or ducks.

The whole body penetrating radiation exposure from external sources of Hanford origin was estimated at 6 mr/year from swimming 240 hours in the Columbia River (or from twice that number of hours of boating). Such exposure is ~1 per cent of the applicable maximum permissible limit. There may have been a small contribution to the thyroid dose as a result of I^{131} intake, primarily from foodstuffs. This is estimated to have been < 150 mrem per year.

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* Since this estimate is based on a Pasco resident ingesting locally grown foodstuffs, the average exposure to all persons in the neighboring communities of the Hanford controlled area is less than 250 mrem/yr.

The preceding estimates fit within the framework of variation of individual dietary habits and other uncertainties. However, it is not intended that they represent boundary conditions. By comparison with relevant permissible limits for persons in the vicinity of controlled areas, the situation for Hanford during 1959 remained substantially as stated by H. M. Parker during recent Congressional Hearings.

> "In summary, for man in the Hanford environs, the GI tract dose is generally the highest organ dose. Expressed as percentage of the corresponding permissible limits, GI tract dose, bone dose, and reproductive-organ dose rank about equally. The estimated representative contribution in each case is in the range of 3 per cent to 15 per cent of the limit. The corresponding maxima for exceptional cases where unusual amounts of local fish and leafy vegetables are eaten seem to be contained within the general range of say 40 per cent to 60 per cent of the limits."

V. ACKNOWLEDGEMENTS

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The cooperation and provision of information by the United States Geological Survey Records Center, Portland, Oregon; the Pasco, Washington, City Water Department and the several state and federal agencies who operated air filter sample stations contributed substantially to the report.

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APPENDIX A

ANALYTICAL METHODS

1. Water Analyses*

All water samples are analyzed for alpha emitters, beta emitters, and selected radionuclides. Alpha emitters are extracted with diethyl ether from 9 N nitric acid. The gross alpha activity is measured with an alpha scintillation counter. Gross beta activity is determined by evaporating a sample to dryness and counting the residual salts on a gas-flow proportional beta counter.

Rare earths plus yttrium, silicon-31, iodine-131, phosphorous-32, strontium-89 and strontium- 90 are measured by beta counting after chemical separation. The rare earths are isolated as a group by hydroxide, fluoride, and oxalate precipitations; silicon is precipitated as the dioxide; iodine is isolated by carbon tetrachloride extraction and precipitation as silver iodide; phosphorous by extraction of phosphomolybdic acid with butanol in diethyl ether; and strontium by successive precipitation of the nitrate and the carbonate. Yttrium-90, separated from the strontium after secular equilibrium is established, is measured to determine strontium-90. Beta decay curves are extrapolated to sampling time to determine the initial activity levels and to check separation effectiveness.

Manganese-56, zinc-69 and gallium-72 are determined by measurement of their characteristic gamma peaks with a milti-channel gamma energy spectrometer using a 3 inch x 3 inch thallium-activated sodium iodide (NaI(Th)) scintillation crystal detector. The measurements are made after the following chemical separations; manganese by precipitation as the dioxide, zinc by precipitation as the phosphate and ion exchange purification, and gallium by extraction with iso-propyl ether and precipitation as the

* L. F. Lust. Radiological Chemical Analysis Operation, General Electric Company, HAPO, Private Communication.

hydroxide. Sodium-24, neptunium-239, chromium-51 and cobalt-60 are also determined using a multi-channel gamma energy spectrometer, but are determined from a direct count of residual salts from the evaporated sample, without chemical separations. However, it may be necessary to chemically separate neptunium-239 and cobalt-60 for samples with low concentrations.

Copper-64 is determined from gamma-coincidence counting measurements of the annihilation photons produced by positron emission. Scandium-46 is measured by gamma-coincidence counting of the 0.885 Mev and 1.12 Mev photons.

Arsenic-76 is determined from the counting rate of its 2.97 Mev beta. Particles of lower energy from other beta emitters are shielded out by use of a 504 mg/cm^2 absorber.

Uranium concentrations are determined with a fluorophotometer, using standard techniques.

2. Vegetation and Produce Analyses*

Samples of native grasses (vegetation samples) are collected routinely and analyzed with a multi-channel gamma energy spectrometer for selected radionuclides. The spectrometer utilizes the 3 inch x 3 inch NaI(Th) scintillation crystal used in analyzing water samples. These analyses are conducted for 150 gram samples which have been shredded and placed in a 9-ounce glass jar. Background analysis includes the effects of the jar glass which contains minute amounts of radioactivity. There is no ashing or chemical separation performed on vegetation samples.

Farm products, including milk, are analyzed for several radionuclides including those measured in vegetation samples. Since farm produce represents a more direct means of exposure to man and because of the relatively short growing season, more sensitivity in the analytical method is desired.

* L. S. Kellogg. Radiological Chemical Analysis Operation, General Electric Company, HAPO. Private Communication.

and the phosphorous is precipitated as magnesium ammonium phosphate. After dissolving the precipitate in hydrochloric acid, ammonium citrate is again added and phosphorous is reprecipitated as magnesium ammonium phosphate.

The precipitate is dried in a 1½-inch stainless steel counting dish under heat lamps and counted over a period of two weeks in a gas-flow, proportional beta counter.

3. Air Sample Analyses*

Air-borne concentrations of radioactive materials and radiation dosage rates are measured by equipment located in 31 atmospheric monitoring stations, and by portable ionization chambers placed at selected field locations. Twenty-seven of the monitoring stations are within project territory, while the remainder are situated in the four perimeter towns located south and southeast of the project.

Iodine-131 scrubber samplers are operated in twelve of the monitoring stations concentrated around the separations plants. These samplers consist of a calibrated, electrically-driven vacuum pump which draws 2.0 cfm (3.4 m^3/hr) of air through one liter of 0.1 normal NaOH solution. A balancing platform and siphon arrangement permits introduction of distilled water into the scrubber at a rate equal to the rate of evaporation. This water feeder helps maintain constant liquid head, air flow rate, and scrubber efficiency.

After one week of operation, the scrubber bottle is replaced and taken to the radiochemical analysis laboratory for determination of the iodine-131 content. The analytical procedure used provides for the addition of an iodine carrier and $AgNO_3$ to the scrubber solution, followed by filtration of the resulting silver iodide precipitate. The radiation from the I^{131} on the filter is measured by an end-window GM tube connected to a scale-of-64 scaler. Atmospheric concentrations of I^{131} are then calculated

* Soldat, J. K. Monitoring for Air-Borne Radioactive Materials at Hanford Atomic Products Operation. Presented at the Air Pollution Control Association Meeting in Los Angeles, California, June 21-26, 1959. To be published.

Increased sensitivity is achieved by using a 9-inch diameter well-type NaI(Th) scintillation crystal as the detector of a multi-channel gamma energy spectrometer. In addition, the analysis includes a determination of the radiostrontium and radiophosphorous after chemical separation. The chemical separation for radiostrontium analysis is performed in the following manner:

500 g samples of produce and 1000 g samples of milk are first dehydrated and then ashed at 500-650 C from four to six hours. The ash is dissolved in nitric acid, barium and strontium carriers are added, and the alkaline earths are precipitated as carbonates. Calcium is removed by controlled nitrate precipitation of strontium as alkaline earth metals with fuming nitric acid, washing with acetone, dissolution and reprecipitation with fuming nitric acid. The rare earths are removed from an aqueous solution of the nitrates by a $Fe(OH)_3$ precipitation and barium is removed as the chromate. Strontium is precipitated as the carbonate and then dried in a one-inch stainless steel counting dish to constant weight. The strontium mixture is counted for one hour in a low background (anti-coincidence) gas-flow proportional beta counter.

Strontium-90 is allowed to reach secular equilibrium with its daughter, yttrium-90, which is then extracted with buffered TTA. Yttrium-90 is counted in the same manner as the strontium mixture. The strontium-90 content is calculated from the yttrium-90 counting rate, and the strontium-89 content from the difference in counting rates of total strontium and strontium-90.

The chemical separation for radiophosphorous is performed on samples of sufficient size to yield 40-50 mg of phosphorus.

The sample is wet ashed with nitric acid. Phosphorous is precipitated from the acid solution as ammonium phosphomolybdate. This precipitate is dissolved in ammonium hydroxide, ammonium citrate is added to complex most of the remaining interferring elements, from these counting rates by applying factors for counter calibration, chemical recovery of the I^{131}, scrubber efficiency and the volume of air sampled.

Measurements for concentrations of radioactive particulates in the atmosphere are made with 2 inch x 4 inch HV-70 filter paper. Twenty-four of these Motoaire filter samplers are operated within the project, four are operated in nearby towns, and nine others are located in remote locations scattered throughout the Pacific Northwest. The filters are changed on either a daily or a weekly schedule and then are autoradiographed using Eastman Kodak, Type-K, X-ray film. The filters are placed in direct contact with the film for one week, the filter is removed, and the film is developed. The developed film is viewed on a standard X-ray viewer and each image produced is counted as one radioactive particle. Air-borne concentrations of radioactive particles are calculated by dividing the number of images obtained per filter by the total volume (nominal 2.5 cfm) of air sampled.

External radiation dosage rates in the project environs result from radioactive materials suspended in the atmosphere, deposited on the ground, or in the river. Measurement of the low dosage rates encountered in the river is accomplished through the use of small portable ionization chambers and a novel chamber reader developed at Hanford.* Results from these chambers in use on land were seriously affected by the extreme temperatures encountered in this semi-arid region and therefore, are not reportable. The situation is currently under investigation.

4. Remarks on Units

Analytic results for concentrations are reported in $\mu c/g$ or in $\mu c/cc$ where the mass or volume refers to the sample material and not any particular chemical element. There are some results which cannot reasonably be reported in microcuries. This is due to either insufficient information regarding the particular radionuclides present in the sample and/or insufficient accuracy in the sampling method, i.e., the data reported in Appendix B-4, Alpha Emitters in Sanitary Water. Suitable isotopic analysis of the water

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* Roesch, W. C., R. C. McCall and F. L. Rising. A Pulse Reading Method for Condenser Ion Chambers. Health Physics Journal 1, No. 3, pp. 340-344. December, 1958.

samples could be made thereby enabling one to convert from disintegrations per second per cc to μc per cc. However, this would add considerably to the cost of analysis. The additional cost is not justified since the 1959 results, as represented by the data in Appendix B-4, are extremely small even when compared to the MPC for the most toxic alpha emitter. Therefore these data are more useful in observing trends rather than estimating exposure.

Data which are not reported in units of microcuries for the preceding reasons are contained in the following appendices:

Appendix	Title	Units
B-4	Alpha Emitters in Sanitary Water - 1959	α-d/s/cc
B-8	Beta Emitters in River Mud - 1959	β-d/s/g
B-9	Beta Emitters in Columbia River Water - 1959	β-d/s/cc
C-2	Average Beta Activity on Filters from Selected Northwest U. S. Sampling Stations - 1959	β-d/s/cc

APPENDIX B-1

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN SANITARY WATER AT PASCO, WASHINGTON - 1959

10^{-9} μc/cc

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	As^{76}	Sr^{89} + Sr^{90}	Sr^{90}	Np^{239}	Zn^{69m}
1-6-59	7.5	57	21	7,100	30	80	45	7.0	<0.68	4,600	NA
1-13-59	8.2	640	21	11,000	240	140	320	7.9	0.71	4,000	NA
1-20-59	15	610	15	4,900	250	13	900	4.9	<0.50	1,600	<10
1-27-59	<6.8	670	12	5,300	180	110	140	5.9	<0.50	2,400	<10
2-3-59	13	780	21	5,800	280	160	270	5.9	<0.75	2,700	16
2-10-59	9.4	400	37	5,400	120	52	180	Lost	Lost	1,800	<10
2-17-59	60	740	42	8,800	340	150	620	Lost	Lost	3,200	5.0
2-24-59	23	430	38	6,500	190	190	250	5.6	0.77	2,300	280
3-3-59	38	610	38	6,200	290	380	270	6.7	0.83	3,100	7.1
3-10-59	29	1,600	120	5,500	580	49	1,400	4.2	<0.37	2,100	<67
3-17-59	42	570	27	4,600	450	66	230	4.5	0.53	1,900	<36
3-24-59	60	1,200	<6.4	3,700	270	240	57	4.8	<0.48	2,100	25
3-31-59	16	790	12	5,500	170	130	95	5.0	<0.47	1,600	7.5
4-7-59	44	2,000	29	5,400	670	170	350	4.9	<0.38	2,700	45
4-14-59	43	1,500	12	4,500	590	210	190	4.5	Lost	4,100	28
4-21-59	31	1,600	18	4,200	650	150	320	3.6	<0.43	2,100	61
4-28-59	18	250	7.1	2,300	250	100	150	6.5	0.66	990	<56
5-5-59	18	370	<6.7	2,200	420	54	170	7.0	<0.34	1,500	<22
5-12-59	9.0	640	<3.7	1,300	330	73	850	3.1	<0.39	730	42
5-19-59	16	310	5.9	2,300	310	95	70	3.6	<0.91	1,100	22
5-26-59	25	1,000	7.8	2,100	520	73	260	3.5	<0.76	1,200	56
6-2-59	41	1,100	13	1,300	690	61	99	3.1	<0.41	790	<42
6-9-59	23	600	7.2	1,400	450	58	110	2.3	<0.38	600	28
6-16-59	74	330	<3.6	1,100	770	28	280	1.6	<0.36	530	<35
6-23-59	22	350	<6.6	1,000	380	25	58	2.3	<0.40	500	<99
6-30-59	14	130	<3.6	730	170	26	63	2.1	0.62	630	<16
7-7-59	8.7	250	<3.6	1,100	240	23	69	2.6	<0.67	880	<41
7-14-59	18	230	<6.7	1,300	240	21	52	1.7	0.60	520	<16
7-21-59	24	130	<6.6	1,100	340	24	70	4.2	0.57	590	<22

NA = No Analysis

APPENDIX B-1 (contd.)

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	As^{76}	$Sr^{89} + Sr^{90}$	Sr^{90}	Np^{239}	Zn^{69m}
7-28-59	30	210	<6.2	1,300	310	240	470	2.9	<0.62	490	<14
8-4-59	34	660	14	1,800	510	32	300	3.4	0.60	650	<18
8-11-59	53	580	21	2,100	690	38	260	3.7	0.80	740	<15
8-18-59	52	1,000	28	3,900	750	48	480	4.9	<0.73	1,900	34
8-25-59	45	1,100	23	3,600	710	37	450	5.1	1.3	1,600	<33
9-1-59	26	550	23	4,000	320	46	320	5.3	1.1	1,400	<20
9-9-59	30	1,100	18	4,800	640	32	380	4.3	<0.94	2,100	<32
9-15-59	19	720	25	3,000	490	32	350	4.2	0.66	1,300	28
9-22-59	24	320	23	2,500	120	58	140	4.6	0.61	850	32
9-29-59	12	360	28	2,800	120	37	280	6.0	0.88	1,300	<15
10-6-59	44	540	65	3,000	350	60	670	4.1	0.75	1,300	<19
10-13-59	28	250	95	3,800	120	49	560	5.0	0.81	1,400	<18
10-20-59	57	550	100	3,900	420	79	940	6.0	<0.74	1,800	<21
10-27-59	56	480	120	1,900	330	100	900	5.3	0.72	1,100	<16
11-3-59	50	240	96	3,200	150	61	470	3.0	0.61	1,100	<34
11-10-59	7.4	84	8.7	1,000	76	52	250	2.6	<0.63	120	<14
11-17-59	15	30	86	3,300	31	36	49	3.8	0.70	210	<13
11-24-59	59	690	140	7,000	450	99	430	6.3	0.73	2,700	<20
12-1-59	16	81	31	3,900	59	49	130	5.2	0.53	1,500	<16
12-8-59	29	230	33	4,800	220	90	190	3.8	0.74	1,500	<45
12-15-59	130	26	130	4,200	150	60	310	5.9	0.82	1,400	<15
12-22-59	42	54	49	4,600	87	150	970	6.9	0.60	1,400	<34
12-29-59	89	170	140	4,900	150	53	480	9.7	0.51	2,300	<47

APPENDIX B-2

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN SANITARY WATER AT KENNEWICK, WASHINGTON - 1959

10^{-9} μc/cc

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	As^{76}	Sr^{89}+ Sr^{90}	Sr^{90}	Np^{239}	Zn^{69m}
1-13-59	16	210	53	4,700	200	36	480	2.1	<0.55	840	NA
1-20-59	22	330	40	2,600	180	13	290	1.3	<0.58	580	<10
1-27-59	21	180	29	3,100	190	64	270	1.1	<0.51	520	22
2-3-59	25	86	30	2,900	230	22	330	<1.3	Lost	540	37
2-17-59	93	610	110	5,100	650	110	850	2.8	0.45	1,700	75
2-24-59	39	310	46	3,100	310	53	200	1.7	<0.56	610	47
3-3-59	35	140	33	1,800	130	18	270	1.5	<0.40	300	<32
3-10-59	38	120	32	2,800	240	34	180	1.3	<0.38	560	<45
3-17-59	40	120	28	2,900	250	25	130	1.0	<0.44	510	<23
3-24-59	50	150	30	2,900	240	39	170	<0.9	<0.50	710	<50
3-31-59	28	110	22	3,000	160	38	83	1.0	<0.38	370	<61
4-7-59	36	340	41	2,900	330	41	200	1.3	<0.53	550	29
4-14-59	20	160	35	2,800	300	52	300	1.2	<0.41	580	72
4-21-59	48	150	38	3,100	400	50	230	1.0	<0.33	490	<65
4-28-59	19	98	15	<1,600	130	22	70	1.1	<0.38	<350	<33
5-5-59	23	61	13	<1,600	180	20	48	1.3	<0.30	<310	<36
5-12-59	23	95	15	920	250	29	120	1.8	<0.38	310	<62
5-19-59	13	75	9.4	1,100	150	30	97	<0.88	<0.68	280	<15
5-26-59	28	260	14	1,500	330	31	130	1.2	<0.86	250	<43
6-2-59	46	420	15	1,100	330	50	130	1.3	<0.39	300	<100
6-9-59	14	55	5.4	940	170	32	54	1.0	<0.62	260	<34
6-16-59	25	80	8.1	730	230	18	25	0.70	<0.41	250	<13
6-23-59	32	240	7.3	900	310	14	73	<1.1	<0.39	260	<38
6-30-59	19	130	6.7	790	240	7.5	86	1.0	<0.41	470	<16
7-7-59	12	78	<3.6	760	150	10	36	<0.51	<0.68	190	<12
7-14-59	36	160	<12	1,400	310	9.0	170	1.2	0.37	300	<15
7-21-59	33	99	<6.1	1,300	260	<20	120	1.8	<0.41	340	<28
7-28-59	16	71	<6.6	1,200	170	<18	440	<0.74	<0.59	140	<15

NA = No Analysis

APPENDIX B-2 (contd.)

