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# HANFORD SITE

## ENVIRONMENTAL REPORT

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*for Calendar Year 2008*



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The cover photo shows swards of exotic purple mustard (*Chorispora tenella*) and the remains of last year's Russian thistle (*Salsola tragus*) that dominate swales in the Cold Creek Valley burned by past wildfires. At higher elevations on Rattlesnake Ridge, native perennial bunchgrasses persist after being burned and present green slopes during the spring and early summer. Photo is courtesy of S Butner, Pacific Northwest National Laboratory, Richland, Washington. The cover design is by SB Colson, Pacific Northwest National Laboratory, Richland, Washington.



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## U.S. Department of Energy Hanford Site

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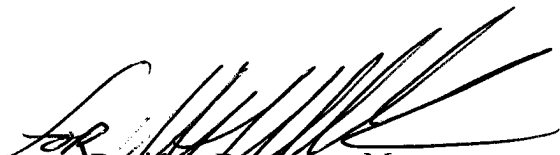
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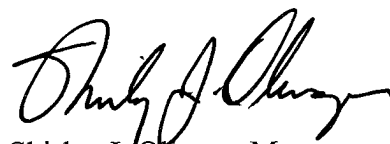
The Hanford Site Environmental Report is prepared and published annually by the U.S. Department of Energy (DOE) for distribution to local, state, and federal government agencies, Congress, the public, news media, and Hanford Site employees. This report includes information for CY 2008 but also includes some early 2009 information. The purpose of the report is to provide the reader with the most recent information available on 1) environmental monitoring efforts on and around the site, 2) Hanford Site cleanup activities, and 3) the status of the Site's compliance with federal, state, and local environmental laws and regulations.

The report was prepared for DOE by the Pacific Northwest National Laboratory (PNNL), with the support of site contractors and describes programs conducted by PNNL, a research and development laboratory; Fluor Hanford, Inc., the former project management contractor responsible for nuclear legacy cleanup and support services; CH2M HILL Plateau Remediation Company, the new plateau remediation contractor responsible for environmental cleanup on the Central Plateau; Washington Closure Hanford, LLC, the river corridor closure contractor responsible for environmental cleanup along the Columbia River Corridor; Washington River Protection Solutions, LLC, the new tank operations contractor responsible for nuclear and chemical waste stored in Hanford's 177 underground storage tanks; Bechtel National, Inc. (BNI), the contractor responsible for designing, building, and commissioning a waste treatment plant for vitrifying Hanford's tank waste; and numerous subcontractors at the Hanford Site.

If you have any questions or comments about this report, please contact us, or you may contact Dana C. Ward, Environmental Management Division, on (509) 372-1261 or by email at [Dana\\_C\\_Ward@rl.gov](mailto:Dana_C_Ward@rl.gov).



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Attachment:  
Hanford Site Environmental Report for Calendar Year 2008

# HANFORD SITE

## ENVIRONMENTAL REPORT



*for Calendar Year 2008*

(Including Some Early 2009 Information)

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September 2009

Prepared for the U.S. Department of Energy by  
personnel from the Pacific Northwest National  
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Washington River Protection Solutions, LLC

Pacific Northwest National Laboratory  
Richland, Washington



# Preface

The Hanford Site environmental report is prepared annually for the U.S. Department of Energy (DOE) in accordance with the requirements in DOE Manual 231.1-1A, “Environment, Safety, and Health Reporting Manual,” and DOE Order 231.1A, “Environment, Safety, and Health Reporting.” The report provides an overview of activities at the Hanford Site; demonstrates the status of the site’s compliance with applicable federal, state, and local environmental laws and regulations, permits, executive orders, and DOE policies and directives; and summarizes environmental data that characterize site environmental management performance. The report also highlights significant environmental and public protection programs and efforts. Some historical and early 2009 information is included where appropriate. More detailed environmental compliance, monitoring, and surveillance information is provided in additional reports referenced in the text.

Although this report was primarily written to meet DOE reporting requirements and guidelines, it is also intended to provide a broad spectrum of environmental information to DOE managers, the public, Native Americans, public officials, regulatory agencies, Hanford Site contractors, and elected officials. Appendix A lists helpful information to aid the reader, including scientific notation, units of measure, unit conversion information, and nomenclature. Appendix B is a glossary of terms.

The Pacific Northwest National Laboratory’s Public Safety and Resource Protection Project produced this report for the DOE Richland Operations Office. Battelle Memorial Institute (Battelle) operates the Pacific Northwest National Laboratory for DOE. Battelle is a non-profit, independent, science and technology contract research institute. Personnel

from the Pacific Northwest National Laboratory and Fluor Hanford, Inc. and its principal subcontractors wrote major portions of the report. Washington Closure Hanford, LLC; Bechtel National, Inc.; CH2M HILL Plateau Remediation Company; and Washington River Protection Solutions, LLC also prepared or provided significant input to selected sections.

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## Report Availability

This environmental report was produced in both paper and electronic formats. The paper formats include this technical report, two supplemental data appendixes, and a less-detailed summary report (PNNL-18427-SUM). The report is available in portable document format (PDF) on compact disk and electronically at the following website: <http://hanford-site.pnl.gov/envreport>. Report copies are also available at libraries in communities near the Hanford Site, at several university libraries in Washington and Oregon, and at the DOE’s Public Reading Room located at the Washington State University Tri-Cities Consolidated Information Center in Richland, Washington. All versions of the report can be obtained from JP (Joanne) Duncan, Pacific Northwest National Laboratory, P.O. Box 999, MS K6-85, Richland, Washington, 99352 ([joanne.duncan@pnl.gov](mailto:joanne.duncan@pnl.gov)), while supplies last.



# Summary

JP Duncan

Each year, the U.S. Department of Energy (DOE) prepares this integrated Hanford Site Environmental Report in accordance with DOE Order 231.1A, "Environment, Safety and Health Reporting." This report is designed to inform the public, regulators, stakeholders, and other interested parties of Hanford Site environmental performance for the 2008 calendar year. Individual sections are designed to provide detail on the following:

- The Hanford Site and its mission
- Hanford Site compliance with all applicable DOE, federal, state, and local regulations
- Status and results of Hanford Site cleanup and remediation activities
- Hanford Site environmental management performance
- Hanford Site environmental and groundwater monitoring programs and monitoring data findings
- Potential radiation doses to onsite staff and the public residing in the Hanford Site vicinity
- Data quality assurance methods.

The current mission of DOE at the Hanford Site includes site cleanup and remediation and reduction in land size. DOE directs that all activities be performed in compliance with applicable federal, state, and local laws and regulations; DOE Orders; Secretary of Energy Notices; and directives, policies, and guidelines from DOE Headquarters.

## Compliance with Federal, State, and Local Laws and Regulations in 2008

A key feature in the Hanford Site compliance program is the *Hanford Federal Facility and Consent Order*, also known as the Tri-Party Agreement. The Tri-Party Agreement is an agreement among the Washington State Department of Ecology, the U.S. Environmental Protection Agency (EPA), and DOE to achieve compliance with the remedial action provisions in the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and with treatment, storage, and disposal unit regulations and corrective action provisions in the *Resource Conservation and Recovery Act of 1976* (RCRA). The Tri-Party Agreement has evolved to meet changing conditions as site cleanup requirements have progressed. During 2008, there were 52 specific Tri-Party cleanup milestones scheduled for completion: 42 were completed on or before their required due dates, 1 was completed beyond the established due date, 2 were extended to beyond 2008, and 7 were not yet complete at the end of 2008. During 2008, 21 negotiated change requests to the Tri-Party Agreement were approved.

Compliance with federal acts on Hanford Site work activities conducted in 2008 is summarized in Table S.1 and discussed in detail in Chapters 3 and 5 of this report.

## Hanford Site Cleanup Operations

In 1996, when Hanford Site cleanup activities began, the primary focus was on former liquid effluent sites. Progress

**Table S.1. Status of Compliance with Federal Acts on the Hanford Site in 2008**

<b>Regulation</b>	<b>What It Covers</b>	<b>2008 Status</b>
<i>American Indian Religious Freedom Act; Antiquities Act of 1906; Archaeological and Historic Preservation Act of 1974; Archaeological Resources Protection Act of 1979; Historic Sites, Buildings, and Antiquities Act; National Historic Preservation Act of 1966; and Native American Graves Protection and Repatriation Act of 1990</i>	Cultural resources.	During 2008, 113 cultural resource reviews were requested on the Hanford Site. DOE determined that 103 activities would not affect cultural resources and were exempt from further review; 10 requests required full reviews. Forty-five cultural resources sites were visited in 2008 to assess the effects of erosion, weathering, and unauthorized excavation and collection. Fifteen new archaeological sites and 15 new isolated finds were recorded on the Hanford Site in 2008.
<i>Atomic Energy Act of 1954</i>	Proper management of radioactive materials.	In 2008, six DOE regulations and directives pertaining to the management and control of radioactive materials on the Hanford Site were issued or underwent significant revision. In addition, six technical standards or handbooks underwent significant revision.
<i>Clean Air Act</i>	Air quality, including emissions from facilities and unmonitored sources.	In coordination with the Washington State Department of Health and the Benton Clean Air Agency, the Washington State Department of Ecology issued Renewal 1 of the Hanford Site air operating permit for a period of 5 years, effective January 1, 2007. One revision to the air operating permit was approved in 2008. The Washington State Department of Health, the Washington State Department of Ecology, and the Benton Clean Air Agency conducted over 25 inspections in 2008.
<i>Clean Water Act of 1977</i>	Point-source discharges to U.S. surface waters.	The Hanford Site has one National Pollutant Discharge Elimination System permit, one storm water permit, and several state sanitary wastewater discharge permits. There were no permit violations in 2008.
<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)</i>	Sites already contaminated by hazardous materials.	Institutional controls are implemented and maintained in accordance with CERCLA decision documents. During 2008, field inspections of institutional controls at waste sites were performed in the 100-IU-2 and 100-IU-6 Operable Units, three burial grounds in the 300-FF-2 Operable Unit, and at the Environmental Restoration Disposal Facility. Warning sign information was updated at two of the inactive burial grounds in the 300 Area in response to this inspection. Trespass events and excavation permit use were reviewed in 2008; no findings were identified.
<i>Emergency Planning &amp; Community Right-to-Know Act of 1986</i>	The public's right to information about hazardous materials in the community and the establishment of emergency planning procedures.	In early 2009, Hanford Site officials issued the <i>2008 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory</i> report to the Washington State Department of Ecology's Community Right-To-Know Unit; local emergency planning committees for Benton, Franklin, and Grant Counties; and both the city of Richland and Hanford Site fire departments. The <i>2008 Hanford Site Toxic Chemical Release Inventory</i> was released in June 2009.
<i>Endangered Species Act of 1973</i>	Rare plant and animal species.	Numerous plants and animals on the Hanford Site are federal- or state-listed as endangered, threatened, sensitive, or candidate species. Ecological compliance reviews are conducted prior to project initiation on the Hanford Site to prevent adverse impacts to biological resources, including listed species. In 2008, 202 reviews were performed, including 91 ecological compliance reviews for general site activities and 111 reviews for environmental restoration activities.
<i>Federal Insecticide, Fungicide, and Rodenticide Act of 1975</i>	Storage and use of pesticides.	On the Hanford Site, pesticides are applied by commercial pesticide operators licensed by the state.
<i>Migratory Bird Treaty Act</i>	Migratory birds or their feathers, nests, or eggs.	All Hanford Site projects with a potential to affect federal- or state-listed species of concern complied with the requirements of this act by using the ecological compliance review process to minimize adverse impacts to migratory birds.

Table S.1. (contd)

<b>Regulation</b>	<b>What It Covers</b>	<b>2008 Status</b>
<i>National Environmental Policy Act of 1969 (NEPA)</i>	Environmental impact statements for major federal projects that have the potential to significantly affect the quality of the human environment.	In October 2008, DOE released the <i>Draft Global Nuclear Energy Partnership Programmatic Environmental Impact Statement</i> , providing an analysis of the potential environmental consequences of alternatives to the present open fuel cycle, in which nuclear fuel is used one time and sent to geologic disposal. A supplemental analysis to the 1999 <i>Hanford Comprehensive Land-Use Plan Environmental Impact Statement</i> was issued in August 2008. The <i>Draft Planning Report/Environmental Impact Statement Yakima River Basin Water Storage Feasibility Study, Yakima Project, Washington</i> , was released in January 2008; the final version was published in December 2008 for public comment. The <i>Final Conservation Plan and Environmental Impact Statement for the Hanford Reach National Monument</i> was issued in August 2008; the Record of Decision was issued in November 2008. Two draft environmental impact statements were in preparation in 2008: 1) the environmental impact statement for the disposal of greater-than-Class-C low-level radioactive waste; and 2) the Tank Closure and Waste Management Environmental Impact Statement.
<i>Pollution Prevention Act of 1990</i>	Reduction or prevention of wastes by treatment, control, reuse, and/or recycling.	In 2008, 1,530 metric tons (1,690 tons) of sanitary and hazardous wastes were recycled through site-wide programs on the Hanford Site.
<i>Resource Conservation and Recovery Act of 1976 (RCRA)</i>	Tracking hazardous waste from generator to treatment, storage, or disposal (referred to as cradle-to-grave management).	DOE is operating under an expired facility RCRA permit at the Hanford Site while the Washington State Department of Ecology drafts a new permit. During 2008, 40 revisions to the Hanford Facility RCRA Permit Part A Form and 1 RCRA Part B permit application were submitted to the state for review and approval. One treatment, storage, and disposal unit was approved for closure in 2008. Washington State Department of Ecology performed 28 RCRA inspections on the Hanford Site during 2008 to assess compliance with applicable requirements. Two RCRA non-compliance documents were received at the Hanford Site in 2008: 1) violations involving dangerous waste designation at the T Plant Complex; and 2) violations for the removal and shipment of anhydrous ammonia cylinders from the 100-N Area. All issues were resolved with no impact to the environment.
<i>Safe Drinking Water Act of 1974</i>	Drinking water systems.	There were nine drinking water systems on the Hanford Site in 2008. The systems were monitored for radiological and chemical contaminants and disinfection residuals and byproducts. There were no microbiological detections during 2008, and all chemical concentrations in Hanford Site drinking water were well below the maximum contaminant levels established by the EPA. Systems demonstrated compliance with the filtration and disinfection treatment technique requirements and limits for disinfectant residuals and disinfection byproducts.
<i>Toxic Substances Control Act</i>	Hazardous chemical regulation and tracking; primarily polychlorinated biphenyls (PCBs).	During 2008, the 2007 PCB annual document log report for the Hanford Site and a 2007 PCB annual report were submitted to the EPA as required. EPA-approved risk-based disposal approvals were used in 2008 for retrieving waste from selected single-shell underground waste storage tanks; for the removal of containers of treated sludge from the K-East Basin; and continued storage of two water tower tanks containing PCB-contaminated paint.
DOE = U.S. Department of Energy. EPA = U.S. Environmental Protection Agency.		

has reduced the number of liquid effluent sites requiring remediation, allowing current cleanup activities to shift to the remediation of waste burial grounds. The volume of contamination in waste burial grounds is generally less than at liquid effluent waste sites; however, identification, characterization, and disposal of the wastes may involve additional time and scope. During 2008, remediation activities continued in the 100, 200, and 300 Areas, and for Hanford Site groundwater and the vadose zone.

**Remediation of 100 Areas Waste Sites.** Remediation in the 100 Areas during 2008 focused on waste burial grounds and miscellaneous waste sites in the 100-B/C, 100-K, 100-D, 100-H, and 100-F Areas (Section 6.2.2.1). A total of 367,500 metric tons (405,125 tons) of contaminated soil from the 100 Areas remediation activities were disposed of at the Environmental Restoration Disposal Facility (near the 200-West Area) during 2008. The majority of the contaminated soil was from the 100-D and 100-H Areas. Several remediated and backfilled waste sites in the 100-F Area were

revegetated with native grass seed and sagebrush, bitterbrush, and hopsage seedlings in 2008.

Pump-and-treat systems continued to help remove contaminants from the groundwater beneath the 100 Areas in 2008 (Table S.2).

**K Basins Closure Activities.** For nearly 30 years, the K Basins stored 2,100 metric tons (2,300 tons) of Hanford N Reactor spent fuel and a small quantity of irradiated fuel from older Hanford Site reactors. The fuel was removed in an effort that ended in 2004, but fuel corrosion over the years left behind sludge and debris. During 2008, K Basins cleanup continued with the removal of debris from both the K-East and K-West Basins. The K-West Basin floor and pit sludge was containerized in underwater containers. All sludge from the K-East Basin was removed, completing deactivation and allowing the start of decommissioning activities, including the demolition of the K-East Basin

**Table S.2. Summary of Groundwater Pump-and-Treat Systems and a Vadose Zone Soil-Vapor Extraction System**

<u>Location</u>	<u>Startup Date</u>	<u>Contaminant</u>	<u>Mass Removed 2008</u>	<u>Mass Removed Since Startup</u>
100-D Area (100-DR-5 Pump-and-Treat System)	2004	Chromium	50.6 kilograms (112 pounds)	211 kilograms (465 pounds)
100-D Area (100-HR-3-D Pump-and-Treat System)	1997	Chromium	22.9 kilograms (50 pounds)	287 kilograms (630 pounds)
100-H Area (100-HR-3-H Pump-and-Treat System)	1997	Chromium	2 kilograms (4 pounds)	51 kilograms (112 pounds)
100-K Area (100-KR-4 Pump-and-Treat System)	1997	Chromium	18.1 kilograms (40 pounds)	330 kilograms (728 pounds)
100-K Area (Pump-and-Treat System near K-West Reactor)	2007	Chromium	15.1 kilograms (33.2 pounds)	31 kilograms (68 pounds)
200-West Area (200-ZP-1 Pump-and-Treat System)	1994	Carbon tetrachloride	462 kilograms (1,000 pounds)	11,400 kilograms (25,000 pounds)
200-West Area (200-UP-1 Pump-and-Treat System)	1994	Carbon tetrachloride	3.0 kilograms (6.6 pounds)	37.7 kilograms (83 pounds)
		Nitrate	6,380 kilograms (14,100 pounds)	41,500 kilograms (91,500 pounds)
		Technetium-99	4.6 grams (0.01 pound)	124 grams (0.27 pound)
		Uranium	3.5 kilograms (7.7 pounds)	216 kilograms (476 pounds)
Waste Management Area S-SX	2003	Technetium-99	~0.08 gram (0.003 ounce)	0.38 gram (0.01 ounce)
200-West Area (Soil-Vapor Extraction System)	1991	Carbon tetrachloride	200 kilograms (440 pounds)	79,400 kilograms (175,000 pounds)

structural steel superstructure. Further information concerning K Basins remediation and closure activities in 2008 is discussed in Section 6.2.2.2.

#### **Remediation of Waste Sites on the Central Plateau.**

Remedial investigation or feasibility study activities continued on waste sites on the Hanford Site Central Plateau in 2008. Pipeline sampling, geophysical logging, direct-push technology evaluations, and characterization drilling were performed at several operable units, and feasibility studies and proposed plans were issued for several sites. Discussions of these activities are provided in Section 6.2.1.

Pump-and-treat systems and a soil-vapor extraction system continued to help remove contaminants from the ground-water and vadose zone beneath the 200 Areas in 2008 (Table S.2).

**Remediation of 300 Area Waste Sites.** Remediation efforts in 2008 focused on the 300-FF-2 Operable Unit waste sites; activities at these waste sites began in 2002. In 2008, 163,000 metric tons (180,000 tons) of contaminated soil from the 300-FF-2 Operable Unit was removed and disposed of at the Environmental Restoration Disposal Facility. The 618-7 Burial Ground, located just west of the 300 Area, was remediated in 2008. Discussions of these activities are provided in Section 6.2.3.

## **Facility Decommissioning and Deactivation Activities**

**Decommissioning of 100 Areas Facilities.** During 2008, 100 Areas deactivation, decontamination, decommissioning, and demolition activities focused on the 100-N Area, where 30 buildings and facility stacks were demolished. In addition, 105-B Reactor roof repairs were completed (Section 6.3.4).

#### **Decommissioning of Facilities on the Central Plateau.**

The transition and decommissioning of facilities on the Central Plateau continued in 2008. Activities at the Plutonium Finishing Plant included the de-inventory of plutonium for shipment to the Savannah River Site in South Carolina; continued cleanout of contaminated equipment; leak testing of plutonium shipping containers; and draining and blanking the hydrofluoric acid lines in the main Plutonium Finishing Plant process building

(Section 6.3.1.1). Additional activities in 2008 including surveillance, maintenance, and decontamination or stabilization of over 500 waste sites, including former waste disposal cribs, ponds, ditches, trenches, unplanned release sites, and waste burial grounds continued at buildings and waste sites in the 200-East, 200-West, and 200-North Areas and the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit. Periodic surveillances, radiation surveys, and herbicide and pesticide applications also were conducted (Section 6.3.1.2).

**Decommissioning of 300 Area Facilities.** During 2008, 300 Area deactivation, decontamination, decommissioning, and demolition activities continued to focus on removing physical barriers to performing remedial actions in the 300-FF-2 Operable Unit. Fifteen facilities and buildings were demolished in the 300 Area in 2008 (Section 6.3.2).

#### **Deactivation of 400 Area Facilities – Fast Flux Test Facility.**

After multiple studies, a final decision was made by DOE to complete facility deactivation, including removing all nuclear fuel, draining the sodium systems, and deactivating systems and equipment to place the facility in a low-cost, long-term surveillance and maintenance condition by September 2009. During 2008, fuel removal from the 400 Area Property Protected Area was completed. A RCRA permit for mixed waste container storage for greater than 90 days, issued by the Washington State Department of Ecology in November 2007, allowed the storage of mixed waste in the 400 Area Interim Storage Area (Building 4718) in 2008. Deactivation activities continued in 2008, including shipment of four polychlorinated biphenyl (PCB)-laden transformers for disposal, the shutdown of operating systems (electric, fire suppression, water, ventilation, etc.), and cleanout and closure of the reactor containment building and supporting facilities (Section 6.3.3).

## **Waste Management**

Hanford Site cleanup activities generate non-regulated, radioactive, non-radioactive, mixed, and hazardous waste (Chapters 5 and 6). Mixed waste contains both radioactive and hazardous non-radioactive substances. Hazardous waste contains either dangerous waste or extremely hazardous waste, or both. This waste is handled and prepared for safe storage at the site or shipped to offsite facilities for treatment

and disposal. Table S.3 provides a summary of waste stored, generated, and treated at the site or received from offsite in 2008.

In addition to newly generated waste, significant quantities of legacy waste remain from years of nuclear materials production and waste management activities. Most legacy

**Table S.3. Hanford Site Waste Summary for 2008**

<b>Activity</b>	<b>Waste Type</b>	<b>Amount</b>
Solid waste generated during onsite cleanup activities	Solid mixed waste	313,500 kilograms (346 tons)
	Radioactive waste	361,400 kilograms (398 tons)
Solid waste received at the Hanford Site from offsite (includes Hanford Site generated waste treated by an offsite contractor and returned to the Hanford Site as newly generated waste)	Solid mixed waste	416,300 kilograms (459 tons)
	Radioactive waste	403,700 kilograms (445 tons)
Dangerous waste shipped off the Hanford Site	Containerized waste (dangerous waste only)	115,800 kilograms (128 tons)
	Bulk solids	0 kilogram
	Bulk liquids	200,600 kilograms (221 tons)
Waste volume pumped from underground single-shell waste storage tanks to double-shell waste storage tanks	Liquid waste (includes flush/dilution water)	260 thousand liters (69 thousand gallons)
Waste volume in underground single-shell waste storage tanks at the end of 2008	Liquid waste	113 million liters (29.8 million gallons)
Waste volume evaporated at the 242-A Evaporator	Liquid waste	0 liter (0 gallon)
Waste added to underground double-shell waste storage tanks	Liquid waste	322 thousand liters (85 thousand gallons)
Waste volume in underground double-shell waste storage tanks at the end of 2008	Liquid waste	101 million liters (26.7 million gallons)
Waste dispositioned and shipped offsite from the Waste Receiving and Processing Facility	Solid waste	515 cubic meters (18,200 cubic feet)
Waste treated or directly disposed of at the Mixed Low-Level Waste Treatment and Disposal Facility	Mixed low-level solid waste	816 cubic meters (28,800 cubic feet)
Waste disposed of at the Environmental Restoration Disposal Facility	Solid waste	642,800 metric tons (708,600 tons)
Volume of aqueous waste received at the Liquid Effluent Retention Facility	Wastewater containing low levels of organic compounds and tritium	65.1 million liters (17.2 million gallons)
Volume of liquid effluent treated at the Effluent Treatment Facility	Wastewater containing toxic metals, radionuclides, ammonia, and organic compounds	68 million liters (18 million gallons)
Volume of wastewater treated at the 242-A Evaporator	Liquid waste from single-shell tanks	0 liter (0 gallon)
Volume of effluent disposed of at the 200 Area Treated Effluent Disposal Facility	Uncontaminated, treated liquid waste	276 million liters (73 million gallons)
Volume of wastewater treated and disposed of at the 300 Area Treated Effluent Disposal Facility	Industrial wastewater	161 million liters (42.4 million gallons)

waste from past operations at the Hanford Site resides in RCRA-compliant waste sites or is stored in places pending clean up and ultimate safe storage or disposal. Examples include high-level radioactive waste stored in single-shell and double-shell underground waste storage tanks, and transuranic waste stored in vaults and on storage pads (Sections 6.4 and 6.5).

**Solid Waste Management.** Waste management at the Hanford Site in 2008 included the treatment, storage, and disposal of solid waste at many site locations (Section 6.4.3). Onsite solid waste facilities include the Central Waste Complex, Waste Receiving and Processing Facility, T Plant Complex, Environmental Restoration Disposal Facility, Radioactive Mixed Waste Disposal Facility, and low-level burial grounds.

Waste is received at the Central Waste Complex (Section 6.4.3.1) in the 200-West Area from sources at the Hanford Site, and any offsite sources authorized by DOE to ship waste to the Hanford Site for treatment, storage, and disposal. Ongoing cleanup, research, and development activities at the Hanford Site generate most waste received at the Central Waste Complex. Characteristics of waste received vary greatly, including low-level, transuranic, or mixed waste, and radioactively contaminated PCBs.

The Central Waste Complex can store as much as 20,800 cubic meters (735,000 cubic feet) of low-level mixed waste and transuranic waste. This capacity is adequate to store the projected volumes of low-level, transuranic, and mixed waste, and radioactively contaminated PCBs to be generated from the activities identified above, assuming on-schedule treatment of the stored waste. Treatment reduces the amount of waste in storage and makes room for newly generated mixed waste. The dangerous waste designation for each waste container is established at the point-of-origin based on process knowledge or sample analysis. The current volume of waste stored at this complex totals approximately 7,500 cubic meters (265,000 cubic feet).

Waste destined for the Waste Receiving and Processing Facility (Section 6.4.3.2) includes stored waste as well as newly generated waste from current Hanford Site cleanup activities. The waste consists primarily of contaminated cloth, paper, rubber, metal, and plastic. This facility, which

began operating in 1997, dispositioned and shipped 515 cubic meters (18,200 cubic feet) of waste offsite in 2008.

The T Plant Complex in the 200-West Area provides waste treatment, storage, and decontamination services for the Hanford Site as well as for offsite facilities (Section 6.4.3.3). In 2008, one thousand, five hundred and twenty-eight 208-liter (55-gallon) drum equivalents of transuranic waste were repackaged to meet offsite waste acceptance criteria.

During 2008, there were 816 cubic meters (28,800 cubic feet) of mixed low-level waste treated or disposed of at the Mixed Low-Level Waste Treatment and Disposal Facility (Section 6.4.3.4).

One defueled reactor compartment from the U.S. Navy was shipped to Trench 94 in the 200-East Area in 2008, bringing the total number of U.S. Navy reactor compartments received to 118 (Section 6.4.3.5).

During 2008, approximately 642,800 metric tons (708,600 tons) of remediation waste were disposed of at the Environmental Restoration Disposal Facility (Section 6.4.3.6). Approximately 7.2 million metric tons (7.9 million tons) of remediation waste have been disposed of at the Environmental Restoration Disposal Facility from initial operations startup through 2008. The total available expansion area of the Environmental Restoration Disposal Facility site was authorized in the 1995 record of decision to cover as much as 4.1 square kilometers (1.6 square miles).

The Radioactive Mixed Waste Disposal Facility consists of two trenches (Trenches 31 and 34) in the 200-West Area (Section 6.4.3.7). Disposal to Trench 34 began in September 1999 and the first layer of waste has been completed and covered with compacted gravel and soil. The second waste layer was started and is approximately half filled. Currently, there are approximately 4,130 cubic meters (146,000 cubic feet) of waste in Trench 34. There are approximately 2,670 cubic meters (94,300 cubic feet) of waste in Trench 31, which began receiving waste in May 2005.

The low-level burial grounds (Section 6.4.3.8) consist of eight burial grounds located in the 200-East and 200-West Areas that are used for disposal of low-level waste and mixed waste (i.e., low-level radioactive waste with a

dangerous waste component). The low-level burial grounds have been permitted to remain operational under a RCRA Part A permit since 1985. Transuranic waste has not been placed in the low-level burial grounds without specific DOE approval since August 19, 1987. On June 23, 2004, DOE issued a record of decision for the Solid Waste Program at the Hanford Site. Part of the record of decision stated that DOE will dispose of low-level waste in lined disposal facilities. Only two of the low-level burial ground trenches are lined (Trenches 31 and 34); therefore, since that date, all low-level waste as well as mixed low-level waste has been disposed of in these two trenches (Section 6.4.3.7). Disposal of U.S. Navy reactor compartments (Section 6.4.3.5) in the low-level burial grounds is not affected by this record of decision.

The Integrated Disposal Facility (currently not operational) is located in the south-central part of the 200-East Area, and is an expandable RCRA-compliant landfill. The facility will receive immobilized low-activity tank waste and other low-level radioactive waste from the Hanford Tank Waste Treatment and Immobilization Plant (Section 6.4.3.9).

**Liquid Waste Management.** Liquid effluent is managed in facilities to comply with federal and state regulations and facility permits (Section 6.4.4).

Approximately 53 million liters (14 million gallons) of liquid waste were stored at the Liquid Effluent Retention Facility at the end of 2008 (Section 6.4.4.1). The volume of wastewater received for interim storage in 2008 was approximately 65 million liters (17 million gallons). The volume of wastewater transferred from this facility to the Effluent Treatment Facility for treatment in 2008 was approximately 68 million liters (18 million gallons).

The Effluent Treatment Facility (Section 6.4.4.2) in the 200-East Area treats liquid effluent to remove toxic metals, radionuclides, and ammonia, and destroy organic compounds. The treated effluent is stored in tanks, sampled and analyzed, and discharged to the State-Approved Land Disposal Site (also known as the 616-A Crib). The volume of wastewater treated and disposed of in 2008 was approximately 68 million liters (18 million gallons).

In 2008, the 200 Area Treated Effluent Disposal Facility (Section 6.4.4.3) disposed of 276 million liters (73 million

gallons) of unregulated effluent. The major source of this effluent was uncontaminated cooling water from various Hanford Site facilities and steam condensate from the 242-A Evaporator.

Industrial wastewater generated throughout the Hanford Site is collected and treated in the 300 Area Treated Effluent Disposal Facility (Section 6.4.4.4). The wastewater consists of cooling water, steam condensate, and other industrial wastewater. The volume of industrial wastewater treated and disposed of during 2008 was 161 million liters (42.4 million gallons).

The 242-A Evaporator (Section 6.4.4.5) in the 200-East Area concentrates diluted liquid tank waste by evaporation. This reduces the volume of liquid waste sent to the double-shell tanks for storage and reduces the potential need for more double-shell tanks. In 2008, no waste campaigns were processed through the 242-A Evaporator. The 242-A Evaporator completed a single cold run (raw water feed) as part of maintenance testing and personnel training. The volume of process condensate transferred to the Liquid Effluent Retention Facility for subsequent treatment in the Effluent Treatment Facility was 0.72 million liter (0.19 million gallon).

**Underground Waste Storage Tanks.** In 2008, 262,000 liters (69,000 gallons) of liquid waste (including water used in waste retrieval activities) were pumped from the single-shell tanks to the double-shell tanks, leaving 113 million liters (29.8 million gallons) of waste remaining in the single-shell tanks. At the end of 2008, there were 101 million liters (26.7 million gallons) of waste in the double-shell tanks (Section 6.5).

**Hanford Tank Waste Treatment and Immobilization Plant.** The Hanford Tank Waste Treatment and Immobilization Plant is being built on 26 hectares (65 acres) adjacent to the 200-East Area to treat radioactive and hazardous waste currently stored in 177 underground tanks. Four major facilities are being constructed: a pretreatment facility, a high-level waste vitrification facility, a low-activity waste vitrification facility, and an analytical laboratory, as well as supporting facilities. Construction of these facilities continued in 2008 (Section 6.6).



## Radiological Release of Property from the Hanford Site

No property with detectable residual radioactivity above authorized levels was released from the Hanford Site in 2008 (Section 7.0.1).

**Radiological Release of Personal Property Potentially Contaminated with Hard-to-Detect Radionuclides.** In 2007, new authorized limits were approved for use for hard-to-detect radionuclides on real property; based on these limits, no property with detectable residual radioactivity was released from the Hanford Site in 2008 (Section 7.0.1.1).

**Radiological Clearance for Ion-Exchange Resin for Offsite Shipment and Regeneration.** Ion-exchange resin is currently being used to remove hexavalent chromium from groundwater. Once saturated, the spent resin is removed and readied for shipment to an offsite facility for regeneration and reuse. Based on past Hanford Site activities, the resin has the potential to contain residual radioactivity. During 2007, authorized limits for the ion exchange resin were established for seven radionuclides (Section 7.0.1.2). In 2008, approximately 151,000 kilograms (332,000 pounds) of resin was shipped offsite for regeneration under the authorized limits.

**Radiological Clearance for Granular Activated Carbon for Offsite Shipment and Regeneration.** A soil-vapor extraction system that uses granular activated carbon to remove carbon tetrachloride from groundwater in the unconfined aquifer has been operational for over 10 years. When the granulated activated carbon canister has reached volatile organic compound saturation, it is removed from the system and made ready for shipment to an offsite facility for regeneration and reuse. Based on past Hanford Site activities, the granular activated carbon has the potential to contain residual radioactivity. During 2007, authorized limits for the granular activated carbon were established for 21 radionuclides (Section 7.0.1.3). In 2008, approximately 24,500 kilograms (54,000 pounds) of granular activated carbon was shipped offsite for regeneration under the authorized limits.

## Columbia River Corridor Assessment and Integration

Sampling of upland, riparian, and near-shore environments for the River Corridor Baseline Risk Assessment was conducted in 2006 and 2007; results are being used to prepare the River Corridor Baseline Risk Assessment (Draft B), which is scheduled for regulatory and stakeholder review in 2009 (Section 7.0.2.1).

In early 2008, the DOE Richland Operations Office updated the interface control agreement, which originated in 2003, to reflect commitments to Congress to improve integration and coordination between programs (Section 7.0.2.1).

## Columbia River Corridor Long-Term Stewardship

This task focuses on achieving end-state closure and transition of the River Corridor to long-term stewardship. Elements include risk assessment activities, orphan site evaluations, remedial action reports, and long-term stewardship plans that will provide a basis for independent closure reviews of the 100 and 300 Areas by independent experts. Independent closure reviews will assure that implemented remedies meet the remedial action objectives established in records of decision, and that no further actions are needed to protect human health and the environment.

## Environmental Occurrences

Environmental releases of radioactive and regulated materials from the Hanford Site are reported to DOE and other federal and state agencies as legally required. The specific agencies notified depend on the type, amount, and location of the individual occurrence. The Hanford Site Occurrence Notification Center maintains both a computer database and a hardcopy file of event descriptions and corrective actions. Six significance categories have been established: operational emergency; recurring; Category 1 (significant impact); Category 2 (moderate impact); Category 3 (minor impact); and Category 4 (some impact) (see Section 8.0).



In 2008, there were no occurrences ranked as significance impact Category 1, Category 3, operational emergency, or recurring.

There was one moderate impact Category 2 occurrence with potential environmental implications on the Hanford Site in 2008. In July, contamination was discovered on an Environmental Restoration Disposal Facility container hinge plate. The contamination was contained and corrective actions established.

There were two Category 4 occurrences in 2008. Small brush fires were reported in June and August 2008, burning up to 240 hectares (600 acres). Also, several areas of legacy contamination were discovered in 2008, involving contaminated tumbleweeds, rabbit feces, wind, and mud daubers.

## Pollution Prevention Program

The Pollution Prevention Program (Section 9.0) is an organized and continuing effort to reduce the quantity and toxicity of hazardous, radioactive, mixed, and sanitary waste generated at the Hanford Site.

In 2008, 1,530 metric tons (1,690 tons) of sanitary and hazardous wastes were recycled through site-wide programs. The Hanford Site generated 2,210 cubic meters (78,000 cubic feet) of cleanup/stabilization waste (i.e., low-level waste, mixed low-level waste, and hazardous waste) along with 152,100 metric tons (167,700 tons) of non-radioactive hazardous and *Toxic Substances Control Act* cleanup and stabilization waste.

## Environmental and Resource Protection Programs

DOE Orders require that environmental monitoring programs be conducted at the Hanford Site to verify protection of the public and site workers, comply with government regulations, and protect the site's environmental and cultural resources. Programs and projects include Effluent and Near-Facility Environmental Monitoring Programs, Public Safety and Resource Protection Projects, the Soil and Groundwater Remediation Project, the Drinking Water

Monitoring Project, the Biological Control Program, and the Washington State Department of Health Oversight Monitoring Program (Section 10.0; Table S.4).

## Air Emissions

Hanford Site contractors monitor airborne emissions from site facilities to assess the effectiveness of emission treatment and control systems, pollution management practices, and determine compliance with state and federal regulatory requirements. Small quantities of tritium, strontium-90, iodine-129, cesium-137, plutonium-238, plutonium-239/240, plutonium-241, americium-241, and a few other isotopes are released at state and federally permitted discharge points, usually stacks or vents, in the 100, 200, 300, 400, and 600 Areas of the Hanford Site (Section 10.1.1).

Non-radioactive air pollutants are emitted from power-generating and chemical-processing facilities. These facilities are monitored when activities are known to generate potential pollutants of concern, which include carbon monoxide, gaseous ammonia, lead, nitrogen oxides, particulate matter, sulfur oxides, and volatile organic compounds (Section 10.1.2).

Air emissions data collected in 2008 were comparable to those collected in 2007.

## Ambient-Air Monitoring

Radioactive constituents in air are monitored on the Hanford Site near facilities and operations, at site-wide locations away from facilities, and offsite around the site perimeter and in nearby and distant communities.

**Ambient-Air Monitoring Near Facilities and Operations.** In 2008, ambient air was monitored at 92 locations on the Hanford Site near facilities and operations (Section 10.2.1). Samplers were located primarily at or within approximately 500 meters (1,640 feet) of sites or facilities having the potential for, or a history of, environmental releases. Samples were collected biweekly and analyzed. The 2008 data indicate a large degree of variability by location.

Samples collected from locations at or directly adjacent to Hanford Site facilities had higher radionuclide



Table S.4. Summary of Contaminant Monitoring On and Around the Hanford Site, 2008

	<u>What Was Monitored?</u>	<u>The Bottom Line</u>
Air	Radioactive and non-radioactive emissions were monitored at Hanford Site facilities. Air particles and gases were monitored for radioactivity onsite near facilities and offsite. Air samples were collected at 92 locations near Hanford Site facilities, at 23 locations around the site away from facilities, at 11 site perimeter locations, and at 8 community locations.	All measurements of radioactive materials in air were below recommended guidelines. In general, radionuclide concentrations near facilities were at or near Hanford Site background levels, and were much less than DOE-derived concentration guides. Some Hanford Site values were greater than concentrations measured offsite. The data also show that concentrations of certain radionuclides were higher and widely variable within different onsite operational areas.
Columbia River Water and Sediment	Columbia River water and sediment samples were collected from multiple Hanford Reach sampling points and from locations upstream and downstream of the Hanford Site. The samples were analyzed for radioactive and chemical contaminants.	As in past years, small amounts of radioactive materials were detected downriver from the Hanford Site. However, the amounts were far below federal and state limits. During 2008, there was no indication of any deterioration of Columbia River water or sediment quality resulting from operations at the Hanford Site.
Columbia River Shoreline Spring Water and Sediment	Groundwater beneath the Hanford Site discharges to the Columbia River along the Hanford Site shoreline. Discharges above the water level of the river are identified as shoreline springs. Samples of spring water and sediment were collected at locations along the Hanford Reach.	Measurements of radiological contaminants in samples collected at the shoreline springs were less than applicable concentration guides. Most of the 2008 chemical sample results were similar to those reported previously. Concentrations of volatile organic compounds were near or below their detection limits in all samples. Trace amounts of chlorinated organic compounds were observed at some locations. Concentrations of most metals were below Washington State ambient surface-water chronic toxicity levels.  Radionuclide concentrations measured in shoreline sediment samples were similar to concentrations measured in Columbia River sediment, with the exception of the 300 Area where uranium concentrations were above the background concentration measured in the sediments from the reservoir behind Priest Rapids Dam. Metals concentrations in all samples were also similar to concentrations measured in Hanford Reach Columbia River sediment samples.
Food and Farm Products	Samples of milk, potatoes, tomatoes, and cherries were collected from locations upwind and downwind of the Hanford Site.	Radionuclide concentrations in samples of food and farm products were at normal environmental levels.
Fish and Wildlife	Game animals and other animals of interest on the Hanford Site and fish from the Hanford Reach of the Columbia River were monitored. Carcass, liver, and muscle samples were analyzed to evaluate radionuclide and metals concentrations. Populations of selected fish and wildlife species were also surveyed or monitored.	Samples of carp, suckers, smallmouth bass, mule deer, and clams were collected and analyzed. Radionuclide levels in wildlife samples were well below levels that are estimated to cause adverse health effects to animals or to the people who may consume them. Most trace metal concentrations in liver samples were similar to or less than concentrations measured in background samples. Onsite wildlife samples had elevated maximum values for some trace metals. Concentrations of uranium in clam samples were highest from clams exposed to the 300 Area uranium groundwater plume.
Soil	Ninety-five routine soil samples were collected onsite near facilities and operations in 2008 to verify known radiological conditions. There were also 41 soil samples collected site-wide and at offsite locations to investigate potential contamination.	In general, radionuclide concentrations in routine samples collected from or adjacent to waste disposal facilities in 2008 were higher than concentrations measured in distant communities in previous years. There were 16 instances of radiological contamination in soil samples investigated in 2008. Of the 16, 9 were cleaned up. The contamination levels at the other locations did not exceed the radiological control limits for the sites and the soil was left in place.
Vegetation	Samples of perennial vegetation were collected near Hanford Site facilities and operations in 2008 and analyzed for radiological contaminants.	Concentrations of radionuclides were elevated in vegetation samples collected near facilities and operations when compared to concentrations in samples from distant communities collected in 2004.

concentrations than samples collected farther away. In general, analytical results for most radionuclides were at or near Hanford Site background levels, which are much less than EPA concentration limits but greater than those measured offsite. The data also show that concentrations of certain radionuclides were higher and widely variable within different onsite operational areas. Naturally occurring beryllium-7 and potassium-40 were routinely identified.

**Hanford Site-Wide and Offsite Ambient-Air Monitoring.** During 2008, samples were collected at 42 continuously operating site-wide and offsite locations: 23 onsite (site-wide), 11 at perimeter locations, 7 in nearby communities, and 1 in a distant community (Section 10.2.2). Airborne particle samples were collected at each station biweekly and monitored for gross alpha and gross beta concentrations. Biweekly samples were combined into quarterly composite samples and analyzed for gamma-emitting radionuclides. Samples of atmospheric water vapor were collected every 4 weeks and analyzed for tritium at 20 locations in 2008. All sample results showed very low radiological concentrations. All radionuclide concentrations in air samples collected in 2008 were below the EPA *Clean Air Act* dose standard of 10 millirem (100 microsievert) per year, with the exception of tritium samples that were cross-contaminated at the analytical laboratory (Section 10.2.2.2).

## Liquid Effluent Monitoring

Liquid effluents are discharged from some facilities at the Hanford Site. Effluent streams were sampled for gross alpha and gross beta concentrations, as well as for concentrations of selected radionuclides. In 2008, facilities in the 200 Areas discharged radioactive liquid effluent to the ground at a single location, the State-Approved Land Disposal Site. Liquid effluent from the 100 Areas, primarily secondary cooling water from the 100-K Area, was discharged to the Columbia River via a permitted outfall. Non-radioactive hazardous materials in liquid effluent were monitored in the 100, 200, 300, and 400 Areas to determine compliance with permits before discharging to the State-Approved Land Disposal Site or the Columbia River (Section 10.3).

## Surface-Water and Sediment Monitoring

Samples of surface water and sediment on and near the Hanford Site were collected and analyzed to determine the concentrations of radiological and chemical contaminants from the site. Surface water bodies included the Columbia River, onsite ponds, and offsite irrigation sources. Aquatic sediment monitoring was conducted for the Columbia River and one onsite pond (Section 10.4).

**Columbia River Water.** During 2008, Columbia River water samples were collected with automated samplers at fixed-location monitoring stations at Priest Rapids Dam and the city of Richland, Washington, and analyzed for radionuclides. Samples were also taken from cross-river transects and near-shore locations near the 100-N Area, Vernita Bridge, Hanford town site, the 300 Area, and the city of Richland and analyzed for both radionuclides and chemicals. Transect samples were collected at multiple locations on a line across the Columbia River and at several near-shore locations. Radiological constituents of interest included gamma-emitting radionuclides, tritium, strontium-90, technetium-99, uranium-234, uranium-235, uranium-238, plutonium-238, and plutonium-239/240. Gross beta and gross alpha concentrations were also monitored. Chemicals of interest included metals and anions. All radiological contaminant concentrations measured in Columbia River water at the fixed sampling locations during 2008 were less than 1/25th of the DOE standard of 100 millirem (1 microsievert) per year. Tritium, uranium-234, and uranium-238 were consistently measured in transect and near-shore samples, but all measured concentrations were less than applicable Washington State ambient surface-water quality criteria. Metals and anions were detected in Columbia River transect water samples both upstream and downstream of the Hanford Site. All concentrations measured in 2008 were below regulatory limits (Section 10.4.1).

**Columbia River Sediment.** During 2008, samples of the surface layer of Columbia River sediment were collected from the Priest Rapids Dam, McNary Dam, and Ice Harbor Dam reservoirs; slack-water areas along the Hanford Reach;



and the city of Richland. Radionuclides consistently detected in Columbia River sediment in 2008 included natural potassium-40, cesium-137, uranium-234, uranium-235, uranium-238, plutonium-238, plutonium-239/240, and daughter products from naturally occurring radionuclides. Detectable amounts of most metals were found in all river sediment samples; however, there are no Washington State freshwater sediment quality criteria for comparison to the measured values (Section 10.4.2).

**Pond Water and Sediment.** Two onsite ponds, West Lake and the Fast Flux Test Facility Pond, were sampled in 2008. Water samples were obtained quarterly from both ponds and sediment samples were obtained semiannually from West Lake. All samples were analyzed for tritium, and samples from the Fast Flux Test Facility Pond were also analyzed for gross alpha, gross beta, and gamma-emitting radionuclides. All radionuclide concentrations in onsite pond water samples were less than applicable DOE-derived concentration guides and Washington State ambient surface-water quality criteria. Concentrations in sediment samples were similar to concentrations measured in prior years (Section 10.4.3).

**Offsite Irrigation Water.** In 2008, samples were collected from an irrigation canal located in the Riverview area of Pasco east of the Columbia River and downstream from the Hanford Site, and from an irrigation water supply in Benton County near the southern boundary of the Hanford Site. All radionuclide concentrations were at the same levels detected in Columbia River water obtained upstream of the Hanford Site and below applicable DOE-derived concentration guides and Washington State ambient surface-water quality criteria (Section 10.4.4).

## Columbia River Shoreline Springs Monitoring

Samples of Columbia River shoreline spring water and sediment were collected along the Hanford Reach and analyzed for Hanford Site-associated radiological and chemical contaminants that are present in groundwater beneath the site (Section 10.5).

**Columbia River Shoreline Springs Water.** Samples were obtained from numerous locations in the fall of 2008

when Columbia River flows were low. Most samples were analyzed for gamma-emitting radionuclides, gross alpha, gross beta, and tritium. Samples from selected springs were analyzed for strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238. Most samples were also analyzed for metals and anions. Samples from some locations were monitored for volatile organic compounds. All radiological contaminants measured in shoreline springs during 2008 were less than applicable DOE concentration guides (Section 10.5.1.2). For most locations, the 2008 chemical sample results were similar to those previously reported. Concentrations of volatile organic compounds were near or below the analytical laboratory's required detection limits in all samples. Trace amounts of chlorinated organic compounds were observed at some locations. The concentrations of most metals measured in spring water samples in 2008 were below Washington State ambient surface-water chronic toxicity levels. However, the maximum concentrations of dissolved chromium in water at some locations were above the Washington State ambient surface-water chronic and acute toxicity levels. Concentrations of arsenic in all samples were below the Washington State ambient surface-water chronic toxicity level, but exceeded the EPA limit for the protection of human health for the consumption of water and organisms (Section 10.5.1).

**Columbia River Shoreline Springs Sediment.** During 2008, shoreline springs sediment samples were collected in the 100-B, 100-K, 100-H, and 100-F Areas, the 300 Area, and at the Hanford town site. Radionuclide concentrations were similar to concentrations measured in Columbia River sediment, with the exception of the 300 Area where uranium concentrations were above the background concentration measured in the sediment from the reservoir behind Priest Rapids Dam. Metals concentrations in all samples were also similar to concentrations measured in Columbia River sediment samples (Section 10.5.2).

## Radiological Monitoring of Hanford Site Drinking Water

Samples of treated drinking water were collected monthly at facilities in the 100-K, 100-N, 200-West, and 400 Areas. Water used in the 400 Area is pumped from wells. Water

treated at other locations is obtained from the Columbia River. Water samples were analyzed for gross alpha, gross beta, tritium, and strontium-90. During 2008, annual average concentrations of all monitored radionuclides in Hanford Site drinking water were below federal and state maximum allowable contaminant levels (Section 10.6).

## Groundwater Monitoring

At the Hanford Site, liquid waste released to the ground over many years has reached the groundwater. Hazardous chemicals in the groundwater include carbon tetrachloride, chromium, and nitrate. Radioactive contaminants include tritium, strontium-90, technetium-99, iodine-129, and uranium. Currently, groundwater contaminant levels are greater than drinking water standards beneath 12% of the area of the Hanford Site. Site groundwater is not a source of public drinking water and does not significantly affect offsite drinking water sources, such as the Columbia River and city wells. There are, however, possible near-shore effects where Hanford Site groundwater flows into the Columbia River (Section 10.7).

## Food and Farm Products Monitoring

During 2008, food and farm products including milk, potatoes, tomatoes, and cherries were collected at places around the Hanford Site and analyzed for radiological contaminants. The concentrations of most radionuclides in food and farm product samples in 2008 were below levels that could be detected by the analytical laboratories. However, tritium and uranium-234 were detected in low levels in some samples, as was naturally occurring potassium-40 (Section 10.8).

## Soil Monitoring

In 2008, soil samples were collected near facilities and operations at the Hanford Site to evaluate long-term trends in the environmental accumulation of radioactive materials, to detect potential contaminant migration, and to monitor the deposition of onsite facility emissions. Samples were analyzed for radionuclides expected to occur in the areas sampled. In general, radionuclide concentrations in soil samples collected from or adjacent to waste disposal facilities

in 2008 were higher than the concentrations in samples collected farther away and were significantly higher than concentrations measured offsite in previous years. The data also show that concentrations of certain radionuclides in 2008 were higher within different operational areas when compared to concentrations measured in distant communities in previous years. Generally, the predominant radionuclides detected were fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas (Section 10.9).

## Vegetation Monitoring

Section 10.10 includes discussions on surveys and monitoring of plant populations, monitoring of contaminants in perennial vegetation growing near Hanford Site facilities and operations, and control of contaminated or unwanted vegetation on the site.

**Plant Communities and Population Surveys.** Plant populations monitored on the Hanford Site include taxa listed by Washington State as endangered, threatened, or sensitive, and species listed as review group 1. Data are used to develop baseline information and to monitor for changes resulting from Hanford Site operations. Surveys for rare annual species were conducted as part of annual compliance review activities (Section 10.10.1.2).

**Vegetation Monitoring Near Hanford Site Facilities and Operations.** Vegetation samples were collected on or adjacent to former waste disposal sites, and from locations downwind and near or within the boundaries of operating facilities and remedial action sites to monitor for radionuclide contaminants. In general, radionuclide concentrations in vegetation samples collected from, or adjacent to, waste disposal facilities in 2008 were higher than concentrations in samples collected farther away, including concentrations measured offsite. Generally, the predominant radionuclides detected were activation and fission products in the 100-N Area, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas (Section 10.10.2).

**Investigations of Radioactivity in Vegetation Near Hanford Site Facilities and Operations.** During 2008, radiological contamination was found in 127 vegetation samples. Two samples were grasses, and 125 were

tumbleweeds (Russian thistle) or tumbleweed fragments; all were disposed at a licensed facility (Section 10.10.2.3).

**Vegetation Monitoring at Site-Wide and Offsite Locations.** Vegetation samples were collected at 14 locations on and around the Hanford Site in 2008, and designated as onsite or offsite. Vegetation samples, consisting of the current year's growth of leaves, stems, and new branches from sagebrush and rabbitbrush, were analyzed for gamma-emitting radionuclides, strontium-90, uranium isotopes (uranium-234, uranium-235 and uranium-238) and plutonium isotopes (plutonium-238 and plutonium-239/240). Uranium-238 was detected in all vegetation samples collected in 2008, and plutonium-239/240 was detected in three vegetation samples collected onsite and at one offsite sampling location (Section 10.10.3).

**Vegetation Control Activities.** Vegetation control at the Hanford Site consists of cleaning up or removing contaminated plants that can be a threat to site workers or the public, controlling or preventing the growth or re-growth of plants in contaminated or potentially contaminated areas on the site, and monitoring and removing the 10 high-priority noxious plant species (Section 10.10.4).

## Fish and Wildlife Monitoring

Fish and wildlife monitoring on the Hanford Site includes surveying and monitoring Hanford Site animal populations, monitoring fish and wildlife tissues for contaminants from the site, and managing organisms that might affect site workers or have become radiologically contaminated.

**Wildlife Population Monitoring.** Four fish and wildlife species on the Hanford Site are monitored annually: fall Chinook salmon, steelhead, bald eagles, and mule deer (Section 10.12.1). The number of fall Chinook salmon redds in the Hanford Reach is estimated by aerial surveys. The peak redd count in the fall of 2008 was estimated at 5,588, higher than 2007, but below the previous 5-year average of 7,206. Two aerial observation flights were flown on the Hanford Reach from north of the city of Richland to document the occurrence of any steelhead spawning along the shoreline regions; none were found. Thirty-four eagles (18 adults and 16 juveniles) were observed during two surveys along the Hanford Reach from Vernita Bridge downstream to the city of Richland in 2008. Roadside

surveys were conducted for mule deer on the Hanford Site to assess age and sex ratios and the frequency of testicular atrophy in males. A combined total of 566 deer observations were made over 5 repeated surveys during November 2008 to January 2009, which included multiple observations of the same animals in some cases.

**Habitat and Species Characterizations.** In 2008, characterizations focused on Woodhouse's toads and their breeding locations, habitat use, and distribution on the Hanford Site. Distribution of burrowing owls, a Washington State candidate species and federal species of concern, was also evaluated (Section 10.12.2). Sixteen Woodhouse's toads were fitted with radio transmitters and movements and habitat data were collected July through October 2008. The majority of toad activity occurred within 200 meters (656 feet) of the Columbia River or high-water channel of the 100-F Slough. Burrowing owl nest locations were found to be widely distributed across the Hanford Site. Between 2005 and 2008, 53 burrowing owl nests have been documented.

**Monitoring Fish and Wildlife for Hanford-Produced Contaminants.** In 2008, sucker, common carp, smallmouth bass, and deer were collected at locations on and around the Hanford Site (Section 10.12.4). Tissue samples were monitored for strontium-90 contamination and gamma emitters, including cesium-137. Cesium-137 was below detection limits in all samples in 2008. Strontium-90 was not found above the analytical detection limit in the carp, smallmouth bass, sucker, or deer samples collected during 2008. Liver tissues from most organisms were monitored for up to 17 trace metals that have the potential to accumulate in certain tissues and are potential contaminants of concern. Antimony and beryllium were not detected in any fish or deer samples. Concentrations of aluminum, arsenic, cadmium, mercury, and selenium in smallmouth bass samples were elevated for many samples collected from the 300 Area in 2008. Maximum concentrations of copper, silver, and zinc in liver samples from carp and suckers collected near the 300 Area were elevated compared to maximum concentrations in liver samples from fish collected from the reference location in 2006 and 2008. Maximum concentrations of aluminum, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, thorium, uranium, and zinc in

bass collected between the 100-N and 100-D Areas were similar to or less than maximum concentrations of these metals in bass collected near Desert Aire, Washington, in 2008. The maximum concentration of cadmium in liver samples from fish collected between the 100-N and 100-D Areas was elevated compared to concentrations in liver samples from fish collected from the reference location in 2006 and 2008. Most trace metal concentrations in deer samples collected on the Hanford Site in 2008 were similar to or less than concentrations measured in the liver sample from a deer collected near Olympia, Washington. Aluminum, cadmium, copper, lead, and selenium levels were elevated in samples collected onsite compared to concentrations in reference samples collected in 2008 and previous years.

In addition, a special study was performed in 2008 whereby Asiatic clam soft tissue and shells near the 300 Area were sampled and analyzed for uranium. Uranium concentrations measured in clam soft tissues and shells were highest from clams sited near Spring 9 and Spring 10, which were exposed to the 300 Area uranium groundwater plume (Section 10.12.4.3).

**Control of Pests and Contaminated Biota.** Animal species such as the domestic pigeon, Northern pocket gopher, house mouse, and deer mouse must be controlled when they become a nuisance, health problem, or contaminated with radioactivity. Biological control personnel responded to approximately 33,000 animal control requests from Hanford Site employees in 2008, ranging from requests to remove animals within radioactive waste facilities to insect invasions of work areas. There were 33 contaminated animals or animal-related materials discovered during 2008 (Section 10.12.5).

## External Radiation Monitoring

In 2008, external radiation at the Hanford Site was monitored onsite in relative close proximity to known, suspected, or potential radiation sources (Section 10.13). The Harshaw thermoluminescent dosimeter system is used to measure external radiation at the Hanford Site. Additionally, radiation surveys were conducted at some locations using portable instruments to monitor and detect contamination, providing a coarse screening for external radiation fields.

**External Radiation Monitoring Near Hanford Site Facilities and Operations.** During 2008, external radiation fields were monitored at 124 locations near onsite facilities and operations. Measured radiation levels were similar to or lower than levels measured in 2007 (Section 10.13.1.1).

**Radiological Surveys at Active and Inactive Waste Disposal Sites.** During 2008, 473 environmental radiological surveys were conducted at active and inactive waste disposal sites and the terrain surrounding them to detect and characterize radioactive surface contamination. Vehicles equipped with radiation detection devices and global positioning systems were used to accurately measure the extent of contamination. Routine radiological survey locations included former waste disposal cribs and trenches, retention basin perimeters, ditch banks, solid waste disposal sites (e.g., burial grounds), unplanned release sites, tank farm perimeters, stabilized waste disposal sites, roads, and firebreaks in and around Hanford Site operational areas. During 2008, the Hanford Site had approximately 3,583 hectares (8,853 acres) of outdoor contaminated areas of all types and approximately 584 hectares (1,443 acres) that contained underground radioactive materials, not including active facilities. No new areas of significant size were discovered during 2008. Approximately 9 hectares (22 acres) of previously posted contamination and/or underground radioactive materials areas underwent remediation action and were closed for the interim in 2008 (Section 10.13.1.2).

## Potential Radiological Doses from 2008 Hanford Site Operations

During 2008, potential radiological doses to the public and biota from Hanford Site operations were evaluated in detail to determine compliance with pertinent regulations and limits (Section 10.14). Doses were assessed in terms of 1) total dose (multiple pathways) to the hypothetical, maximally exposed individual at an offsite location (0.045 millirem [0.45 microsievert] per year at Sagemoor in Franklin County, approximately 1.4 kilometers [0.8 mile] east of the Hanford Site across the Columbia River); 2) average dose to the collective population living within

80 kilometers (50 miles) of Hanford Site operating areas (0.44 person-rem [0.0044 person-sievert] per year); 3) dose to a maximally exposed individual for air pathways using EPA methods (0.041 millirem [0.41 microsievert] per year at Sagemoor); 4) annual dose to site workers consuming drinking water (0.1 millirem [1 microsievert] per year); 5) dose from non-DOE industrial sources on and near the Hanford Site (less than 0.002 millirem [0.02 microsievert] per year); and 6) absorbed dose received by aquatic organisms exposed to contaminants released to the Columbia River and in onsite surface water bodies (less than dose limits and guidelines). Estimated dose to a member of the public for radionuclides released from all potential sources of airborne radionuclides was 0.052 millirem (0.52 microsievert) at Sagemoor.

## Cultural and Historic Resources

DOE is responsible for managing and protecting the Hanford Site's cultural and historic resources. The Hanford Cultural and Historic Resources Program, which is managed by DOE, ensures cultural and historic resources entrusted to DOE are managed responsibly and in accordance with applicable regulatory requirements (Section 10.15).

Cultural resources reviews must be conducted before a federally funded, federally assisted, or federally licensed ground disturbance or building alteration/demolition project can take place. As such, cultural resource reviews are required at the Hanford Site to identify properties within the proposed project area that may be eligible for, or listed in, the National Register of Historic Places, and evaluate the project's potential to affect any such property. During 2008, 113 cultural resource reviews were requested by Hanford Site contractors. In 1987, a monitoring program to assess the effects of weathering and erosion or unauthorized excavation and artifact collection of Hanford Site's cultural resources was established. In 2008, 45 sites were visited and minor impacts due to recreation, natural erosion, and animal activity were recorded.

## Climate and Meteorology

Meteorological measurements support Hanford Site emergency preparedness and response, operations, and atmospheric dispersion calculations. Activities include weather forecasting and maintaining and distributing climatological data (Section 10.16).

During 2008, average temperature and precipitation totals were below normal. The average temperature for 2008 was 11.3°C (52.4°F), which was 0.7°C (1.2°F) below normal (12.0°C [53.6°F]). Five months during 2008 were warmer than normal, and seven months were cooler than normal. Precipitation during 2008 totaled 13.9 centimeters (5.49 inches), which is 79% of normal (17.7 centimeters [6.98 inches]). Snowfall for 2008 totaled 77.7 centimeters (30.6 inches), compared to normal snowfall of 39.1 centimeters (15.4 inches).

The average wind speed during 2008 was 3.6 meters per second (8.1 miles per hour), which was 0.2 meter per second (0.5 mile per hour) above normal. The peak gust for the year was 26.4 meters per second (59 miles per hour) on February 7. Two dust storms were recorded at the Hanford Meteorology Station during 2008, less than the five per year average for the entire period on record (1945–2008).

## Quality Assurance

Comprehensive quality assurance programs, which include various quality control practices and methods to verify data, are maintained by monitoring and surveillance projects to assure data quality (Section 10.17). The programs are implemented through quality assurance plans designed to meet requirements of the American National Standards Institute/American Society of Mechanical Engineers and DOE Orders. Quality assurance plans are maintained for all activities, and auditors verify conformance. Samples are collected and analyzed according to documented standard procedures. Analytical data quality was verified by a continuing program of internal laboratory quality control, participation in inter-laboratory crosschecks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories.





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# 1.0 Introduction

This environmental report, published annually since 1959 (<http://hanford-site.pnl.gov/envreport>), provides information and analytical data related to the Hanford Site for the 2008 calendar year, including a brief history of the site and its mission; compliance with applicable federal, state, and local environmental laws, regulations, permits, executive orders, and U.S. Department of Energy (DOE) policies and directives; and descriptions and summary data from environmental-related programs.

Included are sections that describe the following:

- Site compliance with local, state, and federal environmental laws and regulations
- Site operations, including environmental restoration efforts and cleanup and closure activities
- Environmental occurrences
- Effluent and emissions from site facilities
- Results of onsite and offsite environmental and groundwater monitoring efforts
- Cultural and biological resource assessments.

Readers interested in more detail than is provided in this environmental report should consult the technical documents cited in text and listed in the reference sections. Descriptions of specific analytical and sampling methods used in the monitoring efforts are contained in the *Environmental Monitoring Plan United States Department of Energy Richland Operations Office* (DOE/RL-91-50, Rev. 4).

## 1.0.1 Current Hanford Site Mission

Prior to 1988, the primary Hanford Site mission was the production of plutonium for national defense purposes. The

current primary Hanford Site mission is environmental remediation and cleanup, including the remediation of contaminated areas and the decontamination and decommissioning of Hanford Site facilities.

The *Performance Management Plan for the Accelerated Cleanup of the Hanford Site* (DOE/RL-2002-47, Rev. D) describes the cleanup mission, which includes six strategies:

1. Restore the Columbia River Corridor by remediating Hanford Site sources of radiological and chemical contaminants that threaten the air, groundwater, or Columbia River by 2012.
2. End the tank waste program by 2033 by accelerating waste retrieval, completing tank waste treatment by increasing the capacity of the Hanford Tank Waste Treatment and Immobilization Plant (under construction in 2008) and using supplemental technologies for waste treatment and stabilization, and closing underground waste storage tanks.
3. Clean up other Hanford Site facilities that are considered urgent risks.
4. Treat and dispose of mixed low-level waste, including retrieval of transuranic waste and its shipment offsite.
5. Clean up excess facilities on the Central Plateau.
6. Monitor and remediate contamination sources and treat groundwater beneath the Hanford Site.

The main goal of these strategies is to expedite completion of Hanford Site cleanup in a cost-effective manner that protects the environment and public and worker health and safety.

## 1.0.2 Hanford Site Overview

The Hanford Site lies within the semi-arid Pasco Basin of the Columbia Plateau in southeastern Washington State

(Figure 1.0.1). The site occupies an area of approximately 1,517 square kilometers (586 square miles) located north of the city of Richland (DOE/EIS-0222-F). This area has restricted public access and provides a buffer for areas on the site that were used for nuclear materials production, waste storage, and waste disposal. The Columbia River flows eastward through the northern part of the site and then turns south, forming part of the eastern site boundary.

Major DOE operational, research, and administrative areas within and around the Hanford Site (Figure 1.0.1) include the following:

- **100 Areas** – The 100 Areas, consisting of six distinct sites, are situated along the shore of the Columbia River in the northern portion of the site. These areas were the location of nine nuclear reactors that have since been retired. Collectively, the 100 Areas occupy approximately 11 square kilometers (4 square miles). On August 19, 2008, the B Reactor, located in the 100-B Area, was designated as a National Historic Landmark. The B Reactor was the world's first industrial-scale nuclear reactor and where the plutonium was produced for the first atomic explosion (the Trinity Test) and the Nagasaki, Japan, atomic bomb. As a result of increased interest, DOE has improved access to the reactor, offering additional tours of the site.
- **200 Areas** – The 200-East and 200-West Areas, covering approximately 16 square kilometers (6 square miles), are located on the Central Plateau, approximately 8 and 11 kilometers (5 and 7 miles) south and west, respectively, of the Columbia River. The plateau surface is approximately 100 meters (328 feet) above the level of the Columbia River and about 85 meters (280 feet) above the underlying water table. These areas contain underground waste storage tanks and housed facilities (known as “separations plants”) that extracted plutonium from dissolved irradiated fuel. The 200-North Area, now considered part of the 600 Area, is located near Gable Mountain, north of the 200 Areas and approximately 7 to 12 kilometers (4 to 7.5 miles) south of the 100 Areas. Covering approximately 23.7 hectares (58.6 acres), operations were mainly related to irradiated nuclear fuel interim storage. Thermal cooling of the spent fuel required water, which was disposed of at several sites within the 200-North Area. Remediation of these sites is ongoing.
- **300 Area** – The 300 Area is located just north of the city of Richland and covers approximately 1.5 square kilometers (0.6 square mile). From the early 1940s until the advent of the cleanup mission, nuclear fuel fabrication and research and development activities on the Hanford Site were performed in the 300 Area.
- **400 Area** – The 400 Area is located northwest of the 300 Area, and covers approximately 0.61 square kilometer (0.23 square mile). This area includes the Fast Flux Test Facility, which has not operated since 1992 and was undergoing deactivation during 2008. This nuclear reactor was designed and used to test various types of nuclear fuel, produce medical and industrial isotopes, and conduct cooperative international research.
- **600 Area** – The 600 Area includes all of the Hanford Site not occupied by the 100, 200, 300, and 400 Areas.
- **Former 1100 Area** – The former 1100 Area is located between the 300 Area and the city of Richland and covers 3.1 square kilometers (1.2 square miles). In October 1998, this area was transferred to the Port of Benton as part of DOE's Richland Operations Office economic diversification efforts and is no longer part of the Hanford Site. However, DOE contractors continue to lease facilities in this area.
- **Richland North Area (offsite)** – This area includes the Environmental Molecular Sciences Laboratory, Pacific Northwest National Laboratory, and other DOE and contractor facilities (mostly office buildings), generally located in the northern part of the city of Richland.
- **700 Area (offsite)** – The 700 Area includes DOE administrative buildings in the central region of the city of Richland.
- **Volpentest Hazardous Materials Management and Emergency Response Training and Education Center** (also called HAMMER) – This worker safety training facility is located on the Hanford Site near the city of Richland. It consists of a 0.31-square-kilometer (0.12-square-mile) main site and a 40.4-square-kilometer (15.6-square-mile) law enforcement and security training site. The facility is owned by DOE, was managed by Fluor Hanford, Inc. during 2008, and is used by site contractors, federal and state agencies, tribal governments, and private industries.



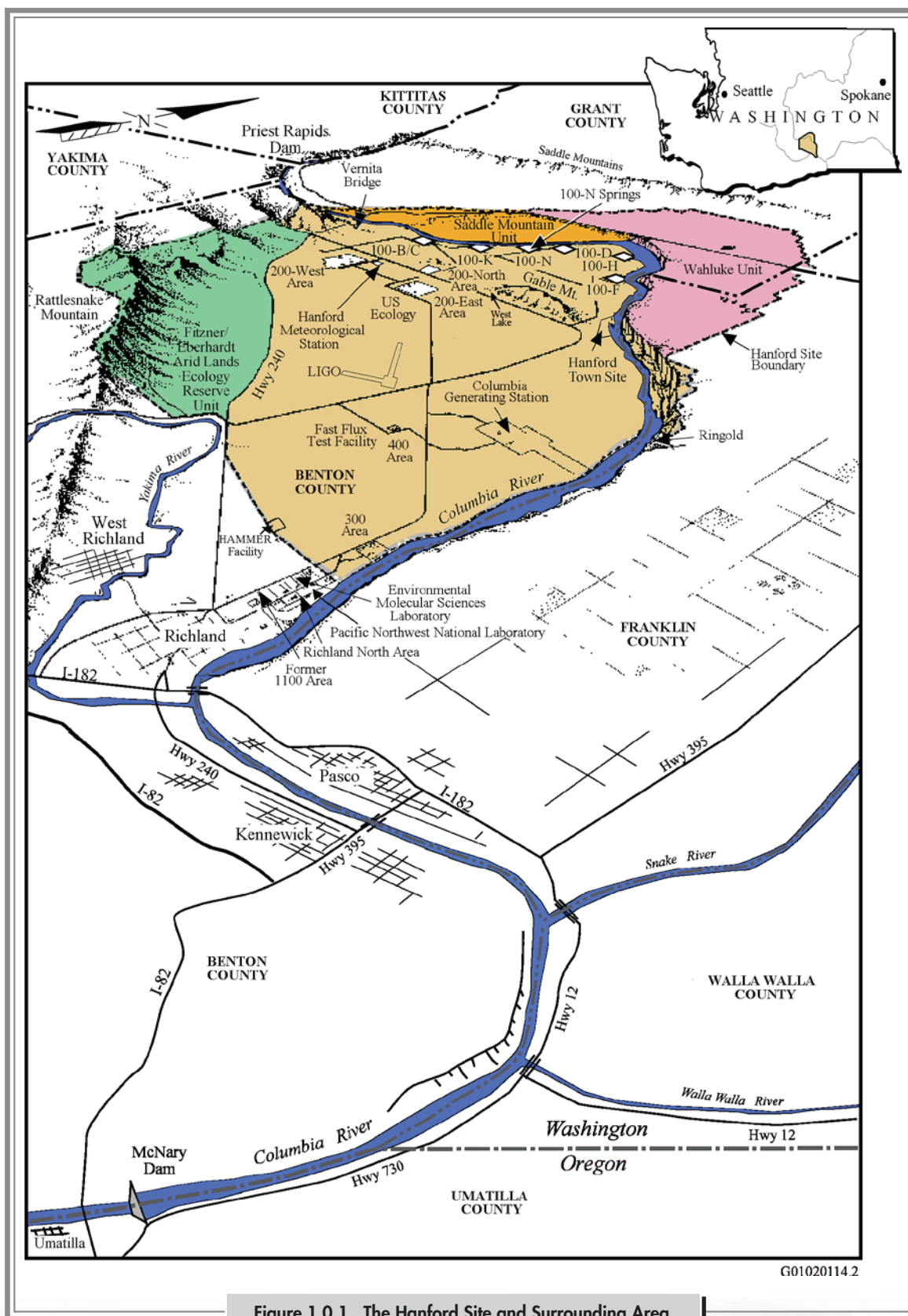


Figure 1.0.1. The Hanford Site and Surrounding Area

**Non-DOE Operations and Activities on Hanford Site Leased Land** – These include commercial power production by Energy Northwest at the Columbia Generating Station (440 hectares [1,090 acres]) and operation of a commercial low-level radioactive waste burial site by US Ecology Washington, Inc. (40 hectares [99 acres]). The Laser Interferometer Gravitational-Wave Observatory (60 hectares [148 acres]), located west of the 400 Area, is sponsored by the National Science Foundation and operated jointly by the California Institute of Technology and the Massachusetts Institute of Technology.

**Rattlesnake Mountain** – The top of Rattlesnake Mountain is DOE-owned land, but is managed by the U.S. Fish and Wildlife Service as part of the Hanford Reach National Monument. DOE has leased this land to public and private agencies, including public utility districts, communication businesses, emergency management facilities, Energy Northwest, Battelle Memorial Institute, the Alliance for the Advancement of Science through Astronomy, and others for decades. In March 2008, the DOE Richland Operations Office announced it would not renew existing permits, licenses, and easements on Rattlesnake Mountain, and that structures would be removed, returning the land to natural conditions. The Rattlesnake Mountain Observatory was removed in June 2009; it was built in 1971 by Battelle using privately donated funds for astronomical research and donated by Battelle to the Alliance for the Advancement of Science Through Astronomy in 2005.

**Non-DOE Nuclear Operations Near the City of Richland** – Immediately adjacent to the southern boundary of the Hanford Site, AREVA NP, Inc. operates a commercial nuclear fuel fabrication facility, and Perma-Fix Northwest, Inc. operates a low-level and mixed low-level radioactive waste processing facility. Westinghouse Electric Company operates the Richland Service Center, located in north Richland, which provides chemical cleaning, decontamination, and other waste processing services to the nuclear industry.

**Hanford Reach National Monument** – The 789-square-kilometer (305-square-mile) Hanford Reach National Monument (Figure 1.0.2) was established on the Hanford Site by a Presidential Proclamation in June 2000 (65 FR 37253-37256). The purpose of the monument is to protect the

nation's only non-impounded stretch of the Columbia River upstream of Bonneville Dam in the United States, and the remaining shrub-steppe ecosystem that once blanketed the Columbia River Basin.

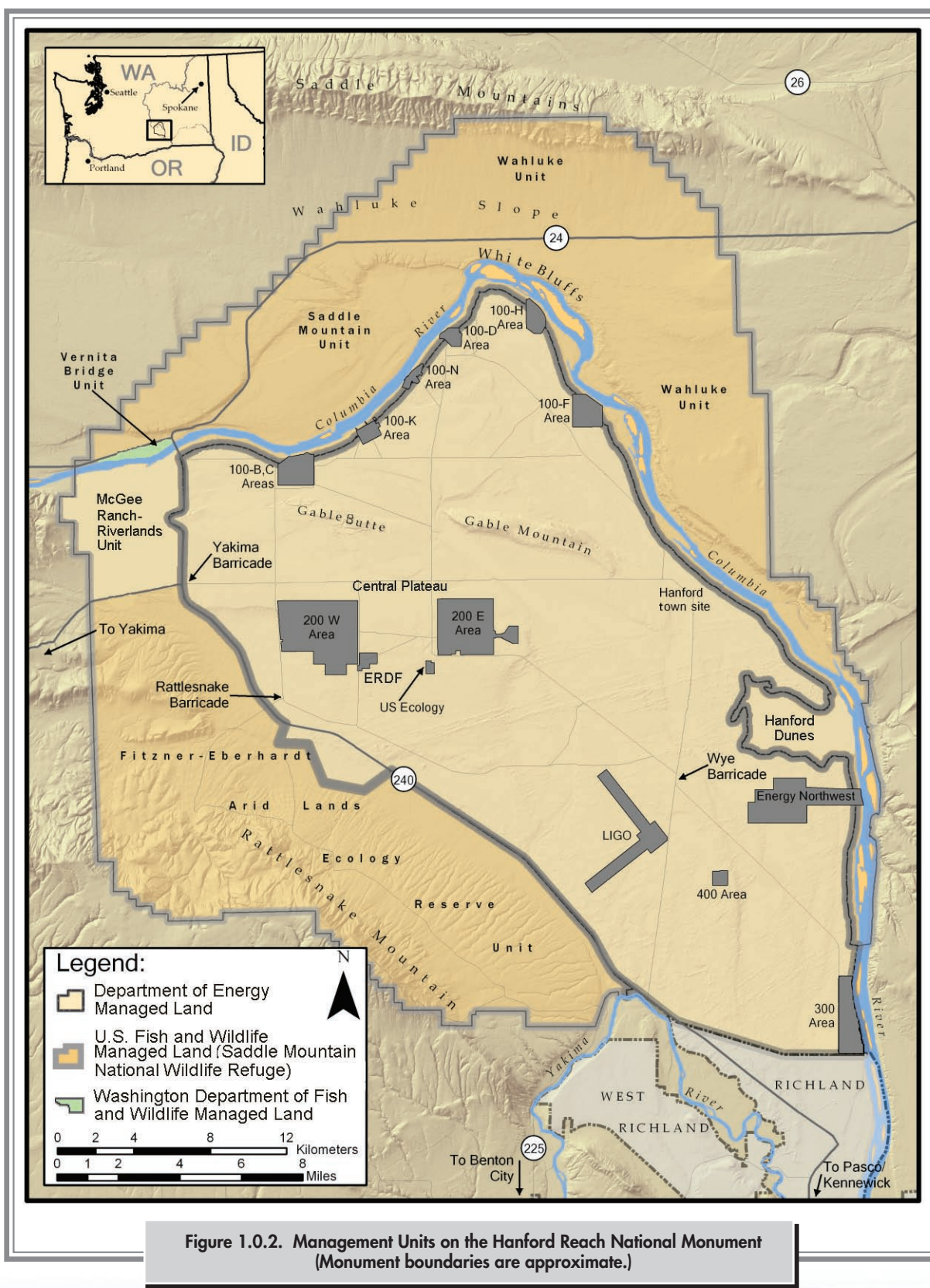
### 1.0.3 Hanford Site Management

DOE is responsible for operating the Hanford Site. The DOE Richland Operations Office and DOE Office of River Protection jointly manage the Hanford Site through several contractors and their subcontractors. Each contractor is responsible for safe, environmentally sound maintenance and management of its activities or facilities; waste management; evaluation and determination of all discharges to the environment; and for monitoring any potential effluent to assure environmental regulatory compliance. DOE, the U.S. Fish and Wildlife Service, and the Washington Department of Fish and Wildlife each manage portions of the Hanford Reach National Monument.

**DOE Richland Operations Office.** The DOE Richland Operations Office serves as landlord of the Hanford Site and manages cleanup of legacy waste and related research, and other programs. During 2008, the principal contractors for the DOE Richland Operations Office and their respective responsibilities included the following:

- On September 3, 2008, DOE selected Mission Support Alliance, LLC as the mission support contractor for the Hanford Site. The contractor will be responsible for Hanford Site infrastructure and support services, with five primary functions: safety, security and environment; site infrastructure and utilities; site business management; information resources/content management; and portfolio management. The contractor was scheduled to assume full rights on January 1, 2009. On September 22, 2008, Computer Sciences Corporation filed a protest against the contract, which required resolution by the Government Accountability Office within 100 days. On December 30, 2008, the Government Accountability Office dismissed the protest, with the stipulation that concerns identified in the protest be addressed before infrastructure management and support services transferred. On April 28, 2009, DOE reaffirmed its selection of the Mission Support Alliance, LLC as the





mission support contractor. Transition began in May 2009 and is to be completed within 90 days. Mission Support Alliance, LLC includes Lockheed Martin, LLC; Jacobs Engineering Group, Inc.; and Wackenhut Services, Inc. Subcontractors include Abadan, Akima Facilities Management, Dade Moeller & Associates, HPM Corporation, Longenecker and Associates, Protection Strategies, R. J. Lee Group, Vivid Learning Systems, Westech International, TestAmerica, and Lampson International.

- Washington Closure Hanford, LLC, a limited liability company owned by Washington Division of URS Corporation (formerly Washington Group International), Bechtel National, Inc., and CH2M HILL Hanford Group, Inc. was awarded the River Corridor Closure Contract in March 2005. The purpose of this contract is to clean up waste sites and conduct environmental restoration along the Columbia River Corridor, an area roughly 544 square kilometers (210 square miles) along the Benton County side of the Columbia River's Hanford Reach. This contractor's work includes placing the remaining deactivated plutonium-production reactors in interim safe storage (also known as "cocooning" the reactors), continuing with cleanup of the remaining waste sites located near the Columbia River, demolishing contaminated facilities, and operating the Environmental Restoration Disposal Facility. The principal subcontractor to Washington Closure Hanford, LLC is Eberline Services Hanford, Inc.
- Fluor Hanford, Inc. managed the Project Hanford Management Contract from September 1996 through September 2008. The purpose of this contract was to dismantle former nuclear processing facilities on the Hanford Site, monitor and clean up site contaminated groundwater, retrieve and process transuranic waste for offsite shipment, maintain site infrastructures, provide fire protection and security, and operate the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER). Fluor Hanford, Inc.'s principal subcontractors were EnergySolutions Federal Services of Hanford, Inc. and Numatec Hanford Corporation, a subsidiary of AREVA Group. Other subcontractors to Fluor Hanford, Inc. included Lockheed Martin Information Technology, LLC, and the Fluor Government Group. On October 1,

2008, the new plateau remediation contractor, CH2M HILL Plateau Remediation Company, assumed responsibility for many of Fluor Hanford, Inc.'s projects. Fluor Hanford, Inc. continued to maintain Hanford Site's support services by providing fire protection (Hanford Fire Department) and security (Hanford Patrol), operating the Waste Sampling and Characterization Facility, and operating the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER). Fluor Hanford, Inc. will continue providing these services until the Mission Support Contract is finalized.

- AdvanceMed Hanford was the occupational health contractor on the Hanford Site in 2008. The company provides occupational medicine and nursing; medical surveillance and evaluations; ergonomics assessment; exercise physiology; case management; psychology counseling and evaluations; fitness-for-duty evaluations; health education; infection control; immediate health care; industrial hygiene; and health, safety, and risk assessments.

The DOE Richland Operations Office also manages portions of the Hanford Reach National Monument. The portion of the monument administered by the DOE Richland Operations Office includes the 36.4-square-kilometer (14-square-mile) McGee Ranch/Riverlands Unit (north and west of State Highway 24 and south of the Columbia River) in Benton County, and the Columbia River Corridor Unit, which includes the Hanford Reach islands in Benton County and a 0.4-kilometer- (0.25-mile-) wide strip of land along the Hanford Reach shoreline from the Vernita Bridge to just north of the 300 Area. This 101-square-kilometer (39-square-mile) unit in Benton, Franklin, and Grant Counties also includes the 25.6-square-kilometer (9.9-square-mile) Hanford Site dunes area north of Energy Northwest (Figure 1.0.2).

**DOE Office of River Protection.** The DOE Office of River Protection was established by Congress in 1998 as a field office to manage Hanford Site tank-waste storage, retrieval, treatment, and disposal. The prime contractors for the DOE Office of River Protection in 2008 and their respective responsibilities included the following:

- Bechtel National, Inc. – This contractor's mission is to design, build, and initiate the operation of the Hanford Tank Waste Treatment and Immobilization Plant,

located on a 0.26-square-kilometer (0.1-square-mile) site on the Central Plateau of the Hanford Site. This facility is designed to convert liquid radioactive waste into a stable glass form (vitrification). The 10-year contract for this work was awarded in December 2000.

