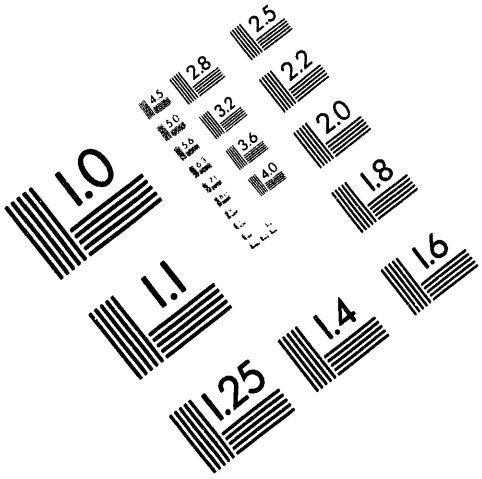

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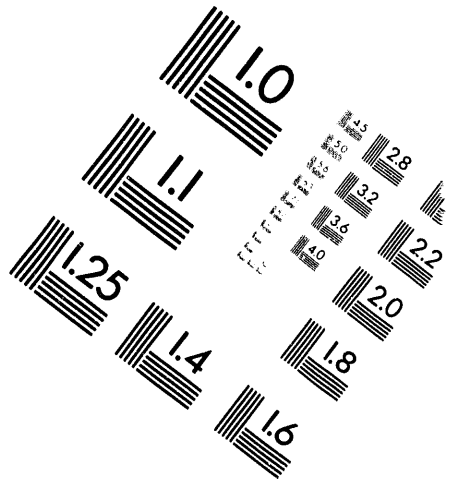

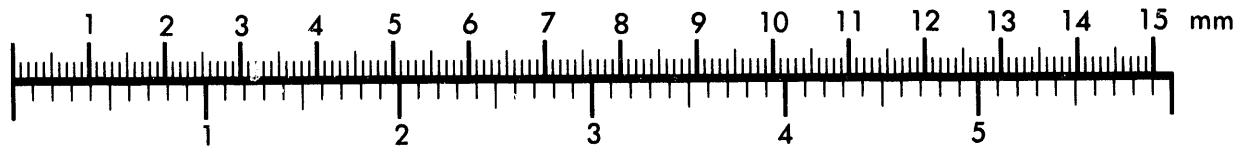

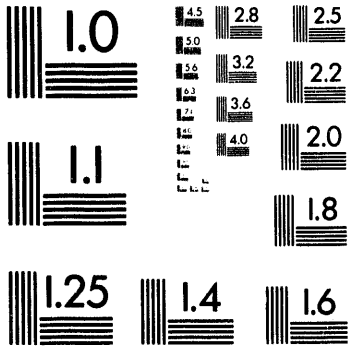

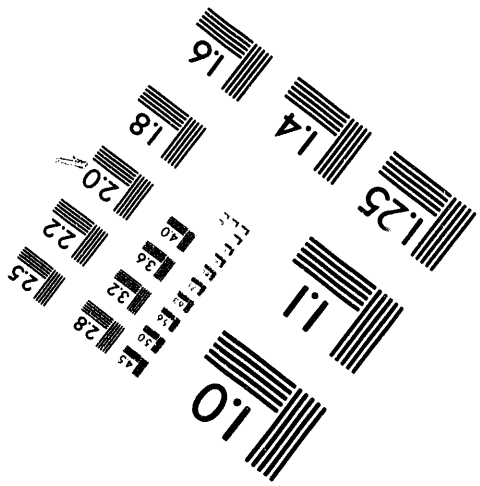

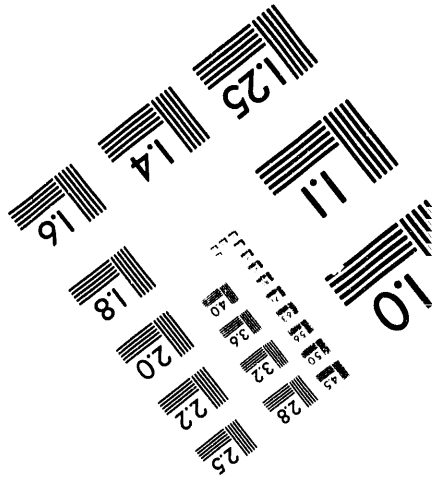

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Overview of Vegetation Monitoring Data, 1952-1983

Hanford Environmental Dose
Reconstruction Project

J. P. Duncan

March 1994

Letter Report for the Technical Steering Panel
and the Centers for Disease Control and Prevention
under Contract 200-92-0503(CDC)/18620(BNW)

Battelle
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Richland, Washington 99352

Preface

In 1987, the U.S. Department of Energy (DOE) directed the Pacific Northwest Laboratory, which is operated by Battelle Memorial Institute, to conduct the Hanford Environmental Dose Reconstruction (HEDR) Project. The DOE directive to begin project work followed a 1986 recommendation by the Hanford Health Effects Review (HHER) Panel. The HHER Panel was formed to consider the potential health implications of past releases of radioactive materials from the Hanford Site near Richland, Washington.

Members of a Technical Steering Panel (TSP) were selected to direct the HEDR Project work. The TSP consists of experts in the various technical fields relevant to HEDR Project work and representatives from the states of Washington, Oregon, and Idaho; Native American Tribes; and the public. The technical members on the panel were selected by the vice presidents for research at major universities in Washington and Oregon. The state representatives were selected by the respective state governments. The Native American tribes and public representatives were selected by the other panel members.

A December 1990 Memorandum of Understanding between the Secretaries of the DOE and the U.S. Department of Health and Human Services (DHHS) transferred responsibility for managing the dose reconstruction and exposure assessment studies to the DHHS. This transfer resulted in the current contract between Battelle, Pacific Northwest Laboratories (BNW) and the Centers for Disease Control and Prevention (CDC), and agency of the DHHS.

The purpose of the HEDR Project is to estimate the radiation dose that individuals could have received as a result of radionuclide emissions since 1944 from the Hanford Site. A major objective of the HEDR Project is to estimate doses to the thyroid of individuals who were exposed to iodine-131 by drinking milk obtained from cows that ate vegetation contaminated by iodine-131 released into the air from Hanford facilities.

The HEDR Project work is conducted under several technical and administrative tasks, among which is the Environmental Monitoring Data Task. The staff on this task assemble, evaluate, and summarize key historical measurements of radionuclide concentrations in the environment around the Hanford Site. This effort has resulted in the publication of vegetation monitoring data for 1945-1951 (Denham et al. 1993; Hanf el al. 1993). The information presented in this report is the result of a search for vegetation monitoring data beyond 1951. No milestone numbers were established for such an activity.

Summary

This report is a result of the Hanford Environmental Dose Reconstruction (HEDR) Project. The goal of the HEDR Project is to estimate the radiation dose that individuals could have received from emissions since 1944 at the Hanford Site near Richland, Washington. Members of the HEDR Project's Environmental Monitoring Data Task have developed databases of historical environmental measurements of such emissions. The HEDR Project is conducted by Battelle, Pacific Northwest Laboratories.

This report is the third in a series that documents the information available on measurements of iodine-131 concentrations in vegetation. The first two reports provide the data for 1945-1951. This report provides an overview of the historical documents, which contain vegetation data for 1952-1983.

The overview is organized according to the documents available for any given year. Each section, covering one year, contains a discussion of the media sampled, the sampling locations, significant events if there were any, emission quantities, constituents measured, and a list of the documents with complete reference information.

Because the emissions which affected vegetation were significantly less after 1951, the vegetation monitoring data after that date have not been used in the HEDR Project. However, access to these data may be of interest to the public. This overview is, therefore, being published.

The information in this report has been compiled without analysis and should only be used as a guide to the original documents.

Contents

Introduction

To support the Hanford Environmental Dose Reconstruction (HEDR) Project's objective of estimating the radiation dose that individuals could have received as a result of emissions from the Hanford Site, HEDR Project staff developed a database of historical environmental measurements. The data from these measurements are made available to the applicable HEDR tasks and the public.

One database of historical environmental measurements consists of vegetation monitoring data. The vegetation monitoring data for 1945-1951 have been published (Denham et al. 1993; Hanf et al. 1993). Those data are being used for validation purposes in the HEDR Project.

The information presented in this report is the result of a search to determine the availability of vegetation monitoring data beyond 1951. The data in this report are not being used by the HEDR Project because the emissions after 1951 were not as significant. Because access to these data may be of interest to the public, however, an overview of the available vegetation monitoring data for 1952-1983 is being published.

Data Quality Objectives

The information in this report has been compiled without analysis. The original purpose was to provide an overview of the data available. Because it was determined that the vegetation monitoring data beyond 1951 would not be used in the HEDR Project, no data quality objectives were established nor were the data submitted to a rigorous data quality review. The information presented in this report should only be used as a guide to the original documents. The original documents need to be consulted directly prior to use of any of the data presented in this report.

General Information

This report is divided into sections, one section for each year of vegetation monitoring data. Pertinent resource document numbers are provided in the text of each section. The document numbers and reference information for those documents where vegetation monitoring data may be found are provided at the end of each section.

The overwhelming majority of vegetation samples in which radioactivity was measured were sagebrush samples. Whenever measurements are for other types of vegetation (fruits, vegetables, etc.), the type of vegetation is denoted. In every sample, iodine-131 (I-131) was measured. This report indicates in which years and locations gross alpha and non-volatile beta emitters were measured. Any numbers in the tables that are in bold denote the highest value for that data series.

In many of the documents from which the data came, there were statements that "vegetation samples were analyzed according to standard procedures and techniques used in the control laboratory" (Paas 1952). These standard procedures are defined in Healy et al. (1951).

References

Denham, D. H., R. L. Dirkes, R. W. Hanf, T. M. Poston, M. E. Thiede, and R. K. Woodruff. 1993. *Phase I Summaries of Radionuclide Concentration Data for Vegetation, River Water, Drinking Water, and Fish*. PNWD-2145 HEDR, Battelle, Pacific Northwest Laboratories, Richland, Washington.

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Healy, J. W., R. C. Thorburn, and Z. E. Carey. 1951. *H. I. Control Laboratory Routine Chemical Procedures*. HW-20136, General Electric Company, Hanford Works, Richland, Washington.

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1952

Media Sampled

During 1952, over 100,000 vegetation samples were collected and analyzed for radionuclide contamination. Over 7500 of these samples were obtained from locations within the perimeter of the Hanford reservation and the adjoining communities of the Tri-City area. The remainder of the samples were collected from remote locations in Washington, Oregon, and Idaho (HW-25866, HW-26493, HW-27510, HW-27641).

Vegetation samples were analyzed according to "standard procedures and techniques." The counting rates were corrected for counting efficiencies, decay, and sample weight (HW-25866).

The main vegetation sampled was sagebrush. Based on experiments performed on vegetation in the area, [a] it was decided that native sagebrush was the best absorbent of effluent gases.

All vegetation specimens collected were analyzed for I-131. In addition, approximately one-half of the samples were analyzed for the activity density from non-volatile beta emitters. This measurement included the activity resulting from naturally occurring isotopes such as potassium-40 and uranium. Samples from nine representative areas in the Hanford area were also analyzed to determine the activity density from gross alpha emitters (HW-25866, HW-26493, HW-27510, HW-27641).

Several samples of fruit from orchards around the perimeter of Hanford were analyzed during the third quarter of 1952. Peaches and apricots were analyzed for I-131 activity and non-volatile beta emitters. The whole fruit, as well as the outer skin, pulp and seed, was analyzed (HW-27510).

Several samples of sugar beets were analyzed in December for total beta particle emitters (HW-27641).

A special monitoring survey was done in May 1952, after a cargo truck on a routine trip from Arco, Idaho, to the Hanford Plant was found to be contaminated with significant amounts of radioactive material. Vegetation, water, soil, and air samples were collected and analyzed. Vegetation samples were examined for non-volatile beta emitters, I-131 emitters, and alpha activity (HW-24727).

(a) Report on early vegetation experiments and tests (HEDR Project Document No. 03930002) from R. C. Dozer (General Electric Company) to B. V. Andersen (General Electric Company), August 13, 1957, Richland, Washington.

Sampling Locations

Routine vegetation sampling locations included north of the 200 Areas; near the 200 Areas; Route 3; 200 West Gate; 200 East Tower #16; Batch Plant; Meteorology Tower; south of the 200 Areas; Richland and Kadlec Hospital; Pasco, Sacajawea Park, and the junction of U.S. Highway 410; Kennewick and Kennewick Highlands; Benton City and Cobb's Corner; Benton City-Kiona; Richland "Y"; Hanford; 200 East Area; 200 West Area; Redox Construction Area; Wahluke Slope; Goose Egg Hill; Rattlesnake Mountain; PSN (Position Number) 300-310-320; Pasco to Ringold; Prosser to Paterson to McNary; eastern Washington; southern Washington and northern Oregon; Yakima Barricade to Ellensburg; and Priest Rapids (HW-25866, HW-26493, HW-27510, HW-27641).

Off-site sampling locations were further broken down into individual towns to include Yakima Barricade to Ellensburg, Yakima, Yakima to Ellensburg, Ellensburg, Buena, Zillah, Granger, Sunnyside, Sunnyside to Horse Thief Point, Moxee City, Union Gap, Wapato, Toppenish, Toppenish to Goldendale, Goldendale, Goldendale to Wishram, Lyle, Bingen, Camas, Vancouver, Portland, Troutdale, Bonneville, Hood River, The Dalles, Moody, Rufus, Blalock, Arlington, Heppner Junction, Boardman, Umatilla, Cold Springs, Hermiston, Pendleton, Meacham, Stanfield Junction, Wallula, Touchet, Lowden, Walla Walla, Dixie, Waitsburg, Dayton, Dodge, Pomeroy, Lewiston, Uniontown, Pullman, Colfax, Steptoe, Rosalia, Spangle, Spokane, Cheney, Sprague, Ritzville, Lind, and Connell (HW-25066, HW-26493, HW-27510, HW-27641).

Sugar beets were sampled from the Pasco Improvement Farm (HW-27641).

Vegetation sampled during the special monitoring survey in May were collected from Pendleton, La Grande, Baker, Ontario, Caldwell, Boise, Bliss, 10-1/2 miles west of Rupert, 8 miles west of Rupert, Rupert, American Falls #1, American Falls #2, Pocatello, Blackfoot, Arco Project, Arco, Shoshone, McCall, Lewiston, and Walla Walla (HW-24727).

Vegetation samples analyzed for gross alpha emitters were collected from the 200 West gatehouse; Batch Plant; Rt. 4S, Mile 4; Meteorology Tower; Rt. 4S, Mile 6; 300 Area; Richland; Pasco; and Benton City (HW-25866, HW-26493, HW-27510, HW-27641).

Significant Events/Emission Quantities

The operation of the Redox Facility was started in January 1952 (HW-54636).

Total I-131 emissions from the separation facilities stacks averaged 2.2 curies per day during the first quarter of 1952. The maximum emission was approximately 9 curies over a twenty-four hour period (HW-25866).

Activity density results for non-volatile beta emitters during the first quarter were higher than expected due to Nevada bomb tests (HW-25866).

The average daily emissions from the separation facilities stacks for the second quarter were 4 curies per day. A maximum emission of 21 curies per day was released from the Redox stack (HW-26493).

During the latter part of April 1952, there was a reduction in operation of the B Facility (HW-26493).

During May and June, Nevada bomb tests, including an atomic blast detonated at Yucca Flats, Nevada, on May 7, created fallout giving greater than expected non-volatile beta emitter activity densities (HW-26493, HW-24727).

Total I-131 emissions from the separation area stacks averaged 3 curies per day during the third quarter of 1952. A maximum value of 16.4 curies per day was emitted from the 202-S stack when the silver reactor failed (HW-27510).

The average daily emissions from all separation facilities stacks were 1.4 curies per day for the fourth quarter. The maximum emission of 5.2 curies per day was from the Redox facility (HW-27641).

The increased production at the T Plant contributed to a nearly three-fold increase in the amount of I-131 emitted from the separations facilities during December. Emissions at the T Plant increased from an average of 0.1 curies per day in November, to an average of 0.8 curies per day in December. The maximum emissions from this facility were 2.2 curies per day (HW-26720 E).

During mid-November and early December, nuclear testing caused greater than expected activities from non-volatile beta emitters (HW-27641).

Constituents Measured/Reported

Analysis results for the activity densities of I-131 and non-volatile beta emitters were reported in table form in units of 10^{-6} μCi/g. Results for alpha emitters were reported in units of 10^{-8} μCi/g (HW-25866, HW-26493, HW-27510, HW-27641).

Maximum activity densities for the first quarter of 1952 were found in an elongated area that included nearly all of the 200 West Area and extended eastward to a point inside the 200 East Area. The average activity density in this region exceeded 1×10^{-4} μCi/g (HW-25866).

In February, the average activity density was over 2.5×10^{-4} μCi/g near the 200 West Area gatehouse. The maximum activity from I-131 in this area was 1.2×10^{-2} μCi/g (HW-25866).

Changes in deposition patterns during the first quarter of 1952 were due to meteorological conditions, since the overall emissions of I-131 from the separations area stacks did not change significantly (HW-25866).

Samples obtained from southern Washington and northern Oregon had average activity densities for I-131 below the detection limit of 3×10^{-6} μCi/g for most of the quarter. The maximum activity density in this area was 69×10^{-6} μCi/g observed in February (HW-25866).

Vegetation samples from Sunnyside and Moxee City during the first quarter showed activity densities from I-131 to be 5 to 7×10^{-5} μCi/g (HW-25866).

During the first quarter of 1952, average I-131 activity densities on vegetation samples from Richland, Pasco, Kennewick, and Benton City were 27×10^{-6}, 13×10^{-6}, 23×10^{-6}, and 16×10^{-6} μCi/g, respectively. Maximum I-131 activities were 580×10^{-6}, 75×10^{-6}, 250×10^{-6}, and 72×10^{-6} μCi/g, respectively (HW-25866).

Samples analyzed for non-volatile emitters during the first quarter of 1952 gave higher than expected results due to contamination from Nevada bomb tests. One sample collected from eastern Washington showed the activity density from non-volatile emitters to be 1.7×10^{-4} μCi/g. Excluding samples taken from within the separations areas, the maximum activity detected in samples from Hanford Works was 1.1×10^{-4} μCi/g (HW-25866).

Deposition maps for each month of the year and each quarter were provided to illustrate the pattern of I-131 contamination deposited on vegetation (HW-25866, HW-26493, HW-27510, HW-27641).

With the exception of samples collected near the 300 Area, the average activity density from gross alpha emitters during the first quarter of the year ranged from 1.0 to 6.8×10^{-7} μCi/g throughout the area. Near the 300 Area, the average activity was 2.4×10^{-6} μCi/g and the maximum activity was 4.3×10^{-6} μCi/g (HW-25866).

The high deposition of alpha emitters near the 300 Area was not related to the emissions from the separation or reactor area stacks, but with 300 Area sources (HW-25866).

During the second quarter of 1952, the amounts of I-131 decreased due to the reduction in operation of the B Facility during the latter part of April and meteorological conditions which diluted the stack effluent (HW-26493).

The maximum deposition of I-131 during the second quarter was measured in a small region of 1 to 2 square miles near the southwest corner of the 200 West Area. The average activity density was greater than 1×10^{-4} μCi/g and the maximum was 2.2×10^{-4} μCi/g (HW-26493).

During April, May, and June 1952, large areas within the project showed the activity density from I-131 to be below the detection limit of 3×10^{-6} μCi/g. The deposition of I-131 during May was greater due to the increased emissions from the Redox Facility. An average of 4.3 curies of I-131 per day were emitted from the Redox Area during May, as compared with average emissions of 1.9 and 1.1 curies per day during April and June, respectively (HW-26493).

In general, the mean activity density from I-131 during the second quarter of 1952 averaged less than 3×10^{-6} μCi/g in off-area locations. Trace activities were found in six of the fifty-eight

communities surveyed. The maximum average concentration of I-131 was 13 x 10^{-6} μCi/g found in Cold Springs, Oregon. The maximum individual sample from an off-area location was 2.2 x 10^{-5} μCi/g found at Connell, Washington (HW-26493).

Average I-131 activities for Richland, including Kadlec Hospital, the Pasco area, and Benton City/Cobb's Corner were less than 3 x 10^{-6} μCi/g for the second quarter. The average and maximum activities for the Kennewick area were 4 x 10^{-6} and 2.0 x 10^{-4} μCi/g, respectively (HW-26493).

Maximum on-site I-131 activity for the second quarter, 2.2 x 10^{-4} μCi/g, was found at Route 3, 200 West Gate, and the Redox Construction Area (HW-26493).

The activity density from non-volatile beta emitters was higher than expected from normal Hanford operations during the second quarter due to Nevada bomb tests during May and June. Maximum measurements for non-volatile emitters for May and June were as high as 5.8 x 10^{-4} and 1.0 x 10^{-3} μCi/g for Cold Springs and the Yakima Barricade to Ellensburg samples, respectively (HW-26493).

The activity density from gross alpha emitters decreased during the second quarter. Maximum measurements, 2.0 x 10^{-6} μCi/g, were from near the 300 Area, consistent with trends in data collected since 1951. The maximum activity density from alpha emitters from an outlying area was in Pasco, with a reading of 8.1 x 10^{-7} μCi/g (HW-26493).

During the third quarter of 1952 there was a continued decrease in the deposition of I-131 on plants due to the decrease in the amount of I-131 being discharged from the separation area stacks. Maximum deposition measured directly east and south of the 200 West Area did not exceed 4 x 10^{-5} μCi/g (HW-27510).

The maximum I-131 activity for the third quarter was 7.2 x 10^{-5} μCi/g, found at the Redox Construction Area in September. The average activity was 1.3 x 10^{-5} μCi/g (HW-27510).

Average I-131 activities for the third quarter were below the detection limit of 3 x 10^{-6} μCi/g in all off-area locations. The maximum activity was 1.4 x 10^{-5} μCi/g sampled at Connell, Washington (HW-27510).

The average activity density from non-volatile beta emitters decreased at all locations by nearly 50% during the third quarter (HW-27510).

Several samples of fruit were collected from orchards around the project perimeter during the third quarter. The activity density for I-131 was less than 3 x 10^{-6} μCi/g in all samples analyzed. Non-volatile beta particle emitters ranged from 1 to 4 x 10^{-5} μCi/g. The outer skin from several of the peach and apricot samples was analyzed separately from the pulp and seed, giving no significantly different results (HW-27510).

The majority of samples analyzed for gross alpha particle emitters during the third quarter had activities with less than 5 x 10^{-8} μCi/g. However, samples collected in the vicinity of the separations areas showed higher results than those previously observed. Maximum values of 1.1 x 10^{-6} and

1.5 x 10^{-6} μCi/g found at the Batch Plant and Meteorology Tower, respectively, were two to three times higher than those of the second quarter. The higher values were found during July, with values during August and September barely exceeding the detection limit of 5 x 10^{-8} μCi/g (HW-27510).

During October, the values for I-131 deposition on vegetation were among the lowest measured since the start-up of the Hanford Operation. Levels measured on vegetation from off-site locations were less than 3 x 10^{-6} μCi/g in nearly every sample analyzed (HW-27641).

During the fourth quarter, I-131 deposition on vegetation averaged 1 x 10^{-5} μCi/g close to the separations areas and from less than 3 x 10^{-6} to 5 x 10^{-6} μCi/g in the residential area around the project perimeter. The maximum deposition was 1.3 x 10^{-4} μCi/g near the 200 West Area at the Batch Plant (HW-27641).

Maximum off-site deposition of I-131 during the fourth quarter was 5.4 x 10^{-5} μCi/g at Touchet, Washington. The maximum average values were 1.3 x 10^{-5} and 7 x 10^{-6} μCi/g for Touchet, Washington, and Lind, Washington, respectively (HW-27641).

During October, the only areas having positive amounts of I-131 were found in the region due southeast of the separations facilities, correlating to the prevailing wind directions. Most of the areas of deposition were confined to random areas of about one square mile each. However, the deposition of I-131 in Kennewick and Richland covered a larger area than detected near the separations facilities. November showed a general increase in the size of the areas where the I-131 was detected, with Kennewick and Richland showing positive areas comparable to those in the vicinity of the separation facilities (HW-27641).

The increased production at the T Plant contributed to a nearly three-fold increase in the amount of I-131 emitted from the separations facilities during December. These increased emissions and undesirable meteorological conditions causing low dilution of the stack effluent caused higher I-131 deposition values during the latter part of the fourth quarter (HW-27641).

The activity density from non-volatile emitters increased by a factor of two during the fourth quarter. The month of October and through November 10, had measurements similar to those of the third quarter. Samples collected after November 10 showed increased average activities from 3 x 10^{-5} to 5 x 10^{-4} μCi/g due to nuclear testing (HW-27641).

During the fourth quarter, a maximum off-site value of 6.8 x 10^{-4} μCi/g for non-volatile emitters was found in the vegetation sample from Yakima Barricade to Yakima (HW-27641). The maximum on-site activity was 1.9 x 10^{-3} μCi/g from vegetation collected at the 200 West Area (HW-28300, HW-27641).

During the latter part of December, non-volatile activity densities decreased to that expected from normal Hanford operations (4 x 10^{-5} μCi/g) (HW-27641).

Activity densities from gross alpha particle emitters in the separation areas during the fourth quarter were comparable to those of the third quarter. Average values in the immediate vicinity of

the separations areas were in the range of 1×10^{-7} μCi/g to 3×10^{-7} μCi/g. The activity for outlying areas was less than 5×10^{-8} μCi/g. Maximum values for alpha particle emitters were 1.9×10^{-6} μCi/g found in the 300 Areas (HW-27641).

Samples of sugar beets collected from the Pasco Improvement Farm in early December gave two positive results—1.6×10^{-5} and 2.2×10^{-5} μCi/g total beta particle emitters (HW-27641).

A special monitoring survey was done in May after a cargo truck on a routine trip from Arco, Idaho, to the Hanford Plant was found contaminated with significant amounts of radioactive material. A maximum non-volatile activity density of 0.024 μCi/g (corrected to sampling time) was collected at Blackfoot, Idaho. The elevated radioactivity amounts were believed due to the radioactive cloud produced by a test atomic blast detonated at Yucca Flats, Nevada, on May 7 (HW-24727).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1953

Media Sampled

During 1953, 15,742 vegetation samples were collected and analyzed for radionuclide contamination, including both routine and special vegetation surveys. Over half of these samples were obtained from locations within the perimeter of the Hanford reservation and the adjoining communities of the Tri-City area. The remainder of the samples were collected from remote locations in Washington, Oregon, and Idaho (HW-28009, HW-29514, HW-30174, HW-30744, HW-30423 E).

All vegetation samples collected were analyzed for I-131 and/or I-133. In addition, many of the samples were analyzed for non-volatile beta particle emitters, which included the activity resulting from naturally occurring isotopes such as potassium-40 and uranium. Samples from nine representative areas on and adjacent to the Hanford environs were also analyzed to determine the activity density from gross alpha emitters (HW-28009, HW-29514, HW-30174, HW-30744).

During the third quarter of 1953, several crops and fruits were collected from the farming areas near Hanford and analyzed for I-131 contamination and non-volatile beta particle emitters (HW-30174).

A special survey was conducted in May 1953 to determine the magnitude and extent of fallout produced from Nevada nuclear blasts. As part of this survey, samples were collected from area farms and analyzed for I-131 and I-133 and non-volatile beta particle emitters. Crops examined included asparagus, strawberries, mint, wheat, alfalfa, hay, and grape buds (HW-28925).

Sampling Locations

Routine vegetation sampling locations included north of the 200 Areas, near the 200 Areas, Route 3, 200 West Gate, 200 East Tower #16, Batch Plant, Meteorology Tower, south of the 200 Areas, Richland, Pasco Environs, Kennewick Environs, Benton City-Kiona, Richland "Y", Hanford, 200 East Area, 200 West Area, Redox Construction Area, Wahluke Slope, Goose Egg Hill, Rattlesnake Mountain, PSN-300-310-320-330, Pasco to Ringold, Prosser to Paterson to McNary, eastern Washington, and southern Washington and northern Oregon (HW-28009, HW-29514, HW-30174, HW-30744).

Off-site locations were further broken down into individual towns to include Moxee City, Union Gap, Wapato, Toppenish, Toppenish to Goldendale, Goldendale, Goldendale to Wishram, Lyle, Bingen, Camas, Vancouver, Portland, Troutdale, Bonneville, Hood River, The Dalles, Moody, Rufus, Blalock, Arlington, Heppner Junction, Boardman, Umatilla, Wallula, Touchet, Lowden, Walla Walla, Dixie, Waitsburg, Dayton, Pullman, Colfax, Steptoe, Rosalia, Spokane, Cheney, Sprague, Ritzville, Lind, Connell, Pomeroy, Lewiston, Uniontown, Hermiston, Stanfield, Pendleton,

Meacham, Spangle, Omak, LaGrande, North Powder, Haines, Baker, Pleasant Valley, Durkee, Huntington, Payette, Junction of US #30, Middleton, Boise, and Caldwell (HW-28009, HW-29514, HW-30174, HW-30744).

Collection sites for vegetation samples examined for gross alpha particle emitters included 200 West Gatehouse, Batch Plant, Rt. 4S Mile 4, Meteorology Tower, Rt. 4S Mile 6, 300 Area, Richland, Pasco, and Benton City (HW-28009, HW-29514, HW-30174, HW-30744).

A special vegetation survey was conducted on May 26, 1953, after a nuclear test in Nevada. The surveys covered an area bounded by Spokane, Washington; Lewiston, Idaho; Pendleton, Oregon; Yakima, Washington; and Ellensburg, Washington. Samples were collected at nearly all communities within this area and also at intervals of five to ten miles between the communities. Locations comprising this special survey included the Tri-City Residential Areas (in which 34 samples were collected from areas to include the outside of the 300 Area barricade, North Richland, Richland, Richland "Y", Kennewick, Kennewick Highlands, and Pasco), inside of the Hanford Atomic Products Operation Exclusion Area (22 samples from areas including 7 miles East of the Redox stack, Rt. 4S, Rt. 2S, Rt. 2N, White Bluffs, Rt. 1, Riverland, Rt. 11A, Meteorology Tower, 200 West main gate, and Cold Creek), Benton City, Prosser, Paterson, Plymouth Region (23 samples), Pasco to Lewiston via Connell, Washtucna, and Pullman (60 samples to include Eltopia, Ritzville, Kahlotus, Colfax, Colton, Walla Walla, Clarkston, Dayton, Pomeroy, and Waitsburg), Moxee City, Yakima, Sunnyside Region (28 samples including Union Gap, Prosser, Grandview, Cobb's Corner, Enterprise, Hemminger City, and Yakima Barricade), Yakima-Spokane Region (28 samples to include Ellensburg, Vantage, Moses Lake, Ritzville, Cheney, Sprague, Reardon, Davenport, Harrington, Odessa, and Lind), and the Walla Walla-Pendleton Region (22 samples to include Wallula and Lowden). Samples were collected and analyzed for I-133 and non-volatile beta particle emitters (HW-28925).

Crops collected as part of the special vegetation survey after the fallout of May 26, were collected from Kennewick Highlands, south of Kennewick, South Kennewick Highlands, West Pasco, and the Riverview District (HW-28925).

Significant Events/Emission Quantities

Total I-131 emissions from the separation facilities stacks averaged 1.9 curies per day during the first quarter of 1953. A maximum emission of 17 curies per day was released from the Redox stack during January as a result of a faulty silver reactor (HW-28009).

The average daily emissions from the separation facilities during the second quarter was 1.9 curies of I-131 per day. A maximum quantity of 19 curies per day was discharged into the atmosphere from the S-Facility stack (HW-29514).

Nevada nuclear testing on May 26 resulted in significant increases in radioactive iodine deposition and the highest amounts of non-volatile beta particle emitters ever detected (HW-29514, HW-28925).

An average of 2.5 curies per day was released into the atmosphere from the separation facilities during the third quarter. A maximum emission of 27 curies over a twenty-four hour period was released from the S-Plant stack on July 7 (HW-30174).

In September, the failure of a silver reactor at the 202-S Facility caused a maximum emission of 12 curies of I-131 on September 3, and a total of 23 curies to be released over the three days following the failure (HW-30174).

Trace amounts of I-131 were detected in many remote locations during September as a result of reactor failures at the Redox facilities (HW-30174).

During mid to late August and late September nuclear explosions at foreign locations caused elevated activity densities (HW-30174).

Iodine-131 emissions from the separations facilities averaged 1.7 curies per day for the fourth quarter. The maximum emission, 10 curies per day, occurred on October 21 at the S-Plant (HW-30744).

On November 13, 1953, the failure of a silver reactor at the 202-S Facility caused a gross emission of 3.7 curies over a twenty-four hour period (HW-30744).

Constituents Measured/Reported

Analysis results for the activity densities of I-131 and non-volatile beta particle emitters collected in routine vegetation sampling were reported in a table format listing individual sampling sites and results in units of 10^{-6} μCi/g. Results for alpha particle emitters were reported in units of 10^{-8} μCi/g (HW-28009, HW-29514, HW-30174, HW-30744).

Analysis results for a special vegetation survey done on May 26, 1953, were reported in table form in units of 10^{-3} μCi/g. Individual collection sites were listed and samples were analyzed for I-133 and non-volatile beta particle emitters (HW-28925).

Maximum I-131 deposition during the first quarter of 1953 occurred at the 200 West Area gatehouse, where the average activity density was 4.2×10^{-5} μCi/g and the maximum activity density was 1.9×10^{-4} μCi/g (HW-28009).

Isoactivity maps for each month and each quarter were provided to illustrate the pattern of I-131 deposition on vegetation (HW-28009, HW-29514, HW-30174, HW-30744).

The repair of the faulty silver reactor at the Redox Facility in February resulted in decreased I-131 deposition on vegetation during February and March (HW-28009).

During the first quarter, high I-131 deposition (2.5×10^{-5} to 1×10^{-4} μCi/g) was confined to a region that did not exceed a five mile radius from the source (HW-28009).

The activity density of I-131 during the first quarter averaged less than 3×10^{-6} μCi/g at all remote locations except in area east of the plant which included the Colfax-Pullman area and the Lind-Connell area. The high deposition found in these two areas was during the month of March when negligible deposition was found in the immediate- Hanford area. When higher emissions and deposition were taking place on the Hanford reservation, in January and February, off-site samples did not exceed 8×10^{-6} μCi/g. In March, the maximum off-site measurement was 2.2×10^{-5} μCi/g (HW-28009).

Results from the analysis of vegetation samples for non-volatile beta emitters showed a general decrease in activity densities in nearly all locations during the first quarter. The maximum activity density was 2.5×10^{-3} μCi/g, observed from a sample collected from the 200 West Area. The maximum activity from off-site locations was 1.1×10^{-4} μCi/g found at Troutdale, Cheney, and Lind. Nearly all of the maximum measurements were observed in the early part of January when residual particulate contamination from nuclear testing remained on vegetation (HW-28009).

During the first quarter of 1953, the activity density of alpha particle emitters on vegetation increased by a factor of 2 to 5. The maximum deposition value obtained from outlying areas was 5.6×10^{-7} μCi/g, from a sample collected in Richland in February. The maximum on-site alpha particle deposition value was 1.7×10^{-5} μCi/g, observed from a sample from the 300 Area in March. This maximum deposition was one of the highest measurements obtained since data have been reported (HW-28009).

During April and early May, radioactive iodine deposited on vegetation barely exceeded the detection limit of 3×10^{-6} μCi/g throughout the Hanford area. Average values increased during June due to nuclear fallout and were on the order of 10^{-4} μCi/g with a maximum measurement of 4.8×10^{-3} μCi/g occurring at the Redox Construction Area. The maximum off-site value was 4.4×10^{-3} μCi/g from the Colfax to Pullman area. By the middle of June, radioactive iodine values decreased to below the detection limit around the plant perimeter (HW-29514).

In general, non-volatile activity densities rarely exceeded 1×10^{-4} μCi/g during normal Hanford operations, and seldom exceeded 1×10^{-3} μCi/g during periods of contamination from other sources (HW-29514).

During the second quarter, the maximum on-site non-volatile activity density was 1.7×10^{-2} μCi/g from a sample collected at the Redox Construction Area. The maximum off-site non-volatile activity was 6.1×10^{-2} μCi/g measured at Pomeroy. These values were among the highest ever detected due to the Nevada nuclear testing in late May (HW-29514).

The activity densities from gross alpha particle emitters during the second quarter averaged 1×10^{-7} to 1.3×10^{-6} μCi/g in the Hanford vicinity. The maximum value, 6.2×10^{-6} μCi/g, obtained from near the 300 Area, exhibits a significant decrease from the first quarter. The maximum activity density for outlying areas was 8.4×10^{-7} μCi/g, measured in Benton City, a value higher than that of the first quarter (HW-29514).

After nuclear testing in Nevada on May 26, average off-site non-volatile activities ranged from 2.0×10^{-4} in the Toppenish/Goldendale area to 2.7×10^{-2} μCi/g in the Colfax/Pullman area (HW-29514).

In comparing the values obtained from May 26, 1953, and similar measurements obtained when the only source of contamination was the Hanford works, non-volatile beta particle emitters were found to be approximately 100 times greater than normally found (HW-28925).

The activity density from radioactive iodine after May 26 was approximately 1000 times higher than normal in the remote residential areas and about 100 times above normal values at locations inside Hanford Products Operation Exclusion area, due to the nuclear testing (HW-28925).

Decay studies were conducted after the May 26 nuclear blast, using control plots at Richland, Pasco, and Kennewick. Samples were collected daily through July 10, and analyzed for I-131, I-133, and non-volatile beta particle emitters. The average activity densities from radioactive iodine, which ranged from 2 to 6×10^{-4} μCi/g on May 27, decayed to values of less than 3×10^{-6} μCi/g around the middle of June, representative of normal Hanford operations. Non-volatile values also decreased by late June to the 10^{-5} μCi/g level, normal operation levels (HW-28925).

Crop samples analyzed after the May 26 nuclear testing exhibited results comparable to those measured on roadside samples. The maximum radioiodine activity density, 8.2×10^{-4} μCi/g, was measured on a hay sample from South of Kennewick. The maximum non-volatile activity density was 1.7×10^{-2} μCi/g from a mint sample collected from Kennewick Highlands. The overall average non-volatile activity density measured in the crops was 5.21×10^{-3} μCi/g. The overall average for I-131/I-133 activity in crop samples was 2.69 x 10-4 μCi/g (HW-28925).

Maximum activity densities from radioiodine and non-volatile beta particle emitters after the May 26 Nevada nuclear testing were found in an elongated area approximately 25 miles wide extending from near Pullman, Washington, on the east, to Richland, Washington, on the west. A small region in the northeast part of Washington near Sprague and Harrington showed comparable values to those found in the Pullman-Richland region (HW-28925).

During the special vegetation survey on May 26, the maximum activity density from non-volatile beta particle emitters was measured near Dodge, Washington, where individual readings ranged from 4.7×10^{-2} to 6.1×10^{-2} μCi/g. The maximum radioiodine measurement was obtained near Pullman where a value of 4.4×10^{-3} μCi/g was detected. Within the Tri-City residential area, a maximum value for non-volatile beta particle emitters of 2.1×10^{-2} μCi/g was obtained from Southeast Kennewick and outside the 300 Area Barricade. The maximum I-133 activity density for the Tri-City Area was 2.2×10^{-3} μCi/g, obtained from samples from Northwest Pasco and Northwest Kennewick. Within the Hanford Atomic Products Operation Exclusion Area, a maximum non-volatile activity density of 1.7×10^{-2} μCi/g was obtained from a sample collected at Rt. 4S, Mile 13. The maximum I-133 activity density within Hanford Works was 2.4×10^{-3} μCi/g, obtained from a sample collected at Cold Creek, Mile 2 (HW-28925).

During the third quarter, a reduction in the amount of I-131 found deposited on vegetation occurred, as the fallout from the nuclear testing of the second quarter dissipated. Third quarter

values were equal to or less than those of the first quarter when the deposition pattern was not influenced by fallout from sources other than Hanford (HW-30174).

The maximum activity density for I-131 during the third quarter was 2.1×10^{-4} μCi/g obtained from a sample collected south of the 200 Areas. The maximum off-site activity density was 4.7×10^{-5} μCi/g, collected from the Toppenish to Goldendale area (HW-30174).

Average I-131 activities for July and August from off-site locations were less than 3×10^{-6} μCi/g. In September, trace (<3 to 6×10^{-6} μCi/g) amounts of I-131 were observed (HW-30174).

Several crops and fruits were collected from the farming areas near Hanford during the third quarter and analyzed for I-131 and non-volatile beta particle emitters. In all cases, the activity densities were comparable to those found on the vegetation samples routinely collected from the same areas (HW-30174).

During the third quarter of 1953, the activity densities of non-volatile beta particle emitters decreased from the high values observed the previous quarter, which were associated with the Nevada tests. However, values were still higher than those normally found, due to foreign nuclear testing. Average values were three to four times greater than those normally found and maximum measurements were about 10 times greater than the expected maximum value (HW-30174).

The maximum off-site activity density from non-volatile emitters for the third quarter was 9.6×10^{-4} μCi/g from a sample collected in Portland, Oregon. The on-site maximum activity density was 1.3×10^{-2} μCi/g. The average off-site activity ranged from 2.1×10^{-5} in Walla Walla, to 3.6×10^{-4} μCi/g, in Arlington (HW-30174).

During the third quarter, the activity densities from gross alpha particle emitters averaged 7×10^{-8} to 6.9×10^{-7} μCi/g in the Hanford vicinity, with a maximum measurement of 1.2×10^{-6} μCi/g from a sample collected near the 300 Areas. The overall maximum was 1.5×10^{-6} μCi/g from a sample collected in Richland. The average activity densities for outlying areas ranged from $<5 \times 10^{-8}$ μCi/g at Benton City, to 3.8×10^{-7} μCi/g at Richland (HW-30174).

During the fourth quarter, the greatest region in which detectable quantities of I-131 was deposited was confined to the area in and around the separation areas and in an elongated area extending southeast of the separation facilities for approximately 10 miles, correlating with prevailing wind directions (HW-30744).

The failure of the silver reactor at the 200 West facility in November resulted in a maximum activity density for I-131 of 2.7×10^{-4} μCi/g, collected from near the 200 West Area gate. The maximum off-site activity density was 1.8×10^{-5} μCi/g from a sample collected at Blalock, Oregon (HW-30744).

Fourth quarter average on-site activity densities ranged from $<3 \times 10^{-6}$ to 2.0×10^{-5} μCi/g. Average off-site activity was generally below the sensitivity limit of 3×10^{-6} μCi/g. Trace quantities were detected in samples from Pullman, Pomeroy, Lewiston, and Blalock (HW-30744).

During the fourth quarter a decrease in the activity density values for non-volatile beta particle emitters continued. Values from December were the lowest measured since the significant deposition from nuclear fallout occurred during the middle of the year. The average non-volatile deposition in December from on-site and the immediate vicinity ranged from 4.1×10^{-5} μCi/g at Benton City-Kiona, to 4.2×10^{-4} μCi/g at the 200 West Area (HW-30744).

The activity densities from gross alpha particle emitters during the fourth quarter averaged 9×10^{-8} to 6.1×10^{-7} μCi/g in the Hanford vicinity, with a maximum measurement of 1.2×10^{-6} μCi/g at the 200 West Area gatehouse. The maximum activity density value for alpha particle emitters from off-site samples was 2.3×10^{-6} μCi/g collected from Pasco (HW-30744).

Average I-131 activities for December were less than the sensitivity limit of 3×10^{-6} μCi/g at locations in the residential areas surrounding the Hanford Operations and Eastern Washington and Oregon (HW-30423 E).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1954

Media Sampled

During 1954, approximately 9500 vegetation samples were collected and analyzed for radionuclide contamination. Seven thousand of these samples were obtained from locations within the perimeter of the Hanford reservation and the adjoining communities of the Tri-City area. The remainder of the samples were collected from remote locations in eastern and southern Washington, western Idaho, and northern Oregon (HW-31818, HW-33896, HW-36504, HW-36505).

Vegetation samples were analyzed for I-131 and non-volatile beta particle emitters. In addition, samples from nine representative areas in the Hanford vicinity were analyzed to determine the activity densities from gross alpha particle emitters (HW-31818, HW-33896, HW-36504, HW-36505).

During 1954, a special survey was conducted after several radio-ruthenium emissions from the Redox stack caused a severe ground contamination problem. This contamination extended into orchard and field crop areas surrounding the Hanford reservation, prompting crop analyses. Fruits and crops examined included 2500 peaches, 2 lugs of plums, 2 lugs of grapes, 1500 apples, 40 ears of corn, and 40 tomatoes (HW-33068). (A lug is a shipping container for fruit. A lug of grapes weighs approximately 26 lbs, a lug of plums weighs approximately 28 lbs.)

Sampling Locations

Routine vegetation sampling locations included North of the 200 Areas, near the 200 Areas, Route 3, 200 West Gate, 200 East Tower #16, Batch Plant, Meteorology Tower, South of the 200 Areas, Richland, Pasco Environs, Kennewick Environs, Benton City-Kiona, Richland "Y", Hanford, 200 East Area, 200 West Area, Wahluke Slope, Goose Egg Hill, Rattlesnake Mountain, PSN-300-310-330, Redox Construction, Pasco to Ringold, Prosser to Paterson to McNary, Eastern Washington, Southern Washington and Northern Oregon (HW-31818, HW-33896, HW-36504, HW-36505).

Off-site locations were further broken down into individual towns to include Wallula, Touchet, Lowden, Walla Walla, Dixie, Waitsburg, Dayton, Pomeroy, Lewiston, Uniontown, Pullman, Colfax, Steptoe, Rosalia, Spangle, Spokane, Cheney, Spokane to Davenport, Davenport, Davenport to Harrington, Harrington, Harrington to Sprague, Sprague, Ritzville, Lind, Connell, Moxee, Union Gap, Wapato, Toppenish, Toppenish to Goldendale, Goldendale, Goldendale to Wishram, Lyle, Bingen, Camas, Vancouver, Portland, Troutdale, Bonneville, Hood River, The Dalles, Moody, Rufus, Blalock, Arlington, Heppner Junction, Boardman, Reardon, and Eltopia (HW-31818, HW-33896, HW-36504, HW-36505).

Vegetation samples analyzed for gross alpha emitters were collected from the 200 West Gatehouse, Batch Plant, Rt. 4S Mile 4, Meteorology Tower, Rt. 4S mile 6, 300 Area, Richland, Pasco, and Benton City (HW-31818, HW-33896, HW-36504, HW-36505).