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	As^{76}	Sr^{89}+ Sr^{90}	Sr^{90}	Np^{239}	Zn^{69m}
8-4-59	24	310	13	1,800	490	< 20	210	1.3	< 0.45	270	< 13
8-11-59	22	230	10	1,700	340	< 22	130	1.5	< 0.38	230	< 16
8-18-59	9.8	260	10	2,600	310	24	200	1.1	< 0.69	800	< 41
8-25-59	26	370	15	2,500	370	19	190	1.9	< 0.70	420	< 13
9-1-59	6.9	63	6.4	2,100	110	< 20	54	< 0.89	< 0.75	120	< 15
9-9-59	19	35	15	2,800	380	25	260	1.6	< 0.63	490	< 56
9-15-59	5.2	63	6.7	1,900	110	< 18	20	< 1.1	< 0.59	98	< 15
9-22-59	11	90	< 6.6	1,500	82	< 20	60	< 1.1	0.38	110	< 17
9-29-59	5.2	100	7.4	1,800	110	25	85	< 0.90	< 0.32	170	< 18
10-6-59	9.6	160	10	2,000	170	< 19	170	< 1.1	< 0.41	220	< 16
10-13-59	7.5	120	< 5.4	2,500	140	< 19	120	< 1.0	< 0.38	200	< 17
10-20-59	7.8	92	< 6.5	2,200	140	< 18	110	< 1.1	< 0.74	180	< 12
10-27-59	7.1	55	< 6.6	530	130	16	87	< 0.96	< 0.34	20	< 12
11-3-59	10	82	8.7	1,900	49	< 19	18	< 0.62	< 0.41	30	< 14
11-10-59	9.3	59	< 9.7	1,700	110	< 20	82	< 1.0	< 1.4	100	< 13
11-17-59	11	170	11	2,600	140	27	85	< 1.2	< 0.41	290	< 20
11-24-59	9.0	130	13	3,300	140	< 20	110	< 1.2	< 0.42	320	< 32
12-1-59	7.0	6.6	< 6.5	2,100	75	20	< 85	< 0.99	< 0.38	100	< 24
12-8-59	14	14	11	2,000	150	< 20	< 80	< 1.0	< 0.73	190	< 18
12-15-59	18	18	12	2,000	98	20	< 88	< 1.1	< 0.39	240	< 23
12-22-59	12	14	11	2,300	120	13	160	1.0	< 0.57	230	< 52

APPENDIX B-3

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER AT PASCO, WASHINGTON - 1959

10^{-9} μc/cc

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	As^{76}	$Sr^{89}+Sr^{90}$	Sr^{90}	Np^{239}	Zn^{65m}
1-6-59	120	1,000	430	7,800	1,400	410	5,000	7.6	0.86	5,900	NA
1-13-59	200	1,800	500	11,000	2,700	510	5,400	10	0.63	6,500	NA
1-20-59	150	1,300	140	6,000	1,800	260	2,500	15	1.5	3,600	96
1-27-59	130	530	360	2,600	560	140	1,300	4.8	0.50	1,800	44
2-3-59	390	1,800	310	6,000	2,600	310	3,600	5.5	0.77	4,100	170
2-10-59	17	670	32	4,600	350	170	410	Lost	Lost	2,900	23
2-17-59	190	1,300	410	11,000	470	180	2,600	7.9	0.56	4,000	200
2-24-59	320	1,100	320	6,300	1,500	450	2,200	9.6	0.94	3,900	41
3-3-59	310	910	250	6,400	1,100	420	1,800	6.9	0.88	3,400	220
3-10-59	470	1,900	320	5,300	2,600	410	2,300	5.5	0.48	3,500	400
3-17-59	390	1,200	230	6,000	1,500	350	1,100	5.3	0.95	2,800	160
3-24-59	360	1,400	250	4,400	1,400	380	1,300	4.7	<0.49	2,500	180
3-31-59	240	870	200	5,400	890	230	890	5.5	0.41	2,300	79
4-7-59	460	2,600	300	6,900	2,500	390	2,000	5.2	0.46	3,200	290
4-14-59	450	2,600	230	5,500	2,700	400	2,200	5.8	?	3,000	320
4-21-59	370	1,800	220	5,100	2,600	330	2,300	4.5	0.36	2,600	330
4-28-59	140	720	110	2,500	930	220	350	5.3	0.45	1,100	120
5-5-59	300	1,200	110	3,000	3,000	190	670	6.6	0.36	1,500	210
5-12-59	130	730	62	1,500	1,000	180	640	4.3	<0.50	880	480
5-19-59	170	1,200	87	2,400	2,200	180	1,200	2.7	0.96	1,300	130
5-26-59	210	1,200	64	2,600	2,200	150	950	2.7	<0.95	1,300	170
6-2-59	150	800	39	1,600	1,400	150	590	3.1	0.45	750	110
6-9-59	160	800	32	1,300	1,300	130	470	2.4	0.68	740	120
6-16-59	170	690	18	1,200	1,500	100	400	1.7	0.19	580	87
6-23-59	140	370	25	970	1,400	86	410	5.4	1.1	580	24
6-30-59	130	540	21	800	1,100	67	330	2.2	<0.34	690	54
7-7-59	170	700	22	1,500	1,400	91	490	2.3	<0.67	760	72
7-14-59	210	340	20	1,700	1,200	55	360	1.9	<0.37	680	43
7-21-59	100	260	21	1,000	980	59	250	3.0	<0.40	600	22
7-28-59	130	420	24	2,800	1,100	66	800	2.6	<0.57	620	49

NA = No Analysis

APPENDIX B-3 (contd.)

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	As^{76}	$Sr^{89}+Sr^{90}$	Sr^{90}	Np^{239}	Zn^{69m}
8-4-59	200	930	43	2,000	1,700	90	930	4.4	0.57	810	59
8-11-59	190	1,400	48	2,600	2,100	120	820	4.4	0.80	1,100	66
8-18-59	140	1,300	60	4,000	2,200	130	1,200	4.6	1.0	1,800	81
8-25-59	190	1,500	78	3,500	1,800	160	1,100	3.2	0.90	1,700	61
9-1-59	69	1,200	57	3,800	1,700	120	1,300	5.5	1.0	1,800	22
9-8-59	140	1,400	83	4,700	2,000	120	1,400	4.6	<0.65	2,300	16
9-15-59	72	1,300	85	3,400	1,800	130	1,100	4.7	0.68	1,700	25
9-22-59	170	1,400	94	2,700	2,000	150	1,400	4.4	0.58	1,600	40
9-29-59	58	1,100	140	4,000	1,700	120	1,300	5.9	0.79	2,100	18
10-6-59	130	1,300	100	3,400	1,800	160	1,300	3.9	0.81	1,800	34
10-13-59	110	710	140	3,500	910	110	1,200	5.8	0.70	1,900	12
10-20-59	210	1,500	180	4,300	2,400	160	1,800	6.2	<1.0	2,500	27
10-27-59	170	1,100	170	4,300	1,700	180	1,300	4.4	0.64	1,900	26
11-3-59	140	740	110	3,100	970	140	960	4.5	0.71	1,900	19
11-10-59	190	1,500	150	4,600	2,300	190	1,400	4.2	0.65	2,600	40
11-17-59	380	1,800	180	6,100	2,800	250	2,000	6.7	0.71	3,800	80
11-24-59	410	2,100	280	8,700	360	250	2,700	6.7	0.87	4,300	68
12-1-59	140	290	99	2,800	820	150	510	4.1	0.76	1,300	28
12-8-59	180	1,300	200	5,800	2,400	270	1,200	4.4	1.1	3,100	36
12-15-59	380	1,100	230	5,600	1,300	250	1,300	7.4	0.72	3,300	33
12-22-59	220	570	180	5,100	940	190	2,500	11	0.83	2,500	81
12-29-59	290	940	230	5,700	1,300	220	2,300	9.6	0.61	3,000	100

APPENDIX B-4

ALPHA EMITTERS IN SANITARY WATER - 1959

Disintegrations per Second per Cubic Centimeter

Location*	January	February	March	April	May	June	July	August	September	October	November	December
Benton City Water Co.	0.00033	0.00017	0.00038	0.00035	0.00043	0.00058	0.00033	<0.0001	0.00033	NA**	0.00019	NA
Sacajawea Park	0.00036	0.00026	0.00032	0.00032	0.00028	0.00027	0.00045	<0.0001	0.00024	0.00037	0.00018	0.00031

* 19 other locations, off project, were analyzed routinely for alph emitters in sanitary water. All results for these locations were $<5 \times 10^{-4}$ d/s per cc.

** No Analysis

APPENDIX B-5

URANIUM CONCENTRATIONS IN SANITARY WATER - 1959

10^{-9} μc/cc

Location*	January	February	March	April	May	June	July	August	September	October	November	December
Benton City Water Co.	24	2.9	16	11	8.2	19	24	7.1	11	10	-	NA
100-F Area (On Project)	-**	-	-	-	-	2.2	-	-	-	-	-	-
Pasco-Composite Sample	2.3	-	-	2.0	-	-	-	-	-	-	-	6.6
Sacajawea Park	12	10	17	15	16	7.7	16	17	12	15	11	NA
McNary Dam	NA***	-	-	-	-	3.3	2.7	-	-	-	-	NA
Paterson Store	NA	7.1	6.3	4.5	2.7	9.9	-	4.5	-	-	6.9	NA

* 10 other locations, off project, were analyzed routinely for uranium concentration in sanitary water. All results for these locations were less than detection limit.

** Uranium concentrations below the reporting limit are indicated by a dash (-). The reporting limit prior to September 1959 was 2×10^{-9} μc/cc; from September 1959 to date the reporting limit is 6×10^{-9} μc/cc.

*** No Analysis.

APPENDIX B-6

CONCENTRATION OF P^{32} IN SELECTED ORGANISMS FROM THE COLUMBIA RIVER - 1959

Units - 10^{-3} $\mu c/g$ (wet)

Date	Organism	Location	Number of Samples	Average	Maximum
1/4	River Duck	Near Pasco	1	0.056	-
1/9	Minnows, Whole Fish	River near Reactors	10	2.3	3.0
1/20	River Duck	River near Reactors	1	0.19	-
1/29	River Ducks	River Ringold Area	4	0.039	0.056
1/29	Diving Ducks	River Ringold Area	4	1.6	2.9
2/2	Minnows, Whole Fish	River Priest Rapids Area	10	0.00062	0.026
2/2	Whitefish Flesh	River Priest Rapids Area	3	0.22	0.47
2/3	Whitefish Flesh	River near Reactors	3	0.11	0.12
2/5	Minnows, Whole Fish	River Ringold Area	10	1.8	1.9
3/12	Minnows, Whole Fish	River Ringold Area	11	1.1	1.5
4/13	Minnows, Whole Fish	River Ringold Area	24	0.87	1.5
5/13	Minnows, Whole Fish	River Ringold Area	16	0.91	1.9
6/10	Minnows, Whole Fish	River Ringold Area	10	1.1	1.4
7/6	Minnows, Whole Fish	River Ringold Area	10	2.4	3.4
8/3	Minnows, Whole Fish	River Ringold Area	9	10	12
8/31	Minnows, Whole Fish	River Ringold Area	10	10	14
10/12	Minnows, Whole Fish	River Ringold Area	10	17	21
10/15	River Ducks	River Ringold Area	9	0.11	0.49
10/29	Whitefish Flesh	River Ringold Area	1	0.22	-
10/30	Minnows, Whole Fish	River Priest Rapids Area	2	0.040	0.049
10/30	Whitefish Flesh	River Priest Rapids Area	13	0.67	3.5
11/13	Whitefish Flesh	River near Reactors	12	1.4	3.9
12/8	Whitefish Flesh	River near Reactors	14	0.58	1.3
12/9	Whitefish Flesh	River Ringold Area	4	0.40	0.57
12/9	Minnows, Whole Fish	River near Reactors	10	3.3	3.8
12/10	Whitefish Flesh	River Priest Rapids Area	5	0.079	0.25

Data provided by Radioecology Operation; J. J. Davis, D. G. Watson, W. C. Hanson

APPENDIX B-7

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER AT VANCOUVER, WASHINGTON - 1959

(10^{-9} μc/cc)

Date	P^{32}	Cr^{51}	Zn^{65}	Np^{239}
6-23-59	14	710	41	300*
7-28-59	5.3	940	< 20	94
8-25-59	9.8	2,300	39	87
9-29-59	19	1,800	< 19	120
10-19-59	37	Lost	--	--
11-3-59	39	2,300	< 19	160
12-1-59	80	4,000	55	400
12-17-59	43	2,800	67	93

* Questionable analytical result.

