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EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD JANUARY - JUNE, 1965

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EVALUATION OF RADIOLOGICAL CONDITIONS
IN THE VICINITY OF HANFORD
JANUARY - JUNE, 1965

By

The Environmental Studies and Evaluation Staff
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Edited by R. H. Wilson
Radiation Protection Department

November, 1965

PACIFIC NORTHWEST LABORATORY
RICHLAND, WASHINGTON

Printed in USA. Price \$2.00. Available from the
Clearinghouse for Federal Scientific and Technical Information
National Bureau of Standards
U. S. Department of Commerce
Springfield, Virginia

SUMMARY STATEMENT

The evaluation of results obtained from the Hanford environmental surveillance program for the period of January - June, 1965, indicates that most of the environmental radiation exposure for the majority of persons living in the neighborhood of the Hanford project was due to natural sources and world-wide fallout rather than to Hanford operations.

Of the low-level wastes that are released to the environment from the Hanford plants, neutron-induced radionuclides present in reactor cooling water discharged to the Columbia River continued to be the source of greatest potential exposure to people in the environs. The primary pathways of exposure from this source are drinking water derived from the river, consumption of fish and waterfowl which inhabit the river, and foodstuffs grown on land irrigated with water pumped from the Columbia downstream from Hanford.

Residents of Richland are supplied with drinking water from a treatment plant that draws water from the Columbia River. The radiation exposure from drinking this water was estimated to be about 9% of the appropriate limit for the 12 mo period ending June, 1965. The gastrointestinal (GI) tract is the limiting organ for the mixture of radionuclides present in drinking water pumped from the Columbia River. In Pasco and Kennewick, which are further downriver, the estimated exposures from drinking water were respectively about 5% and less than 1% of the limit for the GI Tract. The only persons who received radiation exposures attributable to Hanford that were greater than those that resulted from the drinking water were the people who ate local fish or waterfowl or who regularly consumed produce from nearby farms irrigated with water taken from the Columbia River below the reactors.

The highly unlikely, but plausible combination of circumstances that would result in the greatest exposure to an individual from the radionuclides released by the Hanford plants is postulated as:

The consumption of some 200 meals per year of fish caught downstream from the reactors

- The consumption of meat, milk, fruit, and vegetables grown on irrigated farms in the Riverview District
- The consumption of drinking water from the Pasco system.

During the calendar year 1964, an individual with such habits could conceivably have ingested enough radioactive materials of Hanford origin (mostly P^{32}) to supply about 23% of the annual permissible amount. For this "maximum" individual the bone is the most restrictive organ. This same individual could also have ingested enough Sr^{90} of world-wide fallout origin to equal about 2% of the permissible amount.

I^{131} in the Hanford environs remained at very low concentrations in the first half of 1965. The Chinese nuclear test on May 14, 1965 caused a brief increase in I^{131} , but concentrations soon returned to the low levels experienced during most of 1964. The postulated "maximum" exposure from I^{131} to the thyroid of a small child during 1964 amounted to only about 5% of the Radiation Protection Guide recommended for individuals by the Federal Radiation Council.

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EVALUATION OF RADIOLOGICAL CONDITIONS IN THE VICINITY OF HANFORD

January - June, 1965

INTRODUCTION

Results of the Hanford Environmental Surveillance Program for the first half of 1965 are summarized in this report. Data collected for this reporting period have been added to charts that show the results of measurements from previous years so that trends will be apparent.

On January 4, 1965, the responsibility for the Environmental Surveillance Program was transferred from the General Electric Company to the Pacific Northwest Laboratory of the Battelle Memorial Institute when the latter assumed operational responsibility of the Hanford Laboratories. Also at that time, as part of the Hanford segmentation program, the United States Testing Company assumed responsibility for analyses of routine environmental samples. Many of the environmental sampling programs conducted by Battelle Northwest were temporarily reduced or curtailed during the early part of the year to allow the new United States Testing Company laboratory to reach full capability. By April a major portion of the sampling program was back on normal schedule.

Evaluations of environmental exposure are compared with the guides for exposure and permissible rates of intake of specific radio-nuclides that are recommended by the Federal Radiation Council (FRC).⁽¹⁻³⁾ The National Committee on Radiation Protection and Measurements (NCRP),⁽⁴⁾ and the International Commission on Radiation Protection (ICRP).⁽⁵⁾ Full evaluation of the data presented for the first half of 1965 is not attempted in this report; however, a comprehensive evaluation is made each year (BNWL-90, Evaluation of Radiological Conditions in the Vicinity of Hanford - 1964).⁽⁶⁾

The term "reporting limit" is used on some of the figures in this report to provide some indication of the analytical reliability of the data.