Significant Events/Emission Quantities

Total I-131 emissions from the separations facilities stacks averaged 1.7 curies per day during the first quarter of 1954. The maximum emission was 11 curies per day from the Redox facility (HW-31818).

An increase in the concentration of non-volatile beta particle emitters occurred following a ruthenium emission during the first week of January (HW-31818).

The average daily emissions from the separation facilities stacks for the second quarter was less than 1.3 curies per day. A maximum emission of 15 curies per day was released from the S-Plant stack (HW-33896).

During the month of May, fallout from nuclear testing in the Pacific Islands caused increases in the levels of contamination on vegetation (HW-33896).

Several radio-ruthenium emissions from the Redox stack occurred during 1954, causing a severe ground contamination problem (HW-33068). Elevated non-volatile beta particle measurements were related to the extensive ground contamination in and near the 200 West Area (HW-33896).

Total I-131 emissions from the separations facilities averaged 1.4 curies per day during the third quarter. A maximum emission of 12 curies per day occurred on August 27 from the S-Plant stack (HW-36504).

The combined average I-131 emissions from the separation facilities during the fourth quarter was 1.5 curies per day. Contradicting maximum emissions are reported in this quarterly report. A maximum rate of 7.9 curies from the S-Plant during a 19 hour period on October 29 is reported in the abstract, while a table in the text lists the maximum I-131 discharged as 9.5 curies per day from the S-plant stack in November (HW-36505).

During the weeks of November 11 and December 20, combined weekly emissions of 15 and 13 curies, respectively, resulted in increased I-131 concentrations (HW-36505).

During November and December higher activity densities for non-volatile beta particles were attributed to increased concentrations of airborne beta particle emitters from "sources other than Hanford" (HW-36505).

Constituents Measured/Reported

Analysis results for the activity densities of I-131 and non-volatile beta particle emitters were reported in table form in units of 10^{-6} μCi/g. Results for alpha particle emitters were reported in units of 10^{-8} μCi/g (HW-31818, HW-33896, HW-36504, HW-36505).

Ruthenium emissions in late January caused an increase in non-volatile beta particle emitters in a narrow trajectory extending in a northeast direction from the 200 West Area, where a maximum measurement of 2.3 μCi/g was found (HW-31818).

The significant deposition of non-volatile beta particle emitters during the first quarter influenced the accuracy of the I-131 measurements, causing a number of the I-131 analyses from the trajectory extending northeast of the 200 Area to be deleted from the program (HW-31818).

The mean I-131 deposition within the project perimeter during the first quarter was 1.5×10^{-5} μCi/g. The average deposition for the residential areas neighboring the plant was 3×10^{-6} μCi/g (HW-31818).

Deposition maps illustrating the pattern of I-131 contamination deposited on vegetation were provided for the first three quarters of the year and for the months of January through June and October through December (HW-31818, HW-33896, HW-36504, HW-36505).

Average non-volatile beta particle deposition on the Hanford reservation ranged from 5×10^{-5} μCi/g at perimeter locations to 3.3×10^{-2} μCi/g near the 200 West Area. Average deposition in the residential areas surrounding Hanford was 3×10^{-5} μCi/g (HW-31818).

Average values of $< 3 \times 10^{-6}$ μCi/g for I-131 and on the order of 3×10^{-5} μCi/g for non-volatile beta particle emitters were found at nearly all remote locations sampled except those which were located inside the trajectory followed by the ruthenium emission in January. Samples collected in the Spokane-Davenport-Sprague region in January showed non-volatile beta particle activity densities ranging from 1×10^{-4} to 1.2×10^{-3} μCi/g. Trace amounts of Iodine-131 detected in these same locations appeared to be related to the ruthenium emissions as well (HW-31818).

During the first quarter, the average activity density for alpha particle deposition on vegetation ranged from 7×10^{-8} μCi/g at residential locations (Pasco), to 4.3×10^{-6} μCi/g at the 200 West gatehouse. The maximum measurement was 1.3×10^{-5} μCi/g collected at the 200 West gatehouse (HW-31818).

Maximum measurements for I-131 deposition on vegetation were found in and near the separation areas during the second quarter, where the average activity density for I-131 was 3×10^{-5} μCi/g. This included a maximum measurement of 2.2×10^{-4} μCi/g from a sample collected at the 200 West gate. Within the Hanford boundary, the average I-131 deposition was 1.1×10^{-5} μCi/g (HW-33896).

During the second quarter, trace amounts of I-131 were found in the residential areas surrounding the plant perimeter, where the average deposition was 5×10^{-6} μCi/g. Maximum

measurements of nearly 1 x 10^{-4} μCi/g were found on May 10 and 11, when atmospheric concentrations were higher due to nuclear testing in the Pacific Islands (HW-33896).

Average I-131 activity densities from remote areas throughout Washington and Oregon were generally at or below 3 x 10^{-6} μCi/g during the second quarter (HW-33896).

During the second quarter non-volatile measurement increases appeared to be related to the extensive ground contamination in and near the 200 West Area, where a maximum measurement of 0.31 μCi.g was found in April. The average activity density in this area was 6.5 x 10^{-3} μCi/g (HW-33896).

The maximum contamination on vegetation in the remote areas of Washington and Oregon from non-volatile beta particle emitters was 5.9 x 10^{-4} μCi/g found in a sample from Rufus (HW-33896).

During the second quarter, alpha particle emission values returned to those expected from normal Hanford operations. The average quarterly alpha activity density was on the order of 4 x 10^{-7} μCi/g. By June, all outlying locations exhibited average activity densities of less than 10 x 10^{-8} μCi/g (HW-33896).

The concentrations of radioiodine on vegetation decreased at nearly all sampling locations during the third quarter. Only seven samples from three locations (200 West, Rt. 3, and 200 West gate) exceeded 1 x 10^{-5} μCi/g, the maximum concentration acceptable at Hanford (HW-36504).

During the third quarter, the average and maximum concentrations of I-131 deposited on vegetation at off-site and remote locations in Washington and Oregon were all less than the detection limit of 3 x 10^{-6} μCi/g (HW-36504).

Average concentrations of non-volatile beta particle emitters during the third quarter were lower in most locations than those of the previous quarter. Concentrations in on-site samples were significantly higher than those of off-site samples, due to the high ground contamination within the Hanford Project (HW-36504).

During the third quarter, a maximum non-volatile beta particle measurement of 0.33 μCi/g was found in a sample from Route 10, Mile 8 (South of the 200 Areas) and consisted of ruthenium-rhodium isotopes. The average non-volatile concentration from samples collected off-site was 3.6 x 10^{-5} μCi/g, with a maximum concentration of 1.4 x 10^{-4} μCi/g collected from Prosser-Paterson-McNary (HW-36504).

Concentrations of alpha particle emitters were lower during the third quarter, with all but one average value below the detectable limit of 10 x 10^{-8} μCi/g. The maximum activity density was 40 x 10^{-8} μCi/g from a sample collected from the 200 West Gatehouse (HW-36504).

Significant increases in the concentrations of I-131 were observed during November and December. Maximum concentrations of 1.4 x 10^{-4} μCi/g, collected in the vicinity of 200 West, resulted from higher than normal emissions that occurred during November 11 and December 20 (HW-36505).

During November and December, significant increases in the concentrations of non-volatile beta particle emitters were observed on vegetation due to a source other than Hanford (HW-36505).

Vegetation samples having concentrations of I-131 greater than 5×10^{-6} μCi/g covered areas of 150 and 60 square miles in November and December, respectively. During October and the third quarter, areas of less than 5 square miles were covered. Off-site locations where the I-131 deposition concentrations exceeded 1×10^{-5} μCi/g (the maximum acceptable at Hanford), were in regions of less than one square mile during each month of the fourth quarter (HW-36505).

Average I-131 depositions from remote locations in Washington and Oregon during the fourth quarter were generally less than 3×10^{-6} μCi/g, except for samples collected in Pullman, Rosalia, Spangle, Harrington, and Reardon (HW-34147 E, HW-36505). The maximum activity density for I-131 from remote locations was 5.7×10^{-5} μCi/g from a sample from Pullman (HW-36505).

The maximum activity density from non-volatile beta particle emitters during the fourth quarter was 1.5×10^{-2} μCi/g, from a sample collected at the 200 West Area. The maximum concentration from a remote area was 7.4×10^{-4} μCi/g, collected in Dixie (HW-36505).

The deposition of alpha particle emitters on vegetation increased during the fourth quarter, but concentrations are generally lower than those from earlier in the year. The maximum concentration of 1.1×10^{-6} μCi/g was from a sample collected at the 200 West Area gatehouse. The maximum concentration observed from an outlying area was found in Richland, where the average for the quarter was 1.7×10^{-7} μCi/g and the maximum concentration was 4.5×10^{-7} μCi/g (HW-36505).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1955

Media Sampled

During 1955, approximately 10,100 vegetation samples were collected and analyzed for radionuclide contamination. Over 7800 of these samples were obtained from locations within the perimeter of Hanford reservation and the adjoining communities of the Tri-City area. The remainder of the samples were collected from remote locations in Washington, Idaho, and Oregon (HW-36506, HW-38566, HW-39429, HW-40871).

All vegetation samples were analyzed for I-131 contamination. In addition, approximately 5400 of the samples were analyzed for non-volatile beta particle emitters. Also, about 200 samples from nine representative locations in the Hanford area were analyzed to determine the activity density from alpha particle emitters (HW-36506, HW-38566, HW-39429, HW-40871).

Sampling Locations

Routine vegetation sampling locations included north of the 200 Areas, near the 200 Areas, Rt. 3, 200 West Gate, Batch Plant, Meteorology Tower, south of the 200 Areas, Richland, Pasco Environs, Kennewick Environs, Benton City-Kiona, Richland "Y", Hanford, 200 East Area, 200 West Area-Redox Area, Wahluke Slope, Goose Egg Hill, Rattlesnake Mountain, PSN-50-51-61, Redox Construction, Pasco to Ringold, Prosser to Paterson to McNary, Eastern Washington, and Southern Washington-Northern Oregon (HW-36506, HW-38566, HW-39429, HW-40871).

During the first quarter, off-site remote locations were further broken down into individual towns to include Wallula, Touchet, Lowden, Walla Walla, Dixie, Waitsburg, Dayton, Pomeroy, Lewiston, Uniontown, Pullman, Colfax, Steptoe, Rosalia, Spangle, Spokane, Cheney, Reardon, Davenport, Harrington, Sprague, Ritzville, Lind, Connell, Moxee City, Union Gap, Wapato, Toppenish, Toppenish to Goldendale, Goldendale, Goldendale to Wishram, Lyle, Bingen, Camas, Vancouver, Portland, Troutdale, Bonneville, Hood River, The Dalles, Moody, Rufus, Blalock, Arlington, Heppner Junction, and Boardman (HW-36506).

During the second quarter, the off-site remote locations were also broken down into individual towns. These included those listed during the first quarter study, as well as 5 miles east of Waitsburg, Sprague to Ritzville, Harrington to Sprague, Delaney, Dodge, Central Ferry, 5 miles north of Central Ferry, Dusty, Thornton, Plaza, Deepcreek, Telford, Creston, Wilbur, Almira, 10 miles west of Almira, Coulee City, 12 miles from Coulee City, Soap Lake, Stratford, Stratford to Odessa, Odessa, and Lamona (HW-38566).

There were no individual towns listed for the third and fourth quarters of 1955 (HW-39429, HW-40871).

Vegetation samples analyzed for alpha particle emitters were collected from the 200 West Gatehouse, Batch Plant, Rt. 4S Mile 4, Meteorology Tower, Rt. 4S Mile 6, 300 Area, Richland, Pasco, and Benton City (HW-36506, HW-38566, HW-39429, HW-40871).

Significant Events/Emission Quantities

The average daily I-131 emission from the separation facilities during the first quarter of 1955 was 7.9 curies per day. Unusually high emissions of 92 and 70 curies per day occurred on March 17 and 18, respectively, from the T-Plant. A maximum emission of 17 curies per day occurred on March 8 from the S-Plant stack (HW-36506).

Total I-131 emissions from the separation facilities stacks averaged 2.3 curies per day during the second quarter of 1955. A maximum emission of 18 curies per day occurred on March 26 from the S-Plant stack. The maximum emission from the T-Plant stack was 14 curies per day and occurred on April 7, 1955 (HW-38566).

During April, off-site contamination from non-volatile beta particle emitters increased due to a nuclear detonation (HW-38566).

During May, an increase in radioiodine concentrations was observed in the immediate vicinity and north of the Hanford Atomic Products Operation facilities. The presence of I-133 and I-135 revealed that the deposition originated from off-site nuclear detonations (HW-38566).

The average I-131 emissions from the separation facilities during the third quarter was 1.7 curies per day. A maximum emission of 8.2 curies per day occurred on August 26 and 27 from the T-Plant stack. The maximum emission from the S-Plant stack was 6.8 curies per day on September 22, 1955 (HW-39429).

Average I-131 emissions decreased to 1.0 curies per day during the fourth quarter. The maximum emission was 3.8 curies per day from the T-Plant stack. The maximum emission from the S-Plant stack was 2.5 curies per day (HW-40871).

During December, nuclear detonation fallout resulted in an increase in non-volatile beta particle emitters (HW-40871).

Constituents Measured/Reported

Analysis results for the activity densities of I-131 and non-volatile beta particle emitters were reported in table form in units of 10^{-6} μCi/g. Results for alpha emitters were reported in units of 10^{-8} μCi/g (HW-36506, HW-38566, HW-39429, HW-40871).

During the first quarter of 1955, the average deposition of I-131 increased, with the most extensive contamination occurring in March, due to the high emissions from the separation areas. The monthly average activity density from radioiodine on vegetation exceeded the maximum

acceptable at Hanford (1×10^{-5} μCi/g) over areas of approximately 20 and 250 square miles off the project during January and March, respectively. The maximum I-131 concentration of 1.2×10^{-3} μCi/g was found in a sample collected near the 200 West Gate on March 16 (HW-36506).

Deposition maps for each month of the year were provided to illustrate the pattern of I-131 contamination deposited on vegetation (HW-36506, HW-38566, HW-39429, HW-40871).

Average I-131 deposition in remote areas of Washington and Oregon during the first quarter was generally at or less than 3×10^{-6} μCi/g except at Ritzville, where the average deposition was 4×10^{-6} μCi/g and the maximum deposition was 13×10^{-6} μCi/g (HW-36506).

Contamination from non-volatile beta particle emitters found at most locations during the first quarter remained at levels similar to the last quarter of 1954, with averages ranging from 4.0×10^{-7} μCi/g at Boardman and Lewiston, to 5.3×10^{-4} μCi/g at the 200 West-Redox Area. Maximum values ranged from 5.2×10^{-6} μCi/g at Boardman to 6.8×10^{-3} μCi/g at Wahluke Slope (HW-36506).

Concentrations of alpha particle emitters on vegetation were below 1×10^{-6} μCi/g at all locations except for at the 300 Area where a maximum measurement of 3.4×10^{-6} μCi/g was observed in January. The source of this contamination was found to be uranium (HW-36506).

During the second quarter, the concentrations of radioiodine decreased from one half to one ninth of the average measurements of the previous quarter, with the greatest decline occurring in June. The average concentration at all locations, excluding 200 West Gate, Rt. 3, 200 West-Redox Area, and Redox Construction, had decreased to less than 3×10^{-6} μCi/g by June. This decrease was attributed to radioactive decay and precipitation (HW-38566).

During April, off-site contamination from non-volatile beta particle emitters was widespread and as high as 7.2×10^{-4} μCi/g in Eastern Washington (Creston), due to nuclear testing (HW-38566).

During the second quarter, the maximum on-site contamination from non-volatile beta particle emitters was 4.1×10^{-3} μCi/g found in a sample from the 200 East Area in April (HW-38566).

Second quarter average concentrations for non-volatile beta particle emitters on vegetation from off-site locations ranged from 4.9×10^{-5} μCi/g from a sample collected from Prosser-Paterson-McNary to 6.9×10^{-3} μCi/g from a sample from Eastern Washington. On-site location averages ranged from 6.7×10^{-5} μCi/g at PSN-50-51-61 to 1.8×10^{-4} μCi/g at the 200 West-Redox Area (HW-38566).

The average concentration for alpha particle emitters from samples collected from outlying locations was less than 10×10^{-8} μCi/g for the second quarter. On-site averages ranged from $< 10 \times 10^{-8}$ μCi/g at the 300 Area and Rt. 4S Mile 6 to 3.2×10^{-7} μCi/g at the Meteorology Tower (HW 38566).

During the third quarter, average concentrations of I-131 decreased significantly due to a decrease in nuclear detonations. Activity densities dropped to two-thirds to one-quarter of the average measurements from the previous quarter. Average measurements were $< 3 \times 10^{-6}$ μCi/g at all

sampling locations except for at 200 West Area locations. The maximum activity density was 8.3 x 10^{-5} μCi/g from a sample collected at the 200 West Gate (HW-39429).

There was a general decrease and return to normal values in the average concentrations of non-volatile beta particle emitters at all locations during the third quarter due to rainfall and decay (HW-39429).

During the third quarter average activity densities from non-volatile beta particle emitters from samples collected on-site ranged from 3.3 x 10^{-5} μCi/g at the 200 West-Redox Area to 8.9 x 10^{-5} μCi/g at the 200 West Area. Samples from off-site locations ranged from 2.2 x 10^{-5} μCi/g at southern Washington, northern Oregon to 3.7 x 10^{-5} μCi/g at Benton City-Kiona (HW-39429).

The average concentration for alpha particle emitters during the third quarter was $< 10 \times 10^{-8}$ μCi/g at all locations except for 200 West Gate, Meteorology Tower, and Batch Plant, where averages ranged from 2.1 x 10^{-7} to 3.6 x 10^{-7} μCi/g. The maximum activity density was 9.3 x 10^{-7} μCi/g from the Meteorology Tower (HW-39429).

Activity densities for I-131 on vegetation remained low during the fourth quarter. All off-site locations had average depositions of $< 3 \times 10^{-6}$ μCi/g. A maximum off-site measurement of 1.8 x 10^{-5} μCi/g was sampled from the Kennewick environs in December (HW-40871, HW-40692 E).

Average activity densities for I-131 from on-site locations during the fourth quarter were $< 3 \times 10^{-6}$ μCi/g at all locations except for PSN-50-51-61, Meteorology Tower, Rt. 3, and the 200 West Areas. A maximum concentration of 1.0 x 10^{-4} μCi/g was found in a sample collected at the 200 West Gate in November (HW-40871).

During October and November concentrations from non-volatile beta particle emitters remained low. In December, extensive bomb fallout increased the average concentrations two to three times over those of the previous months. The maximum off-site concentrations of 4.5 x 10^{-4} μCi/g occurred in samples from southern Washington and northern Oregon. The maximum on-site concentration was 8.6 x 10^{-4} μCi/g from the 200 West Area in November (HW-40871).

The concentrations of alpha particle emitters increased significantly during the fourth quarter. While outlying areas generally still averaged $< 10 \times 10^{-8}$ μCi/g, on-site areas average as high as 1.7 x 10^{-6} μCi/g. A maximum measurement of 3.1 x 10^{-6} μCi/g was found at the 200 West Gate (HW-40871).

Fission products are the most potentially hazardous group of radioactive materials available to contaminate food crops. Crops may be contaminated by direct fallout on the plant, or soil contamination, with the products being absorbed into the plants (HW-36734).

Soil contamination, without successive fallouts that could cause fission build-up, would eventually decay and/or be absorbed selectively by plants, resulting in successive crops having decreasing exposures (HW-36734).

The significant fission products that will be absorbed by plants include isotopes of strontium, barium, iodine, and, in certain soil types, cesium. Taking into consideration the half-life, percentage composition in a natural mixture of fission products, and the potential effect on animals, the strontium isotopes are the most important (HW-36734).

Experimentation has shown that the "provisional vegetation contamination limit" of 10^{-5} μCi of I-131/g is safe for grazing animals. The permissible limit for humans is 30 mrem to the thyroid gland per week. With vegetation levels of 10^{-5} μCi/g, this permits a daily intake of 2 quarts of cows milk or 1 1/3 lbs. of garden produce. Studies have shown, to keep the area vegetation at the proposed limit, the daily releases of I-131 must be about one curie or less. A variation of 10 curies per week with not more than 3 curies per day was also proposed (HW-39073).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1956

Media Sampled

During 1956, over 10,100 vegetation samples were collected and analyzed for radionuclide contamination. Over 7900 of these samples were obtained from locations within the perimeter of the Hanford project and the adjoining communities of the Tri-City area. The remainder of the samples were collected from remote locations in southern and eastern Washington and northern Oregon (HW-43012, HW-44215, HW-46726, HW-48374).

All vegetation specimens collected were analyzed for I-131. In addition, approximately 5400 of the samples were analyzed for non-volatile beta particle emitters. Also, 200 samples from selected locations were analyzed to determine the activity density from alpha particle emitters (HW-43012, HW-44215, HW-46726, HW-48374).

Sampling Locations

Routine vegetation sampling locations included 200 West Area, 200 West-Redox, 200 West Gate, Rt. 3, Meteorology Tower, Batch Plant, 200 East Area, near the 200 Areas, north of the 200 Areas, south of the 200 Areas, PSN-50-51-61, Goose Egg Hill, Wahluke Slope, Pasco to Ringold, Richland, Benton City-Kiona, Kennewick Environs, Pasco Environs, Prosser to Paterson to McNary, Eastern Washington, and Southern Washington/Northern Oregon. In addition, during the first quarter of 1956 vegetation from Rattlesnake Mountain was sampled. During the final three quarters of the year vegetation from Richland "Y" and 200 East-Purex was sampled (HW-43012, HW-44215, HW-46726, HW-48374).

Vegetation samples analyzed for alpha particle emitters were collected from 200 West Gate, Meteorology Tower, Batch Plant, Rt. 4S-Mile 4, Rt. 4S-Mile 6, Pasco, and Benton City. During the first quarter samples were also collected from the 300 Area and Richland (HW-43012, HW-44215, HW-46726, HW-48374).

Significant Events/Emission Quantities

The total average I-131 emission from S-Plant, T-Plant, and Semi-Works stacks was 0.24 curies per day during the first quarter of 1956. Approximately 90% of this I-131 came from the S-Plant stack, where the quarterly average and maximum were 0.22 and 1.36 curies per day, respectively (HW-43012).

During the first quarter, I-131 emissions from the T-Plant decreased significantly due to shut down, resulting in an average daily emission of less than 4×10^{-3} curies per day (HW-43012).

Iodine-131 emissions from the Semi-Works stacks increased during March, resulting in a maximum and average emission of 0.46 and 0.039 curies per day, respectively (HW-43012).

During late March, an increase in radioiodine deposition on vegetation was noted as a result of nuclear fallout (HW-43012).

The average daily I-131 emissions from the A-Plant, S-Plant, and Semi-Works stacks for the second quarter was 2.0 curies per day, a significant increase over that of the previous quarter. Approximately 60% of the emissions came from the A-Plant stack, where the quarterly average and maximum were 1.2 and 26 curies per day, respectively (HW-44215).

A total of 61 curies of I-131 was emitted from the A-Plant stack during the seven day period from June 20 to June 27 (HW-44215).

During April and June, significant increases in radioiodine deposition on vegetation was found to be as a result of nuclear bomb fallout (HW-44215).

The total average I-131 emission from the A-Plant, S-Plant, and Semi-Works stacks was 0.28 curies per day during the third quarter. Approximately 80% of the I-131 emissions came from the A-Plant stack, where the quarterly average and maximum were 0.23 and 1.6 curies per day, respectively (HW-46726).

During July and August, deposition from nuclear bomb fallout caused increased radioiodine and non-volatile beta particle emitter activities (HW-46726).

The average daily I-131 emission from A-Plant and S-Plant stacks for the fourth quarter was 1.5 curies per day. (The Semi-Works stack emissions were less than the detection limit due to extended shutdown.) The maximum emission of 23 curies per day came from the S-Plant stack, where 52 curies were released during a seven day period in December. The maximum emission from the A-Plant stack was 4.4 curies per day (HW-48374).

Constituents Measured/Reported

Analysis results for the activity densities of I-131 and non-volatile beta particle emitters were reported in table form in units of 10^{-6} μCi/g. Results for alpha particle emitters were reported in units of 10^{-8} μCi/g (HW-43012, HW-44215, HW-46726, HW-48374).

Deposition maps for the months of January through April, June through August, and December were provided to illustrate the pattern of I-131 contamination on vegetation. There was no significant deposition during the months of May, and September through November (HW-43012, HW-44215, HW-46726, HW-48374).

During the first quarter, the average I-131 deposition on vegetation was $< 3 \times 10^{-6}$ μCi/g at all sampling locations, with the exception of Prosser to Paterson to McNary. A maximum measurement of 4.8×10^{-5} μCi/g was found 10 miles south of Prosser on March 22 (HW-43012, HW-41703).

Significant concentrations of non-volatile beta particle emitters were found throughout the first quarter at all locations as a result of continuing bomb fallout. Off-site average concentrations ranged from 8.2×10^{-5} μCi/g for samples collected at Benton City-Kiona, to 1.3×10^{-4} μCi/g, for samples from southern Washington/northern Oregon. The maximum off-site non-volatile beta particle emitter activity density was 4.4×10^{-4} μCi/g, collected in southern Washington/northern Oregon in March. Average on-site non-volatile concentrations ranged from 8.6×10^{-5} μCi/g, collected from Wahluke Slope, to 7.8×10^{-4} μCi/g, collected at the 200 West Area. The maximum on-site measurement was 1.4×10^{-2} μCi/g sampled from South of the 200 Areas (HW-43012).

The average activity density from alpha particle emitters for off-site locations during the first quarter was below the detection limit of 1×10^{-7} μCi/g. The maximum measurement was 1.5×10^{-7} μCi/g from a sample collected at Pasco (HW-43012).

The average activity density from alpha particle emitters for on-site locations during the first quarter ranged from 2.0×10^{-7} μCi/g at the 300 Area to 2.4×10^{-6} μCi/g at the 200 West gate. A maximum measurement of 3.8×10^{-6} μCi/g was from a sample collected at the 200 West gate (HW-43012).

During the second quarter, average on-site concentrations of I-131 ranged from (<3 to 5) $\times 10^{-6}$ μCi/g. Maximum measurements ranged from 1.2×10^{-5} μCi/g at the Meteorology Tower to 7.3×10^{-5} μCi/g from samples collected near the 200 Areas (HW-44215).

Average off-site I-131 concentration for the second quarter was $<3 \times 10^{-6}$ μCi/g. Maximum measurements ranged from 1.3×10^{-5} μCi/g, collected from the Pasco Environs, to 3.4×10^{-5} μCi/g, sampled from Eastern Washington (HW-44215).

The maximum measurement from non-volatile beta particle emitters found in samples from on-site locations during the second quarter, was 1.5×10^{-3} μCi/g collected from the 200 West Area. Average on-site non-volatile values ranged from 4.8×10^{-5} μCi/g from samples from Goose Egg Hill, to 1.7×10^{-4} μCi/g collected at the 200 West Area (HW-44215).

Average second quarter activity densities from non-volatile beta particle emitters for off-site locations ranged from 5.3×10^{-5} μCi/g from samples collected from the Benton City-Kiona area, to 1.2×10^{-4} μCi/g collected from southern Washington/northern Oregon. A maximum value of 1.8×10^{-3} μCi/g was found in a sample from southern Washington/northern Oregon (HW-44215).

During the second quarter, all vegetation samples collected from off-site locations exhibited alpha particle activity densities of less than the detectable value of 1×10^{-7} μCi/g (HW-44215).

The maximum on-site activity density from alpha particle emitters during the second quarter was 1.6×10^{-6} μCi/g collected at the Meteorology Tower. Average on-site measurements ranged from 1.8×10^{-7} μCi/g from Rt. 4S, Mile 4, to 6.6×10^{-7} μCi/g from the 200 West Gate (HW-44215).

Third quarter radioiodine deposition on vegetation was primarily due to nuclear fallout. Minimum amounts of I-131 were deposited due to Hanford sources (HW-46726).

The maximum I-131 measurement for the third quarter was 2.0 x 10^{-4} μCi/g, which occurred on July 10, and was found at Rt. 4S-Mile 20 (South of the 200 Areas). Off-site maximum measurements during July ranged from 1 x 10^{-5} μCi/g from samples collected in southern Washington/northern Oregon, to 1.5 x 10^{-4} μCi/g, collected from the Pasco to Ringold area and eastern Washington. Deposition decreased as the third quarter progressed, so that by September the average deposition at all locations, both on and off the project, with the exception of Batch Plant, PSN-50-51-61, and 200 West Gate, was less than the detectable limit of 3 x 10^{-6} μCi/g (HW-46726).

Concentrations of non-volatile beta particle emitters on vegetation during the third quarter were primarily due to nuclear bomb fallout, and gradually decreased to near normal values by September (HW-46726).

The maximum on-site non-volatile beta particle deposition found on vegetation during the third quarter was 1.9 x 10^{-3} μCi/g , from a sample collected at Goose Egg Hill in July. The maximum off-site measurement of 2.1 x 10^{-3} μCi/g was found in a sample collected from the Pasco to Ringold region (HW-46726).

Samples analyzed for non-volatile beta particle emitters during July had averages ranging from 3.9 x 10^{-5} μCi/g, collected from southern Washington/northern Oregon, to 4.0 x 10^{-4} μCi/g from the Pasco to Ringold region. By September, average values ranged from 4.5 x 10^{-5} μCi/g, collected from southern Washington/northern Oregon, to 1.6 x 10^{-4} μCi/g from the 200 West Area (HW-46726).

The average concentrations of alpha particle emitters on vegetation decreased during the third quarter. On-site average activity densities ranged from < 1 x 10^{-7} μCi/g at the Meteorology Tower and Rt. 4S, Mile 6, to 1.4 x 10^{-7} μCi/g at 200 West Gate and Rt. 4S, Mile 4. The off-site average concentration was less than 1 x 10^{-7} μCi/g. The maximum alpha measurement for the quarter was 2.7 x 10^{-7} μCi/g from a sample collected at the 200 West Gate (HW-46726).

The average deposition of I-131 on vegetation during October and November was less than 3 x 10^{-6} μCi/g at all sampling locations with the exception of 200 East-Purex. During December, off-site concentrations remained at this level, while on-site concentrations increased due to the emissions from the chemical processing plant. Average on-site concentrations in December ranged from <3 x 10^{-6} to 1.5 x 10^{-5} μCi/g, with a maximum measurement of 1.6 x 10^{-4} μCi/g from south of the 200 Areas (HW-48374).

Concentrations of non-volatile beta particle emitters on vegetation remained at low levels throughout the fourth quarter, with averages ranging from 5.1 x 10^{-5} μCi/g from samples collected at Pasco, to 1.4 x 10^{-4} μCi/g collected at 200 West-Redox. The maximum non-volatile concentration was 8.1 x 10^{-4} μCi/g, from a sample collected at Wahluke Slope (HW-48374).

The average concentration of alpha particle emitters on vegetation remained below the detection limit of 1 x 10^{-7} μCi/g in off-site locations during the fourth quarter, but nearly tripled in locations near the chemical processing areas. The maximum alpha particle concentration was 1.2 x 10^{-6} μCi/g from a sample collected at the 200 West Gate, and on-site averages ranged from less than 1 to 5.6 x 10^{-7} μCi/g (HW-48374).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1957

Media Sampled

During the first half of 1957, over 5000 vegetation samples were collected during routine sampling and analyzed for radionuclide contamination. Over 4200 of these samples were collected from locations within the perimeter of the Hanford Project and the adjoining communities of the Tri-City area. The remainder of the samples were collected from remote locations in Washington and Oregon (HW-51009, HW-52803).

All of the vegetation samples collected during the first half of the year were analyzed for I-131 using wet chemistry techniques. In addition, 2800 of the samples were analyzed for non-volatile beta particle emitters, a total beta count providing a gross measurement with no radioisotopic species identification. Eighty samples from representative locations were analyzed for alpha particle emitters (HW-51009, HW-52803).

During the second half of 1957, a new technique involving gamma ray spectrometric analyses was applied to vegetation testing. This technique enabled the quantitative analyses of I-131, Ce-141/Ce-144/Pr-144, Zr/Nb-95, Ru-103/Ru-106, Ba/La-140, and "fission products less I-131." Cesium-137 was also identified in samples from Zone B only (HW-52038). During the third quarter, duplicate sampling from several locations was done to compare the results from the new gamma energy technique with the former wet chemistry technique (HW-54841, HW-54913, HW-54842).

Starting in July, 1957, ten 15 gram vegetation samples were collected from each of twenty-five zones. These samples were then composited in the laboratory into one 150 gram sample per zone, placed into 9 ounce jars, and counted on a 3 inch x 3 inch NaI crystal connected to a 100 channel gamma spectrometer. (There was a discrepancy between report HW-54841 and report HW-52038 as to the amount of vegetation collected from each zone. The former stated that ten 150 gram samples were collected and composited into one 150 gram sample, while the latter stated that ten 15 gram samples were collected and composited.) Approximately 230 composite samples were collected on the project and 260 composite samples were collected from off-project areas in Washington and Oregon during the second half of the year. Fifty 25 gram vegetation samples were analyzed for alpha particle emitters (HW-54841, HW-54842, HW-52038).

Several crops were analyzed in a special study to determine the effects of exposure to reactor effluent water on vegetation. Crops examined included blackeyed peas, tomatoes, okra, string beans, corn, grapes, pasture grass and barley. Concentrations of radiozinc were reported (Davis et al. 1958).

A special study to determine if Hanford contributes Sr-90 to the environment involved sampling from both on-site and off-site locations. Grasses, sage, and cheatgrass (old growth and new) were collected and analyzed (HW-55117).

Sampling locations

Routine vegetation sampling locations during the first half of 1957 consisted of on-project locations including 200 West Area, 200 West-Redox, 200 West Gate, Rt. 3, Meteorology Tower, Batch Plant, 200 East Area, 200 East-Purex, near the 200 Areas, north of the 200 Areas, south of the 200 Areas, PSN-50-51-61, Goose Egg Hill, Wahluke Slope, and, during April and May, Rattlesnake Mountain. Off-project locations included Pasco to Ringold, Richland, Benton City-Kiona, Richland "Y", Kennewick Environs, Pasco Environs, Prosser to Paterson to McNary, Eastern Washington, and Southern Washington/Northern Oregon (HW-51009, HW-52803).

During the second half of 1957, vegetation samples were collected from twenty-five zones encompassing the Hanford Project, the surrounding communities, and remote areas of Washington and Northern Oregon. These zones were then combined into six group locations: Separations Areas (zones A,B,C,D), Project (zones E,F,G,H,J), Wahluke Slope (zones O,P), Residential Areas (zones I,K,L,M,N,Q), Eastern Washington (zones R,S,T,U), and South-Central Washington/Northern Oregon (zones V,W,X,Y). Individual towns comprising the Residential Group include Richland, Pasco, Kennewick, Richland "Y", Benton-City-Kiona, Prosser to Paterson to McNary, and Ringold. Towns in the Eastern Washington Group include Wallula, Touchet, Walla Walla, Dixie, Waitsburg, Dayton, Pomeroy, Lewiston, Uniontown, Pullman, Colfax, Rosalia, Spokane, Reardon, Davenport, Harrington, Sprague, Ritzville, Lind, and Connell. Towns in the South-Central Washington/Northern Oregon Group include Boardman, Arlington, Blalock, Celilo, The Dalles, Bonneville, Troutdale, Portland, Vancouver, Camas, Stevenson, Bingen, Lyle, Goldendale, Goldendale to Lyle-Mile 10, Toppenish, Toppenish to Goldendale-Miles 10, 20, and 30, Wapato, Union Gap, and Moxee (HW-54841, HW-54842, HW-52038).

Crops sampled as part of the study to determine the effects of effluent water, were collected from a farm approximately 46 kilometers downstream from the reactors, the closest farm utilizing Columbia River water for irrigation purposes (Davis et al. 1958).

Vegetation samples analyzed for alpha particle emitters were collected from 200 West Gate, Meteorology Tower, Batch Plant, Rt. 4S-Mile 4, Rt. 4S-Mile 6, Pasco, and Benton City (HW-51009, HW-52803, HW-54841, HW-54842).

Vegetation samples for the strontium study were collected from Pasco to Ringold, Wahluke Slope, Goose Egg Hill, Route 3, Route 2S, Route 10, Route 11A, M.P. Post #7, M.P. Post #14, M.P. Post #22, Toppenish, Toppenish to Goldendale-Mile 30, Goldendale, Lyle, Vancouver, Camas, The Dalles, Troutdale, Seaside, and Hood River (HW-55117).

Significant Events/Emission Quantities

The total average I-131 emission from the A-Plant and S-Plant stacks for the first quarter was 1.4 curies per day. Approximately 70 % of the I-131 was emitted from the S-Plant stack, where the maximum emission was 9.6 curies per day. The maximum emission from the A-Plant stack was 3.0 curies per day (HW-51009).

During the second quarter, the average I-131 emission from A-Plant and S-Plant stacks was 0.8 curies per day. Approximately 80 percent of the I-131 was emitted from the A-Plant stack, where the average and maximum measurements for the quarter were 0.69 and 2.5 curies per day, respectively. The maximum emission from the S-Plant stack was also 2.5 curies per day (HW-52803).

During June, increases in radioiodine activities and non-volatile beta particle emitters were the result of bomb fallout from nuclear tests in Nevada (HW-52803, HW-52038).

The total average I-131 emission from A-Plant and S-Plant stacks for the third quarter was 1.0 curie per day. Approximately 60% of this I-131 was emitted from the A-Plant stack, where the maximum emission was 4.6 curies per day. The maximum emission from the S-Plant stack was 2.1 curies per day (HW-54841).

Fourth quarter total average I-131 emission from A-Plant (Purex) and S-Plant (Redox) stacks was 0.9 curies per day. Approximately 60% of the I-131 was emitted from the S-Plant stack, where a maximum emission of 13 curies per day occurred in November. The maximum emission from the A-Plant stack was 1.3 curies per day (HW-54842). (There was a discrepancy in this report concerning the maximum emissions. The abstract stated that 60 percent of the I-131 was emitted from the A-Plant stack. However, after examining the table containing the actual measurements, one may observe that 60% of the emission actually originated at the S-Plant stack.)

Nuclear testing resulted in significant increases in I-131 and "Fission Products less I-131" during October (HW-54842).

Constituents Measured/Reported

Analysis results were reported in table form in units of 10^{-6} μCi/g, with the exception of alpha particle emitter results, which were reported in units of 10^{-7} μCi/g (HW-51009, HW-52803, HW-54841, HW-54842, Healy et al. 1958).

Early use of gamma ray spectroscopy techniques for vegetation analysis indicated that the wet chemistry techniques being used for I-131 determinations yielded results that were low by a factor of three. As a result, all positive I-131 vegetation results for the first and second quarters of 1957 were multiplied by three, giving increased quarterly averages when compared to previous results (HW-51009, HW-52803). Later comparisons of I-131 measurements obtained from gamma spectroscopy techniques and wet chemistry techniques revealed that results obtained from the gamma spectroscopy method averaged a factor of 1.6 times those obtained with the wet chemistry technique (HW-54841).

"Local limits permit the emission of 10 curies per week of iodine-131" (Healy et al. 1958).

The average I-131 deposition from off-site locations during the first quarter was at or below the detectable limit of 3 x 10^{-6} μCi/g, with the exception of Richland "Y", where the average was 4 x 10^{-6} μCi/g. The maximum deposition was 2.2 x 10^{-5} μCi/g, collected from the Kennewick Environs

and Pasco to Ringold. On-site average deposition ranged from less than 3 x 10^{-6} μCi/g, from samples collected from North of the 200 Areas, to 2.0 x 10^{-5} μCi/g, from samples collected at 200 West-Redox. The maximum on-site measurement was 2.8 x 10^{-4} μCi/g, collected from Goose Egg Hill (HW-51009).

The off-project limit for I-131 on vegetation is 1 x 10^{-5} μCi/g (HW-52038).

Non-volatile beta particle emitters remained at low levels throughout the first quarter. The average off-site measurements ranged from 6.0 x 10^{-5} μCi/g, from samples collected from Benton City-Kiona, to 9.8 x 10^{-5} μCi/g, from samples collected in Eastern Washington. The maximum measurement was 1.25 x 10^{-3} μCi/g, sampled in Eastern Washington. On-site non-volatile values ranged from 6.0 x 10^{-5} μCi/g, collected from PSN-50-51-61 and Goose Egg Hill, to 1.1 x 10^{-4} μCi/g, collected from 200 East Area, 200 West Area, and 200 West-Redox. The maximum on-site measurement was 7.6 x 10^{-4} μCi/g, sampled from North of the 200 Areas (HW-51009).

During the first quarter the average concentration of alpha particle emitters near the Chemical Processing Areas doubled over that of the previous quarter, with an average value of 5.9 x 10^{-7} μCi/g. The maximum value of 2.5 x 10^{-6} μCi/g was collected at the 200 West Gate. Increases were also noted in off-site locations, where a maximum measurement of 2.7 x 10^{-7} μCi/g was obtained from a sample collected at Pasco (HW-51009).

During April and May, off-site average I-131 values were less than 3 x 10^{-6} μCi/g at all locations, with the exception of the Pasco to Ringold area, where the average measurement was 5 x 10^{-6} μCi/g. Off-site average I-131 measurements for June ranged from 1.0 x 10^{-5} μCi/g, sampled from Eastern Washington, to 4.6 x 10^{-5} μCi/g, collected at Richland. The maximum measurement for June was 2.1 x 10^{-4} μCi/g, collected from Richland and the Pasco to Ringold area (HW-52038).

Average I-131 values on vegetation samples collected on-site during the second quarter decreased from 5 x 10^{-6} μCi/g during April, to 3 x 10^{-6} μCi/g during May. June's average I-131 increased to 4.9 x 10^{-5} μCi/g, due to nuclear fallout. The maximum on-site measurement was 2.28 x 10^{-3} μCi/g, from a sample collected from near the 200 Areas (HW-52803).

On-site non-volatile average values ranged from 5.4 to 25 x 10^{-5} μCi/g for the month of April. May's measurements decreased, ranging from 6.4 to 13 x 10^{-5} μCi/g. During the month of June, average non-volatile activity densities ranged from 2.7 to 4.8 x 10^{-4} μCi/g. The maximum on-site value was 4.03 x 10^{-3} μCi/g, collected from near the 200 Areas (HW-52803).

Non-volatile average off-site activities for the month of April ranged from 3.4 x 10^{-5} μCi/g from samples collected at Benton City-Kiona, to 1.2 x 10^{-4} μCi/g, collected from Eastern Washington. May average values decreased, with measurements ranging from 3.5 to 7.1 x 10^{-5} μCi/g. June's nuclear fallout resulted in an increased averages, ranging from 1.5 to 5 x 10^{-4} μCi/g. The maximum off-site non-volatile measurement for the quarter was 1.16 x 10^{-3} μCi/g, collected from the Pasco to Ringold location (HW-52803).

During June, radioiodine values on vegetation increased by a factor of 10 and non-volatile beta particle emitter values exhibited a three-fold increase, due to nuclear testing in Nevada (HW-52803).

The use of alpha scintillation counting in April, resulted in a new alpha particle detection limit of 3×10^{-8} μCi/g, replacing the old limit of 1×10^{-7} μCi/g (HW-52803).

The average activity density from alpha particle emitters for the second quarter for samples collected from off-site locations was $<0.3 \times 10^{-7}$ μCi/g, with a maximum measurement of 0.5×10^{-7} μCi/g. On-site averages ranged from 0.8×10^{-7} μCi/g, from a sample collected at Rt. 4S, Mile 6, to 12×10^{-7} μCi/g from samples collected at the 200 West Gate. The maximum on-site alpha value was 5.5×10^{-6} μCi/g, from a sample collected at the 200 West Gate (HW-52803).

In early 1957, Sr-90 analysis of vegetation samples indicated an average on-site value of 1×10^{-7} μCi/g. Perimeter area samples averaged 0.3×10^{-7} μCi/g, and samples collected from long distances (60 to 250 km from the project) averaged 2×10^{-7} μCi/g (Healy et al. 1958).

Deposition maps illustrating the pattern of I-131 contamination deposited on vegetation were provided. Maps depicting results obtained from wet chemistry analyses were furnished for the months of January through July. Deposition maps showing radioiodine contamination results obtained from gamma spectrometry techniques were provided for the months of July through December (HW-54841, HW-52803, HW-51009, HW-54842).

Starting in July, 1957, gamma spectroscopy techniques were applied to vegetation analyses. Previous wet chemistry methods involved the leaching of the I-131 from a vegetation sample with a hot, dilute HNO_3 solution, followed by a carrier precipitation of I-131 as silver iodide. The I-131 was then measured by beta counting. This method sometimes gave low and erratic yields, occasional contamination from other fallout radioisotopes, and low sensitivity. The non-volatile analysis, or "total beta," only provided a gross measurement, with no information as to the radioisotopic species being measured. The gamma spectroscopy technique has enabled the quantitative analyses of I-131, Ce-141/144, Ru-103/106, Zr/Nb-95, and Ba/La-140 (HW-54913).

During the third quarter, the average I-131 and Fission Products less I-131 activity densities on vegetation decreased at all sampling locations. Iodine-131 values were less than 1.5×10^{-6} μCi/g at all locations with the exception of the Separation Areas, where 2.7×10^{-6} μCi/g was recorded (HW-54841).

During the third quarter, the average alpha particle emitter activity density increased by a factor of 2 at locations near the Separation Areas. The quarterly average ranged from 1.9×10^{-7} μCi/g from samples collected at the Meteorology Tower, to 2.7×10^{-6} μCi/g, collected at the 200 West Gate. The maximum measurement of 5.7×10^{-6} μCi/g was sampled from the 200 West Gate. Off-site alpha measurements averaged 0.3×10^{-7} μCi/g, with a maximum value of 0.6×10^{-7} μCi/g, collected from Benton City (HW-54841).

Measurements for Fission Products less I-131 for the third quarter ranged from 1.6×10^{-5} μCi/g, from samples collected in south/central Washington and northern Oregon, to 1.1×10^{-4} μCi/g,

collected from the Separation Areas. Values for Eastern Washington and the Residential Areas were 3.7×10^{-5} μCi/g and 3.1×10^{-5} μCi/g, respectively (HW-54841).