APPENDIX B-8

BETA EMITTERS IN RIVER MUD - 1959

Disintegrations per Second per Gram

Location	January	February	March	April	May	June	July	August	September	October	November	December
Columbia River												
Wills Ranch (Upstream from Project)	0.54	0.79	0.74	0.70	0.62	0.61	0.81	0.98	0.74	0.45	0.52	NA*
Hanford (old townsite)	3.2	2.5	1.3	3.5	1.2	1.2	2.0	2.2	3.3	4.4	4.5	NA
Below 300 Area (Downstream from Project)	3.2	1.9	1.7	5.6	2.5	1.4	2.1	2.1	3.2	2.3	3.0	NA
Byers Landing	1.3	2.0	2.2	1.4	0.72	0.75	0.82	1.9	1.2	1.9	2.4	NA
Richland	1.6	2.8	1.2	1.3	1.9	0.65	1.2	1.6	1.8	1.5	2.8	NA
Pasco-Kennewick Bridge-South End	5.0	1.6	1.6	1.3	0.68	0.86	0.88	2.1	1.3	1.4	0.84	NA
Sacajawea Park	1.8	2.1	2.2	1.3	1.6	0.94	0.70	1.1	1.1	1.0	1.6	NA
McNary - Below Dam	0.62	0.91	0.94	0.74	0.64	0.67	1.1	0.72	0.82	1.4	1.1	NA
Paterson	0.94	0.95	1.0	0.95	0.61	1.0	0.86	1.2	0.81	1.2	0.96	NA
Other Muds												
Snake River (Near Mouth)	0.49	0.86	0.85	0.69	0.52	0.58	0.58	0.86	0.57	0.53	0.84	NA

*NA = No Analysis

APPENDIX B-9

BETA EMITTERS IN COLUMBIA RIVER WATER - 1959

Disintegrations per Second per Cubic Centimeter

Location*	January	February	March	April	May	June	July	August	September	October	November	December
Wills Ranch (Upstream from Project	<0.0020	<0.0020	0.0034	0.00092	<0.00050	0.00074	0.00067	0.00059	<0.00050	0.00056	<0.00050	NA**
Hanford (Old Townsite)	3.5	2.8	2.8	2.7	1.3	0.55	0.55	1.2	1.4	2.0	1.9	2.3
Richland Dock	0.67	0.43	1.2	1.0	0.54	0.21	0.26	0.42	0.51	0.76	0.79	1.0
Pasco Filter Plant Inlet	1.2	0.70	0.54	0.55	0.45	0.15	0.12	0.21	0.39	0.50	0.66	NA
Pasco-Kennewick Bridge- North End	1.2	0.72	0.82	0.59	0.31	0.16	0.15	0.32	0.34	0.49	0.46	NA
Sacajawea Park	0.82	0.46	0.63	0.43	0.24	0.12	0.10	0.18	0.24	0.30	0.30	0.48
McNary - Below Dam	0.14	0.028	0.11	0.064	0.066	0.037	0.033	0.045	0.030	0.062	0.046	0.056
Paterson Ferry-Oregon	0.17	0.096	0.093	0.056	0.087	0.038	0.042	0.030	0.043	0.067	0.047	0.060
Hood River, Oregon	0.072	0.016	0.035	0.025	0.037	0.036	0.018	0.018	0.016	0.021	0.018	0.037
Vancouver, Washington	0.050	0.025	0.027	0.017	0.023	0.016	NA	0.0068	0.0089	0.013	0.016	0.026

* 15 other locations, off project, were analyzed routinely for beta emitters in Columbia River water. Results for these locations were $<1 \times 10^{-4}$ d/s per cc.

** No Analysis.

APPENDIX B-10

URANIUM CONCENTRATIONS IN RIVER WATER - 1959

10^{-9} $\mu c/cc$

Location**	January	February	March	April	May	June	July	August	September	October	November	December
Columbia River												
Wills Ranch (Upstream from Project)	- *	3.1	-	3.5	2.2	2.6	3.8	2.5	-	-	-	NA
Hanford (Old Townsite)	-	2.2	3.7	-	2.3	2.3	2.2	-	-	-	-	NA
Richland Dock	-	-	3.0	-	-	-	-	-	-	-	-	NA
Pasco-Kennewick Bridge- *North End*	3.4	-	-	-	4.3	-	-	-	-	6.4	-	NA
McNary - Below Dam	NA***	3.1	3.6	-	3.2	-	2.1	-	-	-	12.1	NA
Paterson Ferry-Oregon	2.5	2.7	-	-	-	2.0	-	-	-	-	-	NA
Hood River, Oregon	2.5	-	-	-	-	2.4	3.1	-	-	-	-	NA
Vancouver, Washington	3.2	5.9	-	3.6	3.3	2.6	NA	2.4	2.4	-	-	NA
Other Waters												
Snake River-Near Mouth	4.1	-	-	2.0	2.5	4.0	-	2.4	-	-	9.1	NA

* Uranium concentrations below the reporting limit are indicated by a dash (-). The reporting limit prior to September 1959 was 7×10^{-5} d/s per cc; from September 1959 to date the reporting limit is 2×10^{-4} *d/s per cc.*

** 8 other locations, off project were analyzed routinely for uranium concentrations in river water. Results for these locations were below detection limit.

*** No Analysis.

APPENDIX B-11

ESTIMATED RATE OF TRANSPORT FOR SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER PASSING PASCO, WASHINGTON - 1959

curies/day

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	As^{76}	$Sr^{89}+Sr^{90}$	Sr^{90}	Np^{239}	Zn^{69m}
1-6-59	21	180	76	1,400	250	72	900	1.3	0.15	1,000	NA
1-13-59	40	360	100	2,200	550	100	1,100	2.0	0.13	1,300	NA
1-20-59	36	310	34	1,400	430	62	600	3.6	0.36	860	23
1-27-59	30	120	84	600	130	33	300	1.1	0.12	420	10
2-3-59	99	460	78	1,500	660	78	910	1.4	0.19	100	44
2-10-59	3.3	120	6.3	900	69	33	80	Lost	Lost	570	4.5
2-17-59	40	270	86	2,300	98	38	540	1.7	0.12	840	42
2-24-59	76	260	76	1,500	360	110	520	2.3	0.22	930	9.7
3-3-59	75	220	60	1,500	270	100	430	1.7	0.21	820	53
3-10-59	120	490	82	1,400	670	110	590	1.4	0.12	900	100
3-17-59	99	300	58	1,500	380	89	280	1.3	0.24	710	41
3-24-59	91	360	64	1,100	360	97	330	1.2	<0.12	640	46
3-31-59	57	210	48	1,300	210	55	210	1.3	0.098	550	19
4-7-59	120	690	79	1,800	660	100	530	1.4	0.12	850	77
4-14-59	130	740	66	1,600	770	110	630	1.7	?	860	91
4-21-59	120	580	71	1,700	840	110	740	1.5	0.12	840	110
4-28-59	56	290	44	1,000	370	89	140	2.1	0.18	440	48
5-5-59	160	640	59	1,600	1,100	100	360	3.5	0.19	800	110
5-12-59	76	430	36	870	580	100	370	2.5	<0.29	510	280
5-19-59	100	710	51	1,400	1,300	110	710	1.6	0.57	770	77
5-26-59	150	860	46	1,900	1,600	110	680	1.9	<0.68	930	120
6-2-59	120	660	32	1,300	1,200	120	490	2.6	0.37	620	91
6-9-59	140	710	28	1,100	1,100	110	410	2.1	0.60	650	110
6-16-59	160	640	17	1,100	1,400	92	370	1.6	0.18	540	80
6-23-59	150	380	26	1,000	1,500	89	430	5.6	1.1	600	25
6-30-59	140	560	22	830	1,100	70	340	2.3	<0.35	720	56
7-7-59	150	600	19	1,300	1,200	79	420	2.0	<0.58	660	62
7-14-59	150	400	14	1,200	860	40	260	1.4	<0.27	490	31
7-21-59	68	180	14	680	660	40	170	2.0	<0.27	410	15

NA = No Analysis

APPENDIX B-11 (contd.)

Date	RE+Y	Na^{24}	P^{32}	Cr^{51}	Cu^{64}	Zn^{65}	As^{76}	$Sr^{89}+Sr^{90}$	Sr^{90}	Np^{239}	Zn^{69m}
7-28-59	79	260	15	1,700	670	40	490	1.6	<0.35	380	30
8-4-59	90	420	19	900	760	40	420	2.0	0.26	360	26
8-11-59	69	510	18	950	770	44	300	1.6	0.29	400	24
8-18-59	41	380	18	1,200	650	38	350	1.4	0.29	530	24
8-25-59	48	380	20	890	460	41	280	0.81	0.23	430	15
9-1-59	17	300	14	940	420	30	320	1.4	0.25	440	5.4
9-8-59	34	340	20	1,100	480	29	340	1.1	<0.16	560	3.9
9-15-59	20	360	24	950	500	36	310	1.3	0.19	470	7.0
9-22-59	62	510	34	990	730	55	510	1.6	0.21	590	15
9-29-59	20	380	49	1,400	590	42	450	2.0	0.27	730	6.2
10-6-59	36	360	28	940	500	44	360	1.1	0.22	500	9.4
10-13-59	29	190	37	930	240	29	320	1.5	0.19	510	3.2
10-20-59	64	450	55	1,300	730	48	550	1.9	<0.30	760	8.2
10-27-59	56	360	56	1,400	790	53	430	1.5	0.21	630	8.6
11-3-59	43	230	34	950	300	43	300	1.4	0.22	590	5.9
11-10-59	56	440	44	1,300	670	56	410	1.2	0.19	760	12
11-17-59	85	400	40	1,400	630	56	450	1.5	0.16	850	18
11-24-59	110	590	78	2,400	100	70	750	1.9	0.24	1,200	19
12-1-59	48	99	34	960	280	51	170	1.4	0.26	450	9.6
12-8-59	42	300	46	1,300	550	62	280	1.0	0.25	720	8.3
12-15-59	85	250	51	1,200	290	56	290	1.7	0.16	740	7.4
12-22-59	52	140	43	1,200	220	45	590	2.6	0.20	590	19
12-29-59	59	190	47	1,200	260	44	470	1.9	0.12	610	20

APPENDIX B-12

ESTIMATED RATE OF TRANSPORT FOR SEVERAL RADIONUCLIDES IN COLUMBIA RIVER WATER PASSING VANCOUVER, WASHINGTON 1959

curies/day

Date	P^{32}	Cr^{51}	Zn^{65}	Np^{239}
6-23-59	19	960	55	400*
7-28-59	3.8	670	< 14	67
8-25-59	3.2	750	13	28
9-29-59	8.8	830	< 9	55
10-19-59	16	Lost	--	--
11-3-59	17	1,000	< 8	70
12-1-59	39	2,000	27	200
12-17-59	16	1,000	25	34

* Questionable analytical result

APPENDIX B-13

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN LOCALLY PURCHASED OYSTERS* - 1959

10^{-6} $\mu c/g$

Code	Type	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95}-Nb^{95}	Cs^{137}	$Ru^{103+106}$	I^{131}	Cr^{51}	$Ce^{141+144}$
Reporting Limits				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5
Oysters												
401	Freshly Shelled	Wash. Coast	11/25	-**	2.8	67	-	-	-	-	-	-
401	Shells of above		11/25	-	0.41	1.4	1.4	-	-	-	0.50	0.66
402	Brand A	Wash. Coast	11/25	-	2.1	47	-	-	-	-	-	-
409	Brand A	Wash. Coast	12/7	-	1.8	39	-	-	-	-	-	-
410	Brand B	Wash. Coast (?)	12/7	0.16	2.2	53	-	-	-	-	2.7	1.6

* Strontium-89 and strontium-90 were less than 0.004 and 0.002, respectively in oysters.

** Results less than reporting limit are indicated by a (-).

APPENDIX B-14

Zn^{65} IN LOCALLY PURCHASED OYSTERS - 1959*

Sample No.	Packing	Origin	Zn^{65} 10^{-6} $\mu c/g$
1	Fresh	West Coast	63
2**	Fresh	Willapa Bay, Wash.	56
3	Fresh	South Bend, Wash.	38
4	Canned	West Coast	15
5	Canned Oyster Stew	Seattle, Wash.	4.1
6	Canned	Gulf of Mexico	< 0.14
7	Canned	New Orleans, La.	0.30
8	Canned	Biloxi, Mississippi	< 0.14
9	Fresh	Port Norris, N. J.	0.18
10	Canned	Japan	0.18
11	Canned	Japan	< 0.22
12	Canned	Japan	< 0.14
13	Canned	Japan	< 0.22

* Data supplied by Radiological Chemistry Operation

** Sampled September 5, 1959, from Willapa Bay near Bay Center, Washington.

APPENDIX B-15

Zn^{65} IN COMMON MARINE FOOD ORGANISMS*

(Specimens collected April 1959)

Location	Sample Type	10^{-6} μc/g (Wet)
Coos Bay, Oregon	Burrowing Clams (soft parts)	0.45
	White Perch (minus gut content)	2.0
	White Perch (" " ")	1.8
	White Perch (" " ")	3.1
Lewis State Park, Ore.	Razor Clams (soft parts)	28
Illwaco, Washington	Chinook Salmon (dressed)	1.2
	Chinook Salmon (dressed)	2.2
	Starry Flounder (Minus gut content)	13
	Crab (flesh)	15
Long Beach, Wash.	Razor Clams (soft parts)	27
Willapa Bay, Wash.	Oysters (soft parts)	46
	Steamer Clams (soft parts)	1.3
Kalaloch, Wash.	Razor Clams (soft parts)	7.8
	Smelt (minus gut content)	14
Sequim, Wash.	Mixed Clams (soft parts)	0.74
	Oysters (soft parts)	4.2

* Data supplied by Radioecology Operation.

APPENDIX C-1

AVERAGE RADIOACTIVE PARTICLES CONCENTRATIONS* AT SELECTED PACIFIC NORTHWEST LOCATIONS - 1959

Units of Particles per m^3

Date	Rich-land	Proj-ect (2W)	Spokane	Boise	Klamath Falls	Lewis-ton	Walla Walla	Yakima
1-8	0.43	0.26	0.26	0.48	0.42	0.49	0.35	0.66
1-15	0.19	0.26	0.21	0.60	0.34	0.41	0.34	0.095
1-22	0.60	0.45	0.48	0.47	0.78	0.54	0.59	0.17
1-29	0.30	0.27	0.25	0.46	0.40	0.23	0.33	0.14
2-5	0.22	0.24	0.39	0.54	0.50	0.50	0.29	0.23
2-12	0.16	0.16	0.34	0.50	0.28	0.40	0.36	0.13
2-19	0.39	0.29	0.54	0.63	0.23	0.45	0.36	0.24
2-26	0.35	0.22	0.44	0.56	0.46	0.24	0.38	0.18
3-5	0.41	0.35	0.49	0.64	0.80	0.52	0.50	0.40
3-12	0.26	0.33	0.57	0.51	0.64	0.28	0.51	0.34
3-19	0.31	0.27	0.39	0.53	0.57	0.42	0.44	0.24
3-26	0.25	0.34	0.41	0.42	0.61	0.32	0.17	0.33
4-2	0.090	0.10	0.16	0.23	0.19	0.19	0.13	0.17
4-9	0.49	0.52	0.40	0.72	0.37	0.60	0.68	0.73
4-16	0.27	0.12	0.13	0.45	0.33	0.42	0.33	0.21
4-23	0.46	0.53	0.44	0.54	0.79	0.47	0.41	0.50
4-30	0.52	0.38	0.47	0.76	0.34	0.78	0.68	0.59
5-7	0.31	0.34	0.28	0.28	0.15	0.29	0.28	0.30
5-14	0.42	0.34	0.53	0.48	0.24	0.48	0.46	0.36
5-21	0.11	0.088	0.055	0.20	0.30	0.10	0.086	0.17
5-28	0.20	0.17	0.22	0.26	0.22	0.15	0.17	0.34
6-4	0.17	0.14	0.18	0.31	0.20	0.24	0.24	0.17
6-11	0.035	0.061	0.073	0.18	0.065	0.048	0.029	0.072
6-18	0.035	0.068	0.10	0.061	0.056	0.090	0.090	0.049
6-25	0.048	0.047	0.073	0.029	0.029	0.056	0.069	0.091
7-2	0.035	0.030	0.038	0.048	0.035	0.036	0.052	0.031
7-9	0.024	0.032	0.028	0.12	0.057	0.034	0.033	0.024
7-16	0.030	0.064	0.099	0.034	0.018	0.031	0.057	0.042

*Based on a nominal flow rate of 2.5 CFM

APPENDIX C-1 (CONTINUED)

Date	Rich-land	Project (2W)	Spokane	Boise	Klamath Falls	Lewis-ton	Walla Walla	Yakima
7-23	0.031	0.045	0.066	0.045	0.031	0.038	0.068	0.032
7-30	0.022	0.030	0.041	0.036	0.034	0.024	0.021	0.045
8-6	0.022	0.043	0.038	0.043	0.028	0.042	0.035	0.028
8-13	0.011	0.043	0.032	0.019	0.028	0.015	0.030	0.030
8-20	0.0097	0.012	0.011	0.020	0.0084	0.011	0.013	0.0097
8-27	0.0098	0.016	0.013	0.0098	0.0056	0.012	0.0097	0.011
9-3	0.0042	0.013	0.0099	0.0053	0.0084	0.0070	0.0083	0.0061
9-10	0.012	0.013	0.0056	0.019	0.0042	0.011	0.0073	0.0098
9-17	0.0085	0.0056	0.0042	0.0098	0.011	0.0052	0.0098	0.0097
9-24	0.0070	0.0042	0.0056	0.013	<0.0014	0.0028	0.0084	0.0017
10-1	0.0098	0.0042	0.0014	0.0085	0.0042	0.0014	0.0028	0.0028
10-8	0.0033	0.011	0.0070	0.0040	0.0045	0.0042	0.0098	0.0097
10-15	0.0036	0.011	0.0070	0.0088	0.0084	0.0087	0.0085	0.0085
10-22	0.0042	0.066	0.0028	0.015	0.0033	0.0054	0.0056	0.0048
10-29	0.0028	0.0042	0.0070	0.0098	0.0037	0.0014	0.0056	0.0056
11-5	0.0014	0.0042	0.0014	0.0028	0.0042	0.0041	<0.0014	0.0028
11-12	0.0056	0.0099	0.0055	0.012	0.0056	<0.0014	0.0056	0.0014
11-19	0.0028	0.0070	0.0014	0.0026	<0.0014	<0.0014	0.0042	0.0014
11-26	<0.0026	0.0033	0.0016	<0.0015	<0.0014	<0.0013	<0.0014	0.0014
12-3	0.0058	0.014	0.0014	0.0077	0.0085	0.0071	<0.0014	0.0062
12-10	0.0014	0.0097	<0.0014	0.0046	0.0014	0.0027	0.0056	0.0033
12-17	0.0028	0.0084	<0.0014	0.0026	0.0014	0.0057	0.0014	0.0070
12-24	<0.0014	0.011	<0.0016	0.0015	0.0014	0.0028	<0.0014	0.0084
12-31	<0.0014	<0.0014	<0.0014	<0.0014	0.0042	<0.0013	0.0014	<0.0014