The analytical detection limit for a specific radionuclide varies with sample type, sample size, counting time, and the amounts of interfering radionuclides present. The "reporting limits" were chosen to represent upper bounds to these fluctuating detection limits. Figures 1 and 2 show the relationship of the Hanford project to the Pacific Northwest and the surrounding communities.

ENVIRONMENTAL CONDITIONS

The radionuclides of particular interest during the first half of 1965 continued to be Sr^{90} , I^{131} , P^{32} , Zn^{65} , Cr^{51} , As^{76} , and Np^{239} . World-wide fallout contributed essentially all of the Sr^{90} and most of the I^{131} while the other nuclides were primarily associated with reactor effluent water. The radiation exposures estimated for people living in the neighborhood surrounding Hanford during 1964⁽⁶⁾ are presented in Figures 3 through 6, for the total body, bone, GI tract, and thyroid. These figures represent the dose in mremms or in percent of the maximum permissible rate of intake (MPRI) for a "maximum" individual and for the average Richland resident. Various recommended exposure limits are indicated and several sources of exposure are identified. The hypothetical "maximum" individual has been assigned dietary and other habits that would result in what would seem the largest possible rational exposure. The "average" Richland resident is assumed to have "average" dietary habits and no unusual living habits. Essentially all of his foodstuffs are purchased from commercial outlets.

RADIONUCLIDES IN THE COLUMBIA RIVER

Hanford's production reactors use Columbia River water for cooling. The concentrations of the more important radionuclides released to the river with reactor effluent have been measured extensively at Pasco for several years. In the latter part of 1963, the emphasis on measurement of radioactive materials in the Columbia River was shifted to Richland when their new water treatment plant was put into operation. The seasonal variation in concentrations of radionuclides in river water (Figure 7) are due primarily, but not exclusively, to changes in the river flow rate (Figure 8).

FIGURE 1
Geographical Relationship
of Hanford Works to Pacific Northwest

FIGURE 2

Features of Hanford Project and Vicinity

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FIGURE 3
Calculated Dose to Total Body, 1964

FIGURE 4
Calculated Dose to Bone, 1964

FIGURE 5
Calculated Dose to GI Tract, 1964

FIGURE 6
Calculated Dose to Thyroid, 1964

FIGURE 7
 Concentrations of Radionuclides in Columbia River Water
 at Pasco and Richland, Washington

FIGURE 8
Columbia River Flow at Richland and Bonneville Dam

The rates of transport of certain nuclides, shown in Figure 9, are obtained by multiplying the concentration of the nuclides in the river water by the river flow rate.

RADIONUCLIDES IN DRINKING WATER

The city of Richland is the first community downstream from the Hanford reactors that uses the Columbia River as a source of sanitary water. The cities of Pasco and Kennewick, a few miles further downstream, also use the river as a source for their sanitary supply. The average concentrations of several radionuclides measured in the sanitary water of Richland, Pasco, and Kennewick are summarized in Table I for the first half of 1965.

The concentrations of short-lived radionuclides in the sanitary water at the time it is consumed are less than those shown in Table I because of the flow time through the distribution system between the treatment plant and the consumer. The flow time may vary from a few hours to days, depending upon water use and location of the customer on the distribution system. Lower concentrations of radionuclides are measured in the Kennewick sanitary water than in Pasco water because of the difference in the water systems of the two cities. Kennewick uses a system of "Raney well" collectors located along the river bank, and the river water passes through several feet of river bottom silt before collection by the wells. The Richland and Pasco water treatment plants treat water drawn directly from the river. The municipal water systems of the three cities using Columbia River water serve a total of approximately 20,000 dwellings.

The calculated dose to the GI tract, total body, thyroid, and percentage of MPRI for bone from drinking water for a 12 mo period ending June 30, 1965 is presented in Table II.

Figure 10 shows the estimated GI tract dose at Pasco for the past several years and at Richland beginning in June, 1964.