- Washington Division of URS Corporation (formerly Washington Group International) – A subcontractor to Bechtel National, Inc., Washington Division of URS Corporation participates in the mission to design and construct the Hanford Tank Waste Treatment and Immobilization Plant.
- Washington River Protection Solutions, LLC – On October 1, 2008, this contractor became the tank operations contractor for the Hanford Site. The Tank Operations Contract scope of work includes base operations of the tanks, analytical laboratory support, single-shell tank retrieval and closure, Hanford Tank Waste Treatment and Immobilization Plant support, and supplemental treatment. Hanford Site's tank farms contain 214 million liters (57 million gallons of radioactive and chemically hazardous waste stored in 177 underground tanks generated from more than three decades of plutonium production. Washington River Protection Solutions, LLC was formed by the Washington Division of URS Corporation and EnergySolutions, with AREVA Federal Services, LLC serving as a subcontractor.
- CH2M HILL Plateau Remediation Company – On October 1, 2008, this contractor became the plateau remediation contractor for the Hanford Site, responsible for safe environmental cleanup of the Central Plateau. The Plateau Remediation Contract scope of work includes environmental remediation, groundwater monitoring and remediation, waste site characterization, non-tank farm waste disposal, Fast Flux Test Facility maintenance and shutdown, environmental monitoring and maintenance, and completion of the Plutonium Finishing Plant closure project. The CH2M HILL Plateau Remediation Company team includes CH2M HILL Constructors, Inc.; AREVA Federal Services, LLC; East Tennessee Materials and Energy Corporation, Inc.; Fluor Federal Services, Inc.; ARES Corporation; Babcock Services; GEM Technology International; INTERA, Inc.; ENREP, Inc.; Ascendent Engineering and Safety Solutions; Cavanagh Services Group; and Project Service Group.

- CH2M HILL Hanford Group, Inc. – This contractor was responsible for maintaining tank farm infrastructure and storing, retrieving, and disposing of radioactive and chemically hazardous waste stored in 177 underground tanks on the Hanford Site until October 1, 2008, when Washington River Protection Solutions, LLC became the responsible contractor.
- Advanced Technologies and Laboratories International, Inc. – This contractor provides analytical services to Hanford Site cleanup and restoration contractors. Located in the 200-West Area, this laboratory receives, analyzes, and stores samples and reports analytical results to the appropriate contractor.

**DOE Office of Science.** The Pacific Northwest Site Office of the DOE Office of Science oversees Pacific Northwest National Laboratory (including the Environmental Molecular Sciences Laboratory) to support DOE's science and technology programs, goals, and objectives. Pacific Northwest National Laboratory, a DOE facility in Richland, Washington, is operated by Battelle for the DOE's national security and energy missions. Pacific Northwest National Laboratory delivers scientific solutions by using interdisciplinary teams from multiple scientific disciplines to solve energy, environmental, and national security challenges.

**U.S. Fish and Wildlife Service.** The U.S. Fish and Wildlife Service, under permits and memoranda of agreement with DOE, manages regions of the Hanford Reach National Monument. During 2008, the U.S. Fish and Wildlife Service administered three major management units (Figure 1.0.2) totaling about 668 square kilometers (258 square miles). These included the following:

1. The Fitzner/Eberhardt Arid Lands Ecology Reserve Unit, a 311-square-kilometer (120-square-mile) tract of land in Benton County with no general public access located in the southwestern portion of the Hanford Site.
2. The Saddle Mountain Unit, a 130-square-kilometer (50-square-mile) tract of land in Grant County with no general public access located north-northwest of the Columbia River.



3. The Wahluke Unit, a 230-square-kilometer (89-square-mile) tract of land located north of the Columbia River with public access and adjacent to (east of) the Saddle Mountain Unit.

These land units have served as a safety and security buffer zone for Hanford Site operations since 1943, resulting in an ecosystem that has been relatively untouched for more than 60 years. Together, these units comprise the Saddle Mountain National Wildlife Refuge.

**Washington Department of Fish and Wildlife.** This department manages the Vernita Bridge Unit of the Hanford Reach National Monument, occupying approximately 3.2-square-kilometers (1.25-square-miles) along the north side of the Columbia River, west of the Vernita Bridge, and south of State Highway 243 in Grant County. This unit is open to the public year round.

## 1.0.4 Hanford Site Websites

Additional information about Hanford Site management and contractors can be accessed at the following websites:

- AdvanceMed Hanford:  
<http://www.hanford.gov/?page=65&parent=62>
- Advanced Technologies and Laboratories International, Inc.: <http://www.atlintl.com/>
- Bechtel National, Inc.:  
<http://www.hanford.gov/?page=68&parent=62>
- CH2M HILL: <http://www.ch2m.com/corporate/>
- CH2M HILL Plateau Remediation Company:  
<https://www.plateauremediation.com/>
- DOE Office of River Protection:  
<http://www.hanford.gov/orp/>
- DOE Office of Science: <http://www.er.doe.gov/>
- DOE Richland Operations Office:  
<http://www.hanford.gov/rl/>
- DOE Science and Technology:  
<http://www.energy.gov/sciencetech/>
- Eberline Services Hanford, Inc.:  
[http://www.eberlineservices.com/page\\_field.htm](http://www.eberlineservices.com/page_field.htm)
- EnergySolutions:  
<http://www.energysolutions.com/?id=OTUy>
- Environmental Molecular Sciences Laboratory:  
<http://www.emsl.pnl.gov/>
- Environmental Restoration Disposal Facility:  
<http://www.hanford.gov/rl/backgrounder/EnvRest.pdf>
- Fast Flux Test Facility:  
<http://www.hanford.gov/rl/?page=304&parent=0>
- Fluor Hanford, Inc., Project Hanford Management Contract:  
<http://www.hanford.gov/?page=73&parent=85>
- Hanford Reach National Monument:  
<http://www.fws.gov/hanfordreach>
- Hanford Site Tours:  
<http://www.hanford.gov/?page=317&parent=0>
- Laser Interferometer Gravitational-Wave Observatory:  
<http://www.ligo.caltech.edu/>
- Lockheed Martin:  
<http://www.hanford.gov/?page=74&parent=62>
- Mission Support Alliance, LLC:  
<http://www.msa-hanford.com>
- Numatec Hanford Corporation:  
<http://www.hanford.gov/?page=75&parent=62>
- Pacific Northwest National Laboratory:  
<http://www.pnl.gov/>
- Pacific Northwest Site Office of the DOE Office of Science: <http://pnso.oro.doe.gov/>
- Volpentest Hazardous Materials Management and Emergency Response Training & Education Center (HAMMER): <http://www.hammertraining.com/>
- Washington Closure Hanford, LLC:  
<http://www.washingtonclosure.com/>
- Washington Division of URS Corporation (formerly Washington Group International):  
<http://www.urscorp.com/Divisions/index.php?s=4>
- Washington River Protection Solutions, LLC:  
<http://www.wrpstoc.com/>

Additional information about the local area and region can be accessed at the following websites:

- City of Kennewick: <http://www.ci.kennewick.wa.us/>
- City of Pasco: <http://www.pasco-wa.gov/>
- City of Richland: <http://www.ci.richland.wa.us/>

- City of West Richland: <http://www.westrichland.org/>
- Columbia Plateau:  
<http://www.dnr.wa.gov/ResearchScience/Topics/GeologyofWashington/Pages/columbia.aspx>
- Columbia River Basin:  
<http://yosemite.epa.gov/r10/ecocomm.nsf/Columbia/Columbia>
- Port of Benton: <http://www.portofbenton.com/>
- Tri-Cities: <http://www.visittri-cities.com/>
- U.S. Fish and Wildlife Service: <http://www.fws.gov/>
- Washington Department of Fish and Wildlife:  
<http://wdfw.wa.gov/>

Additional information about other companies in the area can be accessed at the following websites:

- Battelle Memorial Institute: <http://www.battelle.org/>
- Energy Northwest, Columbia Generating Station:  
<http://www.energy-northwest.com/generation/cgs/index.php>
- US Ecology Washington, Inc.:  
<http://www.americanecology.com/richland.htm>
- Perma-Fix Northwest, Inc.:  
<http://www.perma-fix.com/northwest>

## 1.0.5 References

65 FR 37253-37256. 2000. "Establishment of the Hanford Reach National Monument." Proclamation 7319 of June 9, 2000, by the President of the United States of America. *Federal Register*.

DOE/EIS-0222-F. 1999. *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statements*. U.S. Department of Energy, Washington, D.C. Accessed on March 13, 2009, at <http://www.hanford.gov/doe/eis/hraeis/maintoc.htm>.

DOE/RL-91-50, Rev. 4. 2008. *Environmental Monitoring Plan United States Department of Energy Richland Operations Office*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2002-47, Rev D. 2002. *Performance Management Plan for the Accelerated Cleanup of the Hanford Site*. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Accessed on March 13, 2009, at [http://www.hanford.gov/rl/uploadfiles/Perf\\_Mang\\_rl-2002-47.pdf](http://www.hanford.gov/rl/uploadfiles/Perf_Mang_rl-2002-47.pdf).





## 2.0 Public Involvement on the Hanford Site

JP Duncan

The U.S. Department of Energy (DOE) encourages information exchange and public involvement in discussions and decision making regarding Hanford Site cleanup and remediation actions. Active participants include the public; Native American tribes; local, state, and federal government agencies; advisory boards; activist groups; and other entities in the public and private sectors. The roles and association of several stakeholders are described in the following sections.

### 2.0.1 Role of Native American Tribes

JA Conrad

Native American tribal governments are involved in many aspects of the Hanford Site, including participation in site activities and planning meetings. The Hanford Site is located on land formerly occupied by Native American tribes. The Confederated Tribes and Bands of the Yakama Indian Nation and Confederated Tribes of the Umatilla Indian Reservation negotiated with the United States government in the Treaties of 1855 to cede certain land to the government. These tribes, as well as the Nez Perce Tribe, have treaty-protected fishing rights on portions of the Columbia River. The Treaties of 1855 include provisions that the tribes reserved the right to fish at all usual and accustomed places, to hunt, gather roots and berries, and pasture horses and cattle on open and unclaimed land. The United States government has a unique political and legal relationship with tribal governments as defined by treaties, the United States Constitution, court decisions defining the federal trust responsibility, and executive orders. Additional federal laws and regulations requiring DOE to consult with tribes on certain issues include the *American Indian Religious Freedom Act*, the *National Environmental*

*Policy Act of 1969*, the *Archaeological Resources Protection Act of 1979*, the *National Historic Preservation Act of 1966*, and the *Native American Graves Protection and Repatriation Act of 1990*. As Hanford Site cleanup progresses, the tribes review various aspects of cleanup activities including how these activities will affect past cultural resources and any future ability to use and consume the natural resources that once existed at the site.

Native American tribes have been involved at the Hanford Site since the Basalt Waste Isolation Pilot Project in the 1980s. Tribal review of site activities has increased with the environmental restoration and waste management mission at the Hanford Site. The DOE *American Indian & Alaska Native Tribal Government Policy* (DOE 2006) guides DOE's collaborative interaction with tribes regarding site-related plans and activities. The policy states the following:

“The Department will consult with any American Indian or Alaska Native tribal government with regard to any property to which that tribe attaches religious or cultural importance which might be affected by a DOE action.” (DOE 2006)

DOE provides financial assistance through cooperative agreements with the Confederated Tribes and Bands of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe to support their involvement in environmental management activities at the Hanford Site. Funding enables tribes to retain staff to facilitate the review and comment on site-related draft documents and plans, as well as participate in meetings and activities. Representatives from the Confederated Tribes and Bands of the Yakama Indian Nation, Confederated Tribes of the Umatilla Indian Reservation, and Nez Perce Tribe participate in DOE-supported groups

such as the State and Tribal Government Working Group, the Hanford Natural Resources Trustee Council, and the Hanford Cultural and Historic Resources Program.

Both the Wanapum and the Confederated Tribes of the Colville Reservation are also provided an opportunity to comment on draft documents and participate in cultural resource management activities. The Wanapum are not a federally recognized tribe; however, they have historic ties to the Hanford Site as their descendants resided there before the land was ceded to the United States government for the Manhattan Project in the 1940s. The Confederated Tribes of the Colville Reservation, whose descendants also used Hanford Site land, also have historic ties to the site.

## 2.0.2 Consultations and Meetings with Tribes, Interested Parties, and the State Historic Preservation Office

EP Kennedy

Federal legislation and policies require DOE to consult with the Washington State Department of Archaeology & Historic Preservation, Native American tribes, and interested parties on cultural resource matters. Specifically, Section 106 of the *National Historic Preservation Act of 1966* requires DOE to seek and gather input from tribes and interested parties, and obtain concurrence from the Washington State Department of Archaeology & Historic Preservation on the identification of cultural resources, evaluation of the significance of these resources, and assessment of impacts of DOE undertakings on cultural resources. DOE's Cultural and Historic Resources Program routinely consults with the Washington State Department of Archaeology & Historic Preservation, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Indian Nation, the Confederated Tribes of the Colville Reservation, the Nez Perce Tribe, and the Wanapum. Program officials also consult with parties that express an interest in cultural resources located on the Hanford Site. These include groups such as the B Reactor Museum Association, the White Bluffs Pioneers, the Benton County Historical Society, the East Benton County Historical Museum, and the Franklin County Museum. Program officials also conduct regular

meetings with tribal cultural resources personnel. Discussions focus on cultural resource reviews and issues regarding the protection of Hanford Site cultural resources. Program officials hold meetings with interested parties on an as-needed basis. Section 10.15 of this report further addresses cultural and historic resource activities.

## 2.0.3 Hanford Natural Resource Trustee Council

DC Ward

Under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended, the United States is liable for damages for injury to, destruction of, or loss of natural resources, including the cost of assessing such damage. CERCLA and the *National Contingency Plan* establish DOE as both a CERCLA lead response agency on departmental facilities and a trustee for natural resources under its jurisdiction. The President of the United States, by Executive Order 12580, "Superfund Implementation" (52 FR 2923), appointed the Secretary of Energy as the primary trustee for all natural resources located on, over, or under land administered by DOE, including the Hanford Site. Other designated federal trustees for Hanford Site natural resources include the U.S. Department of the Interior represented by the U.S. Fish and Wildlife Service, and the U.S. Department of Commerce represented by the National Oceanic and Atmospheric Administration. CERCLA § 107(f)(2)(B) authorizes state governors to designate a state trustee to coordinate all state trustee responsibilities. State organizations include the Washington State Department of Ecology and the Oregon Department of Energy. Native American tribes also participate as members of the Hanford Natural Resource Trustee Council. Tribes include the Confederated Tribes and Bands of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe.

The Hanford Natural Resource Trustee Council was established in 1996 via a Memorandum of Agreement (1996) and is a voluntary association of trust organizations. Members collaborate and coordinate on many issues, documents, and actions concerning natural resources. The primary purpose of the council is to facilitate the coordination and cooperation of the trustees in their efforts to mitigate the effects to natural

resources that result from either hazardous substance releases on the Hanford Site or remediation of those releases. The council has adopted bylaws to direct the process of arriving at consensus on all substantive decisions.

During 2008, the trustees met as a formal council six times to discuss CERCLA natural resource issues for the Hanford Site. The senior trustees (upper-management level representatives from each trust organization) conducted two conference calls in 2008 to discuss policy and management issues.

On April 3, 2007, the federal trustees issued a letter to the State and Tribal Trustees informing them it was appropriate to move forward in the natural resource damage assessment process for the Hanford Site. This action was in accordance with the natural resource damage assessment regulations in 43 CFR Part 11.23(f)(4). The federal trustees determined that moving forward with damage assessment activities, and specifically the development of a phased, natural resource damage assessment plan that addresses potential natural resource injuries associated with the currently listed National Priorities List areas, is the best progressive action in the damage assessment process for the Hanford Site. A phased assessment process will allow for an iterative natural resource damage assessment process that is continually updated by ongoing CERCLA activities and remedial decision making, including ecological risk assessments.

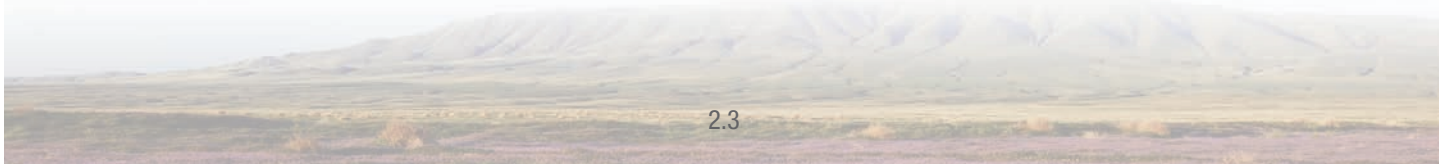
Federal trustees issued a draft conceptual design for the Hanford Site natural resource damage assessment plan with the following actions:

- Complete the CERCLA ecological risk assessments
- Initiate the U.S. Department of the Interior Assessment Plan Phase in parallel with risk assessments
  - Continue analysis of existing data
  - Continue development of conceptual site model and pathway analysis and identification of key receptors of concern
  - Identify data gaps regarding potential injury to natural resources
  - Prepare an assessment plan
- Implement the assessment plan

- Initiate preliminary restoration planning
- Perform early restoration, if appropriate.

During 2008, the Hanford Natural Resource Trustee Council performed the following actions:

- Attended workshops and meetings concerning the ecological risk assessment for the Central Plateau and the Columbia River Corridor.
- Organized a 1-day workshop with outside experts to discuss sturgeon sampling designs.
- Participated in meetings to provide input into the revision of the *Hanford Site Biological Resources Management Plan* (DOE/RL-96-32, Rev. 0).
- Participated in discussions with Robert Foley of the U.S. Fish and Wildlife Service concerning his experience with trustee councils and specifically the Hudson River Superfund Site.
- Hired a temporary administrative assistant to organize the Administrative Record (1994 to present) and process the official Natural Resource Trustee Council records, making electronic copies accessible.
- Discussed funding concerns related to trust organization support to ecological risk assessments and for the natural resource damage assessment on the Hanford Site, council governance, facilitation of council meetings, and leadership of the natural resource injury assessment planning effort. The trustees developed a 2010 budget for inclusion in DOE's 2010 budget request.
- Completed a successful solicitation to identify and hire a contractor to work with the council on the natural resource damage assessment, performing Phase 1 and developing a proposed scope of work and cost estimate for Phase 2, in the preparation of an injury assessment plan.
- Conducted a series of meetings related to planning for a collaborative injury assessment to identify contaminants, receptors, and priorities.
- The trust organizations chose to remain as one council as determined by Trustee Council Resolution 08-04. It will provide advice to the Tri-Parties (Washington State Department of Ecology, U.S. Environmental Protection Agency [EPA], and DOE) on Hanford Site



cleanup response actions, and it will meet its obligations as trustees to proceed with a natural resource damage assessment.

- Participated in site-specific training on the natural resource damage assessment process.
- Organized the trustees into technical working groups to better understand resources on the Hanford Site, and to assist in developing conceptual site models for the injury assessment plan.
- Initiated an update to the Trustee Council Memorandum of Agreement to include the National Oceanic and Atmospheric Administration.

Information about the Hanford Natural Resource Trustee Council, including its history and projects, can be found at its website located at <http://www.hanford.gov/?page=291&parent=0>.

## 2.0.4 Public Participation in Hanford Site Decisions

### CC French and TE Olds

DOE's Richland Operations Office and Office of River Protection believe public involvement is essential to the ultimate success of Hanford Site cleanup. These offices coordinate, plan, and schedule public participation activities for DOE on the Hanford Site.

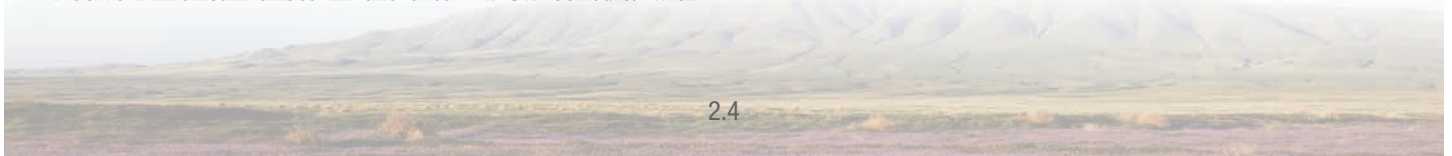
The *Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan* (Tri-Party Agreement Agencies 2002) outlines the public participation processes used by the Tri-Parties (Washington State Department of Ecology, EPA, and DOE) and identifies various ways the public can participate in Hanford Site cleanup decisions (see Section 3.0.1). The plan was developed and approved with public input in 1990 and revised in 2002. The most current revision is available on the Hanford Site website located at <http://www.hanford.gov> under the Community Relations Plan.

A key goal of public involvement is to facilitate broad-based participation and obtain stakeholder and public perspectives on Hanford Site cleanup decisions. DOE is committed to maintaining a government-to-government relationship with Native American tribes in the area. DOE consults with

tribal governments prior to taking action, making decisions, or implementing programs that may affect the tribes.

DOE uses various forums to inform the public of upcoming public involvement and participation opportunities. These include, but are not limited to, the following:

- **The Hanford Cleanup Line** – The Hanford Cleanup Line (1-800-321-2008) responds to information requests about the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement [Ecology et al. 1989]) cleanup activities. The Tri-Parties strive to provide a timely response to all requests. The line is advertised frequently in a variety of ways, including all Tri-Party Agreement media information such as newspaper notices, brochures, meeting notices, and Hanford Site fact sheets.
- **Mailing List** – The Tri-Parties maintain a mailing list of about 3,300 individuals who have expressed interest in Hanford Site cleanup issues. The mailing list is used to provide information to the public on upcoming cleanup decisions and activities. Information can be received by mail or electronically. To be added to the list, call the Hanford Cleanup Line at 1-800-321-2008.
- **Hanford Site Public Involvement Activities** – A Hanford Site Public Involvement Activities document is produced quarterly to provide an overview of anticipated public involvement opportunities for the coming months. It identifies the current forums and emerging opportunities to inform and involve stakeholders and the public. It is available at the following website under the Public Involvement section: <http://www.hanford.gov>. Additionally, a list of public involvement opportunities is posted at <http://www.hanford.gov/?page=179&parent=29>.
- **Fact and Focus Sheets** – Fact and focus sheets provide information on Hanford Site issues, cleanup activities, and public involvement opportunities.
- **Meeting Summaries** – Summaries of certain public meetings are available upon request from DOE's Public Reading Room located at the Washington State University Tri-Cities Consolidated Information Center, 2710 University Drive, Richland, Washington. Further information regarding the DOE Public Reading Room is available at its website: <http://reading-room.pnl.gov/>.



- **Comment and Response Documents** – Following a DOE or Tri-Party Agreement public comment period, a comment and response document is developed to record public comments received on an issue. Comment and response documents are distributed to those members of the public who provide comments or request copies. The documents are posted in DOE's Public Reading Room, in the Tri-Party Agreement's Administrative Record as part of the decision documentation, and at the following website: <http://www.hanford.gov/?page=91&parent=0>.
- **Informational Public Meetings** – All Tri-Party Agreement quarterly public involvement planning meetings, semiannual meetings, special meetings, and workshops are open to the public. In addition, the Tri-Parties welcome opportunities for co-sponsoring meetings organized by local, state, and tribal governments and citizen groups.

Hanford Site cleanup documents are also available to the general public through the Tri-Party Agreement's Administrative Record and Public Information Repository located at the following website: <http://www2.hanford.gov/arpir>.

The public is provided a variety of opportunities to offer input and influence Hanford Site cleanup decisions. These opportunities include informal and formal public comment periods, such as those described in the Tri-Party Agreement (Ecology et al. 1989), CERCLA, the *Resource Conservation and Recovery Act of 1976* (RCRA), and NEPA; Hanford Advisory Board meetings; annual state of the site and budget meetings; and other Hanford Site-related public involvement/information meetings, workshops, or activities.

For more information about Hanford Site cleanup activities, contact the Tri-Party Agreement agencies at the following contact numbers:

- DOE Richland Operations Office (509) 376-7501
- DOE Office of River Protection (509) 372-8656
- Hanford Cleanup Line (1-800) 321-2008
- EPA (509) 376-8631.

To view public involvement and outreach activities conducted by the Tri-Party Agreement agencies, visit the Hanford Site website at <http://www.hanford.gov>.

## 2.0.5 Hanford Advisory Board

### CC French and TE Olds

The Hanford Advisory Board is a broadly representative body consisting of a balanced mix of the diverse interests affected by Hanford Site cleanup decisions. The board was created in 1994 by the Tri-Parties and ultimately chartered as one of nine environmental management site-specific advisory boards across the country. The board is composed of 31 members and their alternates, including representatives from the Nez Perce Tribe and the Confederated Tribes and Bands of the Yakama Indian Nation. A representative of the Confederated Tribes of the Umatilla Indian Reservation participates on the board in an ex-officio status. Current members with their affiliation can be found at the following website: [http://www.hanford.gov/hanford/files/HAB\\_bcc.pdf](http://www.hanford.gov/hanford/files/HAB_bcc.pdf).

The Hanford Advisory Board assists the broader public in becoming more informed and meaningfully involved in Hanford Site cleanup decisions through its open public meetings. Its formal advice on cleanup issues reflects the values of its constituents.

Information about the Hanford Advisory Board, including its charter (operating ground rules) and copies of its advice and responses, can be found at the following website: <http://www.hanford.gov/public/boards/hab>.

## 2.0.6 References

43 CFR Part 11.23(f)(4). 2008. "Natural Resource Damage Assessments; Preassessment Screen-General." *Code of Federal Regulations*, Office of the Secretary of the Interior.

52 FR 2923. January 29, 1987. Executive Order 12580 of January 23, 1987, "Superfund Implementation." *Federal Register*, Office of the President.

*American Indian Religious Freedom Act*. 1978. Public Law 95-341, as amended, 42 USC 1996 et seq.

*Archaeological Resources Protection Act of 1979*. 1979. Public Law 96-95, as amended, 16 USC 470-470aa et seq.



*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. 1980. Public Law 96-510, as amended, 94 Stat. 2767, 42 USC 9601 et seq. Accessed April 9, 2009, at <http://www.epa.gov/lawsregs/laws/cercla.html>.

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DOE/RL-96-32, Rev. 0. 2000. *Hanford Site Biological Resources Management Plan*. Vols. 1 and 2. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology – Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy. 1989. *Hanford Federal Facility Agreement and Consent Order* (The Tri-Party Agreement). Document No. 89-10, as amended, Olympia, Washington. Accessed April 9, 2009, at <http://www.hanford.gov/?page=91&parent=0>.

Memorandum of Agreement. 1996. *Memorandum of Agreement Among the United States Department of Energy, United States Department of the Interior, Nez Perce Tribe, State of Oregon, Confederated Tribes of the Umatilla Indian Reservation, State of Washington (including the Departments of Ecology and Fish and Wildlife), and the Confederated Tribes and Bands of the Yakama Indian Nation*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

*National Contingency Plan*. 1980. Public Law 96-510, as amended, 94 Stat. 2767, 42 USC 9605 et seq.

*National Environmental Policy Act of 1969*. 1969. Public Law 91-190, as amended, 42 USC 4321 et seq.

*National Historic Preservation Act of 1966*. 1966. Public Law 89-665, as amended, 16 USC 470 et seq.

*Native American Graves Protection and Repatriation Act of 1990*. 1990. Public Law 101-601, as amended, 25 USC 3001 et seq.

*Resource Conservation and Recovery Act of 1976*. 1976. Public Law 94-580, as amended, 90 Stat. 2795, 42 USC 6901 et seq. Accessed April 9, 2009, at <http://www.epa.gov/lawsregs/laws/rcra.html>.

Tri-Party Agreement Agencies. 2002. *Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan*. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Accessed April 9, 2009, at <http://www.hanford.gov/hanford/files/tpa/pdf/crp.pdf>.





## 3.0 Regulatory Oversight on the Hanford Site

TG Beam

Several federal, state, and local regulatory agencies are responsible for monitoring and enforcing compliance with applicable environmental regulations on the Hanford Site. These agencies include the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology, the Washington State Department of Health, and the Benton Clean Air Agency. EPA is the primary federal regulatory agency that develops, promulgates, and enforces environmental regulations and standards as directed in statutes enacted by Congress. In some instances, EPA has delegated authority to the state or authorized the state program to operate in lieu of the federal program when the state's program meets or exceeds EPA requirements. In other activities, the state program is assigned direct environmental oversight of the U.S. Department of Energy (DOE) program, as provided by federal law. Where federal regulatory authority is not delegated or only partially authorized to the state, the EPA Pacific Northwest Regional Office (Region 10) is responsible for reviewing and enforcing compliance with EPA regulations as they pertain to the Hanford Site. EPA periodically reviews state environmental programs and may directly enforce federal environmental regulations.

### 3.0.1 Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement)

TW Noland

The *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement [Ecology et al. 1989]) is an agreement among the Washington State Department of Ecology, EPA, and DOE (Tri-Parties) to achieve environmental regulation compliance on the Hanford Site with the *Comprehensive Environmental*

*Response, Compensation, and Liability Act of 1980* (CERCLA); the *Superfund Amendments and Reauthorization Act of 1986* remedial action provisions; and the *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and disposal unit regulations and corrective action provisions. The Tri-Party Agreement 1) defines RCRA and CERCLA cleanup commitments, 2) establishes responsibilities, 3) provides a basis for budgeting, and 4) reflects a concerted goal to achieve regulatory compliance and remediation with enforceable milestones. A companion document to the Tri-Party Agreement is the *Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan* (Tri-Party Agreement Agencies 2002). This plan describes how public information and involvement activities are conducted for Tri-Party Agreement decisions.

The Tri-Party Agreement (Ecology et al. 1989) has evolved as Hanford Site cleanup has progressed. The Tri-Parties have negotiated changes to the agreement since its publication in 1989 to meet the changing conditions and needs of cleanup on the Hanford Site. All significant changes undergo a process of public involvement that enhances communication and addresses public concerns prior to final approvals. As changes are approved through the Tri-Party Agreement change control process, they are incorporated into the Tri-Party Agreement and displayed on the Internet version of the Tri-Party Agreement, which is maintained at the following website: <http://www.hanford.gov/?page=91&parent=0>. Printed copies of Revision 7 of the Tri-Party Agreement, which is current as of July 23, 2007, are publicly available at DOE's Public Reading Room located in the Consolidated Information Center, 2770 University Drive, in Richland, Washington, and at public information repositories in Seattle and Spokane, Washington, and Portland, Oregon.

To be placed on the mailing list to obtain Tri-Party Agreement information, contact EPA or DOE directly, or call the Hanford Cleanup Line at (1-800) 321-2008. Requests can be sent to the following address:

Hanford Mailing List  
P.O. Box 1000  
M/S B3-30  
Richland, WA 99352

### 3.0.2 Status of Tri-Party Agreement Milestones

TW Noland

The Tri-Party Agreement (Ecology et al. 1989) commits DOE to comply with the remedial action provisions of CERCLA as well as with RCRA treatment, storage, and disposal unit regulations and corrective-action provisions, including Washington State's implementing regulations (WAC 173-303, "Dangerous Waste Regulations"). From 1989 through 2008, a total of 1,025 Tri-Party Agreement milestones were completed and 299 target dates were met. During 2008, 52 specific cleanup milestones were scheduled for completion; 37 were completed early, 5 were completed on time, 1 was completed late, 2 were extended to beyond 2008, and 7 were not yet complete at the end of 2008.

### 3.0.3 Approved Modifications to the Tri-Party Agreement

TW Noland

During 2008, 21 negotiated change requests to the Tri-Party Agreement were approved; these changes can be viewed at the Tri-Party Agreement website: [http://www.hanford.gov/triparty/tpa\\_changes.cfm](http://www.hanford.gov/triparty/tpa_changes.cfm).

### 3.0.4 Washington State Department of Health

TG Beam

The Washington State Department of Health has regulatory authority to enforce federal and state standards applicable

to all sources of ionizing radiation in the state. EPA provided delegation of authority to the Washington State Department of Health to implement and enforce the federal standards and requirements in 40 CFR 61, Subparts A and H. Subpart H of 40 CFR 61, which covers radioactive air emissions, is enforced along with the state standards and requirements of WAC 246-247, "Radiation Protection—Air Emissions," and WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," issued under the authority of the *Washington Clean Air Act*. These regulations include requirements to obtain Washington State Department of Health approval before constructing any new or modified source of airborne radionuclide emissions, and for the Washington State Department of Health to issue and enforce the resulting licenses covering construction and operation. The Washington State Department of Health also inspects emission sources within the state that may emit airborne radioactive material to verify that the operations, emissions, and record keeping and reporting are in compliance with all applicable licenses and federal and state regulations. To protect public health with an adequate margin of safety, the state enforces an "as low as reasonably achievable" environmental approach to minimizing airborne emissions. The Washington State Department of Health maintains an office in Richland, Washington, with staff assigned to oversee Hanford Site operations.

### 3.0.5 References

40 CFR 61, Subpart A. 2008. "National Emission Standards for Hazardous Air Pollutants; General Provisions." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 61, Subpart H. 2008. "National Emission Standards for Hazardous Air Pollutants; National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. 1980. Public Law 96-510, as amended, 94 Stat. 2767, 42 USC 9601 et seq. Accessed April 9, 2009, at <http://www.epa.gov/lawsregs/laws/cercla.html>.



Ecology – Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy. 1989. *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). Document No. 89-10, as amended, Olympia, Washington. Accessed April 9, 2009, at <http://www.hanford.gov/?page=91&parent=0>.

*Resource Conservation and Recovery Act of 1976*. 1976. Public Law 94-580, as amended, 90Stat. 2795, 42 USC 6901 et seq. Accessed April 9, 2009, at <http://www.epa.gov/lawsregs/laws/rcra.html>.

*Superfund Amendments and Reauthorization Act of 1986*. 1986. Public Law 99-499, as amended, 100 Stat. 1613, 42 USC 11001 et seq.

Tri-Party Agreement Agencies. 2002. *Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan*. U.S. Department of Energy, Richland Operations Office, Richland, Washington. Accessed April 9, 2009, at <http://www.hanford.gov/hanford/files/tpa/pdf/crp.pdf>.

WAC 173-303. 2007. “Dangerous Waste Regulations.” *Washington Administrative Code*, Olympia, Washington.

WAC 173-480. 2007. “Ambient Air Quality Standards and Emission Limits for Radionuclides.” *Washington Administrative Code*, Olympia, Washington.

WAC 246-247. 2005. “Radiation Protection–Air Emissions.” *Washington Administrative Code*, Olympia, Washington.

*Washington Clean Air Act*. RCW 70.94, as amended. *Revised Code of Washington*, Olympia, Washington.





## 4.0 Environmental Program Information

The U.S. Department of Energy (DOE) requires that all Hanford Site contractors develop environmental and chemical management systems. The following sections provide information on these systems.

### 4.0.1 Environmental Management Systems

HT Tilden, BL Becker-Khaleel, PT Day, KA Hadley, and KA Peterson

Hanford Site contractors have established Integrated Environment, Safety, and Health Management Systems as mandated by their contracts with DOE. These systems are intended to protect workers, the public, and the environment by integrating environmental, safety, and health considerations into the way work is planned, performed, and improved.

DOE verified that all Hanford Site entities under DOE Policy 450.4, "Safety Management System Policy," had Integrated Environmental, Safety, and Health Management Systems in place before the specified implementation date of December 31, 2005. In 1996, Pacific Northwest National Laboratory established an International Organization for Standardization (ISO) 14001 Environmental Management System (ISO 14001:1996); registration of that system was obtained in 2002. Re-registration to the updated ISO 14001:2004 standard occurred in 2005 and again in 2008. Based in part on its Environmental Management Systems, Pacific Northwest National Laboratory was accepted into the U.S. Environmental Protection Agency's National Environmental Performance Track program for a second 3-year membership in 2007.

Efforts continued in 2008 to improve these environmental, safety, and health programs. With the 2008 issuance of DOE Order 450.1A, "Environmental Protection Program," Hanford Site contractors may be required to incorporate new DOE requirements and update their Environmental Management Systems in conjunction with their respective DOE field office in 2009.

### 4.0.2 Chemical Management Systems

RE Johnson

Hanford Site contractors developed and documented formal systems to manage chemicals in 1997 that are still in use today. These Chemical Management Systems apply to the acquisition, use, storage, transportation, and final disposition of chemicals, including hazardous chemicals as defined in the "Occupational Safety and Health Standards" (29 CFR 1910, Subpart Z, Appendices A and B). The Chemical Management Systems are reviewed periodically and improvements are made as needed. Section 5.1.1 provides details on the inventories of hazardous chemicals stored on the Hanford Site in 2008.

### 4.0.3 References

29 CFR 1910, Subpart Z. 2008. "Occupational Safety and Health Standards." Subpart Z, "Toxic and Hazardous Substances." *Code of Federal Regulations*, U.S. Department of Labor.

DOE Order 450.1A. 2008. "Environmental Protection Program." U.S. Department of Energy, Washington, D.C.

DOE Policy 450.4. 1996. "Safety Management System Policy." U.S. Department of Energy, Office of Environment, Safety and Health, Washington, D.C.

ISO 14001:1996. *Environmental Management Systems – Specification with Guidance for Use*. American Society for Testing and Materials, West Conshohocken, Pennsylvania.

ISO 14001:2004. *Environmental Management Systems – Requirements with Guidance for Use*. American Society for Testing and Materials, West Conshohocken, Pennsylvania.





## 5.0 Compliance Summary

JP Duncan

U.S. Department of Energy (DOE) policy mandates that all DOE activities on the Hanford Site are performed in compliance with applicable federal, state, and local environmental laws and regulations; DOE Orders; Secretary of Energy Notices; and DOE Headquarters and site operations office directives, policies, and guidance. This includes specific requirements, actions, plans, and schedules identified in the *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement [Ecology et al. 1989]) and other compliance or consent agreements. Both the DOE Richland Operations Office and the DOE Office of River Protection recognize the importance of maintaining a proactive program of self-assessment and regulatory reporting to assure environmental compliance is achieved and maintained on the Hanford Site.

This section summarizes the various laws and regulations that impact Hanford Site activities with regard to federal environmental protection statutes and associated state and local environmental regulations. Permits required under specific environmental protection regulations are also discussed, as well as notices of violations and notices of non-compliance issued by the U.S. Environmental Protection Agency (EPA) or the Washington State Department of Ecology. Notices of violation are the regulatory means of informing organizations that their work activities are not meeting requirements. Notices of non-compliance are informal notifications of regulatory violations.





## 5.1 Hazardous Materials

This section provides information regarding federal statutes related to hazardous material regulations and directives relevant to the Hanford Site.

### 5.1.1 *Emergency Planning & Community Right-to-Know Act of 1986*

RE Johnson

The *Emergency Planning & Community Right-to-Know Act of 1986* requires each state to establish an emergency response commission and local emergency planning committees, and develop a process to distribute information on hazardous chemicals present in local facilities. These committees gather information and develop emergency plans for local planning districts. Personnel from facilities that produce, use, or store extremely hazardous substances in quantities above threshold planning quantities (quantities that trigger notifications to the state and local emergency response organizations) must identify their facilities to the state emergency response commission and the local emergency planning committee. Facility personnel must periodically provide information to support the emergency planning process. The threshold planning quantities are predetermined amounts established by state and local authorities. Facility personnel must also notify the state emergency response commission and local emergency planning committee immediately after an accidental release of an extremely hazardous substance (40 CFR 355, Appendices A and B) over the reportable quantity. Two annual reports are required by the *Emergency Planning & Community Right-to-Know Act of 1986*: 1) the *Tier Two Emergency and Hazardous Chemical Inventory*, which contains information about hazardous chemicals stored at each facility in amounts exceeding minimum threshold

levels; and 2) the *Toxic Chemical Release Inventory*, which contains information about total annual releases of certain toxic chemicals and associated waste management activities.

On February 25, 2009, Hanford Site officials issued the 2008 *Hanford Site Tier Two Emergency and Hazardous Chemical Inventory* report (DOE/RL-2009-05, Rev. 0) to the Washington State Department of Ecology's Community Right-To-Know Unit; local emergency planning committees for Benton, Franklin, and Grant Counties; and both the city of Richland and Hanford Site fire departments. The 2008 *Hanford Site Toxic Chemical Release Inventory* (DOE/RL-2009-07, Rev. 0), which included releases and waste management activities involving the metal lead and the chemical propylene, was electronically transmitted to EPA and the Washington State Department of Ecology on June 22, 2009. Table 5.1.1 provides an overview of 2008 reporting under the *Emergency Planning & Community Right-to-Know Act of 1986*.

Types, quantities, and locations of hazardous chemicals are tracked through Chemical Management System requirements that are specific to prime contractors (Section 4.0.2). Table 5.1.2 summarizes the information reported and lists the average quantities of the 10 hazardous chemicals stored in greatest quantity on the Hanford Site in 2008.

### 5.1.2 *Resource Conservation and Recovery Act of 1976*

CD Wollam

The *Resource Conservation and Recovery Act of 1976* (RCRA) was enacted in 1976 with the objective of protecting human health and the environment. In 1984, the *Hazardous and Solid Waste Amendments of 1984*

**Table 5.1.1. Emergency Planning & Community Right-to-Know Act of 1986 Compliance Reporting on the Hanford Site, 2008**

<u>Sections of the Act</u>	<u>Yes<sup>(a)</sup></u>	<u>No<sup>(a)</sup></u>	<u>Not Required<sup>(a)</sup></u>
302-303: Planning notification	X <sup>(b)</sup>		
304: Extremely hazardous substances release notification			X
311-312: Material safety data sheet/chemical inventory	X		
313: Toxic chemical release inventory reporting	X		
(a) "Yes" indicates that notifications were provided and/or reports were issued under the applicable provisions. "No" indicates that notifications or reports should have been provided but were not. "Not Required" indicates that no actions were required under the applicable provisions, either because releases were too small to require action or no releases occurred.			
(b) These notifications apply to the Hanford Site but were completed prior to 2008.			

**Table 5.1.2. Average Quantity of the Ten Hazardous Chemicals<sup>(a)</sup> Stored in Greatest Quantities on the Hanford Site, 2008**

<u>Hazardous Chemical</u>	<u>Average Quantity, kg (lb)</u>
Sodium	1,240,000 (2,730,000)
Mineral oil	1,100,000 (2,430,000)
Diesel fuel (grades 1 and 2)	352,000 (776,000)
Portland cement	318,000 (701,000)
Bentonite	221,000 (487,000)
Lead acid batteries	200,000 (441,000)
Fly ash (class F)	114,000 (251,000)
Propane	100,000 (220,000)
Petroleum distillates (unspecified)	91,800 (202,000)
Gasoline	90,900 (200,000)

(a) Includes chemicals defined as hazardous under "Hazard Communication" (29 CFR 1910.1200(c)) .

reauthorized RCRA, imposing new requirements on hazardous waste management. The most important aspect of RCRA is its establishment of cradle-to-grave management to track hazardous waste from generator to treatment, storage, and disposal. The Washington State Department of Ecology has the authority to enforce RCRA requirements in the state under WAC 173-303, "Dangerous Waste Regulations." The Hanford Site is subject to RCRA corrective action authority because the site has been issued a single permit to eventually contain all applicable treatment, storage, and disposal units.

### 5.1.2.1 Hanford Facility RCRA Permit SA Thompson

The Washington State Department of Ecology issued the Hanford Facility RCRA Permit on September 27, 1994 (Ecology 1994). The permit is the foundation for RCRA permitting on the Hanford Site in accordance with provisions established in the Tri-Party Agreement (Ecology et al. 1989) and WAC 173-303. The permit is issued to eight permittees: the DOE Richland Operations Office and the DOE Office of River Protection as the owners/operators of the Hanford Site and six of their contractors: Bechtel National, Inc.; CH2M HILL Plateau Remediation Company; Fluor Hanford, Inc.; Pacific Northwest National Laboratory; Washington Closure Hanford, LLC; and Washington River Protection Solutions, LLC, as co-operators. The permit expired on September 27, 2004; however, DOE continues to operate under the expired permit until a new permit is in effect. The Washington State Department of Ecology is working on a draft of the new permit.

### 5.1.2.2 RCRA/Dangerous Waste Permit and Closure Plan

#### SA Thompson

The Hanford Site is considered a single facility for RCRA and WAC 173-303 regulatory purposes. The facility is comprised of 40 treatment, storage, and disposal units. Tri-Party Agreement (Ecology et al. 1989) officials recognized that

not all of the units could be issued dangerous waste permits simultaneously, and a schedule was established to submit unit-specific permit applications and closure plans to the Washington State Department of Ecology.

During 2008, 40 revisions to the Hanford Facility RCRA Permit, WA7890008967 (RCRA Permit) Part A Form (Ecology 1994) were submitted to the Washington State Department of Ecology for review and approval:

- 100 Areas revisions to the Part A Form:
  - 183-H Solar Evaporation Basins
  - 1301-N Surface Impoundment
  - 1324-N Surface Impoundment
  - 1324-NA Percolation Pond
  - 1325-N Liquid Waste Disposal Facility
  - 1706-KE Waste Treatment System.
- 200 Areas revisions to the Part A Form:
  - 207-A South Retention Basin
  - 216-A-10 Crib
  - 216-A-29 Ditch
  - 216-A-36B Crib
  - 216-A-37-1 Crib
  - 216-B-3 Main Pond
  - 216-B-63 Trench
  - 216-S-10 Pond
  - 216-S-10 Ditch
  - 222-S Dangerous and Mixed Waste Treatment Storage and Disposal Unit
  - 241-CX Tank System
  - 242-A Evaporator
  - B Plant Complex
  - Central Waste Complex
  - Double-Shell Tanks System and 204-AR Waste Unloading Station
  - Grout Treatment Facility
  - Hanford Tank Waste Treatment and Immobilization Plant
  - Hexone Storage and Treatment Facility
  - Immobilized High-Level Waste Interim Storage Unit
  - Integrated Disposal Facility
  - Liquid Effluent Retention Facility and 200 Area Effluent Treatment Facility
  - Low-Level Burial Grounds
  - Plutonium Uranium Extraction (PUREX) Plant
  - PUREX Storage Tunnels
  - Single-Shell Tank System
  - T Plant Complex
  - Waste Encapsulation and Storage Facility
  - Waste Receiving and Processing Facility.
- 300 Area revisions to the Part A Form:
  - 300 Area Process Trenches
  - 331-C Storage Unit
  - 325 Hazardous Waste Treatment Units.
- 400 Area revisions to the Part A Form:
  - 400 Area Waste Management Unit.
- 600 Area revisions to the Part A Form:
  - 600 Area Purgewater Storage and Treatment Facility
  - Nonradioactive Dangerous Waste Landfill.

In 2008, one revised RCRA Part B permit application and one closure plan was submitted to the Washington State Department of Ecology. The Part B submittal included the *Hanford Facility Dangerous Waste Part B Permit Application, Low-Level Burial Grounds* (DOE/RL-88-20, Rev. 2). The closure plan submittal included the *241-CX Tank System Closure Plan* (DOE/RL-2008-51, Rev. 0).

The Washington State Department of Ecology approved DOE-certified closure documentation for one treatment, storage, and disposal unit on November 12, 2008: 224-T Transuranic Waste Storage and Assay Facility (located in the 200 Areas).



### 5.1.2.3 RCRA Groundwater Monitoring

MJ Hartman

RCRA groundwater monitoring is part of the Hanford Site Soil and Groundwater Remediation Project (Section 10.7). In 2008, 14 RCRA sites were monitored to determine whether they were contaminating groundwater with hazardous constituents. Seven sites were monitored to assess the extent of known contaminants, and two were monitored to determine the progress of groundwater contamination cleanup activities. The Liquid Effluent Retention Facility and low-level burial grounds (Waste Management Areas 1 through 4) are scheduled to receive permits as operating RCRA facilities in 2009. The Integrated Disposal Facility received a RCRA operating permit in June 2006 and is under a unit-specific groundwater monitoring plan. The other sites monitored under RCRA are scheduled for closure under the Hanford Facility RCRA Permit (Ecology 1994). A summary of groundwater monitoring activities for these sites during 2008 is provided in Section 10.7; more detailed information is available in *Hanford Site Groundwater Monitoring for Fiscal Year 2008* (DOE/RL-2008-66, Rev. 0).

### 5.1.2.4 RCRA Inspections

DL Hagel

Washington State Department of Ecology performed 28 RCRA inspections on the Hanford Site during 2008 to assess compliance with applicable requirements. Hanford Site contractors and DOE worked to resolve any notices of violation and warning letters of non-compliance that were received based on those inspections. These documents identified conditions that were alleged to be non-compliant with RCRA requirements. The following two items summarize the RCRA non-compliance documents received in 2008.

**Notice of Violation from the Dangerous Waste Compliance Inspection of the T Plant Complex Conducted June to August 2007.** A notice of violation was received from the Washington State Department of Ecology on March 4, 2008, in response to a dangerous waste compliance inspection of the T Plant Complex that was conducted

June through August 2007. Two previous inspections in 2000 and 2005 also cited concerns with inadequate waste designation at T Plant.

The inspection identified one violation of WAC 173-303 regarding waste designation. Three concerns identified were related to waste accumulation, container management, and personnel training.

T Plant personnel conducted reviews of containers in storage to ascertain that container identification numbers and major risk labeling were clearly visible, and that containers with deficient, inaccurate, or misleading labeling were corrected.

On May 9, 2008, the DOE Richland Operations Office transmitted a report to the Washington State Department of Ecology identifying all corrective actions that had been completed and provided requested information. On May 22, 2008, project managers met with Washington State Department of Ecology officials who stated they were satisfied with the response provided by DOE. This issue is considered closed.

**Notice of Non-Compliance for the Shipment of Anhydrous Ammonia Cylinders from the 100-N Area.** On September 15, 2008, the Washington State Department of Ecology issued a Notice of Non-Compliance to the DOE Richland Operations Office and Washington Closure Hanford, LLC for the removal and shipment of two anhydrous ammonia cylinders from the 109-N Building during demolition.

Washington Closure Hanford, LLC notified the Washington State Department of Ecology on April 29, 2008, that the cylinders had been removed and improperly shipped to Seattle, Washington, by its subcontractor. The cylinders were approximately 35 years old, were not U.S. Department of Transportation approved containers, and were not shipped in accordance with U.S. Department of Transportation requirements.

When Washington Closure Hanford, LLC discovered the cylinders were in Seattle, they were declared a hazardous waste, overpacked, and shipped to Indiana for treatment. Following treatment, the cylinders were found to contain no anhydrous ammonia.



From information gathered during an inspection of the 109-N Building on May 12, 2008, Washington State Department of Ecology cited two Tri-Party Agreement violations, three *Washington Administrative Code* violations, and three concerns.

On October 17, 2008, DOE responded to the notice and transmitted detailed descriptions of corrective actions taken to prevent similar violations from occurring in the future to the Washington State Department of Ecology. All issues have been resolved.

### 5.1.3 Washington Administrative Code Groundwater Monitoring

MJ Hartman

Groundwater monitoring was required for three regulated, non-RCRA waste facilities in 2008. The 200 Area Treated Effluent Disposal Facility and the State-Approved Land Disposal Site are monitored under state discharge permits (WAC 173-216). The Solid Waste Landfill is monitored for compliance with requirements in WAC 173-304, “Minimum Functional Standards for Solid Waste Handling.” Wells near these facilities were monitored in 2008 for waste constituents specified in the facility permits.

Section 10.7 summarizes groundwater monitoring activities for these sites during 2008; more detailed information is available in *Hanford Site Groundwater Monitoring for Fiscal Year 2008* (DOE/RL-2008-66, Rev. 0).

### 5.1.4 Toxic Substances Control Act

CD Wollam

*Toxic Substances Control Act* requirements that apply to the Hanford Site primarily involve regulation of polychlorinated biphenyls (PCBs). Federal regulations for PCB use, storage, and disposal are provided in 40 CFR 761, “Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.” PCB wastes on the Hanford Site are stored and/or disposed of in accordance with 40 CFR 761. Some radioactive PCB waste remains in

storage onsite pending the development of adequate treatment and disposal technologies and capacities. Electrical equipment that might contain PCBs is also maintained and serviced in accordance with 40 CFR 761.

During 2008, the DOE Richland Operations Office submitted both the 2007 PCB Annual Document Log for the Hanford Site (DOE/RL-2008-30, Rev. 0) and a 2007 PCB Annual Report (DOE/RL-2008-31, Rev. 0) to EPA as required by 40 CFR 761.180. These two documents describe the PCB waste management and disposal activities occurring on the Hanford Site. The *Framework Agreement for Management of Polychlorinated Biphenyls (PBCs) in Hanford Tank Waste* (Ecology et al. 2000), signed on August 31, 2000, resulted in EPA, the Washington State Department of Ecology, and DOE and its Hanford Site contractors working together to resolve the regulatory issues associated with managing PCB waste 1) at the Hanford Tank Waste Treatment and Immobilization Plant (currently under construction); 2) at the waste tank farms; and 3) at affected waste management units adjacent to the waste tank farms. The 1998 PCB disposal amendments in 40 CFR 761 allow for necessary storage and the expedited disposal of PCB waste regulated under the *Toxic Substances Control Act*.

During 2008, single-shell tank waste retrieval activities continued in accordance with EPA Phase I and II risk-based disposal approvals for the use of double-shell tank PCB remediation waste in accordance with 40 CFR 761.61(c). Phase I identifies general conditions that apply to the overall strategy and retrieval process and Phase II identifies tank-specific conditions. Approvals have been received for the eight single-shell tanks classified as integrally sound.

Other risk-based disposal approvals are being implemented on the Hanford Site. K Basins sludge continued to be managed through 2008, and a risk-based disposal approval was accepted by EPA in 2008 for continued storage of two water tower tanks at the Hanford Site. The paint on the tanks’ interior walls contains PCBs greater than 500 parts per million, and the tanks will be disposed of as PCB bulk product waste. The risk-based disposal approval will allow continued storage of the tanks while disposal plans are developed and implemented.



### 5.1.5 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

JW Cammann

During 1980, the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) was enacted to address response, compensation, and liability for past releases or potential releases of hazardous substances, pollutants, and contaminants to the environment. During 1986, CERCLA was amended by the *Superfund Amendments and Reauthorization Act of 1986*, which made several important changes and additions, including clarification that federal facilities are subject to the same provisions of CERCLA as private industries. Federal facilities identified on the National Priorities List, which is the EPA's list of the most serious uncontrolled or abandoned hazardous waste sites, must enter into an interagency agreement with EPA to remediate the sites. Under CERCLA, two kinds of response actions are authorized: 1) short-term removals, where actions may be taken to address releases or threatened releases requiring prompt response; and 2) long-term remedial response actions that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening. These actions can be conducted only at sites listed on the National Priorities List.

The Hanford Site was divided into four aggregate areas when it was placed on the National Priorities List on November 3, 1989, pursuant to CERCLA. The four sites on the National Priorities List included the 100 Areas, Central Plateau, 300 Area, and 1100 Area of the Hanford Site. Since the Hanford Site was placed on the National Priorities List, DOE and its contractors have made considerable progress in cleaning up the site. Progress includes deletion of portions of the 100 Areas from the National Priorities List, including the Wahluke Slope north of the Columbia River, and the entire 1100 Area.

On the Hanford Site, EPA is responsible for oversight of DOE implementation of CERCLA regulations. There can be significant overlap between the RCRA corrective action

program (Section 5.1.2) and the CERCLA program. Many waste management units on the Hanford Site are potentially subject to remediation under both programs. The CERCLA program is implemented via 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," which establishes procedures for characterization, evaluation, and remediation. The Tri-Party Agreement (Ecology et al. 1989) addresses implementation of both CERCLA and RCRA corrective action provisions on the Hanford Site through administrative application of either program while meeting the technical requirements of both programs.

CERCLA mandates that DOE conduct response actions (removal and/or remedial) on the Hanford Site. The CERCLA regulatory framework for both removal and remedial actions consists of five general activities that include 1) investigation, 2) evaluation, 3) decision, 4) implementation, and 5) closeout.

For remedial actions, the investigation phase involves the discovery of a release or the threat of release to the environment by conducting site characterization in accordance with a remedial investigation and feasibility study work plan, data quality objective, sampling and analysis plan, field work plan, and quality assurance plan. The evaluation phase develops alternatives to eliminate the release or threat of release and considers the results of site characterization as documented in remedial investigation reports used to support feasibility studies of candidate remedial technologies. The decision phase is conducted to document implementation of the preferred alternative, obtain regulatory approval, and seek public involvement through issuance of a proposed plan and record of decision. The implementation phase is performed to execute the preferred alternative and involves preparation of a remedial design and remedial action work plan, remedial design report, air monitoring plan, waste management plan, mitigation action plan, and operations and maintenance plan. Finally, the closeout phase includes issuing a remedial site verification package that documents response objectives have been achieved in accordance with the record of decision.

There are three types of removal actions under CERCLA: 1) emergency, 2) time-critical, and 3) non-time-critical. Emergency removals must be initiated within hours or days in response to acute problems and may involve fires,

explosions, imminent contamination of water supplies, or the release or imminent release of hazardous substances. Time-critical removals respond to releases requiring onsite action within 6 months (e.g., removal of drums or small volumes of contaminated soil). Non-time-critical removals respond to releases where a planning period of at least 6 months is available before onsite activities must begin and the need is less immediate. The majority of removal actions conducted on the Hanford Site are non-time-critical.

Non-time-critical removal actions attempt to control the source of potential contamination and may be followed by a remedial action to complete the site response. Non-time-critical removal actions can provide substantial risk reduction by addressing specific problems without requiring the more time consuming remedial investigation/feasibility study process associated with CERCLA remedial actions.

As with remedial actions, non-time-critical removal actions include activities involving investigation, evaluation, decision, implementation, and closeout. A removal site evaluation is conducted to identify the source and nature of the release, evaluate the magnitude of the threat, assess the threat to public health, and determine if more information is needed to characterize the release. Upon completion of the removal site evaluation, an approval memorandum is issued to document the meeting of National Contingency Plan criteria for initiating a non-time-critical removal action and provide detailed information on the site. Following issuance of an approval memorandum, an engineering evaluation and cost analysis process is initiated. This process involves preparation of an engineering evaluation and cost analysis, conducting community relations activities, and documentation of the removal action decision in an action memorandum. The engineering evaluation and cost analysis is comparable to a remedial action remedial investigation/feasibility study, but it is less comprehensive. The action memorandum is comparable to a remedial action record of decision; however, it is less elaborate. A removal action work plan is prepared to implement the decisions in the action memorandum. Closeout of the non-time-critical removal process ensures that all objectives have been met and that no further threats to human health, welfare, or the environment that the removal action was designed to resolve, remain. If completion of non-time-critical removal

actions will constitute the basis for delisting the site from the National Priorities List, the remedial actions procedures for site closeout are followed.

CERCLA requires a status review of response actions (removal and remedial) for contaminated waste sites no less frequently than once every 5 years to determine whether selected actions remain protective of human health and the environment. The first CERCLA 5-year review was initiated by the EPA in 2000. This 5-year review addressed all portions of the Hanford Site for which a decision document has been issued and covered areas that contain hazardous substances, pollutants, or contaminants that will be remediated under CERCLA (EPA 2001). DOE considered the first CERCLA 5-year review, issued by the EPA in April 2001, as the starting point for subsequent 5-year reviews. The first CERCLA 5-year review evaluated the performance of the response actions selected in interim records of decision, including existing institutional controls preventing exposure to the public and the environment. EPA concluded the selected response actions were protective, or would be protective upon completion of the remedial actions. EPA identified deficiencies and corrective actions to address the deficiencies. In conducting the second CERCLA 5-year review in 2005 and 2006, DOE applied the same approach that the EPA used and followed revised EPA and DOE guidance on how to conduct CERCLA 5-year reviews (DOE/RL-2006-20, Rev. 1).

Further information regarding CERCLA process documentation issued during 2008 is discussed in Chapter 6.

### 5.1.5.1 Hanford Site Institutional Controls Plan

#### R Ranade

The *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE/RL-2001-41, Rev. 2) describes the institutional controls for the Hanford Site and how they are implemented and maintained in accordance with CERCLA decision documents. The decision documents present the selected remedial actions chosen in accordance with CERCLA, as amended by the *Superfund Amendments and Reauthorization Act of 1986* and 40 CFR 300. CERCLA decision documents are developed as part of the cleanup mission on the Hanford Site, which

began in 1989 following the end of the national defense mission. The selected remedies chosen may include institutional controls. CERCLA decision documents identify specific requirements for institutional controls.

Institutional controls are primarily administrative in nature and are typically used to augment the engineered components of a selected remedy to minimize the potential for human exposure to contamination. Active institutional controls, such as controlling access to the site or controlling activities that may affect remedial action, generally are employed during remediation. After remediation is completed, passive institutional controls such as permanent markers, public records and archives, or regulations regarding land or resource use are employed. Some active institutional controls, such as monitoring and controlling access to the Hanford Site, may also be employed after remediation is completed.

Section 4.2 of DOE/RL-2001-41, Rev. 2, requires DOE to conduct a Hanford Site-wide assessment every 5 years coinciding with the CERCLA 5-year review. The next site-wide institutional control review is scheduled in 2011. In addition, several CERCLA decision documents require annual reviews of institutional controls for specific areas covered. Annual reviews of these institutional controls are reported in the unit manager's meeting each September. The minutes from the unit manager's meeting are provided in the Tri-Party Agreement's Administrative Record and can be accessed at the following website: <http://www2.hanford.gov/arpir>.

The River Corridor Project has a number of institutional controls in both interim action and final record of decision documents. In 2008, field inspection of institutional controls at waste sites in the 100-IU-2 and 100-IU-6 Operable Units, three burial grounds in the 300-FF-2 Operable Unit, and at the Environmental Restoration Disposal Facility were performed. Warning sign information was updated at two of the inactive burial grounds in the 300 Area in response to this inspection. Trespass events and excavation permit use were reviewed in 2008 with no findings identified. EPA published the 200-ZP-1 record of decision in 2008

(EPA 2008), identifying required institutional controls. The *Sitewide Institutional Control Plan for Hanford CERCLA Actions* (DOE/RL-2001-41, Rev. 2) was revised in April 2009 to include institutional controls identified in the 200-ZP-1 record of decision (DOE/RL-2001-41, Rev. 3).

### 5.1.5.2 CERCLA and Washington Administrative Code Reportable Releases to the Environment

JK Perry

Releases that are reportable to the state and/or EPA include spills or discharges of hazardous substances or dangerous waste to the environment, other than releases permitted under state or federal law. CERCLA, Section 103, requires that releases of hazardous substances that equal or exceed specified reportable quantities, including releases that are continuous and stable in quantity and rate but exceed specified limits, must be reported.

State regulations (WAC 173-303-145) also require that spills or non-permitted discharges of dangerous waste or hazardous substances to the environment be reported. That requirement applies to spills or discharges onto the ground, into groundwater or surface water (e.g., the Columbia River), or into the air such that human health or the environment are threatened, regardless of the quantity of dangerous waste or hazardous substance. Spills are conservatively assessed under WAC 173-303-145, and notifications were provided to the Washington State Department of Ecology for various minor spills on the Hanford Site during calendar year 2008. These spills were cleaned up, and materials were disposed of in accordance with all applicable requirements.

In addition, notifications were conservatively provided to the National Response Center for several spills potentially above the reportable quantities that occurred during remediation activities on the Hanford Site during calendar year 2008. Although subsequent analysis determined these spills did not exceed reportable quantities, they were cleaned up and materials were disposed of in accordance with applicable requirements.



### 5.1.6 *Federal Insecticide, Fungicide, and Rodenticide Act of 1975*

JM Rodriguez

The *Federal Insecticide, Fungicide, and Rodenticide Act of 1975* is administered by EPA. The standards administered by the

Washington State Department of Agriculture to regulate implementation of the act in the state include the *Washington Pesticide Control Act*, the *Washington Pesticide Application Act*, and rules relating to general pesticide use codified in WAC 16-228, “General Pesticide Rules.” On the Hanford Site, commercial pesticides are applied by commercial pesticide operators that are listed on one of two commercial pesticide applicator licenses, and by a licensed private commercial applicator.





## 5.2 Air Quality

TG Beam

This section provides information on federal, state, and local statutes related to the Hanford Site air quality program.

### 5.2.1 Regulatory Authority

The federal *Clean Air Act* was enacted to protect and enhance air quality and is the legal basis for federal, state, and local air quality regulations. The law was originally passed in 1967 and has been revised extensively on numerous occasions. The *Clean Air Act Amendments of 1990* is the most recent revision and is the framework for a significant portion of the current federal air quality regulations. The *Washington Clean Air Act* parallels and supplements the federal law. It has been revised periodically to keep pace with changes at the federal level.

EPA provides high-level programmatic oversight of the air quality program on the Hanford Site, but has delegated authority for implementing applicable *Clean Air Act* regulations to designated state and local regulatory agencies.

The Washington State Department of Health regulates radioactive air emissions on the Hanford Site by enforcing the applicable federal requirements in 40 CFR 61, Subparts A and H, as well as the state requirements in WAC 173-480 and WAC 246-247. The federal regulations contained in 40 CFR 61 which is part of the federal National Emission Standards for Hazardous Air Pollutants (NESHAP) are collectively referred to on the Hanford Site as “Rad NESHAP” because they provide regulations for radioactive air emissions.

The Washington State Department of Ecology regulates criteria and toxic air pollutant emissions on the Hanford Site by enforcing the applicable federal requirements in

40 CFR 52, 40 CFR 60, 40 CFR 61, 40 CFR 63, 40 CFR 68, and 40 CFR 82 as well as the state requirements in WAC 173-400, WAC 173-460, WAC 173-480, and WAC 173-491. Criteria and toxic air pollutant emissions are often referred to as “non-radioactive” air emissions on the Hanford Site. Criteria pollutants are particulate matter, nitrogen oxides, sulfur oxides, carbon monoxide, lead, and volatile organic compounds. Toxic pollutants are other chemical contaminants as regulated by Washington State.

The Benton Clean Air Agency regulates demolition and asbestos renovation activities on the Hanford Site in accordance with the federal requirements in 40 CFR 61, Subpart M. The Benton Clean Air Agency also regulates outdoor burning activities on the Hanford Site in accordance with state requirements in WAC 173-425.

### 5.2.2 Permits

Hanford Site contractors evaluate each proposed new or modified emission unit using the new source review requirements of radioactive air emissions (WAC 246-247), criteria pollutants (WAC 173-400-110), and/or toxic air pollutants (WAC 173-460-040) to determine whether a notice of construction application must be submitted to the Washington State Department of Health and/or the Washington State Department of Ecology, as applicable, for approval before construction or operation of the proposed source.

Hanford Site radioactive air emission sources are operated in accordance with the “The Department of Energy Hanford Site Radioactive Air Emissions License #FF-01” issued by the Washington State Department of Health (2007). The FF-01 license is a compilation of all applicable radioactive air emission requirements. For each emission unit, the

FF-01 license includes either 1) an approval to modify/construct, or 2) an operating license. The FF-01 license is renewed every 5 years. Overall, Hanford Site radioactive air emissions are controlled to sufficiently low levels to ensure the resultant exposure to any offsite individual remains well below the 10 millirem (100 microsievert) per year standard specified in 40 CFR 61.92. Hanford Site radioactive air emissions data are published annually in the radionuclide air emissions report (DOE/RL-2009-14).

As a major source of air pollutants, the Hanford Site is subject to the operating permit requirements of 40 CFR 70 and WAC 173-401. In coordination with the Washington State Department of Health and the Benton Clean Air Agency, the Washington State Department of Ecology issued Renewal 1 of the Hanford Site air operating permit for a period of 5 years, effective January 1, 2007. The air operating permit is a compilation of applicable *Clean Air Act* requirements both for radioactive and criteria/toxic air pollutant emissions, including the Hanford Site air emissions license #FF-01 issued by the Washington State Department of Health (2007) and notice of construction approval orders issued by the Washington State Department of Ecology. The air operating permit requires that semi-annual reports documenting the status of required monitoring and any identified permit deviations be submitted to the regulatory agencies (DOE/RL-2008-48, Rev. 0 and

DOE/RL-2009-02, Rev. 0). An annual report that documents the compliance status of Hanford Site emission sources against applicable *Clean Air Act* requirements is also required (DOE/RL-2009-03), as well as an annual report that documents total emissions of criteria and toxic pollutants on the Hanford Site (DOE/RL-2009-06, Rev. 0). The air operating permit was revised once in 2008 to incorporate new Washington State Department of Health and Washington State Department of Ecology air emission licenses, approval orders, and updated regulatory requirements. Revision D was issued on December 23, 2008.

### 5.2.3 Inspections

The Washington State Department of Health, the Washington State Department of Ecology, and the Benton Clean Air Agency conduct regular inspections of Hanford Site emission sources to verify compliance with applicable *Clean Air Act* requirements. Hanford Site contractors and DOE actively work to resolve any potential compliance issues identified during these inspections. During 2008, the regulatory agencies conducted over 25 *Clean Air Act* inspections on the Hanford Site. None of the inspections resulted in the issuance of any notice of non-compliance (or similar correspondence) or formal enforcement action on the part of the regulatory agencies.





## 5.3 Water Quality Protection

This section provides information on federal, state, and local statutes related to Hanford Site water quality.

### 5.3.1 *Clean Water Act of 1977*

R Ranade

The *Clean Water Act of 1977* applies to point-source discharges to surface waters in the United States. On the Hanford Site, regulations are applied through the “EPA Administered Permit Programs: The National Pollutant Discharge Elimination System” (40 CFR 122) permit that governs effluent discharges to the Columbia River. There is one National Pollutant Discharge Elimination System (NPDES) permit, WA-002591-7, issued by EPA for the Hanford Site (Appendix D, Table D.1). The permit covers three outfalls: outfall 001 for the 300 Area Treated Effluent Disposal Facility, and outfalls 003 and 004 in the 100-K Area. CH2M HILL Plateau Remediation Company is the holder of this permit.

The Hanford Site was covered by one storm water permit during 2008. EPA’s “National Pollutant Discharge Elimination System Storm Water Multi-Sector Permit,” WAR05A57F, (Appendix D, Table D.1) establishes the terms and conditions under which storm water discharges associated with industrial activity are authorized. This multi-sector general permit for storm water discharges issued in October 2000 expired at midnight on October 30, 2005. A new general permit to replace it has been issued. However, EPA Region 10 officials have notified the permit holders that a permit for the federal facilities in Washington State will be issued at a later date. Facilities that obtained coverage under the 2000 multi-sector general permit before its expiration are automatically granted an administrative

continuance of permit coverage. CH2M HILL Plateau Remediation Company is the holder of this permit.

### State Waste Discharge Permits

The Washington State Department of Ecology has a State Wastewater Discharge Permit Program that regulates ground discharges. Five Washington State Department of Ecology state waste discharge permits were in effect during 2008 (ST-4500, ST-4501, ST-4502, ST-4507, and ST-4511). DOE is the holder of all the state waste discharge permits.

Throughout the Hanford Site there are numerous sanitary waste discharges to the ground. Sanitary wastewater from the 400 Area is discharged to a treatment facility at Energy Northwest’s Columbia Generating Station (Figure 1.0.1). Sanitary wastewater from the 300 Area, the former 1100 Area, and other facilities north of and in the city of Richland is discharged to the city’s treatment facility. Sanitary wastewater in the 100 Areas and Central Plateau is primarily treated in a series of onsite sewage systems. Placement of these sewage systems is based on population centers and facility locations. In recent years, extensive efforts have been made to regionalize the onsite sewage systems. Many of the small onsite sewage systems have been replaced with larger systems. These larger sewage systems (with design capacities of 13,300 to 55,000 liters [3,500 to 14,500 gallons] per day) operate under permits issued by the Washington State Department of Health and treat wastewater from several facilities rather than a single facility (Appendix D, Table D.1). Holding-tank sewage systems are also used to dispose of sanitary wastewater. The Washington State Department of Health issues an annual permit to DOE for the operation of Hanford Site sewage systems, which include holding-tank sewage systems.

There were no permit violations during 2008.

## 5.3.2 *Safe Drinking Water Act of 1974*

LM Kelly

The *Safe Drinking Water Act* was originally passed by Congress in 1974. The law established a cooperative program among local, state, and federal agencies to institute drinking water regulations applicable to all public water systems in the United States. States were granted primary responsibility, known as primacy, for administering and enforcing the *Safe Drinking Water Act of 1974*. To obtain primacy, states were required to meet certain criteria, including adoption of regulations equal to or more stringent than EPA regulations.

Washington State was awarded primacy in 1978. The State Board of Health and the Washington State Department of Health became partners in developing and enforcing state drinking water regulations. Hanford Site water systems were designated as public water systems in 1986 and became formally registered as public systems under the jurisdiction of the Washington State Department of Health in 1987.

The *Safe Drinking Water Act of 1974* was amended in 1986 and 1996 (*Safe Drinking Water Act Amendments*). While the 1986 amendments emphasized treatment to ensure safe drinking water, the 1996 amendments focused on source water protection, funding for water system improvements, operator training, public information, and the strengthening of EPA's scientific work, including the use of risk and cost benefit analysis in establishing drinking water standards. The amendments have resulted in the development of several new drinking water regulations that have been or will be published over the next several years.

The Microbial and Disinfection Byproduct Rules address acute threats from microbial contamination and chronic

threats from disinfectant residuals and disinfection byproducts. The first phase of the rulemaking strategy resulted in the Disinfectants and Disinfection Byproduct Rule, Stage 1 (63 FR 69389-69476), the Interim Enhanced Surface Water Treatment Rule (63 FR 69477-69521), and the Long Term 1 Enhanced Surface Water Treatment Rule (67 FR 1811-1844), which strengthened microbial controls for small (<10,000 people) water systems. These rules limit disinfectant residuals and disinfection byproducts in the distribution systems while improving particle removal in the drinking water treatment plants.

In 2006, EPA published the "National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule; Final Rule" (71 FR 653-702) and the "National Primary Drinking Water Regulations: Stage 2 Disinfectants and Disinfection Byproducts Rule" (71 FR 387-493). These rules build upon previously issued rules to strengthen protection against microbial contaminants, and in parallel, reduce potential health risks from disinfectant byproducts. Compliance deadlines are based on system size, with the largest systems required to act first. In 2008, affected Hanford Site systems demonstrated compliance with the filtration and disinfection treatment technique requirements and limits for disinfectant residuals and disinfection byproducts.

To protect the health of workers using public water supplies on the Hanford Site, water systems were monitored during 2008 for microbiological, chemical, physical, and radiological constituents. There were no microbiological detections during the 2008 monitoring cycle, and all chemical concentrations in Hanford Site drinking water were well below the maximum contaminant levels established by EPA. Analytical results for 2008 radiological monitoring are summarized in Section 10.6.





## 5.4 Natural and Cultural Resources

This section provides information on federal statutes and assessments related to ecological compliance and cultural resources on the Hanford Site.

### 5.4.1 Ecological Compliance

MR Sackschewsky

DOE policies require that all Hanford Site projects with the potential to adversely affect biological resources have an ecological compliance review conducted before the project starts. This review determines if the project will comply with the *Endangered Species Act of 1973* and the *Migratory Bird Treaty Act*. The review also examines whether other significant resources such as Washington State-listed species of concern, wetlands, and native shrub-steppe habitats are adequately considered during the project planning process. Where adverse effects are identified, mitigation actions are prescribed. Mitigation actions can include avoidance, minimization, rectification, or compensation.

Because many projects occur during periods of the year when plants are not growing and are difficult to identify or evaluate, each of the operational areas (200-East, 200-West, 100-K, and 300 Areas) are surveyed each spring. All habitat areas within these areas are surveyed, and each building is inspected for nests of migratory birds. These baseline visual surveys provide information about habitat types and species inventories and abundances, which can be used throughout the year to assess potential impacts to resources. These data are also used to support ecological inventory and data requirements for ecological risk evaluations. Examples of the baseline survey maps are available at <http://www.pnl.gov/ecomon/Compliance/comp.html>. There were 202 reviews performed during 2008, including 91 ecological compliance reviews to support general Hanford Site activities, and 111 reviews for environmental restoration activities.

#### 5.4.1.1 *Endangered Species Act of 1973*

Several protected species of plants and animals exist on the Hanford Site and along the Hanford Reach of the Columbia River. Steelhead trout (*Oncorhynchus mykiss*) and spring-run Chinook salmon (*Oncorhynchus tshawytscha*) are listed under the *Endangered Species Act of 1973* as either threatened or endangered (50 CFR 17, Subpart B) and occur onsite. DOE has a management plan in place for these species (DOE/RL-2000-27, Rev. 0). Other species on the Hanford Site are listed by the Washington Department of Fish and Wildlife as endangered, threatened, or sensitive (see Section 10.11).

#### 5.4.1.2 *Migratory Bird Treaty Act*

The *Migratory Bird Treaty Act* prohibits taking or disturbing specified migratory birds or their feathers, eggs, or nests. Over 100 species of birds that regularly occur on the Hanford Site are protected by the *Migratory Bird Treaty Act*. All Hanford Site projects with a potential to affect federal or state-listed species of concern complied with the requirements of this act by using the ecological compliance review process as described in the *Hanford Site Biological Resources Management Plan* (DOE/RL-96-32, Rev. 0). When applicable, the ecological reviews produced recommendations to minimize adverse impacts to migratory birds, such as performing work outside of the nesting season and minimizing the loss of habitat.

### 5.4.2 Cultural Resources

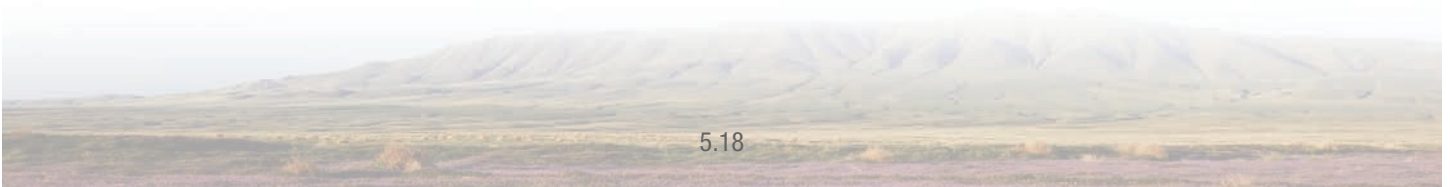
EP Kennedy

DOE's policy is to comply with all cultural resource-related laws and regulations (DOE Policy 141.1). On the Hanford Site, cultural resources are subject to the provisions of

laws, regulations, executive orders, and proclamations. Laws include the *American Indian Religious Freedom Act*; *Antiquities Act of 1906*; *Archaeological and Historic Preservation Act of 1974*; *Archaeological Resources Protection Act of 1979*; *Historic Sites, Buildings and Antiquities Act*; *National Environmental Policy Act of 1969*; *National Historic Preservation Act of 1966*; and *Native American Graves Protection and Repatriation Act of 1990*. Regulations applicable to cultural resources include the following: “Curation of Federally-Owned and Administered Archaeological Collections” (36 CFR 79); “National Historic Landmarks Program” (36 CFR 65); “National Register of Historic Places” (36 CFR 60); “Determinations of Eligibility for Inclusion in the National Register of Historic Places” (36 CFR 63);

“Native American Graves Protection and Repatriation and Regulations” (43 CFR 10); “Protection of Archaeological Resources” (43 CFR 7); and “Protection of Historic Properties” (36 CFR 800). Executive Orders include Executive Order 11593, “Protection and Enhancement of the Cultural Environment” (36 FR 8921); Executive Order 13007, “Indian Sacred Sites” (61 FR 26771-26772); Executive Order 13287, “Preserve America” (68 FR 10635-10638); and Presidential Proclamation 7319, “Establishment of the Hanford Reach National Monument” (65 FR 37253-37256).

See Section 10.15 for details regarding the cultural resource programs on the Hanford Site.





## 5.5 *National Environmental Policy Act of 1969*

JW Cammann

The *National Environmental Policy Act of 1969* (NEPA) requires that an environmental impact statement be prepared for major federal agency actions that have the potential to significantly affect the quality of the human environment. A record of decision documents decisions concerning a proposed action for which an environmental impact statement has been prepared.

An environmental assessment is prepared when it is uncertain if a proposed action would require the preparation of an environmental impact statement. A finding of no significant impact may be issued to present the reasons why an action will not have a significant effect on the human environment, and therefore, will not require preparation of an environmental impact statement.

A mitigation action plan, prepared in accordance with NEPA regulations (10 CFR 1021.331), describes a plan for implementing commitments made in an environmental impact statement and its associated record of decision, or when appropriate an environmental assessment, to mitigate adverse environmental impacts associated with a proposed action.

Occasionally, special environmental analyses may be prepared after consulting with the Council on Environmental Quality for alternative arrangements under 40 CFR 1506.11, which apply where emergency circumstances make it necessary to take action without preparing an environmental impact statement. The special environmental analysis examines the environmental impacts of the emergency action and considers alternatives that include mitigation measures.

A supplement analysis, prepared in accordance with NEPA regulations (10 CFR 1021.314(c)), is used to determine

whether a supplemental or new environmental impact statement should be prepared pursuant to Council on Environmental Quality NEPA regulations (40 CFR 1502.9(c)). A supplement analysis is prepared to consider new information developed since issuance of an environmental impact statement and record of decision. The supplement analysis determines if the proposed action is still bound by the original environmental impact statement and record of decision, or if a supplemental environmental impact statement and amended record of decision are required.

A Notice of Intent is a formal announcement of intent to prepare an environmental impact statement, which is published in the *Federal Register* in accordance with DOE NEPA regulations (10 CFR 1021.311). The EPA Notice of Availability is the official public notification published in the *Federal Register* to announce the issuance and public availability of a draft or final environmental impact statement.

Additionally, certain actions may fall into classes that have already been analyzed and determined to not normally result in a significant environmental impact (10 CFR 1021, Subpart D, Appendix A and B). Known as categorical exclusions, these actions are exempt from NEPA environmental assessment or environmental impact statement requirements if eligibility criteria are met. Some categorical exclusions are applicable to general DOE actions and do not require written documentation for application. Other categorical exclusions are applicable to specific DOE actions and must be documented in writing when applied. Action-specific categorical exclusions must be reviewed and approved by the DOE NEPA Compliance Officer. Some action-specific categorical exclusions apply to routinely conducted activities and are pre-approved by the DOE NEPA Compliance Officer as site-wide categorical exclusions.

There are four conditions that are integral elements for the application of categorical exclusions to Hanford Site activities. The action must not 1) violate regulatory requirements; 2) require construction of waste treatment, storage, and disposal facilities; 3) disturb hazardous substances that could result in an uncontrolled release; or 4) adversely affect environmentally sensitive resources.

Hanford Site NEPA documents are prepared and approved in accordance with NEPA regulations and their implementing procedures. DOE activities conducted under CERCLA requirements incorporate NEPA values including analysis of cumulative, offsite, ecological, and socioeconomic impacts to the extent practicable in work planning documents in lieu of preparing separate NEPA documentation.

## 5.5.1 Hanford Site Environmental Impact Statements

### 5.5.1.1 Tank Closure and Waste Management Environmental Impact Statement

In February 2006, DOE announced its intent to prepare a new environmental impact statement for the Hanford Site pursuant to NEPA requirements titled, "Notice of Intent to Prepare the Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington" (71 FR 5655-5660).

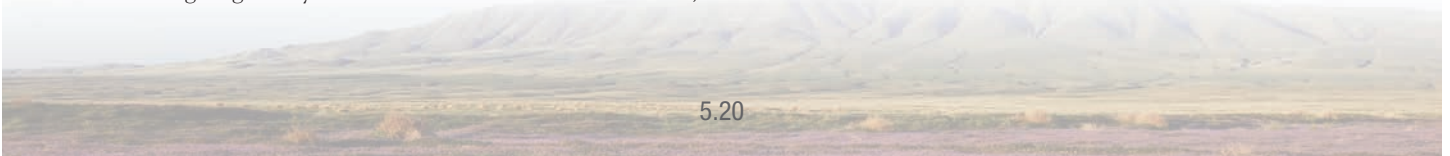
During 2008, work continued on the Tank Closure and Waste Management Environmental Impact Statement to revise, update, and reanalyze groundwater impacts previously addressed in the *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington* (DOE/EIS-0286F), and provide a single, integrated analysis of groundwater for all waste types on the Hanford Site. The Tank Closure and Waste Management Environmental Impact Statement will include a reanalysis of onsite disposal alternatives for the Hanford Site's low-level radioactive and mixed low-level radioactive wastes, and like wastes from other DOE sites. DOE will continue ongoing analysis of alternatives for the retrieval,

treatment, storage, and disposal of underground tank wastes and closure of underground single-shell tanks. In addition, DOE plans to include the scope of the *Fast Flux Test Facility Decommissioning Environmental Impact Statement* (DOE/EIS-0364), which was cancelled in February 2006, in the scope of the new Tank Closure and Waste Management Environmental Impact Statement to provide an integrated presentation of currently foreseeable activities related to waste management and cleanup on the Hanford Site.

The projected issuance date of the draft Tank Closure and Waste Management Environmental Impact Statement is uncertain. The estimated schedule for the final Tank Closure and Waste Management Environmental Impact Statement is March 2010 with a record of decision by April 2010. A new schedule for release of the Tank Closure and Waste Management Environmental Impact Statement is anticipated by the end of July 2009.

### 5.5.1.2 Comprehensive Conservation Plan and Environmental Impact Statement for the Hanford Reach National Monument

The *Hanford Reach National Monument Draft Comprehensive Conservation Plan and Environmental Impact Statement* (USFWS 2006) was prepared by the U.S. Fish and Wildlife Service to evaluate management alternatives for the monument, including the units of the monument that comprise the Saddle Mountain National Wildlife Refuge (Fitzner/Eberhardt Arid Lands Ecology Reserve, Saddle Mountain, and Wahluke Units). As co-manager of the monument, DOE Richland Operations Office is a cooperating agency. The draft document (USFWS 2006) was issued for review in December 2006, with the public comment period ending March 10, 2007. The *Hanford Reach National Monument Final Comprehensive Conservation Plan and Environmental Impact Statement* (USFWS 2008) was issued on August 11, 2008, in the *Federal Register* (FR Doc E8-18445). On November 28, 2008, the U.S. Fish and Wildlife Service announced the availability of the record of decision in the *Federal Register* (FR Doc E8-28214) documenting the preferred management alternative. This alternative is anticipated to protect and conserve the biological, geological, paleontological,



and cultural resources by creating and maintaining extensive areas free of new facility development, thereby minimizing overall impacts.