APPENDIX C-2

AVERAGE BETA ACTIVITY ON FILTERS FROM SELECTED NORTHWEST U. S. SAMPLING STATIONS - 1959

Beta Disintegrations per Second per cc of Filtered Air x 10^{-8}

Date	Richland Wash.	Spokane Wash.	Boise Idaho	Hanford Project (200-W)	Klamath Falls Oreg.	Lewiston Idaho	Walla Walla Wash.	Yakima Wash.
1/8	13	15	18	12	17	19	14	18
1/15	8.2	11	36	12	13	21	12	7.3
1/22	17	13	21	14	25	22	16	19
1/29	12	8.4	17	7.5	14	11	12	6.5
2/5	9.3	9.6	18	6.2	13	15	8.5	8.1
2/12	6.9	8.3	14	4.4	9.5	12	7.8	6.5
2/19	12	12	20	7.7	7.8	15	11	8.6
2/26	11	11	24	7.5	24	15	12	10
3/5	15	18	41	16	35	24	23	19
3/12	10	11	20	7.8	26	14	12	9.8
3/19	10	12	26	6.3	22	13	13	7.9
3/26	13	18	26	9.5	15	15	13	10
4/2	5.0	5.5	12	3.3	7.5	9.6	5.6	5.0
4/9	17	12	32	12	17	22	18	15
4/16	18	16	28	12	26	21	16	19
4/23	20	18	23	14	19	25	15	20
4/30	17	20	24	12	20	36	24	14
5/7	16	15	23	15	12	17	13	13
5/14	20	19	31	13	19	25	18	16
5/21	8.0	5.3	15	5.4	19	10	7.8	6.3
5/28	11	12	18	8.2	14	12	8.5	12
6/4	14	11	24	9.2	18	18	13	11
6/11	5.8	7.3	13	4.7	7.2	9.6	5.4	5.5
6/18	8.9	8.9	6.3	7.0	7.2	12	6.8	7.5
6/25	7.5	7.3	6.4	5.2	4.9	11	7.8	8.3
7/2	4.9	4.9	8.5	3.6	5.6	7.4	5.1	4.5

APPENDIX C-2 (CONTINUED)

Date	Richland Wash.	Spokane Wash.	Boise Idaho	Hanford Project (200-W)	Klamath Falls Oreg.	Lewiston Idaho	Walla Walla Wash.	Yakima Wash.
7/9	2.6	3.0	8.1	1.9	6.0	4.2	3.5	3.3
7/16	4.6	5.0	6.5	3.2	2.9	6.3	4.4	3.6
7/23	4.6	4.5	5.1	3.1	3.2	6.3	4.4	3.8
7/30	3.1	2.9	3.5	2.3	4.7	4.2	3.0	2.8
8/6	3.1	3.1	4.4	2.4	3.1	5.5	3.8	2.6
8/13	2.6	2.5	3.1	2.0	2.4	3.1	3.0	2.4
8/20	1.4	1.4	2.8	0.89	1.7	2.1	1.3	1.6
8/27	1.5	1.1	2.0	1.1	1.3	2.1	1.2	1.3
9/3	1.1	1.3	1.7	0.82	0.92	1.8	1.4	1.1
9/10	1.1	0.69	1.6	0.60	0.65	1.1	0.97	0.83
9/17	1.4	1.1	1.2	0.90	0.97	1.8	1.7	1.1
9/24	0.88	0.78	0.74	0.49	1.0	2.0	2.4	0.36
10/1	0.66	0.47	0.75	0.73	0.69	0.56	0.81	0.64
10/8	1.9	1.1	0.82	1.2	1.1	1.6	1.4	0.93
10/15	1.1	0.72	0.84	1.1	0.83	1.2	1.3	0.76
10/22	1.3	0.91	1.5	1.4	1.0	1.1	1.6	1.1
10/29	1.1	0.64	0.99	1.1	0.55	1.2	1.2	1.1
11/5	1.4	0.93	1.2	1.4	0.69	1.2	1.2	1.1
11/12	2.1	0.92	1.0	2.3	0.63	1.7	1.7	2.0
11/19	1.2	0.70	1.0	1.5	1.0	1.4	1.3	1.1
11/26	0.39	0.54	0.66	1.2	0.39	0.33	0.51	0.33
12/3	0.97	0.49	1.1	2.2	1.2	1.2	1.1	0.97
12/10	1.5	0.43	1.5	1.6	0.80	1.1	0.82	1.6
12/17	0.89	0.48	0.79	0.88	0.40	0.75	0.60	0.63
12/24	2.4	0.31	1.2	1.6	0.53	0.74	0.78	0.65
12/31	1.6	0.46	0.90	1.2	0.87	0.71	0.86	0.72

APPENDIX C-3

ATMOSPHERIC CONCENTRATIONS OF I^{131}

AT PERIMETER COMMUNITIES - 1959

10^{-14} μc I^{131}/cc

Date	Richland, Wash.	North Richland, Wash.	Date	Benton, Wash.	Pasco, Wash.
1/5	78	20	1/6	61	43
1/12	29	8.9	1/13	61	
1/19	4.8	20	1/15		44
1/26	21	20	1/19	24	
2/2	11	15	1/20		33
2/9	9.8	13	1/27	100	74
2/16	17	13	2/3	28	32
2/23	23	8.8	2/10	14	28
3/2	12	7.1	2/17	39	32
3/9	6.3	13	2/24	22	
3/16	4.6	18	2/25		45
3/23	3.5	7.7	3/3	20	
3/30	3.0		3/4		59
4/6	6.9	4.9	3/10	13	37
4/13	9.0	5.0	3/17	25	31
4/20	6.3		3/24	20	17
4/27	3.2	6.4	3/31	14	15
5/4	1.6	7.5	4/7	21	14
5/11	3.6	8.7	4/14	5.0	3.0
5/18	2.5	9.4	4/21	15	5.2
5/26	4.6		4/28	12	
6/1	0.3	3.8	4/29		7.3
6/8	2.1	3.3	5/5	12	8.5
6/15	1.5	1.7	5/12	15	5.0
6/22	2.7	4.7	5/19	16	5.6
6/29	1.0	1.1	5/26	27	19
7/6	1.1	0.8	6/2	12	6.3
7/13	3.0	1.7	6/9	6.1	4.9

APPENDIX C-3 (CONTINUED)

Date	Richland, Wash.	North Richland, Wash.
7/20	22	1.8
7/27	3.5	1.9
8/3	2.1	1.4
8/10	3.5	5.1
8/17	1.8	2.9
8/24	5.7	3.1
8/31	8.1	
9/8	1.3	1.7
9/14	3.8	3.0
9/21	2.6	2.7
9/28	3.3	1.6
10/5	7.8	0.3
10/12	7.0	4.8
10/19	2.5	3.2
10/26	4.6	2.5
11/2	4.7	3.0
11/9	14	18
11/16	3.3	2.1
11/23	1.5	1.2
11/30	7.9	4.0
12/7	6.7	5.7
12/14	2.6	1.6
12/21	7.6	9.9

Date	Benton, Wash.	Pasco, Wash.
6/16	4.6	25
6/23	4.1	2.5
6/30	1.8	2.8
7/7	3.2	0.7
7/14	11	0.6
7/21	2.2	3.7
7/28	1.4	2.7
8/4		1.6
8/6	4.4	
8/11	16	6.6
8/18	1.8	4.7
8/25	2.8	1.7
9/1	3.8	1.8
9/9	1.3	3.4
9/15	4.3	3.4
9/22	1.8	3.1
9/29	1.5	2.6
10/6	3.0	1.0
10/13	3.9	1.6
10/20	23	1.5
10/27	1.7	1.0
11/3	3.3	2.1
11/10	12	1.8
11/17	1.5	3.4
11/23		3.1
11/24	3.1	
11/30		10
12/1	2.3	
12/7		3.5
12/8	11	
12/14		1.6
12/15	3.1	
12/21		3.5
12/22	21	

APPENDIX C-4

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
BENTON CITY, WASHINGTON AND VICINITY, ZONE I - 1959
REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba-La^{140}$	$Zr-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$	Sample Date	$Ba-La^{140}$	$Zr-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0		2.0	2.0	2.0	1.5	5.0
12/30/58	8.4	74	8.7	2.3	78	6/30	-	7.3	-	-	7.5
1/6/59	8.1	97	10	-	83	7/7	-	5.5	-	-	5.1
1/13	6.4	92	11	1.7	100	7/14	-	4.9	-	-	-
1/20	6.3	99	14	-	99	7/21	-	4.7	-	-	5.7
1/27	3.7	140	16	-	110	7/28	-	4.3	-	-	-
2/3	3.0	62	10	2.5	65	8/11	-	-	-	-	-
2/10	3.1	120	14	2.2	87	8/18	-	-	-	-	-
2/17	2.4	83	14	-	76	8/25	-	-	2.2	-	-
2/24	-	87	13	-	67	9/1	-	3.0	-	-	12
3/3	-	86	14	-	69	9/9	-	-	-	-	6.6
3/10	-	99	16	-	73	9/15	-	-	-	-	-
3/17	-	91	16	-	59	9/21	-	-	-	-	6.2
3/24	-	120	21	-	79	9/29	-	-	-	-	-
3/31	-	55	10	-	54	10/6	-	-	-	-	-
4/7	-	51	9.2	-	41	10/13	-	-	-	-	5.9
4/14	-	26	5.1	-	19	10/20	-	-	-	-	6.0
4/21	-	24	5.2	-	20	10/27	-	-	-	-	6.8
4/28	-	16	3.6	-	10	11/2	-	-	-	-	-
5/3	-	17	4.0	-	12	11/10	-	-	-	-	6.4
5/12	-	14	2.7	-	12	11/17	-	-	3.2	1.5	13
5/19	-	8.9	2.2	-	-	11/24	-	2.2	4.8	-	-
5/26	-	6.3	-	-	-	12/1	-	-	3.6	-	8.1
6/2	-	4.4	-	-	-	12/8	-	2.1	2.8	-	17
6/9	-	5.6	-	-	-	12/15	-	-	2.5	1.5	-
6/16	-	5.1	-	-	-	12/22	-	-	5.5	4.3	9.8
6/23	-	7.0	-	-	-	12/29	-	-	3.2	9.4	-

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-5

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
RICHLAND, WASHINGTON AND VICINITY, ZONE K - 1959
REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	Ru^{103}+ Ru^{106}	I^{131}	Ce^{141}+ Ce^{144}	Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	Ru^{103}+ Ru^{106}	I^{131}	Ce^{141}+ Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0		2.0	2.0	2.0	1.5	5.0
12/29/58	8.1	71	9.3	-	81	7/6	-	2.8	-	-	-
1/5/59	5.0	51	10	-	58	7/13	-	4.2	-	-	5.8
1/12	7.6	66	9.1	-	80	7/20	-	4.6	-	-	-
1/19	6.2	100	14	-	92	7/27	-	2.1	-	-	-
1/26	7.3	97	21	-	110	8/3	-	2.4	-	-	-
2/2	6.9	72	12	2.8	75	8/10	-	-	-	-	-
2/9	3.7	110	16	3.2	110	8/17	-	-	-	-	-
2/16	2.2	110	22	2.3	94	8/24	-	-	2.6	-	-
2/25	8.5	220	42	-	220	8/31	-	-	-	-	6.4
3/2	3.8	150	39	-	140	9/8	-	-	-	-	-
3/9	2.2	190	26	-	88	9/14	-	-	-	-	-
3/16	-	120	24	-	140	9/21	-	-	-	-	6.8
3/23	-	88	15	-	57	9/28	-	-	2.0	-	-
3/30	-	40	8.0	-	31	10/5	-	-	-	-	6.8
4/6	-	44	11	-	36	10/12	-	-	-	-	5.3
4/13	-	41	7.3	-	34	10/19	-	-	-	-	-
4/20	-	28	6.8	-	23	10/26	-	-	-	-	10
4/27	-	20	5.6	-	13	11/2	-	4.3	-	-	-
5/4	-	26	5.8	-	16	11/9	-	-	3.3	-	7.3
5/13	-	3.8	12	2.0	22	11/16	-	2.8	3.0	1.9	-
5/19	-	24	5.0	-	13	11/25	-	-	4.1	-	9.7
5/25	-	8.7	-	-	-	12/2	-	-	2.3	-	9.9
6/1	-	5.3	-	-	-	12/9	-	-	-	2.8	7.0
6/8	-	7.7	-	-	-	12/16	-	-	2.7	-	11
6/15	-	9.5	-	-	6.2	12/23	-	-	2.4	6.8	9.6
6/23	-	9.6	-	-	8.6	12/30	-	-	-	4.7	10
6/29	-	4.2	-	-	-						

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-6

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES

KENNEWICK, WASHINGTON AND VICINITY, ZONE L - 1959

REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba-La^{140}$	$Zr-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$	Sample Date	$Ba-La^{140}$	$Zr-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0		2.0	2.0	2.0	1.5	5.0
1/7	5.7	63	11	-	69	7/15	-	-	-	-	-
1/14	5.9	76	9.8	-	92	7/22	-	-	-	-	-
1/21	6.9	100	16	2.4	110	7/29	-	-	-	-	-
1/28	5.6	110	16	-	110	8/5	-	-	-	-	-
2/4	6.5	130	26	3.4	150	8/12	-	-	-	-	-
2/11	4.2	130	22	1.6	170	8.19	-	-	-	-	-
2/18	-	37	21	-	140	8/26	-	-	-	-	-
2/24	2.8	100	21	-	100	9/2	-	-	-	-	10
3/3	-	98	20	-	90	9/10	-	-	-	-	-
3/11	2.0	100	22	-	94	9/16	-	-	-	-	-
3/23	-	160	33	-	120	9/23	-	-	-	-	7.2
3/31	-	100	22	-	88	9/30	-	-	2.3	-	-
4/1	-	52	8.7	-	42	10/7	-	-	-	-	-
4/8	2.0	44	9.5	-	38	10/14	-	-	-	-	-
4/15	-	11	2.8	-	12	10/21	-	-	-	-	-
4/22	-	14	3.1	-	11	10/28	-	-	-	-	7.3
4/29	-	6.0	-	-	-	11/4	-	-	-	-	-
5/6	-	6.9	2.7	-	7.0	11/11	-	-	-	-	-
5/13	-	6.6	2.5	-	-	11/19	-	-	3.1	-	-
5/20	-	14	3.9	-	8.9	11/24	2.4	-	-	-	-
5/27	-	11	-	-	7.5	12/1	-	-	-	-	-
6/3	-	6.0	-	-	5.0	12/8	-	-	2.2	-	-
6/10	-	14	3.7	-	11	12/15	-	-	4.3	-	6.8
6/17	-	6.4	-	-	5.2	12/22	-	-	-	-	7.6
6/24	-	2.1	-	-	-	12/29	-	-	3.4	1.8	9.9
7/1	-	3.4	-	-	-						
7/8	-	3.3	-	-	-						

* Analytical results below reporting limits are indicated by a (-).