FIGURE 9

Rate of Transport of Radionuclides at Pasco and Richland, Washington

TABLE I
CONCENTRATION OF SEVERAL RADIONUCLIDES
MEASURED IN SANITARY WATER

January - June 1965 (pCi/liter)			
Radionuclide	Richland	Pasco	Kennewick
Total Beta	(7.7)*	(2.6)*	(0.5)*
RE + Y	100	40	-
Na ²⁴	2600	800	100
P ³²	20	20	10
Cr ⁵¹	6400	4300	1300.
Cu ⁶⁴	1200	150	60
Zn ⁶⁵	170	110	<20
As ⁷⁶	240	90	<60
Sr ⁹⁰	1	1	<1
I ¹³¹	8	6	<3
Np ²³⁹	1900	1200	80

* Units of c/m per milliliter

TABLE II
CALCULATED DOSE FOR SELECTED ORGANS
FROM ROUTINE INGESTION OF SANITARY WATER

July 1964 - June 1965				
	GI Tract* mrem	Total Body* mrem	Bone* % MPRI	Thyroid** mrem
Richland	43	3	<1	50
Pasco	15	2	<1	35
Kennewick	<5	<1	<0.1	<20

* The "standard man" water intake of 1.2 liters per day was used in this calculation.

** The radiation dose is estimated for a 2 g thyroid of a small child and an average intake of 1 liter per day.

FIGURE 10

Calculated Dose to GI Tract from Pasco and Richland Sanitary Water

RADIONUCLIDES IN FISH AND WATERFOWL

The Columbia River provides popular sports fishing areas both above and below the Hanford reservation where many species of fish may be caught. Those fish that feed downstream from the reactors acquire some radionuclides from the reactor effluent. The two principal nuclides found in fish are P^{32} and Zn^{65} , but the levels vary according to species and season of the year. Whitefish are the game fish that usually contain the highest concentration of P^{32} (Figure 11); in addition they may be caught during the winter months when other sports fish are very difficult to sample. The levels of P^{32} measured during the first half of 1965 were lower than observed during either 1963 or 1964, particularly during the early spring season.

FIGURE 11
 P^{32} in Whitefish Caught in Columbia River
 Between Ringold and Richland

No new data were obtained for waterfowl since hunting is prohibited during the time of year covered by this report.

RADIONUCLIDES IN MARINE ORGANISMS

Zn^{65} and P^{32} are the only two radionuclides of Hanford origin that are found in sufficient abundance beyond the mouth of the Columbia River to be of radiological interest. Of the common seafood organisms, oysters have been found to contain the highest concentrations of Zn^{65} . Samples of oysters are obtained regularly from the Washington Coast for radioanalysis (Figure 12). Concentrations of Zn^{65} in oysters during the first half of 1965 do not appear to be following the gradual decrease noted in 1964. Concentrations of P^{32} , however, have followed the previously observed levels and seasonal trends.

RADIONUCLIDES IN THE ATMOSPHERE

Hanford gaseous waste is released to the atmosphere through 200 ft high stacks after removal of the majority of the radioactive materials. The radionuclide of primary interest in the separations facilities effluent gases is I^{131} . The principal sources of radioactive particulate material in the local environs are world-wide fallout and natural radioactive substances. An extensive network of air sampling stations is maintained around the Hanford project perimeter to sample for I^{131} and radioactive particulates. Routine measurements of I^{131} in air at the Tri-Cities of Richland, Pasco, and Kennewick, and at Benton City during the 12 mo ending June 30, 1965, averaged less than the detection limit of 0.02 pCi/m^3 air. A sustained concentration of I^{131} at this detection level in inspired air would result in an annual radiation dose to the thyroid of a "standard man" of less than 1 mrem.

The gross beta activity measured on air filter samples collected from eastern Washington and northern Oregon was generally below $0.5 \text{ pCi } \beta/\text{m}^3$ of air during the first half of 1965 (Figure 13). The slight increase to $0.5 \text{ pCi } \beta/\text{m}^3$ noted in March was attributed to the seasonal influx of world-wide fallout. Peak values of $1 \text{ pCi } \beta/\text{m}^3$ were noted on samples collected in mid-June following the Chinese nuclear test of May 14, 1965.

FIGURE 12
 Zn^{65} and P^{32} in Willapa Bay Oysters

FIGURE 13
Concentrations of Radioactive Particulates
in the Air in the Hanford Environs

RADIONUCLIDES IN MILK AND AGRICULTURAL PRODUCE

Milk and farm products that are produced locally may contain radionuclides derived from airborne materials or from irrigation water drawn from the Columbia River below the Hanford reactors.