Third quarter values for Zr/Nb-95 ranged from 6×10^{-6} μCi/g from samples collected from south/central Washington and northern Oregon, to 2.9×10^{-5} μCi/g, from samples collected at the Separation Areas (HW-54841).

Ru-103/106 values ranged from $<2 \times 10^{-6}$ μCi/g to 8.3×10^{-6} μCi/g during the third quarter, while Ba/La-140 values ranged from 2.8×10^{-6} μCi/g to 9.0×10^{-6} μCi/g. Ce-141/144 values ranged from 6.7×10^{-6} μCi/g to 5.6×10^{-5} μCi/g (HW-54841).

Iodine-131 deposition on vegetation increased by a factor of almost 10 throughout the Pacific Northwest in October as a result of nuclear bomb fallout. Fission Products less I-131 increased by a factor of 3. Normal values returned by November (HW-54842).

During the fourth quarter, average I-131 deposition ranged from 5.3×10^{-6} μCi/g, from samples collected in south/central Washington and northern Oregon, to 1.2×10^{-5} μCi/g, from samples collected in the Separation Areas. Values from Eastern Washington averaged 6.8×10^{-6} μCi/g (HW-54842).

High I-131 emissions from the S-Plant (Redox) in November resulted in increased deposition on vegetation in the Residential Areas, where the maximum deposition was 3.0×10^{-5} μCi/g from samples collected at Benton City and Richland. The quarterly average for the Residential Areas was 1.0×10^{-5} μCi/g (HW-54842).

Average alpha particle emitter activity densities increased up to a factor of 6 at locations near the Separation Areas during the fourth quarter. A maximum measurement of 1.1×10^{-5} μCi/g was obtained from a sample from the 200 West Gate. Average values ranged from 5.3×10^{-7} to 5.4×10^{-6} μCi/g. A five-fold increase occurred in vegetation sampled from the residential areas, where a maximum measurement of 3.3×10^{-7} μCi/g was found. Average values were 1.3×10^{-7} μCi/g and 1.6×10^{-7} μCi/g for Benton City and Pasco, respectively (HW-54842).

Measurements for "Fission Products Less I-131" for the fourth quarter ranged from 1.32×10^{-4} μCi/g from samples collected from Wahluke Slope, to 2.45×10^{-4} μCi/g from samples collected at the Separation Areas. Values for the Residential Areas, Eastern Washington, and South/Central Washington-Northern Oregon were 1.75×10^{-4}, 1.82×10^{-4}, and 1.35×10^{-4} μCi/g, respectively HW-54842).

Fourth quarter Zr/Nb-95 values ranged from 2.1×10^{-5} to 5.1×10^{-5} μCi/g, while Ru-103/106 measurements ranged from 8.1×10^{-6} to 5.2×10^{-5} μCi/g (HW-54842).

Barium/Lanthanum-140 measurements for the fourth quarter ranged from 2.0×10^{-5} μCi/g from samples collected at Wahluke Slope, to 3.9×10^{-5} μCi/g, from samples collected in Eastern Washington. Values from the Residential Areas averaged 3.8×10^{-5} μCi/g for these isotopes (HW-54842).

Cerium-141/144 values for the fourth quarter ranged from 6.4 x 10^{-5} μCi/g from samples collected from Wahluke Slope, to 1.16 x 10^{-4} μCi/g from samples collected in the Separation Areas. Measurements from South/Central Washington-Northern Oregon, the Residential Areas, and Eastern Washington were 1.01 x 10^{-4}, 9.6 x 10^{-5}, and 8.6 x 10^{-5} μCi/g, respectively (HW-54842).

Results reported from the special Sr-90 study revealed that the deposition from Hanford sources was not measurable above that which originated from nuclear blasts. On-site Sr-90 values ranged from 0.05 $\mu\mu$Ci/g of sample collected from Wahluke Slope, to 1.33 $\mu\mu$Ci/g of sample, collected from Route 3. Off-site values ranged from 0.24 $\mu\mu$Ci/g of sample, collected from Seaside, Oregon, to 1.27 $\mu\mu$Ci/g of sample collected from Camas, Washington (HW-55117).

The maximum monthly average I-131 values for 1957 were 18 x 10^{-6} μCi/g, from on-site in June, 16 x 10^{-6} μCi/g, from perimeter locations in October, and 16 x 10^{-6} μCi/g, from long distances (60-250 km/40-150 miles), in October (HW-89066, Healy et al. 1958).

Gamma ray spectroscopy methods have made it possible to measure I-131 with a sensitivity of about 1 x 10^{-6} μCi/g on a 150 gram sample using a 3 inch x 3 inch NaI (Tl) scintillation spectrometer. By doubling the sample size and using a 3 inch x 5 inch crystal, sensitivity could be improved by a factor of 2 to 3 . This sensitivity is a 10 to 15 fold increase over the original wet chemistry technique. Disadvantages to the larger sample technique are low resolution and about twice the background counting rate (HW-54913).

Radiozinc was found present in all farm produce sampled from the closest farm utilizing Columbia River water for irrigation purposes, approximately 46 km downstream from the reactors. The accumulation of Zn-65 is associated with its long half-life and to the natural zinc deficiency of the soil in which the crops were grown. Small amounts of Cr-51 and Sc-46 were also found in a few of the vegetation samples (Davis et al. 1958).

Pasture grass exhibited higher concentrations of contaminants due to the fact that the land is irrigated using routine flooding, rather than rills. The radiozinc concentration found in the pasture grass was 8.29 x 10^{-5} μCi/g (Davis et al. 1958).

Concentrations of Zn-65 found in blackeyed peas, tomatoes, and okra, were 5.49 x 10^{-7}, 4.58 x 10^{-7}, and 3.94 x 10^{-7} μCi/g, respectively. Concentrations in string beans, corn, and grapes were 2.9 x 10^{-7}, 1.56 x 10^{-7}, and 8.9 x 10^{-8} μCi/g, respectively (Davis et al. 1958).

Crops of barley grown in the same plots, irrigated with undiluted reactor effluents for six years, and reseeded with grain harvested from the plots, have shown no effects from the radioisotopes on the productivity of the crop or germination of the grain (Davis et al. 1958).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1958

Media Sampled

Vegetation sampling was performed weekly to monthly from areas in and around the Hanford project. Specimens, principally grasses and sagebrush, were composited into one 150 gram sample, packed into a 9-ounce jar, then analyzed with a 256-channel gamma-ray spectrometer. Specific isotopic concentrations were calculated from the counting rates obtained after applying correction values for scattering and natural background (HW-61676, Soldat 1960).

Crop samples were analyzed for K-40, Cr-51, Zn-65, Zr/Nb-95, I-131, Cs-137, Ba/La-140, and Ce-141/144. Radiochemical methods and beta counting were used to determine strontium content. Crops collected included potatoes, carrots, tomatoes, onions, squash, green beans, cucumbers, watermelon, sugar beets, parsley, corn, apricots, peaches, cantaloupe, grapes, and alfalfa. Six to ten pound samples of each crop were analyzed (HW-61676).

A special study was done to compare the radioisotopic concentrations found in burned versus unburned cheatgrass fields in May, 1958. One square meter plots were sampled and analysis results for Ce-144, Ru-106, Zr/Nb-96, and Mn-54 were reported. The cheatgrass was clipped at ground level and radionuclide measurements were made using a 256 channel gamma-ray spectrometer. Values were corrected for absorption, geometry, interference radiation, and for radioactive decay to time of collection (HW-69500).

Sampling Locations

Routine vegetation sampling locations were found in 27 geographical zones in and around the project and in Eastern Washington and Northern Oregon (HW-61676).

Twenty-eight crop samples were collected from the Riverview district, which is irrigated by Columbia River water containing Hanford effluents. Seven samples were collected in the Finley district, which is irrigated using Yakima River water, and nine samples were collected from Walla Walla, which in not influenced by Hanford productions (HW-61676).

The sample site for the comparison study of burned and unburned grass fields was located on the edge of the Hanford reservation at the base of Rattlesnake Mountain (HW-69500).

Significant Events/Emission Quantities

The average emissions from the Separations Plant stacks for 1958 were: (HW-61676, Soldat 1960).

Radioisotope	Curies/day
I-131	1.2
RE + Y	0.02
Nb-9	0.01
Zr-95	0.004
Ru-103	0.004
Sr-89	0.0035
Sr-90	0.0005

Numerous nuclear detonations throughout 1958 effected the concentrations of radioisotopes observed (HW-61676).

Constituents Measured/Reported

Local limits restrict the I-131 emission rates from the Separations Plant stacks to 10 curies per week (Soldat 1960).

Iodine-131 is emitted from the Separations Plant stacks in a gaseous form, while the other radioisotopes emitted are associated with particulate material (Soldat 1960).

The pattern of deposition for I-131 and atmospheric particulates were measured by performing radiological surveys on the ground using portable equipment utilizing a 5 inch diameter, 5 inch thick gamma scintillation crystal. When unusual ground contamination was detected, more detailed surveys and supplemental vegetation samples could be collected (HW-61676).

The average concentration of I-131 from samples collected on the Hanford reservation was 4.8×10^{-6} μCi/g for 1958. The average concentrations for samples collected from the plant perimeter and from areas 40 to 140 miles from the Hanford plant were 2.5×10^{-6} and 3.0×10^{-6} μCi/g, respectively (HW-61676).

The yearly average concentration of "other gamma emitters" from samples collected on-site was 1.4×10^{-4} μCi/g. The average concentrations for samples collected from the plant perimeter and from areas 40 to 140 miles from Hanford were 0.9×10^{-4} and 1.0×10^{-4} μCi/g, respectively (HW-61676).

During 1958, the average alpha particle activity density was 6.0×10^{-7} μCi/g from vegetation samples obtained on-site. An average measurement of 0.7×10^{-7} μCi/g was obtained from samples collected from the plant perimeter (HW-61676).

Results obtained in the analyses of various crops collected from Riverview, Walla Walla, and Finley indicate, with the exception of Zn-65, there is no significant difference in isotopic content

between localities. Zn-65 was found in higher concentrations in the crops irrigated with Columbia River water. The average concentration from Riverview crops was 1.8 x 10^{-7} μCi/g while the concentrations obtained from Finley and Walla Walla were 0.49 x 10^{-7} μCi/g and 0.89 x 10^{-7} μCi/g, respectively (HW-61676).

The average concentrations of I-131 found in crop samples from Riverview, Finley, and Walla Walla were 2.1 x 10^{-7}, 1.8 x 10^{-7}, and 1.6 x 10^{-7} μCi/g, respectively (HW-61676).

The isotopic concentrations observed in samples from Walla Walla were due to nuclear weapons fallout, rather than Hanford sources (HW-61676).

The average Sr-89 concentrations found in crop samples from Riverview, Finley, and Walla Walla were 0.27 x 10^{-7}, 0.1 x 10^{-7}, and 0.11 x 10^{-7} μCi/g, respectively. The average Sr-90 concentration was 0.06 x 10^{-7} μCi/g from all three areas (HW-61676).

Results comparing the burned and unburned grass fields indicated that in all cases higher concentrations of radionuclides were found in the unburned plots. This was attributed to the presence of dead vegetation from one or more previous years. The burned area had all previous exposure destroyed by the fire, and the radioactive materials that were liberated to the soil were not effectively available to the new crop via the roots. This substantiated the fact that foliar sorption is the dominant route of fallout accumulation in terrestrial plants (HW-69500).

The concentrations of Ce-144 observed from the burned plot were 10 $\pm$ 2.8 $\mu\mu$Ci/g dry weight and 3300 $\pm$ 1300 $\mu\mu$Ci/m^2. The concentrations found in the unburned plot were 52 $\pm$ 15 $\mu\mu$Ci/g and 10,000 $\pm$ 3100 $\mu\mu$Ci/m^2. Manganese-54 concentrations for the burned plot were 0.38 $\pm$ 0.24 $\mu\mu$Ci/g and 140 $\pm$ 90 $\mu\mu$Ci/m^2, while concentrations in the unburned plot were 3 $\pm$ 1 $\mu\mu$Ci/g and 500 $\pm$ 280 $\mu\mu$Ci/m^2 (HW-69500).

The concentrations of Ru-106 were 3.8 $\pm$ 1 $\mu\mu$Ci/g and 1200 $\pm$ 520 $\mu\mu$Ci/m^2 for the burned plot, and 8 $\pm$ 3 $\mu\mu$Ci/g and 1600 $\pm$ 800 $\mu\mu$Ci/m^2 for the unburned plot. Zirconium/Niobium-96 concentrations were 24 $\pm$ 4 $\mu\mu$Ci/g and 8200 $\pm$ 3700 $\mu\mu$Ci/m^2 for the burned plot, and 100 $\pm$ 23 $\mu\mu$Ci/g and 19,000 $\pm$ 5000 $\mu\mu$Ci/m^2 for the unburned plot (HW-69500).

Differences between the amounts of radionuclides accumulated in the grass from the two plots were less pronounced when comparing the area rather than the weight, due to the fact that the burned area produced a heavier crop of new grass. The standing crops, at maturity, averaged 340 grams and 200 grams dry weight per square meter on the burned and unburned plots, respectively (HW-69500).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1959

Media Sampled

Routine vegetation sampling during 1959 involved the collection of native grasses from 26 zone locations within the perimeter of the Hanford project, adjoining communities, and remote locations in Eastern and Southern Washington, and Northern Oregon. Fifteen-gram samples were collected at each of ten sites within a zone, composited into one 150 gram sample and analyzed with a gamma energy spectrometer. Radionuclides observed included Zr/Nb-95, Ce-141/144, Ru-103/106, I-131, and Ba/La-140 (HW-64371).

Farm crops from the two closest farming areas utilizing Columbia River water for irrigation, Ringold and Riverview, were analyzed. Produce from two farms downwind of the Hanford reservation was also examined, due to air-borne contamination potential. Grain, vegetables, fruits, and alfalfa were analyzed with a multi-channel gamma energy spectrometer for K-40, Sc-46, Cr-51, Zn-65, Zr/Nb-95, Ru-103/106, I-131, Cs-137, and Ce-141/144. Analysis for P-32, Sr-89, and Sr-90 was done using radiochemical separation and beta counting (HW-64371).

A comparison of ditch-irrigated produce and sprinkler-irrigated produce was accomplished. Crops examined included alfalfa, corn, green beans, carrots, tomatoes, cabbage, okra, lettuce, boysenberries, cantaloupe, cucumbers, watermelon, grapes, zucchini squash, pasture grass, wheat, mint, beets, potatoes, strawberries, raspberries, onion tops, red beet tops, and sugar beets. Concentrations of Zn-65 and Cr-51 were compared (HW-63824, HW-64371).

Sampling Locations

Routine vegetation samples were collected from twenty-six zones (delineated by the letters A-Z) encompassing the Hanford project, the surrounding communities, and remote areas of Washington and Northern Oregon. Zones A through H, plus J, were locations within the separations areas and the project. Zone I included Benton City and the surrounding vicinity. Zone K contained Richland and vicinity, while Zone L was comprised of Kennewick and vicinity. Zone M contained the Pasco to Eltopia area, and Zone N included Mesa and the surrounding vicinity. Zones O and P were Wahluke Slope, east and west, respectively, while Zone Q contained Horse Heaven Hills. Zone R included Wallula, Touchet, Walla Walla, Dixie, and Waitsburg, while Zone S included the towns of Dayton, Pomeroy, Lewiston, Uniontown, and Pullman. Colfax, Rosalia, Spokane, Reardon, and Davenport were found in Zone T, and Harrington, Sprague, Ritzville, Lind, and Connell were in Zone U. Zone V included Moxee City, Union Gap, Wapato, and Toppenish, while Goldendale, Lyle, Bingen, and Stevenson were found in Zone W. Bonneville, Camas, Vancouver, Portland, and Troutdale were in Zone X and Zone Y included the towns of The Dalles, Celilo, Blalock, Arlington, and Boardman. Zone Z included the Riverview District of Pasco (HW-64371).

Crops were sampled from the two closest farming areas, as well as two farming areas influenced by air-borne effluents. The Ringold farms, approximately 15 miles downstream of the reactors, and Riverview, approximately 30 miles downstream, utilized Columbia River water for irrigation. Benton City, approximately 20 miles south of the Separations Areas, and Finley, about 40 miles southeast of the Plant, utilized Yakima River water for irrigation (HW-64371, HW-63654 REV). Samples were also collected from the Walla Walla-Spokane-Pendleton-Umatilla districts (HW-63654 REV).

Significant Events/Emission Quantities

Total I-131 emissions from the Separation Facilities stacks during the first quarter averaged 0.49 curies per day. The maximum emission was 2.8 curies per day, which occurred during February (HW-64371).

In the United States, the testing of nuclear devices by detonation was terminated for an indefinite period during the latter part of 1958. However, measurable fallout debris persisted during the early months of 1959 (HW-64371).

During the second quarter, the average I-131 emission was 1.03 curies per day. The maximum emission, which occurred in April, was 2.6 curies per day. During the last week in April, there was a total of 14.8 curies released (HW-64371).

The average I-131 emission from the Separation Area Process stacks during the third quarter was 0.74 curies per day. A maximum emission of 10 curies per day occurred in September (HW-64371).

During the fourth quarter, the average I-131 emission was 0.90 curies per day. A maximum emission of 7.4 curies per day occurred during December (HW-64371).

Constituents Measured/Reported

Results from routine vegetation and farm produce sampling were reported in table form in units of 10^{-6} μCi/g (HW-64371, HW-63654 REV). Results comparing sprinkler-irrigated and ditch irrigated crop samples were reported in concentrations of disintegrations per minute per gram (HW-63824).

The maximum I-131 measurement detected in Zone I (Benton City and vicinity), was 9.4×10^{-6} μCi/g, which occurred on December 29, 1959. The maximum from Zone K (Richland and vicinity) was 6.8×10^{-6} μCi/g, measured on December 23 (HW-64371).

A maximum measurement of 3.4×10^{-6} μCi I-131/gram of vegetation occurred in Zone L (Kennewick and vicinity) on February 4, 1959. The maximum I-131 detected on vegetation samples from Zone M (Pasco to Eltopia) was 3.3×10^{-6} μCi/g, which occurred on November 19 (HW-64371).

The maximum I-131 values detected on vegetation samples from Zone N (Mesa and vicinity) and Zone O (Wahluke Slope East) were 1.8×10^{-6} and 2.3×10^{-6} μCi/g, respectively. Maximum values for Zone P (Wahluke Slope West) and Zone Q (Horse Heaven Hills) were 2.7×10^{-6} and 3.1×10^{-6} μCi/g, respectively.

The maximum measurement from Zone Z (Riverview/Pasco) was 3.4×10^{-6} μCi/g. The maximum values for Zones R,S,T,U,V,W,X, and Y, the remaining off-site locations, were all less than the reporting limit of 1.5×10^{-6} μCi/g (HW-64371).

Concentrations of Zr/Nb-95 were consistently abundant during the first half of 1959 at off-site locations. The maximum value detected was 5.4×10^{-4} μCi/g from a sample from Zone X on March 3rd (HW-64371).

The average concentrations of Zn-65 in grain, vegetable, fruit, and alfalfa samples collected from Riverview were 1.5×10^{-6}, 0.18×10^{-6}, 0.13×10^{-6}, and 1.3×10^{-6} μCi/g, respectively (HW-64371).

Fruit samples collected from Ringold, Benton City, and Finley all had average Zn-65 concentrations of less than 0.1×10^{-6} μCi/g. All of the crop samples collected from Finley had average Zn-65 concentrations of less than the reporting limit of 0.1×10^{-6} μCi/g (HW-64371).

The average concentrations of Cr-51 were less than the reporting limit of 0.5×10^{-6} μCi/g for all grain, fruit, and vegetable samples from Benton City and Finley. Grain and fruit samples from Ringold were also less than this reporting limit, and vegetation samples had an average concentration of 0.62×10^{-6} μCi/g. Average concentrations of Cr-51 in alfalfa ranged from 0.58×10^{-6} μCi/g, from samples collected in Finley, to 6.6×10^{-6} μCi/g, from samples collected at Riverview (HW-64371).

Concentrations of Cr-51 in crop samples from Riverview were 0.7×10^{-6}, 0.53×10^{-6}, 0.66×10^{-6}, and 6.6×10^{-6} μCi/g for grain, vegetables, fruit, and alfalfa, respectively (HW-64371).

Radiozinc concentrations in produce samples irrigated with sprinkler systems were generally higher than those irrigated by ditch irrigation due to direct foliate absorption through the leaves (HW-63824, HW-64371).

Concentrations of Zn-65 in samples of green beans were 1.3×10^{-6} and 0.1×10^{-6} μCi/g for sprinkler irrigated and ditch irrigated samples, respectively. A maximum Zn-65 concentration of 8.9×10^{-6} μCi/g, was found in sprinkler-irrigated alfalfa samples (HW-64371).

A maximum Cr-51 concentration of 8.0×10^{-6} μCi/g was found in flood-irrigated pasture grass in the Riverview district. A measurement of 1.2×10^{-6} μCi/g was obtained from a sprinkler-irrigated lettuce sample (HW-64371).

Flood-irrigated pasture grass provided a maximum Zn-65 concentration of 36×10^{-6} μCi/g. Samples of ditch-irrigated wheat gave a concentration of 4.0×10^{-6} μCi/g (HW-64371).

Scandium-46 concentrations in alfalfa sampled from Riverview and Ringold averaged 1.5×10^{-7} μCi/g and was less than the reporting value of 1×10^{-7} μCi/g at other locations. Other produce samples also had values of less than the reporting limit (HW-64371).

The average I-131 concentration from grain samples was less than 0.7×10^{-6} μCi/g at all sampling locations (Riverview, Ringold, Benton City, and Finley) (HW-64371).

The highest average concentration of Sr-89 found in a grain sample was collected at Ringold, with a value of 0.052×10^{-6} μCi/g. The average concentration of Ce-141/144 was highest in samples from Riverview, with a value of 1.1×10^{-6} μCi/g (HW-64371).

Grain samples collected at Ringold exhibited higher concentrations of Zr/Nb-95, Ru-103/106, and Cs-137 than samples from other locations, with average values of 0.52×10^{-6}, 0.77×10^{-6}, and 0.083×10^{-6} μCi/g, respectively (HW-64371).

Concentrations of Sr-89 on vegetable samples averaged less than 0.01×10^{-6} μCi/g for samples collected from Ringold and Benton City, and 0.014×10^{-6} and 0.013×10^{-6} μCi/g for samples collected from Riverview and Finley, respectively (HW-64371).

The average concentration of I-131 on vegetables was less than 0.1×10^{-6} μCi/g at all locations, with the exception of Ringold, where the value was 0.18×10^{-6} μCi/g (HW-64371).

Cesium-137 concentrations on vegetables were less than 0.05×10^{-6} μCi/g at all locations, with the exception of Riverview, where the average concentration was 0.052×10^{-6} μCi/g (HW-64371).

Concentrations of I-131 on fruit samples were less than 0.1×10^{-6} μCi/g at Riverview, Ringold, and Benton City. Measurements from Finley averaged 0.11×10^{-6} μCi/g (HW-64371).

Generally, the maximum radioisotope concentrations on fruit samples were collected from Ringold, where concentrations of Sr-89, Ru-103/106, and Ce-141/144 were 0.63×10^{-6} μCi/g (HW-64371).

Concentrations of I-131 on alfalfa samples ranged from 0.16×10^{-6} μCi/g, collected from Benton City, to 0.52×10^{-6} μCi/g, collected from Finley (HW-64371).

The maximum average Zr/Nb-95 concentration found on alfalfa samples was 1.7×10^{-6} μCi/g, collected from Benton City. The highest Ce-141/144 concentration from alfalfa samples was 2.7×10^{-6}, collected from Finley (HW-64371).

With the cessation of nuclear tests and the resulting decrease in the amount of fallout radioisotopes on vegetation, the need for a more efficient sample detection system was needed. An increase in sensitivity of about 20 was obtained with the use of a 9 3/8 inch crystal and a 500 gram sample in gamma spectrometric analysis (HW-63824).

Zinc-65 and Cr-51 were present in low concentrations in crops irrigated using Columbia River water, but not detected in significant amounts elsewhere. Cereals and alfalfa (hay) contained larger amounts of Zn-65 than did fruits and vegetables (HW-63654 REV).

Chromium-51 was found in highest concentrations in alfalfa samples, with a maximum measurement of 3.0×10^{-5} μCi/g. The maximum I-131 concentration was 4×10^{-6} μCi/g, obtained from an alfalfa sample collected in Finley (HW-63654 REV).

Generally, alfalfa (hay) and cereal crops contained the highest concentrations of radioisotopes (HW-63654 REV).

Chromium-51 was found on more sprinkler-irrigated samples than ditch-irrigated samples, suggesting that foliate absorption may play a significant part in its uptake. Concentrations ranged from 0.3 d/m/g in red beets to 17.8 d/m/g in pasture grass that was irrigated by flooding (HW-63824).

Concentrations of Zn-65 obtained from sprinkler-irrigated samples ranged from 0.33 d/m/g, for zucchini squash, to 20 d/m/g for alfalfa. Samples of corn, green beans, and lettuce exhibited concentrations of 4.7, 2.8, and 1.0 d/m/g, respectively (HW-63824).

Concentrations of Zn-65 measured in ditch-irrigated samples ranged from 0.08 d/m/g for tomatoes, to 80 d/m/g for pasture grass that was irrigated almost continuously. Samples of corn, green beans, and cabbage that were ditch-irrigated had concentrations of 3.6, 0.21, and 0.62 d/m/g, respectively (HW-63824).

References

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1960

Media Sampled

Routine vegetation sampling for 1960 involved the collection of native grasses from 26 zone locations within the perimeter of Hanford reservation, surrounding communities, and remote locations in southern and eastern Washington and northern Oregon. Fifteen-gram samples were collected from each of ten sites within a zone, composited into one 150 gram sample, and analyzed by a gamma energy spectrometer using a three inch by three inch NaI(Tl) scintillation crystal. Samples were analyzed for Zr/Nb-95, Ce-141/144, Ru-103/ 106, I-131, and Ba/La-140 (HW-68435, HW-67390).

Agricultural produce was sampled from farming areas utilizing Columbia River water for irrigation and farming areas downwind of Hanford. Crops examined included corn, beets, carrots, tomatoes, cantaloupe, cucumber, peaches, grapes watermelon, apricots, cabbage, pears, barley, rye, wheat, and alfalfa. A gamma energy spectrometer utilizing a nine inch diameter well-type NaI(Tl) scintillation crystal was used to analyze for K-40, Sc-46, Cr-51, Zn-65, Zr/Nb-95, Ru-103/106, I-131, Cs-137, and Ce/Pr-144. Radiochemical separation and beta counting was used to determine P-32, Sr-89, and Sr-90 concentrations (HW-68435, HW-67390).

Commercial baby foods were tested for radionuclide contamination. Cereals analyzed included barley, oat, rice, protein, and mixed. Fruits and vegetables examined included applesauce, junior applesauce, bananas, pears, junior pears, peaches, junior peaches, prunes, plums, green beans, junior green beans, beets, carrots, peas, sweet potatoes, junior sweet potatoes, squash, junior squash, and spinach. The baby foods were analyzed for K-40, Cs-137, Sr-89, and Sr-90 (HW-68435, HW-67390).

Sampling Locations

Routine vegetation sampling involved the collection of native grasses from twenty-six zones (delineated by the letters A-Z) encompassing the Hanford project, surrounding communities, and remote areas of Washington and northern Oregon. Zones A through H, plus J, were locations within the separation areas and the project. Zone I contained Benton City and the surrounding vicinity, whereas Zone K included the Richland environs. Zone L was comprised of Kennewick and the surrounding area, Zone M contained the Pasco to Eltopia area, and Zone N included Mesa and the surrounding vicinity. Zones O and P were Wahluke Slope, east and west, respectively, while Zone Q contained Horse Heaven Hills. Zone R included the communities of Wallula, Touchet, Walla Walla, Dixie, and Waitsburg, while Zone S included the towns of Dayton, Pomeroy, Lewiston, Uniontown, and Pullman. Colfax, Rosalia, Spokane, Reardon, and Davenport were located in Zone T, and Harrington, Sprague, Ritzville, Lind, and Connell were found in Zone U. Zone V included the towns of Moxee City, Union Gap, Wapato, and Toppenish, while Goldendale, Lyle, Bingen, and Stevenson were found in Zone W. Bonneville, Camas, Vancouver, Portland, and Troutdale were

located in Zone X, and Zone Y included the towns of The Dalles, Celilo, Blalock, Arlington, and Boardman. Zone Z contained the Riverview District of Pasco (HW-68435).

Crops were collected from the two closest farming areas downriver from the reactors utilizing Columbia River water for irrigation, the Riverview District of Pasco, approximately 30 miles downstream, and Ringold, approximately 15 miles downstream. Crops from the Benton City area, approximately 20 miles south of the Separation Facilities, were also sampled, as well as alfalfa from Eltopia (HW-68435, HW-67390).

Significant Events/Emission Quantities

During 1960, the overall average I-131 emissions from the Separation Facilities stacks was 1.0 curies per day. Zr/Nb-95 emissions averaged 0.01 curies per day, and Ru-103 emissions averaged 0.007 curies per day. Average Ru-106 and Ce-141 emissions were 0.006 and 0.001 curies per day, respectively (HW-68435).

The average I-131 emission during the first quarter was 0.65 curies per day. A maximum emission of 1.7 curies per day occurred in January (HW-68435).

During the second quarter of 1960, the average I-131 emission from the Separation Areas stacks was 0.59 curies per day, with a maximum emission of 1.7 curies per day occurring in May (HW-68435).

Third quarter average I-131 emission from the Separation Facilities was 2.02 curies per day, 2.5 times higher than during the first half of 1960. A maximum emission of 19 curies per day occurred in July, as well as a total weekly emission of 51.3 curies, released July 5-11 (HW-68435, HW-67390).

The average I-131 emission for the fourth quarter was 0.75 curies per day. A maximum emission of 3.9 curies per day occurred in December (HW-68435).

Constituents Measured/Reported

Results for off-project vegetation and crop analyses were presented in table form, in units of 10^{-6} μCi/g (HW-68435, HW-67390).

The maximum average I-131 measurement from off-site zones was 9.9×10^{-6} μCi/g, collected from Zone M (Pasco to Eltopia area) on January 26. Iodine-131 values for vegetation sampled from March through mid-December were generally below the reporting limit of 1.5×10^{-6} μCi/g, with the exception of six samples, the maximum value of these being 2.5×10^{-6} μCi/g (HW-68435).

The local control limit for I-131 on vegetation is 1×10^{-5} μCi/g of vegetation (HW-68435).

The maximum Ce-141/144 value obtained from off-site vegetation samples was 5.2×10^{-5} μCi/g collected from Zone I (Benton City and vicinity) on June 28. The maximum Ru-103/106 measurement obtained from off-site vegetation samples was 1.5×10^{-5} μCi/g, collected from Zone M (Pasco to Eltopia area) on January 26 (HW-68435).

The maximum Zr/Nb-95 measurement obtained from off-site vegetation sampling was 3.2×10^{-5} μCi/g, collected from Zone N on August 2. With the exception of a few samples collected in January and February, the remaining samples had values below the reporting limit of 2.0×10^{-6} μCi/g (HW-68435).

The maximum Ba/La-140 value obtained from off-site vegetation sampling was 4.0×10^{-6} μCi/g, collected from Zone R (southeastern Washington) on August 2. As many as fifty composite samples were obtained from each zone during 1960. No more than 3 samples per zone had measurements of Ba/La-140 greater than the reporting limit of 2.0×10^{-6} μCi/g (HW-68435).

Analysis results for agricultural crops sampled from the Ringold area were below the reporting limits for all radioisotopes examined with the exception of K-40 and Zn-65. Potassium-40 measurements ranged from 1.8×10^{-6} μCi/g to 2.6×10^{-6} μCi/g, both results from apricot samples. One corn sample had a Zn-65 value of 0.21×10^{-6} μCi/g (HW-68435, HW-67390).

Quantities of K-40 measured from crops collected from Benton City and the surrounding vicinity ranged from 0.97×10^{-6} μCi/g, from a corn sample, to 5.5×10^{-6} μCi/g on barley samples. Minimal amounts of Zn-65 were detected on barley, rye, and wheat samples, with a maximum value of 0.15×10^{-6} μCi/g. A Sr-89 measurement of 0.031×10^{-6} μCi/g was observed on a rye sample and Sr-90 values ranged from 0.034×10^{-6} μCi/g, from a barley sample, to 0.051×10^{-6} μCi/g, from a rye sample. Results for Zr/Nb-95, Cs-137, Ru-103/106, I-131, Cr-51, Ce-141/144, and P-32 were less than the reporting limit for each (HW-68435, HW-67390).

Analysis results for Cs-137, Ru-103/106, Ce-141/144, and Sr-89 on crop samples collected from the Riverview District of Pasco were below reporting limits. A Sc-46 value of 0.67×10^{-6} μCi/g was detected on a corn sample. Potassium-40 measurements ranged from 1.1×10^{-6} μCi/g, on a corn sample, to 4.9×10^{-6} μCi/g, from a cantaloupe. Zinc-65 values ranged from 0.1×10^{-6} μCi/g, detected on grapes and carrots, to 2.7×10^{-6} μCi/g on corn samples. Zr/Nb-95 measurements were 0.48×10^{-6} and 0.49×10^{-6} μCi/g for carrots and beets, respectively. The minimum P-32 value of 0.11×10^{-6} μCi/g was found on carrot samples, and the maximum value of 0.6×10^{-6} μCi/g, was found on a corn sample. Strontium-90 measurements ranged from 0.006×10^{-6} μCi/g, on peaches, to 0.016×10^{-6} μCi/g, from carrot samples. Chromium-51 values for carrots and beets were 1.3×10^{-6} and 0.72×10^{-6} μCi/g, respectively (HW-68435, HW-67390).

Alfalfa samples collected from the Riverview District in Pasco exhibited higher radioisotope concentrations than alfalfa samples from Ringold, Eltopia, and Benton City. Scandium-46 measurements were less than reporting limits on samples collected from Eltopia and Benton City and maximum values for Riverview and Eltopia were 2.0×10^{-6} and 0.25×10^{-6} μCi/g, respectively. Potassium-40 measurements ranged from 5.5×10^{-6} μCi/g, on samples collected in Benton City, to 13×10^{-6} μCi/g on Riverview samples. Zinc-65 values in Benton City were less than the reporting limit, while values for Riverview, Ringold and Eltopia were 14×10^{-6}, 3.9×10^{-6}, and

0.5 x 10^{-6} μCi/g, respectively. The maximum Cs-137 measurement was 0.11 x 10^{-6} μCi/g and the maximum I-131 value was 0.58 x 10^{-6} μCi/g. Chromium-51 values were below the reporting limit in Benton City and Eltopia, while measurements in Ringold and Riverview were 8.4 x 10^{-6} and 87 x 10^{-6} μCi/g, respectively. The maximum P-32 value was 4.6 x 10^{-6} μCi/g (HW-68435, HW-67390).

During the month of October, the average concentration of I-131 on vegetation in the immediate vicinity of the Separations Plant was 3.4 x 10^{-6} μCi/g. Vegetation collected from all sampling zones outside of the project boundary gave I-131 values of less than 1.5 x 10^{-6} μCi/g (HW-67439).

During November, the average concentration of I-131 on vegetation from the Separations Plant vicinity was 2.0 x 10^{-6} μCi/g. Vegetation collected from all zones outside of the project boundary had I-131 values of less than 1.5 x 10^{-6} μCi/g (HW-67752).

An average I-131 concentration of 7.4 x 10^{-6} μCi/g was found in the immediate vicinity of the Separations Plant in December. Samples collected from zones outside of the boundary had values of less than 1.5 x 10^{-6} μCi/g (HW-8127).

The majority of baby food samples tested for Sr-89 gave results of less than the reporting limit of 0.004 x 10^{-6} μCi/g. A mixed cereal sample gave a maximum measurement of 0.023 x 10^{-6} μCi/g, while barley cereal had a Sr-89 value of 0.014 x 10^{-6} μCi/g (HW-68435, HW-67390).

A maximum Sr-90 value in baby foods sampled was 0.056 x 10^{-6} μCi/g, found in protein cereal. Mixed cereal had values ranging from (0.007 to 0.03) x 10^{-6} μCi/g, while oat cereal had a value of 0.0069 x 10^{-6} μCi/g. The maximum Sr-90 measurement detected in fruits and vegetables was 0.01 x 10^{-6} μCi/g, from spinach (HW-68435, HW-67390).

The maximum Cs-137 value from baby cereal samples was 0.1 x 10^{-6} μCi/g, from a mixed cereal. With the exception of a sample of junior peaches and a sample of peas, all fruits and vegetables analyzed gave results of less than the reporting limit of 0.03 x 10^{-6}. The result from junior peaches was 0.033 x 10^{-6}, while the peas, which were sampled on December 10, 1959, gave a result of 0.61 x 10^{-6} μCi/g (HW-68435, HW-67390).

Potassium-40 was detected in all but one baby food sample. A maximum measurement of 9.4 x 10^{-6} μCi/g was found in protein cereal, while oat cereal gave a value of 2.6 x 10^{-6} μCi/g. Values for fruits and vegetables ranged from less than the reporting limit of 0.3 x 10^{-6} μCi/g for one applesauce sample, to 2.4 x 10^{-6} μCi/g in a prune sample. The average K-40 detected in all fruit and vegetables sampled was 1.125 x 10^{-6} μCi/g (HW-68435, HW-67390).

References

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1961

Media Sampled

Routine vegetation sampling during 1961 involved the collection of native grasses from 16 zone locations within the perimeter of Hanford reservation and surrounding communities. Fifteen-gram samples were collected at each of ten sites within a zone, composited into one 150 gram sample and analyzed by a gamma energy spectrometer using a three inch by three inch NaI(Tl) scintillation crystal. Samples were analyzed for Zr/Nb-95, Ce-141/144, Ru-103/106, I-131, and Ba/La-140 (HW-71999).

Agricultural produce was sampled from two farming areas utilizing Columbia River water for irrigation as well as a farm downwind of Hanford. Crops examined included alfalfa, apricots, apples, beets, peaches, wheat, green beans, tomatoes, cantaloupe, potatoes, carrots, and corn. A gamma energy spectrometer utilizing a nine inch diameter well-type NaI(Tl) scintillation crystal was used to analyze for K-40, Sc-46, Cr-51, Zn-65, Zr/Nb-95, Ru-103/106, I-131, Cs-137, and Ce/Pr-144. Radiochemical separation and beta counting was used to determine P-32, Sr-89, and Sr-90 concentrations (HW-71999).

Sampling Locations

Routine vegetation samples were collected from sixteen zones (delineated by the letters A-P) within the Hanford project and surrounding communities. Zones A through H, plus J, were locations within the separation areas and the project. Zone I included Benton City and the surrounding vicinity, while Zone K contained the Richland locality. Zone L was comprised of the Kennewick environs and Zone M contained the Pasco to Eltopia area. Zone N included Mesa and the surrounding vicinity, and Zones O and P were Wahluke Slope, east and west, respectively (HW-71999).

Crops were collected from the two closest farming areas downriver from the reactors utilizing Columbia River water for irrigation, the Riverview District of Pasco, approximately 30 miles downstream, and Ringold, approximately 15 miles downstream. Crops from the Benton City area, approximately 20 miles south of the Separation Facilities, were also sampled (HW-71999).

Significant Events/Emission Quantities

During 1961, the overall average I-131 emission from the Separation Facilities stacks was 0.7 curies per day. Zirconium/Niobium-95 emissions averaged 0.005 curies per day, and Ru-103 emissions averaged 0.003 curies per day. Average Ru-106, Ce-141, and Ce-144 emissions were 0.005, 0.006, and < 0.01 curies per day, respectively (HW-71999).

Total I-131 emissions from the Separation Facilities stacks averaged 0.69 curies per day during the first quarter of 1961. A maximum emission of 2.3 curies per day occurred in March, and the maximum seven-day emission was 10 curies in January, both events originating from the Purex Facility (HW-71999, HW-68471, HW-68851, HW-69278).

During the second quarter of 1961, the average I-131 emission from the Separation Facilities stacks was 0.79 curies per day. A maximum emission of 2.3 curies per day occurred in June and originated from the Purex stack. Fourteen curies, the maximum seven day emission, was released from the Purex Facility stacks in June as well (HW-71999, HW-69618, HW-70103, HW-70431, HW-70552).

Total third quarter average I-131 emission was 0.78 curies per day. The Purex Facility was the source of the maximum daily emission of 2.5 curies per day, as well as the maximum seven day emission, which was 8.3 curies, both having occurred in August (HW-71999, HW-70689, HW-71041, HW-71203).

Significant radioisotopic deposition occurred on vegetation in 1961 due to fallout from USSR nuclear testing during the fourth quarter (HW-71999).

Total average I-131 emissions from the Separation Facilities stacks was 0.55 curies per day during the fourth quarter. The maximum daily emission was 2.1 curies per day and the maximum seven day emission was 8.2 curies, both having occurred in October (HW-71999, HW-71678, HW-72012, HW-72338).

Constituents Measured/Reported

Analysis results were presented in table form and reported in units of 10^{-6} μCi/g (HW-71999).

The average concentration of I-131 detected on vegetation sampled from off-site locations for the first three quarters of 1961 was less than the detection limit of 1.5 x 10^{-6} μCi/g. The maximum I-131 concentrations occurred in late October to early November, due to the USSR nuclear testing fallout. Vegetation sampled from Zone I (Benton City and vicinity), exhibited the maximum off-site I-131 concentration of 3.5 x 10^{-5} μCi/g. By late December, I-131 concentrations had dissipated to less than the detection limit at most locations (HW-71999).

The local control limit for I-131 emissions was 10 curies per week (HW-70411, HW-70552, HW-71203). Local limits reduced this limit to 2 curies per week, averaged over a year's time (HW-71999).

The average I-131 concentration on vegetation sampled in the vicinity of the Separation Plants for the first quarter was 2.9 x 10^{-6} μCi/g (HW-68471, HW-68851, HW-69278).

During April, the average I-131 concentration on vegetation from the Separation Facilities was 3.9×10^{-6} μCi/g. During May the average I-131 concentration was less than the detection limit of 1.5×10^{-6} μCi/g, and during June the average concentration was 3.0×10^{-6} μCi/g (HW-69618, HW-70103, HW-70431).

During July, concentrations of I-131 on vegetation sampled from the Separation Plants decreased to 2.1×10^{-6} μCi/g, and by August concentrations were less than the detection limit (HW-70689, HW-71041).

Fourth quarter concentrations of I-131 from vegetation sampled in the Separations vicinity averaged 11×10^{-6} μCi/g. During November, the average concentration was 15×10^{-6} μCi/g (HW-71678, HW-72012, HW-72338).

Increased concentrations of Ba/La-140, Zr/Nb-95, Ru-103/106, and Ce-141/144 during the fourth quarter were also associated with the USSR nuclear fallout, resulting in peak concentrations of 10^{-4} to 10^{-3} μCi/g (HW-71999).

The maximum off-site concentration of Ba/La-140 was 1.3×10^{-4} μCi/g, from a sample collected from Zone I (Benton City and vicinity) during late October (HW-71999).

The maximum off-site concentration of Zr/Nb-95 was 3.7×10^{-4} μCi/g, from a sample collected from Zone O (Wahluke Slope, east), during mid-December (HW-71999).

The maximum off-site concentrations of Ru-103/106 and Ce-141/144 were 9.5×10^{-4} and 1.2×10^{-3} μCi/g, respectively, from samples collected from Zone P (Wahluke Slope, west) (HW-71999).

Alfalfa was sampled from the Riverview District from May through September. Maximum values included 0.83×10^{-6} μCi/g for Sc-46, 1.5×10^{-5} μCi/g for K-40, 3.9×10^{-6} μCi/g for Zn-65, 5.2×10^{-6} μCi/g for Zr/Nb-95, 0.063×10^{-6} μCi/g for Cs-137, 1.2×10^{-5} μCi/g for Ru-103/106, 1.1×10^{-6} μCi/g for I-131, 2.2×10^{-5} μCi/g for Cr-51, 1.2×10^{-5} μCi/g for Ce/Pr-144, 7.4×10^{-6} μCi/g for P-32, 0.01×10^{-6} μCi/g for Sr-89, and 0.084×10^{-6} μCi/g for Sr-90 (HW-71999).

Produce was sampled from Ringold, Riverview, and Benton City during July and August. Values for Cs-137, Ru-103/106, I-131, Ce-141/144, Zr/Nb-95, and Sc-46 from all produce sampled were less than reporting limits. The maximum K-40 measurement obtained from the Ringold vicinity was 6.7×10^{-6} μCi/g, from beets. A wheat sample gave the maximum Zn-65 value of 3.5×10^{-5} μCi/g, as well as maximum Sr-89 and Sr-90 values of 0.009×10^{-6} and 0.017×10^{-6} μCi/g, respectively. The maximum P-32 measurement was 2.1×10^{-6} μCi/g, from green beans, and the maximum Cr-51 value from Ringold was 1.2×10^{-6} μCi/g, obtained from apricots (HW-71999).

The maximum K-40 measurement obtained from produce sampled in the Benton City vicinity was 4.5×10^{-6} μCi/g, from potatoes. The maximum Zn-65 value was 0.15×10^{-6} μCi/g, and the maximum Sr-90 measurement was 0.0056×10^{-6} μCi/g, both obtained from cantaloupe. The maximum P-32 value of 0.17×10^{-6} μCi/g, was obtained from potatoes (HW-71999).

Riverview produce had a maximum K-40 measurement of 6.8×10^{-6} μCi/g, obtained from an apricot sample. The maximum Zn-65 and P-32 values of 0.47×10^{-6} and 0.75×10^{-6} μCi/g, respectively, were obtained from corn samples, as well as the maximum Sr-89 and Sr-90 measurements of 0.014×10^{-6} and 0.044×10^{-6} μCi/g, respectively. The maximum Cr-51 value was 1.1×10^{-6} μCi/g, from an apricot sample (HW-71999).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1962

Media Sampled

During the first quarter of 1962, routine vegetation sampling involved the collection and analysis of composite samples of sagebrush and native grasses bi-monthly from 14 zone locations in and adjacent to the Hanford Project, plus weekly collection and analysis of composite samples from Zone A (200 West) and Zone B (200 East). Samples were analyzed by a gamma spectrometer using a 3 inch by 3 inch NaI(Tl) scintillation crystal for I-131, Zr/Nb-95, Ru-103/106, Ba/La-140, and Ce-141/Ce-144/Pr-144. Samples from Zone B were also analyzed for Cs-137.