#### 5.5.1.3 Planning Report/ Environmental Impact Statement for the Yakima River Basin Water Storage Feasibility Study

A draft environmental impact statement for the Yakima River Basin was issued by the U.S. Department of the Interior Bureau of Reclamation and the Washington State Department of Ecology (with DOE as a cooperating agency) on January 29, 2008. The purpose of the *Draft Planning Report/Environmental Impact Statement Yakima River Basin Water Storage Feasibility Study, Yakima Project, Washington* (U.S. Department of the Interior and Ecology 2008) is to develop and evaluate alternatives that could create additional water storage for the Yakima River Basin, and assess the potential to improve anadromous fish habitat, improve the reliability of the Yakima Project irrigation water supply during dry years, and provide water to meet future demand for municipal water supplies.

The final planning report/environmental impact statement for the Yakima River Basin was published by the U.S. Department of the Interior Bureau of Reclamation on December 19, 2008, and evaluates four alternatives: 1) No Action; 2) Black Rock Reservoir; 3) Wymer Dam and Reservoir; and 4) Wymer Dam plus Yakima River Pump Exchange. The Bureau of Reclamation selected the No Action alternative as the preferred alternative (U.S. Department of the Interior 2008). The public review and comment period ended on February 2, 2009. Responses to comments will be included in a final record of decision scheduled for issuance in 2009.

Washington State Department of Ecology officials decided to forgo the joint environmental process and released a supplemental draft environmental impact statement (Ecology 2008) on December 10, 2008, which assessed a broader range of actions than the U.S. Department of the Interior Bureau of Reclamation environmental impact statement. As a consequence, the non-storage alternatives in the draft Bureau of Reclamation environmental impact statement were deleted from the final document and are

addressed in the Washington State Department of Ecology's State Environmental Policy Act environmental impact statement, published in June 2009 (Ecology 2009).

#### 5.5.1.4 Environmental Impact Statement for Disposal of Greater- Than-Class-C Low-Level Radioactive Waste

Greater-Than-Class-C low-level radioactive waste is defined by the U.S. Nuclear Regulatory Commission in 10 CFR 72.3 as "low-level radioactive waste that exceeds the concentration limits of radionuclides established for Class C waste in 10 CFR 61.55." Greater-Than-Class-C low-level radioactive waste is generated by the U.S. Nuclear Regulatory Commission or Agreement State licensed activities. DOE proposed to evaluate alternatives for Greater-Than-Class-C low-level radioactive waste disposal in a geologic repository, in intermediate-depth boreholes, and in enhanced near-surface facilities. Identified candidate locations for these disposal facilities were the Idaho National Laboratory in Idaho; the Los Alamos National Laboratory and Waste Isolation Pilot Plant in New Mexico; the Nevada Test Site and the proposed Yucca Mountain Repository in Nevada; the Savannah River Site in South Carolina, the Oak Ridge Reservation in Tennessee, and the Hanford Site in Washington. The "Notice of Intent to Prepare an Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste" was issued July 23, 2007 (72 FR 40135-40139).

During 2008, work continued on preparing the draft environmental impact statement scheduled for issuance in November 2009; the final environmental impact statement is scheduled for issuance in November 2010 and issuance of the record of decision is to be determined.

#### 5.5.1.5 Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership

DOE announced its intention to prepare a programmatic environmental impact statement for the Global Nuclear Energy Partnership initiative in the *Federal Register* on January 4, 2007 (72 FR 331-336). The Hanford Site is



included in the list of DOE sites under consideration for the location of a nuclear fuel recycling center and/or an advanced recycling reactor, as well as an advanced fuel cycle research facility.

On October 17, 2008, DOE announced the availability of its *Draft Global Nuclear Energy Partnership Programmatic Environmental Impact Statement* (DOE/EIS-0396). The document provides an analysis of potential environmental consequences of alternatives to the present open fuel cycle, in which nuclear fuel is used one time and eventually sent to geologic disposal. Six programmatic domestic alternatives are assessed: 1) No Action Alternative—Existing Once-Through Uranium Fuel Cycle; 2) Fast Reactor Recycle Fuel Cycle Alternative; 3) Thermal/Fast Reactor Recycle Fuel Cycle Alternative; 4) Thermal Reactor Recycle Fuel Cycle Alternative; 5) Once-Through Fuel Cycle Alternative Using Thorium; and 6) Once-Through Fuel Cycle Alternative Using Heavy Water Reactors or High Temperature Gas-Cooled Reactors.

DOE held 13 public hearings in 9 states and Washington, D.C. on the draft programmatic environmental impact statement. The public comment period ended on March 16, 2009. A decision to cancel the Global Nuclear Energy Partnership environmental impact statement was announced June 29, 2009 (74 FR 31017-31018).

### 5.5.1.6 Hanford Comprehensive Land-Use Plan Environmental Impact Statement

DOE issued a draft supplement analysis to the 1999 *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222F) for informal public comment on March 24, 2008; the comment period closed April 23, 2008, and the final supplement analysis was issued in August 2008 (DOE/EIS-0222-SA-01).

The primary purpose of the supplement analysis was to evaluate whether a supplemental environmental impact statement, a new environmental impact statement, or neither was required. The supplement analysis focused on whether further NEPA review is needed due to any changes in 1) land-use designations, 2) the preferred alternative land-use map depicting the desired future patterns of land use on

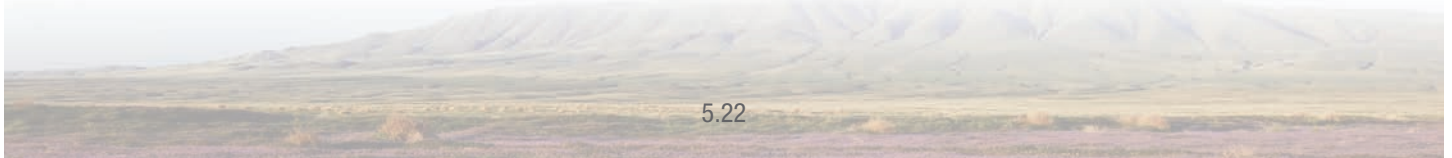
the Hanford Site, 3) land-use policies, 4) implementing procedures described in Chapter 6, or 5) impacts of the changes in items 1 through 4. The *Hanford Comprehensive Land-Use Plan Environmental Impact Statement* was amended on September 26, 2008, and formally announced in the *Federal Register* (FR Doc E8-22676).

Based on the supplement analysis, DOE found no significant new circumstances or information relevant to environmental concerns and bearing on the proposed actions or their impacts as described in the *Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222F). Therefore, DOE has determined that neither a new environmental impact statement nor a supplement is needed at this time. Based on the supplement analysis, DOE concludes that using the regulatory processes in place on the Hanford Site under the framework of the Tri-Party Agreement (Ecology et al. 1989) is an acceptable way to ensure land use is being implemented consistently with the Hanford Comprehensive Land-Use Plan.

## 5.5.2 Hanford Site Environmental Assessments

DOE proposes to dispose part of its excess uranium inventory using one or a combination of two methods: 1) enrichment to either natural uranium or low-enriched uranium product, and subsequent storage or sale of the resultant natural uranium or low-enriched uranium product (the enrichment alternative), and 2) direct sale to appropriately licensed entities (the direct sale alternative).

On December 23, 2008, DOE issued the *Draft Environmental Assessment for the Disposition of DOE Excess Depleted Uranium, Natural Uranium, and Low-Enriched Uranium* (DOE-EA-1607). The draft environmental assessment analyzes the environmental impacts of alternative strategies for the management of excess uranium inventories currently stored at the DOE Portsmouth, Ohio, and Paducah, Kentucky sites. The Environmental Assessment also addresses the AREVA Fuel Fabrication Facility located in Richland, Washington. This facility has a uranium cylinder storage facility for the receipt, handling, and weighing/assaying of cylinder contents. The facility also has capabilities for uranium cylinder recertification.





## 5.6 Atomic Energy Act of 1954

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The *Atomic Energy Act of 1954* was promulgated to assure the proper management of radioactive materials. The act and its amendments delegate the roles and responsibilities for the control of radioactive materials and nuclear energy primarily to DOE, the U.S. Nuclear Regulatory Commission, and EPA. Under the act, DOE regulates the control of radioactive materials under its authority, including the treatment, storage, and disposal of low-level radioactive waste from its operations. Sections of the act authorize DOE to set radiation protection standards for itself and its contractors. Accordingly, DOE promulgated a series of regulations (e.g., 10 CFR 820, 10 CFR 830, and 10 CFR 835) and directives (e.g., DOE Order 435.1 and DOE Order 5400.5, Change 2) to protect public health and the environment from potential risks associated with radioactive materials. Hanford Site operations are subject to the requirements in these regulations and directives. In 2008, the following DOE regulations or directives that potentially impact the management and control of radioactive materials were issued or underwent significant revision:

- DOE Notice 234.1. 2008. "Reporting of Radioactive Sealed Sources."
  - DOE Manual 441.1-1. 2008. "Nuclear Material Packaging Manual."
  - DOE Guide 441.1-1C. 2008. "Radiation Protection Programs Guide for Use with Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection."
  - DOE Order 450.1A. 2008. "Environmental Protection Program."
  - DOE Manual 460.2-1A. 2008. "Radioactive Material Transportation Practices Manual."
  - DOE Order 462.1. 2008. "Import and Export of Category 1 and 2 Radioactive Sources and Aggregated Quantities."
- In addition, in 2008 the following DOE technical standards or handbooks pertaining to the management and control of radioactive materials were issued or underwent significant revision:
- DOE-HDBK-1110-2008. 2008. *ALARA Training for Technical Support Personnel*.
  - DOE-HDBK-1113-2008. 2008. *Radiological Safety Training for Uranium Facilities*.
  - DOE-STD-1121-2008. 2008. *Internal Dosimetry*.
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  - DOE-HDBK-1141-2008. 2008. *Radiological Assessor Training*.
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Directives, regulations, and standards issued in 2008 may be accessed via the DOE Directives, Regulations, and Standards website at <http://www.directives.doe.gov>. DOE handbooks issued during 2008 may be accessed at <http://www.hss.doe.gov/nuclearsafety/ns/techstds/standard/recappts.html>.



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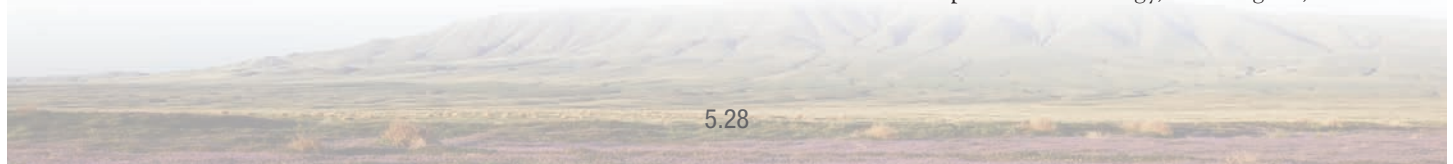
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## 6.0 Environmental Restoration and Waste Management Operations

JP Duncan

Environmental cleanup and decommissioning activities continued on the Hanford Site during 2008. The following sections describe the Hanford Site U.S. Department of Energy (DOE) contracts associated with waste cleanup and environmental restoration, ongoing cleanup operations,

and facility decommissioning activities. This section also describes the status of underground waste storage tanks, the construction of the Hanford Tank Waste Treatment and Immobilization Plant and its associated facilities, and research activities related to waste cleanup.





## 6.1 Hanford Site Cleanup Contracts

JP Duncan

As part of DOE's Hanford Central Plateau acquisition strategy, three new cleanup contracts were awarded in 2008: 1) the Tank Operations Contract, covering tank farm operations and closure; 2) the Plateau Remediation Contract, covering waste and facility disposition; and 3) the Mission Support Contract, covering infrastructure and site-support functions.

### 6.1.1 Tank Operations Contract

On May 29, 2008, DOE selected Washington River Protection Solutions, LLC to implement the Tank Operations Contract on the Hanford Site starting October 1, 2008. Washington River Protection Solutions, LLC is responsible for base operation of the tanks, analytical laboratory support, single-shell tank retrieval and closure, Hanford Tank Waste Treatment and Immobilization Plant support, and supplemental treatment activities. The contractor will also administer the pension and welfare plans for incumbent and legacy tank farm employees.

The mission of Washington River Protection Solutions, LLC includes the following:

- Develop new and innovative technologies to increase the efficiency and cost-effectiveness of tank waste retrieval operations while reducing the overall time required
- Develop infrastructure required to transfer waste from tank to tank, and from the tank farms to the Hanford Waste Treatment and Immobilization Plant
- Assess tank leaks and unplanned releases within the Hanford Site tank farms, including vadose zone contamination

- Decision making regarding contaminant characterization and corrective actions.

Washington River Protection Solutions, LLC is exploring methods and technologies to safely and effectively manage the tank operations mission.

### 6.1.2 Plateau Remediation Contract

DL Foss

DOE selected CH2M HILL Plateau Remediation Company to execute the Plateau Remediation Contract for the Hanford Site starting October 1, 2008. CH2M HILL Plateau Remediation Company is responsible for safe environmental cleanup through decommissioning and remediation of Hanford Site groundwater, vadose zone, and soil; the Central Plateau; and the 100-K Area. Primary goals include protecting the Columbia River; reducing hazards, risks, and costs; shrinking the Hanford Site footprint; and remediating the Central Plateau, 100-K Area, and the 618-10 and 618-11 Burial Grounds.

Paramount to protecting the Columbia River is the following:

- Remediating soil and groundwater
- Operating existing groundwater pump-and-treat systems at the 100 Areas and Central Plateau
- Optimizing and expanding groundwater treatment at the 100 Areas and Central Plateau
- Eliminating or minimizing contamination sources near the Columbia River by deactivating, decontaminating, decommissioning, and demolishing facilities along the river

- Placing the K-East Reactor into interim safe storage
- Moving K Basin sludge away from the Columbia River.

Remediation of waste sites outside the Central Plateau is central to shrinking the Hanford Site footprint. By using an “outside-in” approach, the focus is on completing activities at areas such as the 100-K Area, 400 Area, and outer portions of the Central Plateau to achieve tangible footprint reductions by 2013.

### 6.1.3 Mission Support Contract

On September 3, 2008, DOE selected Mission Support Alliance, LLC to implement the Mission Support Contract for the Hanford Site. Mission Support Alliance, LLC is responsible for Hanford Site infrastructure and site services. The scope of the contract includes safety, security, and environmental protection services; site infrastructure and utilities management; site business management; information resources/content management; and portfolio management.

On September 22, 2008, Computer Sciences Corporation filed a contract award protest with the Government

Accounting Office challenging the cost evaluation. Following an investigation, the Government Accounting Office dismissed the protest on December 30. However, DOE agreed to take corrective action to address the cost evaluation concerns and re-evaluated the bidder’s final proposals and supporting documentation. On April 28, 2009, DOE announced that Mission Support Alliance, LLC was selected to implement the Mission Support Contract.

Support services, currently provided by Fluor Hanford, Inc. will transition to Mission Support Alliance, LLC beginning in May 2009 and will be completed within 90 days.

The Mission Support contractor’s responsibilities include the following:

- Information technology services and telecommunications
- Security and fire protection
- Biological control
- Utilities, roads and grounds, sewer, and sanitary waste management
- Real estate and equipment management
- Personnel management
- Pension administration.





## 6.2 Cleanup Operations

The following sections describe ongoing Hanford Site cleanup and remediation activities.

### 6.2.1 Waste Site Investigations and Remediation Activities on the Central Plateau

CD Wittreich

Remedial investigation/feasibility study activities continued during 2008 at Central Plateau waste sites. Work was performed within the characterization and regulatory framework defined in the *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE/RL-98-28, Rev. 0). Work was performed at a number of operable unit groups, which were at various stages of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation/feasibility study process. The following summarizes activities performed in 2008.

**200-CW-1 Operable Unit.** The 200-CW-1 Operable Unit consists of former ponds and ditches located within the 200-East Area and north and east of the 200-East Area. The 200-CW-1 Operable Unit consists of waste sites that received cooling water from facilities such as the Reduction-Oxidation (REDOX) Plant, T Plant, Plutonium Uranium Extraction (PUREX) Plant, and B Plant. Supplemental remedial investigation activities were conducted during fiscal year 2008, including using direct-push technology and installation of a borehole. Direct-push technology advances a hollow rod directly into the soil, allowing soil sample collection and/or monitoring. Data from this supplemental investigation will be incorporated into Draft B of the feasibility study report (DOE/RL-2002-69,

Draft A) and proposed plan (DOE/RL-2003-06, Draft A) to be submitted per the *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement [Ecology et al. 1989]) Interim Milestone M-015-38B, by November 30, 2011.

**200-CS-1 Operable Unit.** The 200-CS-1 Operable Unit consists of waste sites that received sewer wastewater containing chemicals from major plant facilities in both the 200-West and 200-East Areas. A remedial investigation/feasibility study work plan (DOE/RL-99-44, Rev. 0) was implemented in 2000 to characterize four representative waste sites of the operable unit: the 216-S-10 Pond, 216-S-10 Ditch, 216-B-63 Trench, and 216-A-29 Ditch. A feasibility study (DOE/RL-2005-63, Draft A) and proposed plan (DOE/RL-2005-64, Draft A) was submitted to the Washington State Department of Ecology and the U.S. Environmental Protection Agency (EPA) in March 2006 (Tri-Party Agreement Interim Milestone M-015-39B [Ecology et al. 1989]). An updated draft of the feasibility study (DOE/RL-2005-63, Draft B) and proposed plan (DOE/RL-2005-64, Draft B) were submitted to the Washington State Department of Ecology and EPA in fiscal year 2007. Discussions concerning the feasibility study and proposed plan continued during 2008.

**200-CW-5 Operable Unit.** The 200-CW-5 Operable Unit consists of waste sites that received cooling water and chemical sewer waste from facilities in the 200-West Area, including the Plutonium Finishing Plant and associated facilities. The remedial investigation included pipeline sampling, geophysical logging of shallow drive-point casings, and characterization drilling to the water table to determine vadose zone contamination. Primary contaminants of concern included strontium-90, cesium-137, americium-241, plutonium isotopes, nitrite, and polychlorinated biphenyls

(PCBs). A feasibility study (DOE/RL-2004-24, Draft A) and proposed plan (DOE/RL-2004-26, Draft A) were issued to the Tri-Party agencies (Washington State Department of Ecology, EPA and DOE) in October 2004 (Tri-Party Agreement Interim Milestone M-015-40C [Ecology et al. 1989]). Discussions between the Tri-Party agencies and CH2M HILL Plateau Remediation Company have determined that additional characterization information is not required at this operable unit. The Draft B feasibility study (DOE/RL-2004-24, Draft B) and proposed plan (DOE/RL-2004-26, Draft B) were submitted to EPA on July 30, 2008 (Tri-Party Agreement Interim Milestone M-015-40D [Ecology et al. 1989]).

**200-CW-3 Operable Unit.** In 2007, four waste sites (216-N-2, 216-N-3, 216-N-5, and 216-N-7) located in the 200-CW-3 Operable Unit were remediated and closed. Each of the waste sites received cooling water from interim storage basins in the 212 Buildings located in the 200-North Area of the Hanford Site until the early 1950s.

No field activities were performed in the operable unit in 2008. A Tri-Party Agreement (Ecology et al. 1989) change request (C-07-07) was approved to move all 200-North waste sites into the 200-CW-3 Operable Unit. The *Remedial Design/Remedial Action Work Plan for 200 North Area Waste Sites Located in the 200-CW-3 Operable Unit* (DOE/RL-2007-55, Rev. 0) and the *Sampling and Analysis Plan for Remediation of 200 North Area Waste Sites Located in the 200-CW-3 Operable Unit* (DOE/RL-2007-54) were completed in 2008 for confirmatory sampling of the remaining waste sites. Associated field activities will occur in 2009.

**200-SC-1 Operable Unit.** Waste sites in the 200-SC-1 Operable Unit received steam condensate liquid decontamination wastes from 200-East and 200-West facilities, including the Reduction-Oxidation (REDOX) Plant, T Plant, and the Plutonium Uranium Extraction (PUREX) Plant. Supplemental characterization of the 216-A-30, 216-B-55, and 216-S-6 waste sites was completed in 2008 in accordance with the work plan (DOE/RL-2007-02, Rev. 0). Characterization boreholes were drilled and soil samples obtained from the vadose zone for chemical and radiochemical analyses. Geophysical logging of the boreholes was also performed. Primary contaminants of concern included tritium, strontium-90, cesium-137, plutonium

isotopes, uranium, fluoride, and nitrate. Borehole summary reports were prepared to document the field activities and findings (SGW-38048 for 216-A-30, SGW-38478 for 216-B-55, and SGW-38476 for 216-S-6).

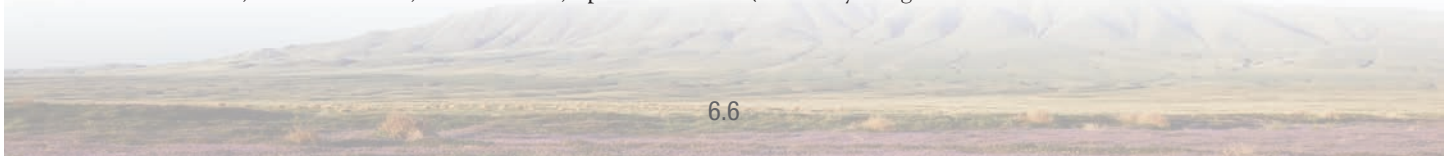
#### **200-TW-1, 200-TW-2, and 200-PW-5 Operable Units.**

The 200-TW-1 Operable Unit consists of waste sites (mostly cribs and trenches) that received waste associated with uranium recovery activities at the U Plant. The 200-TW-2 Operable Unit consists of waste sites (mostly cribs and trenches) that received waste from decontamination processes at the B and T Plants. The 200-PW-5 Operable Unit waste sites received fission-product-rich wastes that were generated during the fuel-rod enrichment cycle and then released when the fuel elements were decladded or dissolved in sodium hydroxide or nitric acid. DOE approved a supplemental remedial investigation work plan (DOE/RL-2007-02, Rev. 0) to collect additional data required for decision making purposes regarding the 200-TW-1, 200-TW-2, and 200-PW-5 Operable Units. Supplemental data collection began in fiscal year 2008 with three direct-push boreholes at the 216-T-18 site. Downhole geophysical logging was also completed; results will be reported during 2009.

#### **200-PW-1, 200-PW-3, and 200-PW-6 Operable Units.**

The 200-PW-1 Operable Unit contains waste sites that received significant quantities of carbon tetrachloride and plutonium, as well as other contaminants associated with process waste from the Plutonium Finishing Plant. The 200-PW-3 Operable Unit waste sites received organic rich plutonium-uranium extraction process waste from A Plant. The 200-PW-6 Operable Unit waste sites received plutonium-rich waste from the Plutonium Finishing Plant complex, but did not receive organic-rich wastes. This operable unit group also includes carbon tetrachloride in the vadose zone that has migrated beyond the boundaries of the waste sites. The work plan for the plutonium/organic-rich operable unit group (200-PW-1, 200-PW-3, and 200-PW-6 Operable Units) was approved by DOE, the Washington State Department of Ecology, and EPA (the Tri-Parties) in 2004 (DOE/RL-2001-01, Rev. 1), and remedial investigation field activities were completed in 2006.

A remedial investigation report (DOE/RL-2006-51, Draft A) was submitted to the EPA for review in October 2006 (Tri-Party Agreement Interim Milestone M-015-45A



[Ecology et al. 1989]). An addendum to the final report on the dense, non-aqueous phase liquid investigation was completed in April 2007 (DOE/RL-2007-22, Rev. 0). This work completed the CERCLA remedial investigation of the 200-PW-1 Operable Unit.

Data from these remedial investigation activities, as well as existing data, were included in Revision 0 of the remedial investigation report (DOE/RL-2006-51, Rev. 0), which was issued in September 2007. These data were used to support the evaluation of remedial alternatives in the feasibility study for the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units waste sites. Draft A of the feasibility study (DOE/RL-2007-27, Draft A) and proposed plan (DOE/RL-2007-40, Draft A) were submitted to EPA in September 2007 in fulfillment of Tri-Party Agreement Interim Milestone M-015-45B (Ecology et al. 1989). In 2008, revisions to the feasibility study and proposed plan continued.

**200-PW-2 and 200-PW-4 Operable Units.** Waste sites in the 200-PW-2 Operable Unit received uranium-rich condensate and process waste, primarily from waste streams generated at the U Plant, Reduction-Oxidation (REDOX) Plant, Plutonium Uranium Extraction (PUREX) Plant, B Plant, and semi-works facilities. Waste sites in the 200-PW-4 Operable Unit received mostly process drainage, process distillate discharge, and miscellaneous condensates from the same facilities, including condensates from the S and A Tank Farms and 242-A Evaporator. Site-specific sampling and analysis plans associated with field activities conducted at the 216-S-1&2 Crib and the 216-A-5 Crib were approved in 2008 in accordance with the supplemental work plan (DOE/RL-2007-02, Rev. 0). Supplemental characterization activities completed in 2008 at these two cribs included four direct-push boreholes (one at the 216-A-5 Crib and three at the 216-S-1&2 Crib) and a deep vadose zone borehole at the 216-A-5 Crib.

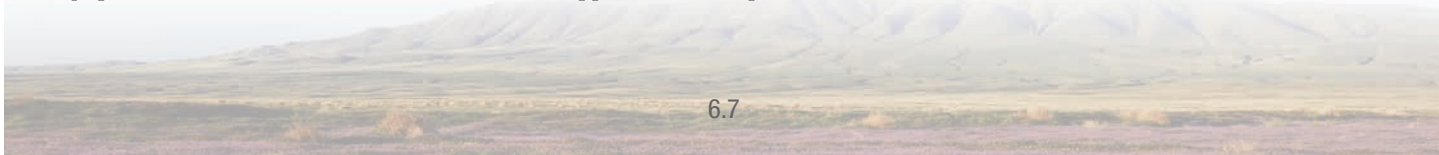
**200-LW-1 and 200-LW-2 Operable Units.** Waste sites in the 200-LW-1 and 200-LW-2 Operable Units received two types of waste: 1) liquid waste resulting from 300 Area process laboratory operations that supported radiochemistry metallurgical experiments; and 2) liquid waste resulting mainly from laboratory operations on the Central Plateau that supported the major chemical processing facilities and equipment decontamination at T Plant. A supplemental

remedial investigation is being planned for four 200-LW-1 and 200-LW-2 Operable Unit waste sites (216-B-10A, 216-T-8, 216-T-34, and 216-Z-16 Cribs). Supporting documentation was prepared and issued in 2008 (SGW-37978; SGW-37980; SGW-37979). Supplemental characterization will include drilling and geophysical logging of boreholes and obtaining soil samples from the vadose zone for chemical and radiochemical analyses. The primary contaminants of concern that have been identified include strontium-90, cesium-137, americium-241, plutonium isotopes, uranium, and nitrate.

A new groundwater monitoring well (C5860 or “K” well) is planned for the 200-BP-5 Groundwater Operable Unit; it will be drilled near the 216-B-6 reverse well, which is a 200-LW-2 Operable Unit soil waste site. Vadose zone characterization data will also be collected during the drilling of K well. Uncertainty in the radiological inventory and the construction of the 216-B-6 reverse well caused safety concerns that resulted in the new K well being classified as a high-risk borehole. A Tri-Party Agreement change notice (TPA-CN-233 [Ecology et al. 1989]) was approved to first drill a direct-push borehole nearby followed by geophysical logging to better define the local radiological conditions. The direct-push borehole (C6911) was drilled in September 2008. Geophysical logging was performed and the results indicate contamination is confined to two thin layers near the bottom of the 216-B-6 reverse well at about 23 meters (75 feet) below ground surface (HGLP-LDR-269). The direct-push borehole was decommissioned and a borehole summary report (SGW-40263) was prepared to document the field activities and findings.

**200-MW-1 Operable Unit.** The waste sites in the 200-MW-1 Operable Unit consist mainly of cribs, trenches, and reverse wells that received moderate- to low-volume equipment decontamination waste and ventilation system waste. The initial work plan for the 200-MW-1 Operable Unit was approved in 2002 (DOE/RL-2001-65, Rev. 0). Since then, the 200-MW-1 Operable Unit has incorporated seven waste sites.

During 2007, supplemental field investigations were completed at the 216-A-2, 216-A-4, and 216-A-21 Cribs and 200-E-102 Trench following a supplemental work plan (DOE/RL-2007-02, Rev. 0). These characterization



activities included subsurface geophysical logging and sediment and groundwater sampling (as applicable) at four shallow direct-push boreholes and two deep drilled boreholes at 200-MW-1 Operable Unit sites south of the Plutonium Uranium Extraction (PUREX) Plant. One borehole was completed as a new groundwater monitoring well near the 216-A-4 Crib (299-E24-23).

During 2008, a remedial investigation report summarizing and evaluating data collected at the 216-A-2, 216-A-4, and 216-A-21 Crib and 200-E-102 Trench progressed. Also, work began on a feasibility study that will support remedial decision making for waste sites in the 200-MW-1 Operable Unit. The remedial investigation and feasibility study reports associated with this work are planned for completion in September 2009.

**200-SW-1 and 200-SW-2 Operable Units.** The 200-SW-1 Operable Unit includes two non-radioactive landfills in the 600 Area: the Nonradioactive Dangerous Waste Landfill and the Solid Waste Landfill. The 200-SW-2 Operable Unit includes 25 landfills located in the 200-East and 200-West Areas. Initial non-intrusive (Phase I-A) field characterization (D&D-28283), completed in fiscal year 2006, included geophysical investigation, passive organic-vapor sampling, radiation surveys, and additional historical information research. In May 2007, an agreement was reached between the Washington State Department of Ecology and the DOE Richland Operations Office to create a remedial investigation/feasibility study work plan that used a phased-characterization approach. In September 2007, a work plan (DOE/RL-2004-60, Draft B) was submitted by the DOE Richland Operations Office to the Washington State Department of Ecology for review and comment. The remedial investigation/feasibility study work plan was finalized and approved by DOE and the Washington State Department of Ecology in December 2008 (DOE/RL-2004-60, Rev. 0).

**200-IS-1 Operable Unit.** The 200-IS-1 Operable Unit consists of pipelines, diversion boxes, catch tanks, and related structures used to transfer single-shell tank waste within and between the 200 Areas. These facilities are the responsibility of the tank operations contractor, Washington River Protection Solutions, LLC and the plateau remediation contractor, CH2M HILL Plateau Remediation

Company. In February 2007, the Tri-Parties concluded negotiations on milestone changes for completing the remedial investigation/feasibility study process and the *Resource Conservation and Recovery Act of 1976 (RCRA)* facility investigation/corrective measures study process for 200 Areas (Central Plateau) non-tank farm operable units. The milestones were revised to allow additional site characterization before making several Central Plateau cleanup decisions. In addition, Tri-Party Agreement Interim Milestones M-015 and M-013 were added and existing milestones modified (Ecology et al. 1989).

Five RCRA treatment, storage, and disposal unit tanks belonging to CH2M HILL Plateau Remediation Company are also included in this operable unit: the 241-CX-70, 241-CX-71, 241-CX-72, 276-S-141, and 276-S-142 Tanks. DOE submitted the 200-IS-1 work plan and sampling and analysis plan (DOE/RL-2002-14, Rev. 1, Draft B) in June 2007 in accordance with Tri-Party Agreement Milestone M-013-27 (Ecology et al. 1989). The document was approved on June 5, 2008.

A portion of the 200-IS-1 Operable Unit work plan (DOE/RL-2002-14, Rev. 1, Draft B) was implemented during the 2008 calendar year. Borehole geophysics data were obtained at 68 locations across the Central Plateau. In addition to this field work, the *241-CX Tank System Closure Plan* (DOE/RL-2008-51, Rev. 0) was submitted to the Washington State Department of Ecology on December 22, 2008. Submittal of the closure plan met Tri-Party Agreement milestone M-020-54 and closed out milestones M-020-00 and M-020-00B (Ecology et al. 1989).

**200-MG-1 and 200-MG-2 Operable Units.** In 2005, EPA and the Washington State Department of Ecology identified a need for additional characterization for many of the Central Plateau waste sites that were being evaluated through the remedial investigation/feasibility study process. The Tri-Parties initiated a supplemental data quality objectives process to evaluate data needs, and to concur on a path forward for supplemental data collection that would augment the waste site database.

Through the supplemental characterization effort, the Model Group 1 waste site group was designated. Model Group 1 contained waste sites with shallow or readily



addressed contamination additionally, decision making for these waste sites was determined to be straightforward and supplemental data were not required (Ecology et al. 2006). This model group included 266 waste sites, which were assigned to two new operable units. Waste sites in Model Group 1, for which the Washington State Department of Ecology is the lead regulatory agency, are now included in the new 200-MG-1 Operable Unit (193 waste sites), which includes the site previously identified as 200-ST-1. Model Group 1 sites, for which EPA is the lead regulatory agency, are in the new 200-MG-2 Operable Unit (73 waste sites). Waste sites include unplanned releases, shallow leaks from pipelines or tanks, and contamination spread by burrowing wildlife.

In early 2008, DOE determined that the 200-MG-1 and 200-MG-2 Operable Unit waste sites contain the potential to release CERCLA hazardous substances, and that a non-time-critical removal action, pursuant to authority delegated under Executive Order 12580, "Superfund Implementation" (52 FR 2923) and Section 7.2.4 of the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al. 1989), is warranted to mitigate the threat of contaminant release.

In October 2008, DOE issued two non-time-critical removal action engineering evaluation/cost analysis documents (DOE/RL-2008-44, Draft A and DOE/RL-2008-45, Draft A) addressing the disposition of contaminated soil and other materials from waste sites contained in the 200-MG-1 and 200-MG-2 Operable Units, respectively. The engineering evaluation/cost analyses evaluated removal action alternatives for each site, including no action; confirmatory sampling/no action; removal, treatment, and disposal; and maintain existing soil cover/institutional controls/monitored natural attenuation. In 2009, the engineering evaluation/cost analyses are expected to be finalized and submitted for public review and comment. An Action Memorandum will then be issued for each of the operable units, and removal action work plans will be developed to support the initiation of removal actions.

**200-UR-1 Operable Unit.** The 200-UR-1 Operable Unit was re-evaluated during 2008, which resulted in the removal of 21 sites from this operable unit. The sites were either rejected or consolidated into other operable units. These

changes were implemented by Tri-Party Agreement (Ecology et al. 1989) Change Request C-07-08, approved on July 8, 2008.

Two major sites have unique site conditions and occupy relatively large geographical areas. The BC Controlled Area, located south of the 200-East Area, encompasses a geographic area approximately equal to the 200-West and 200-East Areas combined (approximately 31 square kilometers [12 square miles]) and can be divided into two regions (Zone A and Zone B). In 2008, the engineering evaluation/cost analysis for the northern part of the BC Controlled Area (DOE/RL-2007-51) was prepared to evaluate the removal of the shallow contamination in the northern portion. Subsequent to the engineering evaluation/cost analysis, the *Action Memorandum for the Non-Time Critical Removal Action for the Northern Part of the BC Controlled Area* (UPR-200-E-83) (DOE/RL-2008-21) recommended removal of soils to 15 centimeters (6 inches) or to preliminary action goals in Zone A and removal of hotspots in Zone B. During the 2008 fiscal year, 26,300 metric tons (29,000 tons) of contaminated material were removed and disposed at the Environmental Restoration Disposal Facility. The balance of the BC Controlled Area is largely uncontaminated, with the few minor contamination sites characterized as radiologically contaminated non-liquid media (i.e., windblown particulates, plant material, and/or animal waste) occupying a thin interval on the surface. This region is expected to be surveyed per an analogue to the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NUREG-1575, Rev. 1).

West Lake, the second major unplanned release waste site, is located approximately 2.9 kilometers (1.8 miles) north of the 200-East Area and includes an area of approximately 7.7 hectares (19 acres). The West Lake site is an intermittent pond located in a natural surface depression; water levels in the pond change in response to water-table fluctuations. Elevated levels of certain radionuclides have been detected in West Lake in the past and deposits of minerals can be seen around the pond edge. In 2008, a data quality objectives report and sampling and analysis plan were in development for this waste site.

**BC Cribs and Trenches Area.** The BC Cribs and Trenches Area (200-BC-1 Operable Unit) was investigated in fiscal



year 2004 with the installation of two boreholes. The borehole data was used to support the preparation of a feasibility study (DOE/RL-2004-66, Draft A) and proposed plan (DOE/RL-2004-69, Draft A) that were submitted to the Tri-Parties in May 2005. Geophysical electrical resistivity characterization was then conducted to delineate the extent of anomalous soil conductivity believed to result from deep, mobile contamination (nitrate, sodium, and technetium-99). Three boreholes were drilled and sampled in fiscal year 2008 to aid in the interpretation of the electrical resistivity characterization data (ground truth). Completion of an electrical resistivity characterization report is anticipated in 2009.

An excavation-based treatability test initiated in 2007 at the 216-B-26 Trench continued during fiscal year 2008. The objective of the treatability test was to evaluate worker dose and remediation costs for the removal and disposal of the contaminated (primarily strontium-90 and cesium-137) surface soil. Work included excavation and soil sampling of one-third of the near-surface contamination from the 216-B-26 Trench, as well as further characterization of the 216-B-26 and 216-B-53A Trenches, and the 216-B-14 Crib using direct-push technology with downhole geophysical logging. A treatability test report is scheduled for completion in 2009.

Preparations for a deep vadose zone treatability test began in 2008 following approval of the *Deep Vadose Zone Treatability Test Plan for the Hanford Central Plateau* (DOE/RL-2007-56, Rev. 0). Testing will initially focus on soil desiccation as a potential remedy to protect groundwater from technetium-99 contamination. A soil desiccation (moisture extraction) pilot test will be conducted in the cribs region of the 200-BC-1 Cribs and Trenches Area to evaluate the dynamics of soil pore-water extraction and its impact on slowing contaminant transport using a combination of field work and laboratory experiments. Activities in 2009 will focus on characterization of the pilot test site and the detailed test design; the pilot test will follow in 2010. The treatability test will be focused on uranium in 2009, which includes laboratory experiments to screen gas-delivered reactants having potential to immobilize uranium associated with pore water.

**Central Plateau Ecological Risk Assessment.** Initiated in 2002, the Central Plateau Ecological Risk Assessment

task was designed to evaluate the potential ecological risks associated with Central Plateau waste sites. A data evaluation report was initiated in 2002, with data quality objectives development and sample planning beginning in 2004. Sampling for Phases I and II was conducted in fiscal year 2005, focusing on background site characterization, a subset of waste sites, and the BC Controlled Area. Phase III data quality objectives development and sample planning activities were conducted in fiscal year 2006, along with associated sampling in the non-waste site areas around the 200-East and 200-West Areas. In November 2006, additional Phase III sampling was performed to fill data gaps observed in the Phase I and II characterization efforts and to supplement data collected from two reference sites located off the Hanford Site. Data from all phases, compiled and evaluated in the *Central Plateau Terrestrial Ecological Risk Assessment* report (DOE/RL-2007-50, Draft A) and published in January 2008, will support the remedial investigation/feasibility study process for the Central Plateau.

## 6.2.2 Cleanup and Remediation Activities in the 100 Areas

This section describes ongoing cleanup and remediation activities in the 100 Areas.

### 6.2.2.1 Remediation of Waste Sites in the 100 Areas

JW Golden and AK Smet

Full scale remediation of waste sites in the 100 Areas began in 1996. Figure 1.0.1 shows the 100 Areas former-reactor region along the Columbia River. Remediation activities in 2008 were performed in multiple locations in the 100 Areas, including the 100-B/C, 100-K, 100-D, 100-H, and 100-F Areas, and the 100-IU-2 and 100-IU-6 Operable Units. Activities included sampling to determine if suspected waste sites exceeded cleanup objectives; sampling to confirm that cleanup objectives had been met; physical excavation operations; waste sorting and segregation; waste treatment; and waste disposal, backfill, and revegetation.

Waste sites vary in complexity and waste type. Typical waste sites include waste burial grounds, liquid effluent waste



sites, burn pits, retired septic systems, piping systems, and miscellaneous waste sites. The primary focus early in the cleanup process was to address waste sites receiving liquid waste because those sites generally contain significant quantities of contaminants and serve as potential sources for groundwater contamination.

Waste burial grounds and miscellaneous waste sites were the focus of remediation in 2008. Waste burial grounds require cleanup but also present a significant health and safety risk to workers as a result of incomplete disposal records and the potential for discovering unknown material from past disposal practices. For example, unknown materials or containers with no marking or labeling could be discovered during cleanup activities that would require further characterization. Characterization of unknown material is critical to ensure worker safety and the proper management of the waste for potential treatment and disposal. Discovery of an unknown material requires additional time and planning to ensure proper protective gear is used in the field when characterizing the material, and to verify that limits and controls identified in approved authorization documents required by DOE are adequate for the work scope. If authorization documents do not adequately cover the material discovered, work is stopped until documentation can be revised and work safely restarted. Based on characterization results, additional waste treatment may be required before disposal.

Miscellaneous waste sites vary in the nature and extent of contamination and are generally smaller-sized areas when compared to waste burial grounds. Sampling requirements for determining if a miscellaneous waste site requires cleanup or is in compliance with post-cleanup goals can vary significantly from one waste site to another.

The 100 Areas waste sites are authorized for remediation activities through the issuance of records of decision approved by EPA, DOE, and the Washington State Department of Ecology. Waste generated from the cleanup of waste sites is disposed of in Hanford's Environmental Restoration Disposal Facility located on the Central Plateau. This centralized disposal facility is the primary disposal pathway, but other disposal options are available, if necessary, should the material not meet the waste acceptance criteria for the facility.

During 2008, a total of 367,500 metric tons (405,125 tons) of contaminated soil from the 100 Areas remediation activities were disposed at the Environmental Restoration Disposal Facility. Quantities and respective locations are as follows:

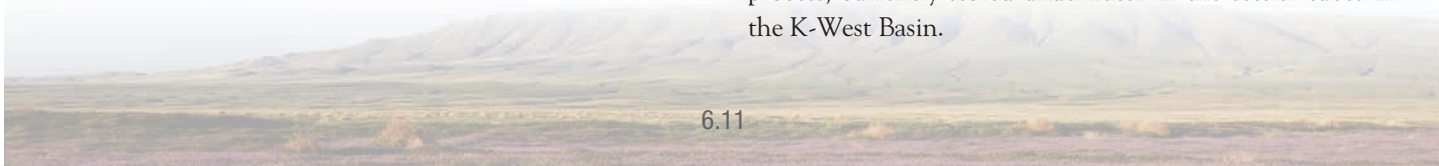
- 1,040 metric tons (1,150 tons) from the 100-B/C Area
- 18,450 metric tons (20,325 tons) from the 100-K Area
- 284,900 metric tons (314,100 tons) from the 100-D Area
- 52,000 metric tons (57,300 tons) from 100-H Area
- 3,500 metric tons (3,850 tons) from the 100-F Area
- 7,625 metric tons (8,400 tons) from the 100-IU-2 and 100-IU-6 Operable Units.

## 6.2.2.2 K Basins Closure Activities

### DJ Watson

Fluor Hanford, Inc. managed the K Basin Closure and Sludge Treatment projects, including K Basins cleanout activities, until September 30, 2008, at which time these activities were transitioned to CH2M HILL Plateau Remediation Company. The K Basins are two indoor, concrete pools attached to the now-closed K-East and K-West Reactors. For nearly 30 years, the basins stored 2,100 metric tons (2,300 tons) of Hanford Site N Reactor spent fuel and a small quantity of slightly irradiated single-pass reactor fuel (fuel from other Hanford Site reactors). The fuel was removed in a major cleanup effort that ended in October 2004.

Corrosion of the fuel during storage, as well as sludge generated during the fuel washing and packaging process, left behind approximately 28 cubic meters (989 cubic feet) of sludge. Sludge was segregated into four streams for subsequent removal and disposition: 1) K-East Basin floor and pit sludge, which has been transferred to underwater storage containers in the K-West Basin; 2) K-West Basin floor and pit sludge, which is currently being stored in underwater storage containers in the K-West Basin; 3) K-West Basin knock-out-pot sludge, generated during the fuel washing and packaging process, and currently stored in underwater containers in the K-West Basin; and 4) settler tube sludge, also generated during the fuel washing and packaging process, currently stored underwater in the settler tubes in the K-West Basin.



Floor and pit sludge is a non-homogenous mixture of debris that includes windblown sand and environmental particulates; concrete fragments from the basin walls; corrosion products from fuel canisters and fuel racks; fuel cladding pieces; tiny pieces of corroded uranium (uranium oxides, hydrates, and hydrides); ion-exchange resin beads; PCBs; and fission products. For the purpose of differentiating spent nuclear fuel and debris from sludge, any material less than or equal to 0.64 centimeter (0.25 inch) in diameter is considered sludge. The K-West Basin fuel cleaning system transferred sludge to either knock-out pots or settler tanks. Knock-out pots collected particles greater than 500 microns (0.02 inch) in size by using either a downstream strainer or an internal screen. Settler tanks, a series of horizontal tubes downstream of the knock-out pots, allowed particles less than 500 microns (0.02 inch) to settle out and not be re-circulated.

The K Basins also contained more than 362 metric tons (400 tons) of debris (solid radioactive waste) and large fuel racks when the fuel removal portion of the closure activities ended. This debris inventory included extensive lengths of hoses, large and small equipment and tools, thousands of canisters and canister lids that formerly held the spent nuclear fuel, and a variety of other miscellaneous debris.

During 2008, the K Basin Closure Project and Sludge Treatment Project made the following progress in cleaning out the K Basins:

- Began preparing a comprehensive cleanup strategy for the 100-K Area designed to integrate Tri-Party Agreement (Ecology et al. 1989) M-34 milestones (associated with K Basins cleanup) and M-16 milestones (associated with completion of all interim response actions for the 100 Areas).
- Completed deactivation of K-East Basin, including the removal of over 3.8 million liters (1 million gallons) of basin water, placement of a grout layer on the basin floor, and backfilling with a controlled density fill to aid in subsequent building demolition.
- Completed demolition of the K-East Basin structural-steel superstructure.
- Completed containerization of K-West Basin floor and pit sludge into underwater containers in the K-West Basin.

- Processed, packaged, and removed remnants of spent nuclear fuel discovered during debris and sludge containerization activities in the K-West Basin, as well as spent nuclear fuel found during remediation of other Hanford Site waste sites, into multi-canister overpacks for drying at the Cold Vacuuming Drying Facility and subsequent shipment to the Canister Storage Building for interim storage.
- Prepared a data quality objectives and sampling and analysis plan for the characterization of containerized sludge stored underwater in the K-West Basin (KBC-33786).
- Initiated containerized sludge sampling and shipment to the 325 Facility for analysis.
- Conducted a comprehensive analysis of alternative scenarios to coordinate the removal, treatment, and temporary storage of K-West Basin sludge.
- Initiated system and component testing associated with the retrieval and handling of sludge at Hanford's Maintenance and Storage Facility in the 400 Area (e.g., the system that will be used to retrieve settler tube sludge and place it into underwater containers).
- Completed a feasibility study for managing knock-out pot sludge using similar methods as used for spent nuclear fuel (KBC-38156, Rev. 0).
- Initiated inspection of knock-out pot sludge to ascertain its physical properties to aid in its removal and disposition using similar methods as used for spent nuclear fuel.

### 6.2.2.3 DOE Richland Operations Office Progress on Defense Nuclear Facilities Safety Board Recommendations

#### SM Hahn

During 2008, the DOE Richland Operations Office made progress on recommendations from the Defense Nuclear Facilities Safety Board.

Defense Nuclear Facilities Safety Board Recommendation 2000-1 (DNFSB 2000) has one remaining open commitment related to K Basins: complete the removal of containerized sludge from the K-West Basin and treat it to meet

applicable waste acceptance criteria by November 30, 2009. Due to the technical complexity and characterization of the material, this date will not be met and a new date has not been established.

The DOE Richland Operations Office completed the following Defense Nuclear Facilities Safety Board commitments during 2008:

- Completed K-West Basin final pass vacuuming
- Completed processing and shipment of all fuel scrap and found fuel from the K-West Basin in September 2008. Recovered found fuel and fuel scrap were loaded into a multi-canister overpack, dried, and transferred to the Canister Storage Building for safe, dry, storage in a below-grade concrete vault.
- Delivered a video briefing to the Defense Nuclear Facilities Safety Board on December 4, 2008, which completed a letter commitment requiring a briefing in response to electrical safety concerns at the Plutonium Finishing Plant.

Additional progress by the DOE Richland Operations Office to Defense Nuclear Facilities Safety Board recommendations included the following in 2008:

- Established a new testing capability, through the Sludge Treatment Project, for sludge treatment at the Maintenance and Storage Facility.
- Selected the K Basin sludge treatment process in December 2008.
- Completed recommended actions to install a raised non-combustible cover over the electrical equipment cabinet in Building 251-E at the A-6 Electrical Substation, which was designed to prevent entry of fire suppression water into the cabinet.
- Supported DOE's response to the Defense Nuclear Facilities Safety Board's letter, dated March 17, 2008, stating its concerns over the high rejection rates of high-efficiency particulate air filters. DOE Richland Operations Office's subject matter expert is providing support to develop and implement a DOE-Health Safety and Security Action Plan to address these concerns.
- Performed major assessments of nuclear facilities' vital safety systems and verified these systems can and will continue to be able to perform their safety functions.

#### 6.2.2.4 Revegetation of Washington Closure Hanford, LLC's Remediated Waste Sites in the 100 Areas

AL Johnson

Washington Closure Hanford, LLC's Field Remediation Project revegetated several remediated and backfilled waste sites in the 100-F Area and the 100-IU-6 Operable Unit in November and December 2008. The revegetation project planted native grass seed, sagebrush, bitterbrush, and hopsage seedlings over nearly 20 hectares (50 acres).

#### 6.2.3 Remediation of Waste Sites in the 300 Area

DE Faulk, S Parnell, and AK Smet

Full scale remediation work began in the 300 Area in 1997 and focused on the 300-FF-1 Operable Unit waste sites and several 300-FF-2 Operable Unit waste sites. Remediation of the 300-FF-1 Operable Unit waste sites was completed in February 2004, including backfill and revegetation. Remediation activities in 2008 focused on the 300-FF-2 Operable Unit waste sites. The 300-FF-2 Operable Unit record of decision (EPA/ROD/R10-01/119) authorized remediation activities for the 300-FF-2 Operable Unit, which began in September 2002. Remediation activities included sampling to determine if suspected waste sites exceeded cleanup objectives; sampling to confirm that cleanup objectives were met; conducting physical excavation operations; sorting and segregating waste; sampling, treating, and disposing of waste; and backfilling and revegetating affected sites. Waste generated from cleanup of these waste sites is disposed at the Hanford Site's Environmental Restoration Disposal Facility located on the Central Plateau and other EPA-approved disposal facilities. The Environmental Restoration Disposal Facility is discussed in Section 6.4.3.6.

Waste burial grounds require cleanup but also present a significant health and safety risk to workers as a result of incomplete waste disposal records and the potential for discovering unknown material from past disposal practices. This unknown material may require further characterization, which is critical to ensure worker safety and proper management of waste for potential treatment and disposal.

Discovery of unknown material requires additional time and planning to ensure proper protective gear is utilized in the field when characterizing the material, and to verify that limits and controls identified in approved work authorization documents (as required by DOE) are adequate for the work scope. If work authorization documents do not adequately cover the material discovered, work is stopped until the documents can be revised and work can be safely restarted. Based on the characterization results, additional waste treatment may be required before disposal.

More than 163,000 metric tons (180,000 tons) of contaminated soil from the 300-FF-2 Operable Unit was disposed of at the Environmental Restoration Disposal Facility in 2008. Approximately 800 barrels, vessels, and small containers were also excavated. These wastes were treated before disposal at the Environmental Restoration Disposal Facility or were treated at offsite facilities before disposal at the Environmental Restoration Disposal Facility. No waste was shipped to the Waste Isolation Pilot Plant in New Mexico.

The 618-7 Burial Ground, located west of the 300 Area, operated from 1960 to 1973 and was remediated in 2008. Remediation of the 618-1 Burial Ground, located in the northern 300 Area and operated from 1945 to 1951, began in September 2008 and will be completed in 2009.

The 618-10 Burial Ground, located just west of Route 4 South, operated from 1954 to 1963 and is approximately 2.1 hectares (5.2 acres) in size. The 618-11 Burial Ground, located close to the Energy Northwest nuclear power plant, operated from 1962 to 1967 and is approximately 3.5 hectares (8.6 acres) in size. Both burial grounds received waste, including transuranic material, from the 300 Area laboratory facilities. The burial grounds consist of multiple trenches, vertical pipe units, and caissons. Significant challenges for remediation are present at the 618-10 and 618-11 Burial Grounds. In August 2005, responsibility for remediation of these two burial grounds was transferred from Fluor Hanford, Inc. to Washington Closure Hanford, LLC. After the transfer, Washington Closure Hanford, LLC developed a design solution for the burial grounds, which included evaluating waste removal, packaging technologies, and disposal pathways to determine the most cost-effective methods; the design solution was then submitted to DOE on December 31, 2006. DOE evaluated the design solution and determined characterization was needed prior to proceeding with remediation. Washington Closure Hanford, LLC prepared a sampling and analysis plan in 2008 to address non-intrusive characterization of the 618-10 and 618-11 Burial Grounds (DOE/RL-2008-27, Draft A). Non-intrusive characterization field activities are planned to begin in 2009.





## 6.3 Facility Deactivation and Decommissioning Activities

This section provides information regarding the transition of Hanford Site facilities from stabilization, surveillance and maintenance, to eventual decommissioning. Decommissioning activities include the interim safe storage of plutonium production reactors; and deactivation and decommissioning facilities in the 100, 200, 300, and 400 Areas and ancillary reactor facilities.

### 6.3.1 Facility Decommissioning on the Central Plateau

This section provides information about the transition and decommissioning of facilities on the Central Plateau.

#### 6.3.1.1 Plutonium Finishing Plant WG Cox

During 1949, the Plutonium Finishing Plant began processing plutonium nitrate solutions into metallic plutonium for shipment to nuclear weapons-production facilities. Operation of this plant continued into the late 1980s. In 1990, DOE issued a shutdown order for the Plutonium Finishing Plant and in 1996, authorized deactivation and transition of the plutonium-processing portions of the facility in preparation for decommissioning.

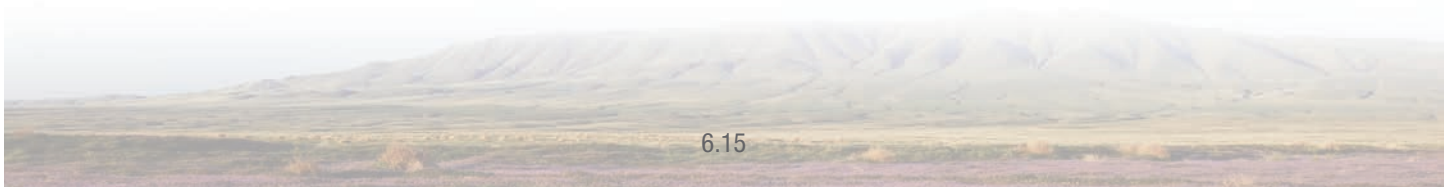
In 2004, Fluor Hanford, Inc. workers at the Plutonium Finishing Plant complex completed a large and multifaceted effort to stabilize, immobilize, repackage, and/or properly dispose of nearly 18 metric tons (19.8 tons) of plutonium-bearing materials in the plant. Workers then focused on decontaminating and deactivating the processing facilities,

while still providing for the safe and secure storage of nuclear materials until final disposition.

In 2008, the Plateau Remediation Contract, which includes the Plutonium Finishing Plant, was awarded to CH2M HILL Plateau Remediation Company.

Significant accomplishments achieved by Fluor Hanford, Inc. and CH2M HILL Plateau Remediation Company at the Plutonium Finishing Plant during 2008 included the following:

- Cleaned out contaminated equipment from two major plutonium-processing gloveboxes and four “hoods” (open-faced enclosures used for working with plutonium). Four gloveboxes and four hoods were also removed from the main Plutonium Finishing Plant process building for disposal at the Environmental Restoration Disposal Facility.
- Completed opening, draining, and blanking the B-acid (hydrofluoric acid) lines throughout the main Plutonium Finishing Plant process building.
- Completed integration of 216-Z-9 Trench removal actions with 200-PW-1 Remedial Action Milestone M-83-41 negotiations (Tri-Party Agreement [Ecology et al. 1989]).
- Completed required leak testing of plutonium shipping containers.
- Achieved significant progress on plutonium de-inventory, including start of shipments to the Savannah River Site in South Carolina.



### 6.3.1.2 Surveillance, Maintenance, and Deactivation Activities on the Central Plateau and on the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit

GJ LeBaron

Disposition of Central Plateau facilities includes the surveillance, maintenance, and deactivation of buildings and waste sites in the 200-East, 200-West, and 200-North Areas, and on the Fitzner/Eberhardt Arid Lands Ecology Reserve. Facilities include interim-status RCRA treatment, storage, and disposal units awaiting closure; the canyon facilities (Plutonium Uranium Extraction [PUREX] Plant, B Plant, Reduction-Oxidation [REDOX] Plant, and U Plant); three operating major air emission stacks; and two operating minor emission stacks.

Surveillance, maintenance, and decontamination or stabilization of over 500 waste sites continued in 2008, including former waste disposal cribs, ponds, ditches, trenches, unplanned release sites, and waste burial grounds. Periodic surveillances, radiation surveys, and pesticide and herbicide applications were performed at these sites, as well as at buildings on the Fitzner/Eberhardt Arid Lands Ecology Reserve, and timely responses to identified problems were initiated. The overall objective was to maintain these sites in safe and stable configurations and prevent contaminants at these sites from spreading in the environment.

Facilities and waste sites are remediated as funding is available and in accordance with requirements and agreements with the regulatory agencies.

### 6.3.1.3 Investigation of the Potential for Using the Central Plateau Chemical Separations Plants as Waste Disposal Facilities

CB Walker

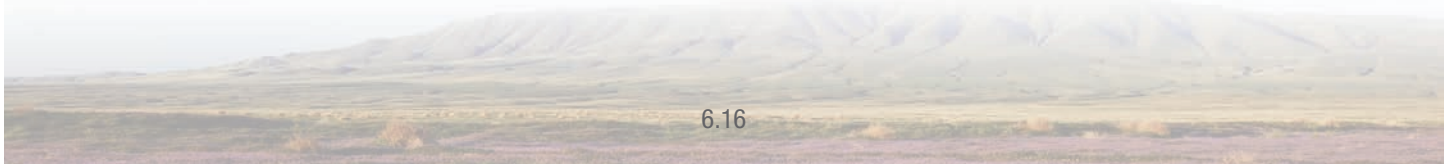
The Canyon Disposition Initiative was created to investigate the potential for using the five canyon buildings (B Plant, T Plant, U Plant, Plutonium Uranium Extraction [PUREX] Plant, and Reduction-Oxidation [REDOX] Plant)

on the Hanford Site as disposal facilities for Hanford Site remediation waste, rather than demolishing the structures. The U Plant was selected as the pilot project for the Canyon Disposition Initiative. The remaining canyon buildings are to be addressed on a case-by-case basis, building on previous canyon disposition work.

Planning and sampling activities to support preparation of a CERCLA feasibility study for implementation of the Canyon Disposition Initiative at U Plant began in the mid-1990s. In December 2004, the Canyon Disposition Initiative (221-U Facility) final feasibility study (DOE/RL-2001-11, Rev. 1) and the associated proposed plan (DOE/RL-2001-29, Rev. 0) were released for public review. These documents examine five alternatives for remediation of the 221-U Facility: 1) no action, 2) full removal and disposal, 3) entombment with internal waste disposal, 4) entombment with internal and external waste disposal, and 5) close in place-collapsed structure. In fall 2005, the EPA issued the 221-U Facility (Canyon Disposition Initiative) record of decision (DOE et al. 2005), selecting the close in place-collapsed structure alternative. In accordance with the record of decision, process equipment already in the plant will be consolidated into the belowground plant process cells; the cells, galleries, and other void spaces will be back-filled with grout; the exterior walls and roof will be collapsed in place; and the site will be covered with a barrier.

In December 2006, DOE issued the first draft of the *Remedial Design/Remedial Action Work Plan for the 221-U Facility* for review by the regulatory agencies; final approval was achieved in December 2008 (DOE/RL-2006-21, Draft B). Several engineering studies to support remedial activities were issued in May and June 2007 (HNF-34169, D&D-33945, D&D-33637, and D&D-33135). In addition, a report titled *Project Experience Report, Canyon Disposition Initiative (221-U Facility)* was completed in January 2008 (D&D-35827).

Current plans do not include waste importation as part of U Plant remedial actions. While U Plant remediation is a prototype for the remaining canyon buildings, remedial action decisions will be reached independently for each of the remaining canyon buildings, taking into account each building's significant differences.



## 6.3.2 Decommissioning of 300 Area Facilities

### CP Strand

During 2008, deactivation, decontamination, decommissioning, and demolition activities in the 300 Area continued to focus on removing physical barriers to performing remedial actions in the 300-FF-2 Operable Unit. These activities were conducted as non-time critical removal actions under CERCLA in accordance with *Memorandum #1 for the 300 Area Facilities* (DOE and EPA 2005) and *Memorandum #3 for the 300 Area Facilities* (DOE and EPA 2006b). Additionally, *Memorandum #2 for the 300 Area Facilities* (DOE and EPA 2006a) issued in 2006, authorized deactivation, decontamination, decommissioning, and demolition activities for the 324 and 327 Facility complexes.

The following 300 Area buildings were demolished during 2008:

- 384 Power House
- 3128 Gas Bottle Dock
- 3503A Building
- 3718 Storage Building
- 3718A Lab Equipment Central Pool Building
- 3718B Storage Building
- 3718C Storage Building
- 3718E Storage Building
- 3718G Storage Building
- 3718N Insulation Shop
- 3721 Classified Shredder Facility
- 3727 Classified Vault
- 3728 Geotechnical High-Bay
- Mobile Office MO-036
- Mobile Office MO-741.

Facility deactivation, characterization, and demolition planning is ongoing for many other buildings located in the 300 Area.

## 6.3.3 Deactivation of 400 Area Facilities

### LE Harville

The Fast Flux Test Facility is a DOE-owned, formerly operating 400-megawatt (thermal) liquid-metal cooled (sodium) research and test reactor located at the 400 Area on the Hanford Site. Built in the late 1970s, the original purpose of the facility was to develop and test advanced fuels and materials for the Liquid Metal Fast Breeder Reactor Program, and to serve as a prototype facility for future Liquid Metal Fast Breeder Reactor Program facilities; other missions were subsequently pursued. The Fast Flux Test Facility operated from April 1982 to April 1992 and provided the nuclear industry with significant advances in fuel performance, medical isotope production, material performance, and passive and active safety systems testing. The reactor was placed in a standby mode in December 1993. After multiple studies, a final decision was made to complete facility deactivation, including removing all nuclear fuel, draining the sodium systems, and deactivating systems and equipment to place the facility in a low-cost, long-term surveillance and maintenance condition by September 2009.

During 2008, all fuel was removed from the 400 Area Property Protected Area. Three empty interim storage casks used to store fuel assemblies remain in storage at the 400 Area Interim Storage Area. One disposable solid waste cask was shipped to the Environmental Restoration Disposal Facility, and two others are stored in the 400 Area Interim Storage Area awaiting shipment in 2009.

Draining of bulk-liquid sodium metal from the Fast Flux Test Facility was completed in 2006. One hundred and nine core component pots (tubes used to move core components between the interim-decay storage vessel and the interim examination and maintenance cell) were removed from the interim-decay storage vessel and placed in two storage boxes. Each storage box contains about 757 liters (200 gallons) of contaminated sodium. Removal of the core component pots allowed the remaining sodium in the interim-decay storage vessel to be successfully drained and transferred to the Sodium Storage Facility. This sodium will be converted to sodium hydroxide for later use by the DOE Office of River

Protection (i.e., Hanford Tank Waste Treatment and Immobilization Plant). The remaining residual sodium will be converted to sodium hydroxide at the Fast Flux Test Facility or removed during decommissioning.

The storage boxes containing contaminated sodium were declared mixed waste in late 2006, requiring the establishment of a RCRA storage unit. An application for a RCRA treatment, storage, and disposal container storage area, designated as the 400 Waste Management Unit, was submitted to DOE in November 2006. The Washington State Department of Ecology issued a RCRA permit for mixed waste container storage for greater than 90 days (effective November 2007), which authorized storage of mixed waste in the Fuel Storage Facility (Building 403), which already contained mixed waste, and in the 400 Area Interim Storage Area (Building 4718), where mixed waste was placed in 2008.

Four PCB-laden transformers were shipped for disposal in 2008. One PCB transformer remains in the 400 Area and is scheduled for removal and disposal in 2009. Other deactivation activities continued during 2008. The shutdown of operating systems (electric, fire suppression, water, ventilation, etc.) and cleanout and closure of the reactor containment building and supporting facilities will continue into 2009, culminating in a long-term, low-cost surveillance and maintenance condition. Final decommissioning depends on ongoing environmental impact statement activities for waste management and tank farms. The resultant record of decision will determine the final end-state for the Fast Flux Test Facility.

## 6.3.4 Decommissioning of Facilities in the 100 Areas

### RL Cathel

During 2008, 100 Areas deactivation, decontamination, decommissioning, and demolition activities focused on the 100-N Area. These activities were conducted as non-time critical removal actions under CERCLA. The following 100-N Area buildings were demolished during 2008:

- 11-N and 13-N
- 105-NB
- Explosive demolition of the 116-N air stack
- 163-N
- 183-N, 183-NA, 183-NB, 183-NC, and 183-ND
- 184-N, 184-NA, 184-NB, 184-NC, 184-ND, 184-NE, and 184-NF, including explosive demolition of the 184-N stack to support demolition activities
- 1330-N
- 1524-N and 1525-N
- 1705-N, 1705-NA, and 1705-NB (below-grade)
- 1706-N
- 1712-N
- 1714-N, 1714-NA, and 1714-NB.

Additional actions completed in 2008 included 105-B Reactor roof repairs, and the demolition of the 1802-N Pipe Trestle (initiated in 2005), which extended between the 109-N Building and the 185-N Building.





## 6.4 Waste Management Operations

This section provides information regarding liquid and solid waste management at the Hanford Site.

### 6.4.1 Waste Classifications

WE Toebe and JO Skolrud

Hanford Site cleanup operations result in the generation of solid wastes that must be evaluated for proper management. Solid wastes are reviewed against procedures in WAC 173-303-070(3) and are classified as dangerous when the criteria for this classification are met. The radionuclides in solid waste are exempt from evaluation under WAC 173-303-070(3), but are subject to evaluation and categorization as transuranic, high-level, or low-level under the *Atomic Energy Act of 1954*. Wastes that contain constituents regulated under both WAC 173-303 and the *Atomic Energy Act of 1954* are classified as mixed wastes.

Radioactive and/or mixed wastes are currently handled in several ways. High-level waste is stored in large underground single- and double-shell tanks, as well as in capsules. Low-level waste is typically stored in either tanks or containers. The method used to store low-level waste depends on the source, composition, and waste concentration. Transuranic waste is stored in vaults or on aboveground storage pads, or stored in a manner to allow its retrieval. An annual report lists the dangerous and mixed wastes that are generated, treated, and disposed of onsite or shipped offsite (DOE/RL-2009-08, Rev. 0). Dangerous and mixed wastes are treated, stored, and prepared for disposal at several Hanford Site facilities. Dangerous waste generated at the site is also shipped offsite for treatment and/or disposal. Some types of dangerous waste, such as used lead-acid batteries and aerosol products (e.g., spray paint), are shipped offsite for recycling.

Waste that does not contain hazardous or radioactive substances is non-regulated waste. Non-regulated waste generated at the Hanford Site was historically disposed of on the Hanford Site. Beginning in 1999, non-regulated waste including refuse, asbestos-containing waste, and drummed non-hazardous waste has been disposed of at municipal or commercial solid waste disposal facilities. Since 1996, medical waste has been shipped to a commercial medical waste treatment and disposal facility. Non-regulated waste originates at several areas across the Hanford Site. Examples include construction debris, office trash, cafeteria waste, and packaging materials. Other materials and items classified as non-dangerous waste are solidified filter backwash and sludge from the treatment of Columbia River water, failed and broken equipment and tools, air filters, uncontaminated used gloves and other clothing, and certain chemical precipitates (such as oxalates). Non-regulated demolition waste from 100 Areas decommissioning projects is buried in situ or in designated disposal locations on the Hanford Site.

DOE issued a formal determination in 2008 regarding radioactive waste classifications for various Hanford Site tank waste streams. The determination implements provisions of DOE Manual 435.1-1, "Radioactive Waste Management Manual," related to management of radioactive waste resulting from or associated with reprocessing spent nuclear fuel.

### 6.4.2 Solid Waste Inventories

N Weston

The Solid Waste Information Tracking System is a computer database used to track a portion of mixed and radioactive waste at the Hanford Site primarily non-CERCLA containerized waste, managed by CH2M HILL Plateau

Remediation Company, Fluor Hanford, Inc., and Washington River Protection Solutions, LLC. The database does not include all waste from the Environmental Restoration Disposal Facility or any Pacific Northwest National Laboratory wastes. The database also does not include high-level radioactive waste volumes managed at Hanford Site tank farms.

Quantities for both mixed and radioactive wastes generated onsite or received from offsite sources and disposed of at the Hanford Site from 2004 through 2008, as tracked by the Solid Waste Information Tracking System database, are shown in Tables 6.4.1 and 6.4.2. Quantities of dangerous waste shipped offsite from 2004 through 2008, as tracked by the database, are shown in Table 6.4.3. Hanford Site solid waste management is discussed in Section 6.4.3.

### 6.4.3 Solid Waste Management

Solid waste management includes the treatment, storage, and/or disposal of solid waste produced as a result of Hanford Site operations, or received from offsite sources authorized

by DOE to ship waste to the site. The following sections describe specific waste treatment, storage, or disposal locations at the Hanford Site.

#### 6.4.3.1 Central Waste Complex BM Barnes

Waste is received at the Central Waste Complex, located in the 200-West Area, from sources on the Hanford Site and any offsite sources that are authorized by DOE to ship waste to the Hanford Site for treatment, storage, and disposal. Ongoing cleanup, research, and development activities at the Hanford Site generate most of the waste received at the Central Waste Complex. Offsite waste has been primarily from other DOE sites and U.S. Department of Defense facilities. Characteristics of waste received vary greatly, including low-level, transuranic, and mixed waste, and radioactively contaminated PCBs. The current volume of waste stored totals approximately 7,500 cubic meters (265,000 cubic feet).

**Table 6.4.1. Quantities of Solid Waste<sup>(a)</sup> Generated on the Hanford Site, 2004 Through 2008, kg (tons)**

<u>Waste Category</u>	<u>2004</u>	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>
Mixed	144,512 (159)	349,416 (385)	315,188 (347)	235,378 (259)	313,513 (346)
Radioactive	906,591 (999)	1,188,212 (1,310)	465,340 (513)	299,701 (330)	361,370 (398)

(a) Solid waste includes containerized liquid waste.

**Table 6.4.2. Quantities of Solid Waste<sup>(a)</sup> Received on the Hanford Site from Offsite Sources, 2004 Through 2008, kg (tons)**

<u>Waste Category</u>	<u>2004</u>	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>
Mixed	255,690 <sup>(b)</sup> (282)	190,020 <sup>(b)</sup> (209)	152,487 <sup>(b)</sup> (168)	176,647 <sup>(b)</sup> (195)	416,309 <sup>(b)</sup> (459)
Radioactive	519,609 (573)	83,123 (92)	71,244 (79)	167,947 (185)	403,659 (445)

(a) Solid waste includes containerized liquid waste. Solid waste quantities do not include U.S. Navy reactor compartments.

(b) Total includes Hanford Site-generated waste treated by an offsite contractor and returned as newly generated waste.

**Table 6.4.3. Quantities of Dangerous Waste<sup>(a)</sup> Shipped Off the Hanford Site, 2004 Through 2008, kg (tons)**

<b>Waste Category</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>
Containerized	75,296 <sup>(b)</sup> (83)	71,601 <sup>(b)</sup> (79)	18,700 <sup>(b)</sup> (21)	47,979 <sup>(b)</sup> (53)	115,764 <sup>(b)</sup> (128)
	49,560 <sup>(c)</sup> (55)	61,422 <sup>(c)</sup> (68)	33,285 <sup>(c)</sup> (37)	35,146 <sup>(c)</sup> (39)	50,852 <sup>(c)</sup> (56)
Bulk Solids	0	0	0	0	0
Bulk Liquids	35,057 (39)	49,154 (54)	917 (1)	96,653 (107)	200,640 (221)
<b>Total</b>	159,913 (176)	182,177 (201)	52,902 (58)	179,778 (198)	367,256 (405)

(a) Does not include *Toxic Substances Control Act* waste.

(b) Dangerous waste only.

(c) Mixed waste (radioactive and dangerous).

The Central Waste Complex can store as much as 20,800 cubic meters (735,000 cubic feet) of low-level mixed waste and transuranic waste. This capacity is adequate to store the projected volumes of low-level, transuranic, and mixed waste, and radioactively contaminated PCBs to be generated from the activities identified above, assuming on-schedule treatment of the stored waste. Treatment will reduce the amount of waste in storage and make room for newly generated mixed waste. The dangerous waste designation for each container is established at the point of origin based on process knowledge or sample analysis.

### 6.4.3.2 Waste Receiving and Processing Facility

#### HC Boynton

Waste destined for the Waste Receiving and Processing Facility includes stored waste as well as newly generated waste from current Hanford Site cleanup activities. The waste consists primarily of contaminated cloth, paper, rubber, metal, and plastic. Processed waste that qualifies as low-level radioactive waste and meets disposal requirements is buried onsite. Low-level radioactive waste not meeting burial requirements is processed in the facility for onsite burial or prepared for future treatment at other onsite or offsite treatment, storage, and disposal facilities. Waste determined at the facility to be transuranic is certified and

packaged for shipment to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, for permanent disposal. Other materials requiring further processing to meet disposal criteria are retained, pending treatment.

The Waste Receiving and Processing Facility, which began operating in 1997, analyzes, characterizes, and prepares drums and boxes of waste for disposal. The 4,800-square-meter (52,000-square-foot) facility, along with two 2,000-square-meter (21,500-square-foot) storage buildings, is located north of the Central Waste Complex on the Central Plateau. The facility dispositioned and shipped 515 cubic meters (18,200 cubic feet) of waste offsite during 2008.

### 6.4.3.3 T Plant Complex

#### PW Martin

The T Plant Complex, located in the 200-West Area, provides waste treatment, storage, and decontamination services for the Hanford Site as well as for offsite facilities. The T Plant Complex currently operates under RCRA interim status. The following activities occurred at the T Plant Complex in 2008:

- Numerous containers and boxes of waste were sampled, characterized, treated, and repackaged to meet waste acceptance criteria and land-disposal restrictions requirements.

- One thousand five hundred and twenty-eight 208-liter (55-gallon) drum equivalents of transuranic waste were repackaged to meet offsite waste acceptance criteria and eventual disposal at the Waste Isolation Pilot Plant in Carlsbad, New Mexico.
- Construction of a roof addition to the 221-T Canyon Building began in December 2007 and was completed in February 2008. The metal roof addition covers the existing flat asphalt roof and is similar in design to the roof additions on the B Plant and Plutonium Uranium Extraction (PUREX) Canyon Buildings.
- Construction of a cover over an existing outside waste storage area at the T Plant Complex began in November 2007 and was completed in February 2008. The roof provides weather protection to workers and waste containers.
- A super-compactor, installed in the 221-T Canyon in March 2007 to crush empty waste containers to conserve landfill space in the onsite disposal units, crushed 1,028 empty containers in 2008.
- In July 2008, cleanup of an excess storage area (Bone Yard) at T Plant resulted in recycling 15,200 kilograms (33,580 pounds) of metallic material and disposal of 61 cubic meters (2,150 cubic feet) of non-metallic material.
- Drafting of the T Plant RCRA Part B permit application for final status began in June 2008. Review, approval, and issuance by the Washington Department of Ecology are expected in 2009.

#### 6.4.3.4 Mixed Low-Level Waste Treatment and Disposal Facility

DE Nester

On a pretreatment volume basis, 816 cubic meters (28,800 cubic feet) of mixed low-level waste were treated and/or directly disposed of during 2008.

- Seven hundred and forty-four cubic meters (26,300 cubic feet) of mixed low-level waste, or approximately 3,577 drum equivalents (based on a standard 208-liter [55-gallon] drum), were shipped from the

Hanford Site and non-thermally treated to RCRA land-disposal restriction standards by offsite commercial waste processors. The treated waste was returned to the Hanford Site and disposed at the Mixed Waste Disposal Facility and the Environmental Restoration Disposal Facility. This waste contributed toward Tri-Party Agreement Milestone M-91-42(E) (Ecology et al. 1989).

- Seventy-two cubic meters (2,540 cubic feet) of mixed low-level waste, or approximately 346 drum equivalents, was shipped from the Hanford Site and thermally treated to RCRA land-disposal restriction standards by offsite commercial waste processors. The treated waste was returned to the Hanford Site and disposed of in Trenches 31 and 34 at the Radioactive Mixed Waste Disposal Facility. This waste contributed toward Tri-Party Agreement Milestone M-91-42(E) (Ecology et al. 1989).

The treated waste residues resulting from waste treatment were disposed of at the Hanford Site Mixed Waste Disposal Facility. Waste volumes contributed to the successful completion of Tri-Party Agreement Milestones M-91-43(C) on September 2, 2008, and M-91-42(E) on December 31, 2008 (Ecology et al. 1989).

#### 6.4.3.5 Disposal of U.S. Navy Reactor Compartments

SG Arnold

In 2008, a defueled U.S. Navy reactor compartment was received and placed in Trench 94 of the 218-E-12B Burial Ground, bringing the total number of reactor compartments received to 118. All U.S. Navy reactor compartments shipped to the Hanford Site for disposal originated from decommissioned nuclear-powered submarines or cruisers. Decommissioned submarine reactor compartments are approximately 10 meters (33 feet) in diameter, 14.3 meters (47 feet) long, and weigh between 900 and 1,400 metric tons (1,000 and 1,500 tons). Decommissioned cruiser reactor compartments are approximately 10 meters (33 feet) in diameter, 12.8 meters (42 feet) high, and weigh approximately 1,362 metric tons (1,500 tons).



### 6.4.3.6 Environmental Restoration Disposal Facility

#### MA Casbon

The Environmental Restoration Disposal Facility is located near the 200-West Area. The facility began operations in July 1996 and serves as the central disposal site for contaminated waste removed during Hanford Site cleanup operations conducted under CERCLA regulations. To provide a barrier to prevent contaminant migration from the inground facility, the Environmental Restoration Disposal Facility was constructed to RCRA Subtitle C minimum technology requirements, which includes a double liner and leachate collection system (40 CFR 264.301). Remediation waste disposed in the facility includes soil, rubble, or other solid waste materials contaminated with hazardous, low-level radioactive, or mixed (combined hazardous and radioactive) low-level waste.

There are currently six waste cells within the Environmental Restoration Disposal Facility. Initially, cells 1 and 2 were constructed and waste placement in these cells is nearly complete. Interim covers have been placed over a portion of cells 1 and 2. Cells 3 and 4 have reached their operational capacity. Cells 5 and 6 began receiving waste in January 2005. Construction of cells 7 and 8 started in 2008 and are nearing completion; the cells will begin receiving waste in 2009. All eight cells are roughly equal in size, each holding approximately 1.27 metric tons (1.4 million tons) or approximately 610,000 cubic meters (21.5 million cubic feet).

In 2008, approximately 642,800 metric tons (708,600 tons) of remediation waste were disposed at the Environmental Restoration Disposal Facility. Approximately 7.2 million metric tons (7.9 million tons) of remediation waste have been placed in the facility from initial operations startup through 2008. The total available expansion area was authorized in a 1995 record of decision (EPA/ROD/R10-95/100) to cover as much as 4.1 square kilometers (1.6 square miles).

### 6.4.3.7 Radioactive Mixed Waste Disposal Facility

#### DE Nester

The Radioactive Mixed Waste Disposal Facility, located in the 218-W-5 Low-Level Waste Burial Ground in the 200-West Area, is designated as Trenches 31 and 34. Trenches 31 and 34 are rectangular landfills, with approximate base dimensions of 76 by 30 meters (250 by 100 feet). The bottom of the excavation slopes slightly (nominally 1:3), giving a variable depth of 9 to 12 meters (30 to 40 feet). These trenches comply with RCRA requirements because they have double liners and systems to collect and remove leachate. The bottom and sides of the facilities are covered with a layer of soil 1 meter (3.3 feet) deep to protect the liner system during fill operations. There is a recessed section at the end of each excavation that houses a sump for leachate collection. Access to the bottom of each trench is provided by ramps along the perimeter walls.

These disposal units were originally designated for disposal of mixed low-level waste only; however, beginning in July 2004, disposal of low-level waste in unlined trenches ceased on the Hanford Site. Low-level waste is currently being disposed in Trenches 31 and 34.

Disposal in Trench 34 began in September 1999 and disposal in Trench 31 began in May 2005. Currently, there are approximately 4,130 cubic meters (14,600 cubic feet) of disposed waste in 4,041 waste packages in Trench 34. During summer 2004, the first operational layer of waste packages was covered with compacted gravel and soil. The second waste layer was started and continues to be filled; it is currently approximately half-filled.

Currently, there are approximately 2,670 cubic meters (94,300 cubic feet) of waste disposed in 2,197 waste packages in Trench 31. Disposal is taking place on the first operational layer (i.e., the base level) and is approximately half-filled.

The current combined packaged waste volume in Trenches 31 and 34 is 6,800 cubic meters (240,000 cubic feet); however, some of the waste in these trenches has



been radiologically stabilized in grout monoliths, which uses additional disposal space. Taking these monoliths into account, the current realized disposal volume (i.e., trench space utilization) in Trenches 31 and 34 is approximately 7,600 cubic meters (268,000 cubic feet).

#### 6.4.3.8 Low-Level Burial Grounds

##### BM Barnes

The low-level burial grounds consist of eight burial grounds located in the 200-East and 200-West Areas. Two of these burial grounds are used for the disposal of low-level waste and mixed waste (i.e., low-level radioactive waste with a dangerous waste component regulated by WAC 173-303). Seven burial grounds were previously used for disposal of low-level waste. Transuranic wastes were placed in retrievable storage in four of these burial grounds; one burial ground (218-W-6) was never used. The low-level burial grounds have been permitted under a RCRA Part A permit since 1985.

Three trenches receive mixed waste regulated by WAC 173-303. Trenches 31 and 34 in the 218-W-5 Burial Ground are lined trenches with leachate collection and removal systems (Sections 6.4.3.4 and 6.4.3.7). Trench 94 in the 218-E-12B Burial Ground is used for disposal of defueled U.S. Navy reactor compartments (Section 6.4.3.5). Low-level waste and transuranic waste have been placed in the other burial grounds. Transuranic waste has not been placed in the low-level burial grounds without specific DOE approval since August 19, 1987. The transuranic waste was placed in a manner that allows for retrieval and/or removal in the future.

On June 23, 2004, DOE issued a record of decision (69 FR 39449-39456) for the Solid Waste Program on the Hanford Site. Part of the record of decision stated that the DOE will dispose of low-level waste in lined disposal facilities. Only two of the low-level burial ground trenches are lined (Trenches 31 and 34); therefore, since that date, all low-level waste, as well as mixed low-level waste, is being placed in these two trenches. Disposal of U.S. Navy reactor compartments in the low-level burial grounds is not affected by this record of decision.

Retrieval of suspect-transuranic retrievably stored waste in the 218-W-4C Burial Ground was initiated in October

2003 in accordance with the Tri-Party Agreement (Change Number M-91-03-01 [Ecology et al. 1989]). Retrieval of suspect transuranic retrievably stored waste in the 218-W-4B Burial Ground was initiated in January 2007. Retrieval of suspect transuranic retrievably stored waste in the 218-W-3A Burial Ground was initiated in August 2007. Retrieval of suspect transuranic retrievably stored waste continues in accordance with Tri-Party Agreement Milestone M-91-40 (Ecology et al. 1989).

A draft revision to the RCRA Part B permit application for the low-level burial grounds was submitted to the Washington State Department of Ecology in June 2002. A new RCRA Part B permit application is expected to be submitted in 2009. Discussions between DOE and the state concerning the permit application are ongoing. In addition, the low-level burial grounds are included in a draft remedial investigation/feasibility study work plan (DOE/RL-2004-60, Draft B). The plan outlines possible characterization and remediation activities for specified landfills on the Hanford Site.

In January 2008, a new RCRA Part A permit was approved for the low-level burial grounds to allow for in-cell treatment of waste within Trenches 31 and 34 of the 218-W-5 Burial Ground. Waste will be treated to meet land-disposal restriction requirements. The treatment capability consists primarily of the use of immobilization technologies for mixed-waste debris.