APPENDIX C-7

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES

PASCO TO ELTOPIA, WASHINGTON, ZONE M - 1959

REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$	Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0		2.0	2.0	2.0	1.5	5.0
1/7	3.8	66	9.7	-	61	7/8	-	2.6	-	-	-
1/14	6.7	94	12	-	92	7/15	-	2.6	-	-	-
1/21	5.3	110	11	1.9	91	7/22	-	-	-	-	-
1/28	7.8	130	19	-	140	7/29	-	-	-	-	-
2/4	6.3	140	27	-	170	8/5	-	2.5	-	-	-
2/11	6.2	190	38	2.9	190	8/12	-	-	-	-	-
2/18	6.0	150	28	-	160	8/19	-	-	-	-	-
2/24	2.5	91	13	-	70	8/26	-	-	-	-	-
3/3	-	120	27	-	110	9/2	-	2.1	2.1	-	12
3/11	2.0	130	23	-	110	9/10	-	2.3	2.5	-	8.9
3/18	-	120	21	-	89	9/16	-	-	-	-	-
3/25	-	93	17	-	67	9/23	-	-	-	-	5.9
4/1	-	56	8.6	-	53	9/30	-	-	-	-	-
4/8	-	42	6.2	-	37	10/7	-	-	-	-	-
4/15	-	33	6.1	-	30	10/14	-	-	-	-	-
4/22	-	49	8.6	-	41	10/21	-	-	-	-	-
4/29	-	18	4.0	-	16	10/28	-	2.0	-	-	11
5/6	-	25	6.7	-	16	11/4	-	-	-	-	5.4
5/13	-	16	4.0	-	11	11/11	-	-	-	-	8.4
5/20	-	17	3.3	-	14	11/19	-	-	3.7	3.3	8.9
5/27	-	8.4	-	-	6.6	11/24	-	-	2.4	-	5.1
6/3	-	5.1	-	-	-	12/1	-	-	-	-	6.3
6/10	-	12	3.4	-	9.0	12/8	-	-	4.6	2.2	-
6/17	-	6.3	-	-	5.2	12/15	-	-	2.3	-	13
6/24	-	2.4	-	-	-	12/22	-	-	-	-	-
7/1	-	3.5	-	-	-	12/29	-	-	4.4	-	-

* Analytical results below reporting limits are indicated by a (-).

APPENDIX C-8

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
MESA, WASHINGTON AND VICINITY, ZONE N - 1959
REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba-La^{140}$	$Zr-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$	Sample Date	$Ba-La^{140}$	$Zr-Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0		2.0	2.0	2.0	1.5	5.0
1/7	4.6	65	12	-	69	7/8	-	3.9	-	-	-
1/14	5.2	78	11	-	87	7/15	-	6.1	-	-	-
1/21	3.7	75	7.8	-	58	7/22	-	3.4	-	-	-
1/28	5.9	110	22	-	130	7/29	-	-	-	-	-
2/4	7.8	140	28	-	170	8/5	-	-	-	-	-
2/11	7.8	170	31	-	110	8/12	-	-	-	-	-
2/18	4.9	150	32	-	170	8/19	-	-	-	-	-
2/24	2.1	100	20	-	110	8/26	-	-	-	-	-
3/3	4.7	140	28	-	130	9/2	-	-	2.5	-	5.7
3/11	-	140	28	-	130	9/10	-	4.5	5.0	-	18
3/18	2.2	160	29	-	100	9/16	-	-	-	-	6.0
3/25	-	150	20	-	95	9/23	-	-	-	-	-
4/1	-	38	6.8	-	33	9/30	-	-	-	-	-
4/8	-	28	4.2	-	18	10/7	-	-	-	-	-
4/15	-	27	4.3	-	22	10/14	-	-	-	-	8.9
4/22	-	14	3.5	-	15	10/21	-	-	2.6	-	-
4/29	-	15	3.3	-	11	10/28	-	-	-	-	-
5/6	-	16	3.4	-	11	11/4	-	-	2.4	-	-
5/13	-	23	3.2	-	15	11/11	-	-	-	-	15
5/20	-	13	2.9	-	12	11/19	-	-	-	1.8	7.0
5/27	-	4.1	-	-	-	11/24	2.0	-	-	-	8.0
6/3	-	4.8	-	-	-	12/1	-	-	-	-	5.2
6/10	-	9.8	2.1	-	7.9	12/8	-	-	-	-	12
6/17	-	3.4	-	-	-	12/15	-	-	2.1	-	-
6/24	-	5.1	-	-	-	12/22	-	2.4	4.3	-	14
7/1	-	5.5	-	-	-	12/29	-	-	5.4	-	9.7

* Analytical results below reporting limits are indicated by a (-).

APPENDIX C-9

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES

WAHLUKE SLOPE EAST, ZONE O - 1959

REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$	Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0		2.0	2.0	2.0	1.5	5.0
1/5	9.1	150	16	-	110	7/6	-	4.9	-	-	-
1/12	7.8	110	13	-	110	7/13	-	5.5	-	-	5.5
1/19	8.5	130	17	-	110	7/20	-	3.9	-	-	-
1/26	9.6	220	20	-	170	7/27	-	3.0	-	-	-
2/2	4.1	100	12	-	87	8/3	-	2.7	-	-	-
2/9	3.4	99	12	-	85	8/10	-	2.3	-	-	-
2/16	3.0	170	26	-	130	8/17	-	-	-	-	-
2/23	4.2	120	18	-	100	8/24	-	3.2	3.2	-	-
3/2	3.5	100	16	-	87	8/31	-	2.3	3.0	-	5.2
3/10	-	82	14	-	69	9/8	-	-	2.7	-	6.0
3/16	-	76	15	-	62	9/14	-	-	-	-	-
3/23	-	73	14	-	58	9/21	-	-	2.3	-	7.9
3/30	-	55	4.9	-	36	9/28	-	-	4.1	-	-
4/6	-	35	6.6	-	30	10/5	-	-	-	-	-
4/13	-	26	3.4	-	20	10/12	-	-	-	-	-
4/20	-	29	6.9	-	21	10/19	-	-	-	-	9.7
4/27	-	29	6.6	-	19	10/26	-	-	-	-	8.7
4/30	-	23	4.8	-	17	11/2	-	-	2.4	-	5.9
5/4	-	15	3.6	1.6	8.3	11/9	-	-	2.3	2.0	5.9
5/11	-	12	3.0	-	6.2	11/16	-	-	6.3	2.3	11
5/18	-	17	2.9	-	9.9	11/23	-	-	-	-	-
5/25	-	8.2	-	-	5.2	11/30	-	-	11	-	-
6/1	-	8.6	2.1	-	6.3	12/7	-	-	5.2	2.1	8.5
6/10	-	13	2.9	-	10	12/14	-	-	9.0	-	17
6/15	-	6.6	2.2	-	-	12/21	-	-	2.2	-	-
6/22	-	6.2	-	-	-	12/28	-	2.9	8.5	-	23
6/29	-	5.5	-	-	-						

* Analytical results below reporting limits are indicated by a (-).

APPENDIX C-10

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES

WAHLUKE SLOPE WEST, ZONE P - 1959

REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$	Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	$Ru^{103}+Ru^{106}$	I^{131}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	2.0	2.0	1.5	5.0		2.0	2.0	2.0	1.5	5.0
1/5/59	5.9	93	-	1.9	82	6/29	-	7.7	-	-	5.4
1/12	7.2	140	12	2.7	120	7/6	-	4.6	-	-	-
1/19	5.0	130	11	-	110	7/13	-	4.6	-	-	-
1/26	7.5	210	11	-	140	7/20	-	4.1	-	-	-
2/2	3.9	120	10	-	85	7/27	-	4.3	-	-	-
2/9	2.5	100	12	1.8	83	8/3	-	3.6	-	-	-
2/16	2.0	110	12	1.8	71	8/10	-	2.2	-	-	-
2/23	3.1	110	23	-	99	8/17	2.0	2.1	-	-	-
3/2	-	96	16	-	77	8/24	-	3.4	2.4	-	11
3/10	-	74	83	-	47	8/31	-	2.3	-	-	10
3/16	-	68	11	-	47	9/8	-	-	-	-	-
3/23	-	58	7.6	-	32	9/14	-	-	-	-	-
3/30	-	42	5.9	-	32	9/21	-	-	-	-	-
4/6	-	38	4.9	-	30	9/28	-	-	-	-	-
4/13	-	20	3.7	-	16	10/5	-	-	-	-	-
4/20	-	27	6.9	-	22	10/12	-	-	-	-	-
4/27	-	30	6.8	-	16	10/19	-	-	-	-	-
4/30	-	15	3.9	-	9.3	10/26	-	-	2.8	-	7.5
5/4	-	22	4.6	-	13	11/2	-	-	-	-	5.2
5/11	-	12	2.3	-	8.3	11/9	-	-	3.2	1.5	14
5/18	-	17	2.5	-	8.9	11/16	-	2.9	3.5	-	13
5/25	-	9.0	2.3	-	-	11/23	-	-	-	1.5	7.0
6/2	-	8.0	-	-	5.8	12/14	-	-	7.0	2.1	14
6/10	-	10	3.2	-	8.6	12/21	-	-	-	-	-
6/15	-	8.3	2.5	-	13	12/28	-	-	2.9	-	14
6/22	-	6.8	-	-	5.0						

* Analytical results below reporting limits are indicated by a (-).

APPENDIX C-11

CONCENTRATION OF SELECTED RADIONUCLIDES ON NATIVE GRASSES

HORSE HEAVEN HILLS, ZONE Q - 1959

REPORTED IN UNITS of 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	Ru^{103+} Ru^{106}	I^{131}	Ce^{141+} Ce^{144}	Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	Ru^{103+} Ru^{106}	I^{131}	Ce^{141+} Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0		2.0	2.0	2.0	1.5	5.0
12/22/58	17	97	13	-	100	7/9	-	3.4	-	-	-
12/30	8.7	61	9.8	-	58	7/16	-	-	-	-	-
1/15/59	9.0	120	22	-	160	7/23	-	-	-	-	-
1/22	10	120	25	1.7	130	7/30	-	4.7	-	-	5.0
1/29	11	190	31	-	180	8/6	-	-	-	-	-
2/5	4.1	140	25	3.0	140	8/13	-	4.2	-	-	-
2/12	5.4	120	23	-	120	8/20	-	-	2.5	-	-
2/19	4.5	170	35	-	160	8/27	-	2.6	-	-	12
2/26	-	97	21	2.4	100	9/3	-	-	3.1	-	6.5
3/5	4.4	180	31	-	170	9/11	-	-	-	-	5.2
3/12	-	180	35	-	150	9/17	-	-	-	-	5.3
3/26	-	120	22	-	90	9/24	-	-	-	-	-
4/1	-	48	8.2	-	41	10/1	-	-	4.8	-	5.8
4/9	-	49	10	-	46	10/8	-	-	-	-	6.9
4/16	-	37	8.3	-	30	10/15	-	-	-	-	8.8
4/23	-	29	5.5	-	21	10/22	-	-	-	-	-
5/7	-	8.7	2.6	-	8.2	10/29	-	-	-	-	5.7
5/14	-	15	2.7	-	7.7	11/5	-	-	-	-	7.6
5/21	-	13	3.1	-	7.8	11/11	-	-	-	-	8.7
5/27	-	15	2.9	-	8.0	11/19	-	-	2.4	2.0	-
6/4	-	9.7	2.1	-	5.9	11/23	-	-	2.1	-	5.6
6/11	-	7.7	2.0	-	7.9	12/2	-	-	3.6	-	-
6/18	-	5.1	-	-	-	12/9	-	-	3.0	-	5.5
6/25	-	-	-	-	-	12/16	-	-	2.0	-	11
7/2	-	2.4	-	-	-	12/23	-	-	-	3.1	16

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-12

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES WALLA WALLA, WASHINGTON AND VICINITY, ZONE R - 1959 REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	$Ru^{103}+$ Ru^{106}	I^{131}	$Ce^{141}+$ Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
12/9/58	29	74	13	-	120
1/13/59	14	130	29	-	180
2/10	8.6	160	29	-	170
3/10	3.4	280	45	-	250
4/15	-	23	5.6	-	20
4/28	-	33	7.2	-	27
5/19	-	21	5.1	-	12
7/8	-	2.8	-	-	-
8/18	-	7.9	4.9	-	27
9/1	-	-	4.3	-	8.0
10/6	-	-	-	-	-
10/27	-	-	-	-	-

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-13

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES LEWISTON, IDAHO AND VICINITY, ZONE S - 1959 REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	Ru^{103}+ Ru^{106}	I^{131}	Ce^{141}+ Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
1/13	31	240	55	-	330
2/10	5.5	120	27	-	140
3/10	2.4	250	45	-	210
4/15	-	27	4.5	-	19
4/28	-	21	3.8	-	13.7
5/19	-	12	2.4	-	9.9
7/7	-	7.8	-	-	5.3
8/18	-	4.4	-	-	7.8
9/1	-	-	4.6	-	7.9
10/6	-	-	-	-	7.7
10/27	-	-	-	-	-

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-14

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES

SPOKANE, WASHINGTON AND VICINITY, ZONE T - 1959

REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	Ba-La^{140}	Zr-Nb^{95}	Ru^{103}+ Ru^{106}	I^{131}	Ce^{141}+ Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
8/5/58	11	20	4.8	-	28
8/25/58	2.8	11	3.5	-	14
1/14/59	18	210	40	-	280
2/11	10	230	44	-	240
3/10	4.6	250	42	-	200
4/15	-	41	6.4	-	35
4/28	-	47	8.7	-	32
5/20	-	17	3.1	-	12
7/8	-	-	-	-	-
8/19	-	9.7	-	-	16
9/1	-	3.8	4.5	-	15
10/6	-	2.2	-	-	12
10/27	-	-	-	-	-

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-15

CONCENTRATION OF SELECTED RADIONUCLIDES ON NATIVE GRASSES RITZVILLE, WASHINGTON AND VICINITY, ZONE U - 1959 REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba-La^{140}$	$Zr-Nb^{95}$	$Ru^{103}+$ Ru^{106}	I^{131}	$Ce^{141}+$ Ce^{144}
Reporting Limits *	2.0	2.0	2.0	1.5	5.0
1/14	12	130	18	-	160
2/12	5.1	200	33	-	170
3/11	3.4	230	37	-	200
4/15	-	32	4.8	-	27
4/29	-	11	2.5	-	8.8
5/20	-	10	2.2	-	8.8
7/8	-	6.7	-	-	-
8/19	-	3.1	-	-	-
9/2	-	-	-	-	6.3
10/7	-	-	-	-	6.6
10/28	-	-	-	-	-

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-16

CONCENTRATION OF SELECTED RADIONUCLIDES ON NATIVE GRASSES TOPPENISH, WASHINGTON AND VICINITY, ZONE V - 1959 REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	Ru^{103}+ Ru^{106}	I^{131}	Ce^{141}+ Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
10/7/58	-	7.7	-	-	8.0
12/2/58	8.4	20	4.4	-	33
1/7/59	16	94	17	-	100
2/3	3.3	81	13	-	81
3/3	8.3	120	19	-	96
4/8	-	18	3.0	-	14
4/20	-	28	5.4	-	22
5/12	-	2.9	-	-	-
6/23	-	3.4	-	-	-
7/28	-	-	-	-	-
8/25	-	-	-	-	6.1
9/29	-	-	-	-	-
10/19	-	-	-	-	5.4
11/4	-	-	-	-	-
12/1	-	-	2.6	-	-

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-17

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
GOLDENDALE, WASHINGTON AND VICINITY, ZONE W - 1959
REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	$Ru^{103}+$ Ru^{106}	I^{131}	$Ce^{141}+$ Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
10/7/58	2.0	4.0	-	-	5.9
12/2/58	32	81	15	-	120
1/7/59	12	82	14	-	97
2/3	18	340	56	-	420
3/3	-	320	62	-	310
4/8	2.2	65	10	-	64
4/20	-	44	10	-	39
5/12	-	21	3.9	-	15
6/23	-	3.3	-	-	-
7/28	-	2.3	-	-	-
8/25	-	3.0	4.5	-	-
9/29	-	-	-	-	-
10/19	-	-	2.7	-	-
11/4	-	-	-	-	6.8
12/1	-	-	-	-	5.4

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-18

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
PORTLAND TO BONNEVILLE, OREGON, ZONE X - 1959
REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	Ba-La^{140}	Zr-Nb^{95}	Ru^{103+} Ru^{106}	I^{131}	Ce^{141+} Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
10/7/58	2.0	9.8	-	-	11
12/2/58	27	54	13	-	94
1/8/59	15	100	24	-	150
2/3	28	460	85	-	590
3/3	9.8	540	82	-	500
4/9	-	130	22	-	130
4/20	-	29	6.6	-	24
5/13	-	17	2.7	-	12
6/24	-	7.1	-	-	5.1
7/29	-	2.2	-	-	-
8/26	-	3.9	-	-	-
9/29	-	5.4	2.7	-	22
10/19	-	3.8	-	-	27
11/4	-	-	-	-	-
12/1	-	2.3	2.0	-	9.9

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-19

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES THE DALLES TO BOARDMAN, OREGON, ZONE Y - 1959 REPORTED IN UNITS OF 10^6 μc/g VEGETATION

Sample Date	$Ba\text{-}La^{140}$	$Zr\text{-}Nb^{95}$	Ru^{103}+ Ru^{106}	I^{131}	Ce^{141}+ Ce^{144}
Reporting Limits*	2.0	2.0	2.0	1.5	5.0
10/8/58	-	6.0	-	-	8.3
12/3/58	18	61	7.6	-	75
1/8/59	3.7	59	9.7	-	58
2/4	4.7	130	17	-	120
3/4	4.8	170	31	-	140
4/9	-	35	7.1	-	30
4/20	-	37	8.1	-	26
5/13	-	17	3.9	-	11
6/24	-	4.5	-	-	-
7/29	-	-	-	-	-
8/26	-	2.2	-	-	6.2
9/30	-	-	-	-	6.2
10/20	-	-	-	-	10
11/4	-	3.7	-	-	21
12/2	-	-	4.0	-	-

*Analytical results below reporting limits are indicated by a dash.