Agricultural produce was sampled from two farming areas utilizing Columbia River water for irrigation, as well as farming areas south and east of Hanford. Pasture grass and farm products were analyzed using a multi-channel energy spectrometer that utilized a 9-inch diameter well-type NaI(Tl) scintillation crystal. Radionuclides observed included K-40, Zn-65, Zr/Nb-95, Cs-137, Ru-103/106, I-131, and Ce/Pr-144. Radiochemical separation and beta counting was used to determine P-32, Sr-89, and Sr-90 concentrations. Crops and produce sampled included alfalfa, wheat, pasture grass, asparagus, rhubarb, strawberries, carrots, onions, parsnips, cherries, raspberries, Romaine lettuce, mustard greens, leaf lettuce, spinach, red cabbage, parsley, radish tops, onion tops, beet tops, turnip tops, cabbage, onions, radishes, turnips, big onions, beets, Swiss chard, parsnip tops, parsnip roots, apples, apricots, peaches, string beans, green apples, broccoli, cucumbers, peppers, corn on the cob, squash, tomatoes, cantaloupe, plums, beans, dill, and potatoes (HW-76526).

Vegetables and baby foods were purchased from local stores and analyzed for radionuclide contamination using the same procedure as was used to analyze agricultural produce. Foods analyzed included asparagus, rhubarb, apricots, peaches, grapes, lettuce, carrots, apples, potatoes, beet tops, beet roots, mustard greens, string beans, peas, baby food-mixed vegetables, carrot tops, leaf lettuce, head lettuce, radishes, bread, and prune juice. Baby foods analyzed included strained applesauce, apple juice, prunes, orange juice, orange-apple juice, pears, apricots, peaches, peas, carrots, green beans, garden vegetables, oatmeal, dry rice cereal, hi-protein cereal, mixed dry cereal, dry barley cereal, cereal-egg and bacon, and oatmeal with bananas and apples. (All baby foods were Gerber brand) (HW-76526).

A special vegetation survey was conducted to determine any environmental effects produced from an incident involving a large emission from the 291-Z stack on April 7th (HW-77345).

Sampling Locations

Routine vegetation samples during the first quarter of 1962 were collected from sixteen zones (delineated by the letters A-P) within the Hanford Project and surrounding communities. Zone A (200 West Area), Zone B (200 East Area), and Zones C-H, plus J, were locations within the Hanford Project. Zone I included Benton City and the surrounding vicinity, while Zone K contained the

Richland locality. Zone L was comprised of the Kennewick environs, and Zone M contained the Pasco to Eltopia area. Zone N included Mesa and the surrounding vicinity, and Zones O and P were Wahluke Slope, east and west, respectively.

Crops were collected from the two closest farming areas downriver from the reactors utilizing Columbia River water for irrigation, the Riverview District of Pasco, approximately 30 miles downstream, and Ringold, approximately 15 miles downstream. Crops from the Benton City area, approximately 20 miles south of the Separation Facilities, were also sampled, as well as pasture grass from Mesa and Eltopia, areas directly east of the Separation Facilities (HW-76526).

A special vegetation survey was conducted following an incident involving the emission of a large quantity of fission products from the 291-Z stack on April 7. Samples were collected every 0.1 to 0.2 mile around the perimeter of the 200 West Area, and every mile along the road between Byer's Landing and Ringold in the afternoon of April 7 (HW-77345).

Significant Events/Emission Quantities

During 1962, the yearly average I-131 emission from the Separation Facilities stacks was 0.35 curies per day. Zirconium/niobium-95 emissions averaged 0.0024 curies per day, and Ru-103 emissions averaged 0.0009 curies per day. Average Ru-106, Ce-141, and Ce-144 emissions were 0.0036, 0.0002, and 0.015 curies per day, respectively (HW-76526).

Total I-131 emissions from the Separation Facilities stacks averaged 0.25 curies per day during the first quarter of 1962. A maximum emission of 1.2 curies per day occurred in January, as did a seven day maximum emission of 3.9 curies (HW-76526, HW-72691, HW-72691-2, HW-72691-3).

During the second quarter, the average I-131 emission from the Separation Facilities stacks was 0.53 curies per day. The maximum daily emission was 24 curies per day, and the maximum seven day emission was 43 curies, both occurring in April (HW-76526, HW-72691-4, HW-72691-5, HW-74307).

The third quarter total average I-131 emission from the Separation Facilities stacks was 0.44 curies per day. A maximum daily emission of 11 curies per day occurred in September, as did a seven day maximum emission of 14 curies (HW-76526, HW-74307-7, HW-74307-8, HW-74307-9).

During the third quarter, increased concentrations of radioisotopes in the air were due to worldwide fallout from weapons testing (HW-75431).

Total I-131 emissions from the Separations Facilities stacks during the fourth quarter averaged 0.17 curies per day. The daily maximum of 0.77 curies per day, and the seven day maximum of 3.3 curies both occurred in December (HW-76526, HW-74307-10, HW-74307-11, HW-74307-12).

On April 7, 1962, at about 11 am, approximately 1000 curies of noble gases and fission products were released from the 291-Z stack. Over the next two days an additional 200 curies were released (HW-77345).

Constituents Measured/Reported

The local operational guide for stack releases is 2 curies per week, averaged over a year's time. The previous limit was 10 curies per week, which was reduced in October, 1961 (HW-73366).

Analysis results were presented in table form in units of $\mu\mu$Ci/g (HW-76526).

The average concentration of I-131 measured on leafy vegetables sampled from local farms and vegetable markets during May through September was 0.2 $\mu\mu$Ci/g (HW-76526).

Results from special surveys following the emission incident on April 7 indicated that there were no environmental effects detectable at off-project locations (HW-77345).

The average K-40 concentration found on alfalfa samples collected in November and December was 16.2 $\mu\mu$Ci/g. The maximum value was 26 $\mu\mu$Ci/g. Concentrations of Zn-65 found on alfalfa were below the reporting limit for all samples except one, which had a value of 0.11 $\mu\mu$Ci/g. Maximum concentrations of I-131, Cs-137, and Ba/La-140 from alfalfa samples were 0.29, 1.6, and 8.2 $\mu\mu$Ci/g, respectively. The maximum concentration of Zr/Nb-95 was 39 $\mu\mu$Ci/g, with an average of 11.1 $\mu\mu$Ci/g. The average Ru-103/106 concentration on alfalfa was 11.9 $\mu\mu$Ci/g, with a maximum concentration of 39 $\mu\mu$Ci/g. Cerium/Praseodymium-144 concentrations averaged 25.2 $\mu\mu$Ci/g, with a maximum value of 66 $\mu\mu$Ci/g, while the maximum Sr-89 concentration was 0.72 $\mu\mu$Ci/g. The average Sr-90 concentration found on alfalfa samples was 0.047 $\mu\mu$Ci/g, with a maximum value of 0.087 $\mu\mu$Ci/g (HW-76526).

Analysis results from wheat samples collected in March and August yielded lower radionuclide concentrations than those obtained from alfalfa samples. Maximum values for K-40, Cs-137, Ce/Pr-144, Sr-89, and Sr-90 were 5.1, 0.091, 19, 0.092, and 0.011 $\mu\mu$Ci/g, respectively. Results for I-131, Ru-103/106, and Ba/La-140 were below reporting limits, as were results for Zn-65, with the exception of one sample with a value of 2.2 $\mu\mu$Ci/g (HW-76526).

Pasture grass was collected from Ringold, Riverview, Benton City, Eltopia, and Mesa. The maximum K-40 concentration of 34 $\mu\mu$Ci/g was obtained from a sample collected from Ringold on August 1. The maximum Zn-65 value was 110 $\mu\mu$Ci/g, collected from Riverview on the same date. Maximum measurements for Zr/Nb-95, Cs-137, I-131, Ba/La-140, and Sr-90, obtained from samples collected in the Benton City vicinity, were 180, 11, 13, 110, and 0.45 $\mu\mu$Ci/g, respectively. A maximum P-32 value of 31 $\mu\mu$Ci/g and Ru-103/106 value of 88 $\mu\mu$Ci/g, were obtained from samples collected from the Riverview District of Pasco. Maximum Ce/Pr-144 and Sr-89 values of 140 and 7.2 $\mu\mu$Ci/g, respectively, were obtained from samples collected from Eltopia (HW-76526).

The maximum K-40 measurement obtained from farm produce was 26 $\mu\mu$Ci/g, from a dill sample collected in mid-August. This dill sample also gave maximum concentrations for Ce/Pr-144 and Zr/Nb-95 of 13 and 5.8 $\mu\mu$Ci/g, respectively. The maximum Cs-137 value of 0.061 $\mu\mu$Ci/g was obtained from beans analyzed in early August. A maximum Ru-103/106 measurement of 9.8 $\mu\mu$Ci/g was obtained from beet tops, and the maximum I-131 value was 1.9 $\mu\mu$Ci/g, obtained from peaches. Two separate asparagus samples gave maximum Sr-89 and Sr-90 values of 0.126 and 0.141 $\mu\mu$Ci/g,

respectively. The maximum Zn-65 value of 0.9 $\mu\mu$Ci/g, was obtained from onion and carrot samples, and the maximum P-32 value of 0.43 $\mu\mu$Ci/g was obtained from a lettuce sample (HW-76526).

Analysis results were obtained for vegetables and baby foods collected from local stores. Maximum K-40 and Cs-137 values of 42 and 0.28 $\mu\mu$Ci/g, respectively, were obtained from Gerber's hi-protein cereal. Mustard greens gave a maximum P-32 value of 1.2 $\mu\mu$Ci/g. Maximum Ru-103/106, Ce/Pr-144, I-131, Sr-89, and Zn-65 values of 22, 9.3, 2.6, 1.01, and 0.7 $\mu\mu$Ci/g, respectively, were obtained from beet top samples. Carrot tops gave the maximum Zr/Nb-95 measurement of 3.3 $\mu\mu$Ci/g, while the maximum Sr-90 value of 0.118 was obtained from Gerber's orange juice (HW-76526).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1963

Media Sampled

Pasture grass was collected from several communities and farming areas in the vicinity of Hanford Project. Samples were analyzed using a multichannel energy spectrometer that utilized a 9-inch diameter well-type NaI(Tl) scintillation crystal. Radionuclides observed included K-40, Zn-65, Zr/Nb-95, Cs-137, Ru-103/106, I-131, and Ce/Pr-144. Phosphorus-32 and Sr-90 concentrations were determined after radiochemical separation and beta counting (HW-80991).

Agricultural produce from local farms was analyzed using the same procedure as employed with pasture grass samples. Radionuclide examination was also the same, with the exception that there was no analysis for Ru-103/106. Produce surveyed included strawberries, asparagus, lettuce, beets, cabbage, parsnips, cherries, beet tops, beet roots, onions, carrots, beet greens, apples, beans, apricots, turnips, peaches, prunes, potatoes, string beans, berries, cucumbers, sweet corn, okra, parsley, squash, and radishes (HW-80991).

Vegetables and fruits were also purchased from local stores and analyzed for radionuclide contamination. Radionuclide examination was done using the same procedure as previously discussed, and radionuclides surveyed included I-131, Ce/Pr-144, Cs-137, Zr/Nb-95, Zn-65, K-40, and Sr-90. Produce analyzed included lettuce, beet tops, beet roots, radishes, rhubarb, asparagus, cucumbers, carrots, peaches, potatoes, green peppers, celery, cabbage, plums, string beans, green onions, apples, sweet corn, endive, tomatoes, blueberries, Romaine lettuce, strawberries, grapes, apricots, and head lettuce (HW-80991).

Special surveys utilizing controlled iodine releases were conducted to examine the deposition of I-131 on vegetation. Low stature grass, sage brush leaves, Russian thistles, and cheatgrass were examined (HW-80500, HW-81746).

Extensive vegetation sampling was done following an accidental release of 60 curies of I-131 from a Hanford Separation Plant stack in early September. Sampling was performed beginning September 2 and continuing for the next week to determine the I-131 deposition pattern. On-site samples included leafy weeds, cheatgrass, and a bare sage stem that had normal vegetation growth destroyed by fire. Off-site samples included pasture grass from local dairy farms and leafy weeds and grasses from along highways and from the permanent atmospheric monitoring stations (Soldat 1964).

Sampling Locations

Pasture grass was collected from the two closest farming areas downriver from the Hanford reactors that utilized Columbia River water for irrigation, the Riverview District of Pasco,

approximately 30 miles downstream, and Ringold, approximately 15 miles downstream. Pasture grass was also collected from Pasco, Byer's Landing, West Richland, Benton City, Eltopia, and Mesa (HW-80991).

Farm produce samples were collected from local farms, and fruits and vegetables were collected from local stores (HW-80991).

Vegetation collected after I-131 controlled releases were sampled from a large meteorological grid area at Hanford (HW-81746, HW-80500).

Vegetation sampled following the accidental release of 60 curies of I-131 in early September was collected from on-project locations 8 miles NW of the Purex Facility, 8 miles NNW, 9 miles N, 10 miles N, 7 1/2 miles NNE, 1/2 mile SSW, 3 1/2 miles W, 1/2 mile NE, 1 1/2 miles NW, and 2 1/2 mile WSW. Off-project locations included 17 miles SE of the Purex Facility, 28 miles SE, and 15 miles S. Off-project farm locations included 11 miles E of the Purex stack, 17 miles E, 17 miles ESE, 16 miles SSE, 16 miles S, 17 miles S, 18 miles S, 18 miles SE, 22 miles SE, 26 miles SE, 29 miles SE, 52 miles SE, 54 miles SE, 58 miles SE, and 60 miles SE of the Purex stack (Soldat 1964).

Significant Events/Emission Quantities

During 1963, the yearly average I-131 emission from the Separation Facilities stacks was 0.38 curies per day (HW-80991).

First quarter average I-131 emissions from the Separation Facilities stacks was 0.094 curies per day. A maximum emission of 0.34 curies per day occurred on January 5, and the maximum emission over seven days was 2.3 curies, which also occurred in January (HW-80991, HW-76525-1, HW-76525-2, HW-76525-3).

Total I-131 emissions from the Separation Facilities stacks averaged 0.28 curies per day during the second quarter of 1963. The maximum daily emission of 1.33 curies per day, and the maximum seven-day emission of 7.4 curies, both occurred in June (HW-80991, HW-76525-4, HW-76525-5, HW-76525-6).

The failure of a fuel element in the KE Reactor on May 12, resulted in the largest single release of fission products to the Columbia River attributable to Hanford. About 450 grams of uranium was lost, equivalent to 170 curies of I-131. An automatic Columbia River monitor at the 300 Area showed a rise in river activity that lasted 12 to 16 hours, peaking about four hours after the arrival of the leading edge of the activity. The peak activity was about 60% above background (RL-REA-2160).

The third quarter total average I-131 emission from the Separation Facilities stacks was 0.89 curies per day. A maximum daily emission of 46 curies per day occurred on September 2, as a result of an incident at the Purex Separation Plant, and the maximum seven-day emission was 65 curies (HW-80991, HW-76525-7, HW-76525-8, HW-76525-9).

Total I-131 emissions from the Separation Facilities stacks during the fourth quarter was 0.25 curies per day. The daily maximum of 2.2 curies per day, and the seven-day maximum of 6.3 curies both occurred in December (HW-80991, HW-76525-10, HW-76525-11, HW-76525-12).

Constituents Measured/Reported

Analysis results were presented in table form in units of pCi/g (HW-80991).

The average concentration of I-131 measured on samples of leafy vegetables collected from local farms and vegetable markets during the period of May through September, 1963, was equal to or less than the detection level of 0.05 pCi/g (HW-80991).

Results obtained from special controlled I-131 release experiments done on the Hanford meteorological grid indicated that higher iodine deposition was found on green vegetation than on dry vegetation. Green vegetation had approximately 10 nCi/sq.ft of I-131, and the dry cheatgrass had about seven (HW-80500, HW-81746).

Radioiodine loss from field crops was found to occur at a rate faster than physical decay. The effective half-life was 4-5 days, as compared to the 8 day physical half-life (HW-80500).

Maximum radioisotope concentrations found in food samples obtained from local stores (HW-80991):

Radioisotope	pCi/g	Sample
Ce/Pr-144	4.4	beet tops
I-131	0.43	endive
Cs-137	0.34	beet tops
Zr/Nb-95	2.9	beet tops
Zn-65	0.22	head lettuce
K-40	8.3	beet tops
Sr-90	0.025	rhubarb

Maximum radioisotope concentrations found in locally grown farm produce (HW-80991, p. 176-177)

Radioisotope	pCi/g	Sample
P-32	0.44	apricots
Ce/Pr-144	9.6	lettuce
I-131	0.12	beet tops, squash
Cs-137	0.4	onions
Zr/Nb-95	4.0	beet tops
Zn-65	1.3	cucumbers
K-40	10.5	parsley
Sr-90	0.11	lettuce

Maximum radioisotope concentrations found in pasture grass collected from locations surrounding Hanford (HW-80991, p. 156-173):

(Concentrations in pCi/g)

Radioisotope	Riverview	Rinaold	Pasco	River's	W. Rich.	Benton City	Eltopia	Mesa
K-40	26	29	42	48	29	39	37	31
Zn-65	4.6	21	0.84	-[a]	-	0.45	-	0.09
Zr/Nb-95	66	23	45	190	21	36	37	30
Cs-137	6.4	3.6	5.2	5.9	6.0	4.6	3.6	3.5
Ru-103/106	40	19	42	69	23	14	17	20
I-131	2.7	1.3	0.79	0.63	1.2	2.6	0.38	0.48
Ce/Pr-144	46	41	59	63	66	32	48	67
P-32	700	8.4	-	-	-	-	-	-
Sr-90	0.161	0.37	0.26	0.197	-	-	1.47	0.78

(a) - = not analyzed.

Analysis results from the special vegetation survey following the 60 curie accidental release in early September indicated that the Benton City-West Richland area exhibited the highest I-131 deposition, ranging from 1 to 10 pCi/g. The maximum concentration observed from an off-site sample was 13 pCi/g from green hay collected from a farm 20 miles SSE of the Purex stack. The maximum on-site concentration observed on vegetation was 250 pCi/g, from a sample collected 2 1/2 miles WSW of the Purex stack. The maximum I-131 concentration detected on pasture grass was 2.7 pCi/g, sampled from a farm 22 miles SE of the Purex stack (Soldat 1964).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1964

Media Sampled

Pasture grass and agricultural farm products were collected from several communities and farming areas in the vicinity of the Hanford Project. Samples were analyzed using direct gamma ray spectrometry techniques. Two hundred and fifty to three hundred gram samples were packed into 16 ounce polyethylene bottles, placed in the well of a large NaI(Tl) scintillation crystal, and counted. Radioisotopes analyzed included K-40, I-131, Ce/Pr-144, Zr/Nb-95, Zn-65, and Cs-137. Samples of pasture grass were also examined for Ru-106. Phosphorus-32 and Sr-90 concentrations were determined after radiochemical separation and beta counting. Farm produce analyzed included onion tops, radish tops, asparagus, radishes, lettuce, mustard greens, strawberries, rhubarb, cherries, Romaine lettuce, leaf lettuce, fresh peas, raspberries, beans, onions, blackberries, carrots, beets, apples, carrot tops, carrot roots, green beans, peppers, corn (sweet and field), tomatoes, cabbage, cucumbers, potatoes, squash, melons, sugar beets, string beans, peaches, wheat, watermelon, kohlrabi, green peppers, hot peppers, cantaloupe, Hale peaches, Elberta peaches, grapes, plums, pears, and yams (BNWL-90).

Vegetables and fruits were also purchased from local stores and analyzed for radionuclide contamination. Radioisotopes examined included K-40, Zr/Nb-95, I-131, Cs-137, Ce/Pr-144, and Sr-90. Produce analyzed included lettuce, asparagus, carrots, cabbage, green onions, rhubarb, mustard greens, radishes, beets, broccoli, tomatoes, cucumbers, green peppers, zucchini squash, and cauliflower (BNWL-90).

Studies were performed to determine the long-term availability of radionuclides in soil. Field plots that were contaminated with Sr-90 and Cs-137 in 1952 were examined (HW-83613).

Sampling Locations

Pasture grass was collected from the three closest farming areas downriver from the Hanford reactors that utilized Columbia River water for irrigation: two farms in the Riverview District of Pasco, approximately 30 miles downstream, and Ringold, approximately 15 miles downstream. Pasture grass samples were also collected from Pasco, Eltopia, West Richland, and Benton City (BNWL-90).

Farm produce samples were collected from local farms, and fruits and vegetables were collected from local stores (BNWL-90).

Contaminated field plots within Hanford project were examined to determine long-term radionuclide availability in soil (HW-83613).

Significant Events/Emission Quantities

The average I-131 emission from the Separations Plant stacks for 1964 was 0.22 curies per day (BNWL-90).

First quarter average I-131 emissions from the Separations Facilities stacks was 0.11 curies per day. The maximum daily emission of 0.54 curies per day, and the maximum seven-day emission of 2.6 curies both occurred in March (BNWL-90, HW-80892-1, HW-80892-2, HW-80892-3).

Total I-131 emissions from the Separations Plant stacks averaged 0.22 curies per day during the second quarter. The maximum daily emission of 0.77 curies per day occurred on April 30, and the maximum seven-day emission of 3.2 curies occurred in June (BNWL-90, HW-80892-4, HW-80892-5, HW-80892-6).

During the third quarter of 1964, the total average I-131 emission from the Separations Facilities stacks was 0.23 curies per day. The maximum daily emission of 0.98 curies per day occurred in September (BNWL-90, HW-80892-7, HW-80892-8, HW-80892-9).

The fourth quarter average I-131 emissions from the Separations Plant stacks was 0.28 curies per day. The maximum daily emission of 0.85 curies per day occurred in November (BNWL-90, HW-80892-10, HW-80892-11, HW-80892-12).

China conducted a nuclear test on October 16, 1964, which resulted in a temporary increase in I-131 concentrations in the Hanford vicinity (BNWL-90).

During 1964, an estimated 2400 grams of irradiated uranium containing 920 curies of I-131 were lost from fuel elements as a result of 97 cladding failures. The uranium lost from any single fuel element ranged from a few grams to a maximum of about a hundred grams, with an average of 25 grams per failed element. It was assumed that all of the I-131 contained in the uranium was delivered to the river. An additional 800 curies of I-131 was delivered to the Columbia via the effluent water. I-131 was produced as a result of the natural uranium present in the cooling water. Hanford Laboratories determined that the amount of I-131 in the Columbia River for 1964 was about 1100 curies (RL-REA-2160).

Constituents Measured/Reported

Analysis results were presented in table form in units of pCi/g (BNWL-90).

Concentrations of I-131 found on samples of fresh vegetables collected from local farms and markets during the period May through September, 1964, were less than or approximately equal to the detection level of 0.05 pCi/g. There was no significant difference between concentrations found on local farm produce and produce purchased from commercial outlets (BNWL-90).

There were no unusual releases of radionuclides from Hanford sources during 1964, and Sr-90 deposition from world-wide fallout was significantly less in 1964 than during the two previous years (BNWL-90).

Results from the studies involving the long-term availability of radionuclides in soil that was contaminated with Sr-90 and Cs-137 in 1952 indicated that during the twelve year period following contamination, the Sr-90 has moved down the soil profile by approximately twelve inches, with little change in its availability. The Cs-137 remained in the upper layer, with its availability decreasing by 80% during the first year following contamination, and no change thereafter (HW-83613).

Maximum radioisotope concentrations found in produce samples obtained from local stores (BNWL-90):

Radioisotope	pCi/g	Sample
K-40	4.3	mustard greens
Zr/Nb-95	0.05	mustard greens, beets
I-131	0.16	carrots
Cs-137	0.09	mustard greens
Ce/Pr-144	2.2	carrots
Sr-90	0.037	rhubarb, radishes, gr. onions, beets, mustard greens

Maximum radioisotope concentrations found in locally grown farm produce (BNWL-90):

Radioisotope	pCi/g	Sample
P-32	<3.4	tomatoes
K-40	7.0	carrot tops
Zn-65	1.1	sweet corn
Zr/Nb-95	0.06	Hale peaches
I-131	0.19	squash
Cs-137	0.31	string beans
Ce/Pr-144	2.2	carrots
Sr-90	0.043	carrot tops

Maximum radioisotope concentrations found in pasture grass collected from various locations surrounding the Hanford Project (BNWL-90):

(Concentrations in pCi/g)

Radioisotope	Riverview #1	Riverview #2	Ringold	Pasco	Eltopia	W. Rich.	Benton City
P-32	**39.0**	4.7	6.4	1.3	<0.2	11.0	-[(a)]
K-40	28.0	28.0	18.0	25.0	28.0	17.0	**32.0**
Zn-65	**42.0**	7.6	2.4	0.93	<0.1	3.0	<0.1
Zr/Nb-95	**2.2**	0.51	0.33	0.36	0.69	0.40	0.16
Cs-137	2.0	1.3	0.79	1.2	**2.6**	1.8	0.77
I-131	**1.7**	0.46	0.46	1.1	1.6		
Ce/Pr-144	13.0	7.4	9.6	8.2	**15.0**	10.0	5.3
Ru-106	14.0	14.0	8.4	**16.0**	8.1	6.0	4.0
Sr-90	**0.41**	-	0.093	0.099	0.052	0.073	0.073

(a) - = not analyzed.

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1965

Media Sampled

Pasture grass and agricultural farm products were collected from several communities and farming areas in the vicinity of the Hanford Project. Analytical results were supplied by the US Testing Company, Inc., who performed all routine radioassays of environmental samples. Radioisotopes analyzed included K-40, Zn-65, Zr/Nb-95, Cs-137, I-131, Ce/Pr-144, Ru-106, P-32, and Sr-90. Farm produce analyzed included asparagus, carrots, leaf lettuce, string beans, raspberries, apples, potatoes, cabbage, lettuce, new potatoes, red lettuce, green peppers, hot peppers, cucumbers, parsnips, okra, dill, Romaine lettuce, green beans, wax beans, zucchini, rhubarb, red potatoes, strawberries, beets, corn, tomatoes, squash, cantaloupe, green apples, radishes, onions, and wheat (BNWL-316-APP).

Vegetables and fruits were also purchased from local stores and analyzed for radionuclide contamination. Radioisotopes examined included K-40, Cs-137, and I-131. Produce analyzed included cabbage, carrots, potatoes, radishes, lettuce, Romaine, peppers, onions, apples, and corn (BNWL-316-APP).

Sampling locations

Pasture grass was collected from the three closest farming areas downriver from the Hanford reactors that utilized Columbia River water for irrigation: two farms in the Riverview District of Pasco, approximately 30 miles downstream, and Ringold, approximately 15 miles downstream. Pasture grass samples were also collected from Benton City, 20 miles directly south of the Separations Facilities, Eltopia, West Richland, and three farms in Pasco (BNWL-316-APP, BNWL-316).

Farm produce samples were collected from local farms, and fruits and vegetables were collected from local stores (BNWL-316, BNWL-316-APP).

Significant Events/Emission Quantities

The average I-131 emissions from the Hanford Plant stacks for 1965 was 0.3 curies per day (BNWL-SA-601).

A Chinese nuclear weapons test on May 14, 1965, resulted in a temporary increase in I-131 concentrations (BNWL-316, BNWL-165).

The H and F reactors were shut-down permanently on April 21, 1965, and June 25, 1965, respectively (BNWL-316).

During September 17 through 19, a large quantity of Ru-103 and Ru-106 was released from the 202-S building stack (BNWL-CC-913).

On September 29, 1965, the process tube in the Fuel Element Rupture Test Facility failed, resulting in a release of tritium, radioiodines, and noble gases to the atmosphere and to the Columbia River (BNWL-CC-913, BNWL-316).

Constituents Measured/Reported

Analysis results were reported in table form in units of pCi/g (BNWL-316-APP).

Concentrations of radionuclides found on agricultural produce are influenced by the deposition of airborne contaminants and the amounts present in irrigation water (BNWL-316).

The concentrations of I-131 found in samples of fresh vegetables collected from local farms and markets during the first half of 1965 through September was less than or approximately equal to the reporting limit of 0.05 pCi/g. There was no significant difference in concentrations found in local farm produce and in produce purchased from local commercial outlets (BNWL-316, BNWL-165).

World-wide fallout contributed essentially all of the Sr-90 and Cs-137 found in produce sampled in the Tri-City area, as well as the majority of the I-131. However, due to the low rainfall amounts in the region, concentrations are lower than the national average (BNWL-316, BNSA-53, BNWL-165). Concentrations of P-32, Zn-65, Cr-51, As-76, and Np-239 were primarily associated with reactor effluent water (BNWL-165).

Maximum radioisotope concentrations found in produce samples obtained from local stores (BNWL-316-APP):

Radioisotope	pCi/g	Sample
K-40	3.8	potatoes
Cs-137	0.03	potatoes
I-131	0.18	Romaine

Maximum radioisotope concentrations found in locally grown farm produce (BNWL-316-APP):

Radioisotope	pCi/g	Sample
P-32	<1.0	misc. produce
K-40	6.0	asparagus
Zn-65	0.11	tomatoes
Zr/Nb-95	0.06	leaf lettuce
Cs-137	0.18	asparagus
I-131	0.10	misc. produce
Ce/Pr-144	3.4	hot peppers
Sr-90	0.033	green lettuce

Maximum radioisotope concentrations found in pasture grass collected from locations surrounding Hanford (BNWL-316-APP):

(Concentrations in pCi/g)

Location	P-32	K-40	Zn-65	Zr/Nb-95	Cs-137	I-131	Ce/Pr-144	Ru-106	Sr-90
Riverview #1	6.7	32	3.0	8.6	1.2	1.3	19	10	-(a)
Riverview #2	-	30	5.1	2.3	0.59	0.52	14	4.5	-
Ringold	7.1	32	.6	4.3	1.7	0.30	11	12	-
Pasco #1	1.0	31	5.0	3.3	1.6	3.5	6	7.7	0.252
Pasco #2	-	77	-	61.0	0.82	0.45	19	2.2	-
Pasco #3	<1.0	26	3.3	0.20	0.68	0.21	5	15	-
Eltopia	-	32	-	13.0	1.7	0.25	37	20	0.239
W. Richland	2.9	65	0.11	15.0	1.2	0.97	15	2.9	0.387
Benton City	-	56	<0.1	3.4	0.81	0.51	6	6.6	0.039

(a) - = not analyzed.

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1966

Media Sampled

Pasture grass and agricultural produce were collected from several communities and farming areas in the vicinity of the Hanford Project. Analysis results were supplied by the US Testing Company, Inc., who performed all routine radioassays of the environmental samples. Radioisotopes analyzed included P-32, K-40, Zn-65, Zr/Nb-95, Cs-137, I-131, Ce/Pr-144, Ru-106, and Sr-90. Farm produce analyzed included asparagus, cherries, rhubarb, leaf lettuce, radishes, peas, carrots, potatoes, apricots, lettuce, cucumbers, corn on cob, tomatoes, green apples, cabbage, peaches, and apples (BNWL-439, BNWL-439-APP).

Vegetables and fruits were also purchased from local stores and analyzed for radionuclide contamination. Radioisotopes examined included K-40, Zn-65, Cs-137, and Sr-90. Produce analyzed included radishes, potatoes, lettuce, carrots, tomatoes, corn on cob, and cucumbers (BNWL-439-APP).

A special survey was conducted to evaluate the radiological conditions along the riverbank of the Columbia River. Native vegetation growing along the riverbank was collected and examined for radioactivity (BNWL-CC-468).

Sampling Locations

Pasture grass was collected from the three closest farming areas downriver from the Hanford reactors that utilized Columbia River water for irrigation: two farms in the Ringold area, approximately 15 miles downstream, and a farm in the Riverview irrigation district of Pasco, approximately 30 miles downstream. Pasture grass samples were also collected from Benton City, 20 miles directly south of the Separations Facilities, Eltopia, two farms in Pasco, and two farms in West Richland (BNWL-439, BNWL-439-APP).

Farm produce samples were collected from local farms, and fruits and vegetables were collected from local stores (BNWL-439, BNWL-439-APP).

Native vegetation samples collected as part of the special survey to determine radiological conditions along the Columbia riverbank were obtained from Ringold, the area between Hanford and Ringold, the region between Hanford and the 300 Area, and the area between the 300 Area and Richland (BNWL-CC-468).

Significant Events/Emission Quantities

An abnormal release of radioiodines from a production reactor at Hanford to the Columbia River on February 11, 1966, resulted in elevated I-131 concentrations (BNWL-439, BNWL-391).

A Chinese nuclear weapons test on May 9, 1966, resulted in a temporary increase in I-131 concentrations (BNWL-439, BNWL-391).

All Hanford reactors were shut down in early July through late August as a result of a labor dispute. Significant reductions in radionuclide concentrations occurred during this period as a result of the strike (BNWL-439).

On October 27, 1966, Chinese and Russian nuclear tests temporarily increased I-131 concentrations (BNWL-439).

Constituents Measured/Reported

Analysis results were reported in table form in units of pCi/g (BNWL-439-APP).

Concentrations of radionuclides found on agricultural produce are influenced by the deposition of airborne contaminants and the amounts present in irrigation water (BNWL-439).

The concentrations of I-131 found in samples of fresh vegetables collected from local farms and markets during the first half of 1966 through September, was less than or approximately equal to the reporting limit of 0.05 pCi/g. There was no significant difference in concentrations found in local farm produce and in produce purchased from local commercial outlets (BNWL-439, BNWL-391).

Analysis results for 1966 indicated that most of the environmental radiation dose was due to natural sources and world-wide fallout, rather than to Hanford operations (BNWL-439, BNWL-391).

The major source of low-level waste released to the environment from Hanford Plants was reactor cooling water that was discharged into the Columbia River (BNWL-391).

The Riverview and Ringold areas utilize Columbia River water for irrigation. The biologically important radionuclides P-32 and Zn-65, which are relatively long-lived, have been found in sufficient quantities on farm products (BNWL-SA-601).

Vegetation that was irrigated by the Columbia River at least once a year or which obtained water and minerals from the ground close to the river showed a significant concentration of radionuclides. Activity levels ranged from 200 to 1000 counts per minute for Ringold and the area between Ringold and Hanford. Readings at the water's edge at Ringold ranged from 1000 to 3500 counts per minute. In the area between Hanford and the 300 Area, activity levels at the water's edge ranged from 1000 to 3000 counts per minute, decreasing to 250 counts per minute at Richland (BNWL-CC-468).

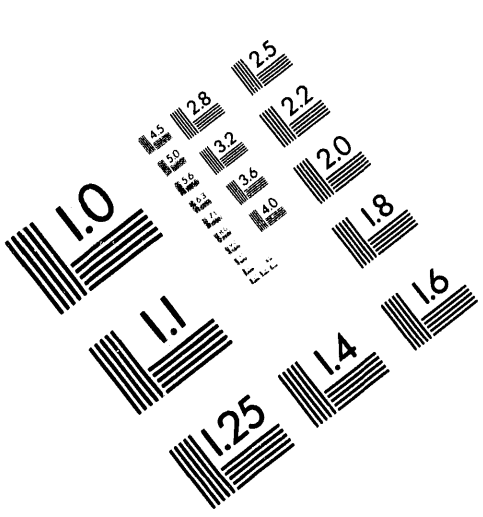
World-wide fallout contributed essentially all of the strontium and cesium found in food products in the Tri-City area. Concentrations of these radioisotopes found in local produce is below the national average due to the low rainfall amounts in the Hanford vicinity (BNWL-SA-601, BNWL-439).

Maximum radioisotope concentrations found in food samples obtained from local stores (BNWL-439-APP):

Radioisotope	pCi/g	Sample
K-40	4.3	potatoes
Zn-65	<0.1	all samples
Cs-137	<0.03	all samples
Sr-90	0.015	carrots

Maximum radioisotope concentrations found in locally grown farm produce (BNWL-439-APP):

Radioisotope	pCi/g	Sample
P-32	3.8	cherries
K-40	6.2	lettuce
Zn-65	0.39	leaf lettuce
Zr/Nb-95	0.29	lettuce
I-131	<0.05	corn on cob
Cs-137	0.08	lettuce
Ce/Pr-144	<1.0	cucumbers, lettuce
Sr-90	0.064	cabbage



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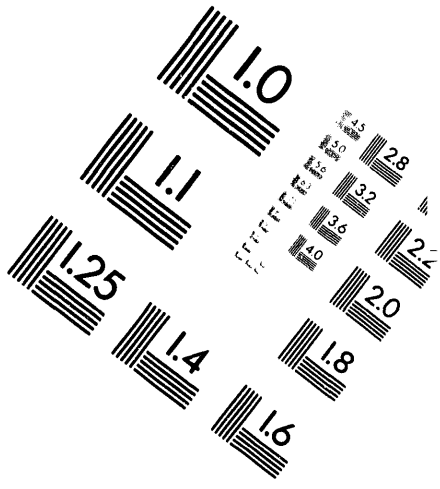

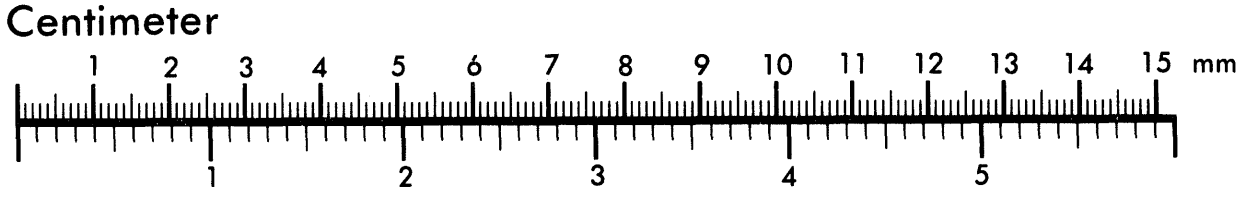

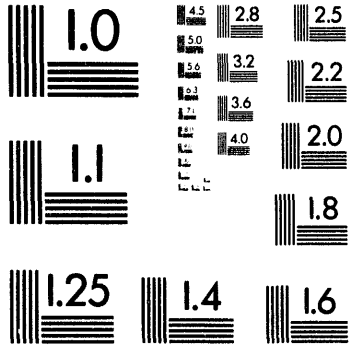

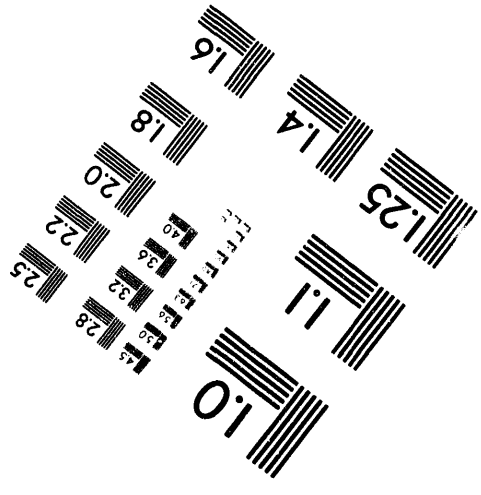

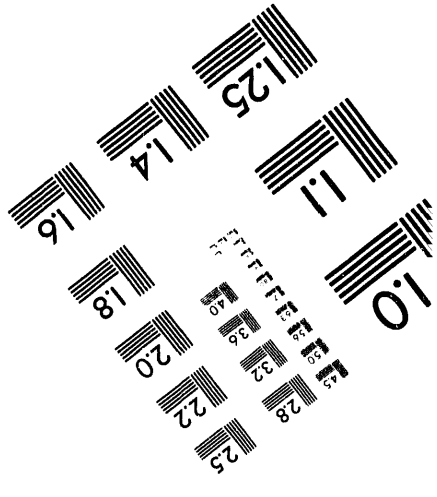

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Maximum radioisotope concentrations found in pasture grass/hay for locations in the vicinity of Hanford (BNWL-439-APP):

(Concentrations in pCi/g)

Location	P-32	K-40	Zn-65	Zr/Nb-95	Cs-137	I-131	Ce/Pr-144	Ru-106	Sr-90
Riverview	1.1	29	**5.4**	6.8	0.80	**0.58**	7.0	2.5	**0.131**
Ringold #1	**50.0**	15	2.4	2.2	0.22	0.16	6.0	**11.0**	0.066
Ringold #2	-[a]	37	1.1	0.16	0.20	0.21	<1.0	1.8	-
Pasco #1	9.0	28	0.68	2.1	0.38	0.26	14.0	1.8	<0.002
Pasco #2	-	32	-	**10.0**	**1.10**	0.16	**58.0**	5.0	-
Eltopia	-	37	0.35	3.4	0.31	0.31	8.0	3.7	<0.002
W.Richland #1	-	15	-	5.2	0.33	0.10	2.0	1.0	-
W.Richland #2	-	25	-	0.29	0.30	<0.05	<1.0	0.60	-
Benton City	-	**53**	0.61	5.7	0.75	0.10	3.0	1.1	-

(a) - = not analyzed.

References

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1967

Media Sampled

Hay and pasture grass and agricultural produce were collected from several communities and farming areas in the vicinity of the Hanford Project. US Testing Company, Inc., provided analytical results after performing all routine radioassays of environmental samples. Radioisotopes analyzed included P-32, K-40, Zn-65, Zr/Nb-95, Ru-106, I-131, Cs-137, and Ce/Pr-144. Farm produce analyzed included cherries, asparagus, strawberries, peas, beans, apricots, lettuce, apples, tomatoes, peaches, potatoes, and eggplant (BNWL-983, BNWL-983-APP).

A special vegetation survey was performed in late August. Several samples of native vegetation including dry weeds and green weeds were analyzed for Sr-90, Ru-103/106, Cs-137, and Zr/Nb-95 (BNWL-CC-1197-6).

Sampling Locations

Hay and pasture grass were collected from the two closest farming areas downriver from the Hanford reactors that utilized Columbia River water for irrigation: a farm in Ringold, approximately 15 miles downstream, and a farm in the Riverview Irrigation District of Pasco, approximately 30 miles downstream. Hay and pasture grass samples were also collected from three farms in Pasco, two farms in Eltopia, two farms in West Richland, a farm in Benton City, and a farm in Mesa (BNWL-983, BNWL-983-APP).

Farm produce samples were collected from local farms (BNWL-983, BNWL-983-APP).

On August 31, native vegetation samples were collected from the backfill area over the old B-ditch (BNWL-CC-1197-6).

Significant Events/Emission Quantities

Fallout from a nuclear weapons test on December 27, 1966, reached the Hanford vicinity in early January, resulting in increased total beta activity (BNWL-CC-1197-6, BNWL-983).

In June, 1967, D Reactor was shut down permanently (BNWL-665, BNWL-983, BNWL-CC-1197-6).

An increased emission rate of I-131 from a chemical separations facility in March resulted in higher I-131 concentrations (BNWL-CC-1197-6).

Iodine-131 concentrations increased in April at the 300 Area following above normal emissions from laboratory buildings (BNWL-CC-1197-6).

In April, 1967, the presence of Sb-122, having a half-life of 2.8 days, was detected in Columbia River water (BNWL-665).

Nuclear weapons testing June 17 resulted in increased radionuclide concentrations (BNWL-983, BNWL-CC-1197-6).

During 1967, the Redox separations plant was retired from routine operation (BNWL-983).

On September 16, 1967, a fuel element cladding failure resulted in approximately 15 curies of I-131 being delivered to the Columbia River (BNWL-CC-1197-6).

Approximately 30 to 35 curies of I-131 were released to the Columbia River on October 27 as a result of a fuel element cladding failure (BNWL-CC-1197-6).

A nuclear weapons test on December 24, 1967, resulted in increased radionuclide concentrations during the last week of December (BNWL-CC-1197-6).

Constituents Measured/Reported

Analysis results were reported in table form in units of pCi/g (BNWL-983-APP).

Analysis results for 1967 indicated that most of the environmental radiation dose was due to natural sources and world-wide fallout, rather than to Hanford operations (BNWL-665).

The major source of low-level radioactive waste released to the environment from Hanford plants is reactor cooling water discharged to the Columbia River (BNWL-983, BNWL-665).

Radioactivity found in local produce is influenced by the deposition of airborne radionuclides and by irrigation with river water containing reactor effluent (BNWL-665).

The concentrations of I-131 found in samples of fresh vegetables and fruits collected from local farms during the first half of 1967 through September, was less than or approximately equal to the analytical limit of 0.05 pCi/g (BNWL-665, BNWL-983).

Samples of dry weeds collected on August 31 from the old B-ditch showed the presence of Sr-90, Ru-103/106, Cs-137, and Zr/Nb-95. A green weed sample contained Sr-90 and Cs-137 (BNWL-CC-1197-6).

Maximum radioisotope concentrations found in locally grown fruits and vegetables (BNWL-983-APP):

Radioisotope	pCi/g	Sample
P-32	<1.0	all samples tested
K-40	8.2	peas
Zn-65	0.40	peas
Zr/Nb-95	<0.07	cherries, peas
Ru-106	<0.88	lettuce
I-131	<0.14	lettuce
Cs-137	<0.11	beans
Ce/Pr-144	<1.0	apricots

Maximum radioisotope concentrations found in hay/pasture grass samples collected from locations surrounding Hanford (BNWL-983-APP):

Concentrations in pCi/g)

Location	P-32	K-40	Zn-65	Zr/Nb-95	Ru-106	I-131	Cs-137	Ce/Pr-144
Riverview	13.0	33	**3.8**	**2.20**	**5.8**	**4.1**	<0.31	**11.0**
Ringold	20.0	45	1.6	0.47	<2.4	<0.89	<0.27	<6.1
Pasco #1	**41.0**	32	<0.34	0.67	<2.6	<0.34	<0.30	<2.5
Pasco #2	-(a)	35	<0.1	0.61	<2.39	1.1	0.29	<3.9
Pasco #3	<1.0	29	<0.30	1.3	<1.7	<0.33	<0.20	<3.8
Eltopia #1	-	32	<0.20	1.1	<2.2	<0.58	**0.38**	<5.1
Eltopia #2	-	30	-	<0.16	<1.3	<0.51	<0.15	<3.6
W.Richland #1	-	17	<0.31	1.30	<1.5	<0.47	0.27	<4.0
W.Richland #2	-	30	-	0.50	<1.5	<0.26	0.36	<2.4
Benton City	-	**68**	-	1.3	<1.9	<0.42	0.22	<3.8
Mesa	-	29	0.68	0.40	<2.1	<0.60	0.28	<4.4

(a) - = not analyzed.