#### 6.4.3.9 Integrated Disposal Facility

##### DG Horton

The Integrated Disposal Facility is currently not operational. Located in the south-central part of the 200-East Area, it is an expandable RCRA-compliant landfill (i.e., a double high-density polyethylene-lined trench with leachate collection and leak detection system). The landfill is divided lengthwise (north to south) into two distinct cells: the east cell for the disposal of low-level radioactive waste and the west cell for the disposal of mixed waste. The constructed liner is approximately 442 meters (1,450 feet) wide by 160 meters (525 feet) long and up to 15 meters (49 feet) deep. When it is put into use, the landfill will have four waste-container layers separated vertically by 0.9 meter (3 feet) of soil and the waste will be segregated into a

RCRA-permitted side and a non-RCRA-permitted side. The current waste disposal capacity is approximately 163,000 cubic meters (5.76 million cubic feet).

## 6.4.4 Liquid Waste Management

Facilities are operated on the Hanford Site to store, treat, and dispose of various types of liquid effluent generated by site cleanup activities. These facilities are operated and maintained in accordance with state and federal regulations and facility permits.

### 6.4.4.1 Liquid Effluent Retention Facility

KJ Lueck

The Liquid Effluent Retention Facility in the 200-East Area consists of three RCRA-compliant surface basins to temporarily store process condensate from the 242-A Evaporator and other aqueous waste. The Liquid Effluent Retention Facility provides for a steady flow and consistent pH of the feed to the Effluent Treatment Facility. Each basin has a maximum capacity of 29.5 million liters (7.8 million gallons). Generally, spare capacity is maintained in each basin in the event a leak should develop in an operating basin. Each basin is constructed of two flexible, high-density polyethylene membrane liners. A system is provided to detect, collect, and remove leachate from between the primary and secondary liners. Beneath the secondary liner is a soil and bentonite clay barrier, should both the primary and secondary liners fail. Each basin has a floating membrane cover constructed of very low-density polyethylene to keep out windblown soil and weeds, and to minimize evaporation of small amounts of organic compounds and tritium that may be present in the basin contents. The facility began operating in April 1994 and receives liquid waste from both RCRA- and CERCLA-regulated cleanup activities. Typically, RCRA and CERCLA wastewater were segregated in the surface basins and processed with different disposal destinations. However, in 2007, the Environmental Restoration Disposal Facility record of decision was amended to allow receipt of all RCRA and CERCLA waste (EPA 2007). Therefore, segregation of RCRA and CERCLA wastewater is currently no longer required.

The volume of wastewater received for interim storage in 2008 was approximately 65.1 million liters (17.2 million gallons). This included approximately 0.64 million liter (0.17 million gallon) of RCRA-regulated wastewater from 242-A Evaporator process condensate and approximately 3.52 million liters (0.93 million gallon) of CERCLA-regulated wastewater from Environmental Restoration Disposal Facility leachate. Contaminated groundwater from 200-UP-1 and 200-ZP-1 wells represented the majority of the wastewater received at the Liquid Effluent Retention Facility. Approximately 54.5 million liters (14.4 million gallons) of groundwater was received direct from the originating source via pipeline, as were the above mentioned waste streams. Approximately 6.44 million liters (1.7 million gallons) of wastewater were received from various facilities by tanker trucks that included approximately 3.8 million liters (1 million gallons) from K-East Basin dewatering activities. The wastewater volume transferred to the Effluent Treatment Facility for treatment and disposal in 2008 was 67.8 million liters (17.9 million gallons).

The volume of wastewater being stored in the Liquid Effluent Retention Facility at the end of 2008 was 52.6 million liters (13.9 million gallons).

### 6.4.4.2 Effluent Treatment Facility

KJ Lueck

The Effluent Treatment Facility, located in the 200-East Area, treats liquid effluent to remove toxic metals, radionuclides, and ammonia, and destroy organic compounds. The treatment process constitutes best available technology and includes pH adjustment, filtration, ultraviolet light and peroxide destruction of organic compounds, reverse osmosis to remove dissolved solids, and ion exchange to remove the last traces of contaminants. The facility began operating in December 1995 and has a maximum treatment capacity of 570 liters (150 gallons) per minute.

The treated effluent is stored in tanks, sampled and analyzed, and discharged via a dedicated pipeline to the State-Approved Land Disposal Site (also known as the 616-A Crib). This disposal site is located just north of the 200-West Area and is an underground drain field. The percolation rates for the field have been established by site testing and evaluation of soil characteristics. Tritium in the

liquid effluent from the Effluent Treatment Facility cannot be practically removed, and the location of the disposal site maximizes the time for migration of the tritium to the Columbia River to allow for radioactive decay (the half-life of tritium is 12.35 years).

The volume of wastewater treated and disposed of in 2008 was approximately 68 million liters (18 million gallons). This was primarily CERCLA-regulated wastewater (groundwater from the 200-UP-1 and 200-ZP-1 Operable Units in the 200-West Area and Environmental Restoration Disposal Facility leachate).

#### 6.4.4.3 200 Area Treated Effluent Disposal Facility

KJ Lueck

The 200 Area Treated Effluent Disposal Facility is a collection and disposal system for non-RCRA-permitted waste streams. The individual waste streams must be treated or otherwise comply with best available technology and all known available and reasonable treatment in accordance with "Submission of Plans and Reports for Construction of Wastewater Facilities" (WAC 173-240), which is the responsibility of the generating facility. The 200 Area Treated Effluent Disposal Facility consists of approximately 18 kilometers (11 miles) of buried pipelines connecting three pumping stations, the 6653 Building (known as the disposal sample station), and two 2-hectare (5-acre) disposal ponds located east of the 200-East Area. The facility began operating in April 1995 and has a capacity of 12,900 liters (3,400 gallons) per minute. The volume of unregulated effluent disposed of in 2008 was 276 million liters (73 million gallons). The major source of this effluent was uncontaminated cooling water and steam condensate from the 242-A Evaporator, with a variety of other uncontaminated waste streams received from other Hanford Site facilities.

#### 6.4.4.4 300 Area Treated Effluent Disposal Facility

DL Halgren

Industrial wastewater generated throughout the Hanford Site is collected and treated in the 300 Area Treated Effluent

Disposal Facility, which began operation in December 1994. The primary sources of the wastewater are laboratories, research facilities, and office buildings in the 300 Area. The wastewater consists of once-through cooling water, steam condensate, and other industrial wastewater. Potentially contaminated wastewater is collected in the nearby 307 Retention Basins where it is monitored and released to the 300 Area process sewer for treatment by the 300 Area Treated Effluent Disposal Facility.

This facility has a storage capacity of up to 5 days at the design flow rate of 1,100 liters (300 gallons) per minute. The treatment process includes iron co-precipitation to remove heavy metals, ion exchange to remove mercury, and ultra-violet light and hydrogen-peroxide oxidation to destroy organics and cyanide. The treated liquid effluent is monitored and discharged through an outfall to the Columbia River under a National Pollutant Discharge Elimination System permit. The volume of industrial wastewater treated and disposed of during 2008 was 161 million liters (42.4 million gallons).

#### 6.4.4.5 242-A Evaporator

TL Faust

The 242-A Evaporator in the 200-East Area concentrates dilute liquid tank waste by evaporation. This reduces the volume of liquid waste sent to double-shell waste storage tanks for storage and reduces the potential need for additional double-shell tanks. In 2008, no waste campaigns were processed through the 242-A Evaporator. The 242-A Evaporator completed a single cold run (raw water feed) as part of maintenance testing and personnel training. The volume of process condensate transferred to the Liquid Effluent Retention Facility for subsequent treatment in the Effluent Treatment Facility was 0.72 million liter (0.19 million gallon).





## 6.5 Underground Waste Storage Tanks

ME Cole

Most Hanford Site waste is stored in 149 large underground single-shell (single-walled) and 28 double-shell (double-walled) tanks located on the Central Plateau near the center of the site. A grouping of tanks is referred to as a farm. The 149 single-shell tanks were constructed in the late 1940s and early 1950s; 67 are assumed to have leaked in the past. Pumpable liquids in the single-shell tanks were transferred to the newer and safer double-shell tanks several years ago under the Interim Stabilization Program to help prevent additional environmental releases. The following sections summarize waste tank-related activities that occurred in 2008.

### 6.5.1 Waste Tank Status

ME Cole

This section provides information about the single-shell and double-shell tanks on the Hanford Site, and activities that

occurred in 2008 related to their operation and closure. Quantities of liquid waste generated in 2008 and stored in underground storage tanks are provided in the *Hanford Facility Annual Dangerous Waste Report Calendar Year 2008* (DOE/RL-2009-08, Rev. 0). Table 6.5.1 summarizes the liquid waste generated from 2003 through 2008 and stored in underground storage tanks.

#### 6.5.1.1 Single-Shell Tanks

ME Cole

The Tri-Party Agreement (Ecology et al. 1989) formally establishes a schedule for interim stabilization, retrieval, and closure of the Hanford Site Central Plateau waste-storage tanks. Interim stabilization of all but one tank (241-S-102) was achieved by transferring pumpable liquid from single-shell tanks to double-shell tanks to help prevent leaks to the environment.

**Table 6.5.1. Quantities of Liquid Waste<sup>(a)</sup> Generated and Stored Within the Tank Farm System on the Hanford Site During 2008 and the Previous 5 Years, 1,000 L (1,000 gal)**

Type of Waste	2003 <sup>(b)</sup>	2004	2005	2006	2007	2008
Volume of waste added to double-shell tanks	9,710 (2,565)	3,316 (876)	3,668 (969)	3,547 (937)	5,901 (1,559)	322 (85)
Total volume in double-shell tanks (year end)	92,693 (24,487)	95,275 (25,169)	98,943 (26,138)	101,411 (26,790)	101,052 (26,695)	101,366 (26,778)
Volume evaporated at 242-A Evaporator	4,720 (1,247)	734 (194)	707 (187)	1,052 (278)	4,500 (1,189)	0 (0)
Volume pumped from single-shell tanks	6,185 <sup>(c)</sup> (1,634) <sup>(c)</sup>	2,778 <sup>(c)</sup> (734) <sup>(c)</sup>	888 <sup>(c)</sup> (235) <sup>(c)</sup>	2,953 <sup>(d)</sup> (780) <sup>(d)</sup>	4,342 <sup>(d)</sup> (1,147) <sup>(d)</sup>	262 <sup>(d)</sup> (69) <sup>(d)</sup>

- (a) Quantity of liquid waste is defined as liquid waste sent to double-shell underground storage tanks during these years, rounded to the nearest 1,000. This does not include containerized (e.g., barreled) waste included in the solid waste category.
- (b) Quantity of liquid waste is defined as shown by different categories on left-hand side of table during these years. This does not include containerized (e.g., barreled) waste included in the solid waste category.
- (c) Volume does not include dilution or flush water.
- (d) Volume does include dilution or flush water.

The tank operations contractor attempted heel removal activities (removal of compacted sludge from the tank floor) on one single-shell tank during 2008 and began retrieval activities on another tank. The FoldTrack<sup>®(a)</sup> crawler vehicle, designed to facilitate heel removal, was placed into Tank 241-C-109 in June 2008 and operated for a short time before it failed. Tank 241-C-110 retrieval activities were started on September 22, 2008; approximately 29% of the 673,800 liters (178,000 gallons) initial waste volume was retrieved by September 24. Retrieval was temporarily halted on September 24 to perform equipment modifications on the receiving double-shell tank.

During 2008, approximately 262 thousand liters (69 thousand gallons) of radioactive and hazardous waste were removed from single-shell tanks to safer double-shell tanks (including water used in waste retrieval activities). The waste material contained an estimated 9.5 thousand curies (350 terabecquerels) of radioactivity. At the end of 2008, there were approximately 113 million liters (29.8 million gallons) of waste remaining in the single-shell tanks.

### 6.5.1.2 Vadose Zone Program

#### DA Myers and DL Parker

The Vadose Zone Program is responsible for implementing the Tank Farm RCRA Corrective Action Program through field characterization, laboratory analyses, technical analyses, risk assessment for past tank leaks, and installation of interim measures that will reduce the threat from contaminants until permanent solutions can be found. Results of vadose zone investigations and interim measures conducted during the last 10 years are documented in the *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas* (DOE/ORP-2008-01, Rev. 0).

In 2008, Vadose Zone Program workers completed the following activities: installed several direct-push boreholes for soil sampling and geophysical logging in the C and TY Tank Farms; completed surface geophysical surveys at Waste Management Area TX-TY; and performed a well-to-well geophysical survey of the SX Tank Farm. An interim surface barrier also was completed over a portion of the

241-T Tank Farm to reduce infiltration of precipitation through the remnants of the 1973 release from Tank T-106.

### Direct-Push Boreholes and Sampling

Direct-push technology, using the hydraulic hammer unit to evaluate subsurface contamination in the vadose zone, was deployed in two tank farms during 2008. Several direct-push boreholes were made in the C Tank Farm to investigate unplanned release sites associated with diversion boxes and pipelines in and adjacent to that farm. The hydraulic hammer unit was also deployed in the TY Tank Farm to assess the extent of contamination in support of a proposed interim barrier in that farm. TY Tank Farm sampling also occurred at eight locations identified from previous investigations as potentially contaminated areas or from historical records as having had tank leaks (RPP-RPT-38320).

### Surface Geophysical Exploration

Surface geophysical exploration a combination of surface-deployed geophysical techniques including pole-to-pole electrical resistivity, electro-magnetic induction, magnetic gradiometry, and ground-penetrating radar are used to help define the presence and distribution of buried infrastructure, so that those features may be considered during resistivity data analysis. The depth to which the resistivity measurements interrogate the subsurface is determined by the distance between electrode pairs (the farther apart, the deeper the interrogation). Because resistivity is an indirect measure of several subsurface phenomena (e.g., moisture distribution, saline contaminants, and soil texture), the greater the depth of interrogation, the lower the resolution of the analysis. During 2008, surface geophysical exploration was performed in Waste Management Area TX-TY (RPP-23752). In addition, a resistivity survey using drywells and adjacent groundwater monitoring wells was performed in support of a proposed interim barrier in the SX Tank Farm (RPP-RPT-38322).

### Interim Surface Barrier

In 1973, single-shell Tank T-106 leaked approximately 435,000 liters (115,000 gallons) of waste into the surrounding soil. Contamination from this leak is present in the

(a) FoldTrack<sup>®</sup> is manufactured by Non Entry Systems Ltd., Swansea, United Kingdom (United Kingdom Patent Application No: 0718573.9).

vadose zone beneath T Tank Farm. The T Tank Farm interim surface barrier, completed in March 2008, was installed to decrease infiltration of water through the contaminated area and thus decrease the potential for further contaminant migration, and to serve as a barrier demonstration project.

Effectiveness of the T Tank Farm interim surface barrier at reducing infiltration is assessed through a barrier monitoring program (PNNL-16538). Pre-barrier data were collected and a monitoring report for fiscal year 2007 was issued in January 2008 (PNNL-17306). Post-barrier data were compiled into a fiscal year 2008 monitoring report, issued in January 2009 (PNNL-18083). Barrier monitoring is ongoing.

### 6.5.1.3 Double-Shell Tanks

ME Cole

Tank farms contain 28 double-shell tanks with a storage capacity of approximately 126 million liters (33 million gallons), which store radioactive and chemical waste. The tanks were built between 1968 and 1986 and contain both liquids and settled solids from past nuclear operations, including waste transfers from older single-shell tanks. The storage space within the double-shell tank system is being managed to store waste pending treatment by the Hanford Tank Waste Treatment and Immobilization Plant or a supplemental treatment process, and includes emergency pumping space available at all times for 3.8 million liters (1 million gallons).

In 2008, the double-shell tank system integrity assessment report (RPP-28538, Rev. 5) was issued to perform a general update and to incorporate changes to *Hanford Double-Shell Tank Thermal and Seismic Project – Summary of Combined Thermal and Operating Loads with Seismic Analysis* (RPP-RPT-28968, Rev. 1). The RPP-28538, Rev. 5 report continues to define the double-shell tank system as fit-for-use.

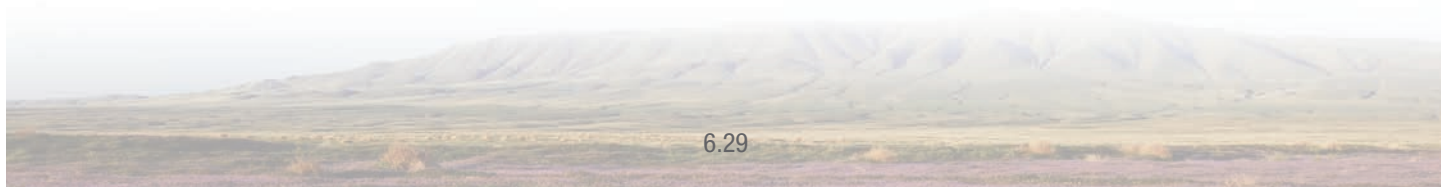
At the end of 2008, there were 101 million liters (26.7 million gallons) of waste in the double-shell tanks.

## 6.5.2 DOE Office of River Protection Progress on Defense Nuclear Facilities Safety Board Recommendations Regarding the Underground Waste Storage Tanks

LJ Croy

DOE, CH2M HILL Hanford Group, Inc., and Washington River Protection Solutions, LLC staff met with and provided information to Defense Nuclear Facilities Safety Board and technical staff throughout 2008 to discuss the following topics:

- Radiation area monitoring and waste retrieval remote camera systems reviews
- Single-Shell Tank Integrity Project and High-Level Waste Tank Integrity Workshops
- Single-Shell and Double-Shell Tank Integrity Programs
- Interim pretreatment system project scope and schedule
- Demonstration bulk vitrification system design status and confinement strategy implementation
- Tank S-102 waste spill corrective actions plan and implementation for emergency response and preparedness, engineering design and management systems, emergency response, and conduct of operations
- DOE Office of River Protection and the tank operations contractor implementation of DOE Order 226.1A, "Implementation of Department of Energy Oversight Policy"
- Tank Operations Contract transition from CH2M HILL Hanford Group, Inc. to Washington River Protection Solutions, LLC on October 1, 2008
- Maintenance management of the tank farms
- Vital safety systems surveillance, inspection, and maintenance



- Authorization basis maintenance activities
- Tanks retrieval and processing
- Double-shell tank corrosion control
- 242-A Evaporator monitoring and control system upgrade
- Software quality assurance and safety-related digital instrumentation and control systems.

The DOE Office of River Protection completed commitments made to the Defense Nuclear Facilities Safety Board, including commitments on electrical systems at the high-level waste tank farms (Letter 2008-87). The DOE Office of River Protection briefed the Board on the status and efforts to correct deficiencies via video conference on December 4, 2008.





## 6.6 Hanford Tank Waste Treatment and Immobilization Plant

JF Brown

The Hanford Tank Waste Treatment and Immobilization Plant is being built on 26 hectares (65 acres) located on the Central Plateau at the 200-East Area to treat radioactive and hazardous waste currently stored in 177 underground tanks. Four major facilities are being constructed: 1) the Pretreatment Facility, 2) the High-Level Waste Vitrification Facility, 3) the Low-Activity Waste Vitrification Facility, and 4) the Analytical Laboratory, along with 20 support buildings and underground utilities.

During 2008, significant progress was made on the Hanford Tank Waste Treatment and Immobilization Plant. The Pretreatment Facility began to advance from 17 to 23.5 meters (56 to 77 feet) in elevation, with substantial steel and concrete placements. The High-Level Waste Vitrification Facility began to advance to the 4.3-meter (14-foot) elevation. The Low-Activity Waste Vitrification Facility's east export bay was enclosed and permanent plant equipment was installed. The Analytical Laboratory's interior walls were framed and the hot-cell divider partitions were started. In the Balance of Facilities, 13 glass-former silos were delivered and installed, as well as the silo blending hoppers. This activity completed the large equipment installation at the glass-former facility, which will store, dispense, and blend the materials to be mixed with the waste to form glass.

The overall project is approximately 45% complete, including the following:

- Approximately 69% design complete
- Approximately 62% construction complete on the Balance of Facilities

- Approximately 58% construction complete on the Low-Activity Waste Vitrification Facility
- Approximately 52% construction complete on the Analytical Laboratory
- Approximately 27% construction complete on the Pretreatment Facility
- Approximately 22% construction complete on the High-Level Waste Vitrification Facility.

Construction was also completed on the Pretreatment Engineering Platform, a one-quarter-scale demonstration facility that will confirm the efficiency and throughput of select pretreatment processes. The Pretreatment Engineering Platform is the second largest processing system at the Hanford Site. Staff from Pacific Northwest National Laboratory, URS-Washington Division, and Bechtel National, Inc. have completed initial testing of the system and have started Phase I testing using non-radioactive waste simulants.

From project inception through 2008, the Hanford Tank Waste Treatment and Immobilization Plant placed 137,000 cubic meters (4.84 million cubic feet) of concrete; erected 12,000 metric tons (13,000 tons) of structural steel; installed 73,000 meters (240,000 linear feet) of pipe; and 67,000 meters (220,000 linear feet) of cable and wire.

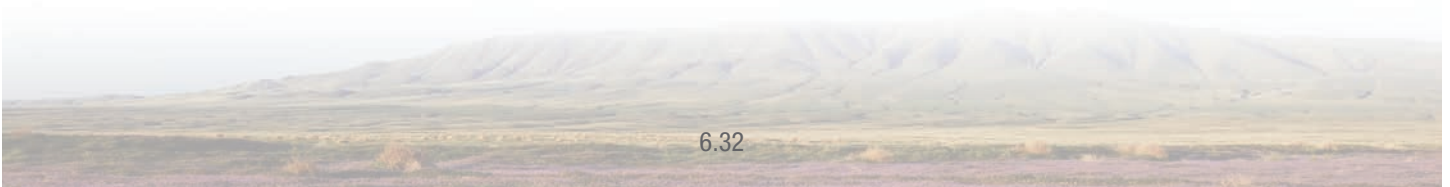


## DOE Office of River Protection Progress on Defense Nuclear Facilities Safety Board Recommendations Regarding the Hanford Tank Waste Treatment and Immobilization Plant Project

LJ Croy

Throughout 2008, the DOE Office of River Protection and Bechtel National, Inc. staff met with and provided information to the Defense Nuclear Facilities Safety Board and its technical staff regarding the following topics for the Hanford Tank Waste Treatment and Immobilization Plant project:

- Hanford Tank Waste Treatment and Immobilization Plant construction and design status
- Cost, schedule, and baseline revisions
- Authorization basis maintenance activities
- Pretreatment engineering platform startup and acceptance testing, operations, and Phase I test plan
- Black-cell piping quality assurance issues and corrective actions
- Use of fire protection methodology as specified in DOE-STD-1066-99 for Hanford Tank Waste Treatment and Immobilization Plant confinement ventilation systems safety classes
- Development and plan for the limited use of Hanford Tank Waste Treatment and Immobilization Plant-Specific Ground Motion for the design of specific equipment
- Summary structural reports for the High-Level Waste Vitrification and Pretreatment Facility
- Industry flow sheet review
- Hydrogen accumulation in pipes and ancillary vessels
- Fire coating of structural steel
- Broad-based review of representative systems and components to determine quality issues in Hanford Tank Waste Treatment and Immobilization Plant project design and procurement
- Cesium ion-exchange system design
- Reduction of material-at-risk (the inventory of radioactive material that could potentially be released to the environment from an accident).





## 6.7 Scientific and Technical Contributions to Hanford Site Cleanup

T Walton

In 2008, Pacific Northwest National Laboratory addressed Hanford Site challenges in chemical and nuclear waste processing and subsurface science and remediation. Researchers from Pacific Northwest National Laboratory supported DOE and its contractors, as well as the DOE Office of Science by performing testing, analyzing data, providing reviews, preparing and operating special facilities, and creating new technologies to address site cleanup challenges.

In 2008, Pacific Northwest National Laboratory continued to provide support to the Hanford Tank Waste Treatment and Immobilization Plant by resolving waste processing and performance issues. In Process Development Laboratory West, staff installed the Pretreatment Engineering Platform, an approximate quarter-scale prototype of the Hanford Tank Waste Treatment and Immobilization Plant sludge treatment system that will confirm waste processing approaches and design for the full-scale plant. Integration and water testing commenced and simulant testing began in late 2008. In addition to Pretreatment Engineering Platform activities, Pacific Northwest National Laboratory used and adapted other research facilities in support of the Hanford Tank Waste Treatment and Immobilization Plant project's technical basis, which included conducting scaled testing with actual tank waste and non-radioactive simulants.

Progress was also made on Hanford Tank Waste Treatment and Immobilization Plant waste feed and pipeline plugging issues. Fluid behavior in waste feeds can lead to plugging of the pipelines that will convey the waste to the treatment plant. Researchers developed and built a slurry test loop and performed hundreds of test runs, providing information and recommendations to reduce the risk of pipeline waste transfer problems from settled solids.

Testing of the Hanford Tank Waste Treatment and Immobilization Plant pulse jet mixer control system, which protects the structural integrity and life of the vessels that will be used in plant waste processing activities, confirmed the adequacy of the control system. This confirmation of the control system will avoid costly rework of system design or impacts on plant operability. Researchers also conducted tests to validate the technical basis for the Hanford Tank Waste Treatment and Immobilization Plant mixing system; data from those tests indicated system changes and additional testing will be necessary.

In 2008, Pacific Northwest National Laboratory researchers conducted geochemical studies and soil column tests that provided insights into the movement of chromium in the vadose zone. Researchers also investigated biostimulation as a way to increase the effectiveness of an underground chemical barrier that reduces chromium in contaminated groundwater. In August 2008, researchers injected a vegetable oil emulsion into the barrier to reduce oxygen and nitrates in the groundwater that hinder chromium reduction; monitoring and evaluation of the treatment zone is ongoing. These tests will support future decisions regarding chromium remediation.

Also in 2008, Pacific Northwest National Laboratory researchers installed a well network in the 300 Area as part of the DOE Office of Science's Environmental Remediation Science Program to characterize the uranium-contaminated subsurface, examine fundamental science issues important to contaminant transport and groundwater remediation, and support future cleanup decisions at the Hanford Site and other DOE sites.



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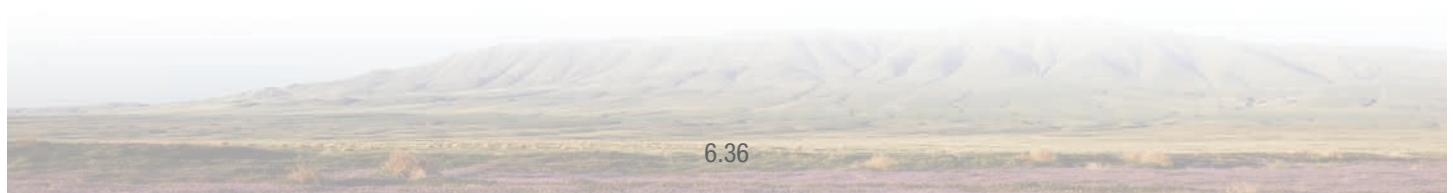
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## 7.0 Hanford Site Closure Activities

This section provides information on Hanford Site cleanup activities as the U.S. Department of Energy (DOE) progresses toward site closure and the likely transfer of property to other entities.

### 7.0.1 Radiological Release of Property from the Hanford Site

#### WM Glines

Principal requirements for the control and release of DOE property containing residual radioactivity are in DOE Order 5400.5, Chg 2, “Radiation Protection of the Public and the Environment.” These requirements are designed to ensure the following:

- Property is evaluated, radiologically characterized—and where appropriate—decontaminated before release.
- The level of residual radioactivity in property to be released is as near background levels as is reasonably practicable, as determined through DOE’s as low as reasonably achievable process requirements, and meets DOE authorized limits.
- All property releases are appropriately certified, verified, documented, and reported; public participation needs are addressed; and processes are in place to appropriately maintain records.

No property with detectable residual radioactivity above authorized levels was released from the Hanford Site in 2008.

#### 7.0.1.1 Radiological Clearance for Personal Property Potentially Contaminated with Hard-to-Detect Radionuclides

##### WM Glines

In the process of performing environmental remediation or related support activities, Hanford Site contractors encounter a wide variety of contaminated personal property including consumables, office items, tools and equipment, and debris. Final disposition of these materials depends on whether the property is considered radiologically contaminated, and whether the disposal of such property is subject to *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) requirements. Radiologically contaminated property is disposed at the Environmental Restoration Disposal Facility if subject to CERCLA requirements and if not, at the Central Waste Complex in the 200-West Area. Personal property that has contamination levels below approved DOE control and release guidelines (DOE Order 5400.5, Chg 2) are considered for release if the property can be reused. Hanford Site contractors routinely encounter a wide variety of radionuclide mixtures ranging from essentially pure plutonium to fission and activation products. Included in these fission and activation products are low-energy beta emitters, such as carbon-14, iron-55, nickel-59, nickel-63, selenium-79, technetium-99, palladium-107, and europium-155 that are difficult or impossible to detect with routine field-survey methods (i.e., hard-to-detect radionuclides).

Traditionally, field detectable or easy-to-detect radionuclides have been used as an analog for the entire mixture of



radionuclides encountered during work activities, and the control and release criteria (DOE Order 5400.5, Chg 2) have been adjusted downward to account for the portion of the activity that is not detectable by field survey methods. As the ratio of hard-to-detect radionuclides to easy-to-detect radionuclides increases, the criteria are reduced to a point where the adjusted limits are difficult or impossible to verify with field survey instruments. Decades of radioactive decay have reduced the contributions of easy-to-detect radionuclides to such low levels that current control and release methodologies are no longer sufficient for verifying that contaminant levels comply with the existing, approved DOE property release guidelines in DOE Order 5400.5, Chg 2.

Accordingly, in May 2006, Washington Closure Hanford, LLC, the prime contractor for the River Corridor Closure Contract, submitted a request to DOE to increase the release criteria (authorized limits) for hard-to-detect radionuclides. The requested authorized limits would apply only to beta-gamma surface contamination on potentially contaminated equipment and materials, and exclude volumetric contamination (contamination that is distributed throughout the volume of the property), contamination in or on persons, unrestricted release of metals, and alpha-surface contamination. Detailed radiological analyses were performed to demonstrate that these authorized limits would be protective of human health and the environment. Based on these analyses, the authorized limits would result in a dose of less than 1 millirem (10 microsievert) in any year to the maximally exposed individual and a collective dose of less than 10 person-rem (0.1 person-Sv) to any exposed population. These authorized limits (Table 7.0.1) were reviewed by DOE Richland Operations Office and DOE

Headquarters personnel and approved for use by Washington Closure Hanford, LLC in May 2007.

In October 2008, CH2M HILL Plateau Remediation Company and Fluor Hanford, Inc. each submitted a request to DOE Richland Operations Office for approval to use the hard-to-detect authorized limits that had been previously approved for Washington Closure Hanford, LLC. DOE Richland Operations Office provided conditional approvals for these requests to CH2M HILL Plateau Remediation Company and Fluor Hanford, Inc. in November and December 2008, respectively.

Although these hard-to-detect authorized limits were approved for use in 2007 and 2008, no property with detectable residual radioactivity was released from the Hanford Site in 2008 using these authorized limits.

### 7.0.1.2 Radiological Clearance for Ion-Exchange Resin for Offsite Shipment and Regeneration

#### WM Glines

Remedial actions are currently in progress at the Hanford Site for the treatment of groundwater containing hexavalent chromium. Although there are no current unacceptable human health risks from contaminants in the groundwater, primarily because exposure is precluded by DOE Hanford Site controls, a qualitative ecological risk assessment concluded that hexavalent chromium concentrations in groundwater exceeds the U.S. Environmental Protection Agency (EPA) ambient water quality criterion of 10 µg/L (0.01 ppm) for protection of freshwater aquatic life. Therefore, these remedial actions are necessary to protect ecological receptors along the Hanford Reach of the Columbia River.

Remedial actions involve the use of pump-and-treat systems to extract groundwater containing hexavalent chromium from specific target areas. The groundwater is treated using an ion-exchange resin treatment process to remove hexavalent chromium, and the treated groundwater is then returned to the aquifer using injection wells. Once saturated, the spent resin is removed from the pump-and-treat system and the resin is prepared for shipment to an offsite facility for regeneration and reuse. Resin regeneration requires chemical washing to release the bound hexavalent chromium.

**Table 7.0.1. Approved Authorized Limits for Select Hard-to-Detect Radionuclides<sup>(a)</sup> for Residual Beta-Gamma Surface Contamination**

Average (dpm/100 cm <sup>2</sup> )	Maximum (dpm/100 cm <sup>2</sup> )	Removable (dpm/100 cm <sup>2</sup> )
50,000	150,000	10,000

(a) Carbon-14, iron-55, nickel-59, nickel-63, selenium-79, technetium-99, palladium-107, and europium-155.  
dpm = Disintegrations per minute.

Based on past Hanford Site activities and the results of characterization sampling, this resin could contain residual radioactivity as a result of site activities. Characterization sampling results were also used to determine specific radionuclides of concern for this residual radioactivity. For any potential residual radioactivity, DOE Order 5400.5, Chg 2 requires that the residual radioactivity not exceed established guidelines, or that radiological release criteria (i.e., authorized limits) be developed and submitted to the applicable DOE field office. Guidelines have not been established for volumetric residual radioactivity for the radionuclides of concern for the resin. In January 2007, Fluor Hanford, Inc. the Hanford Site contractor responsible for these remedial actions submitted a request for authorized limits to permit offsite shipment and resin regeneration.

Requested authorized limits were developed using realistic, yet conservative, radiation dose analyses based on the “likely use” and “worst-plausible use” scenarios. The expected end-use (i.e., likely use scenario) for this resin was as a filtration media in groundwater remediation. The worst-use scenario was use of the resin in another groundwater remediation system outside of the Hanford Site. Detailed radiological analyses were performed to demonstrate that these authorized limits would be protective of human health and the environment. Based on these analyses, the authorized limits would result in a dose of less than 1 millirem (10 microsievert) in any year to the maximally exposed individual, and a collective dose of less than 10 person-rem (0.1 person-sievert) to any exposed population.

The DOE Richland Operations Office coordinated review of this authorized limit request with the U.S. Nuclear Regulatory Commission. Based on a review of DOE’s process for developing authorized limits, the U.S. Nuclear Regulatory Commission stated that such coordination was appropriate “to ensure that site specific release limits and the survey and review protocols are appropriate and acceptable.”<sup>(a)</sup> The U.S. Nuclear Regulatory Commission indicated that on a case-by-case basis, radioactive material has been transferred to unlicensed entities based on an

impact analysis that has demonstrated such a release would result in an “extremely small (i.e., less than 1 millirem/year [10 microsievert/year])”<sup>(a)</sup> exposure to any individual and a minimal collective dose. The analyses performed for these authorized limits indicate that any actual releases would meet these criteria. Following review by DOE Richland Operations Office and DOE Headquarters personnel, these authorized limits (Table 7.0.2) were approved for use by Fluor Hanford, Inc. in August 2007. In October 2008, CH2M HILL Plateau Remediation Company assumed responsibility from Fluor Hanford, Inc. for all Hanford Site groundwater remedial actions. In anticipation of this transfer of responsibility, in September 2008, CH2M HILL Plateau Remediation Company submitted a request to DOE Richland Operations Office for approval to use the authorized limits for resin that had been previously approved for Fluor Hanford, Inc. DOE Richland Operations Office approved this request for CH2M HILL Plateau Remediation Company in October 2008.

In 2008, approximately 151,000 kilograms (332,000 pounds) of resin was shipped offsite for regeneration under these approved authorized limits.

**Table 7.0.2. Approved Authorized Limits for Offsite Shipment and Regeneration of Ion Exchange Resin**

<u>Radionuclide</u>	<u>Authorized Limit (pCi/g)</u>
Tritium	100,000
Strontium/yttrium-90	21,000
Technetium-99	400,000
Uranium-233	3,700
Uranium-234	3,700
Uranium-235 plus short-lived progeny	390
Uranium-238 plus short-lived progeny	3,000

(a) Letter from MF Weber, Chief, Low-Level Waste and Decommissioning Projects Branch, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Agency, to Dr. A Wallo, U.S. Department of Energy, EH-09, dated October 25, 1995.

### 7.0.1.3 Radiological Clearance for Granular Activated Carbon for Offsite Shipment and Regeneration

#### WM Glines

Carbon tetrachloride was found in the unconfined aquifer beneath the 200-West Area on the Hanford Site in the mid-1980s. Groundwater monitoring indicated the carbon tetrachloride plume was widespread and concentrations were increasing. An expedited response action was initiated in 1992 to extract carbon tetrachloride from the vadose zone in the 200-ZP-2 Operable Unit, currently designated as the 200-PW-1 Operable Unit, in the 200-West Area. The 200-PW-1 Operable Unit soil-vapor extraction system includes vapor-phase granular activated carbon canisters to remove carbon tetrachloride from the extracted vapors prior to discharge. This facility was in full operation by 1995.

In 1996, a groundwater pump-and-treat system was installed in a second operable unit, the 200-ZP-1 Operable Unit, to treat contaminated groundwater in the unconfined aquifer. The system includes an air-stripping unit that volatilizes carbon tetrachloride in the groundwater and then discharges the carbon tetrachloride vapors through granular activated carbon canisters that are identical to the large, carbon-steel granular activated carbon canisters in the 200-PW-1 Operable Unit soil-vapor extraction system.

Each of these systems use granular activated carbon canisters to capture the volatile organic compounds removed during the extraction process. When a granular activated carbon canister has reached volatile organic compound saturation, it is removed from the system and the granular activated carbon is prepared for shipment to an offsite facility for regeneration and reuse. Regeneration of the granular activated carbon requires heating it in a hearth furnace to remove the captured volatile organic compounds.

Based on past Hanford Site activities and the results of characterization sampling, this granular activated carbon could contain residual radioactivity as a result of site activities. The characterization sampling results were also used to determine specific radionuclides of concern for this residual

radioactivity. For any potential residual radioactivity, DOE Order 5400.5, Chg 2 requires that the residual radioactivity not exceed established guidelines, or that radiological release criteria (i.e., authorized limits) be developed and submitted to the applicable DOE field office. Guidelines have not been established for volumetric residual radioactivity for the radionuclides of concern for the granular activated carbon. Accordingly, in March 2007, Fluor Hanford, Inc., the Hanford Site contractor responsible for these remedial actions, submitted a request to DOE for authorized limits to permit offsite shipment and regeneration of the granular activated carbon.

These requested authorized limits were developed using realistic, yet conservative, radiation dose analyses based on the “likely use” and “worst-plausible use” scenarios. The expected end-use (i.e., likely use scenario) for this granular activated carbon was as a filtration media for pollution controls in industrial processes. The worst-plausible use scenario was use of the granular activated carbon in a home water filtration system. Detailed radiological analyses were performed to demonstrate that these authorized limits would be protective of human health and the environment. Based on these analyses, authorized limits would result in a dose of less than 1 millirem (10 microsievert) in any year to the maximally exposed individual, and a collective dose of less than 10 person-rem (0.1 person-sievert) to any exposed population.

The DOE Richland Operations Office coordinated review of this authorized limit request with the U.S. Nuclear Regulatory Commission. Based on a review of DOE’s process for developing authorized limits, the U.S. Nuclear Regulatory Commission has stated that such coordination was appropriate “to ensure that site specific release limits and the survey and review protocols are appropriate and acceptable.”<sup>(b)</sup> The U.S. Nuclear Regulatory Commission indicated that on a case-by-case basis, radioactive material is transferred to unlicensed entities based on an impact analysis that demonstrates such a release would result in an “extremely small (i.e., less than 1 millirem/year [10 microsievert/year])”<sup>(b)</sup> exposure to any individual and a minimal collective dose. The analyses performed for

(b) Letter from MF Weber, Chief, Low-Level Waste and Decommissioning Projects Branch, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Agency, to Dr. A Wallo, U.S. Department of Energy, EH-09, dated October 25, 1995.

these authorized limits show that any actual releases would meet these criteria. Following review by DOE Richland Operations Office and DOE Headquarters personnel, these authorized limits were approved for use by Fluor Hanford, Inc. in August 2007 (Table 7.0.3). In October 2008, CH2M HILL Plateau Remediation Company assumed responsibility from Fluor Hanford, Inc. for all Hanford Site groundwater remedial actions. In anticipation of this transfer of responsibility, in September 2008, CH2M HILL Plateau Remediation Company submitted a request to the DOE Richland Operations Office for approval to use the authorized limits for granular activated carbon that had been previously approved for Fluor Hanford, Inc. DOE Richland Operations Office provided approval for this request to CH2M HILL Plateau Remediation Company in October 2008.

**Table 7.0.3. Approved Authorized Limits for Offsite Shipment and Regeneration of Granular Activated Carbon**

<b>Radionuclide</b>	<b>Authorized Limit (pCi/g)</b>
Tritium	940,000
Carbon-14	10,000
Cobalt-60	64
Selenium-79	6,200
Strontium-90	320
Technetium-99	1,600
Iodine-129	170
Cesium-137	250
Europium-152	130
Europium-154	120
Europium-155	2,100
Protactinium-231	38
Thorium-232 plus progeny	18
Uranium-234	360
Uranium-235	390
Neptunium-237	170
Plutonium-238	79
Uranium-238 plus short-lived progeny	370
Plutonium-239	72
Plutonium-240	72
Americium-241	88

In 2008, approximately 24,500 kilograms (54,000 pounds) of granular activated carbon was shipped offsite for regeneration under these approved authorized limits.

## 7.0.2 Columbia River Corridor Mission Completion

### ET Feist

The Columbia River Corridor includes the Hanford Site 100 and 300 Areas, which border the Columbia River. The 100 and 300 Areas include hundreds of contaminated excess facilities, 9 deactivated plutonium-production reactors, and nearly 600 liquid- and solid-waste disposal sites. DOE's award of the River Corridor Closure Contract to Washington Closure, LLC in 2005 has allowed cleanup actions to continue in the 100 and 300 Areas with completion as a primary focus. The principal goals of DOE's River Corridor Closure Contract are to complete the following:

- Deactivate, decontaminate, decommission, and demolish excess facilities
- Place former production reactors in an interim safe and stable condition
- Remediate liquid- and solid-waste disposal sites
- Meet all regulatory requirements
- Determine the adequacy of the current cleanup criteria in protecting human health and the environment
- Prepare the Hanford Site's River Corridor for transfer to long-term stewardship.

The last two items are being addressed under the River Corridor Closure Contract by the Environmental Protection Mission Completion Project. Key project scope includes assessment and integration activities and long-term stewardship support. Ongoing, open communication among the many parties interested in Hanford Site cleanup continued in 2008 as work progressed in these areas. A Washington Closure Hanford, LLC website (<http://www.washingtonclosure.com/projects/endstate.html>) provides current information on these associated activities. The website also includes planned dates for public involvement opportunities.

### 7.0.2.1 Assessment and Integration

JA Lerch

#### River Corridor Baseline Risk Assessment

DOE's cleanup plans for the Columbia River Corridor are based on CERCLA requirements. In 1991, DOE, EPA, and the Washington State Department of Ecology (the Tri-Parties) agreed that interim remedial actions in the 100 and 300 Areas could be implemented by relying on streamlined qualitative risk assessments rather than a quantitative baseline risk assessment. Waste-site cleanup under interim action records of decision was initiated during the mid-1990s and is planned for completion by Washington Closure Hanford, LLC by 2015. The contractor's current focus is on completing the remedial actions so the Tri-Parties can proceed to final CERCLA closeout of the 100 and 300 Areas. A critical step in proceeding toward final CERCLA closeout is a baseline risk assessment, which is now being performed by Washington Closure Hanford, LLC as the River Corridor Baseline Risk Assessment.

The River Corridor Baseline Risk Assessment includes use of a multi-step process. The process began by compiling and summarizing the existing data, and then using the data quality objectives process to identify both data gaps and unresolved issues through open workshops, and by soliciting and incorporating input from regulatory agencies, the Natural Resources Trustees Council, affected Native American tribes, and stakeholders. Based on these discussions, sampling analysis plans were developed to collect the data needed to fill the gaps and address the issues. Risk assessment sampling of upland, riparian, and near-shore environments for the 100 Areas and 300 Area Component was initiated in 2005 and completed in 2006. Additional sampling for the riparian and near-shore environments of the River Corridor within the reactor and operational areas was conducted in 2006 and 2007.

Results from these sampling efforts, combined with relevant existing data, are being used in the preparation of the River Corridor Baseline Risk Assessment (Draft B), which is scheduled for regulatory and stakeholder review in 2009. At the direction of the Tri-Parties and in response to stakeholder feedback, an enhanced characterization of risks associated with groundwater will also be included in the River Corridor Baseline Risk Assessment Draft B report.

The report will support recommendations for final cleanup decisions at source and groundwater units within the River Corridor.

#### Remedial Investigation of Hanford Site Releases to the Columbia River

A remedial investigation under CERCLA has been initiated to evaluate the potential impacts to the Columbia River from Hanford Site-related hazardous substances released from waste sites along the River Corridor and to support final cleanup decisions. Approval of the *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River* (DOE/RL-2008-11) to perform field sampling was completed in October 2008, followed by the initiation of sampling activities. The extent of the remedial investigation includes locations above the Wanapum Dam, focuses on areas within the Hanford Reach and Lake Wallula down to the McNary Dam, and includes some sampling in the vicinity of the Bonneville Dam. Activities include sampling of Columbia River water and incoming irrigation return discharges; pore water, sediment, soils on islands throughout the Hanford Reach; and collection and analysis of six different fish species.

As a precursor to these activities, a habitat survey was completed in November 2008 to assess conditions at potential sampling locations and to verify the presence of key receptor species. In parallel, a survey was conducted to identify the locations where fine-grained sediments have come to reside and where sediment sampling would be performed.

An evaluation of the groundwater plume upwelling within the Hanford Reach of the Columbia River from the 100 Areas down to the 300 Area was initiated in 2008. This work will be completed in 2009 and includes measurements of pore-water specific conductance and temperature. A screening analysis of key Hanford Site indicator contaminants will be performed in 2009 along with sampling of pore water, sediment, and river water at selected locations.

Following completion of field work and compilation of all analytical data, baseline ecological and human-health risk assessments will be conducted to estimate the current risk to humans, animals, and plants; potential impacts from Hanford Site-related contaminants; and whether cleanup actions are needed.



## Integration with Groundwater Actions

Cleanup actions for source and groundwater operable units in the River Corridor have been programmatically separated between DOE Richland Operations Office projects and its associated Hanford Site contractors since 2002. In 2003, an interface control agreement was established to facilitate integration between source and groundwater actions. DOE Richland Operations Office updated the interface control agreement in early 2008 to reflect commitments to Congress to improve integration and coordination between programs, to clarify associated roles and responsibilities, and to identify high-level issues requiring resolution. DOE has directed its Hanford Site contractors to support these integration activities.

Specific integration activities supported by Washington Closure Hanford, LLC in 2008 include participation in Multi-Project Team meetings, strategy development for final records of decision for the River Corridor, and participation in the development of integrated remedial investigation/feasibility study work plans for the six River Corridor decision units (100-B/C, 100-K, 100-N, 100-D, 100-H, 100-F [including the 100-IU-2 and 100-IU-6 Operable Units], and 300 Areas). The work plans are integrated to include summaries of current information and investigation needs for both soil and groundwater. Draft remedial investigation/feasibility study work plans for each of the decision areas will be distributed to EPA and Washington State Department of Ecology for review in 2009 and 2010.

### 7.0.2.2 River Corridor Long-Term Stewardship

#### CS Cearlock

The long-term stewardship task focuses on achieving end-state closure and transition of the River Corridor to long-term stewardship. Within the River Corridor Closure Contract, key elements of the long-term stewardship work include the preparation of remedial actions reports for each CERCLA source operable unit and development of a draft long-term stewardship plan. Preparation for transition to long-term stewardship also includes “orphan site” evaluations. These evaluations include a systematic approach

to review land parcels and identify potential waste sites (orphan sites) in the River Corridor that are not currently listed in existing CERCLA decision documents. Orphan site evaluations consist of comprehensive reviews of historical documentation, field investigations, and geophysical surveys.

In 2008, orphan site evaluations continued for the 100-K and 100-H Areas, and the 100-IU-2 and 100-IU-6 Operable Units. Evaluations were also initiated for the 100-N Area. Additionally, high-resolution aerial photography and topography data were collected and processed for approximately 57,100 hectares (141,000 acres) of the River Corridor. These data will be used in conducting orphan site evaluations of the inter-area portion of the River Corridor that began in 2009.

The results of risk assessment activities, orphan site evaluations, remedial actions reports, and long-term stewardship plans will provide a basis for independent closure reviews of the 100 and 300 Areas by independent experts. The independent closure reviews will assure that implemented remedies meet the remedial action objectives established in the source operable unit records of decision, and that no further action is needed to protect human health and the environment. These activities will culminate in development of a final long-term stewardship plan that will contain a proposed finding of suitability to transfer property in accordance with CERCLA Section 120(h) and the final criteria for long-term stewardship.

## 7.0.3 References

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## 8.0 Environmental Occurrences

BG Fritz

Releases of radioactive and regulated materials to the environment are reported to the U.S. Department of Energy (DOE) and other federal and state agencies as required by law. The specific agencies notified depend on the type, amount, and location of each release event. This section addresses releases or potential releases to the environment that may not be documented by other reporting mechanisms. All Hanford Site occurrences are reported to the Occurrence Notification Center and subsequently recorded in the Occurrence Reporting and Processing System. This system is a DOE electronic database that tracks occurrence reports across the DOE complex (DOE Manual 231.1-2). The following sections summarize occurrences that occurred in 2008 that may have impacted the Hanford Site environment. The occurrences are arranged according to significance category, which are assigned based on the nature and severity of the occurrence. The categories include operational emergency, recurring, Category 1 (significant impact); Category 2 (moderate impact); Category 3 (minor impact); and Category 4 (some impact). In 2008, there were no Hanford Site environmental occurrences ranked as operational emergency, recurring, Category 1, or Category 3.

### 8.0.1 Category 2 – Moderate Impact

Category 2 occurrences are defined as having a moderate impact on safe facility operations, worker or public safety and health, regulatory compliance, or public and business interests. A single Category 2 occurrence with potential environmental implications occurred on the Hanford Site in 2008.

**Environmental Restoration Disposal Facility Container Hinge Plate Contamination.** On July 8, 2008, contamination was discovered on an Environmental Restoration Disposal Facility container hinge plate. Radiological control technicians discovered 2 million disintegrations per minute beta/gamma on the hinge plate, and an additional 1.6 million disintegrations per minute beta/gamma on the ground below the hinge plate. While the container had been loaded with building debris from the 184-N Building located in the 100 Areas, the contamination was similar to contamination excavated from the B/C Cribs. Prior to hauling 184-N Building debris, the container had been loaded with contaminated soil from the B/C Cribs. Workers hauled the container on multiple trips on Hanford Site roads before the contamination was discovered. The contamination was contained and corrective actions established.

### 8.0.2 Category 4 – Some Impact

Category 4 occurrences are defined as having some impact on safe facility operations, worker or public safety and health, regulatory compliance, or public and business interests. Two Category 4 occurrences with potential environmental implications occurred on the Hanford Site in 2008 and are summarized below. Other discoveries of legacy contamination are also briefly summarized.

**Brush Fires.** Several small brush fires were reported in 2008. One occurred on June 29 in the 200-East Area when high winds detached overhead electrical lines from their pole, resulting in the power lines making contact with the

ground. Winds during the occurrence were gusting up to 97 kilometers (60 miles) per hour. Two other brush fires started on August 8 as a result of lightning strikes. One started near the Wye Barricade and burned 0.4 to 0.8 hectare (1 to 2 acres). The other started in the vicinity of the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER) complex (located north of the city of Richland) and was contained after burning 160 to 240 hectares (400 to 600 acres).

**Discovery of Legacy Contamination.** Each year on the Hanford Site, legacy contamination is spread as a result of environmental conditions. Some of this contamination is discovered during routine survey work. Biological vectors also result in the spread of contamination; tumbleweeds, rabbits, and mud daubers (wasps) are all common biological vectors. Tumbleweeds have a deep taproot that can sequester contamination from below the soil surface into the plant body on the surface. Rabbits could eat vegetation located

in contaminated areas, and then deposit contaminated feces outside of the contaminated area. Mud daubers build nests from mud and occasionally use mud from contaminated areas, resulting in the transfer of contamination to uncontaminated areas. Of these three biological vectors, contaminated tumbleweeds occur most frequently and have the potential to transfer contamination the farthest distance from their original locations. High winds are another vector that may result in the spread of legacy contamination beyond posted areas. The reporting of legacy contamination discovered throughout the year is consolidated into quarterly reports. In 2008, 113 occurrences of legacy contamination were documented.

### 8.0.3 Reference

DOE Manual 231.1-2. 2003. "Occurrence Reporting and Processing of Operations Information." Office of Environment Safety and Health, U.S. Department of Energy, Washington, D.C.





## 9.0 Pollution Prevention Program

CE Marple

The U.S. Department of Energy (DOE) Richland Operations Office is responsible for the Hanford Site Pollution Prevention Program and provides program implementation guidance to Hanford Site contractors. The Pollution Prevention Program reflects federal and DOE policies to reduce, reuse, and/or recycle wastes as asserted by the *Pollution Prevention Act of 1990*.

DOE Order 450.1A, "Environmental Protection Program," established new pollution prevention and environmental stewardship goals that enhanced the pollution prevention and environmental management system provisions in DOE Order 450.1A, Executive Order 13148, "Greening the Government Through Leadership in Environmental Management" (65 FR 24595-24607), and Executive Order 13101, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition" (63 FR 49643-49651). These goals are implemented by Hanford Site contractors.

In 2008, 1,530 metric tons (1,690 tons) of sanitary and hazardous wastes were recycled through Hanford Site-wide programs administered through the Project Hanford Management Contract (Table 9.0.1). Purchasing environmentally preferable products under the Project Hanford Management Contract achieved 100% of the 2008 goal. The Hanford Site Solid Waste Information Tracking System indicates that 2,210 cubic meters (78,000 cubic feet) of cleanup and stabilization waste (i.e., low-level, mixed low-level, transuranic, and mixed waste as defined by the *Toxic Substances Control Act*) was generated during fiscal

year 2008, including 152,100 metric tons (167,700 tons) of non-radioactive hazardous and *Toxic Substances Control Act* cleanup and stabilization waste.

**Table 9.0.1. Hanford Site Sanitary and Hazardous Waste Recycled in 2008**

<u>Waste</u>	<u>Metric Tons (tons)</u>	
<b><i>Sanitary Waste</i></b>		
Appliances and furniture	66.1	(72.8)
Ballasts	2.2	(2.4)
Computers and electronics	28.1	(31.0)
Engine oils	26.8	(29.5)
Exit signs	0.10	(0.11)
Iron and steel	392.1	(432.2)
Mixed office paper and corrugated cardboard	437.6	(482.4)
Non-ferrous metal	105.8	(116.6)
Software	4.1	(4.5)
Tires	5.1	(5.6)
Toner cartridges	12.7	(14.0)
<b><i>Hazardous Waste</i></b>		
Antifreeze	319.3	(352.0)
Batteries	62.5	(68.9)
Diesel fuel	22.6	(24.9)
Halon 131	0.16	(0.18)
Lamps	17.5	(19.3)
PCB oil <sup>(a)</sup>	24.0	(26.5)
Shop towels	0.50	(0.55)

(a) Less than 50 ppm PCB oil recycled for energy recovery.  
 PCB = Polychlorinated biphenyl.  
 ppm = Parts per million.

## References

63 FR 49643-49651. September 14, 1998. Executive Order 13101, "Greening the Government through Waste Prevention, Recycling, and Federal Acquisition." *Federal Register*.

65 FR 24595-24607. April 21, 2000. Executive Order 13148, "Greening the Government Through Leadership in Environmental Management." *Federal Register*.

DOE Order 450.1A. 2008. "Environmental Protection Program." U.S. Department of Energy, Washington, D.C.

*Pollution Prevention Act of 1990*. 1990. Public Law 101-508, as amended, 42 USC 13101-13109 et seq.

*Toxic Substances Control Act*. 1976. Public Law 94-469, as amended, 15 USC 2601 et seq.





## 10.0 Environmental and Resource Protection Programs

U.S. Department of Energy (DOE) Orders 450.1 (replaced by DOE Order 450.1A in 2008) and 5400.5 require that environmental monitoring programs be conducted on the Hanford Site to verify protection of the site's environmental and cultural resources, the public, and workers at the site. These monitoring activities support the site's integrated "Safety Management System Policy" (DOE Policy 450.4) and its component Environmental Management System (see Section 4.0.1). Component systems are tools for achieving site and contractor compliance with environmental, public health, and resource protection laws, regulations, and DOE Orders.

The *Environmental Monitoring Plan United States Department of Energy Richland Operations Office* (DOE/RL-91-50, Rev. 4) provides the implementation guidance for the monitoring programs and projects on the Hanford Site. The plan contains the rationale for the required programs and projects, including design criteria, sampling locations and schedules, quality assurance requirements, program and project implementation procedures, analytical procedures, and reporting requirements. The early identification of—and appropriate response to—potentially adverse environmental and resource effects associated with DOE operations are confirmed by the following:

- Pre-operational environmental characterization, assessments, and evaluations
- Effluent and emissions monitoring
- Environmental monitoring and surveillance (as defined in DOE Order 5400.5 and in Appendix B of this report, "Glossary")
- Cultural resources monitoring
- Controlling and monitoring of contaminated and undesirable biota.

The objectives of the monitoring programs include the following:

- Detecting, characterizing, and responding to contaminant releases from Hanford Site DOE facilities and operations
- Providing data to assess the human health and ecological impacts of Hanford Site-produced contaminants
- Estimating contaminant dispersal patterns in the environment
- Characterizing pathways of exposure to the public and biota
- Characterizing exposures and doses to individuals, nearby populations, and biota
- Evaluating potential impacts to biota (and the Columbia River) in the vicinity of DOE Hanford Site activities
- Verifying that environmental monitoring programs are conducted in an integrated fashion to preclude collecting duplicative environmental data
- Verifying early identification of, and appropriate response to, the potentially adverse environmental impact associated with DOE operations
- Promoting long-term stewardship of Hanford Site natural and cultural resources
- Protecting natural and cultural resources.

Other important reasons for conducting these monitoring activities include the following:

- Complying with and confirming site compliance with DOE Orders and local, state, and federal laws and regulations

- Verifying the efficacy of waste-management practices on the Hanford Site
- Providing information to reassure the public that Hanford Site facilities and operations are not adversely affecting people or the environment
- Answering questions or providing information to stakeholders, activist organizations, and the public
- Supporting DOE decisions
- Providing information to support DOE in environmental litigations.

Brief summaries of DOE environmental monitoring programs and projects, including Effluent and Near-Facility Environmental Monitoring Programs, Public Safety and Resource Protection Projects, the Soil and Groundwater Remediation Project, the Drinking Water Monitoring Project, the Biological Control Program, and the Washington State Department of Health Oversight Monitoring Program are provided in the following subsections. Subsections within this chapter address specific media and programs that interrelate with these programs.

## 10.0.1 Effluent and Near-Facility Environmental Monitoring Programs

JJ Dorian

Effluent and near-facility environmental monitoring on the Hanford Site consists of 1) liquid effluent and airborne emissions monitoring at site facilities and operations and 2) environmental monitoring near facilities and operations that have the potential to discharge, or have discharged, stored, or been a disposal site for radioactive and hazardous materials. Categories of effluent that normally or potentially contain radionuclides or hazardous materials include cooling water, steam condensates, process condensates, and wastewater from laboratories and chemical sewers. Airborne emissions can include both radioactive and non-radioactive particulate and gaseous or volatilized materials from facility stacks and vents.

### 10.0.1.1 Liquid Effluent and Airborne Emissions Monitoring

Hanford Site contractors perform real-time monitoring of liquid effluent and airborne emissions at each facility to assess the effectiveness of effluent and emissions treatment and control systems as well as pollution-management practices. Monitoring is also conducted to determine facility and site compliance with state and federal regulatory requirements. Section 10.3 and an annual environmental release report (e.g., HNF-EP-0527-18) summarize information on effluent discharged from site facilities in 2008. Section 10.1 and other reports (e.g., DOE/RL-2009-14) summarize air emissions data for 2008.

### 10.0.1.2 Near-Facility Environmental Monitoring

Near-facility environmental monitoring is conducted near DOE facilities and operations on the Hanford Site that have the potential to discharge, or have discharged, stored, or been a disposal site for radioactive or hazardous contaminants. Monitoring locations are associated with nuclear facilities, such as the Canister Storage Building and the Plutonium Finishing Plant; inactive nuclear facilities, such as N Reactor and the Plutonium Uranium Extraction (PUREX) Plant; and active and inactive waste storage or disposal facilities, such as burial grounds, cribs, ditches, ponds, underground waste storage tanks, and trenches. Much of the monitoring program consists of collecting and analyzing environmental samples and conducting radiological surveys in areas near facilities. The program also evaluates and reports analytical data, determines the effectiveness of facility effluent monitoring and controls, measures the adequacy of containment at waste disposal sites, and detects and monitors unusual conditions. The program implements applicable portions of DOE Orders 435.1, 450.1A, and 5400.5; DOE Manual 231.1-1A; 10 CFR 835 and 40 CFR 61; and WAC 246-247.

Several types of environmental media are sampled routinely near Hanford Site facilities, and various radiological and non-radiological measurements are taken. The media sampled include air, soil, and vegetation. In addition, surface contamination and external radiation levels are monitored.



Media samples are collected from known or expected emissions and effluent pathways, which are generally downwind of potential or actual airborne releases and downgradient of liquid discharges.

Active and inactive waste disposal sites and the terrain surrounding them are surveyed to detect and characterize radioactive surface contamination. Routine radiological survey locations include former waste disposal cribs and trenches, retention-basin perimeters, ditch banks, solid waste disposal sites (e.g., burial grounds), unplanned release sites, tank-farm perimeters, stabilized-waste disposal sites, roads, and firebreaks in and around the site operational areas. Investigations of contaminated biota, soil, and other materials are conducted in the operational areas to monitor the presence or movement of radioactive or hazardous materials around areas of known or suspected contamination or to verify radiological conditions at specific project (e.g., cleanup or construction) sites. Investigations for contaminants are conducted for at least one of the following reasons:

- To follow up on surface radiological surveys that had indicated radioactive contamination was present
- To conduct pre-operational surveys to characterize the radiological and chemical conditions at a site before facility construction, operation, or ultimate remediation
- To determine if biotic intrusion (e.g., animal burrows or deep-rooted vegetation) had created a potential for contaminants to spread
- To determine the integrity of waste-containment systems.

Contamination incidents investigated in 2008 focused on soil, vegetation, wildlife, and wildlife-related materials (e.g., bird nests, animal feces). Most materials were surveyed in the field to detect radioactive contamination. Some materials were sampled, and the samples were submitted for laboratory analysis. Methods for surveying and sampling these contaminated materials are described in *Operational Environmental Monitoring* (FSWO-OEM-001). Laboratory analysis results and field-survey readings for contamination incidents investigated in 2008 are provided in a separate appendix (PNNL-18427, APP. 2).

Sections 10.2, 10.9, 10.10, 10.12, and 10.13 summarize information on contaminant concentrations or radiation levels measured onsite near facilities and operations during 2008. Additional data may be found in PNNL-18427, APP. 2. Table 10.0.1 summarizes the type and general locations of samples collected for near-facility monitoring during 2008. Sections 10.9, 10.10, and 10.12 summarize information on contamination incidents investigated during 2008.

## 10.0.2 Public Safety and Resource Protection Program Projects

JP Duncan

The Public Safety and Resource Protection Program for the Hanford Site is managed by Pacific Northwest National Laboratory for the DOE Richland Operations Office. Projects include the Ecological Monitoring and Compliance Project, the Meteorological and Climatological Services Project, the Surface Environmental Surveillance Project,

**Table 10.0.1. Routine Environmental Monitoring Samples and Locations Near Hanford Site Facilities and Operations, 2008**

Sample Type	No. of Sample Locations	Operational Area										
		100-B/C	100-K	100-N	100-D	100-H	100-F	200-East	200-West	300/400	600	ERDF <sup>(a)</sup>
Air	92	3	10	3	4	4	5	21	24	7	8	3
Soil	85	3	0	0	4	4	5	14	25	14	15	1
Vegetation	66	0	0	3	0	0	0	12	24	13	14	0
External radiation	124	4	18	6	0	0	0	43	25	25	0	3

(a) Environmental Restoration Disposal Facility in the 200-West Area.

and the Cultural Resources Project. These projects are designed to monitor the Hanford Site environment; reassure the public that the Hanford Site is operating in compliance with applicable environmental regulations; and conduct impact assessments to protect the public, worker safety, and cultural and ecological resources. Surveillance data concerning environmental effects as related to public health are collected by an independent contractor not associated with facility contractors or subcontractors, enabling DOE to manage environmental risks on the Hanford Site.

Information summarizing the Public Safety and Resource Protection Program projects is provided in the following sections.

### 10.0.2.1 Meteorological and Climatological Services Project

The Meteorological and Climatological Services Project provides support to DOE and Hanford Site contractors to reassure the public that activities conducted on the site that may be impacted by adverse meteorological conditions (e.g., thunderstorms, strong winds, dense fog, blowing dust, and snowstorms) are conducted in as safe and efficient a manner as possible. The project measures, analyzes, and archives meteorological data, including wind direction, wind speed, temperature, precipitation, atmospheric pressure, and humidity, from monitoring stations positioned on and around the Hanford Site. The project also provides meteorological response in the event of a suspected or actual release of hazardous or radioactive material to the atmosphere, contributing to appropriate and timely decisions.

Comprehensive meteorological records are maintained for other applications as well, including environmental impact statements, dose reconstruction, post-accident analyses, or building design. Section 10.16 summarizes meteorological data for 2008, including some historical climatological information.

### 10.0.2.2 Surface Environmental Surveillance Project

The Surface Environmental Surveillance Project is responsible for measuring the concentrations of radiological and non-radiological contaminants in environmental

media onsite within the 600 Area (site-wide) and offsite at perimeter, community, and distant locations, and to determine the potential effects of these materials on the environment and to the public. Samples of agricultural products, air, fish and wildlife, soil, surface water and sediment, water and sediment from Columbia River shoreline springs, and vegetation are collected routinely and are analyzed for radionuclides and chemicals, including metals, organics, and anions.

Project monitoring activities focus on routine releases from DOE facilities on the Hanford Site. However, the project also conducts sampling and analysis in response to known unplanned releases and releases from non-DOE operations on and near the site. Monitoring results are provided to DOE and the public annually through this Hanford Site environmental report series. Unusually high contaminant concentrations, should they occur, are reported to the DOE Richland Operations Office and the appropriate facility managers on a timely basis.

The general requirements and objectives for the Surface Environmental Surveillance Project are to monitor routine and non-routine contaminant releases to the environment from DOE facilities and operations, assess doses to members of the public, monitor potential impacts of contaminants on other biota, and alert DOE to the possible need for corrective action (DOE Orders 450.1A and 5400.5; DOE/EH-0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*).

The specific objectives of the monitoring activities include the following:

- Collecting and analyzing samples, reviewing and interpreting analytical data, and maintaining and overseeing a long-term computer database for trend analysis
- Determining compliance with applicable environmental quality standards, public exposure limits, and applicable laws and regulations; requirements of DOE Orders; and environmental commitments made in environmental impact statements, environmental assessments, safety analysis reports, or other official DOE documents
- Performing pre-operational assessments



- Assessing radiological doses to the public and environment
- Assessing doses from other local sources
- Reporting alarm levels and potential doses exceeding exposure limits
- Determining contaminant background levels and site contributions of contaminants in the environment
- Determining long-term accumulations of site-related contaminants in the environment and trend predictions
- Characterizing and defining trends in the physical, chemical, and biological conditions of environmental media
- Determining the effectiveness of treatments and controls in reducing effluents and emissions
- Determining the validity and effectiveness of models in predicting environmental pollutant concentrations
- Detecting and quantifying unplanned releases.
- Identifying and quantifying new environmental quality problems
- Maintaining the capability to assess the consequences of accidental contaminant releases
- Reassuring the public and addressing issues of concern to the public, stakeholders, regulatory agencies, and business community
- Increasing public understanding of site environmental issues, primarily through public involvement, and providing environmental information to the public
- Providing environmental data and assessments to assist DOE and its contractors in environmental management of the site.

Annual project reviews are performed to verify that the project is 1) aligned with current operations and missions, 2) focused on those contaminants having the greatest contribution to the potential offsite dose, and 3) providing the greatest amount of useful information for the waste management, cleanup, and environmental assessment activities planned or ongoing on the Hanford Site. Site-wide and offsite surveillance are closely related to, and coordinated with, the Near-Facility Environmental Monitoring Program

described in Section 10.0.1.2 and the Soil and Groundwater Remediation Project (Section 10.0.3).

Sections 10.2, 10.4, 10.5, 10.8, and 10.12 summarize information on contaminant concentrations in project samples collected at site-wide and offsite locations during 2008. Sections 10.11, 10.14, and 10.17 summarize other project information. More detailed contaminant data are provided in the *Hanford Site Environmental Surveillance Data Report for Calendar Year 2008* (PNNL-18427, APP. 1). The types and general locations of samples collected for site-wide and offsite environmental surveillance during 2008 are summarized in Table 10.0.2.

### 10.0.2.3 Ecological Monitoring and Compliance Project

The Ecological Monitoring and Compliance Project has multiple objectives that support both activity-specific ecological compliance requirements and site-wide requirements to verify that natural resources on the Hanford Site are protected. Project personnel monitor the abundance, vigor, and distribution of plant and animal populations on the site and evaluate the cumulative impact of Hanford Site operations on these resources. In addition, project researchers perform baseline ecological resource surveys to document the occurrence of protected resources. The surveys evaluate and document impacts to protected species and habitats as required by the *National Environmental Policy Act of 1969* and the *Endangered Species Act of 1973*, facilitate cost-effective regulatory compliance, and make sure that DOE fulfills its responsibilities to protect natural resources. This project also supports multiple objectives for completing the Hanford Site waste management and environmental restoration mission through the following activities:

- Verifying Hanford Site operational compliance with laws and regulations, including the *Endangered Species Act of 1973*, the *Bald and Golden Eagle Protection Act*, and the *Migratory Bird Treaty Act*
- Identifying biotic contaminant transport pathways and characterization of risks.
- Providing data for environmental impact and ecological risk assessments.



**Table 10.0.2. Types and General Locations of Samples Collected for Site-Wide and Offsite Environmental Surveillance in 2008**

Type	Total Number of Locations	Sampling Locations						
		Onsite <sup>(a)</sup>	Site Perimeter <sup>(b)</sup>	Nearby <sup>(c)</sup>	Distant <sup>(c)</sup>	Columbia River		
						Upstream <sup>(c)</sup>	Hanford Reach <sup>(b)</sup>	Downstream <sup>(c)</sup>
Air	42	23	11	7	1			
Spring water	17						16	1
Spring sediment	11						10	1
Columbia River water	46					5	30	11
Irrigation water	2			2				
Drinking water	4	4						
River sediment	8					2	3	3
Ponds	2	2						
Pond sediment	1	1						
Foodstuffs	5		2	2	1			
Wildlife	5	3		1	1			
Aquatic biota	3					1	2	

(a) Surveillance Zone 1 (between the Near-Facility Environmental Monitoring Program sampling locations and the site perimeter).

(b) Surveillance Zone 2 (near or just inside the site boundary).

(c) Surveillance Zone 3 (in and between communities within an 80-kilometer [50-mile] radius of the site's industrial areas).

- Providing maps and information useful for mitigating the impact on biological resources during facility expansions and decommissioning activities.
- Supporting Hanford Site land-use planning and stewardship.

These activities are intended to help protect the natural resources within the DOE-operated portions of the Hanford Site, including the DOE-managed portion of the Hanford Reach National Monument, as well as to provide information useful to Hanford Site natural resource stakeholders and the public on the status of some of the site's most highly valued biological resources. Ecosystem and compliance monitoring information for 2008 for Hanford Site plant and animal species and communities is summarized in Sections 10.10 and 10.12.

#### 10.0.2.4 Cultural Resources Project

The Cultural Resources Project operates the Hanford Cultural Resources Laboratory for DOE. Project personnel perform baseline cultural resource surveys to document the occurrences of protected resources, evaluate and document impacts to protected resources as required by federal laws,

facilitate regulatory compliance, and make sure that DOE fulfills its responsibilities to protect cultural resources. A summary of Hanford Site cultural resource monitoring activities conducted in 2008 is provided in Section 10.15.

### 10.0.3 Soil and Groundwater Remediation Project

#### DL Foss

The Hanford Site Groundwater Strategy focuses on three key areas: groundwater protection, groundwater monitoring, and remediation of contaminated groundwater. All three of these strategic areas depend on the Soil and Groundwater Remediation Project and its ongoing monitoring and assessment program involving the distribution and movement of existing radiological and chemical contamination in the soil and groundwater beneath the Hanford Site. The project identifies and characterizes potential and emerging groundwater contamination problems in areas of interest that have been organized and referred to as operable units. Monitoring activities in and around these operable units are conducted to comply with a variety of state and federal

regulations, including the *Atomic Energy Act of 1954*, the *Resource Conservation and Recovery Act of 1976* (RCRA), the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), DOE Orders (e.g., 5400.5), and Washington State regulations, as well as requirements for operational monitoring around retired reactors and chemical-processing facilities and requirements for environmental surveillance.

Groundwater samples were collected from 11 groundwater operable units and other portions of the Hanford Site, involving 865 monitoring wells and 297 shoreline aquifer tubes during fiscal year 2008. Section 10.7 summarizes groundwater monitoring activities and analytical results for fiscal year 2008.

## 10.0.4 Drinking Water Monitoring Project

GW Patton and LM Kelly

Public drinking water supplies on sites operated by DOE or a DOE contractor are regulated by the U.S. Environmental Protection Agency (EPA). Radiation dose limits are directed by DOE Order 5400.5, which restricts levels to those mandated by law in 40 CFR 141, “National Primary Drinking Water Regulations”—the federal drinking water standards. State governments administer and enforce EPA limits through their health departments and environmental agencies. The Washington State Department of Health enforces federal drinking water laws through state administrative codes. The Drinking Water Monitoring Project conducts routine monitoring of drinking water supplies on the Hanford Site. Water supplies on the site are provided by the city of Richland and by DOE-owned, contractor-operated water treatment systems, which use water from the Columbia River and wells. Although the city of Richland water supplies are not monitored through the Drinking Water Monitoring Project, the city drinking water intake on the Columbia River is monitored. Section 10.6 summarizes radiological monitoring results for the Hanford Site drinking water systems in 2008.

## 10.0.5 Biological Control Program

AR Johnson

Biological control is any activity to prevent, limit, clean up, or remediate the impact to the environment or human health and safety from radioactively contaminated (contaminated) or undesirable plants or animals. The Biological Control Program is responsible for integrating 1) expanded radiological surveillance for determination of the extent of contaminated biota and soil, 2) control of undesirable plants and animals including noxious weeds, 3) cleanup of contamination spread by biotic vectors, and 4) revegetation of areas affected by radioactive contamination spread by plants and animals as well as blowing dust or sand and recovery of wildland fires or prescribed burns.

The control of weeds and pests is an important part of the Biological Control Program. Weeds on industrial sites on the Hanford Site threaten to accumulate radionuclides, become fire hazards, or interfere with work or machinery. On the Hanford Site, weed control occurs at tank farms (groups of underground radioactive waste storage tanks); radioactive waste pumping installations; industrial sites; power stations; along transmission lines, buildings, storage and work areas; and along fence lines. Pest control prevents, limits, or removes undesirable plants or animals by applying chemicals or by cultural or mechanical methods.

Noxious weeds are controlled onsite to prevent their spread and reduce or eliminate their populations. A noxious weed is a legal and administrative category designated by federal or state regulatory agencies (e.g., U.S. Department of Agriculture or Washington State Department of Agriculture). Noxious weeds are non-native, aggressively invasive, and hard to control. Damage to natural ecosystems and loss of productive agricultural lands can occur unless control measures are taken. Control measures can be mechanical, chemical, or biological. Biological control may include preventive measures or measures in response to existing contamination spread.



Activities to prevent the spread of contamination include radiological surveys, preventive controls (e.g., herbicide spraying), revegetation of eroding areas, and the placement of engineered barriers. If contamination has already spread, typical response measures may include posting the area with radiation-indicating signs, stabilizing the contamination to keep it from spreading, and cleaning up or removing the contamination to an approved disposal location.

In some cases, revegetation is necessary following cleanup and removal of contamination. Revegetation is a common activity on the Hanford Site but has specific meanings and limitations when applied to biological control. Revegetation may include removing and replacing soil, revegetating the soil surface, or placing engineered barriers to stop biological intrusion (biological barriers). Such revegetation on radioactive waste sites is typically performed to prevent recurrence of surface radioactive contamination or colonization by unwanted biota. Sections 10.10 and 10.12 discuss activities conducted for the Biological Control Program in 2008.

## 10.0.6 Washington State Department of Health Oversight Monitoring

JJ Dorian

The Environmental Radiation Monitoring and Assessment Section of the Washington State Department of Health

conducts an independent oversight program on Hanford Site environmental radiation monitoring conducted by DOE contractors. During 2008, the contractors were Pacific Northwest National Laboratory, EnergySolutions, and Fluor Hanford, Inc. The main objectives of the Washington State Department of Health oversight program are to verify the quality of contractor monitoring programs and to make sure the programs are adequate to protect public health.

The objectives of the Washington State Department of Health oversight program are achieved through split sampling with the contractors and independent sampling at contractor sampling sites. The Washington State Public Health Laboratory analyzes Washington State Department of Health samples, which provides a check on contractor analyses. Each year, the Washington State Department of Health compares the measurements of radioactivity in Washington State Department of Health and contractor samples in a quantitative manner to determine the accuracy and reliability of contractor monitoring. The results of the Washington State Department of Health oversight program are published in the Hanford Environmental Oversight Program data summary report (e.g., DOH 320-050).





## 10.1 Air Emissions

DJ Rokkan

Hanford Site contractors monitor airborne emissions from site facilities to assess the effectiveness of emission control equipment and pollution management practices, and determine compliance with state and federal regulatory requirements. Measuring devices quantify most facility emission flows while other emission flows are calculated using process information or fan manufacturers' specifications. Most facility radioactive air emission units are actively ventilated stacks that are sampled either continuously or periodically. Airborne emissions with a potential to contain radioactive materials at prescribed threshold levels are measured for gross alpha and gross beta concentrations and, as warranted, specific radionuclides. Non-radioactive constituents and parameters are monitored directly, sampled and analyzed, or estimated based upon inventory usage.

Emission data are documented in this and other reports, all of which are available to the public. For example, DOE annually submits to EPA and the Washington State Department of Health a report of radionuclide air emissions from the site (DOE/RL-2009-14) in compliance with 40 CFR 61, Subpart H, and with WAC 246-247.

### 10.1.1 Radioactive Airborne Emissions

Small quantities of particulate and volatilized forms of radionuclides are emitted to the environment through state and federally permitted radioactive emission point sources (i.e., stacks). Tritium (i.e., hydrogen-3), strontium-90, iodine-129, cesium-137, plutonium-238, plutonium-239/240, plutonium-241, and americium-241 are the isotopes most commonly measured in the emissions. Emission points

are monitored continuously if they have the potential to exceed 1% of the standard for public dose—10 millirem (100 microsievert) per year.

Distinguishing Hanford Site-produced radionuclides in the environment is challenging because concentrations of emissions from site stacks are comparable to widespread background concentrations of radionuclides that originated from historical atmospheric nuclear weapons testing. Gross alpha and gross beta concentrations in stack emissions are on average equivalent to concentrations in the environment, including concentrations at distant locations upwind of the Hanford Site. Radioactive emissions decreased on the Hanford Site largely because nuclear materials processing ceased.

The continuous monitoring of radioactive emissions from facilities requires analyzing samples collected at points of discharge to the environment, usually a stack. Samples are analyzed for gross alpha and gross beta as well as for selected radionuclides. Specific sampled, analyzed, and reported radionuclides are selected based on 1) an evaluation of the hypothetical maximum potential of emissions of known radionuclide inventories in a facility or an outside activity occurring under normal operating conditions with the calculated effect of pollution-abatement equipment removed; 2) the sampling criteria provided in contractor environmental compliance manuals; and 3) the potential of each radionuclide to contribute to the public dose. Continuous air monitoring systems with alarms are also used at selected emission points when the potential exists for radioactive emissions to exceed normal operating ranges to levels that require immediate personnel alert.

Radioactive emission points are located in the 100, 200, 300, 400, and 600 Areas of the Hanford Site. For 2008, the prime sources of emissions and the number of emission points by operating area are as follows:

- In the 100 Areas, 10 radioactive emission points were active. Emissions originated from normal evaporation and cleanup activities at the 100-K East and 100-K West Fuel Storage Basins, the Cold Vacuum Drying Facility, a low-level radiological laboratory in the 1706-KE Building, and the 107-N Basin Recirculation Building.
- In the 200 Areas, 48 radioactive emission points were active. The primary sources of these emission points were the Plutonium Finishing Plant, T Plant, the Waste Encapsulation and Storage Facility, underground tanks storing high-level radioactive waste, waste evaporators, the Waste Receiving and Processing Facility, and the inactive Plutonium Uranium Extraction (PUREX) Plant.
- In the 300 Area, 11 radioactive emission points were active. The primary sources of these emissions were laboratories and research facilities, including the 324 Waste Technology Engineering Laboratory, the 325 Applied Chemistry Laboratory, the 327 Post-Irradiation Laboratory, and the 340 Complex Vault and Tanks.
- In the 400 Area, five radioactive emission points were active. The sources of these emissions are three facilities that have been shut down: the Fast Flux Test Facility, the Maintenance and Storage Facility, and the Fuels and Materials Examination Facility.
- In the 600 Area, two radioactive emission points were active at the Waste Sampling and Characterization Facility, where low-level radiological and chemical analyses are performed on various types of samples (e.g., particulate air filters, liquids, soil, and vegetation).

Air emissions data collected in 2008 were comparable to those collected in 2007. Table 10.1.1 summarizes Hanford Site radioactive airborne emissions in 2008.

## 10.1.2 Criteria and Toxic Air Pollutants

Criteria and toxic air pollutants emitted from chemical-processing and power-generating facilities are monitored when activities at a facility are known to generate potential pollutants of concern. Table 10.1.2 summarizes the emissions of non-radioactive pollutants discharged to the atmosphere on the Hanford Site during 2008. (Note: the 100 and 400 Areas have no criteria and toxic air pollutants of regulatory concern). Table 10.1.2 also includes emission estimates from the carbon tetrachloride vapor extraction work in the 200-West Area. Those emissions are accounted for in the table category of “Other Toxic Air Pollutants” and do not require reporting because they are less than respective reportable quantities.

In previous years, gaseous ammonia has been emitted from the Plutonium Uranium Extraction (PUREX) Plant, the 242-A Evaporator, the AP Tank Farm, and the AW Tank Farm, all located in the 200-East Area. Ammonia emissions are tracked only when activities at these facilities are capable of generating them. Table 10.1.2 also summarizes reportable ammonia emissions during 2008, which were only produced in the 200 Areas tank farms.

Onsite diesel-powered electric-generating plants emitted particulate matter, sulfur oxides, nitrogen oxides, volatile organic compounds, carbon monoxide, and lead. Total annual releases of these constituents are reported in accordance with the air quality standards established in “General Regulations for Air Pollution Sources” (WAC 173-400). Power plant emissions are calculated from the quantities of fossil fuel consumed, using EPA-approved formulas (*Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*, AP-42).

Release totals are immediately reported to EPA if work activities result in chemical emissions in excess of quantities reportable under CERCLA. If the emissions remain stable at predicted levels, they may be reported annually with EPA’s permission.



**Table 10.1.1. Radionuclides Discharged to the Atmosphere on the Hanford Site, 2008**

<u>Radionuclide</u>	<u>Half-Life</u>	<u>Release, Ci<sup>(a)</sup></u>				
		<u>100 Areas</u>	<u>200-East Area</u>	<u>200-West Area</u>	<u>300 Area</u>	<u>400 Area</u>
Tritium (as HT)	12.3 yr	NM	NM	NM	$7.3 \times 10^1$	NM
Tritium (as HTO)	12.3 yr	NM	NM	NM	$1.8 \times 10^2$	$1.7 \times 10^{-2}$
Krypton-85	10.7 yr	NM	NM	NM	$1.1 \times 10^{-5}$	NM
Strontium-90	29.1 yr	$1.3 \times 10^{-5(b)}$	$8.5 \times 10^{-5(b)}$	$1.4 \times 10^{-5(b)}$	$5.7 \times 10^{-6(b)}$	NM
Iodine-129	16,000,000 yr	NM	$1.3 \times 10^{-3}$	NM	NM	NM
Xenon-131m	11.8 d	NM	NM	NM	$1.0 \times 10^{-10}$	NM
Xenon-133	5.2 d	NM	NM	NM	$5.4 \times 10^{-8}$	NM
Xenon-135	9.1 h	NM	NM	NM	$3.0 \times 10^{-10}$	NM
Cesium-137	30 yr	NM	$3.1 \times 10^{-5}$	$8.0 \times 10^{-7}$	$5.2 \times 10^{-7}$	$9.0 \times 10^{-6(c)}$
Radon-220	55.6 s	NM	NM	NM	$7.4 \times 10^1$	NM
Radon-222	3.8 d	NM	NM	NM	1.7	NM
Plutonium-238	87.74 yr	$1.1 \times 10^{-6}$	NM	$1.1 \times 10^{-8}$	$2.1 \times 10^{-8}$	NM
Plutonium-239/240	24,110 yr	$8.6 \times 10^{-6(d)}$	$1.9 \times 10^{-6(d)}$	$1.8 \times 10^{-5(d)}$	$4.2 \times 10^{-7(d)}$	$2.4 \times 10^{-6(d)}$
Plutonium-241	14.4 yr	$2.0 \times 10^{-5}$	ND	$1.2 \times 10^{-5}$	ND	NM
Americium-241	432.2 yr	$7.1 \times 10^{-6}$	$1.9 \times 10^{-7}$	$3.6 \times 10^{-6}$	$4.2 \times 10^{-8}$	NM
Americium-243	7,380 yr	NM	NM	NM	ND	NM
Curium-243/244	18.1 yr	NM	NM	NM	ND	NM

(a) 1 Ci =  $3.7 \times 10^{10}$  becquerels.