APPENDIX C-20

CONCENTRATIONS OF SELECTED RADIONUCLIDES ON NATIVE GRASSES
RIVERVIEW DISTRICT OF PASCO, WASHINGTON, ZONE Z - 1959
REPORTED IN UNITS OF 10^{-6} $\mu c/g$ VEGETATION

Sample Date	$Ba\text{-}La^{140}$	Zn^{65}	$Zr\text{-}Nb^{95}$	Cs^{137}	$Ru^{103}+Ru^{106}$	I^{131}	Cr^{51}	$Ce^{141}+Ce^{144}$
Reporting Limits*	2.0	1.5	2.0	1.0	2.0	1.5	5.0	5.0
12/31/58	9.5	-	58	3.4	8.7	-	-	66
1/7/59	6.0	-	50	4.5	10	-	-	66
1/14	9.9	-	61	6.4	11	-	-	87
1/21	9.5	4.1	110	9.1	19	-	-	130
1/28	4.1	5.6	74	4.7	15	-	-	78
2/4	5.1	-	39	7.9	26	3.4	-	150
2/11	6.1	1.5	110	7.1	21	-	-	110
2/18	5.1	2.9	140	14	26	-	-	150
2/24	5.1	4.8	120	7.8	22	-	-	120
3/3	6.4	6.1	160	9.2	31	-	-	130
3/11	3.0	4.5	200	9.0	39	-	-	160
3/18	-	2.2	160	9.1	30	-	-	130
3/25	14	9.1	200	14	40	-	-	150
4/1	-	2.3	49	3.8	9.2	-	-	41
4/9	-	1.8	47	4.5	10	-	-	40
4/15	-	1.7	14	1.9	2.2	-	-	-
4/22	-	3.0	11	1.3	3.0	-	-	9.1
4/29	-	1.8	4.1	-	10	-	-	-
5/6	-	1.5	7.2	-	2.2	-	-	-
5/13	-	-	7.1	-	-	-	-	5.0
5/20	-	-	8.3	-	-	-	-	-
5/27	-	-	8.5	-	-	-	-	-

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-20 (contd.)

Sample Date	$Ba-La^{140}$	Zn^{65}	$Zr-Nb^{95}$	Cs^{137}	Ru^{103+} Ru^{106}	I^{131}	Cr^{51}	Ce^{141+} Ce^{144}
Reporting Limits*	2.0	1.5	2.0	1.0	2.0	1.5	5.0	5.0
6/3	-	2.6	8.1	-	-	-	-	-
6/10	-	3.0	5.2	-	-	-	-	-
6/17	-	-	5.2	-	-	-	-	-
6/24	-	-	3.0	-	-	-	-	-
7/1	-	2.5	-	-	-	-	-	-
7/8	-	2.6	2.3	-	-	-	-	-
7/15	-	1.5	-	-	-	-	-	-
7/22	-	-	-	-	-	-	-	-
7/29	-	-	4.0	-	-	-	-	-
8/5	-	2.6	-	-	-	-	-	-
8/12	-	-	2.1	-	-	-	-	-
8/19	-	-	-	-	-	-	-	-
8/26	-	-	-	-	-	-	-	-
9/2	-	-	-	-	2.1	-	-	10
9/10	-	1.9	12	1.4	-	-	-	44
9/16	-	-	2.1	-	2.1	-	-	6.0
9/23	-	3.6	2.9	-	-	-	-	13
9/30	-	-	-	1.5	2.9	-	-	-
10/7	-	-	6.2	1.1	3.1	-	-	25
10/14	-	-	-	-	-	-	-	-
10/21	-	-	-	2.1	2.1	-	-	-
10/28	-	-	-	-	3.7	-	-	8.2
11/4	-	-	2.8	-	-	-	-	20
11/11	-	5.3	-	-	-	-	-	5.1
11/24	-	2.9	2.4	1.5	-	-	-	9.2
12/1	-	3.7	-	-	-	-	-	-
12/8	-	11.	-	-	-	-	-	10
12/15	-	-	3.1	1.9	4.4	-	5.1	18
12/22	-	3.4	-	-	-	-	-	-
12/29	-	-	2.0	-	3.8	1.7	-	15

* Analytical results below reporting limits are indicated by a dash.

APPENDIX C-21

QUANTITY OF I^{131} RELEASED

FROM THE SEPARATIONS AREAS' PROCESS STACKS - 1959

curies/day

Day of Month	January	February	March	April	May	June	July	August	September	October	November	December
1	0.03	2.6	0.47	0.14	1.5	0.63	0.69	0.61	0.41	0.95	0.96	0.22
2	0.023	2.8	0.29	0.34	1.4	0.81	0.46	0.61	0.52	0.28	0.92	1.2
3	0.023	1.2	0.43	0.20	1.4	0.99	0.46	0.64	0.38	0.28	0.82	0.29
4	0.023	0.68	0.23	0.20	1.7	1.8	0.34	0.57	0.40	0.28	0.89	0.45
5	0.24	0.80	0.21	0.19	0.33	2.3	0.33	0.55	0.40	0.25	0.21	0.87
6	0.25	0.72	0.33	0.22	0.66	2.3	0.28	0.69	0.29	0.30	0.92	0.87
7	0.31	0.72	0.33	0.58	0.80	2.3	0.23	1.5	0.28	0.34	1.6	0.92
8	0.54	0.72	0.33	0.64	1.5	2.5	0.27	2.8	0.29	0.24	1.6	1.2
9	0.53	0.27	0.22	0.87	1.7	1.2	0.23	2.8	0.44	0.47	2.0	1.6
10	0.53	0.79	0.48	1.0	1.7	1.0	0.20	0.50	0.35	0.48	2.0	0.45
11	0.53	0.42	0.43	1.6	1.4	0.84	0.19	0.65	0.40	0.47	0.95	0.52
12	0.52	0.11	0.32	1.6	1.3	0.99	0.19	0.24	0.41	0.19	0.82	0.52
13	0.68	0.008	0.60	1.2	1.1	0.99	0.39	0.33	0.41	0.27	1.0	0.51
14	0.34	0.009	0.70	1.5	1.2	0.93	0.37	0.22	0.28	0.49	1.0	0.49
15	1.1	0.010	0.70	1.0	1.3	0.87	0.37	0.21	0.093	0.60	1.0	0.77
16	0.27	0.020	0.84	1.0	0.78	0.83	0.33	0.21	0.41	0.51	1.2	0.99
17	0.003	0.030	0.84	1.1	0.79	0.65	0.34	0.23	0.50	0.51	1.3	1.0
18	0.004	0.019	0.31	1.4	0.76	0.63	0.38	0.20	0.80	0.52	1.3	0.87
19	0.42	0.029	0.58	1.4	0.40	0.62	0.38	0.55	0.83	0.33	0.48	1.2
20	0.45	0.042	0.42	1.2	1.5	0.59	0.34	0.53	0.83	0.58	0.96	1.2
21	0.61	0.042	0.43	1.0	1.3	0.59	1.0	0.84	0.95	0.37	0.96	1.2
22	0.81	0.051	0.43	0.61	1.1	0.73	0.87	0.88	0.72	0.58	0.98	7.4
23	0.90	0.084	0.43	0.67	1.1	0.55	0.65	0.89	1.1	0.44	1.4	1.6
24	0.65	0.060	0.36	2.6	1.0	0.66	1.1	0.94	0.72	0.60	1.5	1.1
25	0.65	0.11	0.61	2.6	0.25	0.71	1.1	0.89	1.4	0.60	0.51	1.1
26	0.62	0.74	0.36	2.6	0.22	0.64	1.1	0.89	1.4	0.64	0.52	1.5
27	0.72	0.47	0.06	2.5	0.16	0.43	0.77	0.59	1.4	0.77	0.43	1.5
28	0.99	0.46	0.06	1.4	0.26	0.43	0.73	0.83	0.64	0.87	0.35	1.5
29	1.4		0.06	1.4	0.37	0.16	1.4	0.79	0.49	1.4	0.35	1.2
30	1.9		0.01	1.7	0.65	0.10	0.93	0.80	10	1.5	0.33	1.1
31	2.6		0.03		0.65		0.61	0.34		0.96		1.2

APPENDIX C-22

CONCENTRATION OF I^{131} IN THYROID TISSUE OF JACK RABBITS* - 1959

Units - 10^{-6} μc I^{131}/g (wet)

Date	Number of Samples	Location**	Thyroid Average	Thyroid Maximum	Muscle Average
1/12	4	Zone J	1800	4100	6.5
1/12	4	E	1400	2600	9.1
1/13	2	O	960	1900	12
2/ 9	4	J	2700	4800	8.1
2/ 9	4	E	2000	3200	5.6
2/10	2	O	700	910	6.6
3/ 4	4	E	430	1000	9.7
3/ 5	4	O	880	1900	7.2
4/ 1	4	J	81	220	5.9
4/ 1	4	E	200	620	5.5
4/ 2	2	O	200	590	2.2
5/ 5	3	J	300	380	4.6
5/ 5	2	E	390	560	3.2
5/ 6	3	O	280	410	6.4
6/11	4	J	240	490	6.1
6/11	4	E	280	620	12
6/12	4	O	380	940	9.4
7/ 7	4	J	390	690	44
7/ 7	4	E	230	970	18
7/ 8	4	O	220	690	17
8/ 5	4	J	130	160	6.9
8/ 5	4	E	210	370	6.2
8/ 6	4	O	65	84	7.9
9/ 1	4	J	230	510	5.0
9/ 1	4	E	110	240	4.2
9/ 2	4	O	150	790	5.3
10/ 5	4	J	1400	2000	5.1
10/ 5	4	E	1800	4600	5.6
10/ 6	4	O	220	350	9.7
11/10	4	E	2200	3800	14
11/11	3	J	1300	2000	6.6
11/11	4	O	1300	4300	6.5
12/ 7	2	J	1800	2800	5.3
12/ 7	3	E	2600	6400	5.2
12/ 8	3	O	2000	2400	15

* Data provided by Radioecology Operation, W. C. Hansen

** Refer to Figure 12 in text

APPENDIX D-1

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN MILK PURCHASED FROM PRODUCERS AT SELECTED LOCATIONS - 1959

10^{-6} $\mu c/g$

Code	Date	K^{40}	Zn^{65}	Cs^{137}	Sr^{89}	Sr^{90}
Reporting Limits*		0.3	0.05	0.05	0.004	0.002
Riverview Irrigation District						
Farm 1						
54	1/ 5	0.81	-	-	-	0.0021
57	2/ 4	1.1	-	-	-	-
59	2/18	0.98	-	-	0.019	-
62	3/11	1.4	-	0.072	0.042	-
65	3/23	0.93	-	0.062	0.036	0.0070
69	4/ 1	1.2	-	0.066	0.062	0.0065
84	4/22	0.71	-	0.048	Lost	Lost
91	4/28	1.3	-	0.058	-	-
117	5/25	0.98	-	0.037	0.021	0.0029
121	6/24	0.84	-	0.036	0.0066	0.0024
Farm 2						
109	5/25	1.3	0.70	0.020	0.0094	0.0025
124	6/30	0.96	0.34	0.035	0.0080	0.0048
387	11/19	1.5	0.58	-	Analysis not Completed	
Ringold Farms						
Farm 1						
305	9/24	1.6	0.42	-	0.0060	0.0020

* Results less than the reporting limit are indicated by a (-).

APPENDIX D-1 (contd.)

Code	Date	K^{40}	Zn^{65}	Cs^{137}	Sr^{89}	Sr^{90}
Local Purchase - Commercial Milk						
Brand A						
55	1/14	0.76	-	0.028	0.0059	0.0038
56	2/ 3	0.75	-	0.022	0.0072	0.0028
58	2/17	0.74	-	0.028	0.0084	-
63	3/11	0.79	-	0.022	0.0040	0.0040
64	3/18	0.86	-	0.036	0.0080	0.0040
72	4/ 9	0.64	-	0.032	0.014	0.0040
74	4/16	1.1	-	0.040	Lost	Lost
82	4/22	0.81	-	0.036	0.027	-
114	5/25	1.1	-	0.036	Lost	Lost
327	9/29	1.2	-	0.024	-	0.0027
386	11/17	1.4	-	-	Analysis not Completed	
413	12/ 8	1.2	-	-	" " "	
Brand B						
88	4/27	1.2	-	0.032	Lost	Lost
110	5/25	1.0	-	0.036	0.018	0.0042
329	9/30	1.0	-	0.038	-	0.0020
382	11/17	1.5	-	0.040	-	0.0035
417	12/ 8	1.3	-	-	Analysis not Completed	
Brand C						
85	4/22	1.6	-	0.032	-	-
115	5/25	0.88	-	0.045	0.0072	0.004
230	8/19	1.4	-	-	-	0.002
325	9/29	1.2	-	-	0.0042	0.0038
384	11/17	1.4	-	0.026	Analysis not Completed	
415	12/ 8	0.92	-	-	" " "	

Results less than the reporting limit are indicated by a (-).

APPENDIX D-1 (contd.)

Code	Date	K^{40}	Zn^{65}	Cs^{137}	Sr^{89}	Sr^{90}
Reporting Limits*		0.3	0.05	0.02	0.004	0.002
Brand D						
90	4/27	1.4	-	0.043	-	-
116	5/25	0.96	-	0.029	0.0087	0.0050
331	9/30	1.4	-	-	0.0086	0.0036
419	12/ 8	0.93	-	-	Analysis not Completed	
Brand E						
89	4/27	1.2	-	0.033	0.014	-
111	5/25	1.0	-	0.036	0.029	0.0072
330	9/30	1.5	-	0.044	Analysis not Completed	
Brand F						
83	4/22	0.62	-	0.020	Lost	Lost
113	5/25	0.87	-	-	0.018	-
332	9/30	1.5	-	-	0.0080	0.0030
381	11/17	0.93	-	-	-	0.0040
418	12/ 8	1.0	-	-	Analysis not Completed	
Brand G						
101	5/19	1.2	-	0.025	Lost	Lost
112	5/25	1.2	-	0.058	0.019	0.0056
228	8/19	1.2	-	-	-	-
326	9/29	1.1	-	0.025	0.0086	0.0036
385	11/17	1.4	-	-	Analysis not Completed	
414	12/ 8	1.5	-	-	" " "	

*Results less than the reporting limit are indicated by a (-).

APPENDIX D-1 (contd.)

Code	Date	K^{40}	Zn^{65}	Cs^{137}	Sr^{89}	Sr^{90}
Reporting Limits*		0.3	0.05	0.02	0.004	0.002

Local Purchase - Coastal Origin - Commercial Milk

Brand H

Code	Date	K^{40}	Zn^{65}	Cs^{137}	Sr^{89}	Sr^{90}
66	3/31	1.3	-	0.073	0.012	0.007
71	4/ 9	Lost	Lost	Lost	-	-
81	4/22	0.98	-	0.091	Lost	Lost
107	5/25	1.0	-	0.091	0.086	0.018
125	6/30	0.77	-	0.080	0.035	0.013
163	6/30	1.5	-	0.084	0.018	0.0082
229	8/19	1.3	-	-	0.0035	0.0020
324	9/29	1.4	-	0.072	0.0097	0.0117
383	11/17	1.3	-	-	Analysis not Completed	
416	12/ 8	0.9	-	0.057	" " "	

*Results less than the reporting limit are indicated by a (-).