References

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1968

Media Sampled

Hay and pasture grass and agricultural produce were collected from several communities and farming areas in the vicinity of the Hanford Project. Analytical results were supplied by the US Testing Company, Inc., who performed all routine radioassays of environmental samples. Radioisotopes analyzed included P-32, K-40, Sc-46, Zn-65, Zr/Nb-95, Ru-106, Sr-89, Sr-90, Ce/Pr-144, I-131, and Cs-137/Ba-137m.[a] Farm produce examined included lettuce, spinach, cabbage, cherries, onions, corn, potatoes, plums, peaches, red cabbage, peppers, tomatoes, carrots, prunes, grapes, beans, squash, cucumbers, rhubarb, green beans, sweet potatoes, dill, cantaloupe, and apricots (BNWL-1341-APP, BNWL-1341).

Special radiation surveys were conducted monthly on roads in the Hanford environs. Contaminated weeds were found in March, May, June, and October (BNWL-CC-1850, BNWL-CC-2026).

Sampling Locations

Hay and pasture grass were collected from several farms surrounding the Hanford reservation. Samples were collected from two farms in the Riverview District of Pasco, which are approximately 30 miles downstream of the Hanford reactors and utilize Columbia River water for irrigation, three farms in Pasco, and a farm in Mesa (BNWL-1341-APP).

Farm produce was collected from local farms in the Hanford vicinity. Sampling areas included the Pasco/Riverview area, Benton City, Ringold, West Richland, and Kennewick (BNWL-1341-APP).

Contaminated weeds, discovered during road surveys, were found along the fence in the southwest corner of the 200 West Area, inside the 200 B-C Crib Area, along the dirt road south of the 200 B-C Crib Area, and inside the fence at the northeast corner of the 200 East Area (BNWL-CC-1850, BNWL-CC-2026).

Significant Events/Emission Quantities

Increased I-131 concentrations in the Hanford environment during January, and higher amounts of total beta activity from airborne particulates during the first half of 1968 were due to fallout from foreign nuclear weapons testing in late December of 1967 (BNWL-1341, BNWL-CC-1850).

(a) The term metastable (m) refers to the relatively stable but transient state of the isotope.

The B Reactor was retired in mid-February, leaving three production reactors operational (BNWL-778-2, BNWL-CC-1850, BNWL-1341).

Slight I-131 emission increases occurred in January, March, April, July, August, September, and November from laboratory buildings, the Purex stacks, and the Chemical Separation facilities, resulting in increased I-131 concentrations (BNWL-CC-1850, BNWL-CC-2026).

An event at the Nevada Test Site during mid-December resulted in a temporary increase in total beta activity in the atmosphere. Highest values were found in the Walla Walla area during the period December 6 through December 20, and were attributed to radiotungsten (BNWL-1341, BNWL-CC-2026).

Constituents Measured/Reported

Analysis results were reported in table form in units of pCi/g, wet weight (BNWL-1341-APP).

Analysis results for 1968 indicated that most of the environmental radiation dose in the Hanford vicinity was due to natural sources and world-wide fallout, rather than to Hanford operations (BNWL-1341).

The major source of low-level wastes released into the environment from Hanford plants in 1968 was reactor cooling water discharged to the Columbia River (BNWL-1341).

Concentrations of I-131 found in samples of fresh leafy vegetables collected from local farms and markets during the period May through September were less than or approximately equal to the analytical limit of 0.05 pCi/g (BNWL-1341).

Amounts of the fallout radionuclides H-3, Sr-90, and Cs-137, are below the national average in the Hanford area due to the low rainfall in the vicinity (BNWL-1341).

During March, contaminated weeds found at the corner of the southwest fence in the 200 West Area gave a reading of 400 c/m (GM) (BNWL-CC-1850).

During May, particulate materials associated with weeds and other organic debris found along the dirt road south of the 200 B-C Crib Area had GM readings as high as 100,000 c/m (BNWL-CC-1850).

During June, radioactive weeds found inside the fence at the northeast corner of the 200 East Area had a maximum radiation level of 150 mrads/hr (Juno) (BNWL-CC-1850).

A contaminated weed found in the 200 B-C Crib Area during a road survey in late October gave a reading of 2000 c/m (GM) (BNWL-CC-2026).

The maximum radionuclide concentrations found in hay/pasture grass samples collected from farming areas in the Hanford vicinity (BNWL-1341-APP, p. 90-91):

(Concentrations in pCi/g)

Location	P-32	K-40	Sc-46	Zn-65	Zr/Nb-95	Ru-106	I-131	Cs-137/ Ba-137m	Ce/ Pr-144
Riverview #1	1.1	26	0.20	<0.49	0.38	<2.2	**<0.57**	**0.38**	**<3.8**
Riverview #2	2.3	24	**1.5**	**2.3**	<0.31	**<2.52**	<0.30	<0.29	<3.0
Pasco #1	<1.0*[a]	**28**	-[b]	-	0.71	<1.6	<0.16	0.17	<3.7
Pasco #2	<1.0*	20	-	-	<0.16	<1.2	-	<0.14	<3.3
Pasco #3	**4.1**	16	-	-	<0.21	<1.8	-	<0.17	<1.8
Mesa	-	24	-	-	**2.5**	<1.4	<0.31	<0.16	<3.7

(a) * = analytical limit.
(b) - = not analyzed.

The maximum radionuclide concentrations found in fruits and vegetables collected from farms in the Hanford vicinity (BNWL-1341-APP, p. 93-95):

(Concentrations in pCi/g)

Location	P-32	K-40	Zn-65	Sr-89	Sr-90	Zr/Nb-95	I-131	Cs-137/Ba-137m
Pasco/ Riverview	**1.2** dill	**31.0** dill	**1.0** dill	**0.012** cabbage	0.035 lettuce	**0.20** dill	**<0.13** lettuce/beans	**<0.14** lettuce/cabbage
Benton City	<1.0*[a] all	4.0 lettuce	<0.19 lettuce	<0.002 tomato	<0.002 tomato	<0.11 lettuce	<0.12 cabbage	<0.11 lettuce
Ringold	<1.0* peaches	1.9 peaches	<0.1 peaches	-[b]	-	-	<0.059 peaches	<0.051 peaches
West Richland	<1.0* all	3.2 carrot	<0.17 peppers	0.003 carrots	0.006 carrots	<0.048 tomatoes	<0.096 squash	<0.088 peppers
Kennewick	<1.0* all	4.2 sweet potatoes	0.18 beans	0.002 carrots	**0.12** carrots	<0.094 beans	**<0.13** beans	<0.090 beans

(a) * = analytical limit.
(b) - = not analyzed.

References

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BNWL-CC-1850. Environmental Evaluation, Radiation Protection, Technical Services Division. 1968. *Environmental Status of the Hanford Reservation for January-June, 1968.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-CC-2026. Environmental Evaluations Staff. 1969. *Environmental Status of the Hanford Reservation for July-December, 1968.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-1341. Environmental Evaluations Staff. 1970. *Evaluation of Radiological Conditions in the Vicinity of Hanford for 1968.* Battelle Northwest Laboratory, Richland, Washington.

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1969

Media Sampled

Hay and pasture grass were collected from several farms in the vicinity of the Hanford Project and nearby communities. Analytical results were supplied by the US Testing Company, Inc., who performed all routine radioassays of environmental samples that were collected by Battelle Northwest employees. Radioisotopes analyzed included K-40, Cr-51, Mn-54, Sr-90, Zr/Nb-95, I-131, Ru/Rh-103, Ru/Rh-106, Cs-137/Ba-137m, Ce-141, and Ce/Pr-144 (BNWL-1505, BNWL-1505-APP).

Fruits were collected from Ringold and the Pasco/Riverview region, two farming areas downriver from the Hanford reactors that utilize Columbia River water for irrigation, as well as from the Richland area. Samples were analyzed for P-32, K-40, Zn-65, Sr-90, I-131, Zr/Nb-95, and Cs-137/Ba-137m by the US Testing Company, Inc., who performed the radioassays and provided analytical results. Fruits analyzed included rhubarb, strawberries, gooseberries, cantaloupe, watermelon, grapes, plums, apples, and cherries (BNWL-1505, BNWL-1505-APP).

Leafy vegetables were collected from the Pasco/Riverview Area by Battelle Northwest employees. Radioassays were performed by the US Testing Company, Inc., who provided analytical results. Radionuclides examined included P-32, K-40, Zn-65, Sr-89, Sr-90, Zr/Nb-95, Ru/Rh-106, I-131, Cs-137/Ba-137m, and Ce/Pr-144. Leafy vegetables sampled included leaf lettuce, spinach, Swiss chard, mustard, beet tops, carrot tops, lettuce, radish tops, and cabbage (BNWL-1505, BNWL-1505-APP).

Other vegetables, excluding leafy varieties, were also collected from the Pasco/Riverview Area. Analytical results were provided by the US Testing Company, Inc., and radionuclides analyzed included P-32, K-40, Zn-65, Sr-90, Zr/Nb-95, Ru/Rh-106, I-131, Cs-137/Ba-137m, and Ce/Pr-144. Vegetables sampled included beets, peas (including shells), carrots, onions, dill, peas (shelled), radishes, peppers, onion tops, squash, corn on the cob, potatoes, tomatoes, cucumbers, eggplant, okra, string beans, and sweet potatoes (BNWL-1505, BNWL-1505-APP).

During the first half of 1969, a special radiological survey was performed around the 200 East Area following reported increases in alpha and total beta concentrations. Vegetation samples were collected and analyzed for total beta and alpha activities. Principal gamma emitters were reported (BNWL-CC-2478).

Desert vegetation was collected from a small area in the southwest section of Hanford during the first half of 1969, in an effort to determine whether the land would be suitable for release for public use. Samples were analyzed for gamma emitters to include Cs-137/Ba-137m, Be-7, K-40, Sc-46, Mn-54, Zr/Nb-95, Ru-103, Ru/Rh-106, Sb-125, Ba/La-140, Ce-141, Ce/Pr-144, Eu-154, Eu-155, Tl-208, Bi-212, and Pb-212. Off-site comparison surveys were also performed (BNWL-CC-2478).

On November 24, 1969, a special radiological survey was performed following reported increases in air contamination. Native vegetation samples were collected and analyzed as part of this survey (BNWL-CC-2583).

Sampling Locations

Hay and pasture grass were collected from several farms in the vicinity of the Hanford reservation. Samples were collected from two farms in the Riverview District (farm #1 and farm # 4), which are approximately 30 miles downstream from the Hanford reactors and utilize Columbia River water for irrigation, two farms in Pasco (farm #2 and farm #4), a farm in Eltopia (#2), farm #1 in West Richland, and farms in Mesa, Benton City, and Finley (BNWL-1505-APP).

Fruits were collected from farms in the Pasco/Riverview area, Ringold (which also utilizes Columbia River water for irrigation and is approximately 15 miles downstream from the Hanford reactors), and Richland. Vegetables were collected from the Pasco/Riverview area (BNWL-1505-APP).

Vegetation was collected as part of a special survey following increased alpha and beta concentrations in the 200 East Area. Samples were collected from areas including the vicinity of well 699-42-42, north of the 200 Area, east of the 200 Area, and near the 200 West Gate (BNWL-CC-2478).

Desert vegetation was collected from the southwest portion of Hanford during the first half of 1969 to determine whether the area could be utilized by the public. Regions surveyed included the Emergency Relocation Center, the boundary fence, Section 8, Section 10, Section 18, and along Highway 240. A comparison survey was performed from off-site locations including Finley, Benton City, Big Pasco Industrial Park, Island View, and Plymouth (BNWL-CC-2478).

On November 24, 1969, a special vegetation survey was conducted between Route 11-A and the north boundary of the 200 East Area after high air concentrations were reported (BNWL-CC-2583).

Significant Events/Emission Quantities

In late January, 1969, elevated releases of I-131 from a laboratory building resulted in increased I-131 concentrations (BNWL-CC-2478).

During the first half of 1969 increases in total beta were attributed to waste handling and processing operations (BNWL-CC-2478).

In April the 100-C Reactor was retired, leaving two single-pass reactors and the N-Reactor in operation (BNWL-1427-REV, BNWL-1505).

A foreign weapons test that took place in late December, 1968, resulted in increased atmospheric total beta in March, with peaks occurring in June and August (BNWL-1505, BNWL-CC-2478).

During early June, 0.58 curies of I-131 were released from the 325-B Annex stack, resulting in increased I-131 concentrations (BNWL-CC-2478).

The Plutonium Recycled Test Reactor (PRTR) was retired in July 1969, and was not operational six months prior to its retirement (BNWL-1427-REV).

In July, an unusual release of I-131 from a lab facility resulted in elevated I-131 concentrations (BNWL-CC-2583).

Foreign nuclear weapons testing occurred on September 22 and 29, 1969, but no significant environmental radiation increases were noted (BNWL-1505, BNWL-CC-2583).

Constituents Measured/Reported

The major source of low-level wastes released to the environment by Hanford operations in 1969 was reactor cooling water discharged to the Columbia River (BNWL-1505).

The Hanford environmental surveillance program for 1969 indicated that most of the radiation dose for the majority of the population in the Hanford vicinity was due to natural sources and world-wide fallout rather than to Hanford operations (BNWL-1505).

Analytical results were reported in table form in units of pCi/g, wet weight (BNWL-1505-APP).

The concentrations of fallout radionuclides found in the Hanford vicinity, principally H-3, Sr-90, and Cs-137, are below the national average due to the low rainfall in the region (BNWL-1505).

Concentrations of I-131 found in fresh leafy vegetables collected from local farms and markets during the period May through September were less than or approximately equal to the analytical limit of 0.05 pCi/g (BNWL-1505).

Analytical results from the special survey performed on November 24 between Route 11-A and the north boundary of the 200 East area indicated the presence of Cs-137 in vegetation samples collected from three locations near the north boundary (BNWL-CC-2583).

The maximum radionuclide concentrations found in locally grown fruits (BNWL-1505-APP):

(Concentrations in pCi/g)

Location	P-32	K-40	Zn-65	Cs-137/Sr-90	Zr/Nb-95	I-131	Ba-137m
Pasco/ Riverview (sample)	<1.0* [a] all	3.4 rhubarb	0.35 plums	<0.200 rhubarb	<0.03* all	<0.085 cantaloupe	<0.052 rhubarb
Ringold (sample)	<1.0* all	2.2 grapes	<0.1* all	<0.20 cherries	<0.03* all	<0.066 cherries	<0.03* all
Richland (sample)	<1.0* all	2.1 rhubarb	<0.1* rhubarb	0.026 rhubarb	<0.03* rhubarb	<0.05* rhubarb	<0.037 rhubarb

(a) * = analytical limit.

Maximum radionuclide concentrations found in leafy vegetables collected from the Pasco and Riverview vicinity (BNWL-1505-APP):

Radionuclide	pCi/g	Sample
P-32	<1.0* [a]	all
K-40	18.0	carrot tops
Zn-6	3.3	carrot tops
Sr-89	0.002*	cabbage
Sr-90	0.075	carrot tops
Zr/Nb-95	3.4	carrot tops
Ru/Rh-106	7.9	carrot tops
I-131	0.55	carrot tops
Cs-137/Ba-137m	0.22	carrot tops
Ce/Pr-144	1.2	carrot tops

(a) * = analytical limit.

Maximum radionuclide concentrations for vegetables (excluding leafy varieties) collected from the Pasco/Riverview Area (BNWL-1505-APP):

Radionuclide	pCi/g	Sample
P-32	<1.0* (a)	all
K-40	6.3	dill
Zn-6	0.39	onion tops
Sr-90	0.039	onions
Zr/Nb-95	0.37	beets
Ru/Rh-10	0.65	beets
I-131	0.19	onions
Cs-137/Ba-137m	0.094	onions
Ce/Pr-144	2.0	potatoes

(a) * = analytical limit.

Maximum radionuclide concentrations observed in hay/pasture grass samples (BNWL-1505-APP):

Radionuclide	pCi/g	Location Sampled
K-40	20.0	Pasco Farm #2, Mesa
Cr-51	<0.71	Benton City
Mn-54	<0.20	Pasco Farm #4
Sr-90	0.007	Riverview Farm #4
Zr/Nb-95	2.4	Pasco Farm #4
Ru/Rh-103	0.33	Pasco Farm #4
Ru/Rh-106	3.7	Pasco Farm #2
I-131	<0.63	Pasco Farm #4
Cs-137/Ba-137m	<0.5	Benton City
Ce-141	0.46	Pasco Farm #2
Ce/Pr-144	<9.0	Pasco Farm #4

Analytical results from a special vegetation survey conducted around the 200 East Area during the first half of 1969 indicated that the highest beta activity observed occurred in the eastern and northern portions of the area. The maximum concentration observed was 13 pCi/g, wet weight, from a sample obtained near well 699-42-42. The principal gamma emitters were Ce/Pr-144 and Cs-137/Ba-137m, with the latter having a concentration of 8.8 pCi/g. The average alpha activity observed on vegetation samples was 0.04 pCi/g, with a maximum activity of 0.09 pCi/g, observed from a sample collected near the 200 West Gate (BNWL-CC-2478).

Desert vegetation collected as part of a special radiological survey to determine the suitability of the southwest portion of Hanford to be used by the public, was analyzed for gamma emitters. The predominant gamma emitter observed was Cs-137/Ba-137m, with a maximum concentration of

2.0 pCi/g detected on a sample collected near the intersection of the Emergency Relocation Center Road and the boundary fence. Other radionuclides present in the area included Zr/Nb-95, Be-7, K-40, Sc-46, Mn-54, Ru-103, Ru/Rh-106, Sb-125, Ba/La-140, Ce/Pr-144, Ce-141, Eu-154, Eu-155, Tl-208, Bi-212, and Pb-212. Concentrations of Cs-137/Ba-137m observed in samples collected from Sections 8, 10, and 18 ranged from 0.3 to 1.7 pCi/g, while samples collected along Highway 240 ranged from 0.1 to 1.1 pCi/g. Comparison surveys indicated that vegetation samples collected from Finley, Benton City, Big Pasco Industrial Park, Island View, and Plymouth had similar radionuclides, but less activity. Cs-137/Ba-137m concentrations from these locations ranged from <0.05 to 0.7 pCi/g. The radioactivity levels observed were believed to be due to weapons testing fallout (BNWL-CC-2478).

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1970

Media Sampled

Hay and pasture grass samples were collected from several farms in the vicinity of the Hanford Project and surrounding communities. Analytical results were supplied by the US Testing Company, Inc., who performed all routine radioassays of environmental samples that were collected by Battelle Northwest employees. Radioisotopes analyzed included P-32, K-40, Zn-65, Zr/Nb-95, Ru-106, I-131, Cs-137/Ba-137m, and Ce/Pr-144 (BNWL-1669-ADD).

Locally grown fruits were collected from the Pasco/Riverview area, a farming region downriver from the Hanford reactors that utilizes Columbia River water for irrigation, as well as from the Benton City area. Composite fruit samples were analyzed for P-32, K-40, Zn-65, Sr-90, I-131, and Cs-137/Ba-137m (BNWL-1669, BNWL-1669-ADD).

Locally grown vegetables were collected and analyzed. Composites of leafy varieties were analyzed for P-32, K-40, Zn-65, Sr-89, Sr-90, Zr/Nb-95, Ru-106, I-131, Cs-137/Ba-137m, and Ce/Pr-144, while composites of non-leafy varieties were analyzed for P-32, K-40, Zn-65, Sr-90, Cs-137/Ba-137m, and Ce/Pr-144 (BNWL-1669, BNWL-1669-ADD).

Commercial vegetables and fruits were purchased from Tri-City stores. Composite samples of leafy vegetables were analyzed for P-32, K-40, Zn-65, Sr-89, Zr/Nb-95, Cs-137/Ba-137m, Sr-90, and Ce/Pr-144. Composite samples of non-leafy vegetables and fruits were analyzed for P-32, K-40, Zn-65, Sr-90, I-131, Zr/Nb-95, and Cs-137 (BNWL-1669, BNWL-1669-ADD).

A special survey was performed in July on vegetation growing at the water's edge of B Swamp and B Ditch. Samples were collected and analyzed for alpha emitters, Sr-90, Zn-65, Zr/Nb-95, Cs-137, and Ru-106 (BNWL-C-96).

Sampling Locations

Hay and pasture grass samples were collected from Riverview Farm #1 and Riverview Farm #3, two farms approximately 30 miles downriver of the Hanford reactors that utilize Columbia River water for irrigation, Benton City Farm #1, and Columbia Basin (BNWL-1669-ADD).

Locally grown fruits and vegetables were collected from the Pasco and Riverview area and Benton City (BNWL-1669-ADD).

Commercial fruit and vegetable samples were purchased from Tri-City stores (BNWL-1669).

Vegetation growing along the edge of B Swamp and B Ditch on the Hanford reservation was collected and analyzed for radioactivity (BNWL-C-96).

Significant Events/Emission Quantities

In February, 1970, the 100-KW Reactor was shut down, leaving the 100-KE, a single-pass reactor, and the 100-N Reactor, a recirculating coolant dual purpose reactor in operation (BNWL-1669, BNWL-C-96).

From February to April, and in September no reactors were operating (BNWL-1669).

Constituents Measured/Reported

Analytical results were reported in units of 10^{-6} μCi/g or pCi/g (BNWL-1669, BNWL-1669-ADD, BNWL-C-96).

Most of the environmental radiation dose for people in the Hanford vicinity was due to natural sources and world-wide fallout, rather than to Hanford operations (BNWL-1669).

Hanford's major contribution of radioactivity to the area was reactor cooling water discharged to the Columbia River (BNWL-1669).

Concentrations of H-3, Sr-90, and Cs-137 in the Hanford area were usually below the national average because of low rainfall (BNWL-1669).

All fruit and vegetable samples were collected during the growing season, May through September (BNWL-1669).

Analytical results from the special vegetation survey in July from samples collected from B Swamp and B Ditch (BNWL-C-96):

(Concentrations in pCi/g)

Location	Alpha	Sr-90	Zn-65	Zr/Nb-95	Cs-137	Ru-106
B Swamp	0.17	280	-	0.9	0.6	2.7
B-Ditch	0.08	52	0.2	0.5	1.4	1.8

Maximum radionuclide concentrations observed in hay and pasture grass samples (BNWL-1669-ADD):

Radionuclide	10^{-6} μCi/g	Location Sampled
P-32	1.4	Riverview Farm #3
K-40	23.0	Riverview Farm #1 & Benton City Farm #1
Zn-65	0.95	Riverview Farm #3
Zr/Nb-95	1.3	Riverview Farm #1
Ru-106	1.9	Riverview Farm #1
I-131	0.05	Riverview Farm #1
Cs-137/Ba-137m	0.24	Riverview Farm #1
Ce/Pr-144	1.8	Riverview Farm #1

Maximum and average radionuclide concentrations observed in composite samples of locally grown fruit samples (BNWL-1669-ADD):

(Concentrations in 10^{-6} μCi/g)

Radionuclide	Pasco & Riverview Area		Benton City	
	Max.	Avg.	Max.	Avg.
P-32	<1.0	0.04	-	-
K-40	3.2	2.4	2.3	2.0
Zn-65	0.14	0.09	<0.05	0.04
Sr-90	0.025	0.01	0.006	0.005
I-131	<0.05	-	-	-
Cs-137/Ba-137m	0.04	0.02	<0.02	0.004

Maximum and average radionuclide concentrations observed in composite samples of locally grown non-leafy vegetables (BNWL-1669-ADD):

(Concentrations in 10^{-6} μCi/g)

Radionuclide	Pasco & Riverview Area		Benton City	
	Max.	Avg.	Max.	Avg.
P-32	<1.0	0.06	-	-
K-40	2.6	1.9	2.6	2.2
Zn-65	0.21	0.09	0.1	0.07
Sr-90	0.065	0.02	0.68	0.35
Cs-137/Ba-137m	0.06	0.01	<0.02	0.01
Ce/Pr-144	<1.0	-	<1.0	-

Maximum and average radionuclide concentrations observed in composite samples of locally grown leafy vegetables (BNWL-1669-ADD):

(Concentrations in 10^{-6} μCi/g)

Radionuclide	Pasco & Riverview Area		Benton City	
	Max.	Avg.	Max.	Avg.
P-32	<1.0	0.28	-	-
K-40	5.6	4.0	4.7	4.4
Zn-65	0.60	0.32	0.2	0.13
Sr-89	0.004	0.004	-	-
Sr-90	0.06	0.05	0.03	0.02
Zr/Nb-95	0.71	0.16	0.16	0.15
Ru-106	0.89	0.22	-	-
I-131	0.41	0.06	-	-
Cs-137/Ba-137m	0.17	0.06	<0.08	0.04
Ce/Pr-144	1.3	0.41	<1.0	0.43

Maximum and average radionuclide concentrations observed in composite samples of locally purchased leafy vegetables (BNWL-1669-ADD):

(Concentrations in 10^{-6} μCi/g)

Radionuclide	Maximum	Average
P-32	<1.0	0.13
K-40	4.9	3.2
Zn-65	0.12	0.09
Sr-89	0.033	0.012
Sr-90	0.031	0.017
Zr/Nb-95	0.26	0.06
Cs-137/Ba-137m	<0.08	0.02
Ce/Pr-144	<1.0	-

Maximum and average radionuclide concentrations observed in composite samples of locally purchased fruits and vegetables (BNWL-1669-ADD):

(Concentrations in 10^{-6} μCi/g)

Radionuclide	Maximum	Average
P-32	< 1.0	0.03
K-40	2.6	2.1
Zn-65	0.12	0.09
Sr-90	0.008	0.006
Zr/Nb-95	-	-
I-131	-	-
Cs-137	0.04	0.02

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1971

Media Sampled

Routine vegetation sampling was performed at 23 stations in and around the Hanford reservation in 1971. Native perennial vegetation was collected by Battelle Northwest employees and radiochemical analyses were performed by the US Testing Company, Inc. Radioisotopes analyzed included plutonium, Sr-90, U, K-40, Zr/Nb-95, Ru-103, Ru-106, Cs-137, Ce-141, Ce/Pr-144, and Th-228/232. Gamma emitters were measured with the use of a sodium iodide crystal (BNWL-B-228).

During a routine Hanford road survey on February 3, vegetation contamination was noted in the 200 East Area. A thistle plant and a weed were found to contain radioactivity (BNWL-B-228).

Green leafy vegetables were collected from local farms and commercial stores as part of a special survey to determine radionuclide concentrations attributable to the Hanford environs. Radionuclides observed included naturally occurring K-40, as well as Sr-90 and Cs-137, which were contributed by world-wide fallout (PNL-2383).

Native perennial vegetation samples, primarily the growth from rabbitbrush plants, were collected from locations within the Hanford reservation and the surrounding vicinity as part of a six-year study. Samples were analyzed for plutonium nuclides using alpha spectroscopy, for uranium and Sr-90 by specific analysis, and for gamma emitting radionuclides using a lithium-drifted germanium detector. Data was presented in the form of log-normal probability plots, as well as a summary table with analyses results in units of pCi/g (dry weight). Radionuclides analyzed included Co-58, Co-60, Zn-65, Zr/Nb-95, Sr-90, Ru-106, I-131, Cs-137, Ba/La-140, Ce/Pr-144, Pu-238, and Pu-239/240 (BNWL-2249).

Locally grown and commercial produce was collected by Battelle Northwest employees and analyzed for radionuclide contamination by the US Testing Company, Inc. Plutonium analysis was performed using alpha spectroscopy. Samples being analyzed for Sr-90 and P-32 were ashed, radiochemically separated, and counted with a gas-flow beta proportional counter. Samples being examined for gamma emitters were analyzed using direct gamma counting utilizing a NaI well crystal. Radionuclides examined included P-32, Zn-65, Sr-90, Zr/Nb-95, Ru-106, I-131, Cs-137, and Ce/Pr-144 (BNWL-1683).

Leafy vegetables were obtained from Riverview farms in July, August, and September, and from local stores in May through October. Composite samples were analyzed for K-40, Zn-65, Sr-90, Zr/Nb-95, Ru/Rh-106, Cs-137/Ba-137m, I-131, and Ce/Pr-144 (BNWL-1683, BNWL-1683-ADD).

Hay samples were collected from West Richland and analyzed for Ru/Rh-106, Zn-65, Cs-137/Ba-137m, K-40, and Zr/Nb-95 (BNWL-1683-ADD).

Thirteen stations for routine vegetation sampling were established around the perimeter of Hanford reservation in 1971. Native perennial vegetation was sampled and analyzed for Co-58, Co-60, Zn-65, Sr-90, Zr/Nb-95, Ru-106, Cs-137, Ce/Pr-144, Pu-238, and Pu-239/240 (BNWL-1683, BNWL-1683-ADD).

Sampling Locations

Hay samples were collected from West Richland farm #1 (BNWL-1683-ADD).

Leafy vegetables and produce were sampled from local farms and area commercial stores. This included farms in the Riverview area, approximately 30 miles downriver from Hanford reactors, which utilized Columbia River water for irrigation (PNL-2383, BNWL-1683, BNWL-1683-ADD).

Routine vegetation sampling occurred at thirteen Hanford perimeter locations in 1971. These included Benton City, ERC, Rt 240-CP #54, Rattlesnake Springs, Yakima Barricade, Vernita Bridge-north end, Wahluke Slope #2, Berg Ranch, Ringold, Byer's Pumphouse, Byer's Landing, Riverview-CP #55, and North Richland-CP #56 (BNWL-1683, BNWL-B-228, BNWL-1683-ADD, BNWL-2249).

Routine on-site vegetation sampling occurred at FFTF-SA, 331 Bldg., West 100-N, 200 East Hill, 200 Fire Station, Rt.4-11A, Redox-P.S., Y Barricade, Hanford, and 100-F (BNWL-B-228). On-site locations sampled in 1971 as part of the six year study encompassing the years 1971-1976, included ALB Field Lab, FFTF CP #62, Wye Barricade, 200 West Area CP #60, 200 Area Fire Station, 200 East Hill CP #61, Hanford Townsite CP #57, Yakima Barricade, 200 Area CP #59, 100 F Area CP #58, and 331 Bldg CP #50 (BNWL-2249).

Activity was detected on a thistle collected near the south end of the SE perimeter fence of the 200 East Area, and a weed collected from the NE corner of the 200 East Area (BNWL-B-228).

Radioactivity that was attributable to Hanford operations included vegetation that was collected east of the California Nuclear burial site, northeast of the 1301-N trench, and Columbia River Island at river mile 340 (near North Richland) (BNWL-2249).

Significant Events/Emission Quantities

In January, 1971, the last single-pass production reactor, KE, was shut down, decreasing the amount of radioactivity released to the Hanford environment to "relative insignificance" (BNWL-1683, BNWL-B-228, BNWL-1701). The only remaining plutonium-producing reactor was the 100 N Reactor, which utilized recirculating demineralized water as a primary coolant (BNWL-1701, BNWL-B-228).

In June, 1971, 71 mCi of I-131 was released in one week from the 327 building (BNWL-1701).

Constituents Measured/Reported

Analytical results were presented in table form in units of 10^{-6} μCi/g or pCi/g (BNWL-2249, BNWL-1683, PNL-2383, BNWL-1683-ADD, BNWL-B-228). Results were also presented in the form of log-normal probability plots (BNWL-2249).

Concentrations of Sr-90 and Cs-137, which are attributable to nuclear fallout, are usually below the national average in the Hanford region, due to the low rainfall (BNWL-1683).

Concentrations of Zn-65, Ru/Rh-106, and Cs-137/Ba-137m observed in hay samples collected from West Richland farm #1 were less than the analytical limits of (0.03, 1.0, and 0.07) x 10^{-6} μCi/g, respectively. The concentration of K-40 observed was 22 x 10^{-6} μCi/g, and for Zr/Nb-95 was 0.37 x 10^{-6} μCi/g (BNWL-1683-ADD).

On the average, concentrations of Zn-65, which originate from reactor processes, were higher in farm products than in locally available commercial products. Concentrations of fallout radionuclides: Sr-90, Cs-137, Ce/Pr-144, Zr/Nb-95, and Ru-106, were higher in commercial foodstuffs (BNWL-1683).

Maximum radionuclide concentrations observed in leafy vegetable composite samples (BNWL-1683-ADD):

(Concentrations in units of 10^{-6} μCi/g)

Radionuclide	Riverview Farm	Commercial
K-40	3.0	4.7
Zn-65	<0.08*[a]	<0.08*
Sr-90	-[b]	0.04
Zr/Nb-95	0.13	0.24
Ru/Rh-106	<0.50*	3.3
I-131	-	0.2
Cs-137/Ba-137m	0.05	0.18
Ce/Pr-144	<0.50*	5.3

(a) * = analytical limit.
(b) - = not analyzed.

Radionuclide concentrations observed in vegetation samples collected from perimeter locations (BNWL-1683-ADD, p. 95, BNWL-1683, p. 40):

(Concentrations in pCi/g)

Location	Zr/Nb-95	Cs-137	Ru-106	Ce-141	Ce/Pr-144	Sr-90	Pu-238	Pu-239/240
Benton City	0.86	0.15	*[a]	*	1.4	0.07	*	*
ERC	1.0	0.21	*	*	2.7	0.14	*	0.002
Route 240	1.5	0.46	1.2	*	4.0	0.18	*	0.006
Rattlesnake Spr	2.2	0.72	*	*	5.9	0.23	*	0.005
Yakima Barr.	1.4	0.31	1.9	*	3.2	0.14	*	0.004
Vernita Bridge	1.6	0.39	*	*	3.7	0.20	*	0.002
WS #2	2.4	0.60	1.4	*	8.8	0.22	**0.004**	**0.010**
Berg Ranch	**2.7**	0.56	**2.7**	*	**11.0**	0.18	*	*
Ringold	0.81	0.15	*	**3.4**	1.8	0.04	*	0.006
Byer's Pump.	0.68	0.25	*	*	1.1	0.12	*	*
Byer's Landing	2.4	**0.82**	*	*	6.5	**0.78**	*	0.005
Riverview	0.73	0.25	*	*	4.0	0.14	*	*
North Richland	2.4	0.67	*	*	7.5	0.26	*	0.005
Average	1.6	0.43	0.95	*	4.7	0.21	*	0.004

(a) * = less than analytical limit.

Concentrations of Co-58, Co-60, and Zn-65 observed in native vegetation samples collected from perimeter locations were less than analytical limits (BNWL-1683, p. 40).

Maximum and average concentrations observed in local and commercial produce samples (BNWL-1683, p. 30):

Radionuclide	Local Produce		Commercial Produce	
	average	maximum	average	maximum
P-32	<1.0*[a]	<1.0*	<1.0*	<1.0*
Zn-65	0.014	0.023	<0.030*	<0.030*
Sr-90	<0.002	<0.002	0.008	0.039
Zr/Nb-95	0.021	0.13	0.046	0.242
Ru-106	<0.370*	<0.370*	0.82	3.3
I-131	<0.025*	<0.025*	<0.025	<0.025*
Cs-137	0.016	0.046	0.047	0.18
Ce/Pr-144	<0.350*	<0.350*	1.5	5.3

(a) * = analytical limit.

Green leafy vegetables were collected as part of a special five year study of radionuclide concentrations found in Hanford Area foodstuffs. Results from 1971 indicated that naturally occurring K-40 was found in the highest concentrations, averaging 2.6 and 2.9 pCi/g (wet weight), for samples from local farms and commercial stores, respectively. Maximum concentrations of K-40 observed were 3.0 and 4.7 pCi/g from local farms and commercial stores, respectively. Concentrations of Cs-137 averaged less than 0.1 pCi/g for all samples (PNL-2383).

Elevated Co-60 concentrations were observed in vegetation samples collected east of the California nuclear burial site, northeast of the 1301-N trench, and at Columbia River Island at river mile 340. This activity was attributable to Hanford operations (BNWL-2249).

The highest radioisotope concentrations observed in vegetation samples collected in 1971 as part of the six year radiochemical analysis study were K-40 isotopes. Radium isotopes were generally not detectible in vegetation samples (BNWL-2249).

The median concentrations of naturally occurring K-40 and uranium in vegetation were 11 and 0.03 pCi/g (dry weight), respectively (BNWL-2249).

During a routine Hanford road survey on February 3, 1971, contamination was detected near the south end of the SE perimeter fence of the 200-East Area. A thistle from the area gave a reading of 3000 cpm (GM). A weed from the northeast corner of the 200 East Area read 8000 cpm (GM) (BNWL-B-228).

The maximum radionuclide concentrations observed in native vegetation collected from perimeter and on-site locations (BNWL-B-228):

(Concentrations in units of 10^{-6} μCi/g)

Radionuclide	Perimeter	Location	On-Site	Location
Sr-90	0.783	Byer's Landing	0.726	Rt 4-11A
Pu	0.011	Wahluke #2	0.007	200-E Hill
Pu-238	0.004	ERC, Wahluke #2	0.005	FFTF-SA
U (μg/g)	0.30	Vernita	0.21	200-E Hill
K-40	8.37	Wahluke #2	7.46	Y-Barricade
Zr/Nb-95	2.68	Berg Ranch	17.9	200-E Hill
Ru-103	1.02	Ringold	-0.483	FFTF-SA
Ru-106	2.71	Berg Ranch	1.83	W.100-N
Cs-137	0.825	Byer's Landing	11.3	200-E Hill
Ce-141	4.17	North Richland	8.95	FFTF-SA
Ce/Pr-144	8.76	Wahluke #2	9.24	Y-Barricade
Th-228/232	0.375	North Richland	0.146	W. 100-N

Median concentrations of artificially created radionuclides in vegetation collected in the Hanford environs for the years 1971-1976 (BNWL-2249):

Radionuclide	pCi/g (dry weight)
Co-58	0.0001
Co-60	0.024
Zn-65	0.45
Sr-90	0.68
Zr/Nb-95	0.60
Ru-106	0.41
I-131	0.25
Cs-137	0.37
Ba/La-140	11.0
Ce/Pr-144	1.8
Pu-238	7.5×10^{-4}
Pu-239/240	1.7×10^{-3}

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Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1972

Media Sampled

Routine vegetation sampling was performed at 13 locations around the perimeter of Hanford reservation and ten sites within the reservation during 1972. Native perennial vegetation was collected by Battelle Northwest employees and radiochemical analyses were performed by US Testing Company, Inc, Richland. Radionuclides analyzed included K-40, Co-60, Zn-65, Sr-90, Ru-106, Zr/Nb-95, Cs-137, Ce/Pr-144, Pu-238, Pu-239, and U (μg/g). Gamma emitters were measured with the use of a NaI crystal (BNWL-B-278, BNWL-1727, BNWL-1727-ADD).

Green leafy vegetable samples such as spinach, leaf lettuce, turnip greens, and mustard greens were collected during the summer growing season from local farms and commercial stores. Composite samples were analyzed for K-40, Zn-65, Sr-89, Sr, Zr/Nb-95, Ru-106, I-131, Cs-137/Ba-137m, and Ce/Pr-144 (BNWL-1727-ADD, PNL-2383).

Native perennial vegetation samples, primarily the growth from rabbitbrush plants, were collected from twenty-three sites within the Hanford reservation and its perimeter as part of a special six-year radiochemical analysis survey. Samples were analyzed for plutonium nuclides using alpha spectroscopy, for uranium and Sr-90 by specific analysis, and for gamma-emitting radionuclides using a lithium-drifted germanium detector. Data was presented in the form of log-normal probability plots, as well as a summary table with analyses results in units of pCi/g (dry weight). Radionuclides analyzed included K-40, U, Mn-54, Co-58, Co-60, Zr/Nb-95, Zn-65, Sr-90, Ru-106, I-131, Cs-134, Cs-137, Ba/La-140, Ce-141, Ce/Pr-144, Ce-144, Pu-238, and Pu-239/240 (BNWL-2249).

A special survey of Wahluke Slope was conducted during September and October, 1972, to determine whether the area should be released for public use. Vegetation samples were collected and analyzed for K-40, Co-60, Sr-90, Ru-103, Zr/Nb-95, Ru-106, Cs-137, Ce/Pr-144, Pu-238, and Pu-239 (BNWL-B-237).

Sampling Locations

Vegetation was collected from thirteen Hanford perimeter sites. These included Benton City, ERC, Rt. 240-CP54, Rattlesnake Springs, Yakima Barricade, Vernita, Wahluke #2, Berg Ranch, Ringold, Byer's Pumphouse, Byer's Landing, Riverview, and North Richland (BNWL-B-278, BNWL-1727, BNWL-1727-ADD).

Ten on-site locations were utilized for vegetation sampling. These included West of 100-N, 331, FFTF, Wye Barricade, Hanford, 100-F, Rt. 4 x 11A, Redox P.S., 200 Fire Station, and 200 East Hill (BNWL-B-278).

Leafy vegetable samples were collected from Riverview farms in July, August, and September, and local commercial outlets in May through October (BNWL-1727-ADD, BNWL-1727, PNL-2383).

Thirty-eight vegetation sampling sites were established on Wahluke Slope during the fall of 1972. The entire slope was surveyed for radionuclide contamination, with the exception of a control zone within 5.5 miles of N Reactor. Sites were delineated by the numbers 1 through 38 and a map showing actual locations was provided (BNWL-B-237).

Vegetation sampled as part of a special 6-year survey of the Hanford environs was collected from Riverview, Benton City, North Richland CP #56, Byer's Pumphouse, Byer's Landing, ALB Field Lab, FFTF CP #62, Wye Barricade, Rattlesnake Springs, Rt. 240-CP #54, Ringold, 200 West Area-CP #60, 200 Area Fire Station, 200 East Hill-CP #61, Hanford Townsite CP #57, Yakima Barricade, 200 Area CP #59, 100F Area CP #58, Vernita Bridge, Wahluke Slope opposite 100-N, 331 Bldg.-CP #50, Berg Ranch, and Wahluke #2 (BNWL-2249).

Radioactivity attributable to Hanford operations included vegetation samples collected east of the California nuclear burial site, northeast of the 1301-N trench, and from Columbia River Island at river mile 340 (near North Richland) (BNWL-2249).

Significant Events/Emission Quantities

The N Reactor was the only production reactor remaining in operation in 1972. Only minor quantities of radioactivity were released to the Columbia River from this reactor, as it utilized recirculating demineralized water as the primary coolant (BNWL-1727).

Constituents Measured/Reported

Analytical results were presented in table form in units of 10^{-6} μCi/g or pCi/g (BNWL-1727, BNWL-1727-ADD, BNWL-B-237, BNWL-B-278, BNWL-2249, PNL-2383). Results were also presented in the form of log-normal probability plots (BNWL-2249).

Routine vegetation surveys yielded no geographical pattern, indicating that radionuclide concentrations detected were due to natural causes and regional fallout (BNWL-1727, BNWL-B-278).

Average radionuclide concentrations were higher in locally grown produce samples than in locally available commercial produce (BNWL-1727).

Analytical results comparing locally grown produce and commercially available produce collected in 1972 (BNWL-1727, p. 30):

(Concentrations in units of 10^{-6} μCi/g)

Radionuclide	Local		Commercial	
	average	maximum	average	maximum
Zn-65	<0.030	<0.030	<0.030	<0.030
Sr-90	0.03	0.03	0.009	0.010
Zr/Nb-95	0.095	0.14	0.034	0.12
Ru-106	<0.370	<0.370	0.38	1.0
I-131	<0.070	<0.070	<0.070	<0.070
Cs-137	0.043	0.090	<0.040	<0.040
Ce/Pr-144	<0.350	<0.350	<0.350	<0.350

Concentrations of radionuclides observed in locally available leafy vegetable composite samples (BNWL-1727-ADD, p. 60, PNL-2383, p. 16):

(Concentrations in units of 10^{-6} μCi/g, wet weight)

Radionuclide	Riverview Farm		Commercial	
	average	maximum	average	maximum
K-40	3.6	4.5	4.0	5.6
Zn-65	<0.08*[a]	<0.08*	<0.08*	<0.08*
Sr-89	-[b]	-	0.006	0.009
Sr-90	0.03	0.03	0.009	0.01
Zr/Nb-95	0.10	0.14	0.03	0.12
Ru-106	<0.80*	<0.80*	0.38	1.0
I-131	0.002	<0.070*	0.020	<0.070*
Cs-137/Ba-137m	0.04	0.0	0.03	<0.045*
Ce/Pr-144	0.03	<0.35*	0.08	<0.35*

(a) * = analytical limit.
(b) - = not analyzed.

Plutonium concentrations observed in vegetation obtained from perimeter sampling locations in 1972 were lower than those from the previous year. However, higher plutonium concentrations were found in samples collected near the 200 Areas. Concentrations of Zr/Nb-95 and Cs-137 were higher in vegetation samples from near the 200 Areas than those from perimeter sites (BNWL-B-278).

Analytical results from the Wahluke Slope radiation survey indicated that radionuclide concentrations were typical of regional fallout except along the Columbia River bank, where activity related to Hanford reactor cooling water was detected (BNWL-B-237, p. 3).

Concentrations of radionuclides observed from native vegetation samples collected from on-site and perimeter locations in 1972 (BNWL-B-278, BNWL-1727-ADD):

(Concentrations in units of 10^{-6} μCi/g)

Radionuclide	On-site			Perimeter		
	average	maximum	max. location	average	maximum	max. location
K-40	11.0	26.0	Redox P.S.	9.1	21.0	Byer's L.
Co-60	0.09	0.16	FFTF	0.02	0.09	Berg R.
Zn-65	0.89	5.5	Redox P.S.	-[a]	-	
Sr-90	0.10	0.34	Redox P.S.	0.13	0.85	Riverview
Zr/Nb-95	4.0	18.0	Redox P.S.	1.0	2.1	ERC
Ru-106	<0.4* [b]	7.2	100-F	3.5	5.7	Wahluke #2 & ERC
Cs-137	22.0	120.0	Redox P.S.	1.7	5.8	Vernita
Ce/Pr-144	<0.4*	0.88	331 & 100 F	0.31	4.4	ERC
Pu-238	0.001	0.005	Hanford	0.003	0.007	Byer's L.
Pu-239/240	0.004	0.008	200 E Hill	0.004	0.010	Rattlesnake Sprg & Byer's L.
Total U	0.07	0.22	331	0.06	0.23	Byer's P.H.

(a) - = not analyzed.
(b) * = analytical limit.

Radionuclide concentrations observed in vegetation samples collected on Wahluke Slope during September and October, 1972 (BNWL-B-237):

(Concentrations in units of 10^{-6} μCi/g)

Radionuclide	Average	Maximum
K-40	17.0	42.0
Co-60	-[a]	0.00
Sr-90	0.06	0.32
Zr/Nb-95	2.0	4.9
Ru-103	0.62	1.3
Ru-106	1.6	7.4
Cs-137	0.61	2.2
Ce/Pr-144	3.0	8.0
Pu-238	0.001	0.003
Pu-239	0.005	0.030

(a) - = less than analytical detection limit.