(b) This value includes gross beta release data, treated as strontium-90 in dose calculations.

(c) This release value is derived entirely from data on gross beta emissions from 400 Area stacks.

(d) This value includes gross alpha release data, treated as plutonium-239/240 in dose calculations.

HT = Elemental tritium.

HTO = Tritiated water vapor.

ND = Not detected (i.e., either the radionuclide was not detected in any sample during the year or the average of all the measurements for that given radionuclide or type of radioactivity made during the year was below background levels).

NM = Not measured.

**Table 10.1.2. Criteria and Toxic Air Pollutants Discharged to the Atmosphere on the Hanford Site, 2008**

<b>Constituent</b>	<b>Release, kg (lb)</b>	
Particulate matter-total	2,700	(6,000)
Particulate matter-10	1,800	(4,000)
Particulate matter-2.5	900	(2,000)
Nitrogen oxides	14,000	(30,000)
Sulfur oxides	0	(0)
Carbon monoxide	14,000	(30,000)
Lead	0.45	(1)
Volatile organic compounds <sup>(a,b)</sup>	10,000	(22,000)
Ammonia <sup>(c)</sup>	5,500	(12,000)
Other toxic air pollutants <sup>(d)</sup>	4,300	(9,500)
<b>Total criteria pollutants<sup>(e)</sup></b>	<b>40,000</b>	<b>(88,000)</b>

- (a) The estimate of volatile organic compounds does not include emissions from certain laboratory operations.
- (b) From burning petroleum to produce steam and to power electrical generators; release value also includes calculated estimates from the 200-East and 200-West Areas tank farms, evaporation losses from fuel dispensing, 200 Area Effluent Treatment Facility, Central Waste Complex, T Plant Complex, and Waste Receiving and Processing Facility.
- (c) Ammonia releases are calculated estimates from the 200-East and 200-West Areas tank farms and the 200 Area Effluent Treatment Facility; the release value also includes ammonia from burning petroleum to produce steam and to power electrical generators.
- (d) Releases are a composite of calculated estimates of toxic air pollutants, excluding ammonia from the 200-East and 200-West Areas tank farms, 200 Area Effluent Treatment Facility, Central Waste Complex, T Plant Complex, and Waste Receiving and Processing Facility.
- (e) Criteria pollutants include particulate matter – total, nitrogen oxides, sulfur oxides, carbon monoxide, lead, and volatile organic compounds.



## 10.2 Ambient-Air Monitoring

BG Fritz and CJ Perkins

Atmospheric releases of radioactive materials from Hanford Site facilities and operations to the surrounding region are potential sources of human exposure. On the Hanford Site, radioactive constituents in air are monitored onsite near facilities and operations, at site-wide locations away from facilities, and offsite around the site perimeter as well as in nearby and distant communities. Information about these ambient-air monitoring efforts, including detailed descriptions of air-sampling and analysis techniques, is provided in DOE's Hanford Site environmental monitoring plan (DOE/RL-91-50, Rev. 4). Section 10.0 of this report briefly summarizes the ambient-air monitoring objectives and the projects that support them.

Comparing measured radionuclide concentrations from locations on and around the Hanford Site to concentrations measured at upwind locations assumed to be uninfluenced by Hanford Site operations provides an evaluation of the impact of radionuclide air emissions from the Hanford Site on surrounding ambient air. Complete listings of all radiological analytical results summarized in the following sections are reported separately (PNNL-18427, APP. 1; PNNL-18427, APP. 2).

In addition to the radiological monitoring networks, a small non-radiological air-monitoring system is operated onsite. This system measures concentrations of atmospheric particulate matter (dust) at a few locations on the Hanford Site. Results are primarily used for scientific studies in an attempt to better understand windblown dust on and around the Hanford Site.

### 10.2.1 Ambient-Air Monitoring Near Facilities and Operations

CJ Perkins

During 2008, a network of continuously operating samplers at 92 locations across the Hanford Site (Table 10.2.1) (sampling locations are illustrated in PNNL-18427, APP. 2) was used to monitor radioactive materials in air near site facilities and operations. Most air samplers were located at or within approximately 500 meters (1,640 feet) of sites and facilities having the potential for, or a history of, environmental releases. The samplers were primarily located in the prevailing downwind direction. Samples were collected according to a schedule established before the 2008 monitoring year. Airborne particle samples were collected at each location by drawing air through a glass-fiber filter. The filters were collected biweekly, field-surveyed for gross radioactivity, held for at least 7 days, and then analyzed for gross alpha and beta activity. The 7-day holding period was necessary to allow for the decay of naturally occurring, short-lived radionuclides that would otherwise obscure the detection of longer-lived radionuclides associated with emissions from nuclear facilities. The gross radioactivity measurements were used to indicate changes in trends in the near-facility environment.

For most specific radionuclide analyses, the amount of radioactive material collected on a single filter during a 2-week period was too small to be measured accurately. The samples were combined into either quarterly or semiannual

**Table 10.2.1. Monitoring Locations and Analyses for Ambient-Air Monitoring Samples Collected Near Hanford Site Facilities and Operations, 2008**

Site	Number of Samplers	EDP Code <sup>(a)</sup>	Analyses	
			Biweekly	Composite <sup>(b)</sup>
100-B/C Area Field Remediation Project	3	N466, N496, N497	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
100-D Area Field Remediation Project	4	N467, N468, N514, N515	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso, <sup>241</sup> Am
100-F Area Field Remediation Project	5	N519, N520, N521, N552, N553	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
100-H Area Field Remediation Project	4	N508, N509, N510, N574	Gross alpha,	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
100-K Area Spent Nuclear Fuels	8	N401, N402, N403, N404, N476, N477, N478, N479	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso, <sup>241</sup> Pu, <sup>241</sup> Am
118-K-1 Field Remediation Project (100-K Area)	3	N403, N534, N535	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
100-N Area D4 Project	3	N102, N103, N106	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso, <sup>241</sup> Am
100-IU-2/6 Field Remediation Project	2	N565, N566	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso, <sup>241</sup> Am
200-East Area	17	N019, N158, N498, N499, N957, N967, N968, N969, N970, N972, N973, N976, N977, N978, N984, N985, N999	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
BC Controlled Area	7	N569, N570, N571, N572, N573, N957, N978	Gross alpha gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso, <sup>241</sup> Pu, <sup>241</sup> Am
Canister Storage Building (200-East Area)	2	N480, N481	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso, <sup>241</sup> Pu, <sup>241</sup> Am
Integrated Disposal Facility (200-East Area)	2	N532, N559	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
200-West Area	23	N155, N161, N165, N168, N200, N304, N433, N441, N442, N449, N456, N457, N554, N555, N956, N963, N964, N965, N966, N974, N975, N987, N994	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
200-UW-1 Decontamination and Demolition Project (200-West Area)	4	N168, N550, N956, N963	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
300 Area Decontamination and Demolition Project	1	N557	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
300-FF-2 Field Remediation Project (300 Area)	6	N130, N527, N537, N538, N539, N540	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
Environmental Restoration Disposal Facility	4	N482, N517, N518, N963	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso
600 Area (Wye Barricade)	1	N981	Gross alpha, gross beta	GEA, <sup>90</sup> Sr, Pu-iso, U-iso

(a) Environmental data point (EDP) code = Sampler location code. See PNNL-18427, APP. 2.

(b) GEA = Gamma spectroscopy; strontium-90; Pu-iso = isotopic plutonium (<sup>238</sup>Pu, <sup>239/240</sup>Pu); U-iso = isotopic uranium (<sup>234</sup>U, <sup>235</sup>U, <sup>238</sup>U).

composite samples for each location to increase the accuracy of the analysis. Composite samples were routinely analyzed for gamma-emitting isotopes, strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240. In addition, americium-241 and plutonium-241 were analyzed at locations associated with spent nuclear fuel processing (Table 10.2.1).

Figure 10.2.1 shows the annual average air concentrations of selected radionuclides in the 100 and 200/600 Areas compared to EPA concentration values and air concentrations measured in distant communities. The EPA concentration values for environmental compliance (40 CFR 61, Appendix E, Table 2) are dose-based reference values used as indexes of performance. The concentration values are concentrations that would result in a dose of 10 millirem (100 microsievert) per year under conditions of continuous exposure. The 2008 data indicate a large degree of variability by location. Air samples collected from locations at or directly adjacent to Hanford Site facilities had higher radionuclide concentrations than samples collected farther away. In general, analytical results for most radionuclides were at or near Hanford Site background levels, which are much less than EPA concentration values but greater than those measured offsite. The data also show that concentrations of certain radionuclides were higher and widely variable within different onsite operational areas. Naturally occurring radionuclides beryllium-7 and potassium-40 were routinely identified. Appendix C, Table C.1 shows the annual average and maximum concentrations of radionuclides in air samples collected near facilities and operations during 2008. Pacific Northwest National Laboratory personnel collected concentrations of radionuclides in air in the 300 and 400 Areas, near some onsite remediation projects, and at offsite distant locations. Section 10.2.2 summarizes results for Pacific Northwest National Laboratory air samples.

Ambient-air monitoring was conducted at three locations at the 100-B/C Area Remedial Action Project site through January 2008 when cleanup activity was completed. Only uranium-234 was consistently detected, while uranium-238 and plutonium-239/240 were detected in 33% of the composited samples.

Ambient-air monitoring was conducted at four locations at the 100-D Field Remediation Project in 2008. Only uranium-234 and uranium-238 were consistently detected.

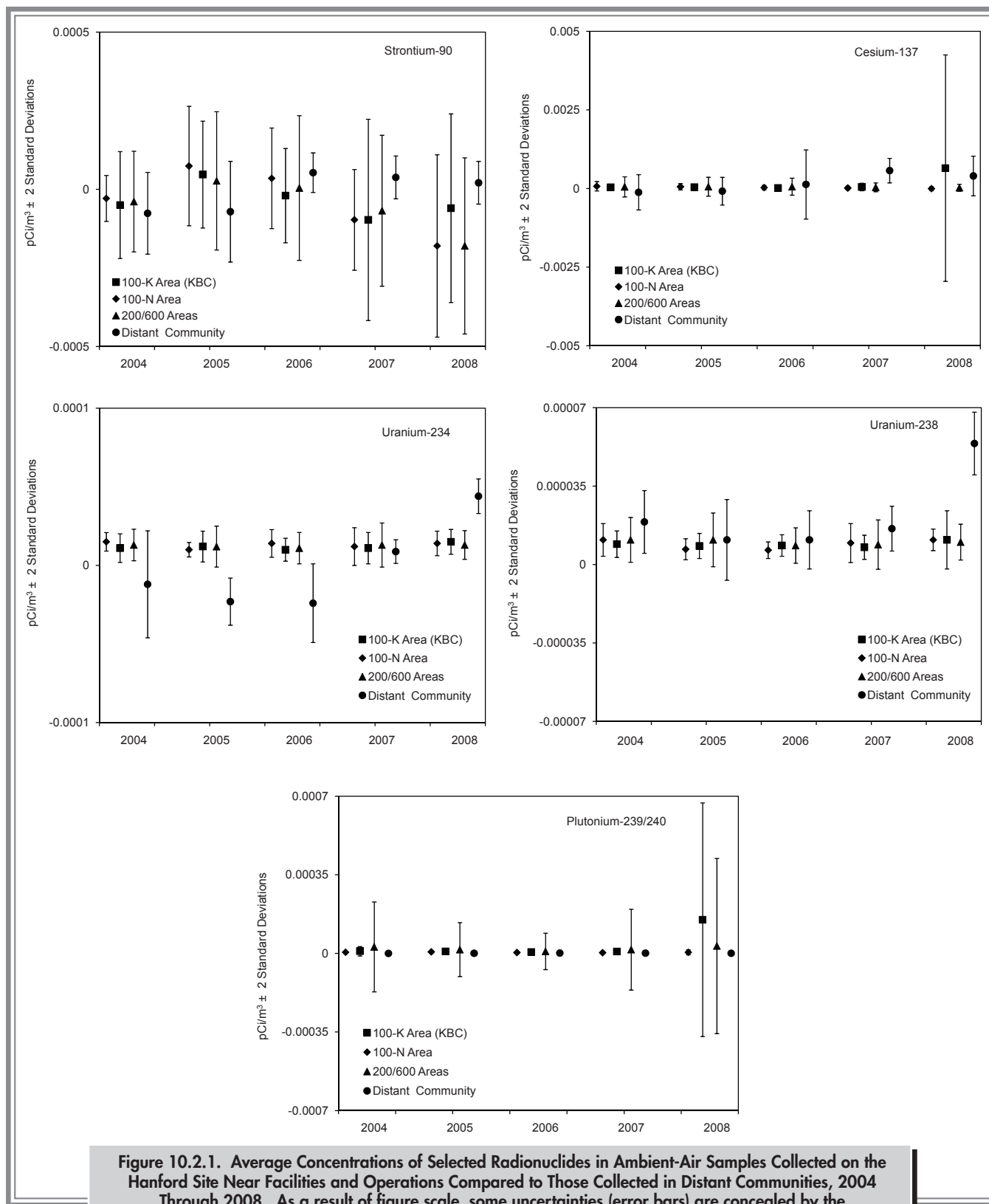
Air monitoring was conducted at five locations at the 100-F Area through April 2008. Results were similar to those observed in previous years; uranium-234 and uranium-238 were detected consistently in approximately 60% of the samples.

In July 2008, ambient-air monitoring was initiated at four locations at the 100-H Field Remediation Project. Uranium-234 and uranium-238 were detected in all of the composite samples and were at typical Hanford Site levels.

Air sampling in support of field remediation activities at the 100-IU-2 and 100-IU-6 Operable Units in the 600 Area was conducted at two ambient-air monitoring stations from February through April during 2008. Only the radionuclides uranium-234, uranium-235, and uranium-238 were detected in 50% of the near-facility air samples.

During 2008, ambient-air monitoring was conducted at eight locations in the 100-K Area (four stations each at the 100-K East and 100-K West Areas). During the second half of 2008, several significantly elevated sample results were observed at the four 100-K East sampling locations. Concentrations of plutonium-239/240 and americium-241 at all four locations were greater than 10% of EPA's concentration values (40 CFR 61, Appendix E, Table 2). The concentration of cesium-137 at one location was also greater than 10% of EPA's concentration value. All results were reported to the Washington State Department of Health. A review of the biweekly air sample results during the period revealed several statistically elevated alpha and beta concentrations during the period. The elevated results were likely attributable to increased demolition activities that took place in 2008 at this facility. For the overall 100-K Area during 2008, uranium-234, uranium-238, and americium-241 were detected in approximately 95% of the samples. Plutonium-239/240 was detected in approximately 63% of the samples, while cesium-137, uranium-235, plutonium-238, and plutonium-241 were detected in approximately 25% of the samples.





Air was sampled at three locations through mid-June 2008 to support the 118-K-1 Field Remediation Project (100-K Area). Uranium-234 and uranium-238 were detected in approximately 80% of the samples, and cesium-137 was detected in approximately 33% of the samples.

Analytical results from three ambient-air sampling locations at the 100-N D4 Project site (100-N Area) in 2008 were similar to those measured in previous years. Uranium-234, uranium-235, and uranium-238 were detected in approximately 95% of the composite samples, americium-241 was detected in 50% of the samples, and plutonium-239/240 was detected in only one sample.

Air sampling was conducted at 21 locations in the 200-East Area during 2008. Radionuclide levels measured in the 200-East Area ambient-air composite samples in 2008 were generally similar to those measured over the previous years. During the first half of 2008, one plutonium-239/240 result ( $1.8\text{E-}03$  pCi/m<sup>3</sup>) at air sampling location N977 (located east of the Plutonium Uranium Extraction [PUREX] Plant) was greater than 10% of EPA's concentration value ( $2.0\text{E-}4$  pCi/m<sup>3</sup>) (40 CFR 61, Appendix E, Table 2) and was reported to the Washington State Department of Health. A review of the biweekly air sample results during the period did not reveal statistically elevated alpha or beta concentrations. Uranium-234 and uranium-238 were detected in approximately 97% of the samples, uranium-235 was detected in approximately 25% of the samples, and cesium-137 and plutonium-239/240 was detected in less than 10% of the samples. Americium-241, analyzed in samples collected from two stations near the Canister Storage Building, was detected in 75% of the samples.

During 2008, air sampling in support of deactivation and decontamination activities at the 200-UW-1 Operable Unit was conducted at four ambient-air monitoring stations. Uranium-234 and uranium-238 were detected in 100% of the samples, and plutonium-239/240 were detected in approximately 25% of the samples.

Air sampling was conducted at 24 locations in the 200-West Area during 2008. Generally, radionuclide levels measured in the 200-West Area were similar to results for previous years. Uranium-234 and uranium-238 were detected in approximately 90% of the samples. Plutonium-239/240

was detected in approximately 40% of the samples and uranium-235 in approximately 20% of the samples. Plutonium-239/240 concentrations at air-sampling location N165 (near the 216-Z-9 Trench) were greater than 10% of the EPA concentration value (40 CFR 61, Appendix E, Table 2) for both 6-month composite samples collected in 2008. Required notifications were made to the Washington State Department of Health in both instances. The elevated plutonium values initially estimated to be related to (upwind) Plutonium Finishing Plant Closure Project activities are now believed to originate from the nearby retired 216-ZP-9 Trench. This facility received liquid waste from the Plutonium Finishing Plant until 1995.

Air sampling in support of decontamination and decommissioning activities in the 300 Area continued at one location in 2008. Results from the quarterly composited samples showed that only uranium-234 and uranium-238 were detected with any consistency (approximately 90% of the samples).

Air sampling was conducted during 2008 in support of remediation work in the 300-FF-2 Operable Unit (near the 300 Area) at six ambient-air monitoring stations. Uranium-234 and uranium-238 were detected in all of the samples, and uranium-235 was detected in 33% of the samples.

Air sampling was conducted in support of remediation activities at the BC Controlled Area site in the 600 Area at seven near-facility ambient-air monitoring stations from May through November during 2008. Generally, radionuclide levels measured at this site were similar to typical Hanford Site levels. Uranium-234 and uranium-238 were detected in 90% of the near-facility air samples, and americium-241 was detected in 33% of the samples. One cesium-137 result ( $2.5\text{E-}03$  pCi/m<sup>3</sup>) at air sampling location N570 (located in the southern portion of the remediation site) was greater than 10% of EPA's concentration value ( $1.9\text{E-}02$  pCi/m<sup>3</sup>) (40 CFR 61, Appendix E, Table 2) and was reported to the Washington State Department of Health. A review of the biweekly air sample results during the period revealed one statistically elevated alpha concentration during the final weeks of project activities.

The air-sampling network at the Environmental Restoration Disposal Facility (200-West Area) used two established

samplers for upwind monitoring (one near-facility sampler and one Pacific Northwest National Laboratory sampler, Station 13 at the 200-West Area southeast location) (Section 10.2.2) and three air samplers at the facility that provided downwind coverage. Most of the 2008 analytical results were comparable to those obtained in previous years. Uranium-234 and uranium-238 were detected in 100% of the near-facility composite samples, and plutonium-239/240 was detected in approximately 25% of the samples.

## 10.2.2 Site-Wide and Offsite Ambient-Air Monitoring

BG Fritz

During 2008, airborne radionuclide samples were collected by 42 continuously operating samplers on the Hanford Site. The sampling stations were grouped into four location classifications: site-wide (onsite; 23 stations), perimeter (11 stations), nearby communities (7 stations), and distant community (1 station) (Figure 10.2.2 and Table 10.2.2). Air samplers on the Hanford Site were located primarily around major operational areas to maximize the capability to detect radiological contaminants resulting from site operations. Perimeter samplers were located around the site boundary with emphasis on the prevailing downwind directions to the south and east. Samplers located in Basin City, Benton City, Kennewick, Mattawa, Othello, Pasco, and Richland, Washington, provided data for the nearest population centers. A sampler in Yakima, Washington, provided background data from a community essentially unaffected by Hanford Site operations.

### 10.2.2.1 Collection of Site-Wide and Offsite Ambient-Air Samples and Analytes Tested

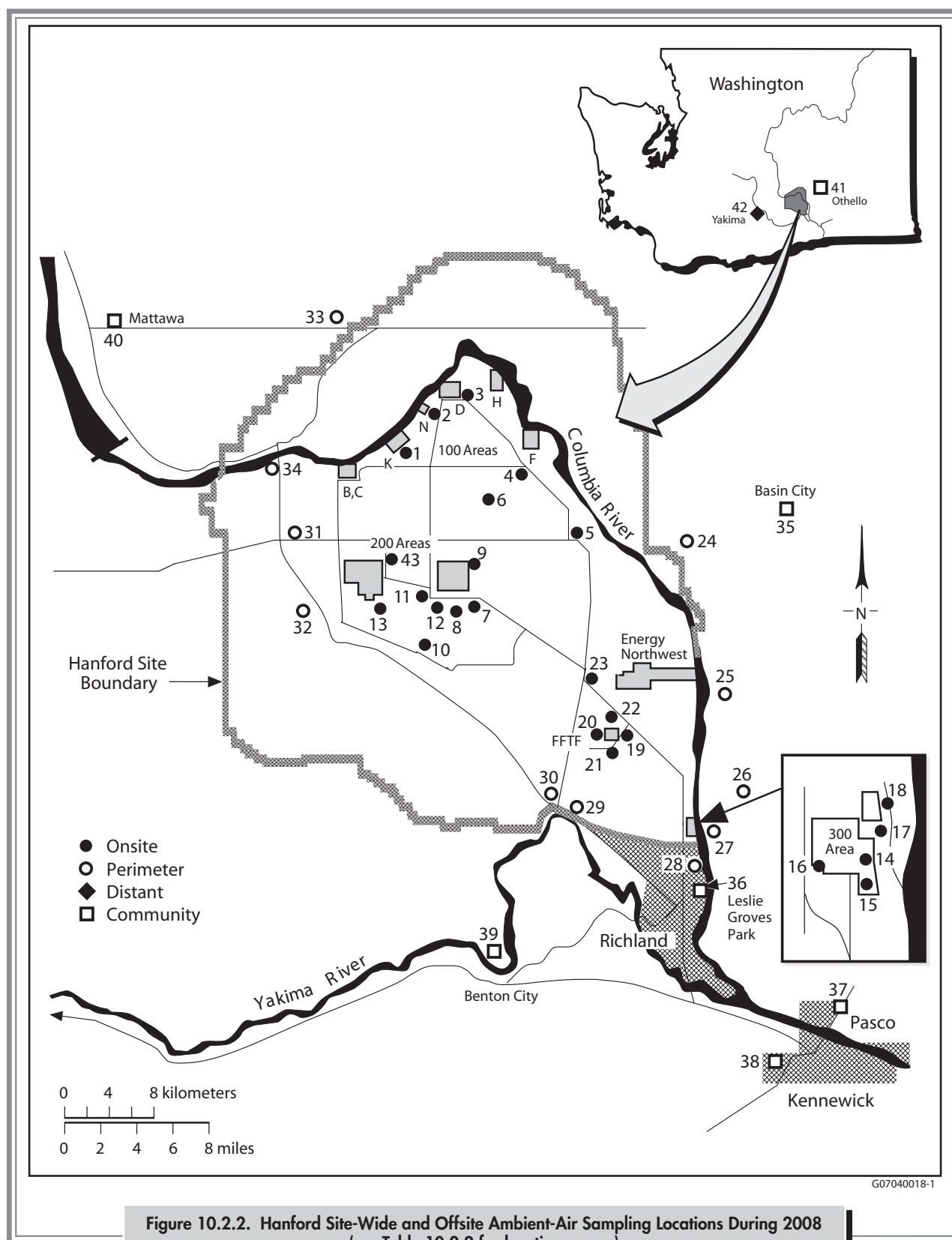
Samples were collected according to a schedule established before the monitoring year (PNNL-17282) and were analyzed for up to eight constituents (Table 10.2.2). Airborne particle samples were collected biweekly at each location by continuously drawing air through a glass-fiber filter. The filter samples were transported to an analytical laboratory and stored for at least 72 hours. The storage period is necessary to allow for the decay of short-lived, naturally occurring radionuclides (e.g., radon gas decay products) that would

otherwise obscure detection of longer-lived radionuclides potentially present from Hanford Site emissions. The filters were then analyzed for gross beta radiation. Selected filters were also analyzed for gross alpha radiation. Historically, for most radionuclides, the amount of radioactive material collected on a filter during a 2-week period has been too small to accurately analyze individual radionuclides of concern. Biweekly samples were combined into quarterly composite samples to increase the sensitivity and accuracy of the analysis. The compositing procedure results in a 12-week average concentration for specific radionuclides present in the atmosphere as particulates. The quarterly composite samples were analyzed for gamma-emitting radionuclides, and most were also analyzed for strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240. A new analytical laboratory was used in 2008 for sample analysis; some differences in the baseline concentrations were expected as a result of this change in analytical laboratories.

Atmospheric water vapor was collected for tritium analysis at 20 locations in 2008 by continuously drawing air through multi-column samplers containing adsorbent silica gel. The water-vapor samplers were exchanged every 4 weeks to prevent loss of the sample as a result of breakthrough (i.e., oversaturation). The collection efficiency of the silica gel adsorbent is discussed in Patton et al. (1997). The collected water was distilled from the silica gel and analyzed for its tritium content. In 2008, there was an incident with the analytical laboratory that resulted in cross-contamination of some samples. That incident is discussed in more detail in the next section of this report.

### 10.2.2.2 Ambient-Air Monitoring Results for Site-Wide and Offsite Samples

All sample results showed very low radiological concentrations in air during 2008. Almost all radionuclide concentrations (Table 10.2.3) were less than their respective DOE-derived concentration guide (Appendix D, Table D.2). The derived concentration guides are concentrations that would result in a dose of 100 millirem (1 millisievert) per year under conditions of continuous exposure. A more conservative dose standard is the EPA *Clean Air Act* standard of 10 millirem (100 microsievert) per year from airborne



**Table 10.2.2. Site-Wide and Offsite Ambient-Air Sampling Locations, Sample Composite Groups, and Analytes, 2008**

<b>Map<sup>(a)</sup></b>	<b>Location</b>	<b>Sampling Location<sup>(b)</sup></b>	<b>Analytes<sup>(c)</sup></b>	<b>Composite Group</b>	<b>Analytes<sup>(d)</sup></b>
<b>Site-Wide (Onsite)</b>					
1		100 K Area	Alpha, beta, <sup>3</sup> H	100 Areas	Gamma, Sr, Pu
2		100 N-1325 Crib	Alpha, beta, <sup>3</sup> H		
3		100 D Area	Alpha, beta		
4		100 F Met Tower	Alpha, beta	Hanford Townsite	Gamma, Sr, Pu
5		Hanford Townsite	Alpha, beta		
6		Gable Mt	Beta	Gable Mt	Gamma
7		200 ESE	Alpha, beta, <sup>3</sup> H, <sup>129</sup> I	200 E Area	Gamma, Sr, Pu, U
8		S of 200 E	Alpha, beta		
9		B Pond	Alpha, beta	B Pond	Gamma, Sr, Pu, U
10		Army Loop Camp	Alpha, beta	200 W South East	Gamma, Sr, Pu, U
11		200 Tel. Exchange	Alpha, beta, <sup>3</sup> H		
12		SW of B/C Crib	Alpha, beta		
13		200 W SE	Alpha, beta	200 West	Gamma, Sr, Pu, U
14		300 Water Intake	Alpha, beta, <sup>3</sup> H	300 Area	Gamma, Sr, Pu, U
15		300 South Gate	Alpha, beta, <sup>3</sup> H		
16		300 South West	Alpha, beta, <sup>3</sup> H		
17		300 Trench	Alpha, beta, <sup>3</sup> H U, gamma	300 NE	Sr, Pu
18		300 NE	Alpha, beta, <sup>3</sup> H U, gamma		
19		400 E	Alpha, beta, <sup>3</sup> H	400 Area	Gamma, Sr, Pu
20		400 W	Alpha, beta		
21		400 S	Alpha, beta		
22		400 N	Alpha, beta		
23		Wye Barricade	Alpha, beta	Wye Barricade	Gamma, Sr, Pu, U
<b>Perimeter</b>					
24		Ringold Met Tower	Alpha, beta, <sup>3</sup> H, <sup>129</sup> I	Ringold Met Tower	Gamma, Sr, Pu
25		W End of Fir Road	Alpha, beta	W End of Fir Road	Gamma, Sr, Pu, U
26		Dogwood Met Tower	Alpha, beta, <sup>3</sup> H	Dogwood Met Tower	Gamma, Sr, Pu, U
27		Byers Landing	Alpha, beta, <sup>3</sup> H, <sup>129</sup> I	Byers Landing	Gamma, Sr, Pu, U
28		Battelle Complex	Alpha, beta, <sup>3</sup> H	Battelle Complex	Gamma
29		Horn Rapids Substation	Alpha, beta	Prosser Barricade	Gamma, Sr, Pu, U
30		Prosser Barricade	Alpha, beta, <sup>3</sup> H		
31		Yakima Barricade	Alpha, beta	Yakima Barricade	Gamma, Sr, Pu
32		Rattlesnake Springs	Alpha, beta		
33		Wahluke Slope	Alpha, beta, <sup>3</sup> H	Wahluke Slope	Gamma, Sr, Pu
34		S End Vernita Bridge	Alpha, beta		

Table 10.2.2. (contd)

<u>Map<sup>(a)</sup></u> <u>Location</u>	<u>Sampling Location<sup>(b)</sup></u>	<u>Analytes<sup>(c)</sup></u>	<u>Composite Group</u>	<u>Analytes<sup>(d)</sup></u>
<b>Nearby Communities</b>				
35	Basin City School	Alpha, beta, <sup>3</sup> H	Basin City School	Gamma, Sr, Pu, U
36	Leslie Groves-Richland	Alpha, beta, <sup>3</sup> H	Leslie Groves-Richland	Gamma, Sr, Pu, U
37	Pasco	Beta	Tri-Cities	Gamma, Sr, Pu
38	Kennewick	Alpha, beta		
39	Benton City	Beta	Benton City	Gamma
40	Mattawa	Beta	Mattawa	Gamma
41	Othello	Beta	Othello	Gamma
<b>Distant Communities</b>				
42	Yakima	Alpha, beta, <sup>3</sup> H, <sup>129</sup> I	Yakima	Gamma, Sr, Pu, U
<b>Non-Radiological Monitoring</b>				
43	Hanford Meteorology Station	PM <sub>10</sub> , PM <sub>2.5</sub> <sup>(e)</sup>		

(a) See Figure 10.2.2.

(b) Sampling location names are derived from the Hanford Environmental Information System database.

(c) Alpha (gross) and beta (gross) samples were collected and analyzed every 2 weeks; <sup>3</sup>H samples were collected and analyzed every 4 weeks; and <sup>129</sup>I samples were collected every 4 weeks but were not analyzed because of an equipment problem at the analytical laboratory.

(d) Gamma spectroscopy, strontium-90, isotopic plutonium (<sup>238</sup>Pu, <sup>239/240</sup>Pu), and isotopic uranium (<sup>234</sup>U, <sup>235</sup>U, <sup>238</sup>U) analyses were performed on quarterly composite samples.

(e) See Section 10.2.2.3.

radiological material. Again, almost all radionuclide concentrations in air samples collected in 2008 were low enough to meet the EPA standard; the few samples that did exceed it were tritium samples.

Tritium concentrations measured during 2008 were impacted by a cross-contamination incident at the analytical laboratory. The root-cause of the incident was never identified; however, the contamination event was traced back to non-Hanford Site samples being analyzed in the same analytical facility, presumably with some common hardware. The analytical laboratory began receiving the non-Hanford Site samples in June 2008; these samples had much higher tritium concentrations than typical Hanford Site samples, resulting in the cross-contamination incident. Results for the entire year are presented because determining which samples were impacted proved impossible. However, results for 2008 before the cross-contamination

incident (January through May 2008) are also provided (Table 10.2.3). This 5-month period is likely a more accurate representation of the concentrations present during 2008 than the entire 12-month data set. There is a marked increase in concentrations after May 2008, coinciding with the suspected source of laboratory cross-contamination.

Gross alpha concentrations were essentially the same at Hanford Site-wide and offsite locations during 2008 (Figure 10.2.3). There were no statistically significant differences (two-sample means t-test, 95% confidence level) in the average gross alpha concentrations measured at the different distance classes. The highest 2-week average gross alpha concentration for 2008 was observed at a site-wide location near the 300 Area (3,400 aCi/m<sup>3</sup> [120 µBq/m<sup>3</sup>]). The average gross alpha concentrations observed in individual location groups during 2008 were higher than the 10-year average concentrations observed

Table 10.2.3. Airborne Radionuclide Concentrations in the Environs of the Hanford Site, 2008 Compared to Previous Years

Radionuclide (approximate detection limit)	Location Group <sup>(a)</sup>	2008				1997-2006				Derived Concentration Guide <sup>(e)</sup>
		No. of Samples	No. of Detections <sup>(b)</sup>	Maximum <sup>(c)</sup>	Average <sup>(d)</sup>	No. of Samples	No. of Detections <sup>(b)</sup>	Maximum <sup>(c)</sup>	Average <sup>(d)</sup>	
				pCi/m <sup>3(f)</sup>	pCi/m <sup>3(f)</sup>			pCi/m <sup>3(f)</sup>	pCi/m <sup>3(f)</sup>	pCi/m <sup>3(f)</sup>
Tritium Entire year (1.0 pCi/m <sup>3</sup> )	300 Area	77	63	2,500 ± 63	55 ± 590	603	492	25 ± 3.0	4.3 ± 7.6	100,000
	Site-wide	64	37	99 ± 6.6	5.5 ± 26	581	376	16 ± 2.4	2.3 ± 4.8	
	Perimeter	90	62	76 ± 8.1	10 ± 30	634	384	74 ± 10	3.4 ± 12	
	Nearby communities	26	19	62 ± 7.9	13 ± 34	345	215	61 ± 8.5	3.6 ± 12	
	Distant communities	13	7	9.8 ± 2.2	3.8 ± 7.7	235	98	24 ± 3.8	1.8 ± 5.0	
Tritium Non- contaminated January through May 2008 (1.0 pCi/m <sup>3</sup> )	300 Area	36	27	23 ± 4.1	4.6 ± 9.1	603	492	25 ± 3.0	4.3 ± 7.6	100,000
	Site-wide	28	14	6.5 ± 1.4	1.8 ± 2.8	581	376	16 ± 2.4	2.3 ± 4.8	
	Perimeter	36	12	16 ± 3.4	2.4 ± 7.4	634	384	74 ± 10	3.4 ± 12	
	Nearby communities	10	4	53 ± 6.9	7.2 ± 32	345	215	61 ± 8.5	3.6 ± 12	
	Distant communities	6	2	2.3 ± 0.54	0.85 ± 1.9	235	98	24 ± 3.8	1.8 ± 5.0	
Gross beta (0.001 pCi/m <sup>3</sup> )	Site-wide	579	579	0.070 ± 0.0033	0.019 ± 0.022	5,166	5,156	0.14 ± 0.0089	0.016 ± 0.019	No standard
	Perimeter	285	285	0.061 ± 0.0027	0.019 ± 0.020	2,279	2,276	0.098 ± 0.010	0.016 ± 0.018	
	Nearby communities	166	166	0.056 ± 0.0028	0.018 ± 0.019	1,887	1,885	0.059 ± 0.0059	0.016 ± 0.018	
	Distant communities	26	26	0.044 ± 0.0020	0.016 ± 0.016	501	499	0.061 ± 0.0024	0.015 ± 0.018	
				aCi/m <sup>3(g)</sup>	aCi/m <sup>3(g)</sup>			aCi/m <sup>3(g)</sup>	aCi/m <sup>3(g)</sup>	aCi/m <sup>3(g)</sup>
Gross alpha (350 aCi/m <sup>3</sup> )	Site-wide	579	496	3,400 ± 970	900 ± 1,200	4,965	3,403	6,300 ± 3,300	600 ± 880	No standard
	Perimeter	284	246	3,300 ± 3,300	920 ± 1,100	2,188	1,577	5,100 ± 1,300	590 ± 810	
	Nearby communities	82	76	4,800 ± 1,200	950 ± 1,700	991	722	6,300 ± 1,700	630 ± 930	
	Distant communities	26	20	2,000 ± 680	770 ± 1,000	501	327	5,500 ± 1,900	550 ± 920	
Cobalt-60 (1,400 aCi/m <sup>3</sup> )	Site-wide	44	1	1,200 ± 670	26 ± 390	471	5	3,800 ± 2,500	73 ± 740	80,000,000
	Perimeter	32	0	1,700 ± 2,200	120 ± 600	320	2	1,000 ± 530	18 ± 730	
	Nearby communities	21	0	1,200 ± 2,100	-15 ± 500	262	1	1,800 ± 3,600	43 ± 830	
	Distant communities	4	0	540 ± 1,000	380 ± 230	88	2	730 ± 1,000	100 ± 580	
Strontium-90 (80 aCi/m <sup>3</sup> )	Site-wide	32	0	76 ± 65	7.6 ± 65	274	67	1,300 ± 280	23 ± 190	9,000,000
	Perimeter	28	1	110 ± 60	18 ± 81	189	24	390 ± 79	6.5 ± 100	
	Nearby communities	12	0	140 ± 117	14 ± 100	108	13	220 ± 190	13 ± 110	
	Distant communities	4	0	53 ± 33	21 ± 68	57	4	300 ± 100	-0.053 ± 130	
Cesium-137 (1,100 aCi/m <sup>3</sup> )	Site-wide	44	0	1,000 ± 900	65 ± 310	471	6	3,500 ± 1,500	11 ± 670	400,000,000
	Perimeter	32	0	1,400 ± 1,100	44 ± 430	320	3	4,600 ± 1,300	36 ± 800	
	Nearby communities	21	0	2,700 ± 2,500	340 ± 740	262	2	2,100 ± 3,100	31 ± 650	
	Distant communities	4	0	1,300 ± 1,300	400 ± 630	88	1	520 ± 520	-4.9 ± 520	
Uranium-234 (10 aCi/m <sup>3</sup> )	Site-wide	28	23	62 ± 33	43 ± 18	217	188	150 ± 52	21 ± 44	90,000
	Perimeter	16	14	94 ± 30	60 ± 40	108	96	135 ± 32	25 ± 47	
	Nearby communities	12	9	100 ± 28	53 ± 44	81	71	58 ± 21	22 ± 37	
	Distant communities	4	3	50 ± 17	44 ± 11	57	48	41 ± 15	14 ± 29	

Table 10.2.3. (contd)

Radionuclide (approximate detection limit)	Location Group <sup>(a)</sup>	2008				1997-2006				Derived Concentration Guide <sup>(e)</sup>
		No. of Samples	No. of Detections <sup>(b)</sup>	Maximum <sup>(c)</sup>	Average <sup>(d)</sup>	No. of Samples	No. of Detections <sup>(b)</sup>	Maximum <sup>(c)</sup>	Average <sup>(d)</sup>	
				aCi/m <sup>3(g)</sup>	aCi/m <sup>3(g)</sup>			aCi/m <sup>3(g)</sup>	aCi/m <sup>3(g)</sup>	
Uranium-235 (10 aCi/m <sup>3</sup> )	Site-wide	28	1	9.6 ± 9.5	3.0 ± 6.1	217	10	6.5 ± 8.5	0.32 ± 3.0	100,000
	Perimeter	16	0	19 ± 13	6.1 ± 9.4	108	7	6.0 ± 6.0	0.58 ± 3.3	
	Nearby communities	12	2	14 ± 11	4.2 ± 9.9	81	5	6.2 ± 5.6	0.25 ± 3.9	
	Distant communities	4	0	10 ± 8.2	5.1 ± 7.8	57	0	7.0 ± 9.3	-0.18 ± 4.2	
Plutonium-238 (3 aCi/m <sup>3</sup> )	Site-wide	40	0	1.7 ± 1.7	0.28 ± 1.4	274	16	13 ± 3.9	0.095 ± 2.3	30,000
	Perimeter	24	2	4.9 ± 3.1	0.78 ± 3.1	189	1	1.9 ± 1.4	-0.11 ± 1.1	
	Nearby communities	12	1	3.8 ± 2.9	0.51 ± 2.6	108	2	3.7 ± 3.6	0.0061 ± 1.5	
	Distant communities	4	1	7.5 ± 4.7	2.1 ± 7.4	57	0	0.98 ± 1.4	-0.32 ± 1.1	
Uranium-238 (10 aCi/m <sup>3</sup> )	Site-wide	28	21	77 ± 22	40 ± 24	217	201	160 ± 37	22 ± 40	100,000
	Perimeter	16	15	96 ± 55	60 ± 37	108	105	140 ± 32	27 ± 37	
	Nearby communities	12	9	85 ± 25	54 ± 40	81	78	56 ± 18	24 ± 22	
	Distant communities	4	3	58 ± 18	54 ± 14	57	56	33 ± 15	17 ± 13	
Plutonium-239/240 (3 aCi/m <sup>3</sup> )	Site-wide	40	8	21 ± 6.6	1.6 ± 8.7	274	74	36 ± 6.4	1.4 ± 7.0	20,000
	Perimeter	24	3	17 ± 6.1	1.1 ± 7.0	189	13	5.2 ± 2.5	0.31 ± 1.7	
	Nearby communities	12	1	3.4 ± 2.2	0.63 ± 2.0	108	7	3.2 ± 4.6	0.39 ± 1.4	
	Distant communities	4	0	1.8 ± 2.0	0.62 ± 1.8	57	2	3.2 ± 2.9	0.29 ± 1.7	

(a) Location groups are identified in Table 10.2.2.

(b) Detection is defined as a value reported above the minimum detectable activity and above the total propagated analytical uncertainty.

(c) Maximum single sample result ± total analytical uncertainty. Negative concentration values are explained in Appendix A.

(d) Average of all samples ± 2 times the standard deviation.

(e) DOE-derived concentration guide (see Appendix D, Table D.2).

(f) 1 pCi = 0.037 Bq.

(g) There are 1 million attocuries (aCi) in 1 picocurie (pCi).

from 1997 through 2006, while the maximum concentrations measured were lower than the maximum concentrations observed from 1997 through 2006 (Table 10.2.3). This increase in average concentrations probably resulted from the new analytical laboratory used in 2008 rather than any real change in atmospheric concentrations of radionuclides across the Hanford Site.

Gross beta concentrations in air peaked during the fall and winter months in 2008 (Figure 10.2.4), repeating a pattern of natural radioactivity fluctuations (Eisenbud 1987). The annual average gross beta concentrations at site-wide locations during 2008 were slightly higher than the concentration measured at the distant location. The differences were small and not statistically significant (two-sample means t-test, 95% confidence level). The average gross beta concentrations reported at each distance class for 2008 were higher than concentrations measured from 1997 through 2006 (Table 10.2.3). In 2004, gross beta concentrations appeared to be inversely proportional to the average wind speed over the sampling period (i.e., as wind speed increased, concentrations decreased). This pattern was evident again in 2008 (Figure 10.2.4).

Plutonium-238 was detected in four air samples collected during 2008 (Table 10.2.3). The maximum reported plutonium-238 concentration in 2008 was  $7.5 \text{ aCi/m}^3$  ( $0.28 \text{ } \mu\text{Bq/m}^3$ ), which was reported at the distant monitoring location.

The annual average plutonium-239/240 concentration in air samples collected in 2008 at Hanford Site-wide

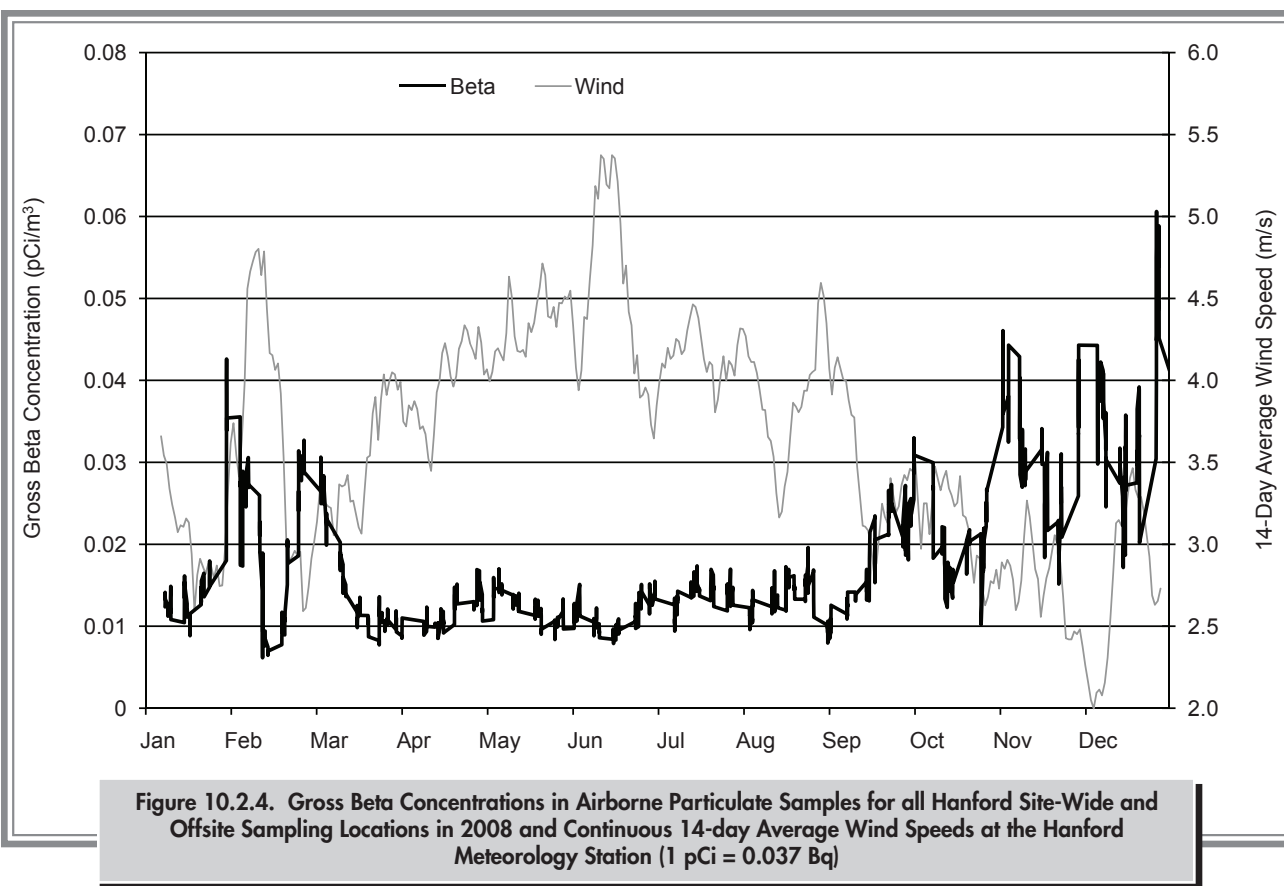
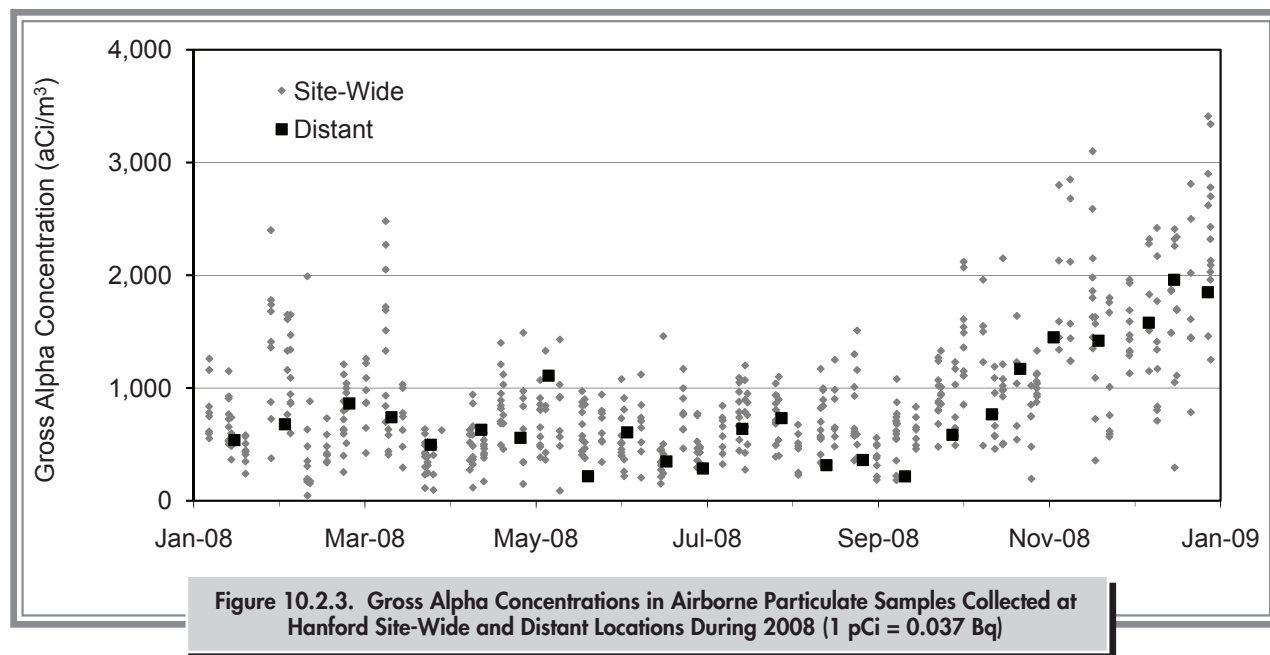
locations was  $1.6 \text{ aCi/m}^3$  ( $0.059 \text{ } \mu\text{Bq/m}^3$ ). Of the 40 site-wide samples analyzed for plutonium-239/240, 8 had detectable concentrations (Table 10.2.3). The maximum reported concentration ( $21 \text{ aCi/m}^3$  [ $0.77 \text{ } \mu\text{Bq/m}^3$ ]) was 1,800 times less than the DOE-derived concentration guide ( $20,000 \text{ aCi/m}^3$  [ $740 \text{ } \mu\text{Bq/m}^3$ ]) for plutonium-239/240.

Average isotopic uranium concentrations (uranium-234, uranium-235, and uranium-238) in airborne particulate matter in 2008 were lower than average concentrations measured from 1997 through 2006 for all location groups (Table 10.2.3). The 2008 annual average uranium-238 concentration at the site perimeter was  $60 \text{ aCi/m}^3$  ( $2.2 \text{ } \mu\text{Bq/m}^3$ ). The annual average site-wide and perimeter uranium-238 concentrations were not statistically different from the concentration measured at the distant location (two-sample means t-test, 95% confidence level). The maximum uranium-238 concentration measured in 2008 ( $96 \text{ aCi/m}^3$  [ $3.6 \text{ } \mu\text{Bq/m}^3$ ]) was only 0.045% of the DOE-derived concentration guide for uranium-238.

Seventy-six airborne particulate samples were analyzed for strontium-90 in 2008 (Table 10.2.3). One sample collected on the site perimeter had a detectable concentration.

All quarterly composite samples collected in 2008 were examined with gamma spectroscopy. Naturally occurring beryllium-7 and potassium-40 were occasionally measured with detectable concentrations. The potential Hanford Site-origin gamma-emitting radionuclide cobalt-60 was detected in a single site-wide sample. No samples had detectable concentrations of cesium-137.







## 10.3 Liquid Effluents from Hanford Site Facilities

DJ Rokkan

Liquid effluents are discharged from a few facilities on the Hanford Site. Effluent streams are sampled for gross alpha and gross beta concentrations, as well as for concentrations of selected radionuclides.

Contaminant data from liquid effluent sampling and analyses are reported to DOE annually in an environmental release report (HNF-EP-0527-18). That report includes summaries of monitoring results on liquid effluents discharged to the Columbia River, which are regulated by the National Pollutant Discharge Elimination System (NPDES) (40 CFR 122) permit and reported to EPA, and liquid effluent discharges to the soil, which are regulated by WAC 173-216 and reported to the Washington State Department of Ecology.

### 10.3.1 Radionuclides in Liquid Effluent

During 2008, facilities in the 200 Areas discharged radioactive liquid effluent to the ground at a single location, the 616-A Crib, also known as the State-Approved Land Disposal Site. Table 10.3.1 summarizes this effluent.

**Table 10.3.1. Radionuclides in 200 Areas Liquid Effluent Discharged to the State-Approved Land Disposal Site on the Hanford Site, 2008**

<u>Radionuclide</u>	<u>Half-Life</u>	<u>Release, Ci<sup>(a)</sup></u>
Tritium	12.35 yr	0.47

(a) 1 Ci =  $3.7 \times 10^{10}$  Bq.

Table 10.3.2 summarizes liquid effluent discharged in the 100 Areas. Generally, this effluent consisted of secondary cooling water discharged from the 100-K Area to the Columbia River via the NPDES-permitted 1908-K Outfall.

**Table 10.3.2. Radionuclides in Liquid Effluent from the 100-K Area Discharged to the Columbia River, 2008**

<u>Radionuclide</u>	<u>Half-Life</u>	<u>Release, Ci<sup>(a)</sup></u>
Strontium-90	29.12 yr	$2.1 \times 10^{-4}$
Plutonium-239/240	24,065 yr	$7.7 \times 10^{-6}$

(a) 1 Ci =  $3.7 \times 10^{10}$  Bq.

### 10.3.2 Non-Radioactive Hazardous Materials in Liquid Effluent

Non-radioactive hazardous materials in liquid effluent are monitored in the 100, 200, 300, and 400 Areas. The effluent is discharged to the State-Approved Land Disposal Site and to the Columbia River. Effluent entering the environment at designated discharge points is sampled and analyzed to determine compliance with the NPDES (40 CFR 122) and state waste discharge permits (WAC 173-216) for the Hanford Site. The release totals are immediately reported to EPA if chemicals in liquid effluent exceed quantities reportable under CERCLA. If chemical levels in effluent remain stable at predicted levels, these levels may be reported annually with EPA permission. Section 5.3.1 provides a brief synopsis of the NPDES and state waste discharge permits.



## 10.4 Surface-Water and Sediment Monitoring

GW Patton

Samples of surface water and sediment on and near the Hanford Site were collected and analyzed to determine the concentrations of radiological and chemical contaminants in the aquatic environment attributed to the Hanford Site. Surface-water bodies monitored included the Columbia River, onsite ponds, and offsite irrigation sources (Figure 10.4.1). Aquatic sediment monitoring was conducted for the Columbia River and one onsite pond. Tables 10.4.1 and 10.4.2 summarize the sampling locations, types, and frequencies, as well as sample analyses included in surface-water and sediment monitoring during 2008. This section describes the monitoring efforts and summarizes the results for these aquatic environments. Detailed analytical results are reported in PNNL-18427, APP. 1.

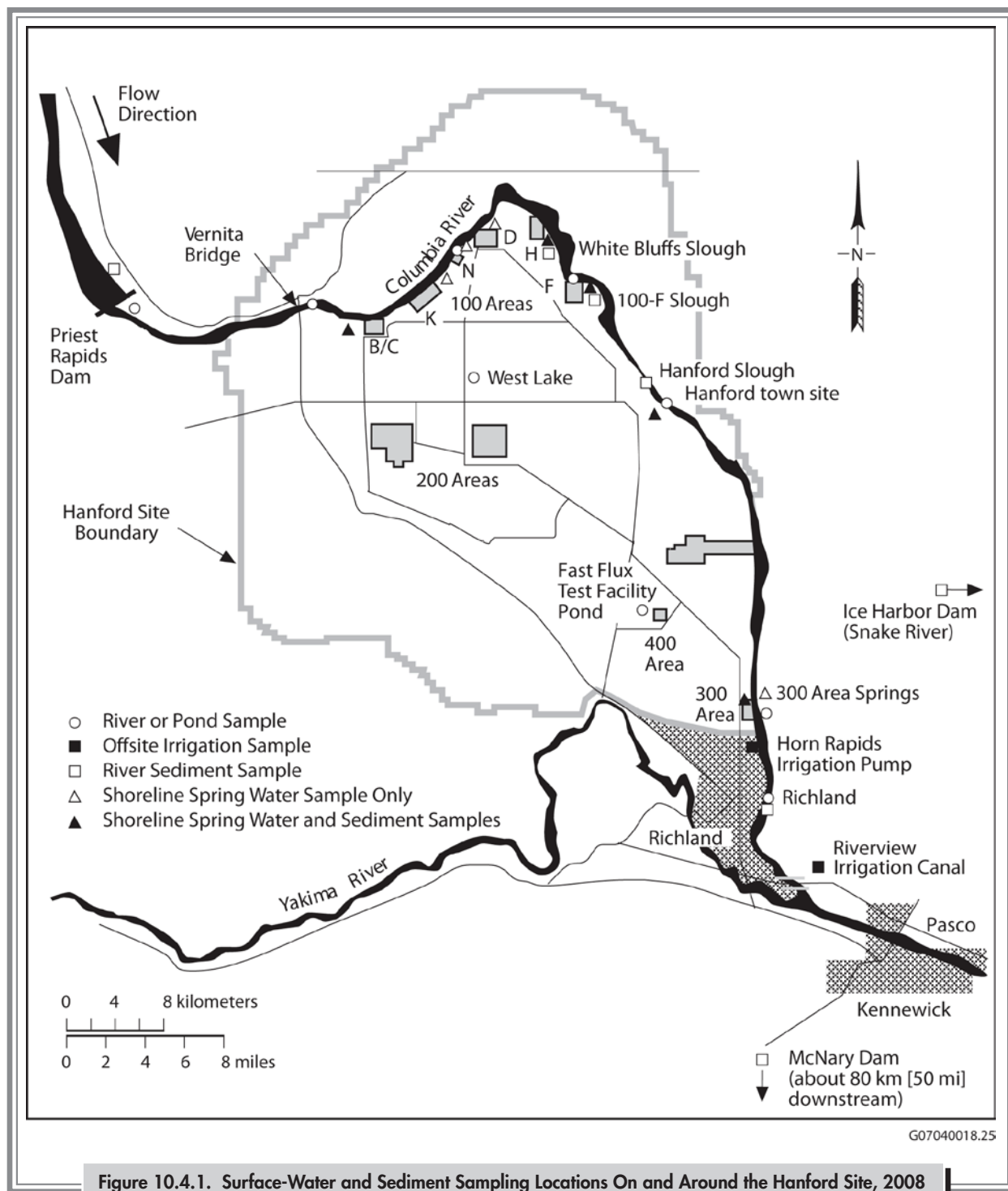
### 10.4.1 Monitoring of Columbia River Water

The Columbia River is one of the largest rivers in the continental United States in terms of total flow and is the dominant surface-water body on the Hanford Site. The original selection of the Hanford Site for plutonium production was based partly on the abundant water supply offered by the river. The river flows through the northern portion of the site and forms part of the site's eastern boundary. The river is used as a source of drinking water for onsite facilities and communities downstream from the Hanford Site. Water removed from the river immediately downstream of the site is also used for crop irrigation in Benton and Franklin Counties. In addition, the Hanford Reach of the Columbia River is used for a variety of recreational activities, including hunting, fishing, boating, water skiing, and swimming.

Originating in the Rocky Mountains of eastern British Columbia, the Columbia River and its tributaries drain

an area of approximately 670,000 square kilometers (260,000 square miles) before discharging to the Pacific Ocean. Three dams in Canada and 11 dams in the United States regulate the flow of the river; 4 of the dams are downstream of the Hanford Site. Priest Rapids Dam is the nearest upstream dam, and McNary Dam is the nearest downstream dam to the site. The Hanford Reach of the Columbia River extends from Priest Rapids Dam downstream to the head of Lake Wallula, created by McNary Dam, near the city of Richland, Washington. The Hanford Reach is the last stretch of the Columbia River in the United States upstream of Bonneville Dam (the first dam upstream from the ocean) that remains unimpounded.

River flow through the Hanford Reach fluctuates significantly and is controlled primarily by operations at upstream dams. The annual average flow of the Columbia River downstream of Priest Rapids Dam is approximately 3,400 cubic meters (120,000 cubic feet) per second (WA-94-1). In 2008, the Columbia River had below normal flows; the average daily flow rate downstream of Priest Rapids Dam was 3,069 cubic meters (108,400 cubic feet) per second. The peak monthly average flow rate occurred during June (6,197 cubic meters [218,800 cubic feet] per second) (Figure 10.4.2). The lowest monthly average flow rate occurred during September (1,826 cubic meters [64,480 cubic feet] per second), based on mean daily flows. Daily average flow rates varied from 1,130 to 7,467 cubic meters (39,900 to 263,700 cubic feet) per second during 2008. As a result of fluctuation in discharges, the depth of the river varies significantly over time. The river stage (water-surface level) may change along the Hanford Reach by up to 3 meters (10 feet) within a few hours (see Section 3.3.7 in PNL-10698). Seasonal changes of approximately the same magnitude are also observed. River-stage fluctuations



**Table 10.4.1. Surface-Water Surveillance On and Near the Hanford Site, 2008**

<u>Location</u>	<u>Sample Type</u>	<u>Frequency</u>	<u>Analyses</u>
<b>Columbia River - Radiological</b>			
Priest Rapids Dam and Richland	Cumulative Particulate (filter)	M Comp <sup>(a)</sup>	Alpha, beta, low <sup>3</sup> H, <sup>(b)</sup> <sup>90</sup> Sr, <sup>99</sup> Tc, U <sup>(c)</sup>
		M Cont <sup>(d)</sup>	Gamma energy analysis
		Q Cont <sup>(e)</sup>	Pu <sup>(f)</sup>
	Soluble (resin)	M Cont	Gamma energy analysis
		Q Cont	Pu
Vernita Bridge and Richland	Grab (transects)	Quarterly	Low <sup>3</sup> H, <sup>90</sup> Sr, U
100-N and 300 Areas and Hanford town site	Grab (transects)	Annually	Low <sup>3</sup> H, <sup>90</sup> Sr, U
<b>Columbia River - Chemical</b>			
Vernita Bridge and Richland <sup>(g)</sup>	Grab	3/year	Temperature, dissolved oxygen, turbidity, pH, alkalinity, anions, suspended solids, dissolved solids, specific conductance, hardness (as CaCO <sub>3</sub> ), Ca, P, Cr, Mg, N, Fe, NH <sub>3</sub> , NO <sub>3</sub> + NO <sub>2</sub>
	Grab (transects)	Quarterly	Anions
	Grab (transects)	Annually	Metals (filtered and unfiltered), volatile organic compounds
100-N and 300 Areas and Hanford town site	Grab (transects)	Annually	Metals (filtered and unfiltered), anions
<b>Onsite Ponds</b>			
West Lake <sup>(h)</sup>	Grab	Quarterly	Alpha, beta, <sup>3</sup> H, <sup>90</sup> Sr, <sup>99</sup> Tc, U, gamma energy analysis
Fast Flux Test Facility Pond	Grab	Quarterly	Alpha, beta, <sup>3</sup> H, gamma energy analysis
<b>Offsite Irrigation Water</b>			
Riverview irrigation canal	Grab	3/year	Alpha, beta, <sup>3</sup> H, <sup>90</sup> Sr, U, gamma energy analysis
Horn Rapids	Grab	3/year	Alpha, beta, <sup>3</sup> H, <sup>90</sup> Sr, U, gamma energy analysis

(a) M Comp indicates river water was collected hourly and composited monthly for analysis.

(b) Low <sup>3</sup>H = Low-level tritium analysis (10-pCi/L detection limit), which includes an electrolytic preconcentration.

(c) U = Isotopic uranium-234, uranium-235, and uranium-238.

(d) M Cont = River water was sampled for 2 weeks by continuous flow through a filter and resin column, and multiple samples were composited monthly for analysis.

(e) Q Cont = River water was sampled for 2 weeks by continuous flow through a filter and resin column, and multiple samples were composited quarterly for analysis.

(f) Pu = Isotopic plutonium-238 and plutonium-239/240.

(g) Numerous water-quality analyses are performed by the U.S. Geological Survey under contract with Pacific Northwest National Laboratory.

(h) Because of high concentrations of suspended sediment, West Lake water is analyzed for tritium; all other analytes are for sediment samples.

Comp = Composite.

Cont = Continuous.

M = Monthly.

Q = Quarterly.

measured at the 300 Area are approximately one-half the magnitude of those measured near the 100 Areas because of the effect of the pool behind McNary Dam (PNL-8580) and the relative distance of each area from Priest Rapids Dam. The width of the river varies from approximately 300 to 1,000 meters (980 to 3,300 feet) as it passes through the Hanford Site.

Pollutants from multiple sources are present in the Columbia River as it passes through the Hanford Reach. These

sources include upstream industry, atmospheric fallout that collects in the river's drainage basin, runoff from agricultural operations, and discharge from the aquifers on either side of the river. Hanford Site pollutants, both radiological and chemical, enter the Columbia River along the Hanford Reach. Effluent from each direct discharge point is monitored routinely and reported by the responsible operating contractor (Section 10.3). Direct discharges are identified and regulated for non-radiological constituents under the NPDES in compliance with the *Clean Water Act of*

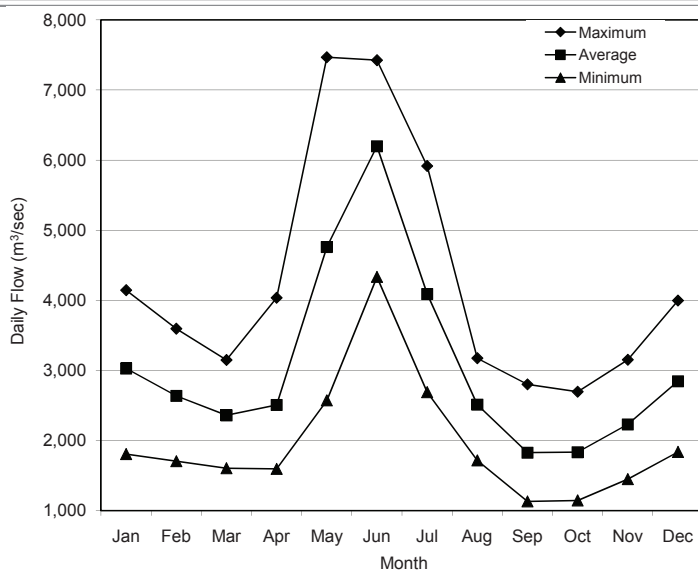
**Table 10.4.2. Columbia River Sediment Surveillance, 2008**

<u>Location<sup>(a)</sup></u>	<u>Frequency</u>	<u>Analyses</u>
<b>Columbia River</b>		River-sediment analyses included gamma energy analysis, <sup>90</sup> Sr, U, <sup>(b)</sup> Pu, <sup>(c)</sup> metals, and total organic carbon
Priest Rapids Dam: Two locations near the dam	Annually	
White Bluffs Slough	Annually	
100-F Slough	Annually	
Hanford Slough	Annually	
Richland	Annually	
McNary Dam: Two locations near the dam	Annually	

(a) See Figure 10.4.1.

(b) U = Isotopic uranium-234, uranium-235, and uranium-238 analyzed by alpha spectrometry (alpha energy analysis).

(c) Pu = Isotopic plutonium-238 and plutonium-239/240.



**Figure 10.4.2. Monthly Average, Maximum, and Minimum Columbia River Flow Rates at Priest Rapids Dam, Washington, 2008 (multiply m³/sec by 35.31 to obtain ft³/sec)**

1977 (Section 5.3.1). In addition to permitted direct discharges of liquid effluent from Hanford Site facilities, contaminants in groundwater from past operational releases to the ground discharge into the river (see Section 10.5 of this report; DOE/RL-92-12, Rev. 1; PNL-5289; PNL-7500; WHC-SD-EN-TI-006). In general, groundwater discharges are considered to be the dominant pathway for Hanford Site contaminants to enter the Columbia River.

Washington State has classified the general water-use and water-quality criteria for the Columbia River downstream from Grand Coulee Dam with an aquatic-life designation of “salmonid spawning, rearing, and migration,” which provides for the protection of spawning, rearing, and migration of salmon and trout as well as other associated aquatic life. The recreational uses designation for the Columbia River downstream from Grand Coulee Dam is “primary contact,” which provides for activities that may involve complete submersion by the participant. The entire Columbia River is designated as suitable for all water supply and miscellaneous uses by Washington State.

### 10.4.1.1 Collection of Columbia River Water Samples and Analytes of Interest

During 2008, Columbia River water samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the city of Richland and analyzed for radionuclides. Cross-river transects and near-shore locations near Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and Richland were analyzed for both radionuclides and chemicals (Figure 10.4.1). Samples were collected upstream from Hanford Site facilities at Priest Rapids Dam and Vernita Bridge to provide data from locations unaffected by site operations. Samples were collected from all other locations, including a municipal drinking water supply and points of withdrawal for irrigation water downstream of the Hanford Site, to identify any increase in contaminant concentrations attributable to the site. The sampling of irrigation water systems is discussed in Section 10.4.4.

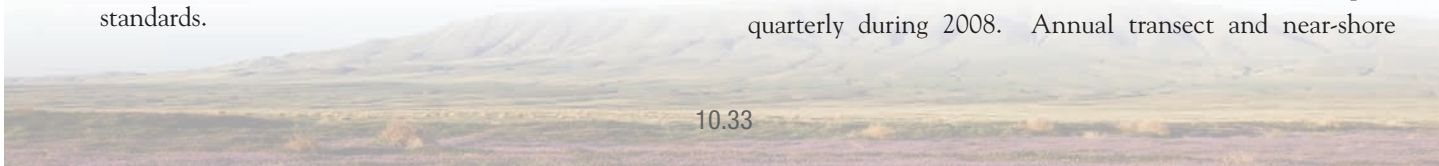
The fixed-location monitoring stations at Priest Rapids Dam and the city of Richland consist of an automated sampler and a continuous flow system. The automated sampler was used to obtain hourly unfiltered samples of Columbia River water (cumulative samples), which were composited for a period of 7 days. These weekly samples were combined into monthly and quarterly composite samples for radiological analyses (Table 10.4.1). The continuous flow system was used to collect particulate and soluble constituents in Columbia River water by passing water through a filter and then through a resin column. Filter and resin samples were exchanged approximately every 14 days and were combined into quarterly composite samples for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in DOE/RL-91-50, Rev. 4.

Radionuclides of interest were selected for analysis based on the following criteria:

- Their presence in effluent discharged from Hanford Site facilities or in near-river groundwater underlying the site
- Their importance in determining water quality, verifying facility effluent controls and monitoring systems, and determining compliance with applicable water-quality standards.

Constituents of interest in Columbia River water samples collected at Priest Rapids Dam and the city of Richland included gamma-emitting radionuclides, tritium, strontium-90, technetium-99, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240. River water samples to be analyzed for iodine-129 were not collected in 2008 because the instrument used for this assay was not operational, and an alternative for this ultra-trace measurement capability was not available. Gross alpha and gross beta measurements were made as indicators of the general radiological quality of the river and provided a timely indication of change. Gamma-energy analysis provides the capability to detect numerous specific radionuclides (Appendix F). Analytical detection levels (defined as the laboratory-reported minimum detectable concentration) for all radionuclides were less than or equal to 10% of their respective Washington State water-quality criteria levels (Appendix D, Tables D.3 and D.4). Unless otherwise noted in this section, the statistical tests for differences are paired sample comparisons and two-tailed t-tests, with alpha at a 5% significance level.

Transect sampling (i.e., multiple samples collected along a line across the Columbia River) was initiated as a result of findings of a special study conducted during 1987 and 1988 (PNL-8531). That study concluded that, under certain flow conditions, contaminants entering the river from the Hanford Site are not completely mixed when sampled at routine monitoring stations located downriver. Incomplete mixing results in a slightly conservative (high) bias in the data generated using the routine, single-point, sampling system at the city of Richland drinking water intake. During 1999, the transect sampling strategy was modified; some of the mid-river sampling points were shifted to near-shore locations in the vicinity of the transect. For example, at the 100-N Area, instead of 10 evenly spaced cross-river transect samples, only 6 cross-river samples were collected, and the other 4 samples were obtained at near-shore locations (typically less than 5 meters [16 feet] from shore). This sampling pattern was used during 2008 and allowed the cross-river concentration profile to be determined and also provided information over a larger portion of the Hanford Site shoreline where the highest contaminant concentrations would be expected. Vernita Bridge and city of Richland transects and near-shore locations were sampled quarterly during 2008. Annual transect and near-shore



sampling were conducted at the 100-N Area, the Hanford town site, and 300 Area locations in late summer when river flows were low, which provides the highest probability of detecting Hanford Site contaminants carried by groundwater to the Columbia River (PNL-8531).

Columbia River transect water samples collected during 2008 were analyzed for both radiological and chemical contaminants (Table 10.4.1). Specific metals and anions were selected for analysis following reviews of existing surface-water and groundwater data, various remedial investigation/feasibility study work plans, and preliminary Hanford Site risk assessments (DOE/RL-92-67, Draft B; PNL-8073; PNL-8654; PNL-10400; PNL-10535). Grab samples of water collected along transects were radiologically and chemically analyzed. Metals analyses included both unfiltered and filtered samples.

In addition to water monitoring conducted by Pacific Northwest National Laboratory for potential Hanford Site contaminants, basic water-quality parameters (e.g., pH, dissolved oxygen, turbidity) and some chemical constituents were monitored by the U.S. Geological Survey under contract to Pacific Northwest National Laboratory. Samples were collected by the U.S. Geological Survey two times per year along Columbia River transects at Vernita Bridge and the city of Richland (Appendix C, Table C.2). Samples were analyzed at the U.S. Geological Survey laboratory in Lakewood, Colorado.

#### 10.4.1.2 Radiological Results for Columbia River Water Sample Analyses

**Fixed Location Samples.** Radiological analyses results of Columbia River water samples collected at Priest Rapids Dam and the city of Richland during 2008 are reported in PNNL-18427, APP. 1, and summarized in Appendix C (Tables C.3 and C.4). Appendix C tables list the maximum and average concentrations of selected radionuclides detected in Columbia River water in 2008 and for the previous 5 years. All individual radiological contaminant concentrations measured in Columbia River water during 2008 were less than 1/25 of the DOE-derived concentration guides (DOE Order 5400.5; Appendix D, Table D.2). The DOE-derived concentration guides are based on a

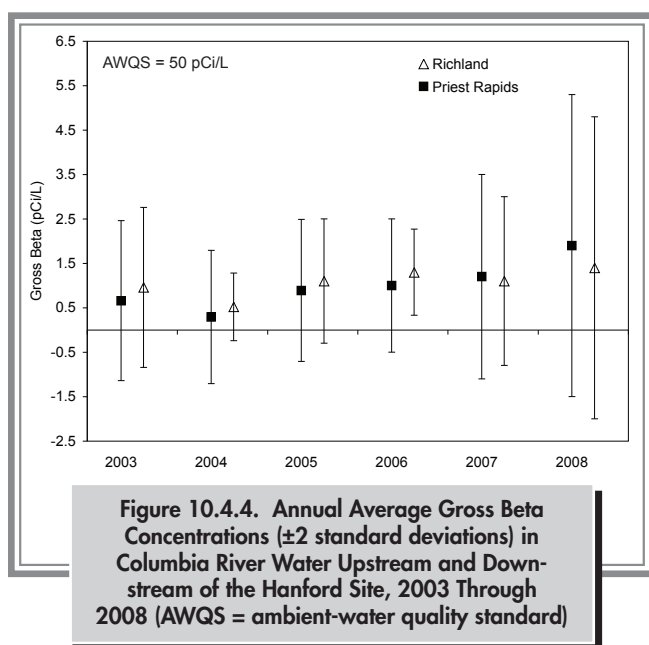
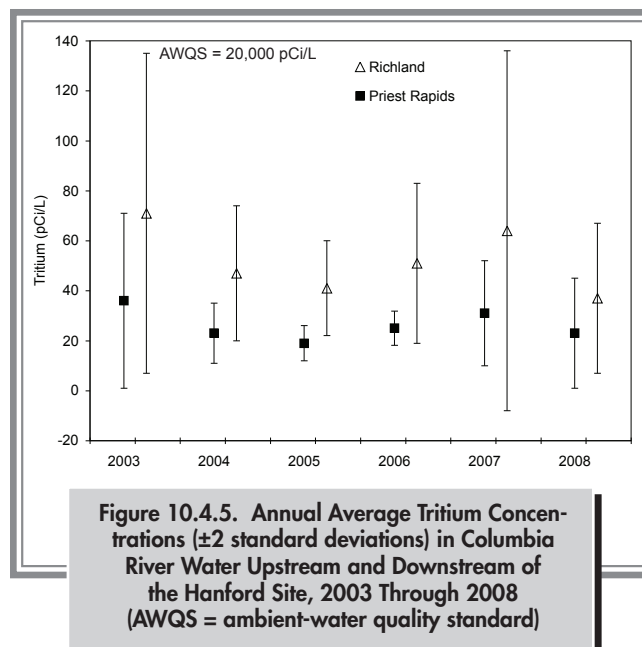
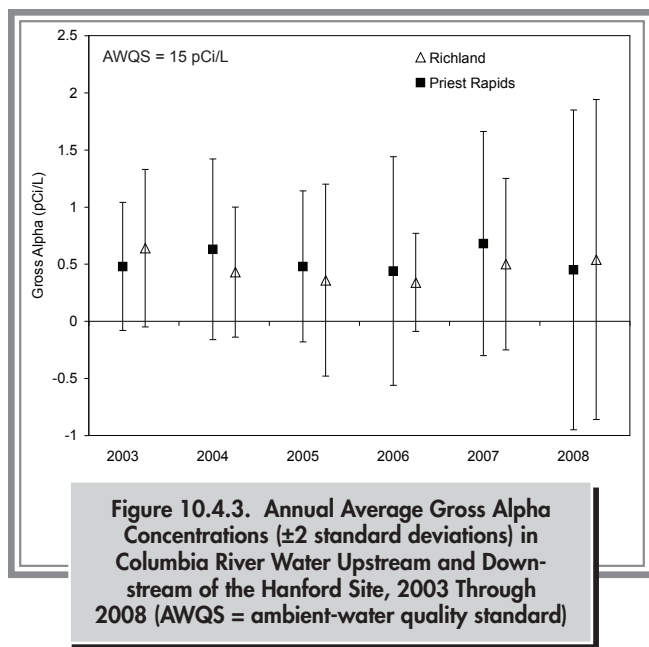
100-millirem (1-milliseivert) per year standard; dividing by 25 allows for more direct comparison to the 4-millirem (0.04-milliseivert) per year drinking water standard and Washington State ambient surface-water quality criteria (40 CFR 141 and WAC 173-201A; Appendix D, Tables D.4 and D.5). Significant results are discussed in the following paragraphs, and comparisons to previous years are provided.

Radionuclide concentrations monitored in Columbia River water were low throughout 2008. Tritium, uranium-234, uranium-238, and naturally occurring beryllium-7 and potassium-40 were measured consistently in river water at levels greater than their reported minimum detectable concentrations. Strontium-90, uranium-235, and plutonium-239/240 were occasionally detected, but all values were near the minimum detectable concentrations. Concentrations of all other radionuclides were typically less than the minimum detectable concentrations. Tritium, strontium-90, and plutonium-239/240 exist in worldwide fallout from historical nuclear weapons testing as well as in effluent from Hanford Site facilities. Tritium and uranium occur naturally in the environment in addition to being present in Hanford Site effluent.

The 2008 average gross alpha and gross beta concentrations measured upstream and downstream of the Hanford Site were similar to those observed during recent years (Figures 10.4.3 and 10.4.4). Statistical comparisons for gross alpha and gross beta concentrations at Priest Rapids Dam and the city of Richland were not performed because most of the concentrations were less than the 1- and 3-pCi/L (0.037- and 0.11-Bq/L) minimum detectable concentrations, respectively. The average gross alpha and gross beta concentrations in Columbia River water at the city of Richland during 2008 were less than the Washington State ambient surface-water quality criteria of 15 and 50 pCi/L (0.56 and 1.9 Bq/L), respectively.

The 2008 annual average tritium concentrations measured upstream and downstream of the Hanford Site were similar to concentrations measured in recent years. Statistical analyses indicated that monthly tritium concentrations in river water samples at the city of Richland were higher than concentrations in samples from Priest Rapids Dam (Figure 10.4.5). However, 2008 average tritium concentrations in Columbia River water collected at the city of

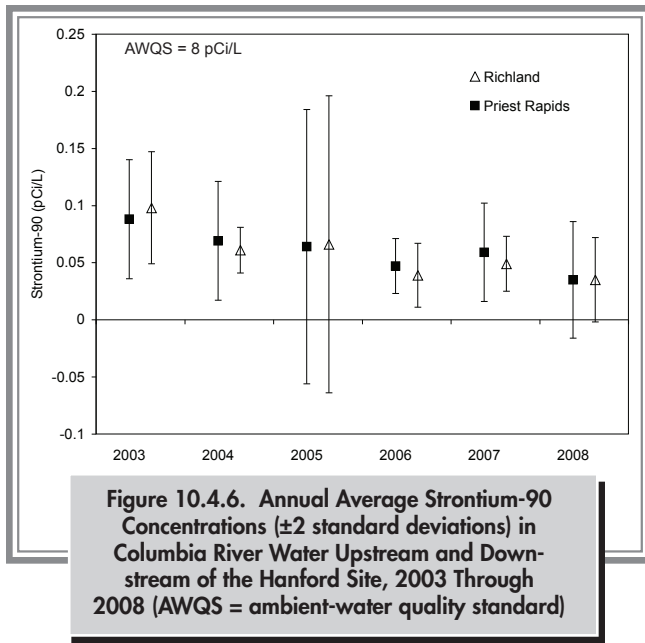




Richland were only 0.18% of the Washington State ambient surface-water quality criterion of 20,000 pCi/L (740 Bq/L). The onsite source of tritium entering the river is groundwater seepage. Although representative of river water used by the city of Richland for drinking water (first municipal water source downstream from the Hanford Site), tritium concentrations measured at Richland tend to overestimate the average tritium concentrations across the

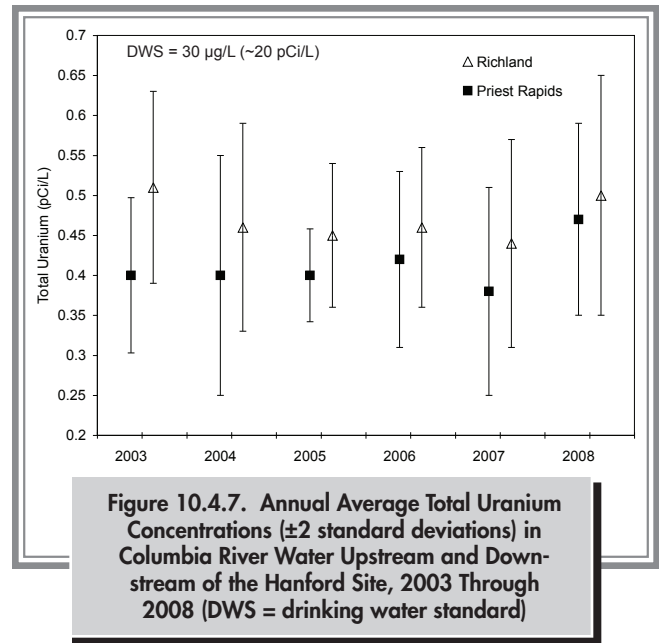
river at this location (PNL-8531). This bias is attributable to a groundwater plume (originating from the 200-East Area entering the river along the portion of shoreline extending from the Hanford town site downstream to downstream of the 300 Area), which is relatively close to the city of Richland water intake. This plume is not completely mixed within the Columbia River at the city of Richland. Sampling along cross-river transects at the city of Richland during 2008 confirmed the existence of a concentration gradient in the river under certain flow conditions and is discussed subsequently in this section. The extent to which samples taken at the city of Richland drinking water intake overestimate the average tritium concentrations in the Columbia River at this location is variable and appears to be related to the flow rate of the river just before and during sample collection.