The comprehensive milk surveillance program includes samples from local farms and dairies and from commercial supplies available in local stores. Concentrations of I^{131} measured in locally produced milk are shown in Figure 14. Following the Chinese nuclear test of May 14, 1965, concentrations of I^{131} in both local and commercial milk increased with the maximum being 23 pCi/liter in local milk on June 29 and 20 pCi/liter in milk from the Puget Sound area on June 1. Sr^{90} from a world-wide fallout measured in local farm and commercial milk supplies is shown in Figure 15.

Milk from local farms where pasture land is irrigated with water drawn from the river downstream from Hanford reactors contain P^{32} and Zn^{65} . Figures 16 and 17 show the average concentrations of these nuclides in milk collected from such irrigated areas during the first half of 1965. Seasonal fluctuations, caused primarily by irrigation and feeding practices, followed the trends expected for this period of the year.

Concentrations of I^{131} measured in samples of vegetables and fruit collected during the first half of 1965 were at or below the detection level of 0.05 pCi/g.

CONCENTRATIONS OF I^{131} IN CATTLE THYROIDS

Beef cattle thyroids are collected periodically by cooperating veterinarians from slaughter houses in Moses Lake, Toppenish, Walla Walla, Wenatchee, and Pasco, Washington, and Klamath Falls, Oregon, for radioanalysis at Hanford. Sampling at Klamath Falls for beef thyroids was started in May of this year. During the early part of 1965, I^{131} concentrations in beef thyroids were generally below the reporting level of 5 pCi/g and only a very few samples approached or exceeded the level of 10 pCi/g

FIGURE 14
 I^{131} in Locally Produced Milk

FIGURE 15
 Sr^{90} in Locally Produced Milk

FIGURE 16
 P^{32} in Locally Produced Milk

FIGURE 17
 Zn^{65} in Locally Produced Milk

(Figure 18). Sharply increased concentrations of I^{131} were noted during the latter part of May following the Chinese nuclear test. The maximum concentrations measured were 150 pCi/g in a sample collected on June 7 at Pasco and 140 pCi/g in a sample collected on May 29 from Moses Lake.

EXTERNAL RADIATION

Ionization chambers are stationed on the Hanford reservation and are submerged in the Columbia River at several locations to measure the gamma radiation dose. Measurements taken in air indicated the exposure for the first half of 1965 averaged approximately 0.3 mR/day (Figure 19) in the vicinity of the Hanford project.

Radiation measurements taken in the Columbia River near Richland indicated the immersion dose averaged 2.4 mR/day, principally from Na^{24} introduced into the river with reactor effluent water.

FIGURE 18
Average Concentrations of I^{131} in Beef Cattle Thyroids

FIGURE 19

External Dose Rate as Measured
at Hanford External Dose Test Location

CONCLUSIONS

Surveillance of the Hanford environs during the first half of 1965 showed that the amounts of radioactive materials present during this period were well within the nationally accepted limits at all times and that releases of radioactive materials from the Hanford plant were adequately controlled. P^{32} released with Hanford effluent in the Columbia River continued to be the radioisotope that contributed the most exposure to individuals who ate locally caught fish in quantity.

REFERENCES

1. "Background Material for the Development of Radiation Protection Standards, Report No. 1," Staff Report of the Federal Radiation Council. May, 1960.
2. "Background Material for the Development of Radiation Protection Standards, Report No. 2," Staff Report of the Federal Radiation Council. September, 1961.
3. "Estimates and Evaluation of Fallout in the United States from Nuclear Weapons Testing Conducted Through 1962, Report No. 4," Staff Report of the Federal Radiation Council. May, 1963. Also as "Radiation Protection Guidance for Federal Agencies, Memorandum for the President," Federal Register. May 18, 1960.
4. "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure," NBS Handbook, No. 69, pp. 1-95. June 5, 1959. Published by Superintendent of Documents, U.S. Government Printing Office, Washington D. C.
5. "Report of ICRP Committee II on Permissible Dose for Internal Radiation (1959), with Bibliography for Biological, Mathematical and Physical Data," Health Phys., vol. 3, pp. 1-380. 1960.
6. R. H. Wilson. Evaluation of Radiological Conditions in the Vicinity of Hanford for 1964, BNWL-90. July, 1965.

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