Elevated Co-60 concentrations were observed in vegetation samples collected east of the California nuclear burial site, northeast of the 1301-N trench, and at Columbia River Island at river mile 340. This activity was attributable to Hanford operations (BNWL-2249).

The median concentrations of artificially created radionuclides detected in vegetation samples collected in the Hanford environs for 1971-1976 (BNWL-2249):

Radionuclide	pCi/g (dry weight)
Mn-54	*(a)
Co-58	0.0001
Co-60	0.024
Zn-65	0.45
Sr-90	0.68
Zr/Nb-95	0.6
Ru-106	0.41
I-131	0.25
Cs-134	*
Cs-137	0.37
Ba/La-140	11.0
Ce-141	*
Ce/Pr-144	1.8
Ce-144	*
Pu-238	7.5×10^{-4}
Pu-239/240	1.7×10^{-3}

(a) * = less than the detectable limit.

References

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BNWL-1727-ADD. Bramson, P. E., and J. P. Corley. 1973. *Environmental Surveillance at Hanford for CY-1972, Data.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-B-237. Bramson, P. E., and J. P. Corley. 1972. *Radiation Survey of Wahluke Slope.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-B-278. Bramson, P. E., J. P. Corley, and W. L. Nees. 1973. *Environmental Status of the Hanford Reservation for CY-1972.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-2249. Miller, M. L., J. J. Fix, and P. E. Bramson. 1977. *Radiochemical Analyses of Soil and Vegetation Samples Taken From the Hanford Environs, 1971-1976.* Battelle Northwest Laboratory, Richland, Washington.

PNL-2383. Fix, J. J., S. C. Leete, and P. E. Bramson. 1977. *Radionuclide Concentrations in Selected Foodstuffs & Wildlife from the Hanford Environs, 1971-1975.* Pacific Northwest Laboratory, Richland, Washington.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1973

Media Sampled

Routine vegetation sampling was performed at 13 locations around the perimeter of Hanford reservation during 1973, as well as 10 sites within the reservation (BNWL-B-336, p. 50); BNWL-1811, p. 41). Native perennial vegetation was collected by Battelle Northwest employees and routine radiochemical analyses were performed by the US Testing Company, Inc., of Richland, Washington (BNWL-1811, p. D.1; BNWL-B-336, p. 1). Radionuclides analyzed included plutonium, Sr-90, U, K-40, Co-58, Co-60, Zn-65, Zr/Nb-95, Ru-106, Cs-137, Ba/La-140, and Ce/Pr-144 (BNWL-B-336, p. 50; BNWL-1811, p. 42). Gamma emitters were measured with the use of a sodium iodide crystal (BNWL-B-336, p. 47).

Green leafy vegetable samples such as spinach, leaf lettuce, turnip greens, and mustard greens were collected during the summer growing season, July, August, and September, from local farms, and from commercial stores during May through October (BNWL-1811, p. 35; PNL-2383, p. 15). Composite samples were analyzed for K-40, Co-60, Zn-65, Zr/Nb-95,Ru-106, I-131, Cs-137 Ba-137m, Ba/La-140, Ce/Pr-144, Sr-89, and Sr-90 (BNWL-1811 ADD, p.67).

Commercial and farm produce samples were analyzed for Zn-65, Zr/Nb-95, Ru-106, Cs-137, Ba/La-140, Ce/Pr-144, and Sr-90 (BNWL-1811, p. 32).

Native perennial vegetation samples, primarily the growth from rabbitbrush plants, were collected from twenty-three sites within the Hanford reservation and its perimeter as part of a special six-year radiochemical analysis survey. Samples were analyzed for plutonium nuclides using alpha spectroscopy, for uranium and Sr-90 by specific analysis, and for gamma-emitting radionuclides using a lithium-drifted germanium detector (BNWL-2249, p. 5). Radionuclides analyzed included K-40, U, Mn-54, Co-58, Co-60, Zr/Nb-95, Zn-65, Sr-90, Ru-106, I-131, Cs-134, Cs-137, Ba/La-140, Ce-141, Ce/Pr-144, Ce-144, Pu-238, and Pu-239,240 (BNWL-2249, p. 13).

Sampling Locations

Vegetation was collected from thirteen Hanford perimeter sites: Benton City, ERC, Rt. 240 CP54, Rattlesnake Springs, Yakima Barricade, Vernita, Wahluke #2, Berg Ranch, Ringold, Byer's Pumphouse, Byer's Landing, Riverview, and North Richland (BNWL-B-336, p. 50; BNWL-1811 ADD, p. 73, 74; BNWL-1811, p. A.6).

Ten on-site locations were utilized for routine vegetation sampling: West of 100-N, 331, FFTF, Wye Barricade, Hanford, 100-F, Rt. 4 and 11A, Redox P.S., 200 Fire Station, and 200-E Hill (BNWL-B-336, p. 50).

Leafy vegetable samples were collected from Riverview farms and local commercial outlets (BNWL-1811, p. 35; BNWL-1811 ADD, 67; PNL-2383, p.16).

Produce samples were collected from local farms and commercial stores (BNWL-1811, p. A.5).

Vegetation sampled as part of a special 6-year survey of the Hanford environs was collected from Riverview, Benton City, North Richland CP#56, Byer's pumphouse, Byer's Landing, ALE field lab, FFTF CP#62, Wye Barricade, Rattlesnake Springs, Rt. 240 CP#54, Ringold, 200 West Area CP#60, 200 Area Fire Station, 200 East Hill CP#61, Hanford Townsite CP#57, Yakima Barricade, 200 Area CP#59, 100F Area CP#58, Vernita Bridge, Wahluke Slope opposite 100N, 331 Building CP#50, Berg Ranch, and Wahluke #2 (BNWL-2249, p. 7).

Significant Events/Emission Quantities

The N Reactor was the only remaining plutonium production reactor in operation during 1973, utilizing recirculating water as the primary coolant (BNWL-B-336, p. 2).

During 1973, radioactive wastes were generated by the N Reactor, chemical processing plants, and laboratories. Controlled releases of low-level radioactive wastes were made to the ground, the atmosphere, and the Columbia River (BNWL-1811, p. 4).

Concentrations of I-131 in the atmosphere were below the detection limit of 7×10^{-14} μCi/ml for 1973 (BNWL-B-336, p. 32).

Constituents Measured/Reported

Analytical results were presented in table form in units of 10^{-6} μCi/g or pCi/g (BNWL-1811, p. 42; BNWL-1811 ADD, p. 67; BNWL-B-336, p. 50; BNWL-2249, p. 9, 13; PNL-2383, p. 16). Results were also presented in the form of log-normal probability plots (BNWL-2249, p. 8, 10, 12, B.2-B.8; PNL-2383, p. 17).

Individual results reported from routine vegetation surveys showed no particular geographical pattern. Concentrations measured were believed to be the result of natural causes and regional fallout (BNWL-B-336, p. 47).

In 1973, the average river radionuclide concentrations were less than 0.5% of the Concentration Guides for all identified radionuclides (BNWL-1811, p. 5).

With the exception of Sr-90, the average radionuclide concentrations for both commercial and farm produce samples were below analytical limits. The maximum concentration for Ru-106 was 1.4×10^{-6} μCi/g, from a farm produce sample. The maximum concentrations of Sr-90 were (0.004 and 0.009) x 10^{-6} μCi/g for farm and commercial produce samples, respectively (BNWL-1811, p. 32).

Concentrations of radionuclides observed in locally available leafy vegetable composite samples (BNWL-1811 ADD, p. 67):

(Concentrations in units of 10^{-6} μCi/g)

Radionuclide	Analytical Limit	Riverview Farm		Commercial	
		average	maximum	average	maximum
K-40	0.80	3.0	4.9	3.3	4.0
Co-60	0.055	(a) *0.002	*	*0.006	*
Zn-65	0.099	*	*	*0.017	*
Sr-89	0.002			*0.002	*
Sr-90	0.002	0.012	0.012	0.009	0.009
Zr/Nb-95	0.029	*0.0007	*	*0.002	*
Ru-106	0.80	*0.43	1.4	*0.137	*
I-131	0.078	*0.003	*	0.006	*
Cs-137/Ba-137m	0.05	*0.01	*	*	*
Ba/La-140	0.44	*0.10	*	*	*
Ce/Pr-144	0.44	*0.12	*	*	*

(a) * = is less than the analytical limit.

Concentrations of radionuclides observed in native vegetation samples collected from on-site and perimeter locations in 1973 (BNWL-B-336, p. 50; BNWL-1811 ADD, p. 73, 74):

(Concentrations in units of 10^{-6} μCi/g)

Radionuclide	On-site			Perimeter		
	average	maximum	max. location	average	maximum	max. location
K-40	11.0	17.0	331	13.0	20.0	Rattlesn. Spr
Co-60	<0.03	<0.03		<0.03	<0.03	
Zn-65	1.1	4.0	Redox P.S.	0.83	1.6	Rattlesn. Spr
Sr-90	0.08	0.28	200-E Hill	0.06	0.21	N. Richland
Zr/Nb-95	1.9	9.5	Redox P.S.	0.32	0.52	Wahluke #2
Ru-106	<0.4	<0.4		<0.4	<0.4	
Cs-137	5.0	27.0	Redox P.S.	0.49	1.9	Wahluke #2
Ba/La-140	18.0	47.0	Redox P.S.	18.0	27.0	Wahluke #2
Ce/Pr-144	<0.3	<0.3		<0.3	<0.3	
Pu-238	0.0007	<0.003		0.0009	0.004	Berg Ranch
Pu-239/240	0.003	0.01	Redox P.S.	0.002	0.006	Rt. 240 CP54
U	0.089	0.69	200-E Hill	0.04	0.11	Wahluke #2

Concentrations of Sr-90 found in green leafy vegetable samples were attributed to fallout (PNL-2383, p. 2).

The median concentrations of man-made radionuclides detected in vegetation samples collected in the Hanford environs for 1971-1976 (BNWL-2249, p. 13):

Radionuclide	pCi/g (dry weight)
Mn-54	* (a)
Co-58	0.0001
Co-60	0.024
Zn-65	0.45
Sr-90	0.68
Zr/Nb-95	0.6
Ru-106	0.41
I-131	0.25
Cs-134	*
Cs-137	0.37
Ba/La-140	11.0
Ce-141	*
Ce/Pr-144	1.8
Ce-144	*
Pu-238	7.5×10^{-4}
Pu-239,240	1.7×10^{-3}

(a) * = less than the detectable limit.

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BNWL-B-336. Nees, W. L., and J. P. Corley. 1975. *Environmental Status of the Hanford Reservation for CY-1973.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-1811. Nees, W. L., and J. P. Corley. 1974. *Environmental Surveillance at Hanford for CY-1973.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-1811 ADD. Nees, W. L., and J. P. Corley. 1974. *Environmental Surveillance at Hanford for CY-1973, Data.* Battelle Northwest Laboratory, Richland, Washington.

PNL-2383. Fix, J. J., S. C. Leete, and P. E. Bramson. 1977. *Radionuclide Concentrations in Selected Foodstuffs & Wildlife from the Hanford Environs, 1971-1975.* Pacific Northwest Laboratory, Richland, Washington.

BNWL-2249. Miller, M. L., J. J. Fix, and P. E. Bramson. 1977. *Radiochemical Analyses of Soil and Vegetation Samples Taken from the Hanford Environs, 1971-1976.* Battelle Northwest Laboratory, Richland, Washington.

Available documents reviewed in which no vegetation data were found: BNWL-B-336, BNWL-1811, BNWL-1811 ADD, PNL-2383, BNWL-2249, BNWL-SA-4614, BNWL-SA-4478, BNWL-2089, BNWL-2140, BNWL-B-303, BNWL-1860, BNWL-1738, BNWL-1794.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1974

Media Sampled

Routine vegetation sampling was performed at locations within the Hanford reservation and its perimeter. Native perennial plants, primarily the new growth from rabbit brush plants, was collected by Battelle-Northwest employees during the autumn of 1974 (BNWL-B-429, p. 35; BNWL-1910, p. 30; BNWL-1910 ADD, P. I-1). Radiochemical analyses were performed by the US Testing Company, Inc. Richland, Washington (BNWL-1910, p. A-1). Radionuclides analyzed included naturally occurring K-40, Ra-224, Ra-226, and total U, and artificially produced Co-58, Co-60, Zn-65, Sr-90, Zr/Nb-95, Ru/Rh-106, I-131, Cs-137, Ba/La-140, Ce/Pr-144, Pu-238, and Pu-239,240 (BNWL-1910, p.33; BNWL-1910 ADD, p. I-3; BNWL-B-429, p. 37). Samples were analyzed for gamma-emitting radionuclides using a lithium-drifted germanium detector, for plutonium isotopes using alpha spectroscopy, and for Sr-90 and U by specific analysis (BNWL-1910, p. 30; BNWL-B-429, p. 35; BNWL-1910 ADD, p.I-1).

Green leafy vegetable samples such as spinach, leaf lettuce, turnip greens, and mustard greens were collected during the summer growing season from local farms and commercial outlets (BNWL-1910, p.26, 27; BNWL-1910 ADD, p. G-1; PNL-2383, p. 15). Composite samples were analyzed for K-40, Mn-54, Co-60, Sr-90, Zr/Nb-95, and Ru-106 (BNWL-1910, p. 27; BNWL-1910 ADD, p. G-8; PNL-2383, p. 16).

Native perennial vegetation samples, primarily the growth from rabbitbrush plants, were collected from twenty-seven sites encompassing Hanford and its perimeter as part of a special six-year radiochemical analysis survey. Radionuclides analyzed included K-40, U, Mn-54, Co-58, Co-60, Zr/Nb-95, Zn-65, Sr-90, Ru-106, I-131, Cs-134, Cs-137, Ba/La-140, Ce-141, Ce/Pr-144, Ce-144, Pu-238, and Pu-239,240 (BNWL-2249, p. 9, 13).

During 1974, watercress samples were collected from two different spring locations and analyzed for Co-60, Zr-95, Mo-99, Ru-103, Ru-106, and I-131 (BNWL-B-429, p. 21).

Sampling Locations

Routine native vegetation samples were collected from on-site locations to include Prosser Barricade, ERC, Radioecology Field Lab, Yakima Barricade, 300 Area South Gate, Cp #40, CP #54, CP #60, CP #59, CP #58, Hanford shoreline, CP #61, 4S and Army Loop Road, and FFTF. Off-site locations included Benton City, Vernita, Wahluke Slope, Wahluke #2, Berg Ranch, Cooke Bros., Baxter Substation, Byer's Landing, Byer's Pumphouse, North Richland, Island #340, and Riverview (BNWL-B-429, p. 37; BNWL-1910, p. 33; BNWL-1910 ADD, p. I-3).

Leafy vegetable samples were collected from Riverview farms, Benton City, and commercial stores (BNWL-1910, p. 26, 27; BNWL-1910 ADD, p. G-8; PNL-2383, p. 15).

Watercress was collected from two spring locations along the 100N Riverbank (BNWL-B-429, p. 20, 21).

Vegetation sampled as part of a special 6-year survey of the Hanford environs was collected from Riverview, Benton City, Island 340, North Richland CP #56, Byer's Pumphouse, Byer's Landing, ALE Field Lab, Prosser Barricade, FFTF CP #62, Rattlesnake Springs, Route 240 CP #54, 4S Army Loop intersection, 200 West Area CP #60, 200 East Hill CP #61, Hanford Shoreline, Cooke Brothers, Yakima Barricade, 200 Area CP #59, 100F Area CP #58, Vernita Bridge, Wahluke Slope opposite 100N, 331 Bldg CP #50, Berg Ranch, Wahluke #2, Baxter Substation, 300 Area South Gate, Army Loop Road CP#40 (BNWL-2249, p. 7).

Significant Events/Emission Quantities

The N Reactor was the only production reactor remaining in operation in 1974, using a closed primary cooling loop (BNWL-1910, p. 1).

June 17, 1974, a nuclear detonation by the People's Republic of China resulted in a slight increase of radionuclides in the atmosphere (BNWL-1910, p. 13).

The majority of radioactivity measured in foodstuffs during 1974 was the result of naturally occurring K-40 and the fallout radionuclide Sr-90 (BNWL-1910, p. 8).

Constituents Measured/Reported

During 1974, elevated concentrations of Co-60 at Island 340, near North Richland, were attributed to Hanford operations (BNWL-2249, p. 9, 11).

Analytical results were reported in table form in units of 10^{-6} μCi/g or pCi/g (BNWL-B-429, p. 37; BNWL-1910, p. 27,33; BNWL-1910 ADD, p. G-8, I-3; PNL-2383, p. 16; BNWL-2249, p. 9, 13). Watercress samples were reported in units of pCi/l (BNWL-B-429, p. 21). Results were also presented in the form of log-normal probability plots (BNWL-2249, p. 8, 10, 12, B.2-B.8; BNWL-B-429, p. 39; PNL-2383, p. 17).

The median concentrations of naturally occurring K-40 and uranium observed in vegetation samples collected during the six-year radiochemical analysis survey were 11 and 0.03 pCi/g (dry weight), respectively (BNWL-2249, p. 9).

Concentrations of radionuclides observed in locally available leafy vegetable samples (BNWL-1910, p. 27; BNWL-1910 ADD, p. G-8; PNL-2383, p. 16):

(Concentrations in units of 10^{-6} μCi/g, wet weight)

Radionuclide	Riverview Farm			Benton City			Commercial		
	max.	min.	avg.	max.	min.	avg.	max.	min.	avg.
K-40	3.6	1.7	2.4±1.4	-[a]	-	7.9	5.2	1.4	2.1±1.8
Mn-54	<0.04*[b]	<0.04*	<0.04*	-	-	<0.04*	0.36	<0.04*	<0.07
Co-60	<0.05*	<0.05*	<0.05*	<0.05*	<0.05*	<0.05*	<0.05*	<0.05*	<0.01
Sr-90	0.016	0.011	0.014	-	-	-	0.01	0.00	0.010
Zr/Nb-95	0.11	<0.03*	<0.04	-	-	0.04	0.77	<0.03*	<0.18
Ru-106	0.96	<0.7*	<0.25	<0.7*	<0.7*	<0.7*	<0.7*	<0.7*	<0.7*

(a) - = not analyzed.
(b) * = detection limit.

Concentrations of radionuclides observed from native vegetation samples collected from on-site and perimeter locations in 1974 (BNWL-B-429, p. 37; BNWL-1910, p. 33; BNWL-1910 ADD, p. G-8):

(Concentrations in units of 10^{-6} μCi/g, dry weight)

Radionuclide	On-site			Perimeter		
	average	maximum	max. location	average	maximum	max. location
K-40	10±6.2	18	CP#59	11±8.1	20	Cooke Bros. U-total
	<0.04	0.21	300 Area south gate	<0.74	7.2	Byer's Ldg.
Co-58	*[a]	0.67	Yakima B.	*	*	all
Co-60	*	*	all	*	*	all
Zn-65	0.73± 0.64	1.4	CP#59	<0.8	1.8	Cooke Bros.
Sr-90	0.07± 0.13	0.17	300 Area south gate	0.07± 0.08	0.14	Baxter Substation
Zr/Nb-95	0.42± 0.75	1.4	4S & Army Loop Road	0.7±2 .2	4.0	Byer's Pumphouse
Ru/Rh-106	*	*	all	*	1.3	Island #340
I-131	*	*	all	*	*	all
Cs-137	0.23± 0.34	0.62	CP#59	0.17± 0.2	0.46	Byer's P.h.
Ba/La-140	12±6.7	17.0	CP#60	14±13	29.0	Cooke Bros.
Ce/Pr-144	<0.34	2.2	300 south gate	<0.38	2.3	Cooke Bros.
Pu-238	<0.0004	0.003	ERC	<0.0004	0.002	Island#340
Pu-239/240	<0.002	0.009	Hanford sh.	<0.003	0.02	Island#340

(a) * = less than detectable.

Concentrations of radionuclides observed in watercress samples collected from two spring locations along the 100 N Riverbank (BNWL-B-429, p. 20, 21):

(Concentrations in units of pCi/l)

Radionuclide	Sample #1	Sample #2
Co-60	8.3	4
Zr-95	5.4	0.04
Mo-99	57.2	* (a)
Ru-108	0.3	*
Ru-106	2.4	*
I-131	208.0	*

(a) * = less than detectable.

The median concentrations of man-made radionuclides detected in vegetation samples collected in the Hanford environs for 1971-1976 (BNWL-2249, p. 13):

Radionuclide	pCi/g(dry weight)
Mn-56	*
Co-58	0.0001
Co-60	0.024
Zn-65	0.45
Sr-90	0.68
Zr/Nb-95	0.6
Ru-106	0.41
I-131	0.25
Cs-134	*
Cs-137	0.37
Ba/La-140	11.0
Ce-141	*
Ce/Pr-144	1.8
Ce-144	*
Pu-238	7.5×10^{-4}
Pu-239,240	1.7×10^{-3}

(* = less than the detectable limit)

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BNWL-B-429. Fix, J. J. 1975. *Environmental Status of the Hanford Reservation for CY-1974.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-1910. Fix, J. J. 1975. *Environmental Surveillance at Hanford for CY-1974.* Battelle Northwest Laboratory, Richland, Washington.

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BNWL-2249. Miller, M. L., J. J. Fix, and P. E. Bramson. 1977. *Radiochemical Analyses of Soil and Vegetation Samples Taken from the Hanford Environs, 1971-1976.* Battelle Northwest Laboratory, Richland, Washington.

PNL-2383. Fix, J. J., S. C. Leete, and P. E. Bramson. 1977. *Radionuclide Concentrations in Selected Foodstuffs and Wildlife from the Hanford Environs, 1971-1975.* Pacific Northwest Laboratory, Richland, Washington.

Available documents reviewed in which no vegetation data were found: BNWL-B-429, BNWL-1910, BNWL-1910 ADD, BNWL-2249, PNL-2383, BNWL-2089, BNWL-2140, BNWL-1970, BNWL-1884.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1975

Media Sampled

Routine vegetation sampling was performed at locations within the Hanford reservation and its perimeter. Native perennial vegetation, primarily the new growth from rabbitbrush plants, was collected by Battelle Northwest employees. Routine radiochemical analyses were performed by the US Testing Company, Inc., Richland, Washington (BNWL-1979 (REV), p. B-1). Samples were analyzed for gamma-emitting radionuclides using a lithium-drifted germanium detector, for plutonium isotopes using alpha spectroscopy, and for Sr-90 and uranium by specific analysis (BNWL-B-477, p. 38; BNWL-1979(REV), p. 34). Radionuclides analyzed included naturally occurring K-40 and total U, and artificially produced Mn-54, Co-58, Co-60, Zn-65, Sr-90, Zr/Nb-95, Ru-106, Ru/Rh-106, I-131, Cs-134, Cs-137, Ce-141, Ce/Pr-144, Ce-144, Pu-238, and Pu-239,240 (BNWL-B-477, p. 41; BNWL-1979 (REV), p. 33).

Green leafy vegetables such as spinach, leaf lettuce, turnip greens, and mustard greens were collected during the summer growing season from local farms and commercial stores (BNWL-1979 (REV), p.27; PNL-2383, p. 15). Composite samples were analyzed for K-40, Sr-90, and Cs-137 (PNL-2383, p. 16; BNWL-1979(REV), p. 8, 27).

During 1975, watercress samples were collected and analyzed for K-40, Co-60, Zn-65, Zr/Nb-95, Ru-106, Sb-125, I-131, Cs-137, and Ce/Pr-144 (BNWL-B-477, p.23).

Native perennial vegetation samples, primarily the growth from rabbitbrush plants, were collected from twenty sites encompassing Hanford and its perimeter as part of a special six-year radiochemical analysis survey. Radionuclides analyzed included K-40, Ra-224, Ra-226, U, Mn-54, Co-58, Co-60, Zn-65, Sr-90, Zr/Nb-95, Ru-106, I-131, Cs-134, Cs-137, Ba/La-140, Ce-141, Ce/Pr-144, Ce-144, Pu-238, and Pu-239,240 (BNWL-2249, p. 13).

A special study was performed to determine the radioactivity associated with the plants and soils of the 216-A-24 Crib. Plant cover on the crib was dominated by rabbitbrush and cheatgrass, as well as sagebrush and numerous herbs (PNL-1948, p. 5). The predominant radionuclide present in the vegetation samples was Cs-137, although Sr-90, Ru-106 and Co-60 were also present (PNL-1948, p. 1). Samples of a contaminated rabbitbrush plant were separated into parts (leaves, twigs, bark, upper wood, and lower wood) and analyzed for Cs-137 (PNL-1948, p. 17).

Sampling Locations

Routine vegetation samples were collected from on-site locations to include 100-N, 100-F (CP#58), CP#59, CP#57, CP#60, CP#2, CP#61, CP#42, 4S and Army Loop Road, FFTF (2 locations), CP#50, (BNWL-B-477, p. 41), Yakima Barricade, Exxon, Prosser Barricade, ALE Field Lab,

and 300 Area (BNWL-B-477, p.41; BNWL-1979 (REV) p. 33). Off-site locations included Wahluke #2, Berg Ranch, and Ringold (BNWL-1979 (REV), p.33; BNWL-B-477, p. 41).

Leafy vegetable samples were collected from Riverview farms, Benton City, and commercial stores (BNWL-1979 (REV), p. 27; PNL-2383, p. 15).

Watercress samples were collected from 100-N Riverbank Spring (BNWL-B-477, p. 23).

Vegetation sampled as part of a special 6-year survey of the Hanford environs was collected from the northeast corner of the Exxon Site, ALE Field Lab, Prosser Barricade, 1/2 mile northeast of the FFTF Site, the southwest side of the FFTF Site, 4S Army Loop Intersection, Ringold, 200-W Area CP#60, east side of the California Nuclear burial ground, 200 East Hill CP#61, Hanford Townsite CP#57, Hanford Shoreline, Yakima Barricade, 200 West Area CP#2, 200 Area CP#59, 100-F Area CP#58, northeast corner of 100-N, 331 Building CP#50, Berg Ranch, and Wahluke #2 (BNWL-2249, p.7).

Contaminated rabbitbrush was collected from the 216-A-24 crib area, as plants growing on the crib were found to emit amounts of radioactivity significantly higher than background (PNL-1948, p. 3).

Significant Events/Emission Quantities

The N Reactor, which used a closed primary cooling loop, was the only production reactor remaining in operation in 1975 (BNWL-1979 (REV), p. 1).

Radioactivity attributable to Hanford operations during 1975 was found east and directly across the road from the 200 West Area, where elevated levels of Pu-239,240 were detected. Elevated uranium levels were found in samples directly north of the 300 Area (near the railroad tracks) (BNWL-B-477, p. 38). Elevated levels of Mn-54, Co-60, Zr/Nb-95, and Ce-144 were found in vegetation samples collected directly south of the 1301-N trench, and elevated Co-60 levels were detected in samples directly east of the Nuclear Engineering Disposal Site (BNWL-B-477, p. 42).

During 1975, elevated Co-60 values were detected northeast of the 1301-N trench (3.4 pCi/g) and the east side of the California Nuclear Burial ground (2.1 pCi/g) (BNWL-2249, p. 12). Elevated Mn-54 and Cs-134 values were also found northeast of the 1301-N trench (BNWL-2249, p.9). These increased activities were attributed to Hanford operations (BNWL-2249, p. 9).

Levels of radioactivity in the atmosphere and the Columbia River during 1975 were attributed to natural sources and fallout, rather than to Hanford operations (BNWL-1979 (REV), p.7).

The majority of radioactivity measured in foodstuffs during 1975 was due to K-40, which occurs naturally, and the fallout radionuclides Sr-90 and Cs-137 (BNWL-1979 (REV), p.8).

Constituents Measured/Reported

Analytical results were reported in table form in units of 10^{-6} μCi/g or pCi/g (BNWL-B-477, p. 23, 41; PNL-2383, p. 16; BNWL-1979 (REV), p. 27. 33; BNWL-2249, p. 9,13). Results were also presented in the form of log-normal probability plots (BNWL-2249, p. 8, 10, 12, B.2-B.8; PNL-2383, p. 17; BNWL-B-477, p. 42) and in units of nCi/g (PNL-1948, p. 18).

The median concentrations of naturally occurring K-40 and uranium observed in vegetation samples collected during the six-year radiochemical analysis survey were 11 and 0.03 pCi/g (dry weight), respectively. Samples examined for naturally occurring Ra-224 and Ra-226 yielded results that were less than detectable (BNWL-2249, p. 9).

Maximum concentrations of radionuclides observed in watercress samples collected from 100-N riverbank during 1975 (BNWL-B-477, p. 23):

Radionuclide	Maximum Concentration, pCi/g (dry weight)
K-40	20
Co-60	9
Zn-65	13
Zr/Nb-95	7.7
Ru-106	51
Sb-125	68
I-131	226
Cs-137	0.8
Ce/Pr-144	59

Concentrations of radionuclides observed in locally available leafy vegetable samples (BNWL-1979 (REV), p. 27; PNL-2383, p. 16):

(Concentrations in units of 10^{-6} μCi/g, wet weight)

Radionuclide	Riverview Farm			Benton City			Commercial		
	max.	min.	avg.	max.	min.	avg.	max.	min.	avg.
K-40	3.3	2.1	2.6±1.0	1.4	1.4	1.4	5.1	2.1	3.3±2.7
Sr-90	0.06	0.02	0.04	0.02	0.02	0.02	0.03	0.004	0.02
Cs-137	<0.1*(a)	<0.1*	<0.1*	<0.1*	<0.1*	<0.1*	<0.1*	<0.1*	<0.1*

(a) * = detection level.

The median concentrations of man-made radionuclides detected in vegetation samples collected in the Hanford environs for 1971-1976 (BNWL-2249, p. 13):

Radionuclide	pCi/g (dry weight)
Mn-56	* (a)
Co-58	0.0001
Co-60	0.024
Zn-65	0.45
Sr-90	0.68
Zr/Nb-95	0.6
Ru-106	0.41
I-131	0.25
Cs-134	*
Cs-137	0.37
Ba/La-140	11.0
Ce-141	*
Ce/Pr-144	1.8
Ce-144	*
Pu-238	7.5×10^{-4}
Pu-239,240	1.7×10^{-3}

(a) * = less than the detectable limit.

Concentrations of radionuclides observed from native vegetation samples collected from on-site and off-site locations during 1975 (BNWL-B-477, p. 41):

(Concentrations in units of 10^{-6} μCi/g, dry weight)

Radionuclide	On-site			Off-site		
	average	maximum	maximum location	average	maximum	maximum location
K-40	20±14	45±5	CP#57	15	16±3	Ringold
total U	<0.05	<0.07	Yakima Barr.,	<0.03	0.04±0.03	Wahluke #2 Exxon
Mn-54	<0.2	1.1±0.2	100-N	<0.2	<0.5	Wahluke #2
Co-58	<0.1	<0.3	CP#50	<0.1	<0.1	all
Co-60	<0.4	3.4±0.4	100-N	<0.5	<0.2	Ringold
Zn-65	<0.2	<0.5	CP#2, CP#50	<0.1	<0.2	Ringold
Sr-90	0.08±0.12	0.48±0.04	CP#50	0.02	0.02±0.007	Ringold
Zr/Nb-95	<0.6	1.5±0.6	100-N	<0.03	<0.4	Ringold
Ru-106	<0.6	<2.0	CP#50	<0.4	<0.6	Ringold
I-131	<3.9	<7.5	CP#50	<1.3	<2.0	Ringold
Cs-134	<0.1	<0.2	CP#2, CP#50	<0.06	<0.08	Ringold
Cs-137	<0.2	0.4±0.1	4S & Army Lp Rd	<0.08	0.1±0.1	Berg Ranch
Ce-144	<0.7	<2.6	CP#50	<0.4	<0.5	
Pu-238	<0.003	0.006±0.003	FFTF	<0.004	<0.005	Ringold
Pu-239,240	<0.003	0.012±0.001	CP#2	<0.002	<0.002	all

Concentrations of Cs-137 observed in samples of a contaminated rabbitbrush plant from the 216-A-24 Crib (PNL-1948, p. 18):

(Concentrations in units of nCi/g, dry weight)

	Branch 1	Branch 2
Shoots		
Leaves	220	280
Twigs	63	58
Bark	54	73
Wood (Upper)	17	19
Wood (Lower)	25	33
Roots		
Bark	.5	1.6
Wood	39	8.5

The leaves of the rabbitbrush plant growing on the 216-A-24 Crib contained higher concentrations of Cs-137 than other plant parts, with concentrations averaging 145 nCi/g dry weight. Average Sr-90 concentration was 0.316 nCi/g dry weight (PNL-1948, p. 23).

Maximum, minimum, and average concentrations of radionuclides observed from native vegetation samples collected from eight perimeter locations during 1975 (BNWL-1979 (REV), p. 33):

(Concentrations in units of 10^{-6} μCi/g, dry weight)

Radionuclide	Maximum	Location	Minimum	Location	Average (± 2 sample dev.)
K-40	40	300 Area-331	4.3	ALE field lab	15±22
U-total	0.04	Exxon, Wahluke#2	<0.03*(a)		0.02
Mn-54	<0.09*		<0.09*		<0.09*
Co-58	<0.10*		<0.10*		<0.10*
Co-60	0.11	Ringold	<0.10*		0.04
Zn-65	<0.2*		<0.2*		<0.2*
Sr-90	0.48	300 Area-331	0.01	Berg Ranch	0.13±0.33
Zr/Nb-95	<0.4		<0.4*		<0.4*
Ru/Rh-106	<0.6*		<0.6*		<0.6*
I-131	<2.4*		<2.4*		<2.4*
Cs-134	<0.08*		<0.08*		<0.08*
Cs-137	0.17	Yakima Barr.	<0.09*		0.10
Ce-141	0.25	Exxon	<0.21*		<0.21*
Ce/Pr-144	1.3	300 Area-331	<0.47*		0.54
Pu-238	<0.003*		<0.003*		<0.003*
Pu-239,240	0.002	Exxon, Prosser Barr., Yakima Barr., ALE	<0.001*		0.002

(a) * = analytical limit.

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PNL-2383. Fix, J. J., S. C. Leete, and P. E. Bramson. 1977. *Radionuclide Concentrations in Selected Foodstuffs and Wildlife from the Hanford Environs, 1971-1975.* Pacific Northwest Laboratory, Richland, Washington.

BNWL-1979 (REV). Speer, D. R., J. J. Fix, and P. J. Blumer. 1976. *Environmental Surveillance at Hanford for CY-1975.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-2249. Miller, M. L., J. J. Fix, and P. E. Bramson. 1977. *Radiochemical Analyses of Soil and Vegetation Samples taken from the Hanford Environs 1971-1976.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-B-477. Fix, J. J., D. R. Speer, and P. J. Blumer. 1976. *Environmental Status of the Hanford Site for CY-1975.* Battelle Northwest Laboratory, Richland, Washington.

PNL-1948. Klepper, E. L., L. E. Rogers, J. D. Hedlund, and R. G. Schreckhise. 1979. *Radioactivity Associated with Biota and Soils of the 216-A-24 Crib.* Pacific Northwest Laboratory, Richland, Washington.

Available documents reviewed in which no vegetation data were found: PNL-2383, BNWL-2249, BNWL-B-477, PNL-1948, BNWL-1979 (REV), BNWL-1885, BNWL-SA-5484, BNWL-2034, BNWL-2140, BNWL-2089, BNWL-SA-5343, BNWL-SA-5451.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1976

Media Sampled

Routine vegetation sampling was performed at locations within the Hanford reservation and its perimeter. Native perennial vegetation, primarily the growth from rabbit brush plants, was collected and analyzed for gamma emitters using a lithium-drifted germanium detector, for plutonium using alpha spectroscopy, and for Sr-90 and uranium by specific analysis (BNWL-2142 ADD, p. X-1; BNWl-2142, p. 17; BNWL-2246, p. 28). Radionuclides analyzed included naturally occurring K-40, Ra-224, Ra-226, and total U, and artificially produced Co-60, Zn-65, Sr-90, Zr/Nb-95, Ru-106, I-131, Cs-137, Ba/La-140, Ce-141, Ce-144, Pu-238, and Pu-239,240 (BNWL-2246, p. 31; BNWL-2142, p. 18; BNWL-2142 ADD, p. X-6, X-7).

Green leafy vegetables such as spinach, leaf lettuce, turnip greens, and mustard greens were collected during the growing season from local farms and commercial stores. Composite samples were analyzed by gamma spectroscopy and specific analysis (BNWL-2142, p. 12, 14). Radioisotopes analyzed included K-40, Co-60, Zn-65, Sr-90, I-131, and Cs-137 (BNWL-2142 ADD, p. VIII-10; BNWL-2142, p. 14).

Native perennial vegetation samples, primarily the growth from rabbit brush plants, were collected from twenty sites encompassing Hanford and its perimeter as part of a special six-year radiochemical analysis survey. Radionuclides analyzed included K-40, Ra-224, Ra-226, U, Mn-54, Co-58, Co-60, Zn-65, Sr-90, Zr/Nb-95, Ru-106, I-131, Cs-134, Cs-137, Ba/La-140, Ce-141, Ce/Pr-144, Ce-144, Pu-238, and Pu-239,240 (BNWL-2249, p. 5, 9, 13).

Vegetation contamination was observed in 45 of 241 radiation zones within the Hanford perimeter during an inspection in 1976. Several of the zones were located in the vicinity of active discharge sites. Contamination was reported as major or minor (ARH-LD-154, p. 81-90).

Vegetation was collected from three controlled plots in the 200 Area outside of the 200 Area security fence. Flora collected included shrubs and herbs, deep and shallow rooted plants, and annuals and perennials. Plants included cheatgrass, mustard, scurf pea, Russian thistle, desert parsley, big sagebrush, hopsage, green rabbitbrush, Sandbur-tomato leaf plant, balsam root, gray rabbitbrush, Sandburg bluegrass, Caested (sic) wheatgrass, and composite samples. Specimens were analyzed for beta emitters, Cs-137, and K-40 (ARH-LD-154, p. 99, 100).

Sampling Locations

Native perennial vegetation samples were collected from locations to include Yakima Barricade, Wahluke Slope #2, Berg Ranch, Ringold, Byer's Landing, Hanford CP#57, 100-F Area CP#58, 200-E Hill CP#61, 4S-Army Loop Intersection, East of 200-W CP#2, east of ALE field lab, northeast corner of Exxon site, east of California nuclear burial ground, 1/2 mile northeast of FFTF, 1 mile

southeast of 1-N Trench, Gable Pond CP#43, 1 mile north of the 300 Area, 1 mile south of the 300 Area, 1 mile north of WPPSS #2 fence, 1 mile south of WPPSS #2 fence, Horn Rapids Road, southeast of old Hanford townsite, and east of the 300 Area (BNWL-2246, 29-31; BNWL-2142, p. 18; BNWL-2142 ADD, p. X-6, X-7).

Leafy vegetable samples were collected from Riverview farms, Benton City, and commercial outlets (BNWL-2142, p. 14; BNWL-2142 ADD, p. VIII-10).

Vegetation sampled as part of the special six-year survey of the Hanford environs was collected from the northeast corner of Exxon site, 1 mile south of the 300 Area, Byer's landing, 1 mile north of the 300 Area, ALE field lab,1/2 mile northeast of FFTF site, 1 mile south of WPPSS 32, 4S-Army Loop intersection, 1 mile north of WPPSS #2, Ringold, east side of California nuclear burial ground, 200 East hill CP#61, Hanford townsite CP#57, Yakima Barricade, 200 West Area CP#2, Gable Pond CP#43, 100-F Area CP#58, 1 mile southeast of 100-N trench, Berg Ranch, and Wahluke #2 (BNWL-2249, p. 7).

Radiation zones where contaminated vegetation was present included 216-A-1, 216-A-8, 216-A-24, 216-A-25, 216-A-29, 216-B-2, 216-B-2-1, 215-B-2-2, 216-B-3, 216-B-14-19, 216-B-20-22, 216-B-35-42, 218-E-2, 218-E-4, 218-E-5, 218-E-9, 218-E-10, 216-C-1, 216-C-2, 216-C-4, 216-C-5, 216-C-6, 216-C-10, 216-S-1, 216-S-2, 216-S-6, 216-S-7, 216-S-10, 216-S-17, 216-S-20, 207-S, 216-T-3, 216-T-14, 216-T-15, 216-T-16, 216-T-17, 216-T-21, 216-T-22, 216-T-23, 216-T-24, 216-T-25, 216-T-30, and UN-216-W-5 (ARH-LD-154, p. 82-90).

Vegetation was collected from three controlled plots in the 200 Area - B-C Crib controlled area, Control Plot #1 (southwest of Redox Pond #4), and Control Area #2 (west of the northwest corner of the 200 West Area, near Army Loop Road) (ARH-LD-154, p. 99).

Vegetation was collected from five stations (designated 54 through 58) from inside the 200 Area Security fence. Station 54 was in the 200 West Area, at the northeast corner of Beloit and 23rd Streets. Station 55 and Station 56 were both located in the 200 West Area, the former being about 80 yards west of pole #746 on Camden Avenue, and the latter southeast of the Redox Stack-55 feet. Station 57 was located in the 200 East Area southeast of the Purex Stack, 100 yards west of pole #447 on Canton Avenue and Station 58, also in the 200 East Area, was east of 291-B stack and northwest of pole #30 (ARH-LD-154, p. 101).

Significant Events/Emission Quantities

The N Reactor, which used a closed primary cooling loop, was the only production reactor remaining in operation in 1976 (BNWL-2142, p. 1). Low-level releases from this reactor contributed to elevated downstream concentrations of Co-60 throughout the year (BNWL-2246, p. vi).

Spill cooler failures on March 25 and November 20 resulted in elevated releases of radionuclides to the Columbia River from the N Reactor (BNWL-2142, p. 7; BNWL-2246, p. vi).

On September 26, 1976, the People's Republic of China tested a low-yield nuclear device reported to be 20-200 kilotons. Fallout debris, first detected in Richland, Washington, moved across the United States, depositing significant radioactive debris along the eastern seaboard, due to heavy precipitation (BNWL-2164, p. 1). Maximum atmospheric radionuclide concentrations were observed following this detonation (BNWL-2142, p. 3; BNWL-2246, p. 5).

On January 23, 1976, the Chinese carried out a smaller nuclear test that produced radioactive levels about 100-fold lower than the test in September (BNWL-2164, p. 2).

There was "no conclusive impact from Hanford operations" on vegetation samples collected during 1976 (BNWL-2246, p. vii).

Radionuclides observed in all foodstuff, wildlife, and soil samples for 1976 were attributed to fallout or natural causes (BNWL-2142, p. 3).

Constituents Measured/Reported

Analytical results were reported in table form in units of 10^{-6} μCi/g or pCi/g (BNWL-2142 ADD, p. VIII-10, X-6, X-7; BNWL-2246, p. 31; BNWL-2142, p. 14, 18; BNWL-2249, p. 9, 13; ARH-LD-154, p. 100, 102). Results were also presented in the form of log-normal probability plots (BNWL-2246, p. 32, 33; BNWL-2249, p. 8, 10, 12, B.2-B.8).

The highest concentrations of radionuclides observed in leafy vegetable samples were from K-40. Strontium-90 concentrations were attributed to world-wide fallout and I-131 concentrations were less than detection limits (BNWL-2142, p. 14).

Elevated concentrations of Co-60 attributable to Hanford operations during 1976 were found at the east side of the California nuclear burial grounds (2.1 pCi/g) and near Gable Mountain Pond (0.9 pCi/g) (BNWL-2249, p. 12).

The median concentrations of naturally occurring K-40 and uranium observed in vegetation samples collected during the six-year radiochemical analysis survey were 11 and 0.03 pCi/g (dry weight), respectively. Samples examined for naturally occurring Ra-224 and Ra-226 yielded results that were less than detectable (BNWL-2249, p.9).

Maximum radionuclide concentrations observed in locally purchased leafy vegetable samples for 1976 (BNWL-2142 ADD, p. VIII-10; BNWL-2142, p. 14):

(Concentrations in units of 10^{-6} μCi/g, wet weight)

Radionuclide	Riverview Farm	Benton City Farm	Commercial
K-40	7.5 ± 2.9	3.3 ± 1.2	3.9 ± 1.1
Co-60	0.14 ± 0.15	-(a)	0.06 ± 0.12
Zn-65	0.03 ± 0.25	0.02 ± 0.14	0.05 ± 0.21
Sr-90	0.07 ± 0.008	0.01 ± 0.002	0.007 ± 0.002
I-131	0.01 ± 0.13	-	0.01 ± 0.19
Cs-137	0.01 ± 0.18	0.002 ± 0.07	0.01 ± 0.11

(a) - = not analyzed.

The median concentrations of man-made radionuclides detected in vegetation samples collected in the Hanford environs for 1971-1976 (BNWL-2249, p. 13):

Radionuclide	pCi/g (dry weight)
Mn-56	* (a)
Co-58	0.0001
Co-60	0.024
Zn-65	0.45
Sr-90	0.68
Zr/Nb-95	0.6
Ru-106	0.41
I-131	0.25
Cs-134	*
Cs-137	0.37
Ba/La-140	11.0
Ce-141	*
Ce/Pr-144	1.8
Ce-144	*
Pu-288	$.5 \times 10^{-4}$
Pu-289,240	1.7×10^{-3}

(a) * = less than the detectable limit.

Major contamination was observed in the following radiation zones during 1976 (ARH-LD-154, p. 82-88):

216-A-1	218-E-4	216-C-6	216-T-14	216-T-24
216-A-8 [a]	218-E-5	216-C-10	216-T-15	216-T-25
216-A-24[a]	218-E-9	216-S-1	216-T-16	
216-B-2-2	216-C-1	216-S-2	216-T-17	
216-B-20-22	216-C-2[a]	216-S-17	216-T-21	
216-B-35-42	216-C-4	207-S	216-T-22	
218-E-2	216-C-5	216-T-3	216-T-23	

(a) In vicinity of active discharge site.

Minor contamination was observed in the following radiation zones during 1976 (ARH-LD-154, p. 82-90):

216-A-25[a]	216-B-2-1	218-E-10[a]	216-S-20
216-A-29[a]	216-B-3	216-S-6	216-T-30
218-E-1	216-B-3[a]	216-S-7	UN-216-W-5
216-B-2[a]	216-B-14-19	216-S-10	

(a) In vicinity of active discharge site.