Average strontium-90 levels measured in Columbia River water collected upstream and downstream of the Hanford Site during 2008 were similar to those reported previously (Figure 10.4.6). Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Areas. Some of the highest strontium-90 levels that have been found in onsite groundwater are the result of past discharges to the 100-N Area liquid waste disposal facilities. Strontium-90 concentrations at Priest Rapids Dam were not statistically compared with the city of Richland



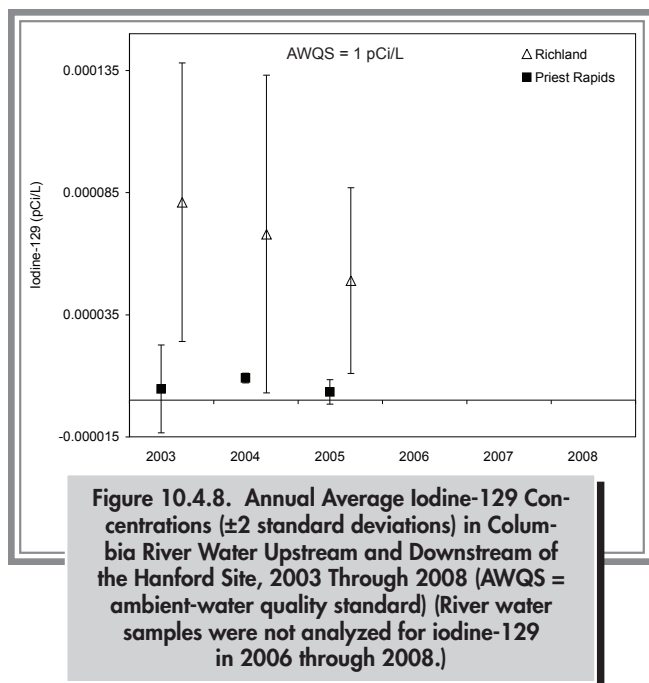
because most of the concentrations were less than the minimum detectable concentration. Average strontium-90 concentrations in Columbia River water at the city of Richland were less than 0.44% of the Washington State ambient surface-water quality criterion (8 pCi/L [0.30 Bq/L]).

Annual average total uranium concentrations (i.e., the sum of uranium-234, uranium-235, and uranium-238) observed in water samples collected upstream and downstream of the Hanford Site during 2008 were similar to those observed during recent years (Figure 10.4.7). Monthly total uranium concentrations measured at the city of Richland during 2008 were not significantly higher than those measured at Priest Rapids Dam. Uranium is present in the groundwater beneath the 300 Area as a result of past Hanford Site operations. Uranium has been detected at elevated levels in shoreline springs at the 300 Area in the past (Section 10.5; PNNL-13692; PNNL-16805). Uranium from non-Hanford Site sources, such as fertilizer use, is also known to enter the Columbia River across from the Hanford Site via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the river (PNL-7500). Most phosphate fertilizers contain trace amounts of naturally occurring uranium. There is no Washington State ambient surface-water quality criterion directly applicable to uranium. However, total uranium



levels in the river during 2008 were well below the EPA drinking water standard of 30  $\mu\text{g/L}$  (approximately 20 pCi/L [0.74 Bq/L], Appendix D, Table D.4).

Columbia River water samples were not collected for iodine-129 analysis in 2008 because the unique instrument for this assay was not operational, and an alternative for this ultra-trace measurement capability was not available. The onsite source of iodine-129 to the Columbia River is the discharge of contaminated groundwater along the portion of shoreline downstream of the Hanford town site (Section 10.5.2). The iodine-129 plume originated in the 200 Areas from past waste disposal practices. In previous years, quarterly iodine-129 concentrations in Columbia River water at the city of Richland were significantly higher than those at Priest Rapids Dam, indicating a Hanford Site source of iodine-129. Past results have shown that iodine-129 values at Priest Rapids Dam are largely unaffected by river stages; however, the concentrations measured for river water at the city of Richland are inversely proportional to the river stage (i.e., during lower flow, the concentrations of iodine-129 are higher and vice versa). The influence of river stage on concentrations of iodine-129 at the city of Richland is reflected in the larger standard deviation, compared to the samples from Priest Rapids Dam, for the annual averages for 2003 through 2005 shown in Figure 10.4.8.



Plutonium-239/240 concentrations for river water samples at the city of Richland were extremely low during 2008. All plutonium concentrations for filtered fractions were reported as undetected by the analytical laboratory. Plutonium concentrations for material collected on the resins (dissolved) were above the detection limits in one of four samples at the city of Richland ( $0.000055 \pm 0.000044$  pCi/L [ $2.0 \pm 1.6$   $\mu$ Bq/L]). Plutonium was reported as undetected for all filter and resin samples from Priest Rapids Dam. All concentrations and detection limits were well below the DOE-derived concentration guide of 30 pCi/L (1.1 Bq/L) (Appendix D, Table D.2). No Washington State ambient surface-water quality criterion exists for plutonium-239/240. Plutonium concentrations at Priest Rapids Dam were not statistically compared with the city of Richland because most of the concentrations were less than the reported minimum detectable concentrations.

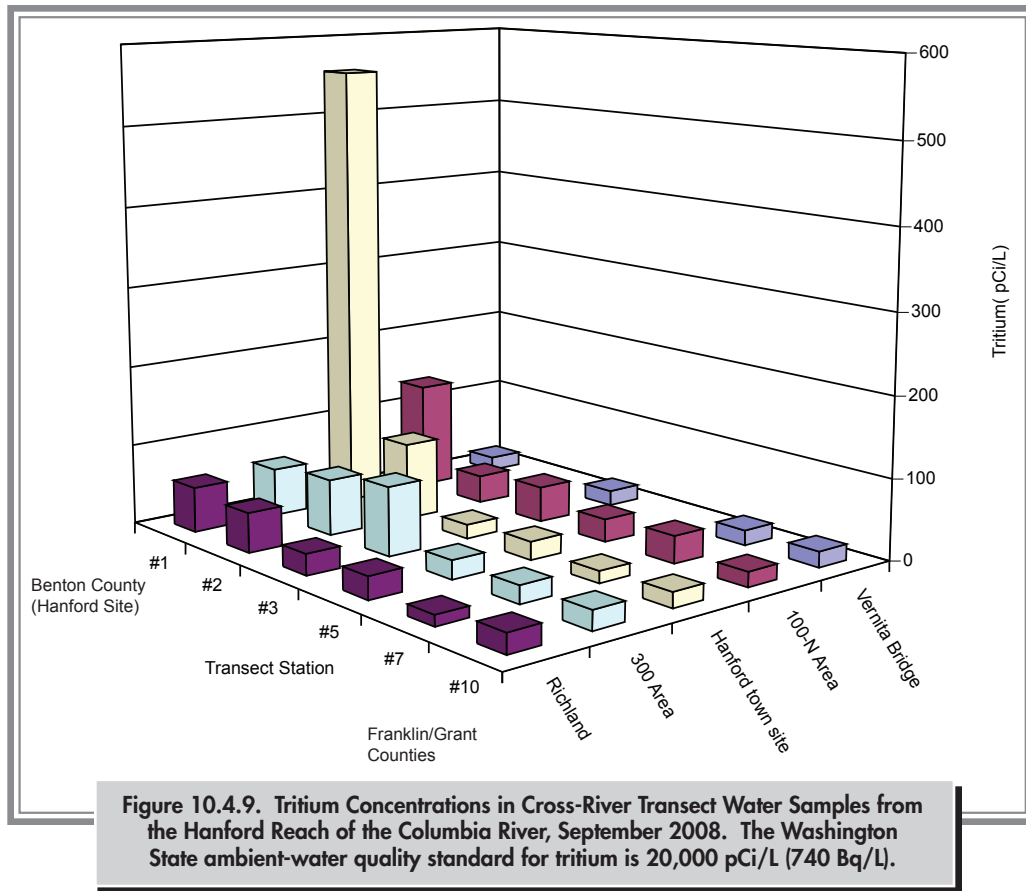
#### Columbia River Transect and Near-Shore Samples.

Radiological results from samples collected along Columbia River transects and at near-shore locations near Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland during 2008 are presented in Appendix C (Tables C.5 and C.6) and PNNL-18427, APP. 1. Sampling locations were documented using a global positioning system receiver. Radionuclides consistently measured

at concentrations greater than the minimum detectable activity included tritium, uranium-234, and uranium-238. Strontium-90 and uranium-235 were occasionally detected, but all values were near the minimum detectable concentrations. All measured concentrations of these radionuclides were less than the applicable Washington State ambient surface-water quality criteria.

Tritium concentrations measured along Columbia River transects at Vernita Bridge, the 100-N Area, Hanford town site, 300 Area, and the city of Richland pump house during September 2008 are depicted in Figure 10.4.9. The transect at Vernita Bridge is the most upstream location. Stations 1 and 10 are located along the Benton County and Grant-Franklin Counties shorelines, respectively. The 100-N Area, Hanford town site, 300 Area, and city of Richland transects have higher tritium concentrations near the Hanford Site (Benton County) shore relative to the opposite shore. The presence of a tritium concentration gradient in the Columbia River at the city of Richland supports previous studies showing that contaminants in the 200 Areas groundwater plume entering the river at, and upstream of, the 300 Area are not completely mixed in the river at the city of Richland (HW-73672; PNL-8531). The gradient is most pronounced during periods of relatively low river flow. Since transect sampling began in 1987 (PNL-8531), the average tritium concentration measured along the city of Richland transect has been less than that measured in monthly composited samples from the fixed-location monitoring station in the city of Richland, illustrating the conservative bias (i.e., overestimate) of the fixed-location monitoring station. For samples collected in 2008, the highest tritium concentration measured in cross-river transect water was  $560 \pm 200$  pCi/L ( $21 \pm 7.4$  Bq/L) at the Hanford town site (Appendix C, Table C.5). The highest tritium concentration measured in near-shore water samples was  $2,900 \pm 610$  pCi/L ( $110 \pm 23$  Bq/L) from a sample collected at the Hanford town site (Appendix C, Table C.6).

During 2008, strontium-90 concentrations in Hanford Reach river water for both transect and near-shore samples were similar to background concentrations for all locations except the 100-N Area, where slightly elevated strontium-90 concentrations were measured in some samples obtained at near-shore locations. The maximum strontium-90



concentration for 2008 was  $0.20 \pm 0.054$  pCi/L ( $0.0074 \pm 0.0020$  Bq/L) for a near-shore water sample collected at the 100-N Area. The average strontium-90 concentration found during transect sampling at the city of Richland was similar to those measured in monthly composite samples at Richland.

Total uranium concentrations in Hanford Reach water during 2008 were elevated along both the Benton and Grant-Franklin County shorelines for the transect and near-shore samples. For September 2008, the highest total uranium concentration was measured for the samples from the Benton County and Franklin County shore of the 300 Area transect, both with values of  $1.1 \pm 0.22$  pCi/L [ $0.041 \pm 0.0081$  Bq/L] (Appendix C, Table C.6; PNNL-18427, APP. 1). However, this concentration was well below the drinking water standard. Elevated uranium concentrations on the Franklin County side of the river likely resulted from groundwater seepage and water from

irrigation return canals that had elevated uranium levels from the use of phosphate fertilizers, which contain some uranium (PNL-7500).

#### 10.4.1.3 Chemical and Physical Water Quality Results for Columbia River Water Samples

Pacific Northwest National Laboratory and the U.S. Geological Survey (under contract to Pacific Northwest National Laboratory) compiled chemical and physical water-quality data for the Columbia River during 2008. A number of the parameters measured have no regulatory limits; however, they are useful as indicators of water quality and contaminants of Hanford Site origin. Potential sources of pollutants not associated with the Hanford Site include irrigation return water; groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500); and industrial, agricultural, and mining effluent introduced upstream from the Hanford Site.

### **Pacific Northwest National Laboratory Samples.**

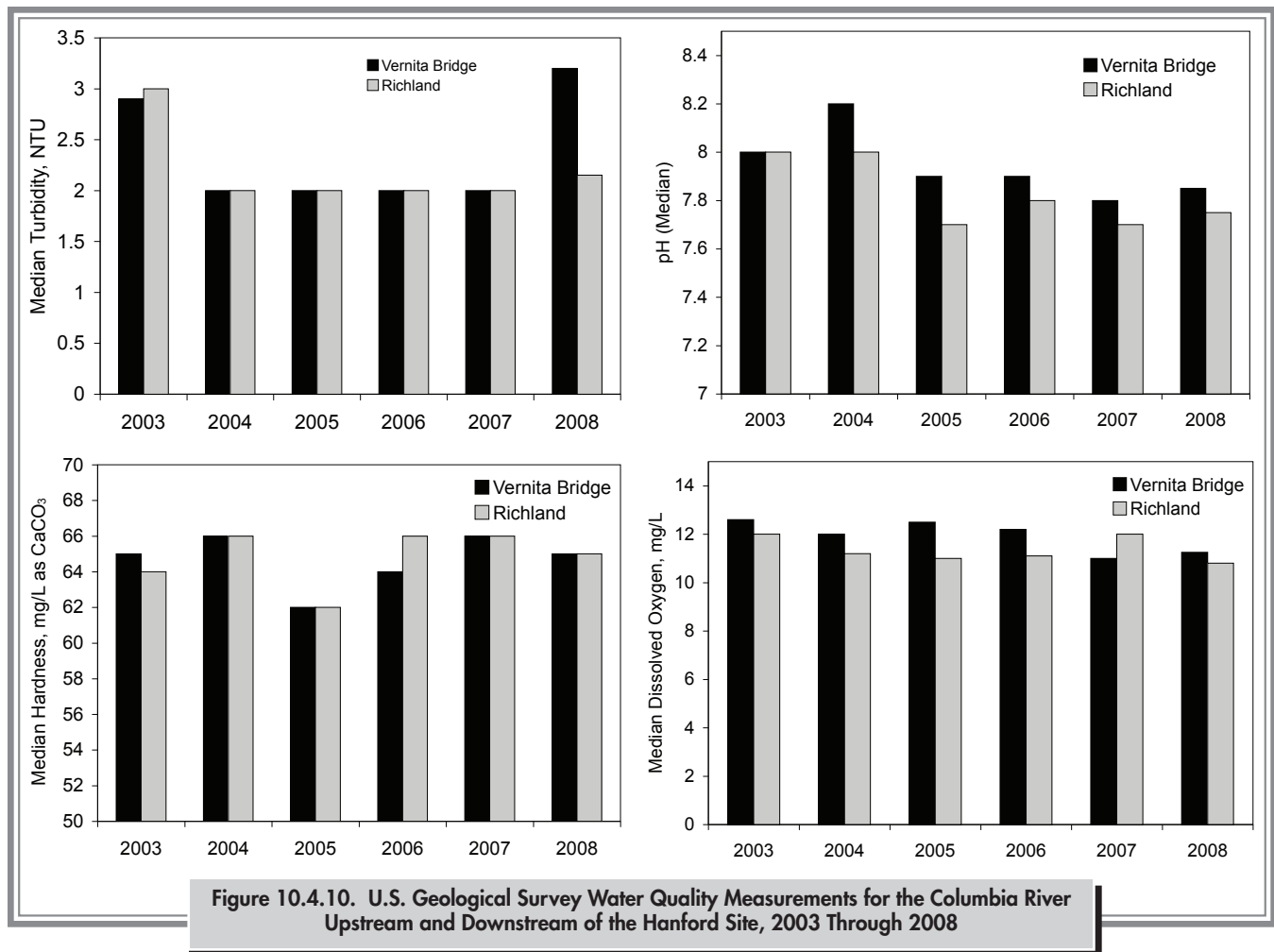
Results of chemical analyses conducted by Pacific Northwest National Laboratory on water collected at Columbia River transect and near-shore locations at Vernita Bridge, the 100-N Area, Hanford town site, 300 Area, and the city of Richland are provided in PNNL-18427, APP. 1. The concentrations of metals and anions observed in river water during 2008 were similar to those observed in the past and remain below regulatory limits. Metals and anions were detected in Columbia River transect samples both upstream and downstream of the Hanford Site. Arsenic, antimony, cadmium, chromium, copper, lead, nickel, selenium, thallium, and zinc were detected in the majority of samples, with similar levels at most locations. Beryllium and silver were below the detection limits for most samples. Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; Appendix D, Table D.5). Increased water hardness (i.e., primarily higher concentrations of calcium and magnesium ions) can reduce the toxicity of some metals by limiting their absorption into aquatic organisms. Criteria for Columbia River water were calculated using a total hardness of 47 mg/L as calcium carbonate, the lowest value based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge and the city of Richland in recent years. The total hardness reported by the U.S. Geological Survey at those locations from 1992 through 2008 ranged from 47 to 77 mg/L as calcium carbonate. All metal and anion concentrations in river water were less than the Washington State ambient surface-water quality criteria for the protection of aquatic life (Appendix C, Table C.7 and Appendix D, Table D.5). Arsenic concentrations exceeded the EPA standard for the protection of human health for the consumption of water and organisms. However, this EPA value is approximately 10,500 times lower than the Washington State chronic toxicity value (Appendix D, Table D.5), and similar concentrations were found at Vernita Bridge and the city of Richland.

For samples collected on the cross-river transects, concentrations of nitrate, chloride, and sulfate were slightly elevated along both shorelines at the 100-N Area. Samples collected and analyzed for anions at the Hanford town site were similar and did not reveal any near-shore gradients. Chloride, nitrate, and sulfate concentrations were elevated,

compared to mid-river samples, along both the Benton and Franklin County shorelines at the city of Richland and the 300 Area. In many cases, the highest anion concentrations are for the Franklin County shoreline. The elevated results along the Franklin County shore likely resulted from groundwater seepage associated with extensive irrigation (the water for which is withdrawn from the Columbia River upstream of the Hanford Site) north and east of the Columbia River. Nitrate contamination of some Franklin County groundwater has been documented by the U.S. Geological Survey (1995) and is associated with high fertilizer and water usage in agricultural areas. Numerous wells in western Franklin County exceed the EPA maximum contaminant level for nitrate (40 CFR 141; U.S. Geological Survey Circular 1144). Average quarterly concentrations of chloride and nitrate were higher at the city of Richland transect than in Vernita Bridge transect. The concentrations of volatile organic compounds in Columbia River water samples (e.g., chlorinated solvents and hydrocarbons) were below the analytical laboratory's required detection limits for all samples, with no indication of a Hanford Site source.

Concentrations of chromium in the Hanford Reach are of interest because groundwater contaminated with chromium above the ambient-water quality criterion intersects the Columbia River at several Hanford Site locations (Section 10.7). All river transect and near-shore filtered water samples for 2008 had chromium concentrations below the ambient-water quality criterion (Appendix C, Table C.7). Some near-shore water samples collected at the 100-N Area, Hanford town site, 300 Area, and the city of Richland had slightly elevated chromium levels compared to upstream samples at Vernita Bridge.

**U.S. Geological Survey Samples.** Figure 10.4.10 illustrates U.S. Geological Survey Columbia River chemical and physical water-quality data for samples collected at Vernita Bridge and the city of Richland for 2003 through 2008 (WDR-US-2007). Results for 2008 are also tabulated in PNNL-18427, APP. 1 and summarized in Appendix C (Table C.2). The 2008 U.S. Geological Survey results were comparable to those reported during the previous 5 years, and applicable Washington State standards for the Columbia River were met. During 2008, there was no indication of any deterioration of water quality along the Hanford



Reach of the Columbia River (Appendix D, Table D.3). For 2008, median concentrations of dissolved chromium were similar for water samples collected from near Vernita Bridge and the city of Richland and were well below the ambient-water quality criterion.

## 10.4.2 Monitoring of Columbia River Sediment

During peak operating years on the Hanford Site, large amounts of effluents associated with reactor operations were discharged to the Columbia River. Some constituents in these effluents may have become associated with particulate matter that accumulated in riverbed sediment, particularly in slack-water areas and in the reservoirs upstream of the dams. The majority of short-lived radioactive constituents have decayed away, but some longer-lived radionuclides,

such as isotopes of cesium, plutonium, strontium, and uranium, are still detectable. Fluctuations in the river flow from operation of upriver hydroelectric dams, annual spring high river flows, and occasional floods have resulted in resuspension, relocation, and subsequent redeposition of sediment (BNWL-2305). Upper-layer sediment in the Columbia River downstream of the Hanford Site contains low concentrations of radionuclides and metals of Hanford Site origin and radionuclides from nuclear weapons testing fallout as well as metals and other non-radioactive contaminants from mining and agricultural activities (Beasley et al. 1981; BNWL-2305; Cox et al. 2004; PNL-8148; PNL-10535; PNNL-13417; PNNL-16990). Periodic sediment sampling confirms that concentrations are low and that no significant changes in concentrations have occurred. The accumulation of radioactive materials in sediment can lead to human exposure from ingestion of

aquatic organisms associated with the sediment or sediment resuspension into drinking water supplies. Sediment with accumulated radioactive materials can be an external radiation source, irradiating people who are fishing, wading, swimming, sunbathing, or participating in other recreational activities associated with the river or shoreline (DOE/EH-0173T).

Since the shutdown of the last single-pass reactor on the Hanford Site in 1971, the contaminant concentrations in Columbia River surface sediment near and downstream of the Hanford Site have been decreasing. This decrease is a result of radioactive decay and the deposition of uncontaminated material on top of the older sediment, which occurs in the reservoirs of the dams downstream of the Hanford Site (Cushing et al. 1981). However, discharges of some pollutants from the Hanford Site to the Columbia River still occur via permit-regulated liquid effluent discharges at the 100-K Area (Section 10.3) and via contaminated groundwater seepage (Section 10.5).

Several studies have been conducted to investigate the difference in sediment grain-size composition and total organic carbon content at routine Columbia River monitoring sites and the effect of grain size and organic content in measured contaminant concentrations (Beasley et al. 1981; PNL-10535; PNNL-13417). Physical and chemical sediment characteristics were found to be highly variable among monitoring sites along the Columbia River. Samples containing the highest percentage of silts, clays, and total organic carbon were generally collected from reservoirs behind dams upstream of the site and from the White Bluffs Slough on the Hanford Reach.

#### 10.4.2.1 Collection of Columbia River Sediment Samples and Analytes of Interest

During 2008, samples of the surface layer of Columbia River sediment were collected at depths of 0 to 10 centimeters (0 to 4 inches) from six river locations that were permanently submerged (some Hanford Reach sampling locations may not be submerged during an extremely low river stage) (Figure 10.4.1 and Table 10.4.2). Sampling locations were documented using a global positioning system receiver. Surface sediment collected using a dredge sampler captures

several years of integrated deposits. The sediment samples collected by the dredge capture both sediment grains and associated pore water. Gibbons (2000) estimated average sediment deposition rates of 0.723 centimeter (0.28 inch) per year for Priest Rapids Dam and 2.25 centimeters (0.89 inch) per year for McNary Dam. Assuming a maximum sediment sampling depth of 10 centimeters (3.9 inches) with the dredge, the samples would integrate up to 14 years at Priest Rapids Dam and 4.4 years at McNary Dam. Sediment deposition rates have not been estimated for Hanford Reach locations.

Samples were collected upstream of Hanford Site facilities from the Priest Rapids Dam reservoir (the nearest upstream impoundment) to provide data from an area unaffected by site operations. Samples were collected downstream of the Hanford Site above McNary Dam (the nearest downstream impoundment) to identify any increase in contaminant concentrations. Any increases in contaminant concentrations found in sediment above McNary Dam compared to that found above Priest Rapids Dam do not necessarily reflect a Hanford Site source. The confluences of the Columbia River with the Yakima, Snake, and Walla Walla Rivers lie between the Hanford Site and McNary Dam. Several towns, irrigation water returns, and factories in these drainages, as well as atmospheric fallout from nuclear weapons testing, may also contribute to the contaminant load found in McNary Dam sediment. Thus, sediment samples are taken periodically in the reservoir above Ice Harbor Dam (the first dam on the Snake River upstream of the river mouth) to assess Snake River input. Sediment samples were also collected along the Hanford Reach of the Columbia River, from slack-water areas where fine-grained material is known to deposit (e.g., the White Bluffs, 100-F Area, and Hanford Sloughs), and from the publicly accessible city of Richland shoreline that lies within the McNary Dam impoundment.

Monitoring sites in the reservoirs behind McNary and Priest Rapids Dams consisted of two stations spaced approximately equidistant on a transect line crossing the Columbia River; the samples were collected near the boat-exclusion buoys immediately upstream of each dam. All other monitoring sites consisted of a single sampling location. Samples were collected using a clam-shell style sediment dredge; this sampling method is discussed in PNNL-16744. All sediment



samples were analyzed for gamma-emitting radionuclides (Appendix F), strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, plutonium-239/240, and metals (DOE/RL-91-50, Rev. 4). The specific analytes selected for sediment samples were based on findings of previous Columbia River sediment investigations, reviews of past and present effluent contaminants discharged from site facilities, and reviews of contaminant concentrations observed in Hanford Site groundwater monitoring wells near the river.

#### 10.4.2.2 Radiological Results for Columbia River Sediment Sample Analyses

Radionuclides consistently detected in river sediment adjacent to and downstream of the Hanford Site during 2008 included potassium-40, cesium-137, uranium-234, uranium-235, plutonium-238, uranium-238, plutonium-239/240, and daughter products from naturally occurring radionuclides. The concentrations of all other radionuclides, including strontium-90, were below the reported minimum detectable concentrations for most samples (PNNL-18427, APP. 1). Cesium-137 and plutonium isotopes exist in worldwide fallout as well as in effluent from Hanford Site facilities. Potassium-40 and uranium isotopes occur naturally in the environment, and uranium isotopes are also present in Hanford Site effluent. No federal or state freshwater sediment criteria are available to assess the sediment quality of the Columbia River (EPA 822-R-96-001). Radionuclide concentrations reported in river sediment during 2008 were similar to those reported for previous years, with the exception of cesium-137 (Appendix C, Table C.8), and there were no obvious differences between locations. Unusual cesium-137 values for sediment samples for 2004 through 2007 were sampled at the White Bluffs Slough, which were roughly two times higher than values from locations above Priest Rapids Dam. The 2008 values for cesium-137 at White Bluffs Slough were slightly elevated compared to Priest Rapids Dam but lower than the 2004 through 2007 values. Previous studies of soils from the White Bluffs Slough detected elevated concentrations of cesium-137 (PNL-3127; PNL-8789). Average, maximum, and minimum concentrations of selected radionuclides measured in Columbia River sediment (2003 through 2008) are presented in Figure 10.4.11.

#### 10.4.2.3 Chemical Results for Columbia River Sediment Sample Analyses

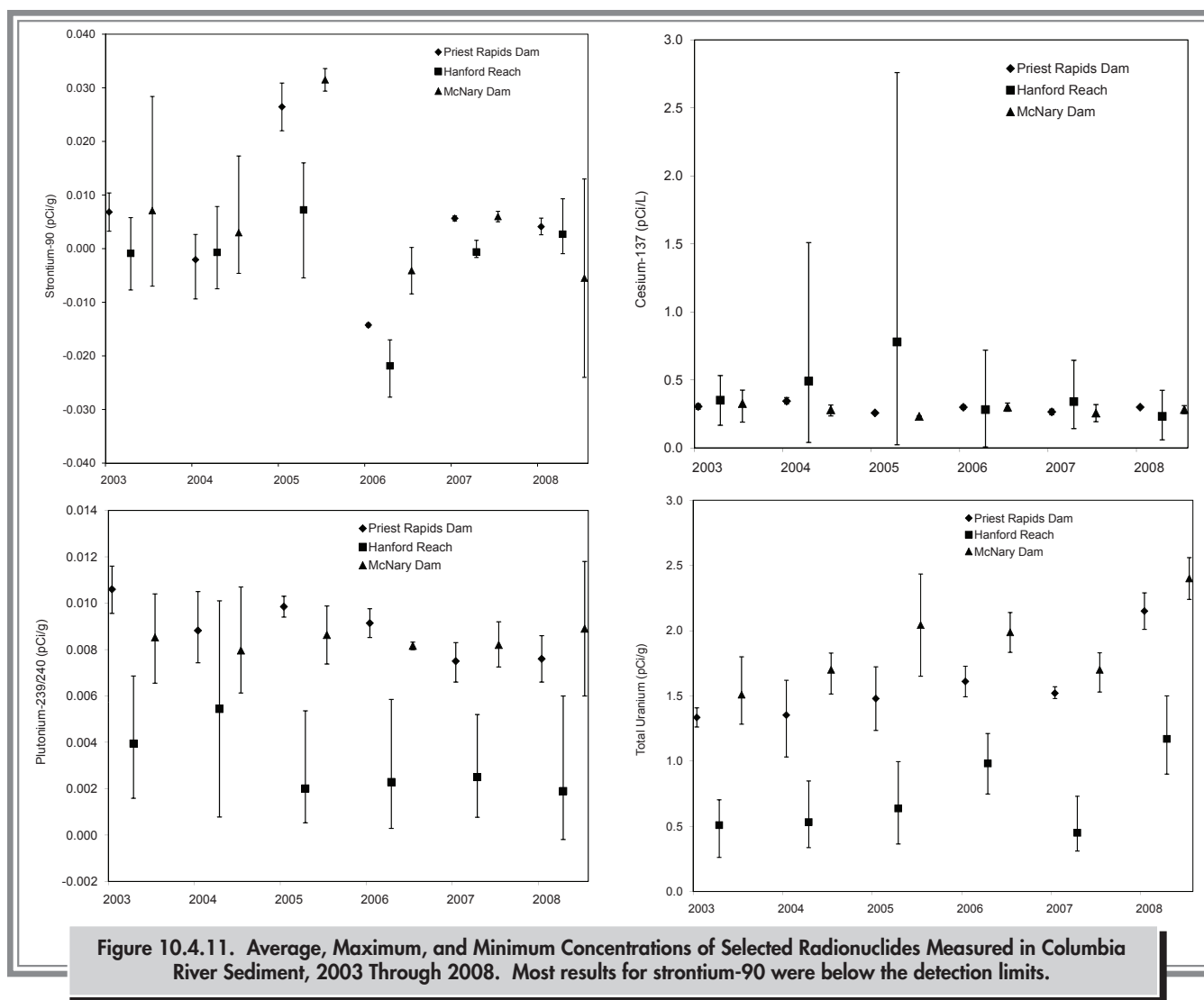
Detectable amounts of most metals were found in all river sediment samples (Figure 10.4.12; Appendix C, Table C.9; PNNL-18427, APP. 1). Maximum and average concentrations of most metals were higher for sediment collected in the reservoir upstream of Priest Rapids Dam than in sediment from either the Hanford Reach or McNary Dam. The concentrations of cadmium, lead, nickel, and zinc differed the most between locations and may be associated with upstream mining activity. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured values.

#### 10.4.3 Monitoring of Onsite Pond Water and Sediment

Two onsite ponds, West Lake and the Fast Flux Test Facility Pond (Figure 10.4.1), located near facilities in various stages of remediation, were sampled periodically during 2008. The ponds are accessible to migratory waterfowl, deer, and other wildlife, creating a potential biological pathway for the dispersion of contaminants (PNL-10174). The Fast Flux Test Facility Pond is a disposal site for process water, primarily cooling water drawn from 400 Area groundwater wells. West Lake, the only naturally occurring pond on the site, is located north of the 200-East Area (ARH-CD-775). West Lake has not received direct effluent discharges from Hanford Site facilities, but it is influenced by precipitation and changing water-table elevations that are related to the discharge of water to the ground in the 200 Areas. The water level in West Lake fluctuates, and the lake changes from standing water in winter and spring to dry or nearly dry in summer and fall.

##### 10.4.3.1 Collection of Pond Water and Sediment Samples and Analytes of Interest

During 2008, grab samples were collected quarterly from the Fast Flux Test Facility Pond (water) and from West Lake (quarterly water and biannual sediment). All water samples were analyzed for tritium. Water samples from the

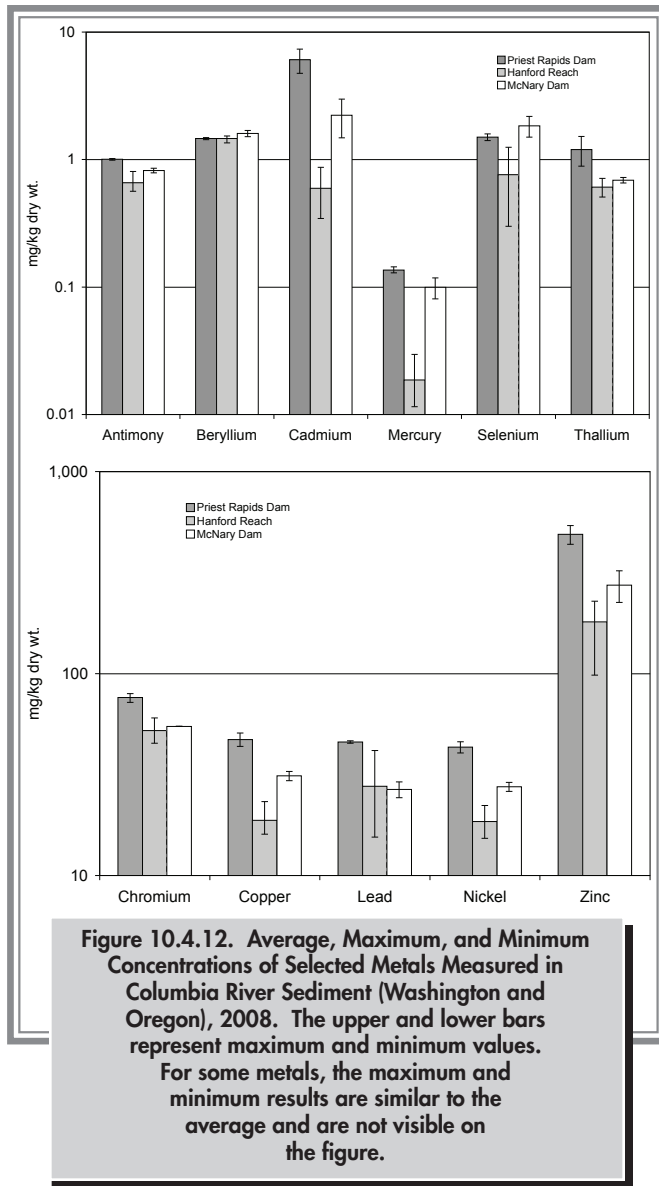


Fast Flux Test Facility Pond were also analyzed for gross alpha and gross beta concentrations as well as gamma-emitting radionuclides. The groundwater table in the 200-East Area has dropped in recent years (Section 10.7), decreasing the size of West Lake and causing the suspended sediment loading to increase. Since 2002, it has not been practical for the analytical laboratory to process West Lake water samples for gross alpha, gross beta, strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238 because of the high sediment load. Consequently, sediment samples were submitted for these analytes. Radionuclides were chosen for analysis based on their presence in local groundwater and their potential to contribute to the overall radiation dose to biota that frequent the ponds.

### 10.4.3.2 Radiological Results for Pond Water and Sediment Sample Analyses

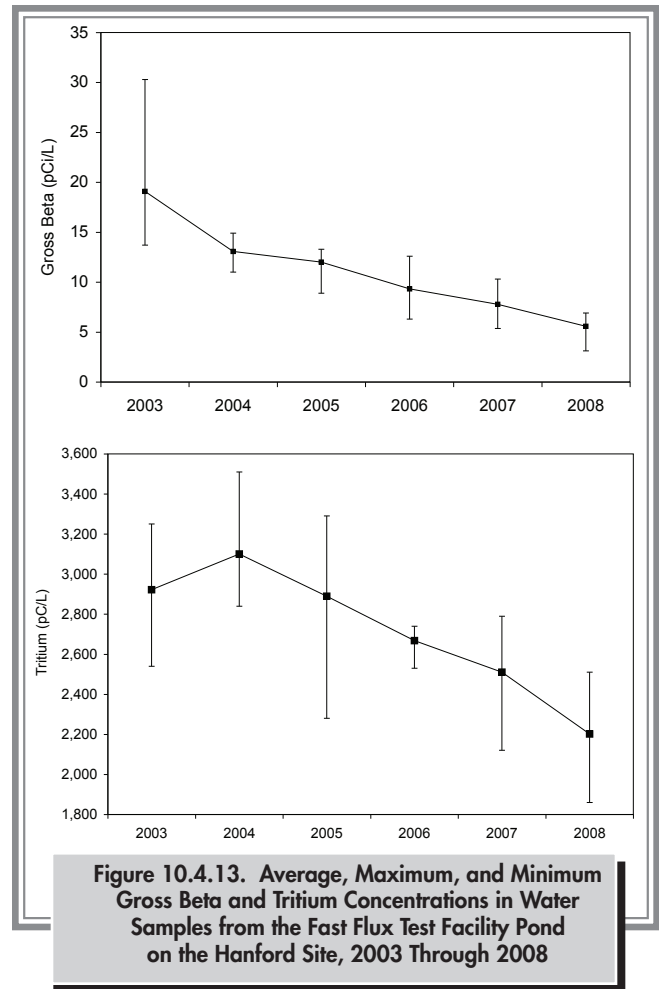
All radionuclide concentrations in onsite pond water samples were less than applicable DOE-derived concentration guides (DOE Order 5400.5; Appendix D, Table D.2) and Washington State ambient surface-water quality criteria (WAC 173-201A; 40 CFR 141; PNNL-18427, APP. 1; Appendix D, Tables D.3 and D.4).

Figure 10.4.13 shows the annual average gross beta and tritium concentrations in Fast Flux Test Facility Pond water from 2003 through 2008. Average levels of both constituents have decreased slightly in recent years. The average



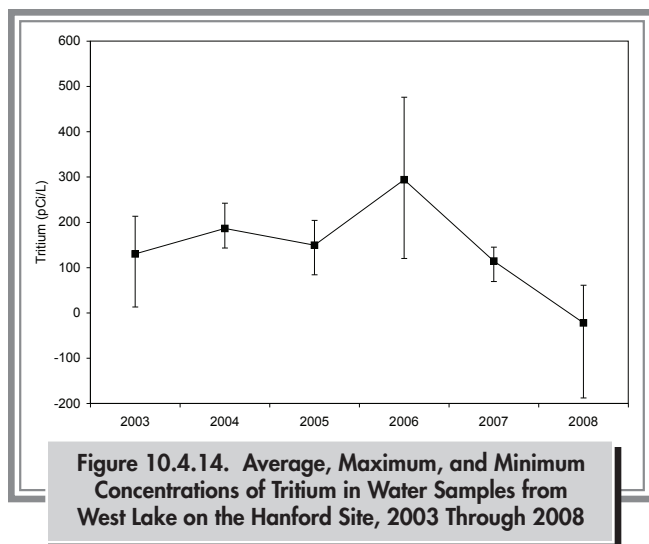
tritium concentration in Fast Flux Test Facility Pond water during 2008 was 11% of the Washington State ambient surface-water quality criterion of 20,000 pCi/L (740 Bq/L). The sources of contaminants in the pond water are groundwater contaminant plumes from the 200 Areas that have migrated to wells within the 400 Area that supply water to facility operations.

Tritium concentrations in West Lake water during 2008 were similar to those observed in the past (Figure 10.4.14). All results for 2008 are below the laboratory-reported detection limits.



Samples of West Lake upper-layer sediment in 2008 had the following ranges of values:

- Gross alpha – 3.5 to 9.5 pCi/g (0.13 to 0.35 Bq/g)
- Gross beta – 18 to 19 pCi/g (0.67 to 0.70 Bq/g)
- Potassium-40 – 17 to 18 pCi/g (0.63 to 0.67 Bq/g)
- Strontium-90 – 0.16 to 0.23 pCi/g (0.0059 to 0.0085 Bq/g)
- Cesium-137 – 0.53 to 0.96 pCi/g (0.020 to 0.036 Bq/g)
- Uranium-234 – 0.78 to 2.8 pCi/g (0.029 to 0.10 Bq/g)
- Uranium-235 – 0.057 to 0.15 pCi/g (0.0021 to 0.0056 Bq/g)
- Uranium-238 – 0.68 to 2.6 pCi/g (0.025 to 0.096 Bq/g).



West Lake sediment samples were collected near the shoreline as grab samples of upper-layer material using a hand-scoop. Radionuclide levels in West Lake surface sediments are similar to previous measurements reported (PNL-7662). Uranium concentrations are most likely from naturally occurring uranium in the surrounding soil (BNWL-1979).

## 10.4.4 Monitoring of Offsite Irrigation Water

As a result of public concerns about the potential for Hanford Site associated contaminants in offsite water, sampling was conducted in 2008 to document the levels of radionuclides in water used by the public. Consumption of vegetation irrigated with Columbia River water downstream

of the site has been identified as one of the primary pathways contributing to the potential dose to the hypothetical, maximally exposed individual and any other member of the public (Section 10.14).

### 10.4.4.1 Collection and Analysis of Offsite Irrigation Water Samples

During 2008, water samples were collected from an irrigation canal located east of the Columbia River and downstream from the Hanford Site at Riverview. Samples were also collected from an irrigation water supply on the Benton County shoreline near the southern boundary of the Hanford Site (Horn Rapids irrigation pumping station) (Figure 10.4.1). Water from the Riverview irrigation canal and the Horn Rapids irrigation pumping station was sampled three times during the 2008 irrigation season. Unfiltered samples were analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, uranium-234, uranium-235, and uranium-238.

### 10.4.4.2 Analytical Results for Offsite Irrigation Water Samples

During 2008, radionuclide concentrations measured in irrigation water were at the same levels detected in Columbia River water samples collected upstream of the Hanford Site (PNNL-18427, APP. 1). All radionuclide concentrations were less than their respective DOE-derived concentration guides and Washington State ambient surface-water quality criteria (DOE Order 5400.5; WAC 173-201A; 40 CFR 141).



## 10.5 Columbia River Shoreline Springs Monitoring

GW Patton

Samples of Columbia River shoreline spring water and associated sediment were collected along the Hanford Reach and analyzed to determine the potential impact of radiological and chemical contaminants from the Hanford Site on the public and the aquatic environment. Sections 10.5.1 and 10.5.2 discuss the collection, analysis, and results for Columbia River shoreline spring water and sediment samples.

### 10.5.1 Water Monitoring at Columbia River Shoreline Springs

The Columbia River is the discharge area for the unconfined aquifer underlying the Hanford Site. Groundwater provides a means for transporting Hanford Site-associated contaminants, which have leached into groundwater from past waste disposal practices, to the Columbia River (DOE/RL-92-12, Rev. 1; PNL-5289; PNL-7500; WHC-SD-EN-TI-006). Contaminated groundwater enters the Columbia River via surface and subsurface discharge. Discharge zones located above the water level of the river are identified in this report as shoreline springs. Routine monitoring of shoreline springs offers the opportunity to characterize the quality of groundwater being discharged to the river, and assess the potential human and ecological risk associated with the spring water. In addition, contaminants in groundwater near the Columbia River are monitored using shoreline groundwater-sampling tubes (aquifer tubes) (Section 10.7; BHI-01153, Rev. 0; PNNL-14444; PNNL-16805; PNNL-16894; SGW-35028).

Shoreline springs were documented along the Hanford Reach long before Hanford Site operations began during World War II (Jenkins 1922). During the early 1980s,

researchers walked a 66-kilometer (41-mile) stretch of the Benton County shoreline of the Hanford Reach and identified 115 springs (PNL-5289). They reported that the predominant areas of riverbank springs at that time were in the vicinity of the 100-N Area, Hanford town site, and 300 Area. In recent years, it has become increasingly difficult to locate shoreline springs in the 100-N Area. Declining water-table elevations, a consequence of the end of operations at N Reactor, have reduced discharge from the springs at the 100-N Area.

The presence of shoreline springs also varies with river stage (river-level elevation). The water table near the Hanford Reach is strongly influenced by river-stage fluctuations. The river stage in the Hanford Reach is controlled by upriver conditions and operations at upriver dams. As river water levels fluctuate, groundwater levels change, which causes the presence of shoreline springs in the Hanford Reach to vary. At the 300 Area, the river stage is also influenced by the elevation of the McNary Dam pool. Columbia River water moves into the Hanford Site aquifer as the river stage rises (bank storage) and then discharges from the aquifer in the form of shoreline springs as the river stage falls. Following an extended period of low river flow, groundwater discharge zones above the water level of the river may cease to exist when the level of the aquifer comes into equilibrium with the level of the river. Thus, springs are most readily identified immediately following a decline in river stage.

Bank storage of river water also affects the contaminant concentration of the springs. Spring water discharged immediately following a river stage decline generally consists of river water or a mixture of river water and groundwater. The percentage of groundwater in the spring water discharge increases over time following a drop in river stage. Measuring the specific conductance of the spring water discharge

provides an indicator of the extent of bank storage because Hanford Site groundwater has a higher specific conductance than Columbia River water.

The effect of bank storage on groundwater discharges and contaminant concentrations variations in aquifer thickness, porosity, and plume concentrations make it difficult to accurately estimate the volume of contaminated groundwater discharging via springs to the Columbia River within the Hanford Reach. Studies of shoreline springs conducted during 1983 (PNL-5289), 1988 (PNL-7500), and 1991 (DOE/RL-92-12, Rev. 1; WHC-EP-0609) and results of near-shore studies in 1997 (PNNL-11933) and 2001 (PNNL-13692) noted that discharges from the springs had only localized effects on river contaminant concentrations.

### 10.5.1.1 Collection of Water Samples from Columbia River Shoreline Springs and Constituents of Interest

Routine monitoring of selected shoreline springs was initiated during 1988. Currently, shoreline spring water samples are collected for contaminant monitoring and to support groundwater operable unit investigations (DOE/RL-91-50,

Rev. 4). Tables 10.5.1 and 10.5.2 and Figure 10.4.1 summarize the sampling locations and frequencies, as well as sample types and analyses included in shoreline springs monitoring during 2008. This section describes the monitoring efforts and summarizes the results for these aquatic environments. Detailed analytical results are reported in PNNL-18427, APP. 1. Analytes of interest for samples from shoreline springs were selected based on findings of previous investigations, reviews of contaminant concentrations observed in nearby groundwater monitoring wells, and results of preliminary risk assessments. Sampling is conducted annually when river flows are low, typically in early fall.

The majority of samples collected during 2008 were analyzed for gamma-emitting radionuclides, gross alpha, gross beta, and tritium. Samples from selected springs were analyzed for strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238. Selected riverbank spring water samples were analyzed for iodine-129 using a gamma spectroscopy method. Most samples were analyzed for metals and anions. Samples from selected locations were analyzed for volatile organic compounds. Only unfiltered samples were analyzed,

**Table 10.5.1. Hanford Reach Shoreline Springs Water Monitoring, 2008**

<b>Springs Locations<sup>(a)</sup></b>	<b>Sample Type</b>	<b>Sampling Frequency</b>	<b>Analyses</b>
100-B Area	Grab	Annually	Alpha, beta, <sup>3</sup> H, <sup>90</sup> Sr, <sup>99</sup> Tc, gamma energy analysis, metals (filtered and unfiltered), anions, VOC <sup>(b)</sup>
100-K Area	Grab	Annually	Alpha, beta, <sup>3</sup> H, <sup>90</sup> Sr, gamma energy analysis, metals (filtered and unfiltered), anions, VOC <sup>(b)</sup>
100-N Area	Grab	Annually	Alpha, beta, <sup>3</sup> H, <sup>90</sup> Sr, gamma energy analysis, metals (filtered and unfiltered), anions
100-D Area	Grab	Annually	Alpha, beta, <sup>3</sup> H, <sup>90</sup> Sr, gamma energy analysis, metals (filtered and unfiltered), anions
100-H Area	Grab	Annually	Alpha, beta, <sup>3</sup> H, <sup>90</sup> Sr, <sup>99</sup> Tc, U, <sup>(c)</sup> gamma energy analysis, metals (filtered and unfiltered), anions
100-F Area	Grab	Annually	Alpha, beta, <sup>3</sup> H, <sup>90</sup> Sr, U, <sup>(c)</sup> gamma energy analysis, metals (filtered and unfiltered), anions, VOC <sup>(b)</sup>
Hanford town site	Grab	Annually	Alpha, beta, <sup>3</sup> H, <sup>129</sup> I, <sup>99</sup> Tc, U, <sup>(c)</sup> gamma energy analysis, metals (filtered and unfiltered), anions
300 Area	Grab	Annually	Alpha, beta, <sup>3</sup> H, <sup>129</sup> I, <sup>90</sup> Sr, U, <sup>(c)</sup> gamma energy analysis, metals (filtered and unfiltered), anions, VOC <sup>(b)</sup>

(a) See Figure 10.4.1.

(b) VOC = Volatile organic compounds.

(c) U = Isotopic uranium-234, uranium-235, and uranium-238 analyzed by alpha spectrometry (alpha energy analysis).

**Table 10.5.2. Hanford Reach Shoreline Springs Sediment Monitoring, 2008**

<b>Springs Locations<sup>(a)</sup></b>	<b>Sampling Frequency</b>	<b>Analyses</b>
100-B Area	Annually	Gamma energy analysis, <sup>90</sup> Sr, U, <sup>(b)</sup> metals
100-H Area	Annually	Gamma energy analysis, <sup>90</sup> Sr, U, <sup>(b)</sup> metals
100-F Area	Annually	Gamma energy analysis, <sup>90</sup> Sr, U, <sup>(b)</sup> metals
Hanford town site	Annually	Gamma energy analysis, <sup>90</sup> Sr, U, <sup>(b)</sup> metals
300 Area	Annually	Gamma energy analysis, <sup>90</sup> Sr, U, <sup>(b)</sup> metals

(a) See Figure 10.4.1.

(b) U = Isotopic uranium-234, uranium-235, and uranium-238 analyzed by alpha spectrometry (alpha energy analysis).

except for metals analyses, in which case both filtered and unfiltered samples were analyzed (Appendix C, Table C.10; PNNL-18427, APP. 1).

### 10.5.1.2 Radiological Results for Water Samples from Columbia River Shoreline Springs

Contaminants of Hanford Site origin continued to be detected in water from shoreline springs entering the Columbia River along the Hanford Site during 2008. Gross alpha, gross beta, tritium, strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238 were detected in spring water (Appendix C, Table C.10). All samples analyzed for iodine-129 in 2008 were below the laboratory-reported detection limit. All radiological contaminant concentrations measured in shoreline springs during 2008 were less than applicable DOE-derived concentration guides, but exceeded the Washington State ambient-water quality criteria for gross alpha at locations discussed below. In addition, uranium concentrations at some 300 Area locations exceeded the drinking water standard (DOE Order 5400.5; Appendix D, Table D.2).

Figure 10.5.1 depicts 6-year trend plots of concentrations of selected radionuclides in 300 Area shoreline spring water (Spring 42-2 and Spring DR 42-2) from 2003 through 2008. Concentrations of radionuclides in 300 Area shoreline springs in 2008 were similar to concentrations measured in previous years. Concentrations of radionuclides in shoreline spring water vary over the years with changes in the degree of Columbia River water and groundwater mixing

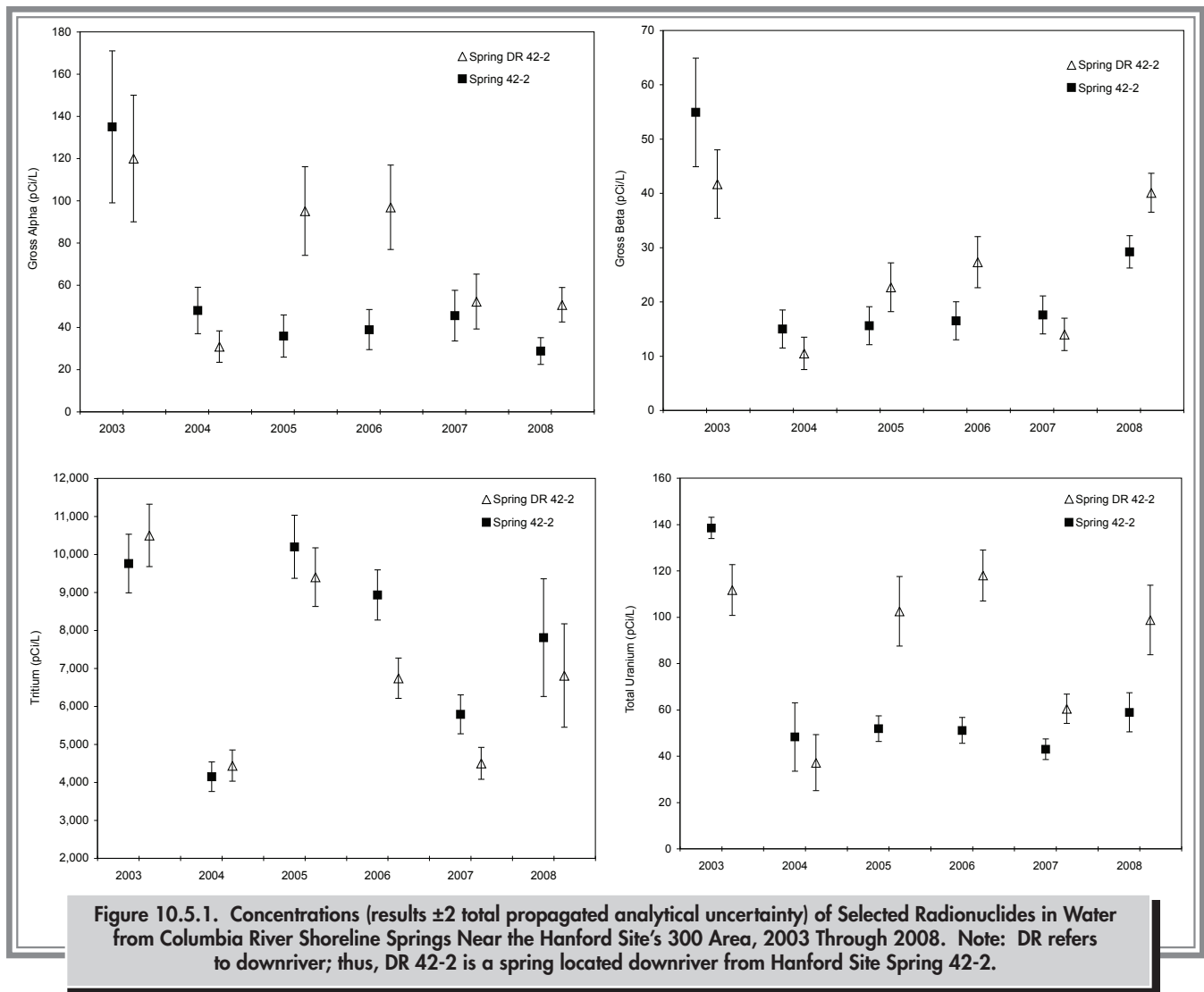
(i.e., bank storage effect). Elevated gross alpha, gross beta, and uranium concentrations measured in the 300 Area riverbank springs are indicators of the contaminated groundwater plume originating at the 300 Area. The elevated tritium levels measured in 300 Area shoreline springs are indicators of the contaminated groundwater plume from the 200 Areas (Section 5.9 in PNL-10698).

Figure 10.5.2 provides concentrations of selected radionuclides in shoreline spring water near the Hanford town site (Spring 28-2 and Spring DR 28-2) from 2003 through 2008. Annual fluctuations in these values reflect the influence of bank storage during the sampling period. The elevated radionuclide levels measured in the Hanford town site shoreline springs are indicators of the contaminated groundwater plume from the 200 Areas (Section 5.9 in PNL-10698).

Gross beta concentrations in shoreline spring water at the 100 Areas locations, Hanford town site, and 300 Area were elevated compared to gross beta concentrations in Columbia River water at Priest Rapids Dam but were below the Washington State 50-pCi/L (2-Bq/L) ambient-water quality criterion. Gross beta concentrations were highest for riverbank spring water at the 300 Area, 100-K Area, Hanford town site, and the 100-H Area.

Tritium concentrations varied widely with location. The highest tritium concentration measured in shoreline springs was at the Hanford town site ( $14,000 \pm 2,800$  pCi/L [ $520 \pm 100$  Bq/L]), which was 70% of the Washington State ambient surface-water quality criterion of 20,000 pCi/L (740 Bq/L) (WAC 173-201A; 40 CFR 141), followed by  $9,100 \pm 1,800$  pCi/L ( $340 \pm 67$  Bq/L) in the 300 Area (Spring 41-9), and  $5,800 \pm 1,200$  pCi/L ( $220 \pm 44$  Bq/L) in the 100-N Area. Tritium concentrations in most shoreline spring water samples were elevated compared to the 2008 Columbia River water concentrations at Priest Rapids Dam.

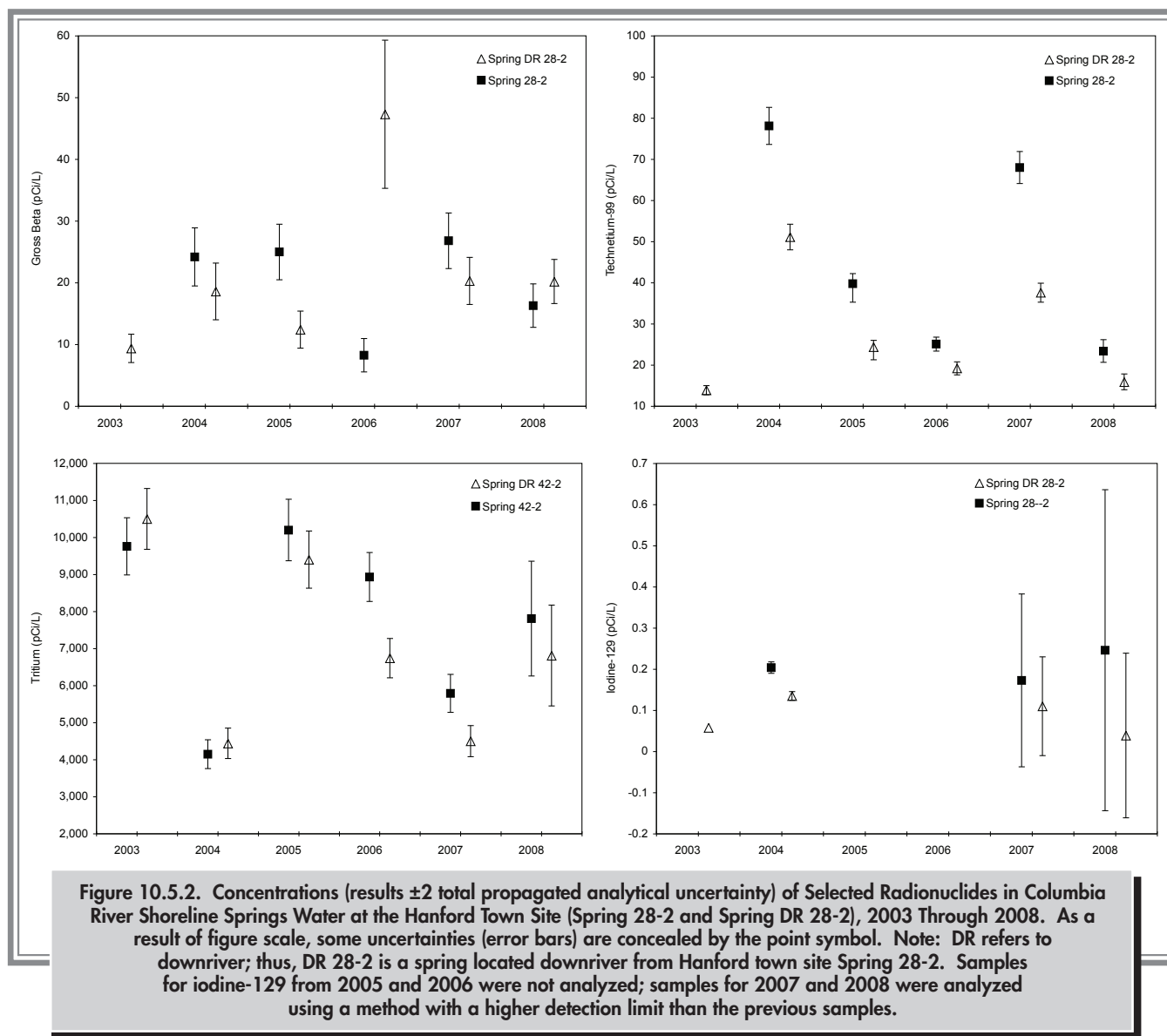
Water samples from shoreline springs were analyzed for strontium-90 in the 100-B, 100-K, 100-N, 100-D, 100-H, 100-F, and 300 Areas. The highest strontium-90 concentration detected in shoreline spring water was at the 100-H



Area ( $6.8 \pm 1.1$  pCi/L [ $0.25 \pm 0.041$  Bq/L]). This value was 85% of the state's ambient surface-water quality criterion of 8 pCi/L (0.30 Bq/L). Groundwater at the 100-N Area historically has had the highest strontium-90 concentrations. However, since 1997, no visible shoreline springs have been observed along the shoreline where strontium-90 concentrations in groundwater are elevated.

Water samples from shoreline springs in the 100-B Area, 100-H Area, and at the Hanford town site were analyzed for technetium-99. All results for technetium-99 were below the EPA drinking water standard of 900 pCi/L (33 Bq/L) (Appendix D, Table D.4). The highest technetium-99 concentration was found in shoreline spring water from the Hanford town site ( $23 \pm 2.8$  pCi/L [ $0.85 \pm 0.10$  Bq/L]).

Water samples from shoreline springs at the Hanford town site and 300 Area were collected from 2003 through 2005 and submitted to a laboratory for iodine-129 analyses using a method with an extremely low detection limit. However, since 2005, the unique instrument used for this assay has not been operational, and an alternative for this ultra-trace measurement capability is not available. The highest concentrations were measured in water samples from the Hanford town site springs from 2003 through 2005, with all values below the state's surface-water quality criterion of 1 pCi/L (0.037 Bq/L) (Appendix D, Table D.4). Riverbank spring water samples were analyzed for iodine-129 for 2007 and 2008 with traditional gamma spectrometry, which has a higher detection limit than the ultra-trace method. All



samples analyzed for iodine-129 for 2007 and 2008 were below the detection limit of 1 pCi/L (0.037 Bq/L).

Uranium was monitored in shoreline spring water samples from the 100-N, 100-H, and 100-F Areas, Hanford town site, and 300 Area in 2008 (Figure 10.4.1). The highest total uranium level was found in 300 Area spring water ( $99 \pm 15$  pCi/L [ $3.7 \pm 0.56$  Bq/L] or approximately  $150 \pm 22$  µg/L), which was collected at Spring DR 42-2 down-gradient from the retired 300 Area Process Trenches. The total uranium concentration in this spring exceeded the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L]). Spring DR 42-2 in the 300 Area

had an elevated gross alpha concentration ( $51 \pm 8.2$  pCi/L [ $1.9 \pm 0.30$  Bq/L]), which exceeded the Washington State ambient surface-water quality criterion of 15 pCi/L (0.56 Bq/L) (Appendix D, Table D.4). Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area in the vicinity of former uranium fuel fabrication facilities and inactive waste sites. Gross alpha and gross beta concentrations in 300 Area shoreline spring water from 2003 through 2008 parallel uranium and are likely associated with its presence. Concentrations of radionuclides in 300 Area shoreline springs in 2008 were similar to concentrations measured in previous years and varied with changes in bank storage.

### 10.5.1.3 Chemical Results for Water Samples from Columbia River Shoreline Springs

Chemical contaminants originating from the Hanford Site continued to be detected in water from shoreline springs entering the Columbia River during 2008. Metals and anions of interest (chloride, fluoride, nitrate, and sulfate) were detected in spring water. Concentrations of volatile organic compounds were near or below the analytical laboratory's required detection limits in all samples. Trace amounts of chlorinated organic compounds were detected below the analytical laboratory's required detection limit for the following locations: trichloroethene for the 300 Area, trichloroethene and chloroform at the 100-B Area, chloroform at the 100-K Area, and methylene chloride at the 100-F Area. Trichloroethene has been consistently detected at trace concentrations in 300 Area shoreline spring water, which is a result of contaminated groundwater in the shallowest part of the unconfined aquifer near the river. Relatively high concentrations recently discovered at depth in the unconfined aquifer, which greatly exceeded regulatory standards (PNNL-16435), were not observed in the riverbank springs.

Table 10.5.3 presents concentration ranges of selected chemicals measured in shoreline spring water during 2003 through 2008. For most locations, the 2008 chemical sample results were similar to those reported previously (PNNL-14687). Nitrate concentrations for 2003 through 2008 were highest in spring water samples from the 100-F Area. Dissolved chromium concentrations were highest in the 100-K, 100-D, and 100-H Areas shoreline springs for 2003 through 2008. Hanford Site groundwater monitoring results for 2008 indicated similar contaminant concentrations at shoreline areas near the discharge locations for the springs (Section 10.7, Figure 10.7.6).

The Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; Appendix D, Table D.5). For comparison purposes, spring water criteria were calculated using the same 47-mg/L calcium carbonate hardness given in Appendix D, Table D.5. Concentrations of most metals measured in water collected from springs

along the Hanford Site shoreline during 2003 through 2008 were below Washington State ambient surface-water chronic toxicity levels (WAC 173-201A). However, for 2003 through 2008, the maximum concentrations of dissolved chromium in shoreline spring water from the 100-B, 100-K, 100-N, 100-D, 100-H, and 100-F (chronic only) Areas were above the Washington State ambient surface-water chronic and acute toxicity levels (Appendix D, Table D.5). For 2008, dissolved chromium was above the Washington State ambient surface-water level for chronic and acute toxicity levels at the 100-K, 100-H, and 100-F Areas and above the chronic toxicity levels at the 100-B and 100-D Areas for riverbank spring water samples. Arsenic concentrations in shoreline spring water were well below the Washington State ambient surface-water chronic toxicity level, but concentrations in all samples (including upriver Columbia River water samples) exceeded the EPA limit for the protection of human health for the consumption of water and organisms. Nevertheless, this EPA value is more than 10,500 times lower than the Washington State chronic toxicity standard (40 CFR 141; Appendix D, Table D.5). Nitrate concentrations at all spring water locations were below the drinking water standard (Appendix D, Table D.4).

### 10.5.2 Monitoring Columbia River Shoreline Springs Sediment

Beginning in the 1990s, periodic studies were conducted to collect and analyze sediment from riverbank springs in the 100 Areas and 300 Area (DOE/RL-92-12, Rev. 1; WHC-EP-0609; WHC-SD-EN-TI-125, Rev. 0; WHC-SD-EN-TI-198). Routine sampling of sediment from shoreline springs began during 1993 at the Hanford town site and 300 Area. Sampling of shoreline springs sediment in the 100-B, 100-K, and 100-F Areas began during 1995 and in the 100-H Area in 2003. Substrates at the shoreline springs in the 100-N and 100-D Areas consist predominantly of large cobble, which is unsuitable for sampling. During 2008, sediment samples were collected at shoreline springs in the 100-B, 100-K, 100-H, 100-F, and 300 Areas and the Hanford town site.



**Table 10.5.3. Concentration Ranges for Selected Chemicals in Water Monitoring Samples from Columbia River Shoreline Springs on the Hanford Site, 2003 Through 2008**

Ambient- Water Quality Criterion Level <sup>(a)</sup>		<u>100-B Area</u>	<u>100-K Area</u>	<u>100-N Area</u>	<u>100-D Area</u>	<u>100-H Area</u>	<u>100-F Area</u>	<u>Hanford town site</u>	<u>300 Area</u>
<b>No. of Samples</b>		10	8	6	12	11	6	17	16
<b>Dissolved Metals (µg/L)</b>									
Antimony	NA	0.11 - 0.31	0.094 - 0.29	0.16 - 0.29	0.16 - 0.30	0.13 - 0.39	0.13 - 0.22	0.15 - 0.29	0.14 - 0.29
Arsenic	190	0.42 - 1.3	0.35 - 1.8	1.5 - 2.5	0.54 - 2.5	0.33 - 2.9	0.38 - 2.2	0.99 - 4.0	0.87 - 6.3
Cadmium	0.59	0.0056 - 0.011	0.0083 - 0.023	0.013 - 0.029	0.0074 - 0.062	0.0020 - 0.040	0.013 - 0.12	0.0087 - 0.028	0.014 - 0.038
Chromium	10 <sup>(b)</sup>	2.2 - 18	0.59 - 72	6.0 - 11	0.49 - 57	0.76 - 37	0.83 - 16	0.52 - 2.7	1.5 - 5.0
Copper	6	0.20 - 1.6	0.25 - 0.45	0.18 - 0.43	0.32 - 1.1	0.40 - 0.58	0.31 - 1.1	0.24 - 0.88	0.30 - 0.47
Lead	1.1	0.011 - 1.4	0.0040 - 0.39	0.011 - 0.24	0.0087 - 0.91	0.011 - 1.0	0.0082 - 0.36	0.0040 - 0.29	0.0040 - 0.41
Nickel	83	0.091 - 1.6	0.11 - 1.3	0.010 - 1.7	0.22 - 6.4	0.099 - 1.5	0.12 - 1.7	0.046 - 1.4	0.17 - 2.1
Silver	0.94 <sup>(c)</sup>	0.0017 - 0.0097	0.0017 - 0.0085	0.0017 - 0.0085	0.0017 - 0.0085	0.0017 - 0.010	0.0017 - 0.0050	0.0017 - 0.015	0.0017 - 0.0085
Thallium	NA	0.0035 - 0.024	0.0038 - 0.015	0.0039 - 0.0090	0.0066 - 0.030	0.0042 - 0.017	0.0063 - 0.013	0.0032 - 0.019	0.0040 - 0.018
Zinc	55	0.14 - 17	0.43 - 3.1	1.2 - 1.7	1.2 - 5.3	1.1 - 4.8	0.66 - 4.2	0.54 - 2.7	0.78 - 4.1
<b>No. of Samples</b>		10	8	6	12	11	6	17	16
<b>Total Recoverable Metals (µg/L)</b>									
Chromium	96 <sup>(d)</sup>	6.5 - 89	0.83 - 74	8.1 - 13	1.5 - 270	0.89 - 63	2.3 - 59	0.69 - 24	1.8 - 30
Mercury	0.012	0.00038 - 0.11	0.00071 - 0.050	0.00040 - 0.0094	0.00047 - 0.30	0.00062 - 0.064	0.0016 - 0.060	0.00070 - 0.018	0.00054 - 0.047
Selenium	5	0.30 - 1.3	0.10 - 2.1	0.50 - 1.0	0.10 - 2.4	0.10 - 1.3	0.16 - 2.0	0.38 - 1.7	1.2 - 3.8
<b>No. of Samples</b>		6	6	4	10	9	5	14	16
<b>Anions (mg/L)</b>									
Nitrate	45 <sup>(e)</sup>	0.37 - 2.4	0.028 - 7.1	2.7 - 4.7	0.10 - 2.6	0.56 - 6.9	2.6 - 10	0.47 - 5.2	1.7 - 6.2

(a) Ambient-water quality criteria values (WAC 173-201A-240) for chronic toxicity unless otherwise noted.

(b) Value for hexavalent chromium.

(c) Value for acute toxicity; chronic value not available.

(d) Value for trivalent chromium.

(e) Drinking water standard (WAC 246-290).

NA = Not available.

### 10.5.2.1 Radiological Results for Sediment Samples from Columbia River Shoreline Springs

Results for 2008 samples were similar to those observed for previous years (PNNL-18427, APP. 1; Appendix C, Table C.11). Potassium-40, cesium-137, uranium isotopes, and daughter products from naturally occurring radionuclides were the only radionuclides reported above the minimum detectable concentrations. During 2008, radionuclide concentrations in shoreline spring sediment were similar to those observed in Columbia River sediment, with the exception of the 300 Area where uranium concentrations were above the background concentrations measured for sediment from Priest Rapids Dam. Elevated uranium concentrations for 300 Area Spring sediment compared to Priest Rapids Dam sediment have been previously reported (PNNL-14687).

### 10.5.2.2 Chemical Results for Sediment Samples from Columbia River Shoreline Springs

Concentrations of metals in shoreline spring sediment samples during 2008 were similar to concentrations in Hanford Reach Columbia River sediment samples (PNNL-18427, APP. 1; Appendix C, Table C.9). Arsenic and lead concentrations in riverbank spring sediment were slightly elevated at the 100-H Area, and chromium levels were slightly elevated at the 100-B Area. Currently, there are no Washington State freshwater sediment quality criteria for comparison to the measured values.





## 10.6 Radiological Monitoring of Hanford Site Drinking Water

GW Patton and LM Kelly

Pacific Northwest National Laboratory scientists conducted radiological monitoring of drinking water supplied to Hanford Site facilities by DOE-owned pumps and water treatment facilities during 2008. Fluor Hanford, Inc., the site water-compliance organization, conducted routine chemical, physical, and microbiological monitoring of onsite drinking water. Individual water systems operated by Fluor Hanford, Inc. and Washington Closure Hanford, LLC performed process monitoring (including chemical and physical sampling) at the water treatment plants and distribution systems to determine compliance with applicable regulations.

WAC 246-290, "Group A Public Water Supplies," requires that all drinking water analytical results be reported routinely to the Washington State Department of Health. Radiological results for Hanford Site drinking water samples are reported to the state through this annual environmental report and through an annual supplemental data compilation (e.g., PNNL-18427, APP. 1). Process monitoring reports are provided directly to the state each month by the contractor responsible for operating the water system. Chemical, physical, and microbiological data are reported to the state directly by the state-accredited laboratory performing the analyses and to Fluor Hanford, Inc. but are not published.

All DOE-owned Hanford Site drinking water systems were in compliance with drinking water standards for radiological, chemical, and microbiological contaminant levels during 2008. Contaminant concentrations measured during the year were similar to those observed in recent years (see Section 10.6 in PNNL-17603 and Section 10.6 in PNNL-16623).

### 10.6.1 Hanford Site Drinking Water Systems

Drinking water was supplied during 2008 to DOE facilities on the Hanford Site by nine DOE-owned, contractor-operated, public water systems (Table 10.6.1). Drinking water for the 200-East Area is supplied from the 200-West facility. Eight of the nine systems used water from the Columbia River. The 400 Area system used groundwater from the unconfined aquifer beneath the site. Fluor Hanford, Inc. operated seven of the public water systems. Two systems were operated by Washington Closure Hanford, LLC. The 300 Area system distributed water supplied by the city of Richland. In addition to the 300 Area, the city of Richland provided drinking water to the Richland North Area and the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER) in 2008.

**Table 10.6.1. Hanford Site Drinking Water Systems and Systems Operators**

<u>System<sup>(a)</sup></u>	<u>Operator</u>
200-West Area	Fluor Hanford, Inc.
100-K Area	Fluor Hanford, Inc.
100-N Area	Washington Closure Hanford, LLC
300 Area	Washington Closure Hanford, LLC
400 Area	Fluor Hanford, Inc.
200-East Area	Fluor Hanford, Inc.
609 Fire Station	Fluor Hanford, Inc.
Wye Barricade	Fluor Hanford, Inc.
Yakima Barricade	Fluor Hanford, Inc.

(a) 400 Area system water is from 400 Area groundwater wells. Water for all other systems is from the Columbia River. Systems in the 100-B Area and at 251-West no longer supply potable water to consumers.

## 10.6.2 Hanford Site Drinking Water Treatment Facilities

Raw water was treated at four DOE-owned water treatment facilities in the 100-K, 100-N, 200-West, and 400 Areas (Figure 10.6.1). Water for the 100-K, 100-N, and 200-West

Areas facilities was obtained from the Columbia River. Water treated in the 400 Area was pumped from wells. The 400 Area continued to use well 499-S1-8J (P-16) as the primary drinking water supply well, and wells 499-S0-8 (P-14) and 499-S0-7 (P-15) were designated as emergency backup sources. The three wells furnished water to a common header that supplies three aboveground storage tanks.

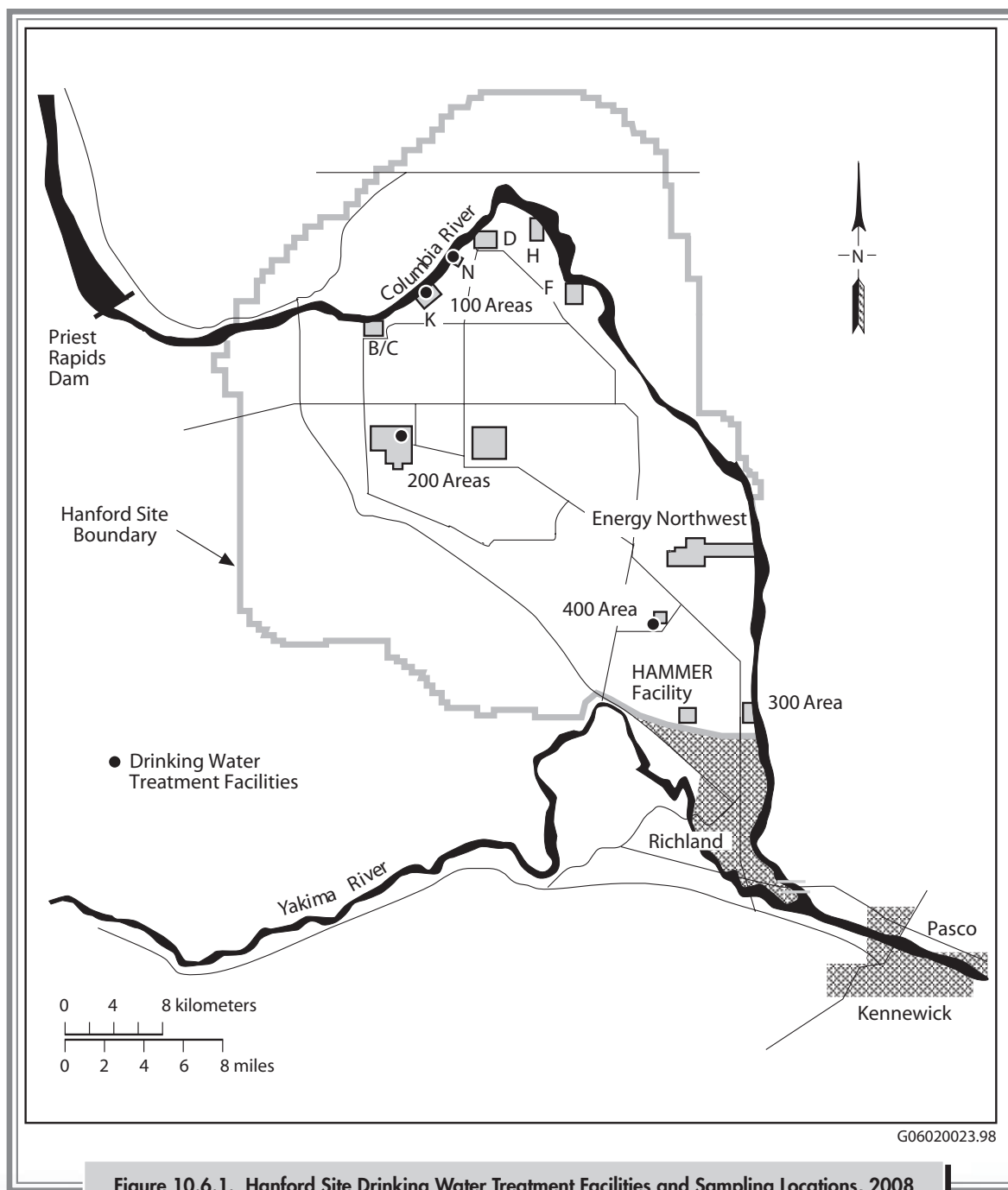


Figure 10.6.1. Hanford Site Drinking Water Treatment Facilities and Sampling Locations, 2008

Well P-14 was used in March 2008 and supplied 786,000 liters (207,600 gallons). Well P-15 did not supply water to the 400 Area in 2008.

### 10.6.3 Collection of Drinking Water Samples and Analytes of Interest

Samples at all four drinking water treatment facilities were collected monthly and analyzed either quarterly or annually for radiological contaminants. All were samples of treated water collected before the water was distributed for general use. Drinking water in the 300 and Richland North Areas and at the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER) was not routinely monitored for radiological contaminants by DOE contractor personnel. However, personnel from Pacific Northwest National Laboratory's Surface Environmental Surveillance Project routinely collected water samples from the Columbia River at the city of Richland river water intake. The Columbia River is a major source of the city of Richland's drinking water. The radiological analytical results for these river water samples are summarized in Section 10.4 and tabulated in Appendix C (Table C.4). The city of Richland also monitors its water for radiological and chemical contaminants as well as for general water quality. Because it is a community

water system, city officials are required to annually report monitoring results and characterize the risks (if any) from exposure to contaminants in the water in what is known as a Consumer Confidence Report. These reports are mailed to all consumers as an insert with a monthly utility bill. Results are also made available on the city of Richland website at <http://www.ci.richland.wa.us/RICHLAND/Utilities/index.cfm?PageNum=15>.

### 10.6.4 Radiological Results for Hanford Site Drinking Water Samples

Drinking water samples collected for radiological analysis in 2008 were analyzed for gross alpha, gross beta, tritium, and strontium-90. Table 10.6.2 summarizes results for radiological monitoring of Hanford Site drinking water during 2008. Individual analytical results are reported in PNNL-18427, APP. 1. The maximum amount of beta-gamma radiation from manmade radionuclides allowed in drinking water by Washington State and the EPA is an annual average concentration that will not produce an annual dose equivalent to the whole body or any internal organ greater than 4 millirem (0.04 millisievert). Maximum contaminant levels for gross alpha (excluding radon and uranium) and radium-226 and radium-228 (a combined total) are 15 pCi/L (0.56 Bq/L) and 5 pCi/L (0.18 Bq/L),

**Table 10.6.2. Annual Average Concentrations (pCi/L)<sup>(a)</sup> of Selected Radiological Constituents in Hanford Site Drinking Water, 2008**

Constituent	No. of Samples Analyzed From Each Location	Systems				
		100-K Area	100-N Area	200-West Area	400 Area	Standards
Gross alpha <sup>(b)</sup>	4 <sup>(c)</sup>	0.58 ± 1.8 <sup>(d)</sup>	1.0 ± 2.4	0.26 ± 0.93 <sup>(d)</sup>	0.58 ± 2.2 <sup>(d)</sup>	15 <sup>(e,f)</sup>
Gross beta <sup>(b)</sup>	4 <sup>(g)</sup>	2.2 ± 1.4	1.5 ± 1.3 <sup>(d)</sup>	2.0 ± 4.2	6.1 ± 2.1	50 <sup>(f)</sup>
Tritium	1 <sup>(h)</sup>	320 ± 270 <sup>(d,i)</sup>	280 ± 260 <sup>(d,i)</sup>	110 ± 250 <sup>(d,i)</sup>	2,100 ± 510 <sup>(b,c)</sup>	20,000 <sup>(f)</sup>
Strontium-90	1 <sup>(h)</sup>	0.38 ± 0.45 <sup>(d,i)</sup>	0.27 ± 1.2 <sup>(d,i)</sup>	0.19 ± 0.41 <sup>(d,i)</sup>	0.68 ± 0.53 <sup>(d,i)</sup>	8 <sup>(e,f)</sup>

(a) Multiply pCi/L by 0.037 to convert to Bq/L.

(b) Annual average ±2 times the standard deviation.

(c) Samples were collected and analyzed quarterly (n=4).

(d) Analytical results for all samples were below the detection limit.

(e) WAC 246-290.

(f) 40 CFR 141.

(g) Samples were collected monthly, composited, and analyzed quarterly.

(h) Samples were collected quarterly, composited, and analyzed annually.

(i) Single result ±2 total propagated analytical error.

respectively. The maximum allowable annual average limit for tritium is 20,000 pCi/L (740 Bq/L) (40 CFR 141; WAC 246-290). These concentrations are assumed to produce a total body or organ dose of 4 millirem (0.04 millisievert) per year. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any internal organ must not exceed 4 millirem (0.04 millisievert).

Annual average concentrations of all monitored radionuclides in Hanford Site drinking water were below state and federal maximum allowable contaminant levels during 2008. Most gross alpha, gross beta, and tritium results for river water samples were below their minimum detectable concentrations (i.e., concentrations were too low to

measure). Strontium-90 was not detected in any river water samples. Gross beta was found in all 400 Area well water samples. Gross alpha and strontium-90 were not detected in 400 Area well water samples (Table 10.6.2).

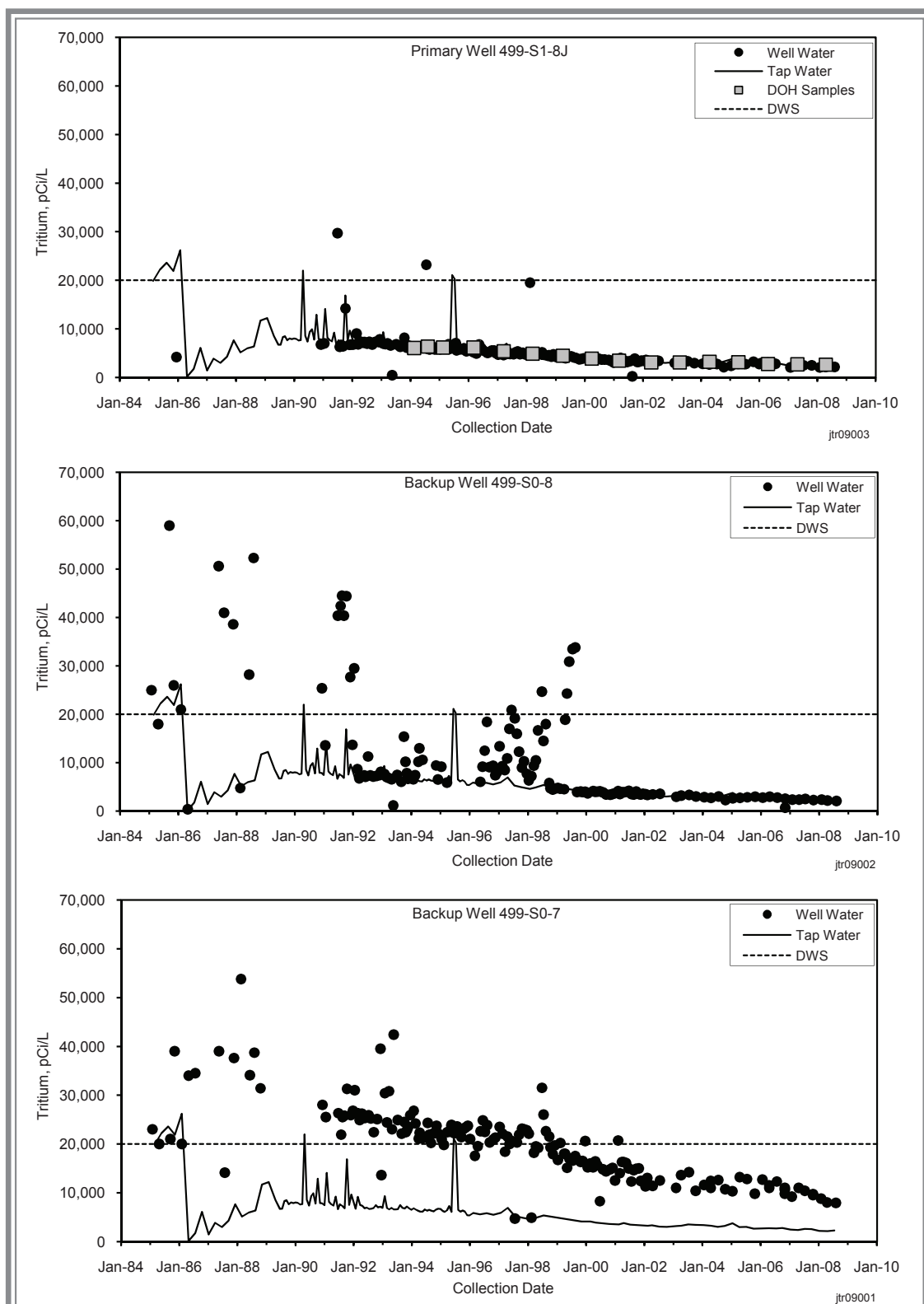
The Soil and Groundwater Remediation Project collected and analyzed raw (untreated) water samples from all three 400 Area drinking water wells (one primary well and two backup wells). A tritium plume that originates in the 200-East Area extends under the 400 Area and has historically affected tritium concentrations in all 400 Area drinking water wells. Annual average tritium concentrations in all three wells were below the 20,000-pCi/L (740-Bq/L) state and federal annual average drinking water standard (Table 10.6.3; Figure 10.6.2) during 2008.