APPENDIX D-2

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN LOCALLY PURCHASED MODIFIED MILK - 1959

10^{-6} $\mu c/g$

Code	Brand	Date	Sc^{46}	K^{40}	Cs^{137}	I^{131}	Cr^{51}	$Ce^{141+144}$
Reporting Limits*			0.1	0.3	0.02	0.1	0.5	0.5
Condensed or Evaporated Milk								
450	C	12/23/59	-	3.0	0.17	-	-	-
451	J	12/23/59	-	1.7	0.041	-	-	-
452	K	12/23/59	-	2.7	0.081	-	-	-
453	L	12/23/59	-	2.8	0.13	-	-	4.6
Dry or Powdered Milk								
333	K	9/30/59	-	14	0.64	-	-	-
380	K	11/17/59	-	14	0.30	-	-	-
391	K	11/23/59	-	15	0.57	0.1	-	-
412	K	12/ 8/59	-	14	0.50	-	-	-
389	C	11/23/59	0.12	14	0.48	0.1	-	-
411	C	12/ 8/59	-	14	0.16	-	-	-
393	H	11/23/59	0.11	14	0.46	-	0.62	-
421	H	12/ 8/59	-	14	0.40	-	-	1.9
392	M	11/23/59	0.12	16	0.52	0.1	-	-
395	N	11/23/59	0.14	13	0.37	-	-	-

*Results less than the reporting limit are indicated by a (-).
No results for $Zr\text{-}Nb^{95}$ or $Ru^{103+106}$ were found above their respective reporting limits of 0.1 and 0.5 x 10^{-6} $\mu c/g$. The strontium analyses are not completed.

APPENDIX D-3

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN CEREAL CROPS PURCHASED FROM GROWERS AT SELECTED LOCATIONS - 1959 IN UNITS OF 10^{-6} $\mu c/g$

Code	Crop	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	$Zr^{95}-Nb^{95}$	Cs^{137}	Ru^{103+} Ru^{106}	I^{131}	Cr^{51}	Ce^{141+} Ce^{144}	Sr^{89}	Sr^{90}
Reporting Limits				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.01	0.006
Riverview Irrigation District														
146	Wheat	Hs	7/16	NA	7.3	1.9	1.3	-	1.1	-	0.98	1.8	0.083	0.036
169	"	Hs	7/22	"	4.7	1.8	0.63	-	0.53	-	-	0.58	0.036	0.012
170	Corn	Hs	7/22	"	2.8	1.7	-	-	-	-	-	4.4	-	-
194	"	Hs	8/10	"	2.7	1.2	-	-	-	-	-	1.1	-	-
206	"	Hs	8/19	"	-	-	-	-	-	-	-	-	-	-
238	"	Pr	8/27	"	3.1	2.2	-	-	-	-	-	-	-	-
240	"	Pr	9/ 1	"	2.7	1.6	-	-	-	-	-	-	-	-
244	"	Pr	9/ 9	"	2.1	1.6	-	-	-	-	-	-	Analysis not Complete	
247	Wheat	Cd	9/ 9	-	5.5	1.4	0.69	-	0.88	-	-	1.0	" " "	
282	Corn } - Replicate Samples	Br	9/17	-	3.2	-	-	-	-	-	-	-	-	-
283	"	Br	9/17	-	2.9	-	-	-	-	-	-	-	Not Analyzed	
284	"	Br	9/17	-	2.3	-	-	-	-	-	-	-	"	"
285	"	Br	9/17	-	2.7	-	-	-	-	-	-	-	"	"
286	"	Br	9/17	-	2.8	-	-	-	-	-	-	-	"	"
311	Milo	Hr	9/24	-	3.1	1.6	0.12	-	-	-	2.1	-	Analysis not Complete	
Ringold Farms														
173	Wheat	Ke	7/22	-	7.7	4.1	0.86	-	-	-	-	0.96	0.052	-
248	"	Me	9/ 9	-	5.6	2.4	0.70	0.15	1.3	-	-	-	Analysis not Complete	
262	Wheat } - Replicate Samples	Pr	9/17	-	3.8	1.4	-	-	-	-	-	0.82	0.014	-
263	"	Pr	9/17	-	3.4	1.2	-	-	-	-	-	0.97	-	-
264	"	Pr	9/17	-	3.4	1.3	-	-	-	-	0.50	1.0	-	0.006
265	"	Pr	9/17	-	3.9	1.4	-	-	-	-	-	1.3	-	-
266	"	Pr	9/17	-	4.0	1.1	-	-	-	-	-	2.8	0.010	-
Grain Elevator, Prosser, Washington														
61	Wheat 1957 Storage		2/26	NA	4.0	-	-	0.071	-	-	-	-	-	0.012
78	" " "		4/16	NA	3.0	-	-	0.063	-	-	-	-	-	0.008
79	" " "		4/16	NA	3.5	-	-	0.072	-	-	-	-	Lost	Lost

Results less than the reporting limit are indicated by a (-). NA - Not Analyzed

APPENDIX D-3 (contd.)

Code	Crop	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	$Zr^{95}-Nb^{95}$	Cs^{137}	$Ru^{103}+Ru^{106}$	I^{131}	Cr^{51}	$Ce^{141}+Ce^{144}$	Sr^{89}	Sr^{90}
Reporting Limits*				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.01	0.006
Benton City and Yakima Valley														
158	Wheat	Bc	7/16	NA	3.3	-	0.44	-	-	-	-	0.57	0.021	0.015
159	Rye	Bc	7/16	"	Lost	-	-	-	-	-	-	-	0.024	0.028
178	Wheat	Bc	7/22	-	3.7	-	0.44	-	-	-	-	0.78	0.023	0.016
322	Wheat	Bc	9/25	-	4.8	-	-	0.070	-	-	-	-	Analysis not Complete	
Finley District														
185	Barley	Sr	7/22	NA	4.8	-	0.22	-	-	-	-	-	"	" "
222	Corn	Cr	8/19	"	2.7	-	-	-	-	-	-	-	-	-
289	Milo } - Replicate Samples	Hs	9/18	-	3.7	-	0.14	-	-	-	-	-	Analysis not Complete	
290	"	Hs	9/18	-	4.1	-	0.14	0.054	-	-	0.80	1.0	Not Analyzed	
291	"	Hs	9/18	-	4.1	-	-	0.081	-	-	-	0.55	"	"
292	"	Hs	9/18	-	4.5	-	0.14	0.064	-	-	-	0.66	"	"
293	"	Hs	9/18	-	4.8	-	0.12	0.053	-	-	-	0.70	"	"
315	Milo	Hs	9/24	-	6.3	-	0.14	0.076	-	-	0.50	0.83	Analysis not Complete	
Walla Walla, Washington														
343	Wheat	Kr	10/ 6	-	3.9	-	0.71	0.42	2.8	-	2.1	3.5	"	" "
Spokane, Washington														
359	Wheat	Cr	10/ 6	-	3.7	-	0.98	0.25	2.5	-	-	4.4	"	" "
Pendleton, Oregon														
340	Barley	Hn	10/ 6	-	4.2	-	-	0.081	-	-	1.0	-	Not Analyzed	
341	"	Hn	10/ 6	-	4.0	-	-	0.052	-	-	-	-	Analysis not Complete	
342	"	Hn	10/ 6	-	4.4	-	-	-	-	-	-	-	Not Analyzed	

*Results less than the reporting limit are indicated by a (-). NA - Not Analyzed

APPENDIX D-4

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN VEGETABLES PURCHASED FROM GROWERS AT SELECTED LOCATIONS - 1959 IN UNITS OF 10^{-6} $\mu c/g$

Code	Crop	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	$Zr^{95}-Nb^{95}$	Cs^{137}	$Ru^{103}+Ru^{106}$	I^{131}	Cr^{51}	$Ce^{141}+Ce^{144}$	Sr^{89}	Sr^{90}
Reporting Limits				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.01	0.006
Riverview Irrigation District														
129	Beans St.	Hs	7/ 9	NA	1.6	-	-	-	-	-	-	-	Not Analyzed	
130	Cabbage	Hs	7/ 9	"	2.0	-	-	-	-	0.13	-	-	-	-
131	Potatoes	Hs	7/ 9	"	2.6	-	-	-	-	-	-	-	Not Analyzed	
132	Carrots	Hs	7/ 9	"	3.3	0.22	-	-	-	-	-	-	-	-
133	Beets	Hs	7/ 9	"	5.3	0.29	0.13	0.098	-	-	-	-	Not Analyzed	
134	Onions	Hs	7/ 9	"	1.0	-	-	-	-	-	-	-	"	"
135	Sugar beets	Hs	7/ 9	"	1.9	0.10	-	-	-	-	-	-	"	"
144	Potatoes	Hs	7/16	"	4.9	0.12	-	-	-	-	-	-	"	"
145	Carrots	Hs	7/16	"	3.9	0.12	-	-	-	-	-	-	"	"
147	Sugar beets	Hs	7/16	"	3.5	-	-	-	-	-	-	-	-	0.009
148	Beans	Hs	7/16	"	3.1	-	-	-	-	-	-	-	0.027	0.026
164	Beans	Hs	7/22	"	3.5	0.18	-	-	-	-	-	-	-	0.006
165	Carrots	Hs	7/22	"	4.5	-	-	-	-	-	-	-	0.010	-
166	Sugar beets	Hs	7/22	"	3.6	-	-	-	-	-	-	-	-	0.008
190	Carrots	Hs	8/10	"	4.4	0.18	-	-	-	-	-	-	-	0.009
191	Beets	Hs	8/10	"	3.0	-	-	-	-	-	-	-	-	0.009
192	Tomatoes	Hs	8/10	"	2.5	-	-	-	-	-	-	-	Not Analyzed	
193	Beans	Hs	8/10	"	5.4	0.15	-	-	-	-	-	-	-	-
205	Tomatoes	Hs	8/19	"	2.4	-	-	-	-	-	-	-	Not Analyzed	
207	Cabbage	Hs	8/19	"	3.5	0.12	-	0.077	0.61	-	1.6	0.82	"	"
208	Cucumber	Hs	8/19	"	2.1	0.94	-	-	-	-	-	-	"	"
209	Carrots	Hs	8/19	"	3.4	0.16	-	-	-	-	0.56	-	-	0.011
210	Beets	Hs	8/19	"	2.3	-	-	-	-	-	-	-	Not Analyzed	
219	Carrots	An	8/19	"	4.2	0.13	-	-	-	-	-	-	0.030	-
220	Cabbage	An	8/19	"	3.0	0.20	-	-	-	-	-	-	Not Analyzed	
221	Tomatoes	An	8/19	"	2.0	0.12	-	-	-	-	-	-	"	"
234	Squash	Pr	8/27	"	2.0	0.16	-	-	-	-	0.50	-	"	"
235	Tomatoes	Pr	8/27	"	3.1	0.20	-	-	-	-	-	-	"	"
236	Carrots	Pr	8/27	"	3.9	0.78	-	-	-	-	2.5	-	0.022	0.016
237	Okra	Pr	8/27	"	3.8	0.80	-	-	-	-	1.3	-	Not Analyzed	
277	Carrots (Replicate Samples)	Mr	9/17	-	4.2	-	-	-	-	-	-	-	"	"
278	" (Replicate Samples)	Mr	9/17	-	4.1	-	-	-	-	-	-	-	Lost	
279	" (Replicate Samples)	Mr	9/17	-	3.5	-	-	-	-	-	-	1.3	Lost	
280	" (Replicate Samples)	Mr	9/17	-	4.0	-	-	-	-	-	-	-	Not Analyzed	
281	" (Replicate Samples)	Mr	9/17	-	4.4	-	-	-	-	-	-	-	-	-
309	Squash	My	9/24	-	5.2	-	-	-	-	-	-	-	Not Analyzed	

APPENDIX D-4 (contd.)

Code	Crop	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95}-Nb^{95}	Cs^{137}	Ru^{103}+ Ru^{106}	I^{131}	Cr^{51}	Ce^{141}+ Ce^{144}	Sr^{89}	Sr[illegible]
Reporting Limits				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.01	0.007
Ringold Farms														
174	Carrots	Pr	7/22	NA	4.0	0.25	-	-	-	-	-	-	-	-
175	Beets	Pr	7/22	"	2.9	0.64	-	-	-	-	-	-	-	-
252	Turnips	Pr	9/17	-	5.5	0.87	-	-	-	0.29	-	1.0	Not Analyzed	
253	"	Pr	9/17	-	5.4	0.28	-	-	-	0.26	-	0.77	"	"
254	"	Pr	9/17	Lost	-	-	-	-	-	-	-	-	"	"
255	"	Pr	9/17	0.17	6.2	1.7	0.17	-	0.76	0.60	2.4	1.6	"	"
256	"	Pr	9/17	-	3.3	-	-	-	-	-	-	-	"	"
307	String beans	Pr	9/24	-	5.4	0.38	-	-	-	-	-	-	-	-
Benton City and Yakima Valley														
95	Asparagus	Bc	5/8	NA	2.9	-	-	-	-	-	-	-	Not Analyzed	
96	"	Gw	5/8	"	1.8	-	-	-	-	-	-	-	"	"
97	"	Ss	5/8	"	2.6	-	-	-	-	-	-	-	"	"
152	Beans	Bc	7/10	"	3.8	-	-	-	-	-	-	-	-	-
154	Potatoes	Bc	7/10	"	4.0	-	-	-	-	-	-	-	-	-
155	Carrots	Bc	7/16	"	3.5	-	-	-	-	-	-	-	-	-
180	Beans	Bc	7/22	"	3.6	-	-	-	-	-	-	-	-	0.0076
181	Potatoes	Bc	7/22	"	3.8	-	-	-	-	-	-	-	Not Analyzed	
182	Carrots	Bc	7/22	"	2.2	-	-	-	-	-	-	-	-	-
183	Beets	Bc	7/22	"	2.5	-	-	-	-	-	-	-	-	-
318	Cucumbers	Bc	9/25	-	1.7	-	-	-	-	-	-	-	Not Analyzed	
320	Cantaloupe	Ss	9/25	-	5.0	0.35	-	-	-	-	-	-	"	"
323	Beans	Bc	9/25	-	4.2	-	-	-	-	-	-	-	0.010	0.0089
Finley District														
98	Asparagus	Ha	5/8	NA	2.5	-	-	-	-	-	-	-	Not Analyzed	
138	Beets	Fy	7/10	"	3.3	-	-	-	-	-	-	-	-	-
139	Beans	Fy	7/10	"	2.2	-	0.30	-	-	-	-	-	0.022	0.017
160	"	Hs	7/17	"	2.7	-	-	-	-	-	-	-	0.013	0.013
184	Potatoes	Sr	7/22	"	4.0	-	-	-	-	-	-	-	-	-
186	Beets	Cs	7/22	"	2.6	-	-	-	-	-	-	-	Not Analyzed	
223	Tomatoes	Cs	8/19	"	2.5	-	-	-	-	-	-	-	"	"
224	Cabbage	Cs	8/19	"	1.7	-	-	-	-	-	-	-	-	-
226	Carrots	Cs	8/19	"	4.2	-	-	-	-	-	-	-	-	-
227	Cucumbers	Cs	8/19	"	1.8	-	-	-	-	-	-	-	Not Analyzed	
287	Squash	Vk	9/18	-	1.5	-	-	-	-	-	-	-	"	"
288	Squash	Vk	9/18	-	2.3	-	-	-	-	-	-	-	"	"
314	Carrots	Hs	9/25	-	4.1	-	-	-	-	-	-	-	-	0.0066

APPENDIX D-4 (contd.)