Maximum radioisotope concentrations observed in plants collected outside the 200 Area Security fence (ARH-LD-154, p. 100):

(Concentrations in units of pCi/g, dry weight)

Radioisotope	B-C Crib		Control Plot #1		Control Plot #2	
	max.	plant	max.	plant	max.	plant
Beta	67,000	cheatgrass	432	desert parsley	962	S. bluegrass
Cs-137	23,000	cheatgrass	345	S. bluegrass	379	S. bluegrass
K-40	15.5	S.tomato leaf	12.5	big sagebrush	28	composite

Concentrations of radionuclides observed in native perennial vegetation samples collected in the Hanford vicinity during 1976 (BNWL-2246, p. 31; BNWL-2142 ADD, p. X-6, X-7):

(Concentrations in units of pCi/g, dry weight)

Radionuclide	Maximum	Max. location	Minimum	Average
K-40	65	1 Mi SE of 100-N trench	8.9	18
U-total	0.04	NE corner Exxon site	<0.03*[a]	<0.03*
Co-60	0.90	Gable Pond CP#43	<0.1*	<0.15
Sr-90	0.13	Wahluke Slope #2 & 200E Hill CP#61	0.01	0.04
Zr/Nb-95	0.14	Gable Pond CP#43	<0.1*	<0.1*
Ru-106	0.17	1 Mi N WPPSS#2 fence	<0.5*	<0.5*
I-131	0.15	Gable Pond CP#43	<0.2*	<0.2*
Cs-137	0.56	East of 200-W CP#2	<0.1*	<0.13
Ba/La-140	0.13	Gable Pond CP#43	<0.3*	<0.3*
Ce-141	0.16	Gable Pond CP#43	<0.1*	<0.1*
Ce-144	1.0	1 Mi. South of 300 Area	<0.4*	<0.43
Pu-288	0.002	East of ALE field lab	<0.003*	<0.003*
Pu-289,240	0.006	East of ALE field lab	<0.001*	0.002

(a) * = detection level.

Concentrations observed in vegetation samples collected inside the 200 Area security fence (ARH-LD-154, p. 102):

(Concentrations in units of pCi/g, dry weight)

Station #	Beta	Cs-137	K-40
54	190	3.48	ND[a]
55	<75	22.5	11.5
56	99	21.6	115.0
57	177	10.6	10.6
58	228	36.7	ND

(a) ND = none detected.

References

BNWL-2142. Fix, J. J., P. J. Blumer, G. R. Hoenes, and P. E. Bramson. 1977. *Environmental Surveillance at Hanford for CY-1976.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-2142 ADD. Blumer, P. J., and J. J. Fix. 1977. *Environmental Surveillance at Hanford for CY-1976, Data.* Battelle Northwest Laboratory, Richland, Washington.

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BNWL-2246. Fix, J. J., P. J. Blumer, and P. E. Bramson. 1977. *Environmental Status of the Hanford Site for CY-1976.* Battelle Northwest Laboratory, Richland, Washington.

BNWL-2249. Miller, M. L., J. J. Fix, and P. E. Bramson. 1977. *Radiochemical Analyses of Soil and Vegetation Samples Taken from the Hanford Environs, 1971-1976.* Battelle Northwest Laboratory, Richland, Washington.

ARH-LD-154. Panesko, J. V., E. H. Carbaugh, D. J. Carrell, R. L. Dirkes, R. L. Laughman, H. L. Maxfield, and R. E. Wheeler. 1977. *Environmental Protection Annual Report-CY 1976.* Atlantic Richfield Hanford Company, Richland, Washington.

Available documents reviewed in which no vegetation data were found: BNWL-2142, BNWL-2142 ADD, BNWL-2164, BNWL-2246, BNWL-2249, ARH-LD-154, BNWL-2199.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1977

Media Sampled

Routine vegetation sampling was performed at locations within the Hanford reservation and its perimeter. Native perennial vegetation, primarily the growth from rabbitbrush plants and annual grasses, was collected and analyzed for gamma-emitting radionuclides using a lithium-drifted germanium detector, for plutonium isotopes using alpha spectroscopy and for Sr-90 and uranium by specific analysis (PNL-2614, p. 17; PNL-2677, p. 27). Radionuclides analyzed included total U, K-40, Co-60, Sr-90, Zr/Nb-95, Cs-137, Ce-141, Ce-144, Pu-238, Pu-239, and Pu-239,240 (PNL-2677, p. 29; PNL-2614, p. 19).

Green leafy vegetables including spinach, leaf lettuce, turnip greens, and mustard greens were collected during the growing season from local farms and commercial outlets. Composite samples were analyzed for K-40, Sr-90, I-131, and Cs-137 (PNL-2614, p. 14).

The Hanford reservation contains nine plant communities: sagebrush/bluebunch wheatgrass community, sagebrush-bitterbrush/cheatgrass-sandberg-bluegrass, sagebrush/cheatgrass-sandberg-bluegrass, cheatgrass, riparian, greasewood, spiny hopsage, winterfat, and thyme buckwheat (PNL-2253, p. 3.1-3.3). Ninety-two plant species occurring on the 200 Area Plateau were identified and listed (PNL-2253, p. 3.3, A.1-A.5).

A study was performed to determine the uptake of radionuclides by tumbleweed shoots and cheatgrass samples on five different Hanford area soils. Radionuclides analyzed included Sr-85, Cs-134, and Tc-99. Soils were amended with the radionuclides and concentration ratios were reported (PNL-2253, p. 5.7, 5.10).

Sampling Locations

Native perennial vegetation samples were collected from locations to include Wahluke #2, Yakima Barricade, ALE Field Lab, Prosser Barricade, northeast of FFTF, southeast of FFTF, Wye Barricade, Hanford Townsite, 200 ENC, 200 East Hill, East of 200 West Area, Riverview, Byer's Landing, Sagemoor, Pettet Farm, Baxter Substation, west end of Fir Road, Ringold, Berg Ranch, Benton City, and Sunnyside (PNL-2677, p. 29; PNL-2614, p. 19).

Leafy vegetables were collected from Riverview, Ringold, Benton City, Sunnyside, and commercial sources (PNL-2614, p. 14).

Vegetation sampled as part of the plant radionuclide uptake study were collected from Lickskillet, Ritzville, Warden, Burbank, and Rupert (PNL-2253, p. 5.7, 5.10)

Significant Events/Emission Quantities

The N Reactor, located in the 100 Areas, was the only remaining reactor in operation. This reactor was a dual purpose reactor, providing plutonium for military purposes, and steam for electrical power generation. The reactor was cooled by recirculating water in a closed loop configuration (PNL-2253, p. 1.5).

On September 17, 1977, the People's Republic of China conducted a nuclear test which resulted in higher atmospheric I-131 concentrations and elevated concentrations of I-131 in milk samples (PNL-2614, p. 3).

All observed radionuclides present in foodstuffs, wildlife, and soil samples during 1977 were attributed to worldwide fallout or natural sources.

Maximum concentrations of airborne radionuclides were attributed to past atmospheric nuclear detonations (PNL-2614, p. 3, 4).

During 1977, a high concentration of Pu-239,240 was observed in a vegetation sample from the plot east of the 200 West Area. A high concentration of Cs-137 was detected in a vegetation sample collected from the 200 ENC site. Both of these events were attributed to Hanford operations (PNL-2677, p. iv).

Hanford operations during 1977 caused no distinguishable impact on concentrations of airborne radionuclides or external radiation dose as measured near to and far from the Hanford site (PNL-2614, p. 3).

Constituents Measured/Reported

Analytical results were reported in table form in units of 10^{-6} μCi/g (PNL-2677, p. 29; PNL-2614, p. 14, 19). Results were also reported as concentration ratios (plant/soil) and plant-shoot uptake concentrations in units of ng/g (PNL-2253, p. 5.8, 5.10), and in log-normal probability plots (PNL-2677, p. 30-31).

Concentrations of radionuclides observed in leafy vegetable samples (PNL-2614, p. 14):

(Concentrations in units of 10^{-6} μCi/g, wet weight)

Location	K-40			Sr-90			I-131	Cs-137
	max.	min.	avg.	max.	min.	avg.		
Riverview	4.0	1.4	2.6±2.4	0.02	0.008	0.01±0.01	*(a)	*
Ringold			3.7			0.007	*	*
Benton City			4.0			0.02	*	*
Sunnyside			3.4			0.01	*	*
Commercial	3.6	1.2	2.1±1.8	0.009	*	<0.01	*	*

(a) * = less than detection limits: K-40 =0.8, Sr-90 =0.002, I -131= 0.2, Cs-137 = 0.05.

Concentrations of radionuclides observed in vegetation samples collected from locations in the vicinity of the Hanford reservation (PNL-2614, p. 19):

(Concentrations in units of 10^{-6} μCi/g, dry weight)

Radionuclide	Maximum	Location of Max.	Average
K-40	65	West End of Fir Rd	24 ± 38
U-total	0.03	Berg Ranch	<0.01
Sr-90	0.17	Riverview	0.06±0.1
Zr/Nb-95	3.6	ALE	<1.7
Cs-137	0.24	ALE	<0.1
Ce-141	0.4	Yakima Barricade	<0.2
Ce-144	2.0	ALE	<0.6
Pu-288	0.06	Pettet	<0.01
Pu-289	0.05	Pettet	0.01±0.03

Concentrations of radionuclides observed in vegetation samples collected within the Hanford reservation (PNL-2677, p. 29):

(Concentrations in units of 10^{-6} μCi/g, dry weight)

Radionuclide	Maximum	Location of Max.	Average
Co-60	0.58	East of 200 West Area	<0.16
Sr-90	0.72	Prosser Barricade	0.19
Zr/Nb-95	9.8	Prosser Barricade	4.1
Cs-137	5.6	200 ENC	<0.85
Ce-141	0.71	Prosser Barricade	<0.46
Ce-144	4.5	Prosser Barricade	2.2
Pu-288	0.02	200 ENC	<0.008
Pu-289,240	0.02	ALE, 200 ENC, E of W-200	<0.008

Results from the investigation involving the uptake of radionuclides from contaminated soils indicated that Tc-99 concentrations generally decreased in tumbleweed shoots with growth time, the reverse of that found for strontium and cesium. Technetium uptake from the soil was large, reducing the soil pool and limiting subsequent plant uptake. Strontium and cesium uptake from the soil was small, with the amount remaining in the soil remaining constant, never limiting uptake (PNL-2253, p. 5.7).

References

PNL-2253. Rogers, L. E., and W. H. Rickard, eds. 1977. *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report.* Pacific Northwest Laboratory, Richland, Washington.

PNL-2614. Houston, J. R., and P. J. Blumer. 1978. *Environmental Surveillance at Hanford for CY-1977.* Pacific Northwest Laboratory, Richland, Washington.

PNL-2677. Houston, J. R., and P. J. Blumer. 1978. *Environmental Status of the Hanford Site for CY-1977.* Pacific Northwest Laboratory, Richland, Washington.

Available documents reviewed in which no vegetation data were found: PNL-2253, PNL-2614, PNL-2677, PNL-2454, BNWL-SA-6380, BNWL-2272, BNWL-2305, PNL-2426, BNWL-2228, PNL-2624, PNL-3147. Carter, M. W. and A. A. Moghissi. 1977. "Three decades of Nuclear Testing." *Health Physics (UK)* 33(1)55-71.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1978

Media Sampled

Routine vegetation sampling was performed at locations within the Hanford reservation and its perimeter. The most broadly distributed type of vegetation on-site belongs to the sagebrush/cheatgrass/bluegrass community (PNL-2933, p. 3). Vegetation samples collected and analyzed consisted of a representative collection of new growth from perennial vegetation including rabbitbrush (*Chrysothamnus* ssp.), bitterbrush (*Purshia tridentata*), and sagebrush (*Artemisisa tridentata*) (PNL-2933, p. 37). Samples were analyzed for gamma-emitting radionuclides using a lithium-drifted germanium detector; for plutonium isotopes using radiochemical separation and alpha spectroscopy; and for Sr-90 using radiochemical techniques (PNL-2933, p. 37; PNL-2932, p. 19). Radionuclides analyzed included Co-60, Sr-90, Zr/Nb-95, Cs-137, Ce-144, Pu-238, and Pu-238,240 (PNL-2933, p. 42). Samples were also analyzed for total uranium and K-40 (PNL-2932, p. 21).

Green leafy vegetables, such as spinach, leaf lettuce, turnip greens, and mustard greens, and fruits (pears, peaches, grapes, and apples) were obtained during the growing season from farms near to and distant from the Hanford site, and commercial outlets (PNL-2932, p. 16, 17). Samples were analyzed for K-40, Sr-90, and Cs-137 (PNL-2932, p. 17).

A special survey was performed to determine the I-129 content in forage and deer at Hanford and surrounding locations (PNL-3357, p. 1). Samples of vegetation and litter (decomposing vegetation) were collected from sampling sites during January and February 1978, and analyzed for I-129 using methods described by Brauer and Tenny (1975) and Brauer and Strebin (1978) (PNL-3357, p. 4). Results were compared to samples collected in 1972 and 1974 (PNL-3357, p. v).

Sampling Locations

Native perennial vegetation samples were collected during August 1978, from locations both on-site and off-site (PNL-2933, p. 37). On-site locations included Wahluke #2, Yakima Barricade, ALE Field Lab, Prosser Barricade, northeast of FFTF, southeast of FFTF, Wye Barricade, Hanford Townsite, 200 ENC, 200 East Hill, and east of 200 West Area. Off-site sampling locations included Harris Farm, Byer's Landing, Sagemoor Farm, Taylor Flats #1, Taylor Flats #2, west End of Fir Road, Ringold, Berg Ranch, Benton City, Sunnyside, and Riverview (PNL-2932, p. 21; PNL-2933, p. 42).

Fruit samples were collected from the Sagemoor vicinity (PNL-2932, p. 17). Samples of leafy vegetables were collected from Riverview, Ringold, the Sagemoor Vicinity, Benton City, Sunnyside, Othello, Walla Walla, and commercial outlets (PNL-2932, p. 17).

Samples of vegetation and litter were collected from Hanford (between 100 D and 100 H Areas); Wooten Game Range in the Blue Mountains along the Tucannon River (160 km east of Hanford);

along the Columbia River near Wenatchee (120 km northwest of Hanford); near Centralia (270 km west of Hanford); and from near Bend, Oregon (approximately 370 km south of Hanford). Samples were also collected from just south of Richland and at various Hanford site locations (PNL-3357, p. 3).

Significant Events/Emission Quantities

The N Reactor, which utilized a closed primary cooling loop, was the only remaining plutonium-production reactor in operation during 1978. This reactor also supplied steam for electrical power generation (PNL-2932, p. 1; PNL-2933, p. 1).

During 1978, Hanford operations caused no distinguishable impact on concentrations of airborne radionuclides near to or far from the Hanford site (PNL-2932, p. 4).

On March 15, 1978, the People's Republic of China conducted an atmospheric nuclear test, resulting in maximum concentrations of airborne radionuclides (PNL-2932, p. 4). Iodine-131 concentrations in the air were below the detection limit during 1978, except during a one month period following the Chinese nuclear test (PNL-2933, p. 14).

Radionuclides observed in foodstuffs, wildlife, and soil samples were attributed to worldwide fallout or natural sources (PNL-2932, p. 4).

Constituents Measured/Reported

Analytical results were reported in table form in units of 10^{-6} μCi/g (PNL-2932, p. 17, 21; PNL-2933, p. 42). Results were also presented in the form of log-normal probability plots (PNL-2933, p. 40, 41), and in units of fCi/g (PNL-3357, p. 10, 13).

Average concentrations of radionuclides observed in fruit samples collected from the Sagemoor vicinity during 1978 (PNL-2932, p. 17):

(Concentrations in units of 10^{-6} μCi/g, wet wt.)

Fruit	K-40	Cs-137
Pears	*(a)	*
Peaches	1.0	*
Grapes	1.8	*
Apples	*	*

(a) * = less than detectable.

Concentrations of radionuclides observed in leafy vegetable samples (PNL-2932, p. 17):

(Concentrations in units of 10^{-6} μCi/g, wet wt.)

Location	K-40			Sr-90			Cs-137		
	max	min	avg	max	min	avg	max	min	avg
Riverview	4.0	*	<2.5	0.06	0.01	0.03	*(a)	*	*
Ringold			2.1			*			*
Sagemoor			3.8						*
Benton City			2.7			*			*
Sunnyside			3.6			0.02			*
Othello			1.9			*			*
Walla Walla	7.5	*	<4.8	0.01	0.007	0.009	*	*	*
Commercial			*			0.005			*

(a) * = less than detectable.

Concentrations of radionuclides observed in perennial vegetation samples (PNL-2932, p. 21):

(Concentrations in units of 10^{-6} μCi/g, dry wt.)

Location	K-40	U-total	Sr-90	Zr/Nb-95	Cs-137	Ce-144	Pu-238	Pu-239,240
Avg Detection Limit	3.0	0.02	0.01	0.1	0.1	0.4	0.003	0.005
Riverview	10	0.12	0.14	0.3	0.2	1.7	*(a)	0.006
Byer's Landing	12	0.02	0.06	*	0.2	0.9	*	0.01
Sagemoor	13	0.04	0.03	*	0.3	0.5	*	*
Taylor Flats 1	15	0.03	0.09	*	*	0.5	*	*
Taylor Flats 2	10	*	0.03	*	0.3	1.1	*	0.006
W End Fir Rd	13	0.04	0.05	0.1	0.2	1.2	*	0.004
Ringold	12	0.04	0.06	*	*	0.6	*	*
Berg Ranch	13	0.02	0.12	*	0.2	0.8	*	0.004
Wahluke #2	8	0.03	0.14	0.2	0.2	1.0	*	0.004
Yakima Barr.	11	0.02	0.10	*	0.2	1.1	*	0.05
ALE	13	0.06	0.15	*	0.5	1.1	*	*
Benton City	8	0.02	0.02	0.1	0.2	0.8	*	*
Sunnyside	9	0.02	0.13	*	0.2	0.7	*	*
Average	11	<0.04	0.09	<0.12	<0.2	0.9	<0.003	<0.009

(a) * = less than the detectable limit.

Concentrations of radionuclides observed in vegetation samples collected from Hanford and the surrounding vicinity (PNL-2933, p. 42):

(Concentrations in units of 10^{-6} μCi/g, Dry Wt.)

Location	Co-60	Sr-90	Zr/Nb-95	Cs-137	Ce-144	Pu-238	Pu-239,240
On-site:							
Wahluke #2	*	0.14	0.24	0.18	0.98	*	0.004
Yakima Barricade	*	0.10	*(a)	0.21	1.1	*	0.05
ALE Field Lab	*	0.15	*	0.53	1.1	*	*
Prosser Barricade	*	0.17	*	0.28	*	*	*
NE of FFTF	*	0.08	*	0.22	1.3	*	*
SE of FFTF	*	0.11	*	0.27	1.3	*	*
Wye Barricade	*	0.14	0.12	0.11	0.85	*	*
Hanford Townsite	*	0.09	*	0.23	1.0	*	*
200 ENC	*	0.19	*	11.0	1.1	*	*
200 East Hill	0.07	0.19	0.07	0.26	0.73	*	0.009
E.-200 West Area	*	0.07	*	0.36	1.4	*	0.006
Avg. on-site	<0.07	0.13	<0.12	1.2	1.0	*	<0.01
Off-site:							
Harris Farm	*	0.14	0.29	0.22	1.7	*	0.006
Byer's Landing	*	0.06	*	0.19	0.90	*	0.01
Sagemoor Farm	*	0.03	*	0.26	0.50	*	*
Taylor Flats #1	*	0.09	*	*	0.51	*	*
Taylor Flats #2	*	0.03	*	0.25	1.1	*	0.006
West End-Fir Rd	*	0.05	0.13	0.23	1.2	*	0.004
Ringold	*	0.06	*	*	0.62	*	*
Berg Ranch	*	0.12	*	0.17	0.84	*	0.004
Benton City	*	0.02	0.11	0.23	0.79	*	*
Sunnyside	*	0.13	*	0.20	0.72	*	*
Avg. off-site	*	0.07	<0.14	<0.19	0.89	*	<0.006

(a) * = less than detection limit.

(Concentrations in units of fCi I-129/g dry wt.)

Location	Litter	Forage
Bend, Oregon	0.013	0.0077
Centralia, Washington	0.018	0.0067
Wenatchee, Washington	0.086	0.027
Wooten, Washington	0.095	0.017
Hanford, Washington	9.2	0.26

Results comparing I-129 concentrations observed in litter, grasses, and shrubs for 1978, 1974, and 1972 (PNL-3357, p. 13):

(Concentrations in units of fCi/g, dry weight)

Distance from Nearest Reprocessing Plant	Date Collected	Litter	Grasses	Shrubs
1	6/74	3.4	0.47	
	6/78	8.4	1.9	1.4
1.5	8/72		150	
	6/74	14	11	4.3
	6/78		2.0	2.4
5	6/74		11	
	6/78	5.8	0.28	0.24
12	10/72	12		
	6/74		0.32	
	6/78	0.72	0.026	0.066
14	6/74		0.59	0.12
	6/78	0.072	0.040	0.055
26	10/72	5.2		
	6/74		0.57	0.14
	6/78	0.51	0.083	0.025
32	10/72	2.0		
	6/74	0.93		
	6/78	0.59	0.019	0.028
47	6/74		0.25	
	6/78	0.079	0.009	0.016

References

PNL-2932. Houston, J. R., and P. J. Blumer. 1979. *Environmental Surveillance at Hanford for CY-1978.* Pacific Northwest Laboratory, Richland, Washington.

PNL-2933. Houston, J. R., and P. J. Blumer. 1979. *Environmental Status of the Hanford Site for CY 1978.* Pacific Northwest Laboratory, Richland, Washington.

PNL-3357. Price, K. R., L. L Cadwell, R. G. Schreckhise, and F. P. Brauer. 1981. *Iodine-129 in Forage and Deer on the Hanford Site and other Pacific Northwest Locations.* Pacific Northwest Laboratory, Richland, Washington.

Available documents reviewed in which no vegetation data were found: PNL-2932, PNL-2933, PNL-3357, PNL-2465, PNL-2499, PNL-2899.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1979

Media Sampled

Routine vegetation sampling was performed at locations within the Hanford reservation and the surrounding vicinity. The most broadly distributed type of vegetation on the Hanford site belongs to the sagebrush/cheatgrass/bluegrass community (PNL-3283, p. 2; PNL-3284, p. 3). Vegetation samples collected during late summer 1979, consisted of a representative collection of new growth from perennial vegetation including rabbitbrush (*Chrysothamnus* ssp.), bitterbrush (*Purshia tridentata*), and sagebrush (*Artemisia tridentata*) (PNL-3284, p. 37,38; PNL-3283, p. 23). Vegetation was collected from each sampling site in proportions equivalent to those present at the site, i.e., if the plant cover at the site was 30% rabbitbrush and 70% sagebrush, then the sample would be collected in the same proportions (PNL-3283, p. 23). Samples were analyzed for gamma emitting radionuclides using a lithium-drifted germanium detector; for plutonium isotopes using radiochemical separation and alpha spectroscopy; and for Sr-90 using radiochemical techniques (PNL-3284, p. 38; PNL-3283, p. 23). Radionuclides analyzed included K-40, Total U, Co-60, Sr-90, Zr/Nb-95, Cs-137, Ce-144, Pu-288, and Pu-239,240 (PNL-3283, p. 26; PNL-3284, p. 42).

Samples of fruit and green leafy vegetables were obtained during the growing season from farms distant to and in the vicinity of the Hanford site. Locations ranged from perimeter sites to 47 miles from the nearest site boundary (PNL-3283, p. 15,17). Leafy vegetables included spinach, leaf lettuce, turnip greens, and mustard greens (PNL-3283, p. 15). Fruit samples included cherries, peaches, plums, pears, apples, grapes, and cantaloupe (PNL-3283, p. 18). All samples were analyzed by gamma spectroscopy for gamma-emitting radionuclides using a 9 inch by 9 inch NaI (Tl) well detector (PNL-3283, p. B.1). Radiochemical techniques were used for Sr-90 analysis. Only the edible portions of the fruits and vegetables were analyzed (PNL-3283, p. 17). Fruit samples were analyzed for K-40 and Cs-137, and leafy vegetables were analyzed for K-40, Sr-90, and Cs-137 (PNL-3283, p. 18).

Vegetation samples were collected as part of a special survey along shorelines and islands of the Columbia River. Samples were collected from 6 sites where contamination levels were below 25 μR/hr at one meter above the ground, and from two sites that were more highly contaminated. Vegetation samples were analyzed for Co-60, Cs-137, and Eu-152, as well as naturally occurring radionuclides (PNL-3127, p. iv, 31, 35).

Sampling Locations

Native perennial vegetation samples were collected from 13 perimeter and distant locations to include Riverview, Byer's Landing, Sagemoor, Taylor Flats #1, Taylor Flats #2, West End of Fir Road, Ringold, Berg Ranch, Wahluke #2, Yakima Barricade, ALE, Benton City, and Sunnyside (PNL-3283, p. 26). In other sampling, vegetation was collected from on-site locations to include Wahluke #2, Yakima Barricade, ALE Field Lab, Prosser Barricade,northeast of FFTF, southeast of

FFTF, Wye Barricade, Hanford townsite, 200 ENC, 200 East Hill, and east of the 200 West Area. Off-site collections were performed at the Harris Farm, Byer's Landing, Sagemoor Farm, Taylor Flats #1, Taylor Flats #2, west end of Fir Road, Ringold, Berg Ranch, Benton City, and Sunnyside (PNL-3284, p. 42).

Fruit samples were collected from the Sagemoor Vicinity and Sunnyside (PNL-3283, p. 18).

Samples of leafy vegetables were collected from Riverview, the Sagemoor Vicinity, Benton City, Othello, Walla Walla, and Sunnyside (PNL-3283, p. 18).

Vegetation samples were collected as part of the special radiological survey of shorelines and islands from the N-Area Shore, F-Area Slough, Hanford Townsite Peninsula, Plant Shore across from Wooded Island, Richland Marina, the McMurray Street Shoreline, the H-Area Slough, and the Hanford Townsite Slough (PNL-3127, p. 33).

Significant Events/Emission Quantities

The N Reactor, which utilized a closed primary cooling loop, was the only remaining plutonium-production reactor in operation during 1979. The reactor also supplied steam for electrical power generation (PNL-3283, p. 1; PNL-3284, p. 1). Operations from the N Reactor produce the majority of radioactivity released to the atmosphere from Hanford (PNL-3284, p. 53).

During 1979, Hanford operations caused no distinguishable impact on concentrations of airborne radionuclides, or on the external radiation dose measured near to or far from the Hanford site (PNL-3283, p. v.)

Concentrations of I-131 detected in the air were below the detection limit during 1979 (PNL-3284, p. 13).

Radionuclides observed in foodstuffs were attributed to worldwide fallout or natural sources (PNL-3283, p. v.)

Elevated concentrations of Cs-137 at 200 ENC were attributed to Hanford operations (PNL-3284, p. 40).

Six accidental releases of radioactive airborne contaminants occurred to the atmosphere during 1979 (PNL-3284, p. 60).

There were six unplanned releases of radioactive liquids to the soil during 1979 (PNL-3284, p. 61).

There were three unplanned releases of radioactive solid wastes during 1979 (PNL-3284, p. 63).

Constituents Measured/Reported

Analytical results were reported in table form in units of pCi/g (PNL-3284, p. 42; PNL-3283, p. 18, 26; PNL-3127, p. 33). Results were also presented in the form of log-normal probability plots (PNL-3284, p. 40, 41; PNL-3283, p. 18, 26).

Average concentrations of radionuclides observed in fruit samples during 1979 (PNL-3283, p. 18):

(Concentrations in units of pCi/g, wet weight)

Location	Fruit	K-40	Cs-137
Sagemoor:			
	Cherries	1.5	0.003
	Peaches	1.6	-0.004
	Plums	1.8	0.003
	Pears	0.73	0.02
	Apples	1.1	0.01
	Grapes	1.9	0.009
Sunnyside:			
	Peaches	1.2	-0.002
	Plums	1.3	0.003
	Pears	0.87	0.01
	Apples	0.65	-0.003
	Cantaloupe	1.1	0.005

Concentrations of radionuclides observed in leafy vegetable samples (PNL-3283, p. 18):

(Concentrations in units of pCi/g, wet weight)

Location	K-40			Sr-90			Cs-137		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Riverview	4.7	1.7	3.5±2.5	0.17	0.002	0.05±0.14	0.02	-0.002	0.01±0.02
Sagemoor			0.81						-0.005
Benton City	3.6	1.9	2.8±1.7	0.01	0.004	0.007±0.006	0.01	-0.008	0.003±0.02
Othello	3.9	2.2	3.1			0.004	0.004	0.003	0.002
Walla Walla	3.7	1.8	2.9±2.0	0.04	0.02	0.03±0.03	0.04	-0.01	0.01±0.05
Sunnyside			2.6			0.01			-0.01

Concentrations of radionuclides observed in perennial vegetation samples (PNL-3283, p. 26):

(Concentrations in units of pCi/g, dry wt.)

Location	K-40	U-total	Sr-90	Zr/Nb-95	Cs-137	Ce-144	Pu-238	Pu-239,240
Avg detection limit	3.8	0.02	0.03	0.34	0.16	0.76	0.006	0.006
Riverview	13	0.03	0.06	0.21	0.22	0.46	-0.002	0.004
Byer's Landing	25	0.23	0.00	-0.23	-0.006	1.0	0.02	0.01
Sagemoor	16	0.05	0.03	-0.03	0.20	0.34	0.0003	0.003
Taylor Flats #1	13	0.03	0.07	0.14	0.14	0.33	-0.0002	0.001
Taylor Flats #2	15	0.05	0.03	0.23	0.09	0.59	0.02	0.001
W. End Fir Road	15	0.03	0.32	-0.10	0.09	0.30	0.001	0.002
Ringold	13	0.04	0.06	0.18	0.19	0.70	-0.001	0.002
Berg Ranch	15	0.06	0.03	0.16	0.01	0.26	0.002	0.002
Wahluke #2	7.0	0.01	0.03	0.03	0.09	0.98	0.0002	0.0002
Yakima Barricade	9.6	0.02	0.09	0.23	0.18	0.72	-0.001	0.002
ALE	12	0.02	0.20	0.23	0.35	0.51	0.004	0.008
Benton City	7.1	0.02	0.46	0.20	0.42	0.81	0.02	0.002
Sunnyside	3.8	0.008	0.11	0.06	0.16	1.2	0.008	0.002

Samples of vegetation and soil collected from several sites along the Columbia River showed "contamination deposits" to consist of a mixture of Co-60, Cs-137 and Eu-152 (PNL-3127, p. iv).

The majority of gamma radiation emitted from samples collected along the Columbia River was from naturally occurring radionuclides in normal concentrations (PNL-3127, p. 31). Samples collected from highly contaminated areas contained greater concentrations of radionuclides and levels above those associated with worldwide fallout (PNL-3127, p.35).

Concentrations of artificially created, long-lived radionuclides observed in vegetation samples collected along the Columbia River shoreline (PNL-3127, p. 33):

(Concentrations in units of pCi/g, wet wt.)

Location	Co-60	Cs-137	Eu-152
N-Area Shore	1.0	0.09	ND[(a)]
F-Area Slough	ND	0.04	ND
Hanford Townsite Peninsula	ND	ND	ND
Plant Shore across from Wooded Island	ND	ND	ND
Richland Marina	ND	0.099	ND
McMurray St. Shoreline	0.13	0.10	ND
H-Area Slough	0.11	4.1	0.24
Hanford Townsite Slough	0.064	0.64	0.21

(a) ND = not detected.

Concentrations of radionuclides observed in vegetation samples collected from Hanford and the surrounding vicinity (PNL-3284, p. 42):

(Concentrations in units of pCi/g, dry wt.)

Location	Co-60	Sr-90	Zr/Nb-95	Cs-137	Ce-144	Pu-288	Pu-289, 240
On-site:							
Wahluke #2	-0.006	0.03	0.03	0.09	0.98	0.0002	0.0002
Yakima Barricade	0.09	0.09	0.23	0.18	0.72	-0.001	0.002
ALE Field Lab	-0.03	0.20	0.23	0.35	0.51	0.004	0.008
Prosser Barricade	0.06	0.08	0.20	0.14	0.36	0.04	0.03
NE of FFTF	0.02	0.07	0.32	0.06	0.70	-0.002	0.002
SE of FFTF	-0.01	0.06	0.13	0.10	0.72	-0.001	0.003
Wye Barricade	0.05	0.07	0.03	-0.01	0.40	-0.002	-0.0006
Hanford Townsite	0.06	0.01	0.02	-0.03	-0.19	0.0006	0.005
200 ENC	0.09	0.20	0.75	3.1	1.2	0.005	0.002
200 East Hill	0.03	0.02	0.17	0.30	1.2	0.02	0.006
East of 200 West	-0.04	0.08	0.08	0.17	0.56	0.001	0.008
Off-site:							
Harris Farm	-0.02	0.06	0.21	0.22	0.46	-0.002	0.004
Byer's Landing	-0.03	0	-0.23	-0.006	1.0	0.02	0.01
Sagemoor Farm	0.08	0.03	-0.03	0.20	0.34	0.0003	0.003
Taylor Flats #1	-0.03	0.07	0.14	0.14	0.33	-0.0002	0.001
Taylor Flats #2	0.21	0.03	0.23	0.09	0.59	0.02	0.001
West End-Fir Rd	-0.03	0.32	-0.10	0.09	0.30	0.001	0.002
Ringold	-0.07	0.06	0.18	0.19	0.70	-0.001	0.002
Berg Ranch	0.07	0.03	0.16	0.01	0.26	0.002	0.002
Benton City	0.25	0.46	0.20	0.42	0.81	0.02	0.002
Sunnyside	-0.01	0.11	0.06	0.16	1.2	0.008	0.002
Detection limit	0.14	0.03	0.34	0.16	0.76	0.006	0.006

References

PNL-3127. Sula, M. J. 1980. *Radiological Survey of Exposed Shorelines and Islands of the Columbia River Between Vernita and the Snake River Confluence.* Pacific Northwest Laboratory, Richland, Washington.

PNL-3283. Houston, J. R., and P. J. Blumer. 1980. *Environmental Surveillance at Hanford for CY-1979.* Pacific Northwest Laboratory, Richland, Washington.

PNL-3284. Houston, J. R., and P. J. Blumer. 1980. *Environmental Status of the Hanford Site for CY 1979.* Pacific Northwest Laboratory, Richland, Washington.

Available documents reviewed in which no vegetation data were found: PNL-3127, PNL-3283, PNL-3284, PNL-2479, PNL-SA-7167, PNL-462, PNL-2713, PNL-3346, PNL-1948.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1980

Media Sampled

Routine vegetation sampling was performed at locations within the Hanford reservation and at sites near to and distant to its perimeter. The most broadly distributed type of vegetation found on-site is the sagebrush/cheatgrass/bluegrass community (PNL-3728, p. 2; PNL-3729, p. 4). Perennial vegetation samples were collected from seven on-site locations and fourteen perimeter and distant locations during 1980. Samples of rabbitbrush, sagebrush, and/or bitterbrush were collected in proportions directly related to their relative abundance on the collection site (i.e., if the site was 30% rabbitbrush, 70% sagebrush, the sample would be comprised of those proportions)(PNL-3729, p. 30; PNL-3728, p. 29). Samples were analyzed for gamma-emitting radionuclides using gamma spectrometry; radiochemical techniques were used for Sr-90 analyses (PNL-3728, p. 22). Radionuclides analyzed included K-40, total uranium, Co-60, Sr-90, Zr/Nb-95, Cs-137, Ce-144, Pu-288, and Pu-289,240 (PNL-3729, p. 31; PNL-3728, p. 31).

Fruit and leafy vegetable samples were collected from farms in the vicinity of and distant to the Hanford site. Leafy vegetables, including spinach, leaf lettuce, turnip greens, and mustard greens, were obtained during the growing season (PNL-3728, p. 22). Fruit samples included cherries, plums, pears, grapes, apples, and peaches (PNL-3728, p. 23). All samples were analyzed by gamma spectrometry for gamma-emitting radionuclides using a 9 inch by 9 inch NaI(Tl) well detector. Radiochemical techniques were used for Sr-90 analyses (PNL-3728, p. 22, B.1). Only edible portions of the fruits and vegetables were analyzed (PNL-3728, p. 22). Fruit samples were analyzed for K-40 and Cs-137, and leafy vegetables were analyzed for K-40, Sr-90, and Cs-137 (PNL-3728, p. 23).

Sampling Locations

Native perennial vegetation samples were collected once during 1980 in late summer (PNL-3728, p. 29). Sampling locations included Riverview, Byer's Landing, Sagemoor, Taylor Flats #1, Taylor Flats #2, west end of Fir Road, Ringold, Berg Ranch, Wahluke #2, Yakima Barricade, ALE, Benton City, Sunnyside, Prosser Barricade, 200 ENC, 200 East Hill, east of 200 West Area, northeast of FFTF, southeast of FFTF, Wye Barricade, and Hanford Townsite (PNL-3728, p. 31; PNL-3729, p. 31).

Fruit samples were collected from the Sagemoor vicinity and Sunnyside (PNL-3728, p. 23).

Samples of leafy vegetables were collected from Riverview, Sagemoor vicinity, Ringold, Benton City, Othello, Moses Lake, Walla Walla, and Sunnyside (PNL-3728, p. 23).

Significant Events/Emissions Quantities

An atmospheric nuclear test on October 16, 1980, by the People's Republic of China caused increased gross beta levels of atmospheric particulate (PNL-3729, p. v, 17; PNL-3728, p. 19).

The N Reactor, which utilized a closed primary cooling loop, was the only remaining plutonium-production reactor in operation during 1980 (PNL-3728, p. 1; PNL-3729, p. 1). This reactor also supplied steam for electrical power generation (PNL-3728, p. 2; PNL-3729, p. 3). The N Reactor was shut down during the months of June through December due to a Hanford-wide labor dispute (PNL-3728, p. 2; PNL-3729, p. 3).

No distinguishable difference was detected between airborne radionuclide concentrations in samples collected near to and distant to the Hanford site (PNL-3728, p. v).

Two accidental releases of radioactive airborne contaminants occurred to the atmosphere during 1980 (PNL-3729, p. 49).

There were seven unplanned releases involving radioactive liquid wastes during 1980 (PNL-3729, p. 50).

There were three unplanned occurrences involving contaminated solid wastes during 1980 (PNL-3729, p. 51).

Radioiodine was not detected in air samples collected during 1980 (PNL-3729, p. v).

Radioactive uranium, plutonium, and strontium, potentially associated with Hanford operations, were found in concentrations within the range attributed to natural variability or worldwide fallout (PNL-3728, p. 29).

Constituents Measured/Reported

Analytical results were reported in table form in units of pCi/g (PNL-3728, p. 23, 31; PNL-3729, p. 31). Results were also presented in the form of log-normal probability plots (PNL-3728, p. 24).

Low concentrations of Sr-90 and Cs-137 observed in leafy vegetable samples were attributable to worldwide fallout (PNL-3728, p.22).

Analysis of vegetable samples from Riverview farms, which irrigate using Columbia River water that has passed the Hanford site, indicated that there were no observable impacts from current or past Hanford operations (PNL-3728, p. 19).

Average concentrations of radionuclides observed in fruit samples during 1980 (PNL-3728, p. 23):

(Concentrations in units of pCi/g, wet weight)

Location	Fruit	K-40	Cs-137
Sagemoor:			
	Cherries	2.2 ± 0.09	0.01 ± 0.007
	Plums	0.77 ± 0.09	-0.004 ± 0.007
	Pears	0.77 ± 0.11	-0.005 ± 0.009
	Grapes	1.4 ± 0.07	0.001 ± 0.006
	Apples	5.0 ± 0.31	0.01 ± 0.02
Sunnyside:			
	Cherries	1.4 ± 0.24	0.006 ± 0.02
	Pears	0.62 ± 0.12	0.01 ± 0.01
	Plums	1.2 ± 0.10	0.005 ± 0.009
	Peaches	1.1 ± 0.11	-0.004 ± 0.01
	Apples	0.89 ± 0.12	0.008 ± 0.01
	Grapes	1.5 ± 0.08	0.02 ± 0.007

Concentrations of radionuclides observed in leafy vegetable samples (PNL-3728, p. 23):

(Concentrations in units of pCi/g, wet weight)

Location	K-40		
	Max.	Min.	Avg.
Riverview	3.9±0.57	3.0±0.17	3.4±0.91
Sagemoor			1.1±0.15
Ringold			25±0.93
Benton City	1.5±0.14	0.53±0.13	1.0±1.4
Othello	3.7±0.22	3.5±0.17	3.6±0.34
Moses Lake			1.7±0.20
Walla Walla			1.3±0.13
Sunnyside			1.3±0.18

Location	Sr-90		
	Max.	Min.	Avg.
Riverview	0.09±0.04	0.05±0.03	0.07±0.056
Sagemoor			
Ringold			0.08±0.03
Benton City	0.01±0.03	0.001±0.04	0.006±0.04
Othello	0.06±0.04	0.03±0.03	0.04±0.06
Moses Lake			0.14±0.007
Walla Walla			0.0±0.03
Sunnyside			0.04±0.05

Location	Cs-137		
	Max.	Min.	Avg.
Riverview	0.02±0.01	-0.02±0.05	0.007±0.05
Sagemoor			0.001±0.01
Ringold			0.14±0.08
Benton City	0.004±0.01	-0.004±0.01	0±0.02
Othello	0.0005±0.02	-0.009±0.01	0.004±0.02
Moses Lake			0.02±0.02
Walla Walla			0.007±0.01
Sunnyside			0.004±0.02

Concentrations of radionuclides observed in on-site vegetation samples (PNL-3729, p. 31):

(Concentrations in Units of pCi/g, dry weight.)

Location	Co-60	Sr-90	Zr/Nb-95	Cs-137	Ce-144	Pu-238	Pu-239,240	U-total
200 ENC	0.02 ± 0.17	0.07 ± 0.01	-0.09 ± 0.27	0.57 ± 0.23	0.29 ± 0.79			0.01 ± 0.01
200 East Hill	-0.05 ± 0.11	0.05 ± 0.01	0.07 ± 0.20	0.08 ± 0.12	-0.02 ± 0.54	0.007 ± 0.003	0.06 ± 0.008	0.005 ±0.01
E. of 200 W.	0.17 ± 0.20	0.05 ± 0.01	-0.03 ± 0.26	-0.01 ± 0.15	-0.12 ± 0.84			0.004 ± 0.01
NE of FFTF	-0.01 ± 0.12	0.03 ± 0.01	0.0006 ± 0.20	0.11 ± 0.13	0.43 ± 0.60			0.01 ± 0.01
SE of FFTF	-0.02 ± 0.23	0.19 ± 0.05	0.11 ± 0.39	0.06 ± 0.23	-0.33 ± 1.2			0.01 ± 0.01
Wye Barricade	0.02 ± 0.16	0.03 ± 0.01	-0.009 ± 0.25	0.02 ± 0.15	0.21 ± 0.80	0.002 ± 0.0008	0.002±0.0007	0.02±0.01
Hanford Site	0.05 ± 0.12	0.12 ± 0.01	0.003 ± 0.18	0.32 ± 0.15	-0.01 ± 0.57			0.04 ± 0.20

Concentrations of radionuclides observed in vegetation samples collected in the Hanford vicinity (PNL-3728, p. 31):

(Concentrations in Units of pCi/g, dry weight.)

Location	K-40	Total-U	Sr-90	Zr/Nb-95	Cs-137	Ce-144	Pu-238	Pu-239,240
Riverview	8.0 ± 3.4	0.008 ± 0.01	0.04 ± 0.01	-0.06 ± 0.20	0.02 ± 0.12	-0.02 ± 0.63		
Byer's Landing	30 ± 6.6	0.05 ± 0.02	0.06 ± 0.04	0.08 ± 0.31	0.18 ± 0.20	-0.14 ± 0.88		
Sagemoor	17 ± 3.4	0.003 ± 0.01	0.05 ± 0.01	0.08 ± 0.16	-0.03 ± 0.08	-0.16 ± 0.47		
Taylor Flts #1	20 ± 5.2	0.07 ± 0.03	0.04 ± 0.01	0.02 ± 0.26	0.01 ± 0.15	-0.30 ± 0.81	0.001 ± 0.001	0.04 ± 0.004
Taylor Flts #2	14 ± 4.3	0.11 ± 0.04	0.08 ± 0.05	-0.03 ± 0.23	0.27 ± 0.17	0.80 ± 0.73		
W. End Fir Rd	17 ± 5.3	0.003 ± 0.01		0.04 ± 0.28	-0.02 ± 0.16	-0.36 ± 0.89	0.02 ± 0.004	0.09 ± 0.009
Ringold	14 ± 4.6	0.02 ± 0.01	0.04 ± 0.01	0.04 ± 0.25	0.21 ± 0.17	0.02 ± 0.77		
Berg Ranch	15 ± 4.6	0.008 ± 0.01	0.05 ± 0.01	0.14 ± 0.26	0.01 ± 0.14	0.49 ± 0.80		
Wahluke #2	15 ± 4.6	0.002 ± 0.01	0.02 ± 0.01	0.003 ± 0.41	-0.05 ± 0.12	-0.22 ± 0.59	0.001 ± 0.004	0.03 ± 0.008
Yakima B.	19 ± 4.9	0.01 ± 0.01	0.07 ± 0.01	-0.08 ± 0.26	0.18 ± 0.17	0.15 ± 0.74		
ALE	11 ± 3.4	0.07 ± 0.03	0.09 ± 0.01	-0.02 ± 0.18	0.03 ± 0.11	0.16 ± 0.54	0.02 ± 0.004	0.15 ± 0.01
Benton City	17 ± 5.8	0.03 ± 0.02	0.06 ± 0.01	-0.12 ± 0.32	-0.01 ± 0.18	-0.003 ± 1.0	0.01 ± 0.004	0.10 ± 0.01
Sunnyside	15 ± 4.5	0.02 ± 0.01	0.03 ± 0.01	0.05 ± 0.25	0.05 ± 0.14	-0.33 ±0.71		
Prosser B.	19 ± 4.2	0.01 ± 0.01	0.03 ± 0.01	0.12 ± 0.21	0.04 ± 0.11	-0.14 ± 0.56		

References

PNL-3728. Sula, M. J., and P. J. Blumer. 1981. *Environmental Surveillance at Hanford for CY-1980.* Pacific Northwest Laboratory, Richland, Washington.