**Table 10.6.3. Tritium Concentrations (pCi/L)<sup>(a)</sup> in Hanford Site 400 Area Drinking Water Wells, 2008<sup>(b)</sup>**

<b>Sampling Date</b>	<b>Primary Drinking Water Well 499-S1-8J (P-16)</b>	<b>Backup Drinking Water Well 499-S0-8 (P-14)</b>	<b>Backup Drinking Water Well 499-S0-7 (P-15)</b>
February 1, 2008	2,100 ± 460	2,400 ± 530	8,800 ± 1,800
April 15, 2008	2,200 ± 480	2,200 ± 480	8,000 ± 1,600
August 5, 2008	2,200 ± 480	2,100 ± 460	7,900 ± 1,600

(a) Multiply pCi/L by 0.037 to convert to Bq/L.

(b) Reported concentration ±2 total propagated analytical error.



**Figure 10.6.2. Tritium Concentrations in Drinking Water from Three Wells in the Hanford Site 400 Area, 1984 Through 2008 (DOH = Washington State Department of Health; DWS = drinking water standard). Multiply pCi/L by 0.037 to convert to Bq/L.**



## 10.7 Groundwater Monitoring

MJ Hartman

Groundwater is a supply of fresh water found in layers beneath the earth's surface. On the Hanford Site, groundwater has been affected by past industrial activities. Fifty years of nuclear weapons production resulted in approximately 1.7 trillion liters (450 billion gallons) of liquid waste released to the ground (DOE/RL-2007-20, Rev. 0). Some of the associated contaminants have reached the groundwater. Hazardous chemicals in the groundwater include carbon tetrachloride, chromium, and nitrate. Radioactive contaminants include tritium, strontium-90, technetium-99, iodine-129, and uranium. Currently, groundwater contaminant levels are greater than drinking water standards beneath 12% of the Hanford Site area (DOE/RL-2008-66, Rev. 0).

Groundwater beneath the Hanford Site is not currently used extensively as a water supply for drinking water or irrigation. Contaminants in groundwater have not been shown to impact offsite sources for water supply, such as the Columbia River and municipal water supply wells. Contaminants carried by groundwater discharging from the site can be detected in the near-shore river environment and, in some locations, at levels that exceed relevant environmental standards.

The *Hanford Integrated Groundwater and Vadose Zone Management Plan* (DOE/RL-2007-20, Rev. 0) describes steps for cleaning up groundwater and the vadose zone. DOE developed the plan in consultation with EPA and the Washington State Department of Ecology. The primary elements associated with managing the site's groundwater and vadose zone are to 1) protect the Columbia River and groundwater; 2) develop a cleanup decision process; and 3) attain final cleanup. The following paragraphs describe these elements in further detail.

**Protect the Columbia River and Groundwater.** Many actions have already been taken to address principal threats to the Columbia River and groundwater. These actions include the following:

- Cease discharge of all unpermitted liquids in the central Hanford Site.
- Remediate the former liquid waste sites in the 100 and 300 Areas to reduce the potential for future contamination to groundwater.
- Contain groundwater plumes and reduce the mass of primary contaminants through remedial actions such as pump-and-treat systems.

**Develop a Process for Cleanup Decisions.** Final decisions will be based on processes outlined in CERCLA and/or RCRA. Five key elements will support final decisions:

- Gather sufficient characterization data, focusing on waste sites with deep contamination that post a future risk to groundwater.
- Evaluate the performance of early actions (waste site remediation along the River Corridor and groundwater interim actions) to help guide future cleanup.
- Identify cleanup goals for waste sites that support long-term groundwater remediation.
- Identify new technologies to reduce the mobility of deep contamination and limit its movement to groundwater.
- Improve integration of cleanup decisions for waste sites and groundwater.

**Attain Final Cleanup.** DOE, EPA, and the Washington State Department of Ecology are committed to completing the cleanup of past-practice waste sites by September 2024. Substantial progress has been made toward cleanup of the

100 and 300 Areas. Strategies used for making final decisions in the 100 and 300 Areas will provide a basis for attaining similar final decisions for the 200 Areas.

The following sections are summarized from the Hanford Site groundwater monitoring report for fiscal year 2008 (DOE/RL-2008-66, Rev. 0).

### 10.7.1 Highlights and Items of Interest

This section briefly describes some of the high-priority groundwater topics for 2008.

**River Corridor Baseline Risk Assessment.** To support the decision-making process for final CERCLA remedial actions within the Columbia River corridor, DOE is conducting a CERCLA remedial investigation, including a baseline risk assessment for the River Corridor portion of the Hanford Site. The risk assessment consists of three components: the 100 Area and 300 Area Component (DOE/RL-2005-42, Rev. 1; DOE/RL-2007-21, Draft A); the Inter-Area Component (WCH-274, Rev. 0); and the Columbia River Component. The 100 Area and 300 Area Component and the Inter-Area Component will be integrated with groundwater into a series of final CERCLA remedial investigation reports for the operational areas of the River Corridor.

**Systematic Planning for the 100 Areas.** A systematic planning process uses a common sense, graded approach to verify the level of detail in planning is commensurate with the importance of the work being planned. DOE, EPA, Washington State Department of Ecology, Native American tribes, and stakeholders initiated the systematic planning process for the 100 Areas in fiscal year 2008. Using this process, DOE is preparing a work plan for a remedial investigation and feasibility study to support the selection of a final alternative under CERCLA for source and groundwater operable units in the 100 Areas (planned for publication in 2009). The work plan will document how decisions are made and specify collection details for required data. It also will describe the procedures for evaluating cleanup alternatives and identifying the preferred alternative.

**100-KR-4 Pump-and-Treat Expansion.** DOE installed new extraction and injection wells in 2008 and constructed a new treatment system with a designed treatment capacity of 2,271 liters (600 gallons) per minute. When it begins operation in 2009, the pump-and-treat system will capture more of the hexavalent chromium plume around the 116-K-2 Trench.

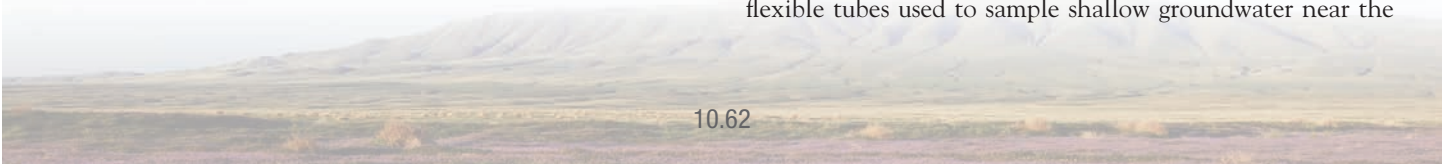
**100-N Apatite Barrier.** Workers conducted a second round of injections of apatite-forming chemicals into a line of groundwater wells along the 100-N Area shoreline in fiscal year 2008. Strontium-90 concentrations initially increased in many wells, but then declined as the remediation took effect. Tests are also being conducted to emplace apatite into the vadose zone by surface infiltration.

**100-HR-3 Characterization and Testing.** In 2008, DOE continued characterization and research in the 100-D and 100-H Areas. Objectives included characterization of the chromium plume between the 100-D and 100-H Areas; location of the source of the chromium plume in the southern 100-D Area; characterization of deep chromium contamination; biostimulation testing, an in situ remediation method for chromium in the aquifer; nanometer-size iron injection testing, a method to increase effectiveness of the redox barrier in the 100-D Area; and electrocoagulation testing, a water treatment process.

**200-ZP-1 Record of Decision.** In September 2008, DOE, EPA, and the Washington State Department of Ecology signed a final record of decision for groundwater remediation in the 200-ZP-1 Operable Unit in the 200-West Area (ROD 2008). The selected alternative combines pump-and-treat, monitored natural attenuation, flow-path control, and institutional controls.

**300-FF-5 Studies.** Scientists continued an aggressive campaign to investigate the uranium plume in the 300 Area in 2008. Work included updating computer simulations of groundwater flow and uranium transport, a limited uranium field investigation involving multiple characterization boreholes, updating the human health and ecological risk assessment, and assessing potential remedial action technologies for the 300 Area uranium plume.

**New Aquifer Tubes.** Aquifer tubes are small-diameter, flexible tubes used to sample shallow groundwater near the



Columbia River. In 2008, DOE installed 140 new aquifer tubes in 60 locations along the Columbia River shoreline from the 100-B/C Area to the 300 Area. The tube locations were chosen to fill gaps in the existing aquifer tube network. The section of the shoreline where the 200 Area tritium plume approaches the river now has 11 new monitoring locations. Early data from the new tubes confirm the known distribution of contaminants in groundwater near the river.

**Tri-Party Well Installation Agreement.** DOE, EPA, and the Washington State Department of Ecology approved an

agreement in August 2008 providing a 3-year rolling prioritized well drilling schedule through calendar year 2011.

**Groundwater Data.** Workers sampled 865 monitoring wells and 297 aquifer tubes between October 2007 and September 2008. Many of the wells and some aquifer tubes were sampled more than once for a total of 2,601 sampling trips. These numbers do not include special groundwater sampling associated with remediation and research. Tables 10.7.1 and 10.7.2 list the number of wells and analyses by groundwater interest area and monitoring purpose.

**Table 10.7.1. A Summary of Hanford Site Groundwater Monitoring by Groundwater Interest Area, Fiscal Year 2008<sup>(a)</sup>**

	<u>Hanford Site</u>	<u>100-BC-5</u>	<u>100-FR-3</u>	<u>100-HR-3-D</u>	<u>100-HR-3-H</u>	<u>100-KR-4</u>	<u>100-NR-2</u>
Number of wells and aquifer tubes	1,166	46	51	209	109	101	100
Number of sampling events	3,939	57	53	1,109	339	581	273
Number of analyses	40,319	579	512	5,982	2,433	3,519	3,316
Number of results	134,509	1,356	2,583	10,684	5,762	8,085	8,736
Percent of results non-detected	48	31	53	18	30	33	41
	<u>1100-EM-1</u>	<u>200-BP-5</u>	<u>200-PO-1</u>	<u>200-UP-1</u>	<u>200-ZP-1</u>	<u>300-FF-5</u>	
Number of wells and aquifer tubes	42	138	103	72	97	98	
Number of sampling events	46	344	271	235	357	274	
Number of analyses	515	7,645	4,677	3,392	4,720	3,029	
Number of results	2,991	26,562	17,118	15,934	20,134	14,564	
Percent of results non-detected	61	51	50	57	53	61	

(a) These numbers do not include special sampling associated with remediation and research.

**Table 10.7.2. A Summary of Hanford Site Groundwater Monitoring by Monitoring Purpose,<sup>(a)</sup> Fiscal Year 2008**

	<u>Restoration<sup>(b)</sup></u>	<u>Waste Management<sup>(c)</sup></u>	<u>Environmental Surveillance<sup>(d)</sup></u>
Number of wells and aquifer tubes	996	693	928
Number of sampling events	2,703	997	1,558
Number of analyses	21,551	17,447	17,292
Number of results	66,337	62,477	59,926
Percent of results non-detected	47	48	49

(a) Because of the co-sampling among groundwater monitoring programs, the wells monitored, sampling events, analyses, results, and non-detectable results overlap among monitoring purposes. Totals exclude special sampling.

(b) Wells associated with remediation activities.

(c) Wells sampled to determine impact, if any, of a waste management unit (e.g., RCRA) on groundwater.

(d) Wells sampled to detect impact, if any, of site operations on groundwater over the entire Hanford Site and adjacent offsite areas.

RCRA = Resource Conservation and Recovery Act of 1976.

## 10.7.2 Groundwater Flow

General directions of groundwater flow are illustrated on the water-table map for March 2008 (Figure 10.7.1). The direction of groundwater flow is inferred from water-table elevations, barriers to flow (e.g., basalt or mud units at the water table), and distribution of contaminants. Groundwater enters the unconfined aquifer from recharge areas to the west and eventually discharges to the Columbia River. Additional water infiltrates through the vadose zone beneath the Hanford Site. Hydrologists estimate that the total discharge of groundwater from the Hanford Site aquifer to the Columbia River is in the range 1.1 to 2.5 cubic meters (39 to 88 cubic feet) per second. This rate of discharge is very small compared to the average flow of the river, which is approximately 3,400 cubic meters (120,000 cubic feet) per second.

The water table beneath the 200-East Area is relatively flat because of the presence of highly permeable sediment of the Hanford formation at the water table. Groundwater enters the 200-East Area vicinity from the west and southwest. The flow of water divides, with some flowing to the north through a gap between Gable Butte and Gable Mountain (Gable Gap) and some flowing southeast toward the central part of the Hanford Site. This groundwater divide may be located near the central part of the 200-East Area, but its precise location is unknown. Ongoing studies will help determine the direction of groundwater flow in this region. In the southern part of the Hanford Site, groundwater enters the 300 Area from the northwest, west, and southwest.

The natural pattern of groundwater flow was altered during the Hanford Site's operating years by water-table mounds. The mounds were created by the discharge of large volumes of wastewater to the ground and were present in each reactor area and beneath the 200 Areas. Since effluent disposal decreased significantly in the 1990s, these mounds have dissipated in the reactor areas and have declined considerably in the 200 Areas. Currently, wastewater is discharged to the ground at the State-Approved Land Disposal Site, north of the 200-West Area, and at the Treated Effluent Disposal Facility, east of the 200-East Area.

Groundwater flow in the unconfined aquifer is currently altered where extraction or injection wells are used for

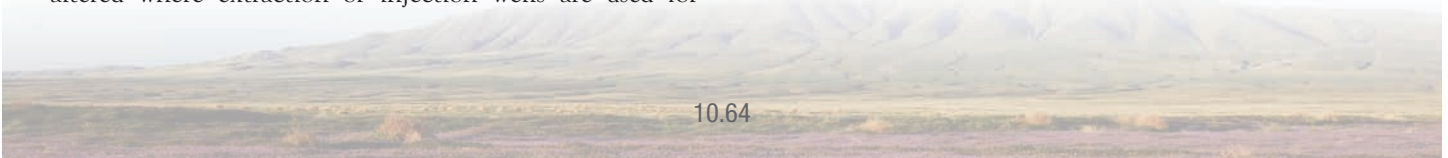
pump-and-treat systems. Extraction wells in the 100-K, 100-D, 100-H, and 200-West Areas capture contaminated water from the surrounding areas. Water flows away from injection wells, which are upgradient of the contaminant plumes, so the injection increases the hydraulic gradient toward the extraction wells.

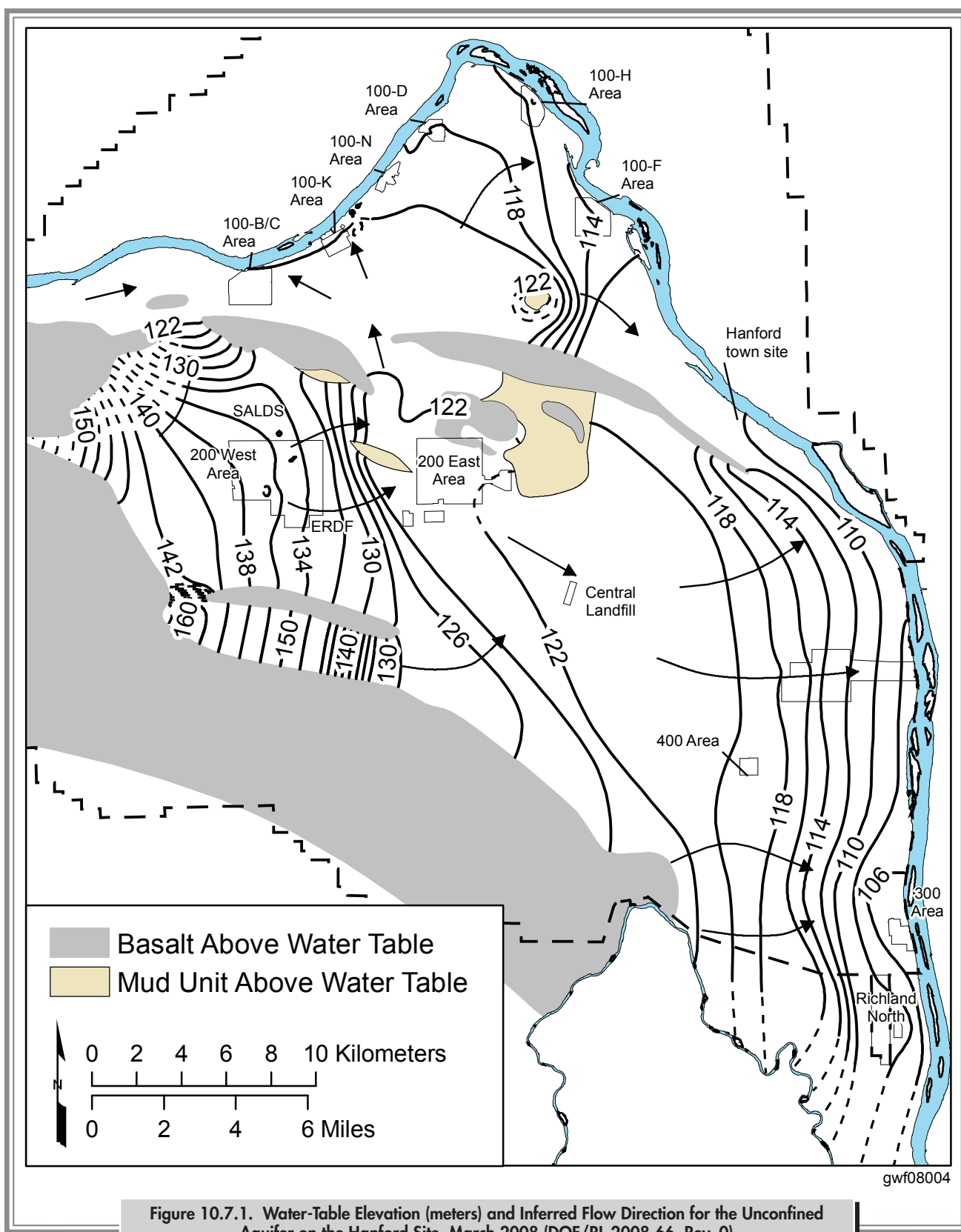
A confined aquifer occurs within sand and gravel of the lowest sedimentary unit of the Ringold Formation. It is confined between basalt and the lower mud unit. The unconfined aquifer does not extend east of the 200-East Area because of the presence of Ringold Formation mud units at the water table (shaded tan on Figure 10.7.1), so the Ringold Formation confined aquifer is the uppermost aquifer in this area. Beneath the Ringold Formation confined aquifer is the upper basalt-confined aquifer, which exists mainly in the Rattlesnake Ridge interbed, the uppermost widespread sedimentary interbed between basalt flows. Groundwater within these confined aquifers is influenced by a residual recharge mound in the vicinity of the B Pond. Several wells north and east of the 200-East Area have shown evidence of intercommunication between the upper basalt-confined aquifer and the overlying aquifers. The intercommunication has been attributed to erosion of the upper Saddle Mountains Basalt and a downward hydraulic gradient. Because an upward gradient exists elsewhere in the 200-East Area/Gable Gap region, the upper basalt-confined aquifer likely discharges to the overlying aquifers, especially within Gable Gap where the Elephant Mountain Basalt was removed by erosion.

## 10.7.3 Groundwater Monitoring and Remediation

DOE monitors groundwater on the Hanford Site to fulfill a variety of state and federal regulations, including the *Atomic Energy Act of 1954*, RCRA, CERCLA, and the *Washington Administrative Code*.

DOE Order 450.1A, "Environmental Protection Program," implements requirements of the *Atomic Energy Act of 1954*. This Order requires environmental monitoring to detect, characterize, and respond to releases from DOE facilities, assess impacts, and characterize exposure pathways. The Order recommends implementing a site-wide approach for





groundwater protection and requires compliance with other applicable environmental protection requirements.

The Hanford Site is divided into operable units, or groupings of similar waste units within a geographic area, so that the CERCLA process can be efficiently implemented. Most operable units are source operable units; others are groundwater operable units. The concept of the groundwater operable unit was adopted to allow separate characterization of the waste sites and the groundwater. Separate characterization recognizes differences between localized contaminants in the soil column at the sources and the more widespread, mingled contamination in groundwater. Monitoring wells are located and sampled to define the nature and extent of the contaminant plumes. Groundwater is also monitored under CERCLA to assess the effectiveness of groundwater remediation. Figure 10.7.2 shows the boundaries of the groundwater operable units. These regulatory-defined groundwater operable units do not cover the entire Hanford Site. Therefore, to provide scheduling, data review, and interpretation for the entire Hanford Site, groundwater staff have defined informal “groundwater interest areas” that include the groundwater operable units and intervening regions (Figure 10.7.2).

The groundwater monitoring requirements for Hanford’s RCRA units fall into one of two categories: interim status or final status. A permitted RCRA unit requires *final status monitoring* as specified in WAC 173-303-645. RCRA units that have not yet been incorporated into permits require *interim status monitoring* as specified in WAC 173-303-400, which invokes 40 CFR 265.

RCRA groundwater monitoring is conducted under one of three possible phases:

- **Indicator Parameter** (or final status detection) – Initially, a detection program uses groundwater data to determine and monitor the impact, if any, of the facility on groundwater.
- **Assessment** (or final status compliance) – If the detection monitoring results indicate a statistically significant change in chemistry, an assessment or compliance phase of monitoring begins.
- **Corrective Action** (via administrative order for interim status sites or during final status) – If the source of the

contamination is determined to be the RCRA unit and the concentration exceeds applicable limits, the Washington State Department of Ecology may require corrective action. Groundwater is then monitored to determine if the corrective action has been effective.

In 2008, detection monitoring at two RCRA sites indicated they may have impacted groundwater quality. Concentrations of the indicator parameter total organic carbon exceeded critical mean values at Low-Level Waste Management Area 4 and the Nonradioactive Dangerous Waste Landfill. Assessment monitoring began at these sites in late 2008. Groundwater monitoring at the other RCRA sites continued under previously established programs. Table 10.7.3 lists Hanford Site RCRA units, the phase of groundwater monitoring, and 2008 status highlights; Figure 10.7.3 shows their locations.

### 10.7.3.1 Overview

Figure 10.7.4 shows the Hanford Site’s principal groundwater contaminant plumes. The total area of contaminant plumes with concentrations above drinking water standards was about 183 square kilometers (70.6 square miles) in 2008 (Table 10.7.4). This area is about 12% of the total area of the Hanford Site and is decreasing with time (Figure 10.7.5). Table 10.7.5 lists the highest levels of contaminants by groundwater interest area.

Of the radionuclide plumes, tritium and iodine-129 have the largest areas with concentrations above drinking water standards. The dominant plumes had sources in the 200-East Area and extend toward the east and southeast. Less extensive tritium and iodine-129 plumes also are present in the 200-West Area. Technetium-99 exceeds its standard in the 200-East and 200-West Areas. One technetium-99 plume extends northward, beyond the 200-East Area. Uranium is less mobile than tritium, technetium-99, or iodine-129; plumes containing uranium are found in the 200-East, 200-West, and 300 Areas. Strontium-90 exceeds standards in the 100 Areas, 200-East Area, and beneath the former Gable Mountain Pond. Cobalt-60, cesium-137, and plutonium exceed drinking water standards in only a few wells in the 200-East Area.

Nitrate is a widespread chemical contaminant in Hanford Site groundwater; plumes originate from the 100 and

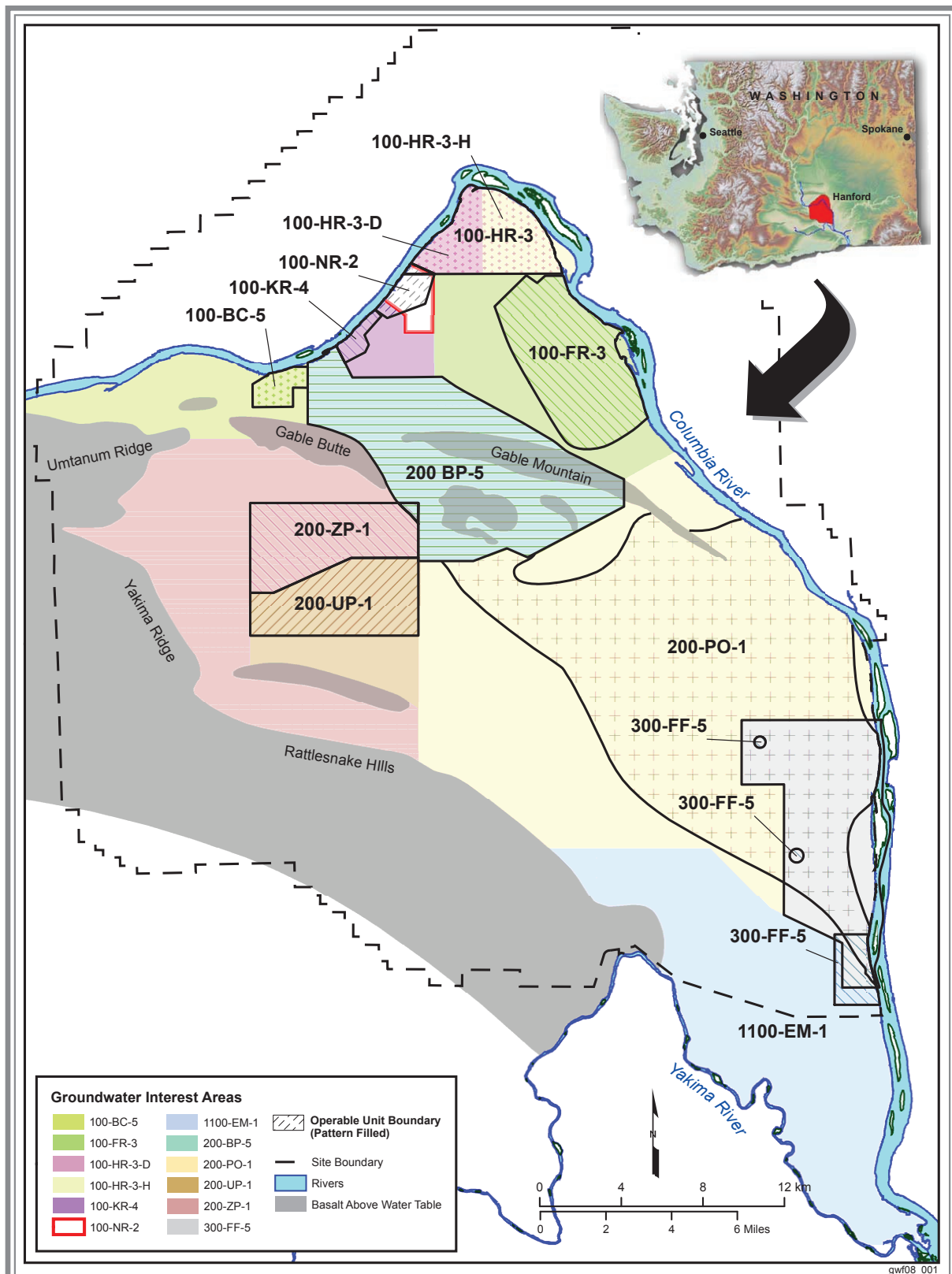


Figure 10.7.2. Groundwater Operable Units and Groundwater Interest Areas on the Hanford Site

**Table 10.7.3. Resource Conservation and Recovery Act of 1976 Units Requiring Groundwater Monitoring on the Hanford Site, Fiscal Year 2008**

RCRA Unit	Fiscal Year 2008 Status
116-N-1 (1301-N) Facility	Continued detection <sup>(a)</sup>
120-N-1, 120-N-2 (1324-N/NA) Facilities	Continued detection. <sup>(a)</sup> One new well completed early fiscal year 2009 to replace seasonally dry well.
116-N-3 (1325-N) Facility	Continued detection <sup>(a)</sup>
116-H-6 (183-H) Evaporation Basins	Corrective action alternative program during interim remedial action. Chromium, nitrate.
216-A-29 Ditch	Continued detection <sup>(a)</sup>
216-B-3 Pond	Continued detection <sup>(a)</sup>
216-B-63 Trench	Continued detection <sup>(a)</sup>
216-S-10 Pond and Ditch	Continued detection. <sup>(a)</sup> Three new wells.
316-5 (300 Area) Process Trenches	Compliance/corrective action. Organics.
Integrated Disposal Facility	Not yet in use. Monitoring results added to background data set.
Liquid Effluent Retention Facility	Two new wells monitor the top of the fractured basalt. DOE and Washington State Department of Ecology pursuing agreement for monitoring.
Low-Level Waste Management Area 1	Continued detection <sup>(a)</sup>
Low-Level Waste Management Area 2	Continued detection <sup>(a)</sup>
Low-Level Waste Management Area 3	Statistical evaluations suspended until upgradient wells installed and background values established.
Low-Level Waste Management Area 4	Total organic carbon exceeded critical mean value in August 2008. Beginning assessment fiscal year 2009. Remaining upgradient wells went dry.
Nonradioactive Dangerous Waste Landfill	Total organic carbon exceeded critical mean value in August 2008. Beginning assessment fiscal year 2009.
PUREX Cribs	Continued assessment: nitrate.
SST Waste Management Area A-AX	Continued assessment (first determination); new well.
SST Waste Management Area B-BX-BY	Continued assessment: nitrate.
SST Waste Management Area C	Continued detection <sup>(a)</sup>
SST Waste Management Area S-SX	Continued assessment: chromium, nitrate.
SST Waste Management Area T	Continued assessment: chromium, nitrate.
SST Waste Management Area TX-TY	Continued assessment: chromium, nitrate.
SST Waste Management Area U	Continued assessment: nitrate.

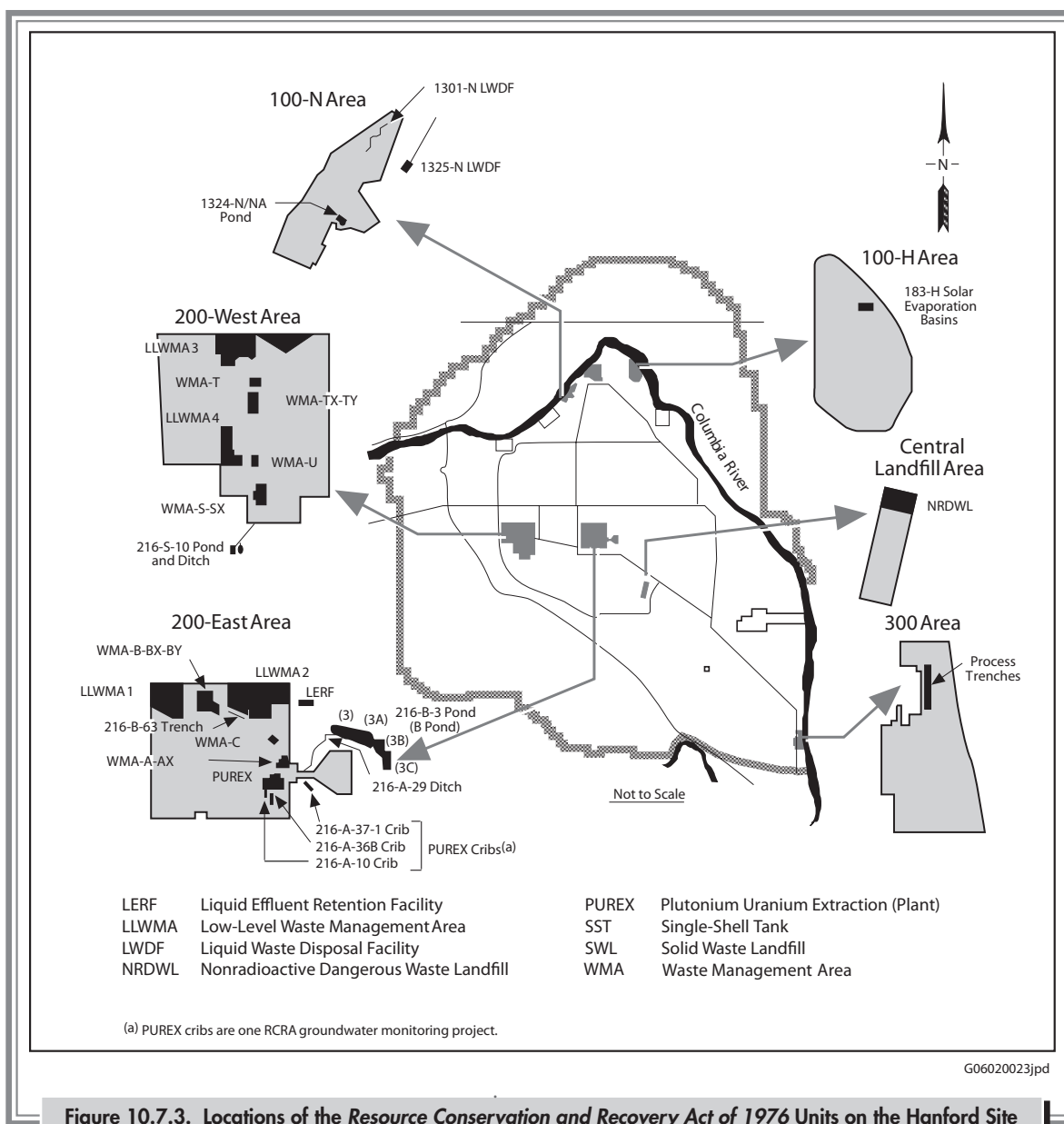
(a) Analysis of RCRA contamination indicator parameters provided no evidence of groundwater contamination with hazardous constituents from the unit.

DOE = U.S. Department of Energy.

PUREX = Plutonium Uranium Extraction Plant.

RCRA = Resource Conservation and Recovery Act of 1976.

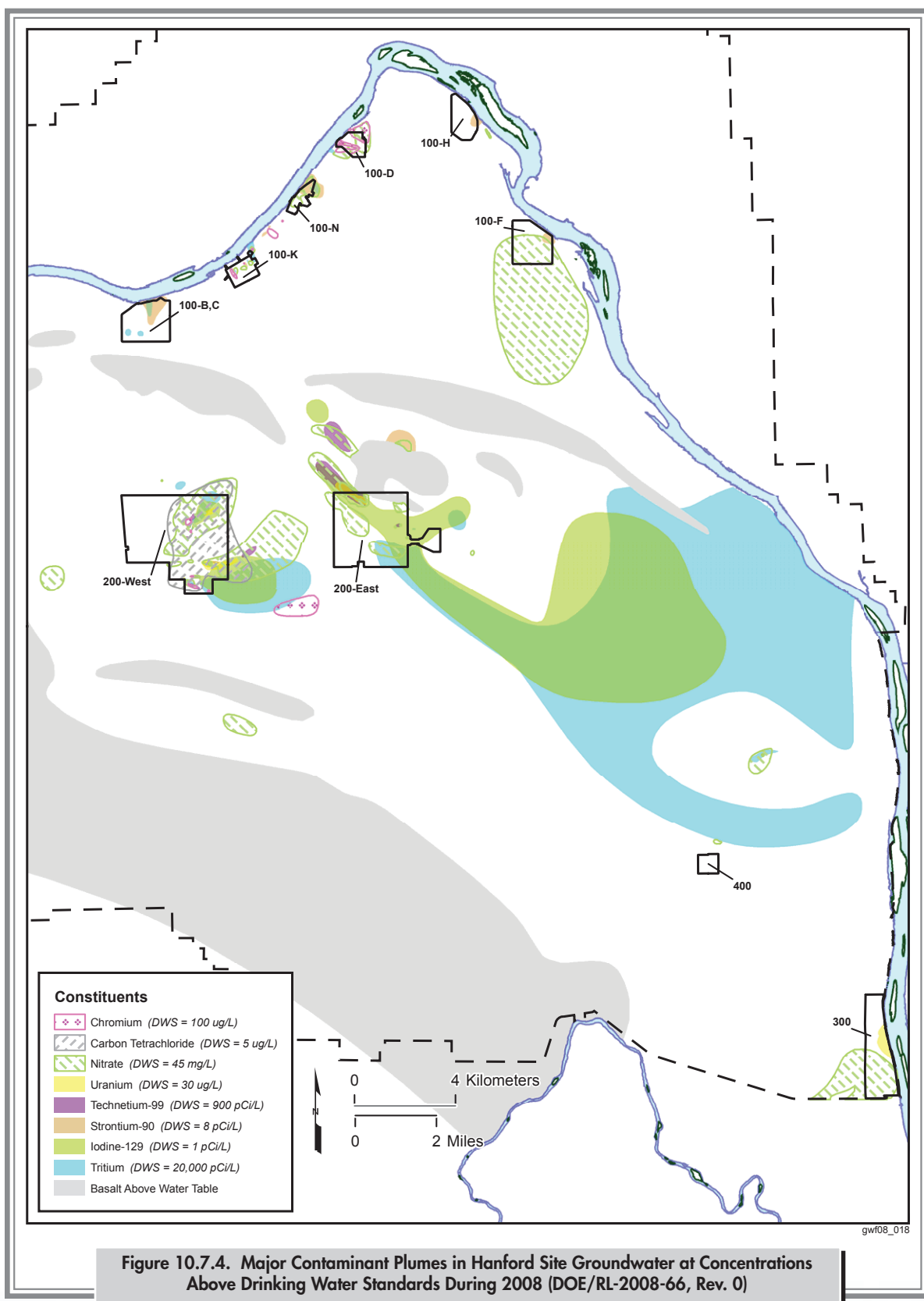
SST = Single-shell tanks.



200 Areas and from offsite industry and agriculture. Carbon tetrachloride is the most widespread organic contaminant on the Hanford Site, forming a large plume beneath the 200-West Area. Other organic contaminants include chloroform (found in 200-West Area) and trichloroethene. The 100-F and 200-West Areas have plumes of trichloroethene with declining concentrations. The 100-K Area has one well that exceeded the trichloroethene standard. Wells completed in a fine-grained layer beneath the 300 Area also detected trichloroethene at levels above the drinking water

standard. Chromium at levels above the 100- $\mu\text{g/L}$  drinking water standard underlies portions of the 100-K and 100-D Areas. Chromium exceeds Washington State's aquatic standard (10  $\mu\text{g/L}$ ) in these areas and portions of the 100-B/C, 100-H, 100-F, and 600 Areas. Local plumes of chromium contamination also are present in the 200 Areas.

The following section discusses groundwater contamination, monitoring, and remediation for each of the groundwater operable units or interest areas and in the confined aquifers.



**Table 10.7.4. Areas of Contaminant Plumes on the Hanford Site at Levels Above Drinking Water Standards, Fiscal Year 2008 (DOE/RL-2008-66, Rev. 0)**

Constituent	Drinking Water Standard	Area, km <sup>2</sup> (mi <sup>2</sup> )		Constituent	Drinking Water Standard	Area, km <sup>2</sup> (mi <sup>2</sup> )	
Tritium	20,000 pCi/L	127	(49.0)	Dissolved chromium	100 µg/L	2.1	(0.8)
Iodine-129	1 pCi/L	65.6	(25.3)	Strontium-90	8 pCi/L	2.2	(0.8)
Nitrate	45 mg/L	36.3 <sup>(a)</sup>	(14.0)	Technetium-99	900 pCi/L	2.4	(0.9)
Carbon tetrachloride	5 µg/L	11.2	(4.3)	Total uranium	30 µg/L	1.5	(0.6)
Trichloroethene	5 µg/L	0.7	(0.3)	Combined plumes		183 <sup>(a,b)</sup>	(70.6)

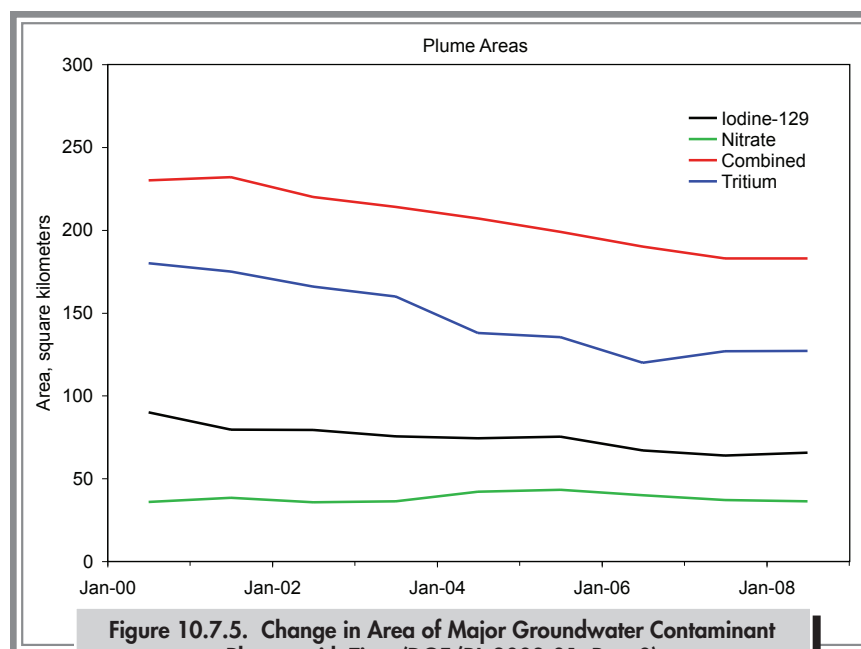
(a) Excludes nitrate from offsite sources.

(b) Total reflects some overlap of contaminant plumes.

1 pCi/L = 0.037 Bq/L.

1 µg/L = 0.001 ppm.

1 mg/L = 1 ppm.

**Figure 10.7.5. Change in Area of Major Groundwater Contaminant Plumes with Time (DOE/RL-2008-01, Rev. 0)**

### 10.7.3.2 Groundwater Monitoring Results for the 100-BC-5 Operable Unit

Most of the groundwater contamination is found in the northern portion of the 100-B/C Area, beneath former waste trenches and retention basins. Tritium and strontium-90 concentrations exceeded drinking water standards (20,000 and 8 pCi/L [740 and 0.3 Bq/L], respectively) in several wells. Chromium and nitrate concentrations continued to be below drinking water standards (100 µg/L and

45 mg/L, respectively) in recent years, but chromium levels exceed the 10-µg/L aquatic standard.

A record of decision has not yet been developed for the 100-BC-5 Operable Unit, and no active remediation of groundwater is underway. Groundwater monitoring has continued since the initial remedial investigation and while waste site remedial actions are being conducted.

### 10.7.3.3 Groundwater Monitoring Results for the 100-KR-4 Operable Unit

The principal groundwater issues in the 100-KR-4 Operable Unit include cleaning up chromium in groundwater, tracking plumes from past-practice sites, and monitoring groundwater near the K-East and K-West Basins. Interim remedial action involves two pump-and-treat systems that remove chromium from groundwater.

**Interim Remedial Action.** A pump-and-treat system is removing hexavalent chromium from the aquifer beneath the 116-K-2 Trench (Figure 10.7.6). Approximately 330 kilograms (728 pounds) of chromium have been removed since startup in 1997. New wells installed in fiscal year 2008

**Table 10.7.5. Summary of Maximum Contaminant Concentrations in Hanford Site Wells by Groundwater Interest Area, Fiscal Year 2008 (DOE/RL-2008-66, Rev. 0)**

	<u>Hanford Site</u>	<u>100-BC-5</u>	<u>100-FR-3</u>	<u>100-HR-3-D</u>	<u>100-HR-3-H</u>	<u>100-KR-4</u>	<u>100-NR-2</u>
Tritium (pCi/L)	1,200,000	57,000	15,000	27,000	5,500	621,000	22,000
Iodine-129 (pCi/L)	37.6	NA	NA	NA	NA	NA	NA
Nitrate (mg/L)	17,800	39.5	114	116	44.3	139	259
Carbon tetrachloride (µg/L)	4,900	NA	ND	NA	NA	ND	NA
Trichloroethene (µg/L)	11	NA	9.7	NA	NA	7.7	NA
Dissolved chromium (µg/L)	39,900	54.8	51.8	39,900	100	3,550	172
Strontium-90 (pCi/L)	17,000	44.7	25.8	7.7	24.8	1,610	17,000
Technetium-99 (pCi/L)	100,000	NA	NA	87	31	63	NA
Total uranium (µg/L)	3,910	NA	17.6	3.89	8.38	6.93	NA
	<u>1100-EM-1</u>	<u>200-BP-5</u>	<u>200-PO-1</u>	<u>200-UP-1</u>	<u>200-ZP-1</u>	<u>300-FF-5</u>	
Tritium (pCi/L)	1,500	170,000	650,000	290,000	1,200,000	940,000	
Iodine-129 (pCi/L)	ND	5.63	10.4	37.1	37.6	NA	
Nitrate (mg/L)	307 <sup>(a)</sup>	17,800	127	868	2,820	293	
Carbon tetrachloride (µg/L)	2.9	3.4	1.0	1,400	4,900	3.5	
Trichloroethene (µg/L)	ND	ND	1.7	9.6	11	4.2	
Dissolved chromium (µg/L)	6.6	233	47.1	823	640	90.7	
Strontium-90 (pCi/L)	NA	3,740	20.2	2.8	3.8	ND	
Technetium-99 (pCi/L)	NA	100,000	8,000	67,000	18,000	225	
Total uranium (µg/L)	26.5	3,910	30	391	48.8	225	

(a) Nitrate from offsite sources.

NA = Not analyzed.

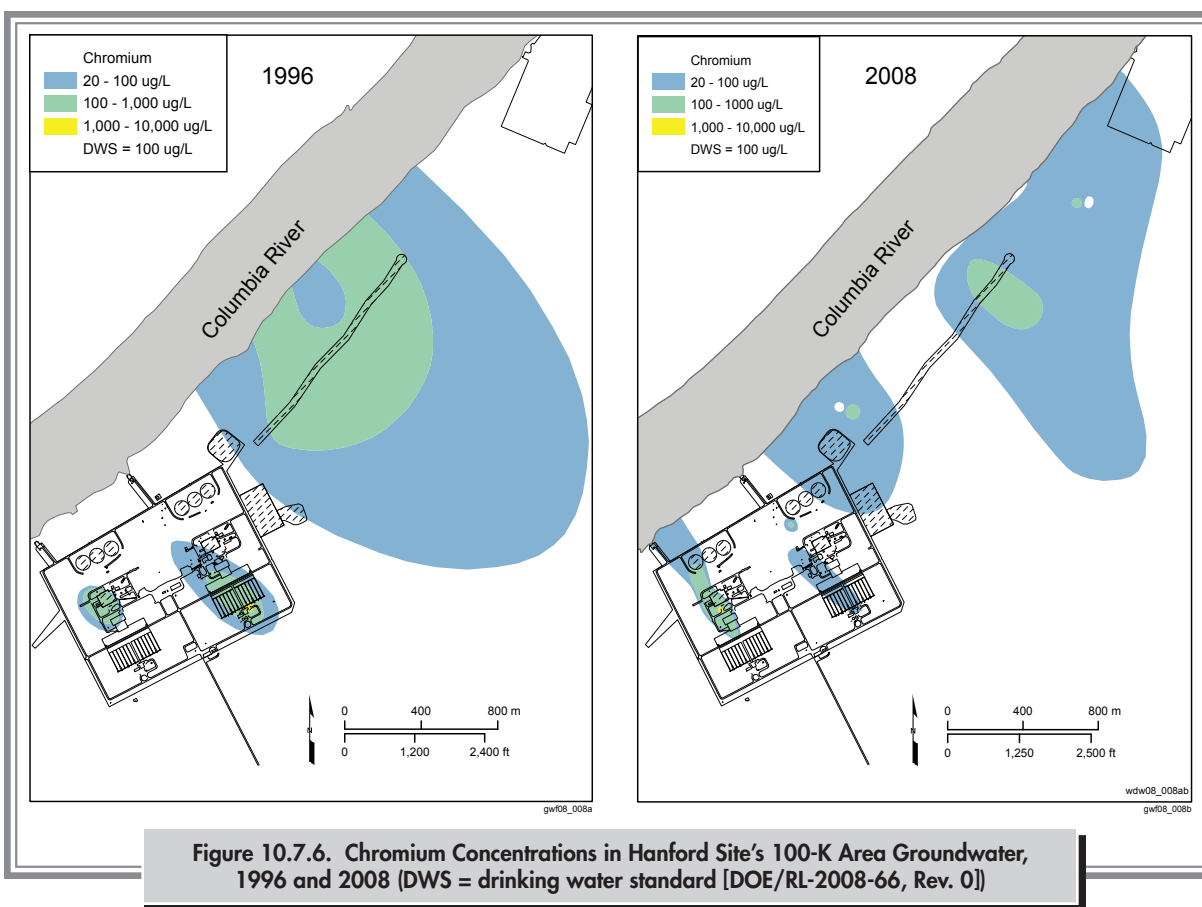
ND = Not detected.

indicate that one portion of the plume with concentrations above 100 µg/L is larger than previously known. Chromium concentrations in most of the compliance wells near the Columbia River have decreased. The concentration goal for the interim remedial action is 22 µg/L. New extraction and injection wells were installed in 2008 and began operation in fiscal year 2009. The expanded system will increase the amount of contaminated groundwater being treated and will prevent the plume from moving downgradient into the 100-N Area.

Chromium concentrations in groundwater near the K-West Reactor began to rise during 1998. Concentrations in this plume are the highest in the 100-K Area. DOE has operated

a pump-and-treat system to clean up the plume since 2007. The system has removed 31 kilograms (68 pounds) of chromium from the aquifer, and concentrations in the extraction wells have declined. Plans are underway to expand the K-West system in 2009.

**Monitoring Past-Practice Waste Sites.** Other contaminants of potential concern in the 100-KR-4 Operable Unit are tritium, carbon-14, strontium-90, nitrate, and trichloroethene. Levels remained above drinking water standards, and these contaminants will be addressed under an upcoming remedial investigation/feasibility study work plan and final record of decision.



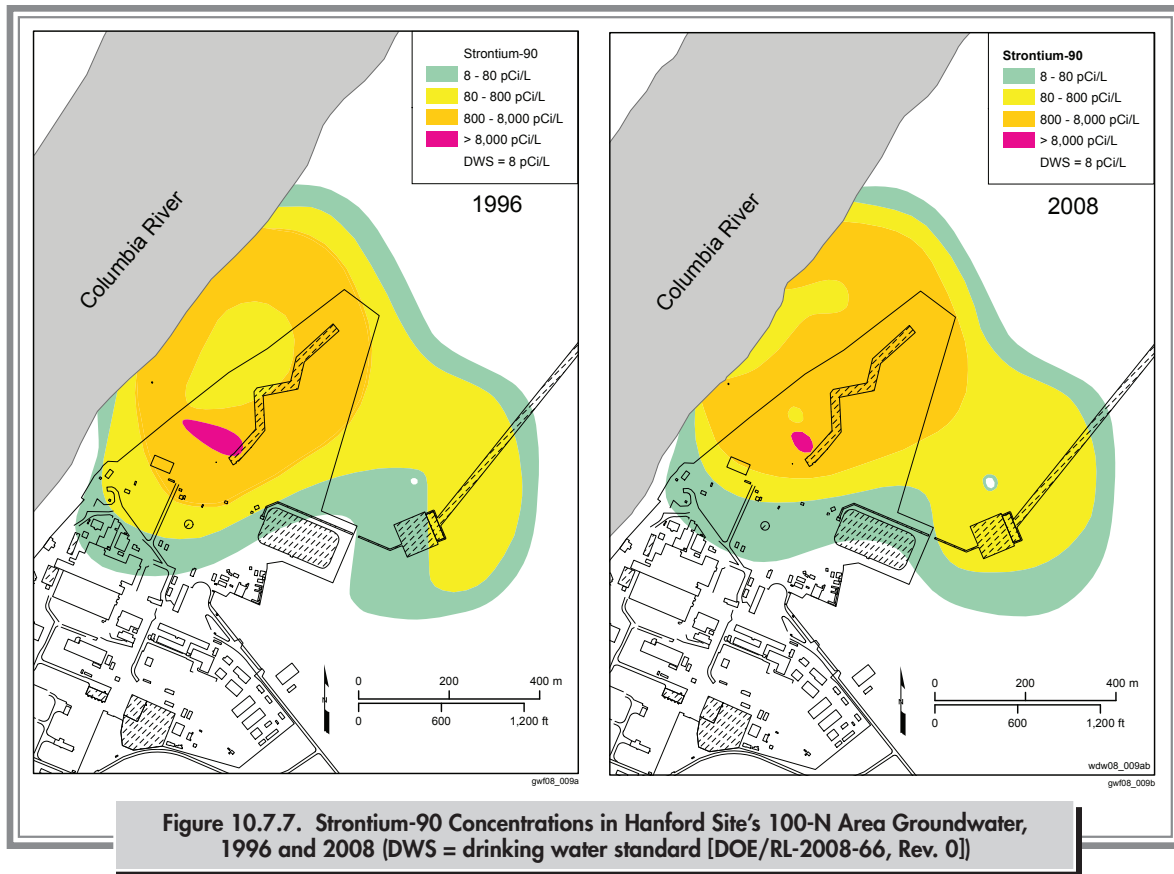
Tritium concentrations in two new wells near the south end of the 116-K-2 Trench are much higher than in surrounding wells. The source for tritium at this location is uncertain; it may represent past disposal to the 116-KE-1 Crib or 116-K-2 Trench, or tritium from a source farther inland, such as the 118-K-1 Burial Ground.

**K-East and K-West Basins.** These concrete basins are integral parts of each reactor building. From the late 1970s through 2004, they were used to store irradiated fuel from the last run of the 100-N Reactor, as well as miscellaneous fuel fragments recovered during remedial actions at other reactor areas. In 2008, monitoring of water levels in the basins and groundwater in downgradient wells indicated no new leaks. Shielding water has been removed from the K-East Basin, and demolition of the basin has begun (Section 6.2.2.2); consequently, the groundwater monitoring strategy will be reviewed.

#### 10.7.3.4 Groundwater Monitoring Results for the 100-NR-2 Operable Unit

The primary groundwater contaminant plume in the 100-N Area is strontium-90, which originated at two liquid waste disposal cribs (Figure 10.7.7). Tritium, nitrate, petroleum hydrocarbons, and sulfate also are present in 100-N Area groundwater.

**Interim Remedial Action.** DOE is applying an in situ technology, apatite sequestration, in the 100-N Area. The goal is to create a permeable, reactive barrier in the aquifer that will capture strontium-90 as groundwater flows through it to the Columbia River. Apatite-forming chemicals were injected into a line of wells along the river shore in 2007 and 2008. As the injected chemicals reacted with the aquifer, strontium-90 levels initially increased in downgradient wells and aquifer tubes (Figure 10.7.8). However, in the weeks and months after the injections, the chemical reactions



progressed, and strontium-90 levels declined. Concentrations in the injection and downgradient wells were much lower at the end of 2008 than they were before the injections.

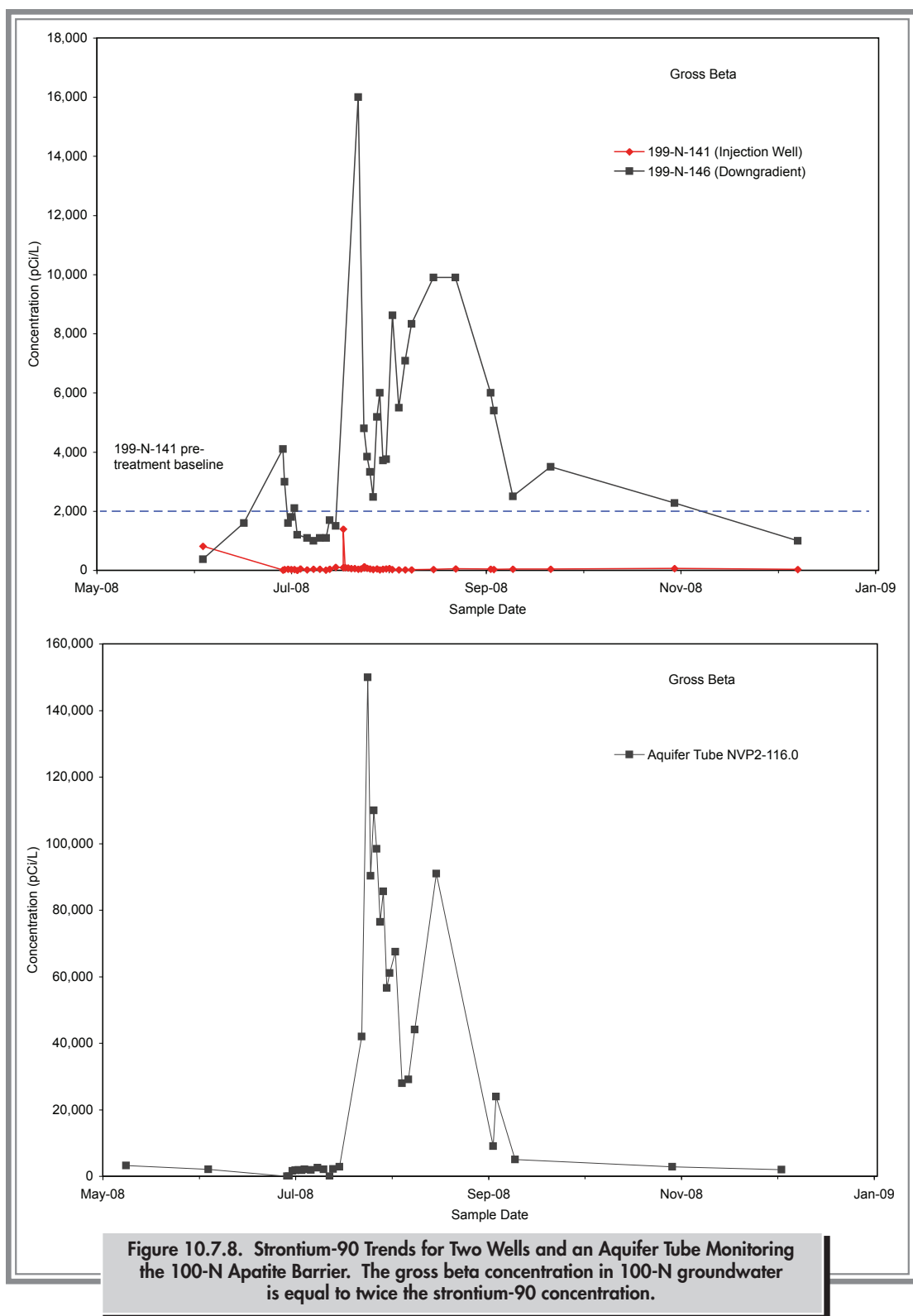
Other forms of remediation being investigated at the 100-N Area include apatite infiltration and phytoremediation (plants) to treat contamination above the average water table and in shallow groundwater.

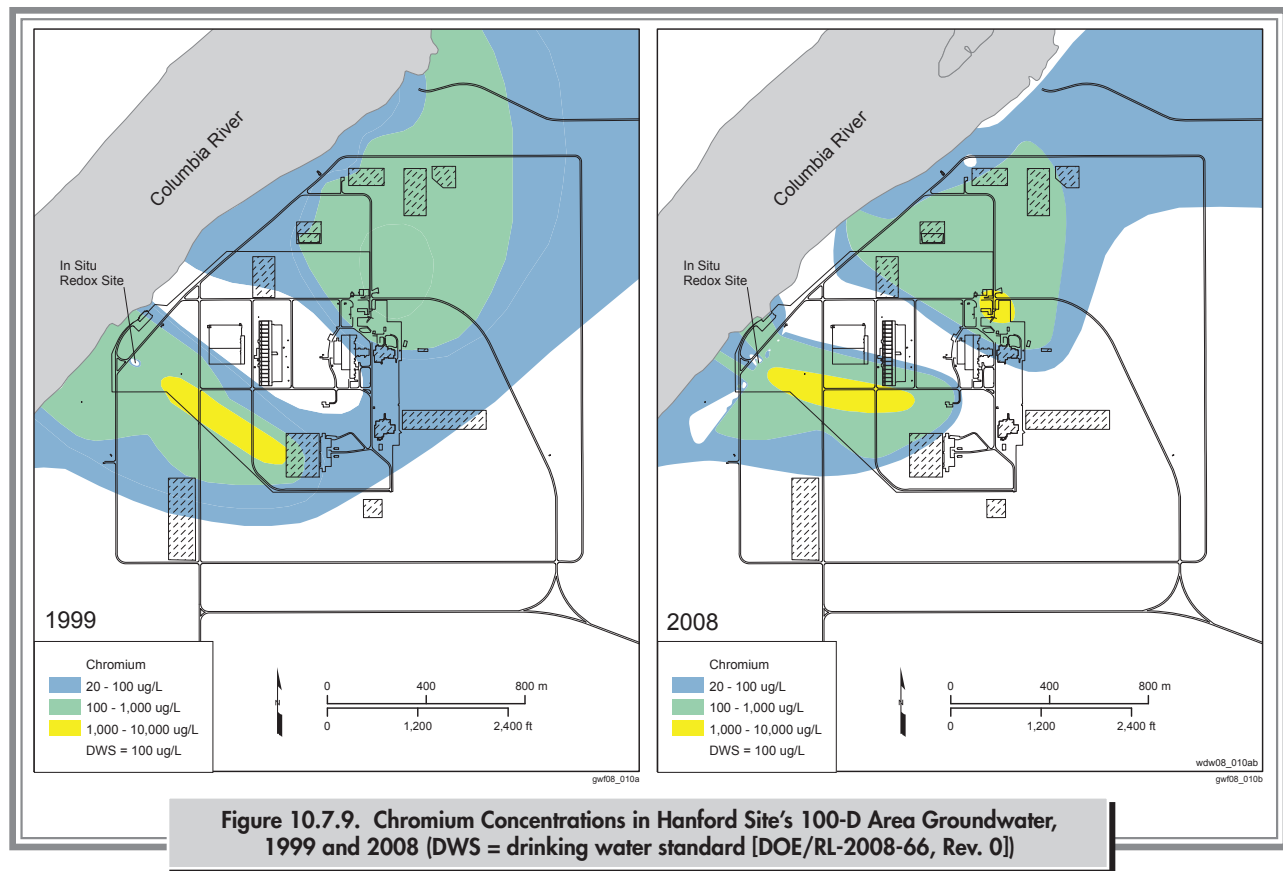
**1301-N, 1324-N, 1324-NA, and 1325-N Facilities.** These four RCRA units are located in the 100-N Area. During 2008, the sites remained in detection monitoring programs. Atomic Energy Act of 1954 and CERCLA monitoring continued to track tritium and strontium-90 plumes from the 1301-N and 1325-N Facilities and sulfate from the 1324-NA Percolation Pond.

### 10.7.3.5 Groundwater Monitoring Results for the 100-HR-3-D Groundwater Interest Area

The 100-HR-3 Operable Unit underlies the 100-D Area, 100-H Area, and the region between them. The western portion of this operable unit is the 100-HR-3-D groundwater interest area. Hexavalent chromium is the principal contaminant of concern in groundwater. A principal cause for this contamination was the routine disposal of reactor coolant, which contained sodium dichromate as a corrosion inhibitor. Periodic spills and leaks of sodium dichromate stock solution to the ground were another source of contamination. Chromium is distributed in northern and southern plumes (Figure 10.7.9). Other contaminants include tritium, strontium-90, nitrate, and sulfate.

**Interim Remedial Actions.** The northern chromium plume is the target of a pump-and-treat system, which is

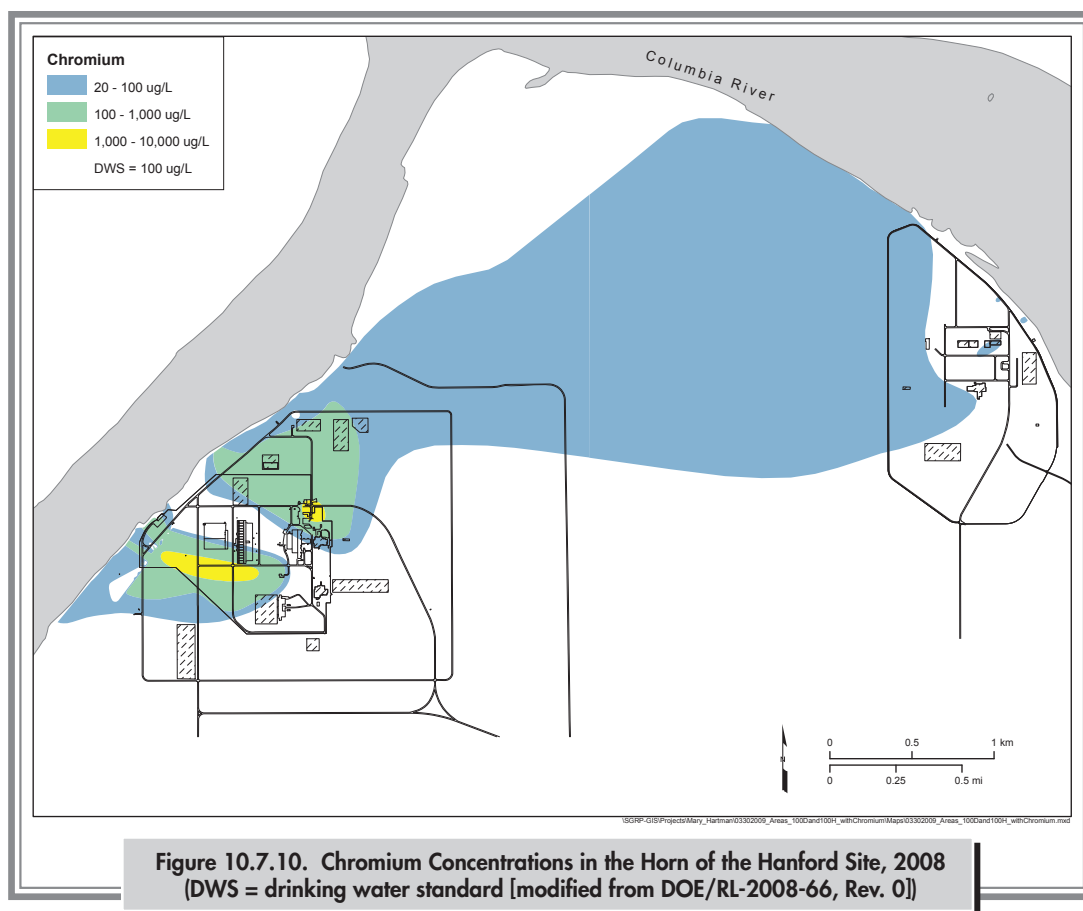




designed to reduce the amount of chromium entering the Columbia River. A second pump-and-treat system intercepts groundwater in the central 100-D Area near the shoreline. Chromium concentrations remained above the remediation goal (22  $\mu\text{g/L}$  for the pump-and-treat systems) in compliance wells during 2008. The two extraction systems the 100-HR-3 and 100-DR-5 pump-and-treat systems have removed 497 kilograms (1,096 pounds) of chromium from the aquifer since 1997. The southwestern chromium plume is being remediated with a permeable “redox” barrier that immobilizes chromium in the aquifer. Data from recent years indicate that in some locations chromium has migrated through the barrier. At the end of fiscal year 2008, concentrations in barrier wells ranged from below detection limits to 780  $\mu\text{g/L}$ . Most of the elevated concentrations are in the northeastern half of the barrier. The remediation goal (20  $\mu\text{g/L}$  for the permeable barrier) was met at only two of the seven compliance wells. However, concentrations have declined overall in most of the compliance wells.

**Five-Year Review Actions.** DOE continued several investigations in the 100-HR-3 Operable Unit that address items identified in a November 2006 CERCLA review.

- **Chromium Plume in the Horn** (Figure 10.7.10). DOE installed wells and aquifer tubes to define the plume between the 100-D and 100-H Areas, the region known as the “horn” of the Hanford Site. Data indicate that concentrations exceeding 20  $\mu\text{g/L}$  extend across the horn.
- **Zero-Valent Iron Injection.** Scientists think that injecting tiny particles of iron into redox barrier wells will help repair the chromium breach in the barrier. Test injections occurred in August 2008. Initial results show that the groundwater affected by the iron eliminates hexavalent chromium from the aquifer.
- **Electrocoagulation Tests.** DOE tested electrocoagulation for treating chromium-contaminated groundwater. Results indicate that the technology has the potential to meet the performance goal for groundwater treatment, but system operation was problematic.



- **Chromium Source Investigation.** DOE installed wells to obtain samples from the vadose zone and to monitor groundwater near suspected sources in the southern 100-D Area. Chromium levels in some of the wells were the highest ever observed in Hanford Site groundwater (Figure 10.7.11).

**Other Research.** DOE conducted additional studies in 2008, including characterizing chromium geochemistry in the vadose zone and using in situ biostimulation as a method of treating chromium contamination in groundwater.

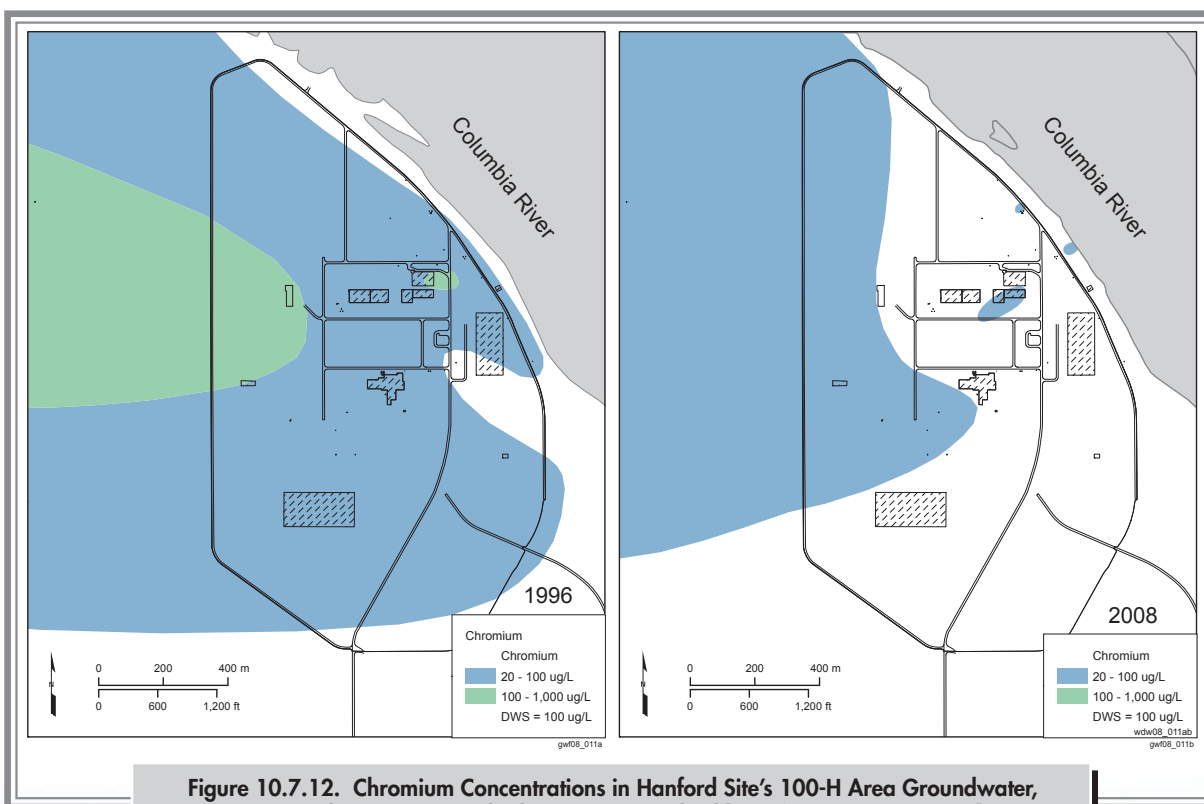
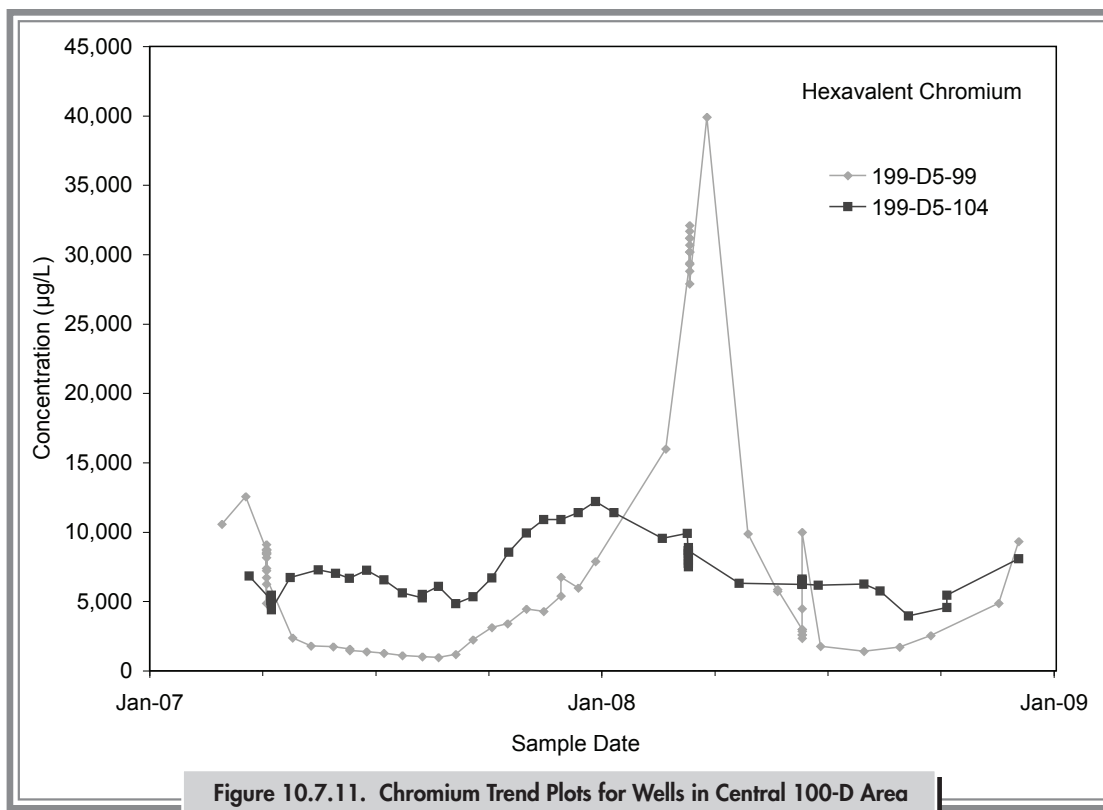
### 10.7.3.6 Groundwater Monitoring Results for the 100-HR-3-H Groundwater Interest Area

The eastern part of the 100-HR-3 Operable Unit (100-HR-3-H groundwater interest area) underlies the 100-H Area. Hexavalent chromium is the principal contaminant of concern, but the plume is smaller, and concentrations are lower than in the 100-D Area (Figure 10.7.12).

Nitrate levels also are above background, but have declined from their peak historical levels. Strontium-90 exceeds the drinking water standard (8 pCi/L [0.3 Bq/L]) beneath former retention basins. Technetium-99 and uranium concentrations are detected in a small area, but have been below drinking water standards in recent years.

**Interim Remedial Action.** The chromium plume in the 100-H Area is the target of a pump-and-treat system. Remediation of the plume has removed approximately 51 kilograms (112 pounds) of hexavalent chromium from the aquifer since 1997. Most hexavalent chromium concentrations in compliance wells were below the 22-µg/L remedial action goal in 2008.

**183-H Solar Evaporation Basins.** These former basins are the only RCRA site in the 100-H Area. Leaks from the basins contaminated groundwater with technetium-99, uranium, chromium, and nitrate. Concentrations of all four contaminants were below drinking water standards



in fiscal year 2008. The site is monitored during the post-closure period to track contaminant trends during the operation of the CERCLA interim action for chromium.

### 10.7.3.7 Groundwater Monitoring Results for the 100-FR-3 Operable Unit

Nitrate concentrations in groundwater exceed the 45-mg/L drinking water standard beneath much of the 100-F Area and the downgradient region. A few wells in the eastern 100-F Area have strontium-90 concentrations above the 8-pCi/L drinking water standard. Two wells in the southwestern 100-F Area exceeded the standard for trichloroethene (5 µg/L), but concentrations are declining. Hexavalent chromium concentrations exceeded the 10-µg/L aquatic standard in some wells.

During remediation of a burial ground in the southwestern 100-F Area, the excavation reached the water table in one location, and a small puddle of water formed. Samplers collected some of the water, and strontium-90 was detected at levels above the drinking water standard. DOE installed

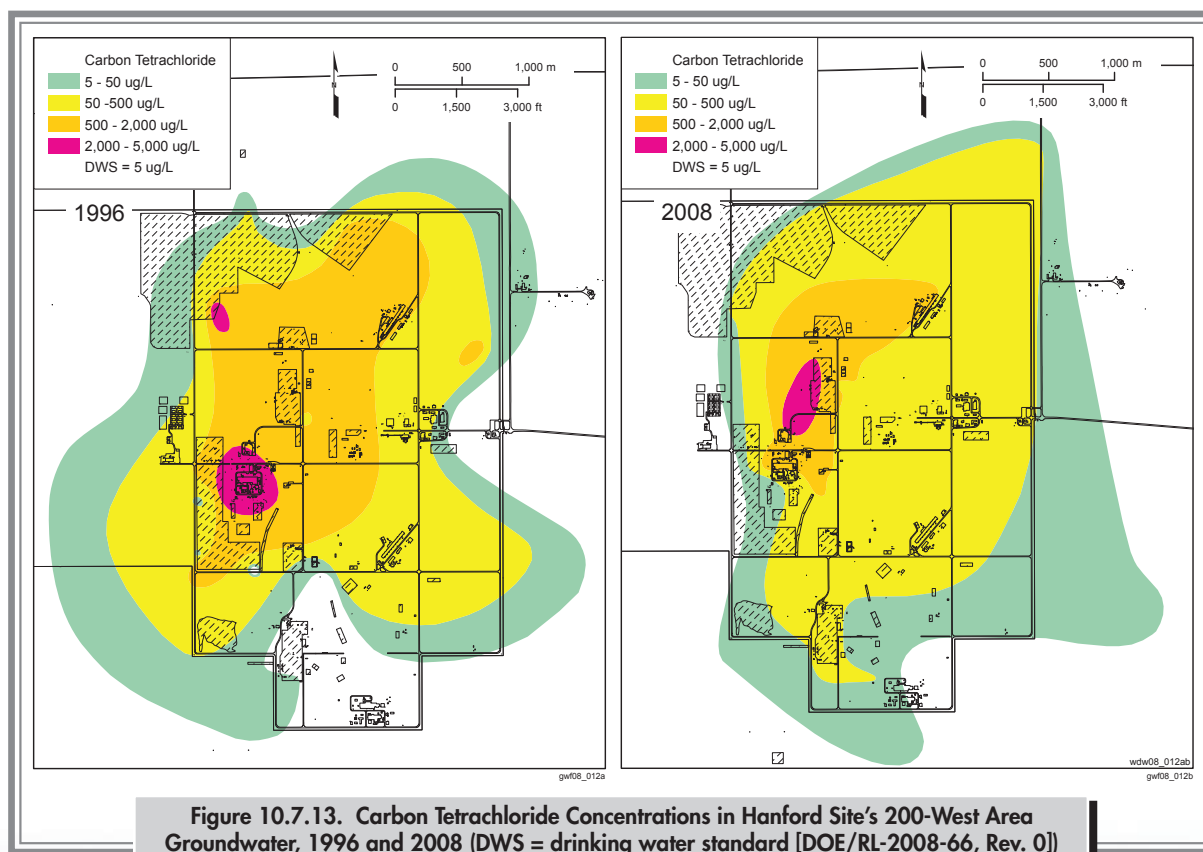
and began monitoring a new well downgradient of the burial ground in 2008. Initial results showed levels of strontium-90 below the drinking water standard.

A record of decision has not yet been developed for the 100-FR-3 Operable Unit, and no active remediation of groundwater is underway. Monitoring contaminant conditions has continued since the initial remedial investigation and while waste site remedial actions are conducted.

### 10.7.3.8 Groundwater Monitoring Results for the 200-ZP-1 Operable Unit

This operable unit encompasses the northern and central portions of the 200-West Area. The principal contaminant of concern is carbon tetrachloride (Figure 10.7.13). Other contaminants include tritium, technetium-99, iodine-129, uranium, chloroform, chromium, fluoride, nitrate, and trichloroethene.

In September 2008, DOE, EPA, and the Washington State Department of Ecology (the Tri-Parties) signed a final record



of decision for groundwater remediation in the 200-ZP-1 Operable Unit (ROD 2008). The goal of the final alternative is to design and implement a remediation system to remove carbon tetrachloride and other contaminants throughout the vertical extent of the aquifer. Further expansion is planned as the final alternative is implemented. The final record of decision combines approaches including pump-and-treat, monitored natural attenuation, flow-path control through injection of treated water, and institutional controls. The pump-and-treat system will be designed to capture and treat contaminated groundwater to reduce the mass of carbon tetrachloride and co-contaminants throughout the operable unit by a minimum of 95% in 25 years.

Carbon tetrachloride contamination occurs at increasing depth to the east (downgradient) of the known source areas. In this area, natural and artificial recharge may have led to reduced carbon tetrachloride concentrations in the upper portion of the aquifer. Carbon tetrachloride is denser than water, which also affects its vertical distribution. The 200-ZP-1 Operable Unit feasibility study (DOE/RL-2007-28, Draft A) illustrates the areal extent of carbon tetrachloride at different depths. The maximum extent of the plume at all depths (i.e., the footprint of the plume) extends beyond the contours shown in Figure 10.7.12.

The 200-ZP-1 groundwater interest area contains one CERCLA interim action for groundwater, one remediation system for the vadose zone, four facilities monitored under RCRA (in conjunction with CERCLA and the *Atomic Energy Act of 1954*), and one state-permitted unit.

**Interim Remedial Action.** Since 1994, DOE has operated an interim action pump-and-treat system to prevent carbon tetrachloride in the upper part of the aquifer from spreading. Four monitoring wells were converted to extraction wells during 2008, bringing the number of extraction wells to 14, with a combined pumping rate of approximately 1,514 liters (400 gallons) per minute. In support of expansion activities, the pump-and-treat system was shut down in late May and, except for process and acceptance testing, remained offline the remainder of fiscal year 2008. The system has removed 11,400 kilograms (25,100 pounds) of carbon tetrachloride from groundwater since 1994.

**Soil-Vapor Extraction.** Soil vapor is extracted from the vadose zone and treated to remove carbon tetrachloride.

The system has removed approximately 79,400 kilograms (175,000 pounds) of carbon tetrachloride from the vadose zone since operations started in 1991.

**Low-Level Burial Grounds Waste Management Area 3.** RCRA groundwater monitoring continued under interim status requirements in 2008. Previous changes to the groundwater flow direction left Low-Level Waste Management Area 3 without any upgradient wells. Until new upgradient wells are installed and background conditions are established, statistical evaluations have been suspended.

**Low-Level Burial Grounds Waste Management Area 4.** RCRA groundwater monitoring continued under interim status requirements in 2008. The remaining upgradient wells went dry in fiscal year 2008. Total organic carbon concentrations in one downgradient well exceeded the critical mean value in August 2008 and in a subsequent confirmatory sample. Groundwater will be monitored under an assessment program in fiscal year 2009.

**Waste Management Area T.** RCRA assessment monitoring continued in 2008. The waste management area has introduced technetium-99 and other tank waste constituents to the uppermost aquifer in the area. In September 2007, two downgradient wells on the east side of the tank farms were converted to extraction wells to remove technetium-99 from the aquifer. Technetium-99 concentrations decreased sharply during 2008 in some downgradient wells and increased in others, most likely as a result of the extraction.