Code	Crop	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95}-Nb^{95}	Cs^{137}	Ru^{103+} Ru^{106}	I^{131}	Cr^{51}	Ce^{141+} Ce^{144}	Sr^{89}	Sr^{90}
Reporting Limits				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.01	0.00[illegible]
Walla Walla, Washington														
347	Romaine	Oe	10/ 6	-	4.2	-	-	-	-	-	-	-	Analysis not Complete	
348	Cabbage	Sr	10/ 6	-	2.6	-	-	-	-	-	-	-	Not Analyzed	
349	Radishes	Mo	10/ 6	-	3.1	-	-	-	-	-	-	-	"	"
Spokane, Washington														
350	Carrots	Sn	10/ 6	-	3.2	-	-	-	-	-	-	-	Analysis not Complete	
351	Lettuce	Ki	10/ 6	-	2.1	-	-	-	-	-	-	-	Not Analyzed	
352	Turnips	Ta	10/ 6	-	1.4	-	-	-	-	-	0.51	-	Analysis not Complete	
Local Purchase - California Grown														
67	Carrots		3/31	NA	2.8	-	-	-	-	-	-	-	0.4	-
68	Carrot tops		3/31	"	2.9	-	3.0	-	0.51	-	-	-	Not Analyzed	
70	Carrots		4/ 9	"	2.7	-	-	-	-	-	-	-	-	-
75	"		4/16	"	3.2	-	-	-	-	-	-	-	Not Analyzed	
76	Carrot tops		4/16	"	6.6	0.11	-	0.095	-	-	-	2.2	-	-
86	Carrots		4/22	"	2.2	-	-	-	-	-	-	-	-	-
87	Carrot tops		4/22	"	-	-	4.1	-	0.60	-	-	4.1	0.12	0.06
108	Carrots		5/25	"	2.5	-	-	-	-	-	-	-	-	-

Results less than the reporting limits are indicated by a (-). NA - Not Analyzed

APPENDIX D-5

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN FRUITS PURCHASED FROM GROWERS AT SELECTED LOCATIONS - 1959. IN UNITS OF 10^{-6} $\mu c/g$

Code	Crop	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95}-Nb^{95}	Cs^{137}	Ru^{103+} Ru^{106}	I^{131}	Cr^{51}	Ce^{141+} Ce^{144}	Sr^{89}	Sr^{90}
	Reporting Limits			0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.01	0.005
	Riverview Irrigation District													
122	Strawberries	Zn	6/29	NA	1.8	0.17	-	-	-	-	-	-	-	-
148	Boysenberries	Pr	7/16	"	3.0	0.23	-	-	-	-	0.90	-	-	-
167	Apricots	Hs	7/22	"	5.5	-	0.21	-	-	-	-	-	0.016	0.0067
168	Apples	Hs	7/22	"	1.4	-	-	-	-	-	-	-	-	-
217	Peaches	An	8/19	"	2.4	-	-	-	-	-	-	-	-	-
267	Grapes } - Replicate Samples	Ar	9/17	-	2.5	-	-	-	-	-	-	-	Analysis not Complete	
268	"	Ar	9/17	-	2.4	-	-	0.056	-	-	-	1.0	Not Analyzed	
269	"	Ar	9/17	-	2.4	-	-	-	-	-	-	1.6	"	"
270	"	Ar	9/17	-	2.3	-	-	-	-	-	-	-	"	"
271	"	Ar	9/17	-	2.6	-	-	-	-	-	-	-	"	"
312	Pears	Ar	9/25	-	2.0	-	-	-	-	-	-	-	-	-
	Ringold Farms													
150	Peaches	Ky	7/16	NA	2.3	-	-	-	-	-	-	-	-	-
151	Apricots	Ky	7/16	"	2.8	-	-	-	-	-	-	-	-	-
171	Peaches	Ky	7/22	"	2.0	0.11	-	-	-	-	-	-	-	-
172	Apricots	Ky	7/22	"	2.7	-	-	-	-	-	-	-	-	0.01[illegible]
195	"	Ky	7/22	"	2.7	-	-	-	1.9	-	-	-	-	-
196	"	Ky	7/22	"	5.3	-	0.12	-	-	-	-	1.4	-	-
212	Pears	Ky	7/22	"	1.6	-	-	-	-	-	-	-	Not Analyzed	
213	Apples	Ky	8/19	"	1.5	-	-	-	-	-	-	-	"	"
214	Plums	Ky	8/19	"	2.5	-	-	-	-	-	-	-	"	"
215	Peaches	Ky	8/19	"	2.5	-	-	-	-	-	-	-	-	-
308	Grapes	Pr	9/24	-	2.7	-	-	-	-	-	-	0.98	Not Analyzed	
	Benton City and Yakima Valley													
156	Peaches	Mg	7/17	NA	3.8	-	0.19	-	-	-	-	-	0.012	0.0081
157	Apricots	Dr	7/16	"	2.8	-	-	-	-	-	-	-	-	-
177	"	Er	7/22	"	3.1	-	0.10	-	-	-	-	-	0.011	0.0082
319	Apples	Se	9/25	-	1.8	-	-	-	-	-	-	-	Not Analyzed	

Results less than the reporting limit are indicated by a (-). NA - Not Analyzed

APPENDIX D-5 (contd.)

Code	Crop	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95}-Nb^{95}	Cs^{137}	Ru^{103}+ Ru^{106}	I^{131}	Cr^{51}	Ce^{141}+ Ce^{144}	Sr^{89}	Sr^{90}
Reporting Limits				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.01	0.006
Finley District														
161	Apricots	Ho	7/17	-	3.4	-	0.13	-	-	-	-	-	-	-
299	Grapes }	Hs	9/24	-	2.5	-	-	-	-	0.15	-	1.5	-	-
300	" }	Hs	9/24	-	2.8	-	-	0.063	-	0.11	-	0.63	Not Analyzed	
301	" } - Replicate	Hs	9/24	-	2.8	-	-	0.066	-	0.17	-	-	"	"
302	" } Samples	Hs	9/24	-	2.4	-	-	-	-	-	-	-	"	"
303	" }	Hs	9/24	-	2.4	-	-	-	-	-	-	-	"	"
Spokane, Washington														
353	Apples	Fz	10/ 6	-	1.3	-	-	-	-	-	-	-	Not Analyzed	
354	"	Ta	10/ 6	-	3.1	-	-	-	-	-	-	-	"	"
355	Peaches	Lr	10/ 6	-	3.3	-	-	-	-	-	-	-	Analysis not Complete	
Lake Bay, Washington														
200	Apples	Br	8/10	-	1.8	-	-	0.058	-	-	-	1.3	" "	"
Hanford Project														
203	Peaches	Da	8/17	-	1.9	-	-	-	-	-	-	-	" "	"

Results less than the reporting limit are indicated by a (-).

APPENDIX D-6

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN ALFALFA, HAY AND PASTURE GRASS PURCHASED FROM GROWERS AT SELECTED LOCATIONS - 1959. IN UNITS OF 10^{-6} $\mu c/g$

Code	Crop	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95}-Nb^{95}	Cs^{137}	Ru^{103}+ Ru^{106}	I^{131}	Cr^{51}	Ce^{141}+ Ce^{144}	Sr^{89}	Sr^{90}
Reporting Limits				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.01	0.006
Riverview Irrigation District														
80	Fresh Alfalfa	An	4/22	NA	5.3	0.48	9.4	0.40	2.3	-	-	6.8	0.20	0.023
92	" "	An	4/29	"	8.2	1.4	3.7	0.48	0.99	-	3.1	2.1	0.19	0.032
93	" "	An	5/ 6	"	10.	0.65	9.5	0.45	2.6	-	-	3.8	Not Analyzed	
99	" "	An	5/13	"	3.4	0.24	1.9	0.13	0.50	-	-	-	"	"
102	" "	An	5/20	"	6.8	0.93	6.5	0.53	1.1	-	-	6.7	-	-
106	" "	Hs	5/25	"	6.0	0.18	2.7	0.21	-	-	-	2.0	0.13	0.022
127	" "	An	7/ 8	"	4.7	1.2	0.22	0.10	-	-	2.8	0.72	-	0.0072
142	" "	An	7/15	"	3.0	3.1	2.0	-	1.1	-	10	1.4	0.020	0.025
143	" "	Hs	7/16	"	6.3	0.12	0.15	-	-	-	-	-	Not Analyzed	
189	" "	Hs	8/10	"	6.3	-	-	-	-	-	-	-	"	"
202	" "	An	8/12	"	6.7	0.36	-	-	-	-	1.2	0.67	"	"
211	" "	Hs	8/19	"	5.7	0.10	0.13	-	-	-	-	-	"	"
218	" "	An	8/19	"	7.8	2.2	0.17	-	0.85	0.27	8.9	3.5	0.093	-
231	" "	An	8/26	"	9.7	2.2	0.24	0.057	0.52	-	7.6	2.7	Not Analyzed	
233	Pasture Grass	Pr	8/27	"	10	8.0	0.49	0.14	-	-	25	-	"	"
240	Fresh Alfalfa	Pr	9/ 1	-	6.4	1.1	-	-	-	-	15	-	0.051	0.022
242	" "	An	9/ 2	0.16	5.6	2.8	-	-	-	-	10	-	0.036	0.020
249	" "	An	9/10	0.28	5.6	1.8	-	-	-	-	31	-	Not Analyzed	
251	" "	An	9/16	-	5.8	0.90	0.15	-	0.85	-	12	-	"	"
272	" " } Replica Samples	Pt	9/17	-	6.2	-	0.24	0.073	1.0	-	-	1.4	"	"
273	" " } Replica Samples	Pt	9/17	-	6.1	-	0.26	0.056	1.0	-	0.98	2.5	"	"
274	" " } Replica Samples	Pt	9/17	0.16	6.4	-	0.18	-	0.81	-	-	3.0	"	"
275	" " } Replica Samples	Pt	9/17	-	6.5	-	0.29	0.062	1.2	-	-	4.2	"	"
276	" " } Replica Samples	Pt	9/17	-	6.6	-	0.22	0.080	0.76	-	-	2.4	"	"
304	Alfalfa	An	9/23	0.34	11	0.36	0.36	0.067	1.7	-	32	1.3	Lost	Lost
310	Fresh Alfalfa	Pt	9/24	-	5.8	1.0	0.40	0.22	1.4	-	1.6	3.2	Lost	Lost
328	" "	An	9/30	0.23	8.1	2.2	0.20	-	0.85	1.3	3.7	1.8	Not Analyzed	
363	" "	An	10/14	0.27	6.0	2.2	0.20	0.10	1.1	-	1.3	3.7	Lost	
364	" "	An	10/21	0.18	6.3	1.7	0.26	0.061	1.3	0.28	7.5	1.9	Analysis not Complete	
365	" "	Pt	10/23	-	4.1	-	0.43	0.20	1.4	0.22	-	2.5	Lost	
374	" "	An	10.28	-	5.3	0.17	0.18	0.060	1.7	0.26	-	1.9	Analysis not Complete	

Results less than the reporting limit are indicated by a (-). NA - Not Analyzed

APPENDIX D-6 (contd.)

Code	Crop	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95}-Nb^{95}	Cs^{137}	Ru^{103}+ Ru^{106}	I^{131}	Cr^{51}	Ce^{141}+ Ce^{144}	Sr^{89}	Sr^{90}
Reporting Limits				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.01	0.006
Ringold Farms														
216	Fresh Alfalfa	Pr	8/19	NA	7.2	0.16	0.13	-	-	0.39	-	0.89	Not Analyzed	
257	" " (Replicate Samples)	Pr	9/17	0.15	6.5	1.4	0.17	-	-	-	5.0	-	0.073	-
258	" " (Replicate Samples)	Pr	9/17	-	5.8	1.3	0.15	-	-	0.37	3.5	0.77	0.052	0.008
259	" " (Replicate Samples)	Pr	9/17	0.13	5.6	1.4	0.15	-	-	-	4.4	1.3	0.050	0.017
260	" " (Replicate Samples)	Pr	9/17	0.20	6.4	1.7	0.13	-	-	-	6.0	0.70	0.074	-
261	" " (Replicate Samples)	Pr	9/17	0.13	6.4	1.2	0.15	0.079	0.67	0.58	2.3	4.2	Analysis not Complete	
316	Alfalfa	Pr	9/24	0.14	12	2.1	0.21	0.054	1.2	-	7.2	1.7	Lost	Lost
367	Fresh Alfalfa	Ke	10/23	0.16	5.3	0.32	0.20	0.20	1.1	0.27	1.8	1.2	Analysis not Complete	
Benton City and Yakima Valley														
104	Fresh Alfalfa	Gv	5/22	NA	5.8	0.11	2.5	0.28	0.84	-	-	1.4	-	-
105	" "	Sa	5/22	"	7.4	0.15	3.7	0.27	0.70	-	-	2.7	Not Analyzed	
153	Dry Hay	Bc	7/22	"	24	-	3.8	-	2.7	-	-	6.4	0.19	0.14
179	" "	Bc	7/22	"	23	-	1.7	-	-	-	-	2.3	-	Lost
321	Fresh Alfalfa	Bc	9/25	-	9.6	-	0.12	-	0.53	-	-	0.87	Analysis not Complete	
368	" "	Bc	10/23	-	5.2	-	0.14	0.14	0.82	0.27	0.98	1.1	Lost	Lost
378	" "	Bc	11/ 2	0.18	4.8	-	0.17	0.17	0.96	0.32	1.0	1.7	Analysis not Complete	
Finley District														
103	Fresh Alfalfa	Sp	5/22	NA	6.0	-	6.0	0.43	1.0	-	-	4.9	-	-
140	" "	Sp	7/10	"	4.2	-	0.32	-	-	-	-	0.62	0.037	0.035
162	Dry Hay	Sp	7/17	"	21	-	3.4	-	2.5	-	-	2.5	0.071	0.290
187	Fresh Alfalfa	Sp	7/22	"	8.5	-	-	-	-	-	-	-	-	0.019
225	" "	Sp	8/19	"	7.3	-	0.27	-	-	-	-	-	0.036	0.021
294	Alfalfa (Replicate Samples)	Sp	9/19	-	5.5	-	0.59	0.12	1.1	-	-	1.9	0.037	0.040
295	" (Replicate Samples)	Sp	9/18	-	12	-	0.40	0.45	1.5	-	-	2.0	Not Analyzed	
296	" (Replicate Samples)	Sp	9/18	-	14	-	0.44	0.17	1.7	-	-	3.7	" "	
297	" (Replicate Samples)	Sp	9/18	-	17	-	0.63	0.23	2.0	-	-	3.0	" "	
298	" (Replicate Samples)	Sp	9/18	-	14	-	0.46	0.15	1.8	-	-	3.4	" "	
313	"	Sp	9/24	-	10	-	1.2	0.21	2.4	-	-	5.9	Analysis not Complete	
366	Fresh Alfalfa	Sp	10/23	-	4.9	-	0.30	0.14	1.5	0.15	-	2.1	" " "	

Results less than the reporting limit are indicated by a (-). NA - Not Analyzed

APPENDIX D-6 (contd.)

Code	Crop	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95}-Nb^{95}	Cs^{137}	Ru^{103+} Ru^{106}	I^{131}	Cr^{51}	Ce^{141+} Ce^{144}	Sr^{89}	Sr^{90}
Reporting Limits				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5	0.01	0.006
Walla Walla, Washington														
344	Alfalfa	Dr	10/ 6	-	10	-	0.30	0.10	1.3	-	-	1.8	Analysis not Complete	
346	"	Zo	10/ 6	-	15	-	0.17	0.12	1.6	-	-	1.4	" " "	
Spokane, Washington														
356	Fresh Alfalfa	Fe	10/ 6	-	6.1	-	0.58	0.16	1.6	-	-	2.2	" " "	
357	" "	Le	10/ 6	-	4.4	-	1.1	0.24	2.6	-	-	4.1	" " "	
358	Alfalfa	Cb	10/ 6	-	11	-	0.57	0.085	1.8	-	-	2.0	" " "	
Pendleton, Oregon														
334	Alfalfa	Bn	10/ 6	-	23	-	0.73	0.29	2.1	-	-	3.4	Lost	
335	"	Bn	10/ 6	-	20	-	0.61	0.29	1.8	-	-	2.1	Not Analyzed	
336	"	Bn	10/ 6	-	20	-	0.57	0.28	2.2	0.53	-	3.0	" "	

Results less than the reporting limit are indicated by a (-).

APPENDIX D-7

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN MISCELLANEOUS LOCALLY PURCHASED FOODSTUFFS* - 1959

10^{-6} $\mu c/g$

Code	Type	Location Code	Date	Sc^{46}	K^{40}	Zn^{65}	Zr^{95}-Nb^{95}	Cs^{137}	Ru^{103}+ Ru^{106}	I^{131}	Cr^{51}	Ce^{141}+ Ce^{144}
Reporting Limits				0.1	0.3	0.1	0.1	0.05	0.5	0.1	0.5	0.5
Meat												
388	Ground Beef	Brand A	11/23	-**	2.0	-	0.32	-	-	-	-	-
390	Ground Beef	Brand B	11/23	-	1.8	-	0.32	-	-	-	-	-
394	Ground Beef	Brand C	11/23	-	2.2	-	-	0.064	-	-	-	-
396	Ground Beef	Brand D	11/23	-	2.6	-	0.33	-	-	-	-	-
Canned Baby Food - Strained												
429	Pork	Brand A	12/10	-	1.8	-	-	0.082	-	-	-	-
430	Beef	Brand A	12/10	-	2.0	-	-	0.072	-	-	-	-
431	Lamb	Brand A	12/10	-	1.6	-	-	0.13	-	-	-	-
432	Chicken	Brand A	12/10	-	0.82	-	-	-	-	-	-	-
434	Peas	Brand A	12/10	-	0.67	-	-	-	0.61	-	-	-

* Strontium analyses are not complete for meat and canned baby food.

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