PNL-3729. Sula, M. J., P. J. Blumer, and R. L. Dirkes. 1981. *Environmental Status of the Hanford Site for CY 1980.* Pacific Northwest Laboratory, Richland, Washington.

Available documents reviewed in which no vegetation data were found: PNL-3728, PNL-3729, PNL-3269, PNL-3768, PNL-SA-8407.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1981

Media Sampled

Routine vegetation sampling was performed at locations within the Hanford reservation and near to and distant to its perimeter. The most broadly distributed type of vegetation found on-site consists of the sagebrush/ cheatgrass/bluegrass community (PNL-4212, p. 3; PNL-4211, p. 3). Samples of perennial shrubs (rabbitbrush, sagebrush, and bitterbrush) were selected from undisturbed, unirrigated locations and collected in proportions relative to their natural abundance at each sampling location (PNL-4211, p. 35; PNL-4212, p. 32). Vegetation samples were collected by cutting a small amount of the new growth from each plant in the area to make up a 1 kg sample, drying and grinding the sample, and taking aliquots for analysis (PNL-4211, p. 35). Samples were analyzed for gamma-emitting radionuclides (Zr/Nb-95, Ru-106, Cs-137, Ce-144, and Co-60), Sr-90, Pu, and U (PNL-4212, p. 32, 33; PNL-4211, p. 38). The gamma-emitting radionuclide analysis was conducted with the use of a 9 inch by 9 inch NaI(Tl) well detector (PNL-4212, p. A.2).

Green leafy vegetables, such as spinach, leaf lettuce, turnip greens, and mustard greens, were obtained during the growing season from sites near to and distant from the Hanford site. Samples were composed of random mixtures of the edible portions (PNL-4211, p. 26). Leafy vegetable samples were analyzed for Sr-90 and Cs-137 (PNL-4211, p. 27).

Fruit samples, including cherries, plums, peaches, pears, grapes, and apples, were collected at their respective picking times and analyzed for Cs-137 (PNL-4211, p. 27).

A special study was conducted to assess the environmental impact of Hanford operations by utilizing C-14 analysis on sagebrush. Ten mature sagebrush plants were collected at each of three sampling sites by severing the plant at ground level. A section of the main stem was then taken to the laboratory and cross-sections of the stems (2.5 cm thick) were cut with a band saw. Annual rings were then precisely separated using a sharp knife, and 10-gram samples of the dried wood were analyzed by the U.S. Testing Company, Inc., Richland, Washington, using a benzene synthesizer (PNL-3766, p. 3).

Sampling Locations

Native perennial vegetation samples were collected during the summer months from both on-site and off-site locations (PNL-4211, p. 35). Locations included Riverview, Byer's Landing, Sagemoor, Taylor Flats #1, Taylor Flats #2, west end of Fir Road, Ringold, Prosser Barricade, ALE, Benton City, Berg Ranch, Wahluke #2, Yakima Barricade, Sunnyside, 200 ENC, 200 East Hill, east of 200 West, northeast of FFTF, southeast of FFTF, Wye Barricade, and Hanford townsite (PNL-4212, p. 33; PNL-4211, p. 38).

Fruit samples were collected from a downwind location near the Hanford site boundary and a distant upwind location (PNL-4211, p. 27).

Samples of leafy vegetables were collected from Riverview, Benton City, the Sagemoor vicinity, Ringold, Othello, Moses Lake, Umatilla, Walla Walla, and Sunnyside (PNL-4211, p. 26, 27).

Sagebrush samples collected as part of the special C-14 study were collected from the Washington State Plant Introduction Station near Moxee City (approximately 60 km west (upwind) of the Hanford 200 Areas); 7 km south of Highway 240 on Horn Road near Benton City and approximately 26 km southeast (downwind) of the Hanford 200 Areas; and approximately 0.5 km east of the Purex fuel reprocessing facility's 90 m tall exhaust stack in the 200 E Area (PNL-3766, p. 3).

Significant Events/Emission Quantities

The N Reactor, which utilized a closed primary cooling loop, was the only remaining plutonium-production reactor in operation during 1981. This reactor also supplied steam for electrical power generation (PNL-4211, p. 4; PNL-4212, p. 5,6).

Levels of airborne radioactivity in the Hanford area were greater in 1981 as a result of nuclear fallout from a foreign atmospheric nuclear test conducted in late 1980 (PNL-4212, p. v). The maximum atmospheric concentrations were observed in the spring months (PNL-4212, p. 10).

Radioiodine was not identified in any air sample during 1981 (PNL-4212, p. v, 10).

There were five unusual occurrences involving liquid wastes in 1981 (PNL-4212, p. 48).

Six unplanned occurrences involving contaminated solid wastes occurred during 1981 (PNL-4212, p. 49).

Observed radionuclide concentrations were, in every case, below all applicable concentration guides and radiation dose standards (PNL-4211, p. v).

There was no distinguishable difference between airborne radionuclide concentrations in samples collected near to and distant from the Hanford site (PNL-4211, p. v).

Low concentrations of fallout radionuclides were observed in foodstuff and vegetation samples, due to worldwide atmospheric nuclear testing. There was no indication of a Hanford contribution to radionuclide levels in vegetation and foodstuffs (PNL-4211, p. v). Non-fallout radionuclides observed were similar to those of previous years and there was no geographical pattern found (PNL-4211, p. 37).

Constituents Measured/Reported

Analytical results were reported in table form in units of pCi/g (PNL-4211, p. 27, 38; PNL-4212, p. 33). Results of C-14 testing were presented as dpm/g of carbon (PNL-3766, p. 6).

No Cs-137 was detected in fruit samples collected from both upwind and downwind of Hanford operations (PNL-4211, p. 27).

Fruits do not accumulate airborne radionuclides as efficiently as leafy vegetables (PNL-4211, p. 27).

Concentrations of radionuclides observed in leafy vegetable samples (PNL-4211, p. 27):

Concentrations in units of pCi/g, wet weight)

Location	Sr-90		Cs-137	
	Maximum	Average	Maximum	Average
Riverview	0.05 ± 0.01	0.02 ± 0.03	0.06 ± 0.03	0.008 ± 0.037
Sagemoor		not analyzed		-0.006 ± 0.02
Ringold		0.006 ± 0.003		-0.007 ± 0.02
Benton City	0.013 ± 0.001	0.01 ± 0.001	< detectable	-0.002 ± 0.016
Othello		0.005 ± 0.00		-0.007 ± 0.02
Moses Lake		0.007 ± 0.0009		-0.01 ± 0.02
Umatilla		0.01 ± 0.001		-0.005 ± 0.01
Walla Walla		0.02 ± 0.001		-0.009 ± 0.02
Sunnyside		0.001 ± 0.001		-0.004 ± 0.02

Concentrations of radionuclides observed in on-site vegetation samples (PNL-4212, p. 33):

(Concentrations in units of pCi/g, dry weight)

Location	Co-60	Sr-90	Zr/Nb-95	Cs-137	Ce-144	Pu-238	Pu-239,240	U-total
200 ENC	-0.01 ± 0.02	0.14 ± 0.003	0.87 ± 0.08	0.11 ± 0.03	0.80 ± 0.12	-0.0007 ± 0.0003	0.001 ± 0.0004	0.01 ± 0.004
200 East Hill	-0.004 ± 0.02	0.07 ± 0.005	0.52 ± 0.07	0.05 ± 0.02	0.62 ± 0.13	0.002 ± 0.001	0.004 ± 0.001	0.008 ± 0.003
East 200 West	-0.002 ± 0.02	0.09 ± 0.005	0.90 ± 0.07	0.05 ± 0.02	1.1 ± 0.12	-0.0007 ± 0.0006	0.003 ± 0.001	0.01 ± 0.004
NE of FFTF	0.003 ± 0.01	0.04 ± 0.004	0.89 ± 0.04	0.04 ± 0.01	0.85 ± 0.07	-0.0005 ± 0.0005	0.001 ± 0.0007	0.02 ± 0.006
SE of FFTF	0.01 ± 0.02	0.04 ± 0.005	1.1 ± 0.08	0.05 ± 0.02	1.1 ± 0.11	-0.0007 ± 0.0003	0.001 ± 0.0006	0.008 ± 0.003
Wye Barricade	-0.02 ± 0.01	0.05 ± 0.006	0.90 ± 0.05	0.05 ± 0.02	1.0 ± 0.09	-0.0006 ± 0.0003	0.003 ± 0.0007	0.01 ± 0.004
Hanford TS	-0.004 ± 0.02	0.06 ± 0.003	0.70 ± 0.07	0.03 ± 0.02	0.62 ± 0.12	-0.0005 ± 0.0003	0.002 ± 0.0006	0.005 ± 0.003

Concentrations of radionuclides observed in perennial vegetation samples (PNL-4211, p. 38):

(Concentrations in units of pCi/g, dry weight

Location	Sr-90	Zr/Nb-95	Ru-106	Cs-137	Ce-144	Pu-238	Pu-239,240	Total-U
Riverview	0.05 ± 0.003	0.48 ± 0.06	0.07 ± 0.13	0.02 ± 0.02	0.56 ± 0.11	-0.0006 ± 0.0005	0.002 ± 0.0009	0.02 ± 0.008
Byer's Landing	0.03 ± 0.004	0.52 ± 0.08	0.34 ± 0.18	-0.006 ± 0.02	0.61 ± 0.14	-0.0005 ± 0.0004	0.0006 ± 0.0004	0.02 ± 0.008
Sagemoor	0.03 ± 0.004	0.41 ± 0.07	0.16 ± 0.16	0.02 ± 0.02	0.52 ± 0.13	-0.0009 ± 0.0004	0.002 ± 0.0009	0.02 ± 0.008
Taylor Flats #1	0.03 ± 0.003	0.59 ± 0.07	0.29 ± 0.17	0.02 ± 0.02	0.71 ± 0.14	-0.00007 ± 0.0005	0.002 ± 0.0006	0.20 ± 0.07
Taylor Flats #2	0.03 ± 0.003	0.66 ± 0.06	0.30 ± 0.11	0.05 ± 0.02	0.80 ± 0.10	-0.0005 ± 0.0004	0.002 ± 0.0006	0.03 ± 0.01
W. End Fir Rd.	0.06 ± 0.007	0.84 ± 0.07	0.22 ± 0.13	0.03 ± 0.02	1.2 ± 0.12	0.0007 ± 0.0006	0.002 ± 0.0007	0.02 ± 0.007
Ringold	0.10 ± 0.01	0.72 ± 0.07	0.20 ± 0.16	-0.010 ± 0.02	0.97 ± 0.13	-0.001 ± 0.0007	0.001 ± 0.0009	0.04 ± 0.01
Prosser B.	0.06 ± 0.005	0.84 ± 0.09	0.20 ± 0.18	0.08 ± 0.03	0.97 ± 0.16	0.0001 ± 0.001	0.004 ± 0.001	0.006 ± 0.003
ALE	0.05 ± 0.005	0.77 ± 0.08	0.49 ± 0.18	0.04 ± 0.03	0.96 ± 0.14	-0.00008 ± 0.0008	0.001 ± 0.0008	0.007 ± 0.002
Benton City	0.04 ± 0.005	0.63 ± 0.07	0.45 ± 0.17	0.03 ± 0.02	0.63 ± 0.13	-0.0002 ± 0.0005	0.002 ± 0.0007	0.009 ± 0.003
Berg Ranch	0.03 ± 0.003	0.50 ± 0.07	0.11 ± 0.16	-0.04 ± 0.02	0.56 ± 0.13	-0.0006 ± 0.0004	0.003 ± 0.0008	0.01 ± 0.005
Wahluke #2	0.05 ± 0.005	0.39 ± 0.06	0.04 ± 0.14	-0.005 ± 0.02	0.24 ± 0.11	-0.0004 ± 0.0004	0.001 ± 0.0005	0.02 ± 0.006
Yakima B.	0.06 ± 0.005	0.54 ± 0.06	0.22 ± 0.13	0.02 ± 0.02	0.62 ± 0.11	0.0006 ± 0.0006	0.002 ± 0.0008	0.12 ± 0.04
Sunnyside	0.19 ± 0.02	0.37 ± 0.06	0.14 ± 0.13	0.03 ± 0.02	0.47 ± 0.11	-0.0007 ± 0.0004	0.003 ± 0.0008	0.01 ± 0.005

Results of the special survey which analyzed the C-14 content in woody sagebrush stems indicated that concentrations did not significantly increase for any time period at off-site locations during the operation of Hanford fuel reprocessing facilities (PNL-3766, p. iii).

Samples from the post-nuclear time period showed a 30% increase in C-14 content over pre-1944 samples, primarily due to worldwide fallout from nuclear weapons testing (PNL-3766, p. iii).

Ring samples from Hanford for the 1956-1972 time period contained greater quantities of C-14 than any other sample period or location (PNL-3766, p. 5).

Samples from on-site near the PUREX facility indicated C-14 content was four times greater than normal (PNL-3766, p. iii).

Content of C-14 found in sagebrush stems (PNL-3766, p. 6):

(dpm/g of carbon)

Location	Pre-1944	1944-1978	1944-1972	1973-1978	1946-1955	1956-1972	1973-1979
Moxee, WA	13.2 (9.4%)	17.8 (15%)					
Benton City, WA (Horn Road)	13.3 (3.9%)		16.6 (13%)	18.0 (5.6%)			
Hanford, WA (PUREX Plant)	13.6 (18%)				12.7 (24%)	67.2 (20%)	17.2 (32%)

References

PNL-3766. Price, K. R. 1981. *Carbon-14 in Sagebrush on the Hanford Site and Vicinity.* Pacific Northwest Laboratory, Richland, Washington.

PNL-4211. Sula, M. J., W. D. McCormack, R. L. Dirkes, K. R. Price, and P. A. Eddy. 1982. *Environmental Surveillance at Hanford for CY-1981.* Pacific Northwest Laboratory, Richland, Washington.

PNL-4212. Sula, M. J., P. J. Blumer, and R. L. Dirkes. 1982. *Environmental Status of the Hanford Site for CY-1981.* Pacific Northwest Laboratory, Richland, Washington.

Available documents reviewed in which no vegetation data were found: PNL-3766, PNL-4211, PNL-4212, PNL-4010, PNL-3647, PNL-3731, PNL-4237.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1982

Media Sampled

Routine vegetation sampling was performed at locations within the Hanford reservation and near to and distant to its perimeter. The most broadly distributed type of vegetation found on-site consists of the sagebrush/ cheatgrass/bluegrass community (PNL-4658, p. 3). Vegetation samples included a mixture of sagebrush, bitterbrush, and rabbitbrush, collected in proportion to their natural relative abundance at each sampling location (PNL-4657, p. 37; PNL-4658, p. 34). Samples were collected from undisturbed, non-irrigated locations (PNL-4657, p. 37). Vegetation samples were collected by cutting a small amount of recent growth from a sufficient number of plants in the area to make up a 1 kg sample. This was then dried and ground, and aliquots were taken for analysis (PNL-4657, p. 37). Samples were analyzed for Cs-137, Sr-90, Pu, and U (PNL-4657, p. 37; PNL-4658, p. 36) and Co-60, Eu-154, and Am-241 (PNL-4658, p. 36). Gamma-emitting radionuclides were determined by a direct count on a Ge(Li) detector with a multichannel pulse-height analyzer (PNL-4658, p. A.2). The majority of the samples were analyzed for radionuclide contamination by the United States Testing Company, Inc., Richland, Washington (PNL-4657, p. 1).

Green leafy vegetables, such as spinach, leaf lettuce, turnip greens, and mustard greens were obtained during the summer from gardens within the sampling areas (PNL-4657, p. 25). Three replicate samples, each composed of mixtures of the edible portions, were obtained and analyzed for Sr-90 and Cs-137 (PNL-4657, p. 25).

Fruit samples, including apples, cherries, and grapes, were collected during their respective picking times, and analyzed for H-3, Sr-90, and Cs-137. Three replicate samples were collected from each location, and only the edible portions were analyzed (PNL-4657, p. 25).

Three replicate samples of field-dried wheat and alfalfa were collected following the final cutting of the growing season, and analyzed for Sr-90 and Cs-137 (PNL-4657, p. 26).

A special study was conducted to estimate the concentrations of uranium and other heavy metals in soil and vegetation samples collected across the Columbia River from the 300 Area due to wind transport (PNL-4466, p. 2). Vegetation at each of the sampling sites consisted of rabbitbrush and sagebrush, with the exception of Riverview and Yakima Barricade, which was comprised exclusively of sagebrush (PNL-4466, p. 6). Vegetation samples consisted of approximately 100 g of recent growth cut from sagebrush or rabbitbrush shrubs, in direct proportion to their occurrence on the site. Samples were dried at 60°C and ground, and aliquots for uranium and heavy metal analyses, 5 g and 1 g, respectively, were taken. Fluorometric and atomic absorption methods were used in the analyses (PNL 1466, p. 9).

Sampling Locations

Native perennial vegetation samples were collected from both on-site and off-site locations. Sites included Riverview, Byer's Landing, Sagemoor, Taylor Flats #2, west end of Fir Road, Ringold, Berg Ranch, Wahluke #2, Vernita Bridge, Yakima Barricade, Rattlesnake Springs, ALE, Prosser Barricade, south of the 300 Area, Benton City, Sunnyside, 1 mile northeast of N Area, 1 mile east of N Area, 100-Area Fire Station, 200 ENC, 1.25 mile east of Purex, 200-East Hill, 2 miles south of Purex, 3 miles south-southwest of Purex, east of 200 W, 2 miles south of 200 W, northeast of FFTF, southeast of FFTF, north of 300 Area, Hanford townsite, and Wye Barricade (PNL-4658, p. 36; PNL-4657, p. 40).

Fruit samples were collected from the Sagemoor, Cold Creek, and Sunnyside areas (PNL-4657, p. 28).

Samples of leafy vegetables were collected from the Wahluke East Area, Sagemoor Area, Riverview Area, Benton City Area, Sunnyside Area, and Moses Lake Area (PNL-4657, p. 28).

Wheat and alfalfa samples were collected from the Sagemoor, Wahluke East, Benton City, Sunnyside, and Moses Lake Areas (PNL-4657, p. 29).

Vegetation samples collected as part of the special uranium and heavy metals survey were collected from the area directly across the Columbia River from the 300 Areas, a site near the Exxon Facility, Riverview, Prosser Barricade, Yakima Barricade, and Sunnyside (PNL-4466, p. 3, 6).

Significant Events/Emission Quantities

The N Reactor, which utilized a closed primary cooling loop, was the only remaining plutonium-production reactor in operation during 1982. This reactor also supplied steam for electrical power generation (PNL-4657, p. 4; PNL-4658, p. 5, 6).

Iodine-131 was not identified in any air sample during 1982 (PNL-4658, p. v).

Most foodstuff samples were found to contain low-levels of fallout radionuclides, but there was no indication that the radioactivity present was associated with Hanford operations (PNL-4657, p. v).

Radionuclide concentrations in vegetation were similar to those of previous years, except for the lack of short-lived fallout radionuclides. No geographical patterns were apparent and any Hanford contribution to radionuclide concentrations on vegetation was negligible compared to contributions from world-wide sources (PNL-4657, p. 39).

There were four unplanned airborne releases in 1982 (PNL-4658, p. 52).

There were five unplanned occurrences involving liquid wastes in 1982 (PNL-4658, p. 53).

Constituents Measured/Reported

Analytical results were reported in table form in units of pCi/g (PNL-4657, p. 28, 29, 40; PNL-4658, p. 36; PNL-4466, p. 28).

There was no distinct difference in radionuclide concentrations apparent in samples of alfalfa and wheat collected from near the site compared to those collected from distant locations (PNL-4657, p. 27).

Cesium-137 was generally not detectable in any of the fruit samples collected (PNL-4657, p. 26).

Concentrations of radionuclides observed in leafy vegetable samples (PNL-4657, 28):

(Units of pCi/g, wet weight)

Location	Sr-90		Cs-137	
	Maximum	Average	Maximum	Average
Wahluke East Area	0.009 ± 0.003	0.007 ± 0.003	0.10 ± 0.05	0.07 ± 0.05
Sagemoor Area	0.007 ± 0.002	0.005 ± 0.004	0.05 ± 0.04	0.03 ± 0.04
Riverview Area	0.021 ± 0.003	.005 ± 0.007	0.03 ± 0.02	0.02 ± 0.02
Benton City Area	0.007 ± 0.001	0.007 ± 0.003	< DL[a]	<0.02
Sunnyside Area	0.003 ± 0.0006	0.003 ± 0.0008	0.10 ± 0.03	0.03 ± 0.09
Moses Lake Area	0.019 ± 0.002	0.011 ± 0.010	0.09 ± 0.04	0.03 ± 0.09

(a) DL = detection limit.

Concentrations of radionuclides observed in fruit samples (PNL-4657, p. 2):

(Concentrations in Units of pCi/g, wet weight)

Fruit/Location	Cs-137		Sr-90		H-3	
	Maximum	Average	Maximum	Average	Maximum	Average
Apples						
Sagemoor Area	<DL[a]	<0.008	<DL	<0.001	500±310	350±290
Cold Creek Area	<DL	<0.008	0.003±0.001	0.0005±0.004	340±140	250±180
Sunnyside Area	<DL	<0.007	0.004±0.001	0.003±0.002	<DL	<350
Cherries						
Sagemoor Area	0.025±0.017	-0.002±0.037	0.002±0.0004	0.001±0.0005	200±160	190±110
Sunnyside Area	<DL	<0.017	0.001±0.0004	-0.0006±0.004	470±140	420±110
Grapes						
Sagemoor Area	<DL	<0.006	0.005±0.003	0.004±0.002	390±260	270±180
Cold Creek Area	<DL	0.005			510±280	280±290
Sunnyside Area	<DL	0.005	<DL	<0.007	480±260	420±160

(a) DL = detection limit.

Radionuclide concentrations observed in wheat and alfalfa samples (PNL-4657, p. 29):

(Concentrations in Units of pCi/g, wet weight)

Location	Sr-90		Cs-137	
	Maximum	Average	Maximum	Average
Wheat				
Wahluke East Area	0.005±0.004	0.004±0.002	<DL[a]	<0.016
Sagemoor Area	0.008±0.002	0.008±0.002	<DL	<0.014
Benton City Area	0.006±0.002	0.005±0.002	0.007±0.004	0.0007±0.01
Sunnyside Area	0.018±0.011	0.011±0.009	0.005±0.005	0.004±0.007
Moses Lake Area	0.006±0.003	0.004±0.002	0.012±0.011	0.008±0.009
Alfalfa				
Wahluke East Area	0.014±0.002	0.009±0.008	<DL	<0.03
Sagemoor Area	0.16±0.013	0.12±0.04	0.21±0.13	0.15±0.14
Benton City Area	0.10±0.01	0.097±0.013	0.016±0.011	0.010±0.014
Sunnyside Area	0.032±0.004	0.029±0.005	0.019±0.014	0.005±0.030
Moses Lake Area	0.038±0.007	0.032±0.011	0.026±0.023	0.022±0.035

(a) DL = detection level.

Radionuclide concentrations observed in vegetation samples (PNL-4657, p. 40):
(Concentrations in units of pCi/g, dry weight)

Location	Sr-90	Cs-137	Pu-239,240	U
Riverview	0.01 ± 0.002	<0.03	<0.0007	0.02 ± 0.006
Byer's Landing	0.008 ± 0.002	0.08 ± 0.06	<0.0008	0.04 ± 0.01
Sagemoor	0.01 ± 0.004	0.05 ± 0.03	<0.0004	0.02 ± 0.006
Taylor Flats #2	0.06 ± 0.003	<0.04	<0.0004	0.03 ± 0.009
W. End Fir Rd.	0.05 ± 0.005	<0.04	<0.0009	0.03 ± 0.01
Ringold	<0.019	<0.08	<0.0004	0.03 ± 0.01
Berg Ranch	0.04 ± 0.002	0.05 ± 0.04	<0.0004	<0.06
Wahluke #2	0.01 ± 0.004	<0.07	0.003 ± 0.0008	0.01 ± 0.005
Vernita Bridge	0.03 ± 0.003	0.09 ± 0.03	0.002 ± 0.0009	0.01 ± 0.005
Yakima Barricade	0.05 ± 0.01	<0.02	0.002 ± 0.001	0.01 ± 0.003
Rattlesnake Springs	0.024 ± 0.004	0.03 ± 0.02	0.0004 ± 0.0003	0.004 ± 0.001
ALE	0.05 ± 0.005	0.03 ± 0.02	<0.0006	0.008 ± 0.003
Prosser Barricade	0.05 ± 0.02	<0.02	<0.0005	0.01 ± 0.003
S. of 300 Area	0.03 ± 0.004	0.02 ± 0.01	0.001 ± 0.0007	0.006 ± 0.002
Benton City	0.05 ± 0.008	<0.08	0.001 ± 0.0009	0.01 ± 0.004
Sunnyside	0.005 ± 0.003	0.04 ± 0.02	0.001 ± 0.0008	0.01 ± 0.005

There were no statistically significant differences between the study area across the Columbia River from the 300 Area and control sites for concentrations of uranium and heavy metals detected in vegetation samples (PNL-4466, p. 28).

The range of uranium (in pCi/g) and heavy metals (in ppm) detected in vegetation samples collected from the study area across the Columbia River from the 300 Area and control sites (PNL-4466, p. 28):

Element	Study Area	Control Sites
Lead	0.5 to 4.5ppm	3.8 to 5.3ppm
Silver	0.19 to 0.48ppm	0.23 to 0.58ppm
Zinc	16 to 37ppm	17 to 32ppm
Copper	7.4 to 17.6ppm	4.5 to 11.9ppm
Uranium	0.005 to 0.054pCi/g	0.008 to 0.059pCi/g

Radionuclide concentrations found in vegetation samples collected from on-site locations during 1982 (PNL-4658, p. 36):

(Concentrations in units of pCi/g, dry weight)

Location	Co-60	Sr-90	Cs-137	Eu-154	Pu-239,240	Am-241	U-total
1 Mile NE of N Area	<0.09	0.03±0.002	<0.06	0.27±0.13	<0.0004		0.01±0.005
1 Mile E of N Area	0.26±0.09	0.05±0.005	0.09±0.07	<0.19	0.0012±0.0010		0.02±0.007
100 Area Fire Station	<0.08	0.05±0.007	<0.07	0.45±0.18	<0.0004		0.008±0.003
200 ENC	<0.06	0.10±0.02	0.23±0.05	<0.18	<0.0007	<0.03	0.006±0.002
1.25 Mile E of PUREX	<0.12	0.14±0.009	0.37±0.13	0.39±0.34	0.0008±0.0007	0.03±0.02	0.01±0.005
200 East Hill	<0.07	.03±0.003	0.08±0.05	<0.15	<0.0006	<0.03	0.006±0.002
2 Miles S of PUREX	<0.05	0.17±0.005	0.05±0.04	0.12±0.10	<0.0006	<0.03	0.01±0.004
3 Miles SSW of PUREX	<0.04	0.05±0.003	0.05±0.02	<0.09	<0.0006	<0.02	0.01±0.003
E of 200 West	0.12±0.08	0.07±0.005	<0.04	<0.22	0.004±0.0008	<0.03	0.01±0.004
2 Miles S of 200 W	<0.07	0.05±0.003	<0.06	<0.18	<0.0007	<0.02	0.01±0.003
NE of FFTF	0.09±0.06	0.009±0.002	<0.04	0.17±0.16	<0.001		0.002±0.0008
SE of FFTF	<0.04	0.02±0.002	<0.02	<0.07	<0.0004		0.007±0.002
N of 300 Area	<0.08	0.008±0.001	<0.05	<0.16	0.003±0.0007		0.01±0.005
S of 300 Area	<0.03	0.03±0.004	0.02±0.01	<0.09	0.001±0.0007		0.006±0.002
Hanford Townsite	<0.04	0.06±0.003	0.07±0.02	<0.10	0.0004±0.0003	0.01±0.002	0.01±0.004
Wye Barricade	<0.07	0.04±0.008	0.07±0.06	<0.20	<0.0008	<0.03	0.005±0.002

References

PNL-4657. Sula, M, J., J.M.V. Carlile, K. R. Price, and W. D. McCormack. 1983. *Environmental Surveillance at Hanford for CY 1982.* Pacific Northwest Laboratory, Richland, Washington.

PNL-4658. Sula, M. J., P. J. Blumer, R. L. Dirkes, and J.M.V. Carlile. 1983. *Environmental Status of the Hanford Site for CY 1982.* Pacific Northwest Laboratory, Richland, Washington.

PNL-4466. Price, K. R., and R. R. Kinnison. 1982. *Uranium and Other Heavy Metals in Soil and Vegetation from the Hanford Environs.* Pacific Northwest Laboratory, Richland, Washington.

Available documents reviewed in which no vegetation data were found: PNL-4657, PNL-4658, PNL-4466, PNL-3777, PNL-4420, PNL-4659.

Vegetation Radionuclide Contamination Overview for Hanford and Vicinity 1983

Media Sampled

Routine vegetation sampling was performed at locations within the Hanford reservation and locations near to and distant to its perimeter. The mostly broadly distributed type of vegetation on the Hanford site is the sagebrush/cheatgrass/bluegrass community (PNL-5038, p. 2; PNL-5039, p. 3). Samples of mature perennial vegetation (rabbitbrush, sagebrush, and bitterbrush) were collected from undisturbed, non-irrigated locations in proportions relative to their natural abundance at each site (PNL-5038, p. 33; PNL-5039, p. 31). Samples were analyzed for gamma-emitting radionuclides, Sr-90, Pu, and U (PNL-5039, p. 31). Radionuclide analyses of most samples were performed by United States Testing Company, Inc., Richland, Washington; some analyses were performed by Pacific Northwest Laboratories (PNL-5038, p. 1). Samples were analyzed for gamma-emitting radionuclides by a direct count of the sample on a Ge(Li) detector with a multichannel pulse height analyzer (PNL-5038, p. C.2). Strontium-90 concentrations were determined using a low-background gas flow proportional counter (PNL-5038, p. C.1). Plutonium concentrations were determined with the use of an alpha spectrometer, while uranium concentrations were determined with a fluorometer (PNL-5038, p. C.1).

Samples of foodstuffs, including wheat, alfalfa, leafy vegetables and fruits, were collected from several locations in the vicinity of Hanford during 1983. Samples were collected primarily from sites downwind of the reservation, to assess any potential Hanford impact. Samples were also collected from upwind locations somewhat distant to the site to provide information on radioactivity levels that could be attributed to worldwide fallout (PNL-5038, p. 22). Samples of leafy vegetables (spinach, leaf lettuce, turnip greens, and mustard greens) were obtained once during the summer from gardens within the sampling area. Three replicate samples, each composed of mixtures of the edible portions of the various leafy vegetables grown at the sampling location, were obtained and analyzed for Cs-137 and Sr-90 (PNL-5038, p. 22). Three replicate samples of cherries, apples, or grapes were collected at respective picking times at each sampling location and edible portions were analyzed for Cs-137, Sr-90, and H-3 (PNL-5038, p. 22). Three replicate samples of wheat and alfalfa were collected from sampling locations following the final cutting of the growing season and analyzed for Sr-90 and Cs-137. Samples for 1983 were reported on a dry weight basis to eliminate any effect due to moisture content (PNL-5038, p. 23, 24).

Sampling Locations

Native perennial vegetation samples were collected from locations to include 1 mile northeast of N Area; 1 mile east of N Area; 100-Area Fire Station; 200 ENC; east of 200 E; 200 ESE; southwest of 200-BC Cribs; south of 200 E; east of 200 W; Army Loop Camp; northeast of FFTF; southeast of FFTF; north of 300 Area; south of 300 Area; Hanford Townsite; Wye Barricade; Riverview; Byer's Landing; Sagemoor; Taylor Flats #2; west end of Fir Road; Ringold; Berg Ranch; Wahluke #2;

Vernita Bridge; Yakima Barricade; Rattlesnake Springs; ALE; Prosser Barricade; Benton City; and Sunnyside (PNL-5038, p. 35; PNL-5039, p. 33).

Samples of leafy vegetables were collected from the Wahluke East, Sagemoor, Riverview, Benton City, Sunnyside, and Moses Lake Areas (PNL-5038, p. 25).

Fruit samples were collected from the Sagemoor, Cold Creek, and Sunnyside Areas (PNL-5038, p. 25).

Wheat and alfalfa samples were collected from the Wahluke East, Sagemoor, Benton City, Sunnyside, Moses Lake, and Riverview Areas (PNL-5038, p. 26).

Significant Events/Emission Quantities

The N Reactor, which utilized a closed primary cooling loop, was the only plutonium-production reactor in operation during 1981. This reactor also supplied steam for electrical power generation (PNL-5038, p. 3; PNL-5039, p. 5,6).

Levels of airborne particulate radioactivity in the Hanford environs were lower in 1983 than in 1982, as worldwide fallout levels declined (PNL-5039, p. v).

I-131 was not identified in any air sample in 1983 (PNL-5039, p. v).

Low levels of radionuclides were observed in most foodstuff samples and was attributed to worldwide fallout. No geographical pattern was observed and there was no indication that the concentrations observed were associated with Hanford operations (PNL-5038, p. v, 33).

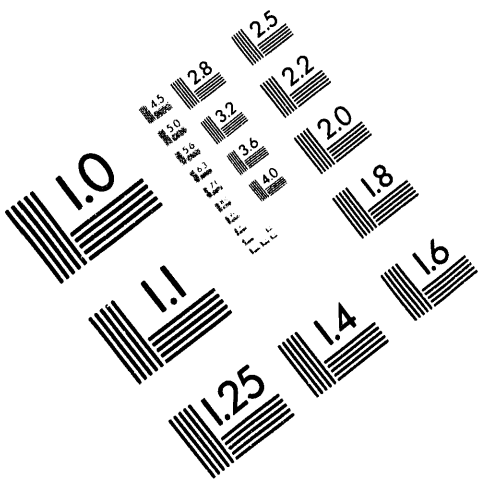
During 1983, there was no indication of a detectable Hanford contribution to radionuclide concentrations in off-site vegetation samples (PNL-5038, p. 33).Trace concentrations of radionuclides associated with worldwide fallout were observed in all vegetation samples collected both upwind and downwind of the Hanford site (PNL-5038, p. 33).

Constituents Measured/Reported

Analytical results were reported in table form in units of pCi/g (PNL-5038, p. 25, 26, 35; PNL-5039, p. 33).

Foodstuffs collected from the Riverview area were irrigated with Columbia River water, and provided information regarding radionuclide concentrations potentially attributable to Hanford operations (PNL-5038, p. 22).

Apples were found to have slightly higher tritium concentrations than other fruits (PNL-5038, p. 23).



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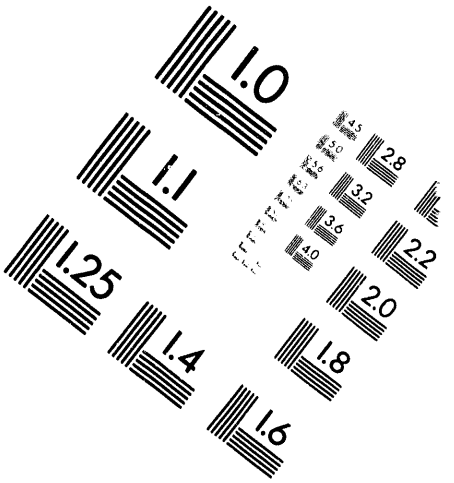

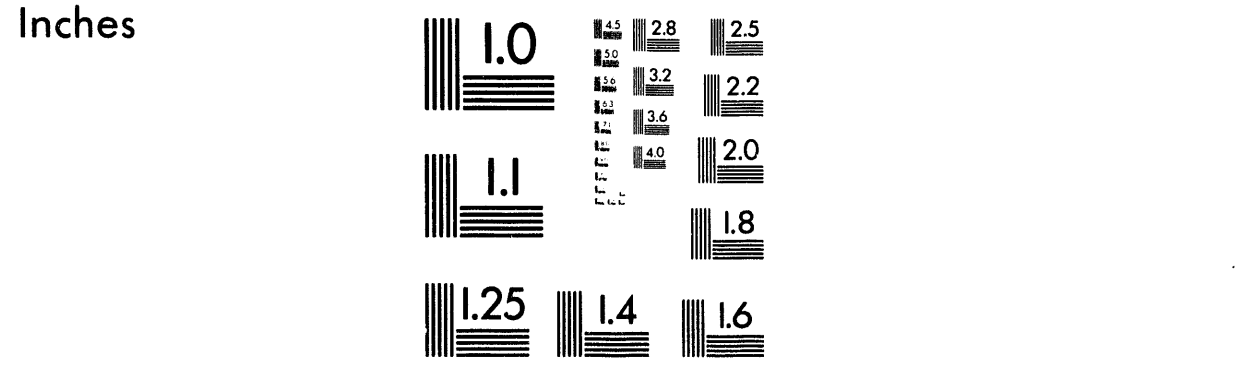

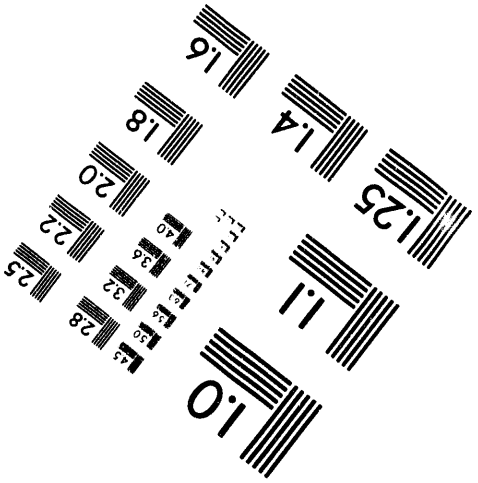

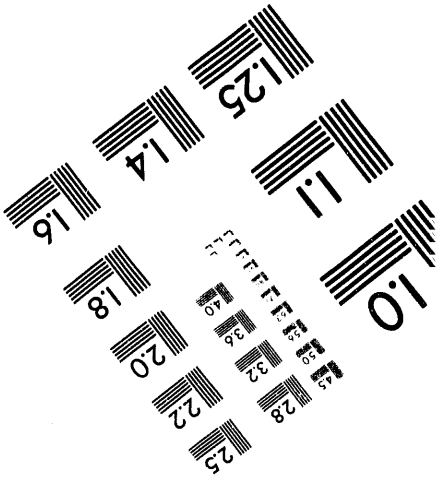

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Cesium-137 was generally not detectable in fruit samples (PNL-5038, p. 23).

Concentrations of radionuclides observed in leafy vegetable samples (PNL-5038, p.25):

(Concentrations in units of pCi/g, wet weight)

Location	Sr-90		Cs-137	
	Maximum	Average	Maximum	Average
Wahluke East Area	0.004±0.002	0.001±0.005	0.025±0.018	0.019±0.013
Sagemoor Area	0.003±0.003	0.001±0.003	<DL(a)	0.002±0.010
Riverview Area	0.038±0.004	0.031±0.010	0.016±0.014	0.007±0.014
Benton City Area	0.020±0.002	0.016±0.005	<DL	-0.002±0.007
Sunnyside Area	0.015±0.002	0.006±0.009	<DL	0.003±0.008
Moses Lake Area	0.015±0.002	0.010±0.005	<DL	0.007±0.008

(a) DL = detection level.

Concentrations of radionuclides observed in fruit samples (PNL-5038, p. 25):

Concentrations in units of pCi/g, wet weight)

Location	Cs-137		Sr-90		H-3	
	Maximum	Average	Maximum	Average	Maximum	Average
Apples						
Sagemoor Area	<DL[a]	-0.002±0.004	0.010±0.005	0.005±0.007	1400±930	970±760
Cold Creek Area	<DL	0.003±0.005	0.005±0.002	0.004±0.002	<DL	650±530
Sunnyside Area	<DL	0.0008±0.006	0.006±0.0008	0.004±0.003	500±220	360±190
Cherries						
Sagemoor Area	<DL	0.006±0.007	0.006±0.002	0.003±0.004	250±210	140±180
Sunnyside Area	<DL	-0.010±0.008	0.007±0.002	0.003±0.005	<DL	66±120
Grapes						
Sagemoor Area	<DL	0.002±0.003	0.010±0.002	0.009±0.002	350±200	170±270
Cold Creek Area	<DL	-0.0004±0.002	0.010±0.003	0.006±0.004	200±200	120±180
Sunnyside Area	<DL	0.002±0.004	0.008±0.002	0.004±0.007	<DL	340±320

(a) DL = detection level.

Concentrations of radionuclides observed in wheat and alfalfa samples (PNL-5038, p. 26):

(Concentrations in Units of pCi/g, dry weight)

Location	Sr-90		Cs-137	
	Maximum	Average	Maximum	Average
Wheat				
Wahluke East Area	0.015±0.0028	0.0097±0.0089	0.0076±0.0059	0.0025±0.0072
Sagemoor Area	0.015±0.0039	0.011±0.0068	<DL	-0.00066±0.0027
Benton City Area	0.0039±0.00071	0.0018±0.0031	0.0080±0.0044	0.0021±0.0087
Sunnyside Area	0.011±0.0025	0.0078±0.0052	<DL	-0.0033±0.0035
Moses Lake Area	0.0099±0.0026	0.0093±0.0019	<DL	0.0013±0.0034
Riverview Area	0.016±0.0021	0.012±0.0064	<DL	0.00024±0.00026
Alfalfa				
Wahluke East Area	0.11±0.0047	0.066±0.051	0.046±0.036	0.015±0.050
Sagemoor Area	0.025±0.0022	0.020±0.0078	<DL	0.016±0.029
Benton City Area	0.068±0.0052	0.052±0.028	0.053±0.032	0.041±0.031
Sunnyside Area	0.12±0.0060	0.072±0.056	<DL	-0.0086±0.030
Moses Lake Area	0.054±0.0061	0.040±0.016	<DL	-0.021±0.024
Riverview Area	0.068±0.0038	0.061±0.011	<DL	-0.0034±0.020

(a) DL = detection level.

Concentrations of radionuclides observed in on-site vegetation samples (PNL-5039, p. 33):

(Concentrations in Units of pCi/g, dry weight)

Location	Sr-90	Cs-137	Pu-239/240	U-Total
1 Mile NE of N Area	0.11±0.02	0.003±0.012	0.0±0.0	0.006±0.003
1 Mile E of N Area	0.29±0.02	0.03±0.01	0.0002±0.0005	0.007±0.003
100-Area Fire Station	0.37±0.02	0.02±0.01	0.032±0.002	0.007±0.003
200 ENC	0.63±0.02	0.18±0.01	0.0003±0.0004	0.007±0.004
E of 200 E	0.91±0.03	0.07±0.01	0.0007±0.0004	0.008±0.003
200 ESE	0.91±0.03	0.05±0.01	0.0005±0.0006	0.007±0.003
SW of 200-BC Cribs	0.53±0.02	0.02±0.01	0.0002±0.0003	0.009±0.004
S of 200 E	0.34±0.02	0.01±0.01	0.0002±0.0002	0.005±0.003
E of 200 W	0.47±0.02	0.03±0.01	0.004±0.001	0.011±0.004
Army Loop Camp	0.34±0.02	0.03±0.01	0.002±0.001	0.007±0.003
NE of FFTF	1.2 ±0.04	0.02±0.01	0.0002±0.0003	0.005±0.003
SE of FFTF	1.7 ±0.04	0.03±0.01	0.0007±0.0007	0.010±0.004
N of 300 Area	0.93±0.03	0.010±0.006	0.0005±0.0004	0.018±0.006
S of 300 Area	0.05±0.01	0.005±0.012	0.0001±0.0002	0.012±0.006
Hanford Townsite	0.29±0.02	0.0111±0.0114	0.0007±0.001	0.011±0.048
Wye Barricade	0.16±0.01	0.02±0.01	0.003±0.0002	0.008±0.004

Concentrations of radionuclides observed in perennial vegetation samples collected near and distant to Hanford reservation (PNL-5038, p. 35):

(Concentrations in Units of pCi/g, dry weight)

Location	Sr-90	Cs-137	Pu-239/240	U-(Natural)
Riverview	1.1±0.033	0.021±0.0067	0.0022±0.00086	0.014±0.0052
Byers Landing	0.12±0.0064	0.013±0.011	0.00040±0.00038	0.015±0.0056
Sagemoor	-0.0063±0.017	0.012±0.012	0.00024±0.00056	0.013±0.0048
Taylor Flats #2	0.037±0.024	0.025±0.012	0.0056±0.00036	0.016±0.0059
W. End Fir Road	0.086±0.020	0.021±0.010	0.00021±0.00029	0.020±0.0068
Ringold	0.65±0.026	0.020±0.0083	0.00±0.00	0.026±0.0089
Berg Ranch	0.023±0.027	0.014±0.0090	0.00051±0.00034	0.012±0.0048
Wahluke #2	0.018±0.016	0.020±0.0079	-0.000011±0.000022	0.011±0.0046
Vernita Bridge	0.10±0.011	0.014±0.010	0.000084±0.00032	0.013±0.0051
Yakima Barricade	0.041±0.0082	0.012±0.010	0.00038±0.00029	0.0078±0.0035
Rattlesnake Spgs	0.69±0.026	0.0037±0.0088	0.00083±0.00096	0.012±0.0047
ALE	0.017±0.023	0.0093±0.0094	0.00033±0.00028	0.0055±0.0029
Prosser Brcd.	0.021±0.022	0.011±0.0075	0.00034±0.00034	0.011±0.0045
S. of 300 Area	0.050±0.011	0.0050±0.012	0.00014±0.00021	0.012±0.0056
Benton City	0.12±0.013	0.022±0.0070	0.00069±0.00048	0.015±0.0058
Sunnyside	0.18±0.026	0.0060±0.0095	0.00031±0.00029	0.0093±0.0038

References

PNL-5038. Price, K. R., J.M.V. Carlile, R. L. Dirkes, and M. S. Trevathan. 1984. *Environmental Surveillance at Hanford for CY 1983.* Pacific Northwest Laboratory, Richland, Washington.

PNL-5039. Price, K. R., P. J. Blumer, J.M.V. Carlile, R. L. Dirkes, and M. S. Trevathan. 1984. *Environmental Status of the Hanford Site for CY 1983.* Pacific Northwest Laboratory, Richland, Washington.

Available documents reviewed in which no vegetation data were found: PNL-5038, PNL-5039, PNL-5041, PNL-4622, PNL-SA-9551.

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