**Waste Management Area TX-TY.** RCRA assessment monitoring continued in 2008. Sources in the waste management area have contaminated groundwater with technetium-99, chromium, and other tank waste constituents. Groundwater flow beneath Waste Management Area TX-TY is changing because of the operation of the 200-ZP-1 pump-and-treat system. Extraction wells operate south and west (upgradient) of the waste management area.

**State-Approved Land Disposal Site.** This active disposal facility is regulated under a state waste discharge permit. Groundwater is monitored for tritium and 15 other constituents. Concentrations of all constituents considered in the permit did not exceed enforcement limits during 2008.

### 10.7.3.9 Groundwater Monitoring Results for the 200-UP-1 Operable Unit

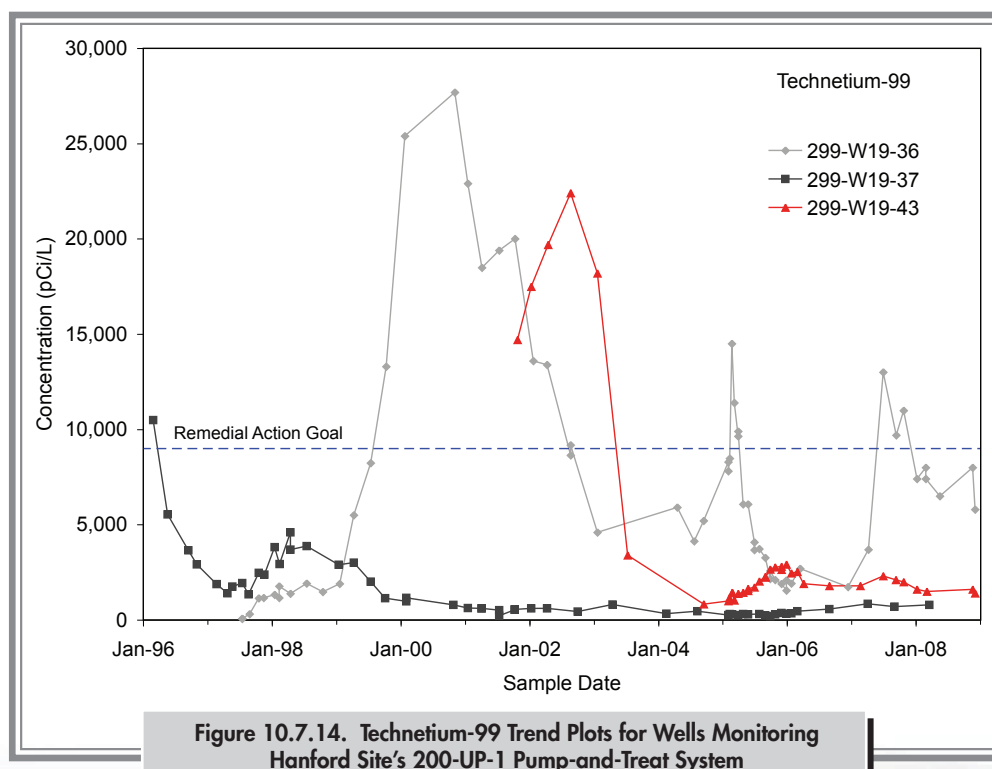
This operable unit underlies the southern portion of 200-West Area. The principal contaminants of concern are technetium-99 and uranium. Tritium, iodine-129, chromium, and nitrate plumes also have sources in this operable unit. Carbon tetrachloride in the 200-UP-1 Operable Unit originated from sources in the 200-ZP-1 Operable Unit. Eight new monitoring wells were drilled in the 200-UP-1 Operable Unit in 2008.

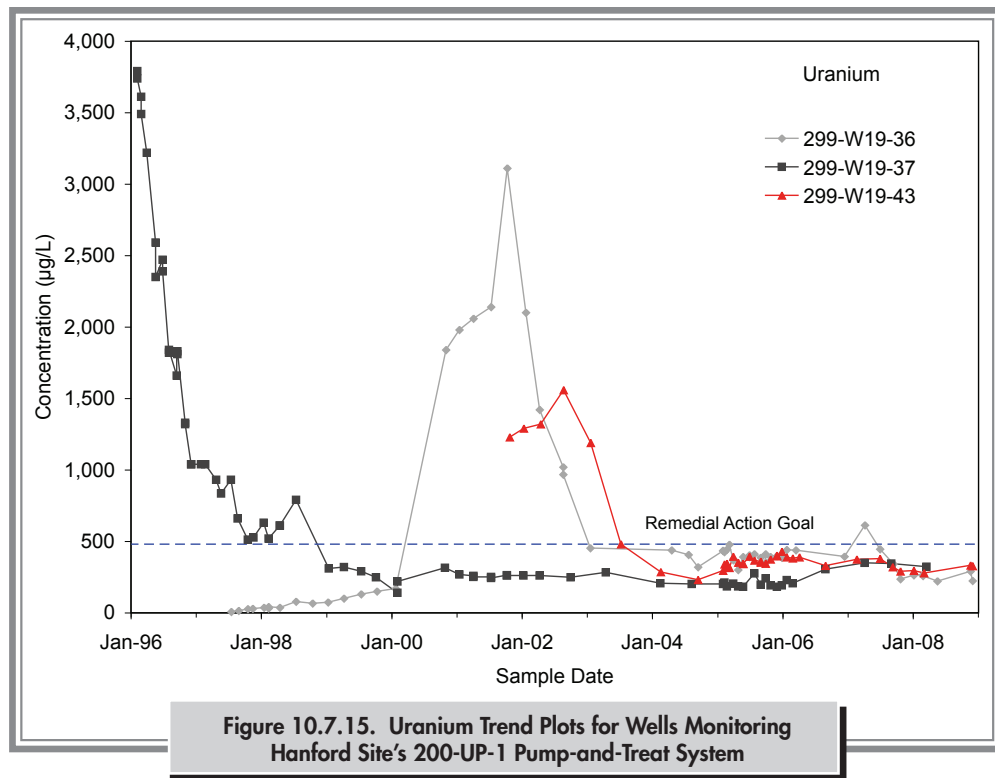
The 200-UP-1 Operable Unit contains one CERCLA interim action, three facilities monitored under RCRA (in conjunction with CERCLA and the *Atomic Energy Act of 1954*), and one CERCLA disposal site.

**Interim Remedial Action.** DOE operated an interim remedial action pump-and-treat system for technetium-99 and uranium from 1994 until early 2005. The effort successfully reduced contaminant concentrations below remedial action goals. DOE shut down the system in January 2005 and conducted a rebound study. The remedial action goal for uranium was ten times the “Washington State Model

Toxics Control Act – Cleanup” (WAC 173-340) cleanup standard at the time the record of decision (ROD 1997) was issued, which was 48 µg/L. Since then, EPA established a drinking water standard of 30 µg/L. In expectation that the remedial action goal will be revised to 300 µg/L (10 times the current standard), DOE resumed groundwater extraction in April 2007 and continued to operate it in 2008. The system has removed 124 grams (4.4 ounces) of technetium-99 and 216 kilograms (480 pounds) of uranium since 1994. Concentrations of technetium-99 and uranium in wells monitoring the pump-and-treat system were below the remedial action goals in 2008 (Figures 10.7.14 and 10.7.15).

**Waste Management Area S-SX.** RCRA assessment monitoring continued in 2008. Groundwater beneath this waste management area is contaminated with tank waste constituents, which include technetium-99, chromium, and nitrate attributed to two general source areas within the waste management area. The highest technetium-99 concentrations in the operable unit occur in the southern plume, which represents a growing contamination issue because the plume is increasing in size. Each time the well





with the highest concentrations is sampled (quarterly), extra groundwater is removed and treated to remove technetium-99. Technetium-99, chromium, and nitrate concentrations also continued to increase in the northern plume at this waste management area.

**Waste Management Area U.** RCRA assessment monitoring continued in 2008. The waste management area has been identified as the source of groundwater contamination that is limited to the downgradient (east) side of the site. Plume constituents of interest include technetium-99 and nitrate.

**216-S-10 Pond and Ditch.** The 216-S-10 Facility continued to be monitored under a RCRA interim status detection program in 2008. One upgradient well and two downgradient wells were installed in 2008 as part of the 200-UP-1 Operable Unit work plan; these will also be sampled as 216-S-10 Facility monitoring wells in 2009.

**Environmental Restoration Disposal Facility.** This facility is a low-level, mixed waste disposal facility for waste generated from surface remedial actions and other activities on the Hanford Site. The site was built under CERCLA

regulations and is designed to meet all hazardous landfill standards. Results of groundwater monitoring continued to indicate that the facility has not adversely impacted groundwater quality. Two downgradient wells were decommissioned to allow for facility expansion to the east during 2008. Two new downgradient wells were constructed as replacements.

#### 10.7.3.10 Groundwater Monitoring Results for the 200-BP-5 Operable Unit

This operable unit includes groundwater beneath the northern 200-East Area and the region to the northwest, where mobile contaminants, including tritium and technetium-99, historically moved northward between Gable Mountain and Gable Butte. Most of the groundwater contamination originated in facilities in the northwestern corner of the 200-East Area, known as the B Complex.

The water table in the northern 200-East Area is virtually flat, making it difficult to determine current directions of groundwater flow. Studies in recent years suggest that groundwater continues to flow slowly to the northwest from the B Complex area.

Tritium and technetium-99 plumes extend northward between Gable Mountain and Gable Butte. Uranium forms a narrow plume that extends northwest of the 200-East Area (Figure 10.7.16). Nitrate forms a plume that extends to the north and probably originated from multiple sources within the 200-East Area. Other contaminants include cobalt-60, strontium-90, iodine-129, cesium-137, plutonium-239/240, uranium, cyanide, and sulfate.

DOE continued to work on the 200-BP-5 Operable Unit remedial investigation/feasibility study (DOE/RL-2007-18) during 2008. Drillers installed nine new wells. Six facilities in the 200-BP-5 Operable Unit are monitored under RCRA in conjunction with CERCLA and the *Atomic Energy Act of 1954*.

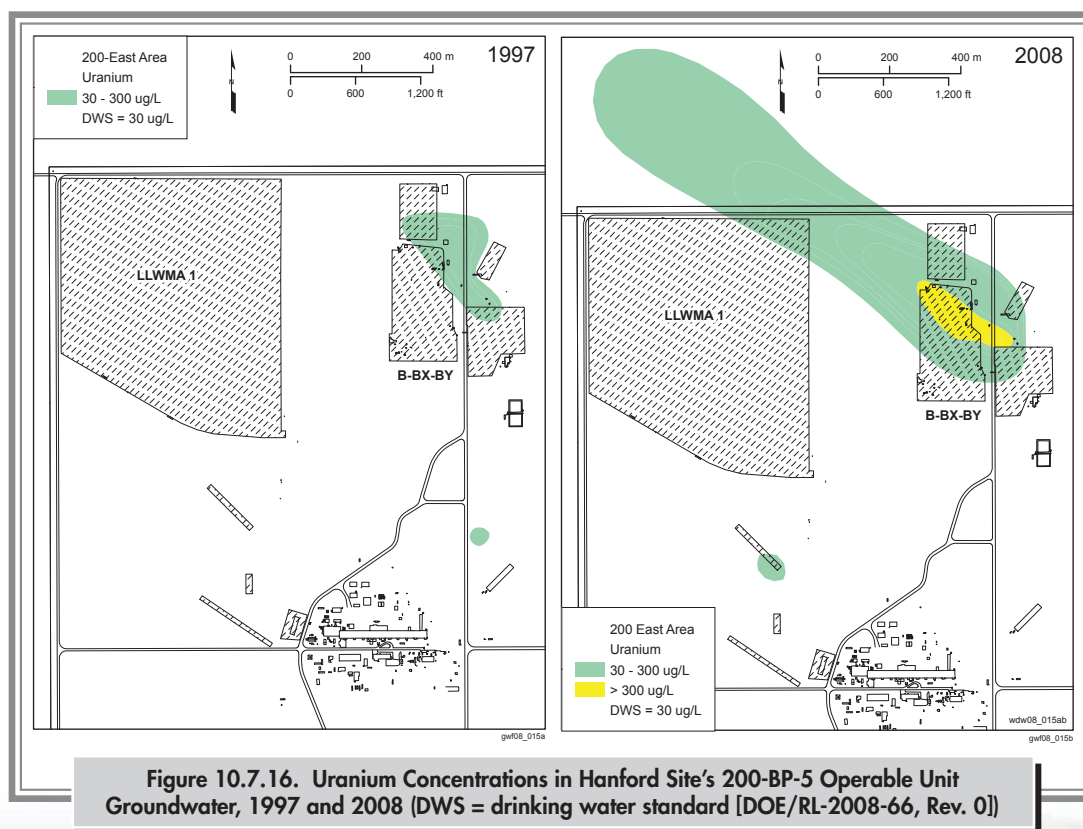
**Waste Management Area B-BX-BY.** RCRA assessment monitoring continued at this site in 2008. Contaminants include technetium-99, uranium, and nitrate. A new well located on the northwestern corner of the B Tank Farm had the maximum uranium concentration (3,910 µg/L) in 2008.

**216-B-63 Trench.** This RCRA site continued to be monitored under an interim status detection-monitoring program, with no indication that it has adversely affected groundwater quality.

**Low-Level Waste Management Area 1.** This site continued to be monitored under RCRA interim status requirements. Specific conductance continued to exceed its critical mean value, but exceedances previously were reported and do not appear to indicate contamination from the waste management area.

**Low-Level Waste Management Area 2.** This site continued to be monitored under RCRA interim status requirements, with no indication that it has adversely affected groundwater quality.

**Liquid Effluent Retention Facility.** The water table at this site has dropped into the top of the fractured basalt in all but two monitoring wells. DOE and the Washington State Department of Ecology are pursuing an agreement for environmental monitoring. In 2008, two new wells were installed to monitor the top of the fractured basalt.



**Waste Management Area C.** This site continued to be monitored under an interim status RCRA detection program in 2008, but is sampled quarterly to meet requirements of a tank waste retrieval work plan (RPP-22393, Rev. 2B). RCRA indicator parameters did not exceed critical mean values, but specific conductance in one well is very close to the critical mean.

### 10.7.3.11 Groundwater Monitoring Results for the 200-PO-1 Operable Unit

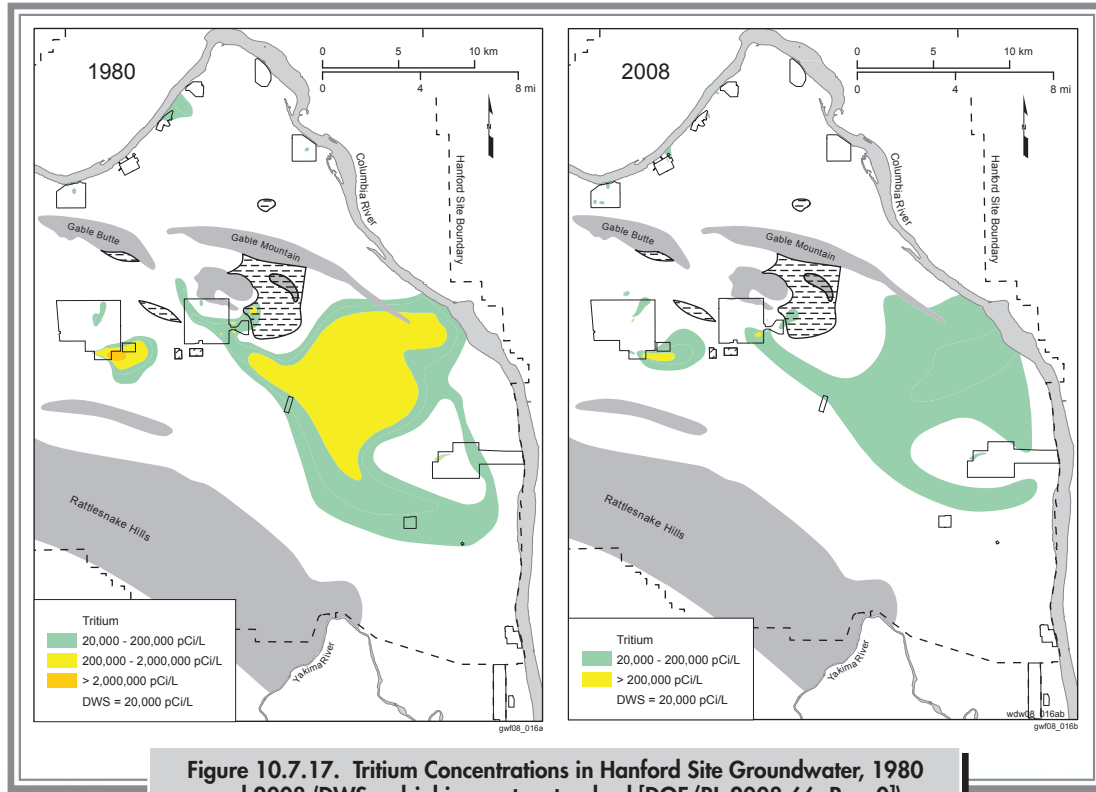
This operable unit encompasses the southern portion of the 200-East Area and a large region to the east and southeast that is contaminated with plumes of tritium (Figure 10.7.17) and iodine-129. Concentrations of tritium continued to decline as the plume naturally attenuates because of radioactive decay and dispersion. Nitrate forms a large plume but typically at levels below the 45-mg/L drinking water standard. Other contaminants include strontium-90 and technetium-99, but these are limited to smaller areas.

The remedial investigation/feasibility study process generated a work plan for the 200-PO-1 Operable Unit

(DOE/RL-2007-31, Draft A) during 2008. The document includes a sampling and analysis plan for routine groundwater monitoring of wells and a characterization sampling and analysis plan. Groundwater is monitored at eight regulated units in the 200-PO-1 Operable Unit. Water supply wells in the 400 Area, which falls within the footprint of the 200-PO-1 Operable Unit, also are monitored.

**Integrated Disposal Facility.** This facility will be an expandable, lined, RCRA-compliant landfill that will be used for disposal of low-level radioactive waste and hazardous waste. Until the facility begins to operate, results from semiannual monitoring will be added to the background data set.

**PUREX Cribbs.** The 216-A-10, 216-A-36B, and 216-A-37-1 Cribbs are monitored jointly under a RCRA interim status assessment program, CERCLA, and the Atomic Energy Act of 1954. The cribbs have contributed to widespread contaminant plumes in the area, including tritium, iodine-129, and nitrate. The tritium and nitrate plumes are generally attenuating throughout most of their area.



**Waste Management Area A-AX.** RCRA assessment monitoring continued in 2008. Technetium-99 concentrations continued to exceed the drinking water standard (900 pCi/L [133 Bq/L]) in two wells. A new downgradient well was installed in fiscal year 2008 to replace two wells that were decommissioned because of corrosion.

**216-A-29 Ditch.** The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations, with no indication that it has adversely affected groundwater quality. Specific conductance remains elevated in three downgradient wells, but is consistent with regional groundwater chemistry.

**216-B-3 Pond.** The groundwater beneath this site continued to be monitored as required by RCRA interim status detection regulations, with no indication that it has adversely affected groundwater quality.

**200 Area Treated Effluent Disposal Facility.** A state waste discharge permit governs groundwater sampling and analysis in the three monitoring wells at this facility. No permit criteria for constituents in groundwater were exceeded in 2008. Because no unconfined aquifer exists beneath the facility, groundwater monitoring wells are installed in the locally confined aquifer below the Ringold Formation lower mud unit.

**Nonradioactive Dangerous Waste Landfill.** This RCRA site is located in the 600 Area, within the footprint of the 200-PO-1 Operable Unit regional plume. Interim status detection monitoring continued in 2008. Total organic carbon concentrations in one downgradient well exceeded the critical mean value in August 2008 and in a confirmatory sample in October 2008. Groundwater will be monitored under an assessment program in fiscal year 2009.

**Solid Waste Landfill.** This facility is adjacent to the Nonradioactive Dangerous Waste Landfill and is regulated under state solid waste regulations. As in previous years, some downgradient wells showed higher chemical oxygen demand, chloride, coliform bacteria, specific conductance, sulfate, total organic carbon, and lower pH than upgradient wells. Some of these constituents may be related to past disposal of sewage materials to the landfill.

**400 Area Water Supply Wells.** Three water supply wells provide drinking water and emergency supply water for

the 400 Area. Because the 400 Area is in the path of the Hanford Site-wide tritium plume, the wells are routinely monitored for tritium. Tritium concentrations in all samples were below the drinking water standard in 2008.

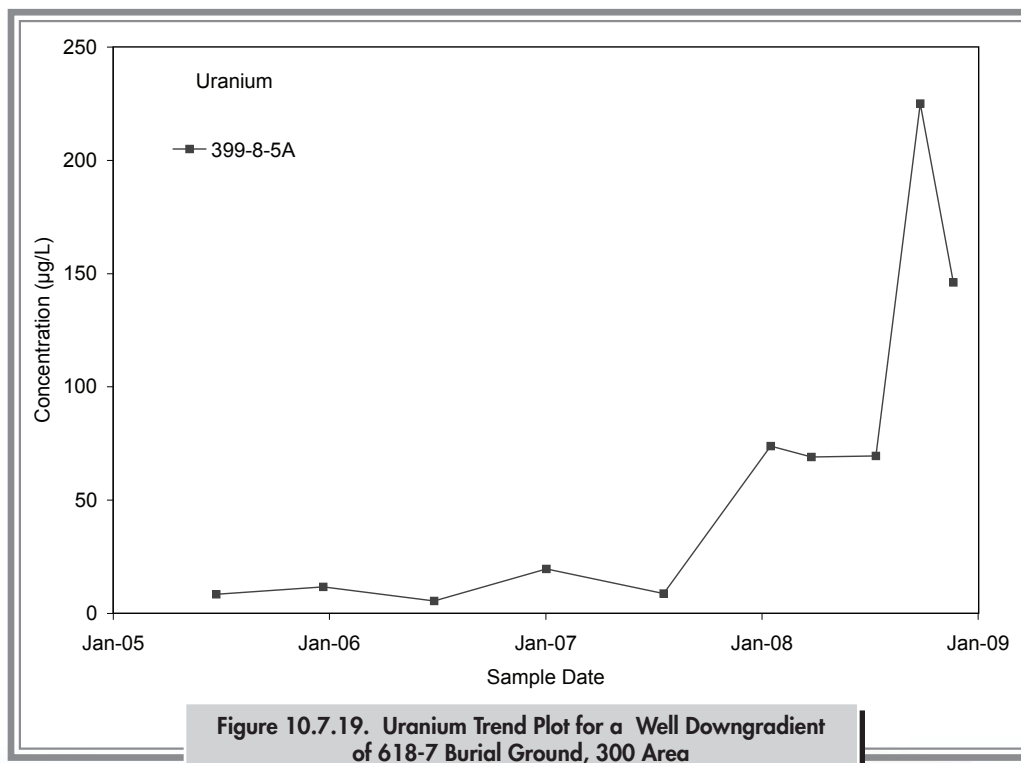
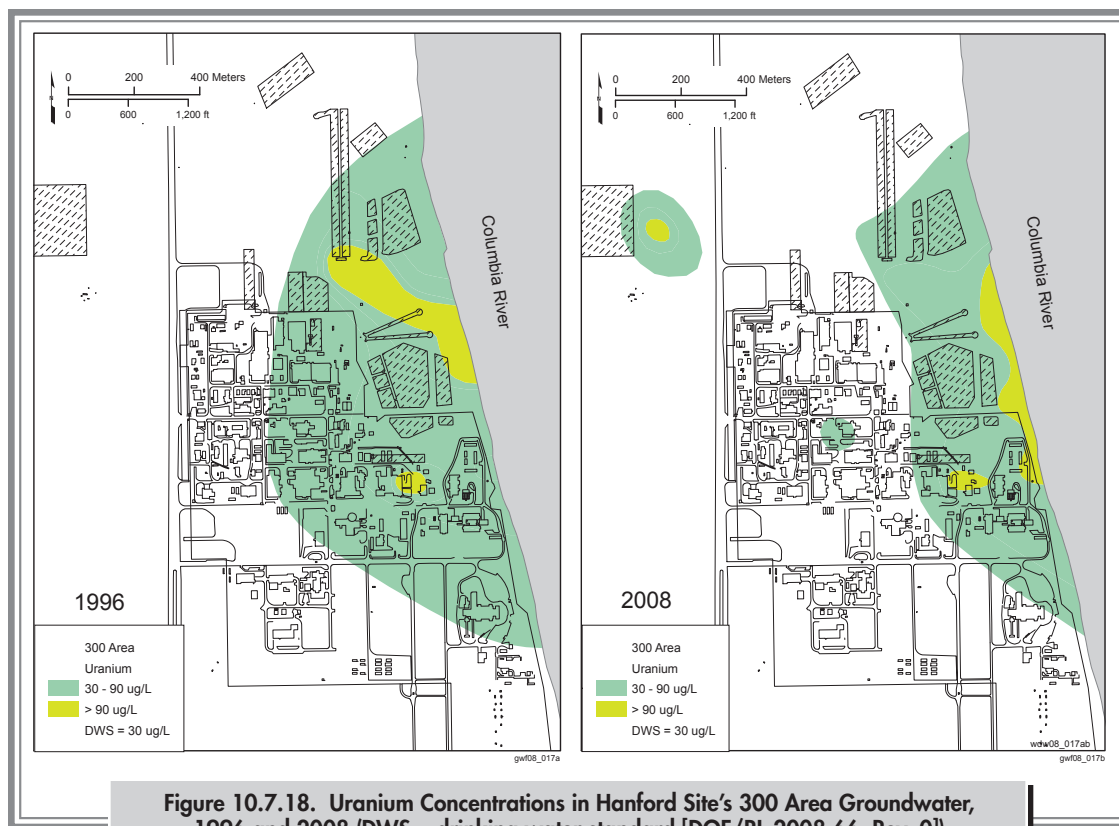
### 10.7.3.12 Groundwater Monitoring Results for the 300-FF-5 Operable Unit

This operable unit includes three geographic regions: the 300 Area, the 618-11 Burial Ground region, and the 618-10 Burial Ground/316-4 Cribs region. The operable unit is currently regulated under a record of decision for interim remedial action (ROD 1996) that calls for groundwater monitoring and institutional controls on the use of groundwater.

DOE installed 35 wells during 2008 to characterize uranium geochemistry and mobility, and 3 wells to define trichloroethene distribution. Recent work in this operable unit included updating computer simulations of groundwater flow and uranium transport, conducting a uranium limited field investigation regarding multiple characterization boreholes, updating the human health and ecological risk assessment, and assessing potential remedial action technologies for the 300 Area uranium plume, many of which were completed during 2008. Continuing work will include interim action monitoring and characterization activities as well as systematic planning of a new work plan for continued remedial investigation and feasibility study activities. These activities are anticipated to contribute information that will lead to a proposed plan for final remediation efforts.

Contaminants of concern in 300 Area groundwater are uranium, cis-1,2-dichloroethene, and trichloroethene. Monitoring and plume characterization activities indicate relatively constant or gradually decreasing levels for these contaminants. Uranium is the principal contaminant of concern and remains above the drinking water standard (30 µg/L) beneath part of the 300 Area (Figure 10.7.18). The uranium concentration in a well downgradient of a recently excavated burial ground west of the 300 Area increased sharply during 2008 (Figure 10.7.19).

Trichloroethene continued to be below the 5-µg/L drinking water standard in wells monitoring the top of the unconfined aquifer. However, higher concentrations were detected in a deeper, fine-grained unit in a limited area.



Groundwater downgradient of the 618-11 Burial Ground is contaminated by a high-concentration tritium plume, probably originating from irradiated material in the burial ground. Concentrations at a well adjacent to the burial ground have decreased from greater than 8 million pCi/L (296,000 Bq/L) in 2000 to 780,000 pCi/L (28,900 Bq/L) in September 2008.

### 300-FF-5 Operable Unit Phase III Feasibility Study.

Because the uranium plume beneath the 300 Area has not decreased in concentration as rapidly as predicted by earlier studies, DOE continued a detailed investigation of the natural processes that cause the plume to persist and the residual sources that may supply uranium to the plume. Results obtained in 2008 did not reveal evidence for high levels of uranium in the vadose zone, nor for a zone of elevated contaminants near the water table. Also, water samples collected from the saturated zone at various depths confirmed that contamination is generally limited to the uppermost hydrologic unit (i.e., saturated Hanford Site gravels). Concentrations in the samples were consistent with those observed during routine groundwater monitoring.

**Uranium Treatability Test.** DOE monitored results of a treatability test during 2008 to immobilize uranium in the aquifer. The test, conducted in fiscal year 2007, involved injecting polyphosphate into the aquifer. Monitoring during 2008 indicated that the method did not perform as well as hoped in permanently sequestering uranium on aquifer solids. The heterogeneity in aquifer sediment and the dynamic nature of hydrologic conditions present challenges to potential in situ remedies.

**Integrated Field-Scale Research Challenge.** This basic research project has focused on the geochemistry and mobility of uranium in the vadose zone at the 300 Area. Initial field activities included drilling 35 characterization boreholes at locations with a potential for encountering residual uranium in the vadose zone. Geophysical investigations associated with this research project continued during 2008.

**316-5 Process Trenches.** This former liquid waste disposal site was the last in the 300 Area to receive uranium-bearing effluent, with discharges ending in the early 1990s. The site, which has been remediated, is regulated under RCRA

in conjunction with CERCLA and the *Atomic Energy Act of 1954*. Uranium currently exceeds the drinking water standard in wells downgradient from the waste site, although concentrations appear to be decreasing with time. Cis-1,2-dichloroethene concentrations exceed the standard at only one downgradient well located near the bottom of the aquifer.

### 10.7.3.13 Groundwater Monitoring Results for the 1100-EM-1 Groundwater Interest Area

The 1100-EM-1 groundwater interest area is located in the southern part of the Hanford Site. It includes the former 1100-EM-1 Operable Unit, which was recently removed from the National Priorities List (40 CFR 300, Appendix B) and is no longer classified as a CERCLA operable unit. Groundwater is also monitored south of the Hanford Site, including the areas formerly designated as the 1100 and 3000 Areas of the site, the city of Richland's landfill, and the North Richland Well Field.

Trichloroethene was the principal contaminant of concern in the former 1100-EM-1 Operable Unit. The final alternative selected for groundwater was monitored natural attenuation of volatile organic compounds, and concentrations of trichloroethene have remained below the 5-µg/L drinking water standard since 2001. Contaminants also flow into the area from offsite sources (e.g., nitrate from agriculture and industry).

Wells in the North Richland Well Field are monitored frequently to detect any changes in Hanford Site contaminants near these wells. The tritium plume originating from sources in the 200-East Area has not been detected in these wells. Low levels of tritium, similar to those detected in Columbia River water, continued to be detected in 2008.

Elevated levels of gross alpha occur downgradient of an offsite industrial facility. If this gross alpha is attributed to uranium, then uranium exceeded the 30-µg/L drinking water standard at this site in 2008. Uranium concentrations in wells downgradient of DOE's inactive Horn Rapids Landfill have been increasing since 1996, but remained below the standard in 2008.



### 10.7.3.14 Groundwater Monitoring Results for the Confined Aquifers

Although most of the Hanford Site's groundwater contamination is in the unconfined aquifer, DOE monitors wells in deeper aquifers because of the potential for downward migration of contamination and the potential migration of contamination offsite through the basalt-confined aquifer. No evidence of offsite migration via the confined aquifer has been detected.

The Ringold Formation confined aquifer occurs within fluvial sand and gravel comprising the lowest sedimentary unit of the Ringold Formation. It is confined below by basalt and above by the Ringold lower mud unit. While effluent disposal was occurring at the B Pond System, mounding within the unconfined aquifer in this area led to downward migration of groundwater into the Ringold Formation confined aquifer. During 2008, seven wells were sampled that are completed in the Ringold Formation confined aquifer. No contaminants exceeded primary drinking water standards.

Groundwater occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds within the upper basalt-confined aquifer system. Six basalt-confined aquifer wells were sampled during 2008. Tritium continued to be detected at low levels in some basalt-confined wells. One elevated tritium concentration near the 200-East Area is associated with intercommunication between the upper basalt-confined aquifer and the overlying unconfined aquifer. Strontium-90, iodine-129, gamma-emitting isotopes, and uranium isotopes were not detected above the minimum detection limits in the upper basalt-confined aquifer. One new well monitoring the upper basalt-confined aquifer in the northwestern part of the 200-East Area detected technetium-99, cyanide, and nitrate contamination. Migration of high-salt waste from the vadose zone or unconfined aquifer via an older, poorly constructed well nearby was responsible for this contamination and has been sealed.

### 10.7.4 Shoreline Groundwater Monitoring

DOE monitors groundwater near the Columbia River via aquifer tubes, which are small diameter, flexible tubes that are implanted in the shallow aquifer, and natural seep points or springs.

Concentrations of strontium-90 continued to exceed the 8-pCi/L (0.3-Bq/L) drinking water standard in aquifer tubes in the 100-B/C, 100-N, and 100-H Areas. Levels exceed the 1,000-pCi/L (37-Bq/L) DOE-derived concentration guide (Appendix D, Table D.2) in 100-N Area tubes, reaching 75,000 pCi/L (2,800 Bq/L) in one tube in July 2008 (Figure 10.7.8). This high concentration represented a brief spike in response to the nearby injection of apatite-forming chemicals.

Tritium concentrations exceeded the 20,000-pCi/L (740-Bq/L) drinking water standard in one tube at the upstream end of 100-D Area. The source is believed to be the 100-N Area plume. Tritium also exceeded the standard in springs and aquifer tubes at the Hanford town site.

Uranium concentrations exceeded the 30-µg/L drinking water standard in the 300 Area aquifer tubes and springs.

Hexavalent chromium concentrations exceeded the 100-µg/L drinking water standard in 100-D Area aquifer tubes. Concentrations in aquifer tubes or springs exceeded the 10-µg/L aquatic standard in the 100-B/C, 100-K, 100-D, 100-H, and 100-F Areas.

Nitrate concentrations exceeded the 45-mg/L drinking water standard in aquifer tubes in the 100-K, 100-N, and 100-H Areas. An aquifer tube in the southern 300 Area also exceeded the standard; the source of this nitrate is a plume from offsite sources.

Trichloroethene was detected in several aquifer tubes in the 300 Area and continued to exceed the 5-µg/L drinking water standard in some tubes monitoring fine-grained units.



### 10.7.5 Well Installation, Maintenance, and Decommissioning

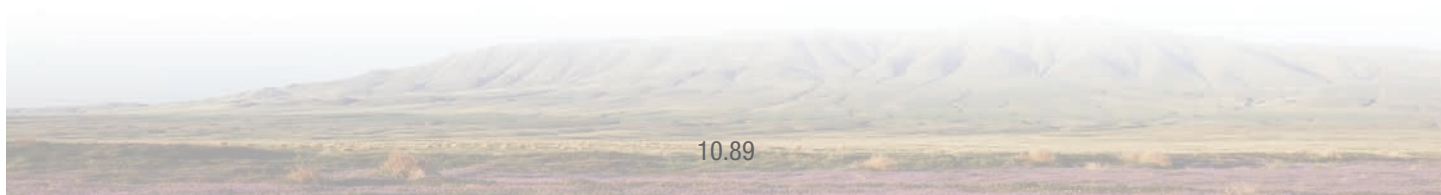
DOE installs new wells when needed for monitoring or characterization, maintains wells to repair problems, and decommissions wells that can no longer be used. The Washington State Department of Ecology, EPA, and DOE (the Tri-Parties) worked together to develop a prioritized list of new wells needed to meet requirements of various groundwater monitoring regulations. In fiscal year 2008, DOE installed 113 new wells.

During 2008, 386 temporary characterization boreholes were installed around the Hanford Site to support various projects. The temporary boreholes are installed for subsurface characterization of radiological constituents, volatile organics (e.g., carbon tetrachloride), or hydrogeologic property determination (e.g., moisture, grain size distribution). While typically installed to characterize the vadose zone, boreholes can be drilled to groundwater to obtain a one-time sample and then be decommissioned.

Approximately 9,695 unique well identification numbers have been assigned within the Hanford Site. These include all wells, characterization boreholes, aquifer tubes, soil-gas

probes, piezometers, or other subsurface installations. To date, 4,272 of these, or approximately 44% of the total, have been either administratively removed from the well inventory or decommissioned (sealed with grout). Wells are decommissioned when they are no longer needed; are in poor condition; are in the path of intended remediation or construction activities; or pose an environmental, safety, or public health hazard. DOE maintains a list of wells that are candidates for decommissioning, which must be reviewed and approved by potential well users before decommissioning. A total of 3,384 unique well identification numbers were documented as “in use” through September 2008. A total of 103 wells were physically decommissioned from October 2007 through September 2008, and 221 temporary boreholes were administratively decommissioned by records management.

Staff performed maintenance on 275 wells from October 2007 through September 2008. Surface maintenance included labeling wells, maintaining well caps, and repairing surface casing, wiring, or pump-discharge fittings. Subsurface tasks included repairing and replacing sampling pumps, performing camera surveys, retrieving pumps and equipment, and replacing tubing.





## 10.8 Food and Farm Products Monitoring

BG Fritz

Food and farm products (milk, potatoes, tomatoes, and cherries) were collected at locations near the Hanford Site (Figure 10.8.1) during 2008. Samples were analyzed to determine concentrations of radiological contaminants and were obtained from the following locations:

- Locations generally downwind (east and southeast) of the Hanford Site where airborne emissions or contaminated dust from the site would potentially be deposited
- Locations generally upwind of and distant from the Hanford Site to provide information on reference (background) contaminant levels
- Farms irrigated with water taken from the Columbia River downstream of the Hanford Site.

Results of sample analyses are used to assess the amounts of Hanford Site contaminants in food and farm products by 1) comparing analytical results obtained from similar samples collected from the same regions over long periods of time; 2) comparing analytical results from samples collected at downwind locations to results from samples obtained from generally upwind or distant locations; and 3) comparing analytical results from samples collected in areas irrigated with water withdrawn from the Columbia River downstream from the Hanford Site to analytical results from samples obtained from locations irrigated with water from other regional sources.

Radionuclide concentrations in most food and farm product samples in 2008 were below levels that could be detected by analytical laboratories. However, some contaminants that potentially could have originated from the Hanford Site (e.g., tritium and uranium) were found at low levels in some samples. These findings are discussed in the following sections. Data for naturally occurring potassium-40 are

included to show the amounts of this natural radioactive element in food products relative to concentrations of contaminants potentially from the Hanford Site. Radiological doses associated with possible site-produced contaminants are discussed in Section 10.14. Where possible, the measured concentrations are compared to the applicable unusual concentration reporting levels. Unusual concentration reporting levels have been established based on environmental concentrations that would result in a 1-millirem (10-microsievert) dose per year (DOE/RL-91-50, Rev. 4).

### 10.8.1 Collection of Food and Farm Product Samples

Several food and farm product samples are collected each year on quarterly or annual schedules; others may only be sampled every 2 or 3 years. The rationale for sampling and analyzing some media more frequently than others is discussed in the *Hanford Site Environmental Monitoring Plan* (DOE/RL-91-50, Rev. 4). The types and numbers of samples scheduled for collection in any given year are documented in the annual Hanford Site environmental surveillance master sampling schedule (e.g., PNNL-17282). Typically, enough crop material for two samples is collected at each location. A portion of this material is submitted to a laboratory for analysis, and the remainder is archived at Pacific Northwest National Laboratory if the analytical laboratory needs additional material for confirmatory or follow-up analyses. Table 10.8.1 shows the products, locations, and frequencies of sampling; types of analyses; and numbers of samples collected and analyzed for radioactive contaminants during 2008. Most samples were

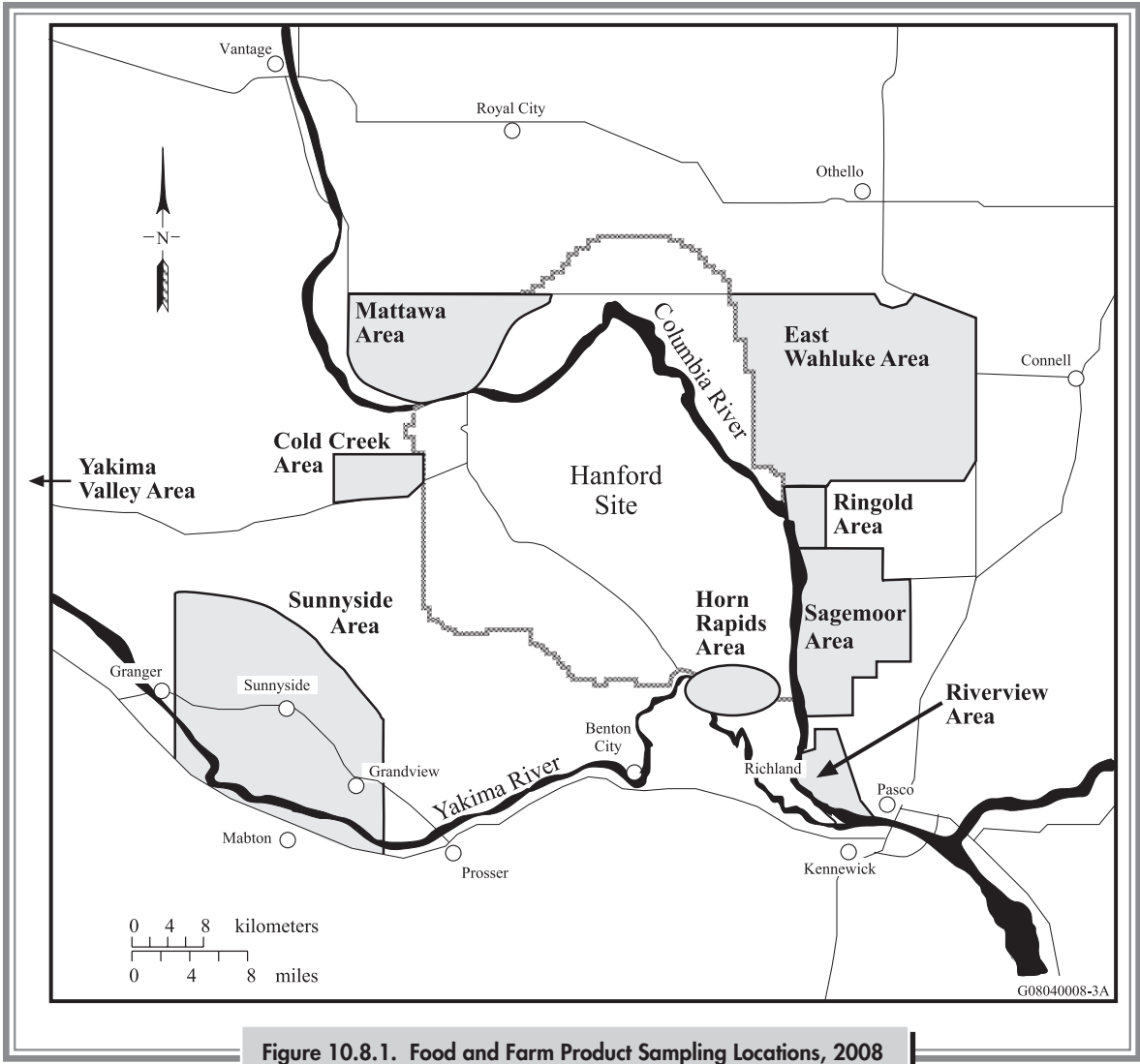


Table 10.8.1. Sampling Locations and Analytes for Food and Farm Products Sampled Around the Hanford Site in 2008

Product	Sampling Locations	Analytes
Milk	Sagemoor, Sunnyside, Wahluke	<sup>3</sup> H, Gamma, <sup>90</sup> Sr
Cherries	Ringold, Sagemoor, Sunnyside, Wahluke	Gamma, <sup>90</sup> Sr
Potatoes	Sunnyside, Wahluke	Gamma, <sup>90</sup> Sr
Tomatoes	Riverview, Sunnyside	<sup>3</sup> H, Gamma, <sup>90</sup> Sr



obtained from commercial producers; however, some were obtained from residential gardens because commercial growers could not be located.

## 10.8.2 Milk

During 2008, milk samples were obtained quarterly from multiple dairies in the East Wahluke sampling area, multiple dairies in the Sagemoor area, and one dairy in the Sunnyside sampling area. The Sagemoor and East Wahluke sampling areas are located near the Hanford Site perimeter and potentially could be affected by airborne contaminants from the site. The Sunnyside area is a reference location generally upwind of the site. If milk was obtained from more than one dairy within a sampling area, the milk samples were combined and the sample (composite) was analyzed. All samples were analyzed for gamma-emitting radionuclides, tritium, and strontium-90. Milk sampling was conducted because Hanford Site-produced radionuclides have the potential to move through the air-pasture-cow-milk or water-pasture-cow-milk food chains to humans. In recent years, levels of Hanford Site-produced radiological contaminants in milk samples have diminished, and concentrations in samples obtained from dairies downwind of the site are now similar to levels measured in samples obtained from the dairy generally upwind of the site.

**Tritium** – Tritium was detected in all but one milk sample collected in 2008. Concentrations ranged from a maximum of 67 pCi/L (2.5 Bq/L) in a Sagemoor area sample to 3.7 pCi/L (0.14 Bq/L) in a Wahluke area sample. Annual average concentrations for the three sampling areas were 45 pCi/L (1.7 Bq/L) for Sagemoor ( $n = 4$ ); 16 pCi/L (0.59 Bq/L) for Wahluke ( $n = 4$ ); and 27 pCi/L (1.0 Bq/L) for Sunnyside ( $n = 4$ ). These concentrations are consistent with concentrations historically measured in these

areas. The unusual concentration reporting level for tritium in milk is an annual average of 54,000 pCi/L (2,000 Bq/L).

**Potassium-40** – Potassium-40 was detected in all milk samples collected in 2008. Potassium-40 is a naturally occurring radionuclide found in soil and in fertilizers applied to soil. It is the predominant radionuclide in foods and human tissues (Eisenbud 1987). Concentrations ranged between 1,200 pCi/L (44 Bq/L) and 1,700 pCi/L (63 Bq/L).

**Strontium-90** – Strontium-90 was not measured at detectable concentrations in any milk samples collected in 2008. The nominal analytical detection limit for strontium-90 in milk was 1 pCi/L (0.037 Bq/L), or 27 times below the unusual concentration reporting level for strontium-90 in milk (27 pCi/L [1.0 Bq/L]).

**Cesium-137** – No manmade gamma emitters were detected in milk samples collected and analyzed in 2008 (PNNL-18427, APP. 1).

## 10.8.3 Cherries, Potatoes, and Tomatoes

Cherry, potato, and tomato samples were collected from upwind and downwind sampling areas during the growing season (Figure 10.8.1). All samples were analyzed for gamma-emitting radionuclides and strontium-90. Tomato samples were also monitored for tritium (Table 10.8.1). The only radionuclide detected in any of the samples was naturally occurring potassium-40. Concentrations of potassium-40 in all samples were less than 5 pCi/g [0.2 Bq/g] wet weight.





## 10.9 Soil Monitoring

The following sections summarize soil monitoring efforts conducted in 2008 on and around the Hanford Site. Radiological monitoring of soil is conducted at a variety of locations: onsite near facilities and operations, onsite away from facilities and operations (site-wide), and offsite at perimeter and distant locations and in nearby communities. Contaminant concentration data are used for the following:

- Determining the effectiveness of effluent monitoring and controls within facilities
- Assessing the adequacy of containment at waste disposal sites
- Detecting and monitoring unusual conditions
- Providing information on long-term radionuclide contamination trends in soil at undisturbed locations.

Soil samples have been collected on and around the Hanford Site for more than 50 years. Consequently, a large amount of data exist that document onsite and offsite levels of manmade radionuclides in Hanford Site soil. These data provide a baseline against which unplanned releases can be compared. For further information about the purpose of soil monitoring efforts and the programs that support them, see Section 10.0 and DOE/RL-91-50, Rev. 4.

### 10.9.1 Soil Monitoring Near Hanford Site Facilities and Operations

JW Wilde

Soil samples are collected near facilities and operations to evaluate long-term trends in the environmental accumulation of radioactive materials, and to detect potential migration and deposition of facility emissions. Soil contamination can occur as the result of direct deposition from facility emissions, resuspension and movement of contaminants from radiologically contaminated surface areas, uptake of contaminants into plants whose roots contact belowground waste, or translocation of buried waste by intruding animals.

#### 10.9.1.1 Soil Sampling Near Hanford Site Facilities and Operations

Soil samples were collected on or adjacent to waste disposal sites and from locations downwind and near or within the boundaries of operating Hanford Site facilities and remedial action sites. Table 10.9.1 summarizes the number and locations of soil samples collected during 2008. Only

**Table 10.9.1. Number and Locations of Soil Samples Collected Near Hanford Site Facilities and Operations, 2008**

Number of Samples	Operational Area									
	100-B/C	100-D	100-H	100-F	200-West <sup>(a)</sup>	200-East <sup>(a)</sup>	600 <sup>(a)</sup>	300 <sup>(a)</sup>	400	ERDF <sup>(b)</sup>
95	3	4	4	5	27	15	18	17	1	1

(a) Number of samples includes one or more replicate samples.

(b) Environmental Restoration Disposal Facility in the 200-West Area.

radionuclides with concentrations consistently above analytical detection limits are discussed in this section. A comprehensive presentation of the analytical data from these samples is provided in PNNL-18427, APP. 2.

Each 1-kilogram (2.2-pound) soil sample represented a composite of five plugs of soil, each 2.5 centimeters (1 inch) deep and 10 centimeters (4 inches) in diameter. Soil samples were sieved in the field to remove rocks and plant debris and then dried in a laboratory before being analyzed to remove residual moisture.

Hanford Site samples were analyzed for radionuclides expected to occur in the areas sampled (i.e., gamma-emitting radionuclides [Appendix F, Table F.1], strontium-90, uranium isotopes, and/or plutonium isotopes). The analytical results from Hanford Site samples were compared to concentrations of radionuclides measured in samples collected offsite in previous years at various sampling locations in Adams, Benton, Franklin, Grant, Walla Walla, and Yakima Counties. These comparisons were used to differentiate concentrations of Hanford Site-produced contaminants from levels resulting from natural sources and worldwide fallout.

Soil sampling results can be compared to the accessible soil concentrations (WHC-SD-EN-TI-070) developed specifically for use on the Hanford Site. These concentration values for radionuclides were established to ensure effective dose equivalents to the public do not exceed the established limits for any reasonable scenario, such as direct exposure, inadvertent ingestion, inhalation, and consumption of foods, including animal products. The accessible soil concentration values are based on a radiation-dose estimate scenario (WHC-SD-EN-TI-070) in which an individual would have to spend 100 hours per year in direct contact with the contaminated soil. The conservatism inherent in

pathway modeling assures the required degrees of protection are in place. These concentrations apply specifically to the Hanford Site with respect to onsite waste disposal operations and cleanup, decontamination, and decommissioning activities. Table 10.9.2 provides a partial listing of these values (see PNNL-18427, APP. 2 for a complete listing of concentrations).

### 10.9.1.2 Analytical Results for Soil Samples Collected Near Hanford Site Facilities and Operations

Some degree of variability is always associated with collecting and analyzing environmental samples. Therefore, variations in sample concentrations from year to year are expected. In general, radionuclide concentrations in soil samples collected from or adjacent to waste disposal facilities in 2008 were higher than the concentrations in samples collected farther away, including concentrations measured offsite. These data also show as expected that concentrations of certain radionuclides in 2008 were higher within different operational areas when compared to concentrations measured in distant communities in previous years. Generally, the predominant radionuclides detected were activation and fission products in the 100 Areas, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas.

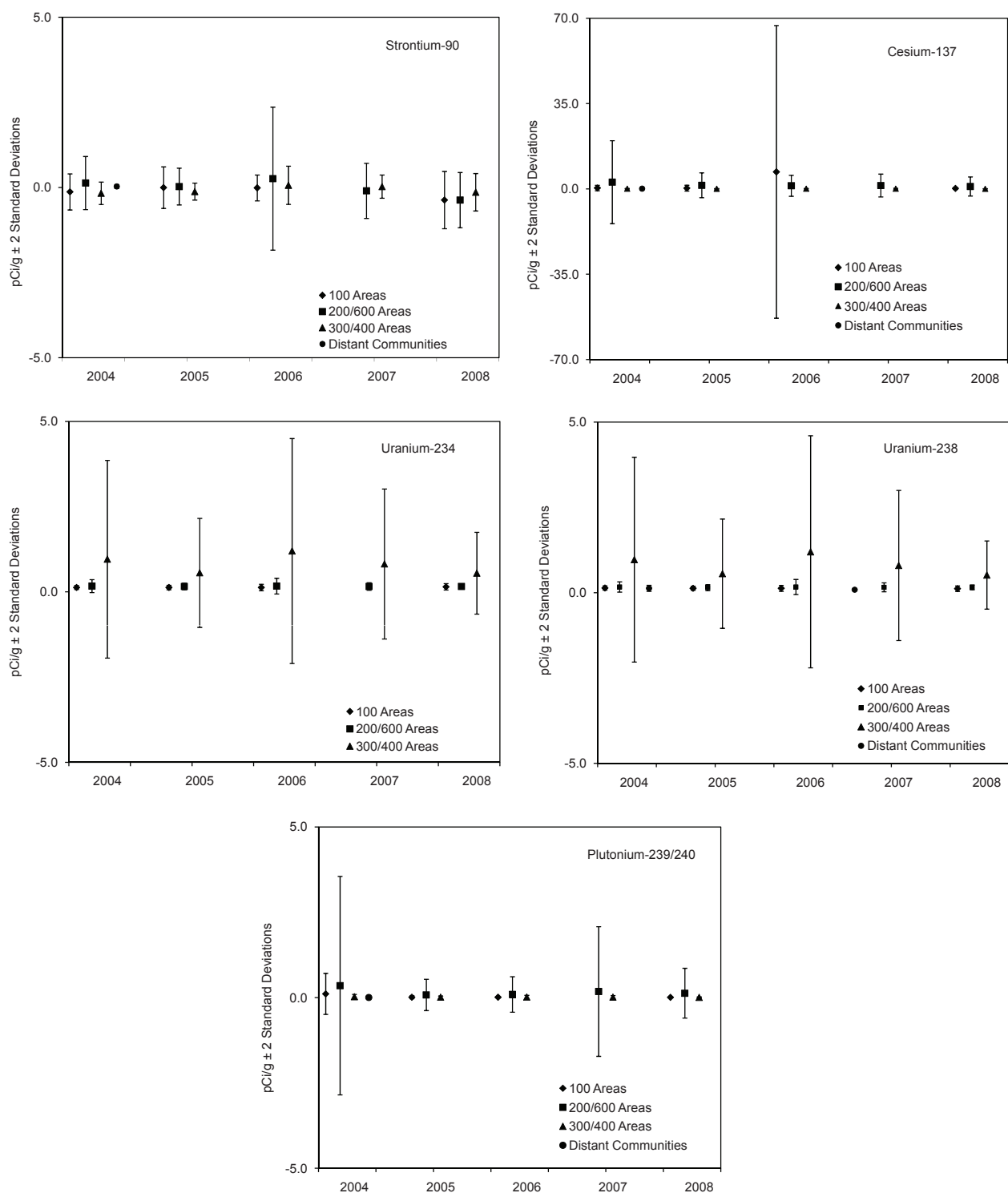
Cesium-134, cesium-137, plutonium-239/240, and uranium were detected consistently in the samples taken in 2008. Concentrations of these radionuclides were elevated near and within facility boundaries when compared to historical concentrations measured offsite at distant communities. Figure 10.9.1 shows the average concentrations of selected radionuclides in soil samples collected during 2008 and the preceding 4 years. Some individual levels demonstrate a high degree of variability, although overall trends are stable.

**Table 10.9.2. Accessible Soil Concentration Limits (pCi/g<sup>[a]</sup> dry wt.) for Selected Radionuclides**

	<u>Cobalt-60</u>	<u>Strontium-90</u>	<u>Cesium-137</u>	<u>Uranium-234</u>	<u>Uranium-235</u>	<u>Uranium-238</u>	<u>Plutonium-239/240</u>
Accessible soil <sup>(b)</sup> concentration limits (WHC-SD-EN-TI-070)	7.1	2,800	30	630	170	370	190

(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.

(b) Hanford Site soil that is not behind security fences.



**Figure 10.9.1. Average Concentrations of Selected Radionuclides in Soil Samples Collected on the Hanford Site Near Facilities and Operations Compared to Those Collected in Distant Communities, 2004 Through 2008. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.**

Table 10.9.3 summarizes selected analytical results for near-facility soil samples collected and analyzed in 2008. The average and maximum results are reported for six operational areas, along with comparative data for the preceding 5 years. Complete listings of radionuclide concentrations for all soil samples collected during 2008, as well as sampling location maps, are provided in PNNL-18427, APP. 2.

Soil samples collected in 2008 at locations in the 100, 200-East, 200-West, 400, and 600 Areas were comparable to previous years. Soil samples collected in the 300 Area showed concentrations of uranium-234 and uranium-238 that were comparable to historical data but remained higher than those measured in the 200 Areas. The higher uranium levels in the 300 Area were expected because of uranium releases to the environment during past fuel-fabrication operations in that area. Plutonium-238 and plutonium-239/240 were found at higher levels in a small number of soil samples in the 200-West, 600, and 300 Areas; this may be due to facility operations in the region or a change in laboratory analytical techniques.

For non-routine soil sampling in support of the environmental restoration contractor projects during 2008, three soil samples were collected at the Field Remediation Project in the 100-B/C Area, four at the 100-D Area, four at the 100-H Area, five at the 100-F Area, three at Operable Units 100-IU-2 and 100-IU-6 (in the 600 Area), and one sample at the Environmental Restoration Disposal Facility. Analytical results from each of these locations were comparable to those observed at other near-facility sampling locations at the Hanford Site. Table 10.9.4 provides a summary of selected analytical results. A complete listing of the data is provided in PNNL-18427, APP. 2.

### 10.9.1.3 Investigations of Radioactive Contamination in Soil Near Hanford Site Facilities and Operations

#### SM McKinney and RC Roos

Investigations for radioactive contamination in soil were conducted in and near operational areas to monitor the presence or movement of radioactive materials around areas of known or suspected contamination or to verify

radiological conditions at specific project sites. All samples collected during investigations were field-surveyed for alpha and beta/gamma radiation. Generally, the predominant radionuclides in samples from the 100 and 200 Areas have been strontium-90, cesium-137, and plutonium-239/240. Uranium-234, uranium-235, and uranium-238 have been routinely found in 300 Area samples.

Sixteen instances of radiological contamination in soil samples were collected during investigations in 2008. Of the 16, 8 were identified as speck contamination, and 9 of the 16 were cleaned up and disposed of onsite in burial grounds. At the remaining locations, the contamination levels did not exceed the radiological control limits for the sites, and the soil was left in place. None of the soil samples were submitted for radioisotopic analysis. The number of soil investigation contamination incidents and range of radiation dose levels in 2008 were generally within historical values (WHC-MR-0418).

Table 10.9.5 summarizes the number and general locations of soil contamination incidents investigated during 2008. Table 10.9.6 provides the number of contamination incidents investigated in 2008 and during the previous 11 years.

## 10.9.2 Soil Monitoring at Hanford Site-Wide and Offsite Locations

### BG Fritz

Soil monitoring provides information on long-term contamination trends and baseline environmental radionuclide activities at undisturbed locations both on and off the Hanford Site (DOE/RL-91-50, Rev 4.). Soil samples, collected on and around the Hanford Site for more than 50 years, have been added to a large database documenting onsite and offsite levels of manmade radionuclides in soil at specific locations. This database contains baseline data against which analysis results from unplanned contaminant releases from the Hanford Site can be compared. Soil at site-wide (onsite away from facilities and operations) and offsite locations was last routinely monitored for radiation in 2004 (Section 8.9.2 in PNNL-15222).



**Table 10.9.3. Concentrations of Selected Radionuclides (pCi/g dry wt.)<sup>(a)</sup> in Near-Facility Soil Samples, 2008 Compared to Previous Years**

Radionuclide	Hanford Site Area	2008				2003-2007			
		Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>
		Samples	Detections <sup>(b)</sup>			Samples	Detections <sup>(b)</sup>		
Cobalt-60	100	16	0	-1.0E-03 ± 1.1E-02	1.3E-02 ± 9.6E-03 <sup>(e)</sup>	69	24	3.2E-01 ± 4.0E+00	1.6E+01 ± 1.5E+00
	200-East	16	0	-3.9E-04 ± 5.8E-03	6.6E-03 ± 1.1E-02 <sup>(e)</sup>	72	0	6.8E-04 ± 7.3E-03	1.0E-02 ± 7.8E-03 <sup>(e)</sup>
	200-West <sup>(f)</sup>	28	1	1.7E-03 ± 9.1E-03	1.1E-02 ± 9.6E-03 <sup>(e)</sup>	137	3	1.4E-03 ± 3.1E-02	1.8E-01 ± 2.0E-02
	300	17	0	-3.4E-04 ± 6.0E-03	5.7E-03 ± 5.5E-03 <sup>(e)</sup>	70	0	-3.4E-04 ± 7.1E-03	8.3E-03 ± 6.3E-03 <sup>(e)</sup>
	400 <sup>(g)</sup>	1	0	2.40E-03	2.4E-03 ± 5.7E-03 <sup>(e)</sup>	5	0	7.8E-04 ± 5.5E-03	5.2E-03 ± 6.9E-03 <sup>(e)</sup>
	600	18	0	-7.4E-02 ± 5.9E-01	3.4E-03 ± 9.3E-02 <sup>(e)</sup>	82	1	2.6E-04 ± 8.3E-03	1.3E-02 ± 1.3E-02
Strontium-90	100	16	0	-3.7E-01 ± 8.4E-01	3.4E-01 ± 4.1E-01 <sup>(e)</sup>	69	6	-4.3E-02 ± 5.1E-01	8.3E-01 ± 2.9E-01
	200-East	16	1	-3.9E-01 ± 8.8E-01	4.8E-01 ± 4.7E-01	72	12	1.1E-01 ± 6.2E-01	1.3E+00 ± 3.2E-01
	200-West <sup>(f)</sup>	28	0	-4.5E-01 ± 6.6E-01	3.7E-01 ± 4.5E-01 <sup>(e)</sup>	137	23	1.1E-01 ± 1.6E+00	8.1E+00 ± 1.6E+00
	300	17	1	-1.3E-01 ± 5.7E-01	6.0E-01 ± 4.6E-01	70	2	-2.5E-02 ± 4.1E-01	1.0E+00 ± 3.5E-01
	400 <sup>(g)</sup>	1	0	-2.70E-01	-2.7E-01 ± 4.2E-01 <sup>(e)</sup>	5	0	4.0E-02 ± 4.1E-01	2.8E-01 ± 2.6E-01 <sup>(e)</sup>
	600	18	1	-1.9E-01 ± 7.9E-01	1.2E+00 ± 5.0E-01	82	8	-8.1E-03 ± 6.2E-01	1.1E+00 ± 2.5E-01
Cesium-137	100	16	16	2.0E-01 ± 4.0E-01	7.9E-01 ± 1.4E-01	69	68	2.4E+00 ± 3.4E+01	1.4E+02 ± 2.6E+01
	200-East	16	16	1.5E+00 ± 6.6E+00	1.4E+01 ± 2.2E+00	72	71	2.1E+00 ± 7.3E+00	1.7E+01 ± 3.0E+00
	200-West <sup>(f)</sup>	28	27	1.0E+00 ± 2.6E+00	5.8E+00 ± 1.0E+00	137	134	1.8E+00 ± 4.6E+00	1.4E+01 ± 2.3E+00
	300	17	14	3.9E-02 ± 8.8E-02	1.9E-01 ± 3.4E-02	70	64	8.7E-02 ± 1.6E-01	3.6E-01 ± 6.4E-02
	400 <sup>(g)</sup>	1	1	2.0E-02 ± 6.1E-06	2.0E-02 ± 1.1E-02	5	5	1.9E-02 ± 1.2E-02	2.7E-02 ± 1.1E-02
	600	18	17	5.8E+00 ± 4.3E+01	9.4E+01 ± 1.7E+01	82	79	1.3E+00 ± 1.3E+01	6.1E+01 ± 9.7E+00
Uranium-234	100	16	16	1.5E-01 ± 9.4E-02	3.1E-01 ± 8.1E-02	68	68	1.3E-01 ± 7.6E-02	3.2E-01 ± 9.9E-02
	200-East	16	16	1.7E-01 ± 6.8E-02	2.4E-01 ± 8.2E-02	72	72	1.6E-01 ± 1.9E-01	8.4E-01 ± 2.8E-01
	200-West <sup>(f)</sup>	28	28	1.5E-01 ± 6.4E-02	2.3E-01 ± 7.6E-02	137	137	1.6E-01 ± 1.2E-01	5.1E-01 ± 1.4E-01
	300	17	17	5.7E-01 ± 1.2E+00	2.2E+00 ± 5.9E-01	70	70	1.0E+00 ± 3.4E+00	8.5E+00 ± 1.6E+00
	400 <sup>(g)</sup>	1	1	2.2E-01 ± 3.2E-05	2.2E-01 ± 7.3E-02	5	5	1.2E-01 ± 5.2E-02	1.6E-01 ± 5.6E-02
	600	18	18	2.0E-01 ± 8.5E-02	2.7E-01 ± 8.4E-02	82	82	1.6E-01 ± 1.7E-01	8.4E-01 ± 2.3E-01
Uranium-235	100	16	11	1.2E-02 ± 1.1E-02	2.2E-02 ± 1.5E-02	66	32	1.1E-02 ± 1.2E-02	2.5E-02 ± 1.7E-02
	200-East	16	9	1.4E-02 ± 8.5E-03	2.1E-02 ± 1.5E-02	72	38	1.3E-02 ± 1.4E-02	3.7E-02 ± 2.0E-02
	200-West <sup>(f)</sup>	28	11	1.2E-02 ± 1.5E-02	3.2E-02 ± 2.3E-02	137	70	1.4E-02 ± 1.7E-02	5.4E-02 ± 2.4E-02
	300	17	13	4.1E-02 ± 1.1E-01	2.5E-01 ± 8.0E-02	70	54	6.4E-02 ± 1.8E-01	4.1E-01 ± 9.8E-02
	400 <sup>(g)</sup>	1	1	2.90E-02	2.9E-02 ± 1.8E-02	5	1	8.1E-03 ± 5.5E-03	1.2E-02 ± 1.3E-02 <sup>(e)</sup>
	600	18	12	2.0E-02 ± 1.4E-02	3.9E-02 ± 2.3E-02	82	45	1.4E-02 ± 2.1E-02	5.6E-02 ± 2.7E-02

Table 10.9.3. (contd)

Radionuclide	Hanford Site Area	2008				2003-2007			
		Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>
		Samples	Detections <sup>(b)</sup>			Samples	Detections <sup>(b)</sup>		
Plutonium-238	100	16	0	-4.1E-03 ± 3.2E-02	2.4E-02 ± 4.2E-02 <sup>(e)</sup>	69	0	7.9E-05 ± 3.5E-02	3.9E-02 ± 3.9E-02 <sup>(e)</sup>
	200-East	16	1	5.9E-03 ± 6.3E-02	1.2E-01 ± 5.5E-02	72	1	4.2E-03 ± 3.6E-02	4.7E-02 ± 3.9E-02 <sup>(e)</sup>
	200-West <sup>(f)</sup>	28	4	2.5E-02 ± 9.7E-02	2.1E-01 ± 5.9E-02	137	6	7.6E-03 ± 4.0E-02	1.2E-01 ± 9.4E-02 <sup>(e)</sup>
	300	17	1	1.2E-03 ± 3.1E-02	3.5E-02 ± 3.8E-02 <sup>(e)</sup>	70	2	4.5E-03 ± 4.4E-02	1.6E-01 ± 6.1E-02
	400 <sup>(g)</sup>	1	0	-2.60E-02	-2.6E-02 ± 3.7E-02 <sup>(e)</sup>	5	0	6.5E-03 ± 9.8E-03	1.1E-02 ± 2.1E-02 <sup>(e)</sup>
	600	18	1	7.7E-03 ± 3.0E-02	2.6E-02 ± 2.4E-02 <sup>(e)</sup>	82	3	1.8E-02 ± 1.8E-01	7.7E-01 ± 2.2E-01
Uranium-238	100	16	16	1.2E-01 ± 7.9E-02	2.1E-01 ± 6.7E-02	69	69	1.3E-01 ± 7.1E-02	2.9E-01 ± 9.3E-02
	200-East	16	16	1.7E-01 ± 6.2E-02	2.4E-01 ± 7.9E-02	72	72	1.7E-01 ± 1.7E-01	7.7E-01 ± 2.6E-01
	200-West <sup>(f)</sup>	28	28	1.4E-01 ± 5.3E-02	1.8E-01 ± 6.3E-02	137	137	1.6E-01 ± 1.3E-01	5.3E-01 ± 1.5E-01
	300	17	17	5.4E-01 ± 1.0E+00	1.6E+00 ± 4.3E-01	70	70	1.0E+00 ± 3.4E+00	8.6E+00 ± 1.6E+00
	400 <sup>(g)</sup>	1	1	2.1E-01 ± 4.4E-05	2.1E-01 ± 6.9E-02	5	5	1.3E-01 ± 3.2E-02	1.5E-01 ± 5.3E-02
	600	18	18	1.9E-01 ± 8.2E-02	2.6E-01 ± 8.1E-02	82	82	1.6E-01 ± 1.4E-01	6.8E-01 ± 1.9E-01
Plutonium-239/240	100	16	0	8.3E-03 ± 1.3E-02	2.9E-02 ± 2.3E-02 <sup>(e)</sup>	69	16	2.9E-02 ± 2.7E-01	1.1E+00 ± 3.0E-01
	200-East	16	3	8.2E-03 ± 1.4E-02	2.6E-02 ± 1.8E-02	72	25	1.4E-02 ± 2.9E-02	6.2E-02 ± 2.9E-02
	200-West <sup>(f)</sup>	28	19	2.5E-01 ± 1.0E+00	2.4E+00 ± 6.2E-01	137	111	1.9E-01 ± 1.4E+00	7.3E+00 ± 1.9E+00
	300	17	5	8.4E-03 ± 1.7E-02	2.5E-02 ± 1.4E-02	70	24	3.1E-02 ± 1.8E-01	7.3E-01 ± 1.5E-01
	400 <sup>(g)</sup>	1	0	4.7E-03 ± 1.8E-06	4.7E-03 ± 9.5E-03 <sup>(e)</sup>	5	0	2.6E-03 ± 1.6E-03	3.6E-03 ± 7.2E-03 <sup>(e)</sup>
	600	18	9	2.9E-02 ± 6.9E-02	1.4E-01 ± 4.3E-02	82	50	2.3E-01 ± 2.7E+00	1.2E+01 ± 3.1E+00

(a) 1 pCi = 0.037 Bq.

(b) Number of samples with measurable concentrations of contaminant.

(c) Average ± two standard deviations of all samples analyzed.

(d) Maximum ± analytical uncertainty.

(e) Maximum value reported is a non-detect.

(f) Includes one sample collected at the Environmental Restoration Disposal Facility.

(g) Average cannot be calculated from a single sample.

**Table 10.9.4. Radionuclide Concentrations (pCi/g<sup>(a)</sup> dry wt.)<sup>(b)</sup> in Environmental Restoration Contractor Field Remediation Projects' Soil Samples, 2008**

Site	Sample Location <sup>(c)</sup>	Sample Date	Cobalt-60	Strontium-90	Cesium-137	Uranium-234	Uranium-238	Plutonium-239/240
100-B/C	D153	02/15/08	-5.5E-03 ± 8.3E-03	-4.5E-01 ± 4.5E-01	2.9E-01 ± 5.1E-02	1.7E-01 ± 5.9E-02	1.4E-01 ± 5.0E-02	1.2E-02 ± 1.3E-02
	D161	02/15/08	4.4E-03 ± 7.8E-03	3.4E-01 ± 4.1E-01	8.2E-02 ± 1.9E-02	1.7E-01 ± 5.9E-02	1.8E-01 ± 6.1E-02	4.2E-03 ± 1.0E-02
	D165	02/15/08	-6.8E-04 ± 6.8E-03	-3.9E-01 ± 3.9E-01	1.2E-01 ± 2.4E-02	1.3E-01 ± 4.7E-02	1.0E-01 ± 3.8E-02	2.0E-03 ± 9.0E-03
100-D	D147	03/12/08	-2.7E-03 ± 4.6E-03	-1.2E-01 ± 4.0E-01	1.9E-01 ± 3.1E-02	1.6E-01 ± 5.9E-02	1.4E-01 ± 5.3E-02	1.3E-02 ± 1.3E-02
	D171	03/12/08	-3.4E-03 ± 1.1E-02	1.1E-02 ± 1.1E-01	4.4E-01 ± 7.2E-02	1.5E-01 ± 5.6E-02	1.2E-01 ± 4.8E-02	6.4E-03 ± 1.1E-02
	D172	03/12/08	-1.3E-03 ± 8.2E-03	-4.7E-01 ± 4.7E-01	1.4E-01 ± 3.0E-02	1.2E-01 ± 4.6E-02	1.2E-01 ± 4.6E-02	8.3E-03 ± 1.2E-02
	D173	03/12/08	-1.0E-03 ± 5.5E-03	-4.7E-01 ± 4.7E-01	6.3E-02 ± 1.3E-02	1.1E-01 ± 4.4E-02	8.8E-02 ± 3.7E-02	4.2E-03 ± 6.0E-03
100-F	D154	04/10/08	-4.3E-03 ± 9.1E-03	-1.9E-01 ± 3.9E-01	1.3E-01 ± 3.3E-02	3.1E-01 ± 8.1E-02	2.0E-01 ± 5.8E-02	5.6E-03 ± 1.1E-02
	D155	04/10/08	1.3E-02 ± 9.6E-03	-2.8E-01 ± 4.1E-01	3.2E-01 ± 6.1E-02	1.1E-01 ± 3.6E-02	7.0E-02 ± 2.7E-02	8.9E-03 ± 9.7E-03
	D168	04/10/08	-2.5E-03 ± 7.0E-03	-7.6E-01 ± 7.6E-01	6.7E-02 ± 1.9E-02	1.4E-01 ± 4.3E-02	1.1E-01 ± 3.7E-02	2.2E-03 ± 1.5E-02
	D169	04/10/08	-2.7E-03 ± 7.6E-03	1.8E-01 ± 3.9E-01	4.5E-02 ± 1.4E-02	1.0E-01 ± 3.7E-02	8.6E-02 ± 3.3E-02	8.1E-03 ± 1.0E-02
	D170	04/10/08	-1.4E-02 ± 1.4E-02	1.4E-01 ± 4.3E-01	4.8E-02 ± 2.1E-02	1.5E-01 ± 4.7E-02	1.0E-01 ± 3.5E-02	2.4E-03 ± 2.4E-02
100-H	D152	07/14/08	4.4E-03 ± 5.9E-03	-4.6E-01 ± 4.7E-01	3.7E-01 ± 6.1E-02	1.4E-01 ± 4.9E-02	1.2E-01 ± 4.3E-02	1.0E-02 ± 1.2E-02
	D176	05/27/08	6.5E-04 ± 6.5E-03	-6.7E-01 ± 6.7E-01	7.9E-01 ± 1.4E-01	1.2E-01 ± 4.3E-02	1.2E-01 ± 4.4E-02	2.9E-02 ± 2.3E-02
	D177	05/27/08	-2.0E-03 ± 8.3E-03	-9.7E-01 ± 9.7E-01	2.1E-02 ± 1.3E-02	1.2E-01 ± 4.3E-02	9.6E-02 ± 3.6E-02	1.1E-02 ± 1.2E-02
	D178	05/27/08	1.6E-03 ± 7.3E-03	-1.3E+00 ± 1.3E+00	3.8E-02 ± 1.2E-02	1.5E-01 ± 5.1E-02	2.1E-01 ± 6.7E-02	6.0E-03 ± 7.1E-03
600 Area	D174	02/29/08	5.0E-05 ± 5.0E-04	-4.0E-01 ± 4.0E-01	3.6E-02 ± 1.6E-02	2.6E-01 ± 8.3E-02	2.0E-01 ± 6.8E-02	8.5E-03 ± 8.8E-03
	D174	03/28/08	-5.7E-03 ± 7.9E-03	-5.0E-01 ± 5.0E-01	1.5E-02 ± 1.2E-02	2.7E-01 ± 8.9E-02	2.6E-01 ± 8.8E-02	1.0E-02 ± 1.0E-02
	D174	04/30/08	-1.3E+00 ± 4.1E+00	-9.5E-02 ± 4.3E-01	9.4E+01 ± 1.7E+01	2.7E-01 ± 8.6E-02	2.4E-01 ± 7.9E-02	8.7E-03 ± 1.1E-02
ERDF	D146	05/28/08	3.8E-03 ± 8.1E-03	-6.3E-01 ± 6.3E-01	8.3E-03 ± 9.8E-03	1.3E-01 ± 4.7E-02	1.7E-01 ± 5.8E-02	8.3E-03 ± 1.0E-02
Accessible soil concentration <sup>(d)</sup>			7.1	2,800	30	630	370	190

(a) 1 pCi = 0.037 Bq.

(b) ± total analytical uncertainty.

(c) Sampling location code. See PNNL-18427, APP. 2.

(d) Hanford Site soil that is not behind security fences.

ERDF = Environmental Restoration Disposal Facility (200-West Area).

**Table 10.9.5. Number and Locations of Soil Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 2008**

<u>Locations</u>	<u>Number of Incidents</u>
200-East Area	
Tank farms	5
Burial grounds	1
Cribs, ponds, and ditches	0
Fence lines	0
Roads and railroads	0
Unplanned release sites	0
Underground pipelines	1
Miscellaneous	1
200-West Area	
Tank farms	4
Burial grounds	2
Cribs, ponds, and ditches	0
Fence lines	0
Roads and railroads	0
Unplanned release sites	1
Underground pipelines	1
Miscellaneous	0
Cross-site transfer line	0
200-BC cribs and trenches	0
200-North Area	0
100 Areas	0
300 Area	0
400 Area	0
600 Area	0
Former 1100 Area	0
<b>Total</b>	<b>16</b>

## Soil Sampling at Hanford Site-Wide and Offsite Locations

Soil samples were collected at 41 locations on and around the Hanford Site during 2008 (Figure 10.9.2). Samples were organized into three distinct groups: 1) site-wide (onsite), 2) perimeter, and 3) distant. Site-wide samples were collected at undisturbed locations around areas of industrial development on the site. Perimeter samples were collected on the edge of the Hanford Site and at locations in Franklin County. Distant samples were collected at George, McNary Dam, Othello, Sunnyside, Toppenish, Walla Walla, Wanapum, and Washtucna, Washington.

Each soil sample consisted of five plugs, each 2.54 centimeters (1 inch) deep and 10.2 centimeters (4 inches) in diameter, collected within 10 meters (33 feet) of one another, which were combined to form one bulk sample. Samples

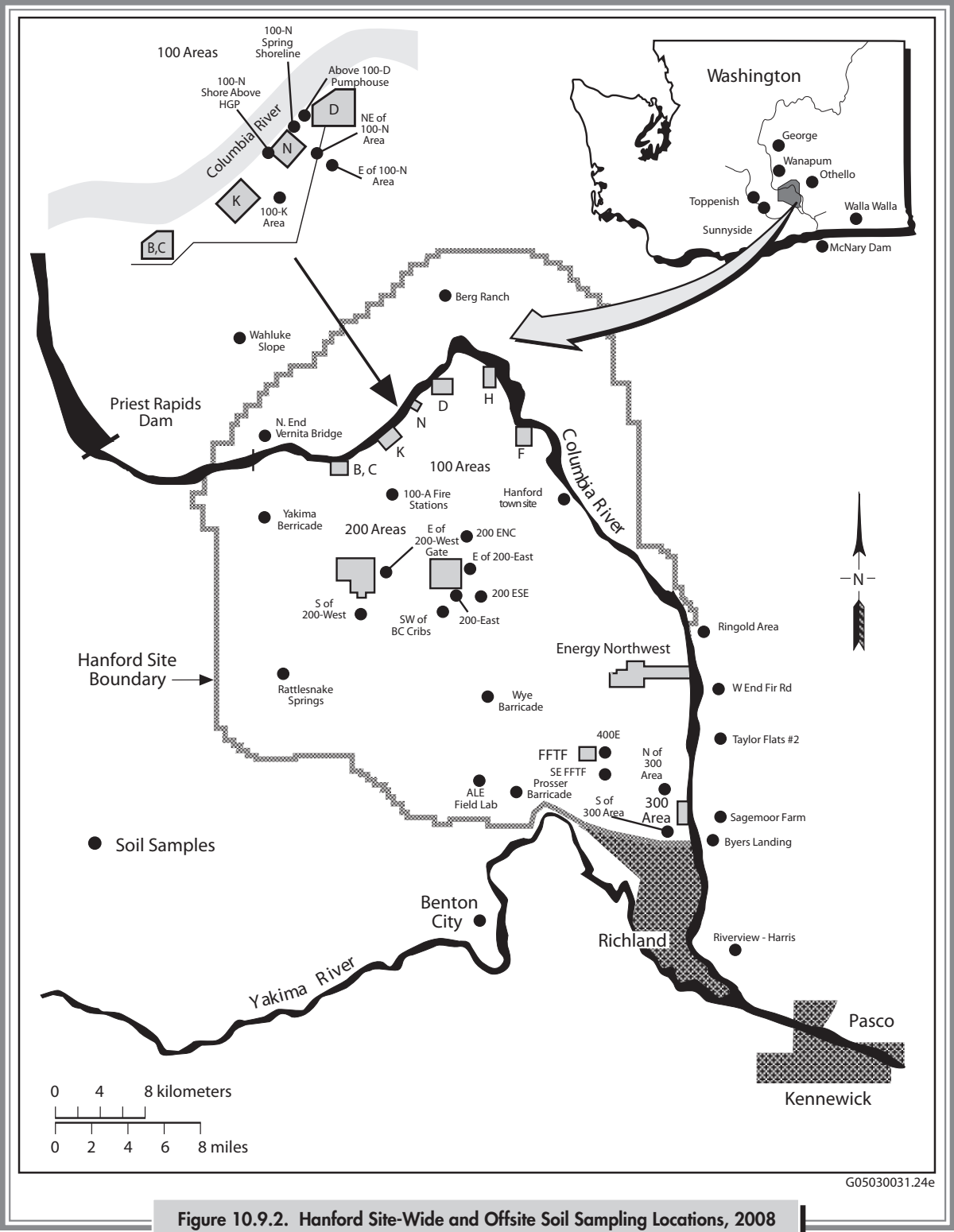
**Table 10.9.6. Annual Number of Soil Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 1997 Through 2008**

<u>Year</u>	<u>Number of Incidents</u>	<u>Year</u>	<u>Number of Incidents</u>
1997	51	2003	30
1998	41	2004	19
1999	42	2005	20
2000	25	2006	25
2001	20	2007	17
2002	22	2008	16

were collected from undisturbed areas to monitor materials deposited on the soil surface. Samples were dried and sieved at a laboratory before analysis to remove residual moisture, rocks, and plant debris.

All samples were analyzed for gamma-emitting radionuclides (Appendix F, Table F.1), strontium-90, uranium-234, uranium-235, uranium-238, plutonium-238, and plutonium-239/240. Selected samples were analyzed for americium-241. Additionally, all samples collected in 2008 were also analyzed for metals using inductively coupled plasma-mass spectroscopy and for mercury using cold vapor atomic absorption. The 2008 radiological analytical results were compared to results from 1998, 2001, and 2004 (Table 10.9.7). Metals data are provided here at a summary level; a future report will provide a more detailed interpretation of the metals results for samples collected in 2008.

In 2008, observed mean radionuclide activities in soil samples for all isotopes in all location groups were generally similar to their respective averages from 1998, 2001, and 2004 (Table 10.9.7). Uranium-238 concentrations appeared, on average, to be slightly higher in 2008 than in previous years. Also, the maximum detectable concentrations for each radionuclide in each group were similar to the maximum concentrations observed in 1998, 2001, and 2004. This indicates there has been no appreciable increase in radionuclide concentrations in soil in the last several years. The Hanford Site-wide average soil concentrations in 2008 were higher than at site perimeter or distant locations for the radionuclides measured (Table 10.9.7). This was consistent with historical data and reflected the higher site-wide soil concentrations associated with years of



**Table 10.9.7. Concentrations of Selected Radionuclides (pCi/g dry wt.)<sup>(a)</sup> in Hanford Site Soil Samples Collected Site-Wide and Offsite, 2008 Compared to Previous Years**

Location	Radionuclide	2008				1998, 2001, and 2004			
		No. of Samples	No. Detected <sup>(b)</sup>	Mean <sup>(c)</sup>	Maximum <sup>(d)</sup>	No. of Samples	No. Detected <sup>(b)</sup>	Mean <sup>(c)</sup>	Maximum <sup>(d)</sup>
Site-Wide (Onsite)	Strontium-90	19	9	0.057 ± 0.13	0.25 ± 0.062	53	36	0.14 ± 0.83	3.1 ± 0.70
	Cesium-137	19	19	0.79 ± 4.3	9.7 ± 1.1	53	50	0.55 ± 3.2	12 ± 1.4
	Plutonium-238	19	8	4.8E-04 ± 1.2E-03	2.8E-03 ± 7.0E-04	53	30	6.9E-04 ± 3.2E-03	8.1E-03 ± 1.3E-03
	Uranium-238	19	19	0.48 ± 0.17	0.66 ± 0.13	53	48	0.15 ± 0.16	0.57 ± 0.11
	Plutonium-239/240	19	19	0.025 ± 0.13	0.29 ± 0.028	53	49	0.034 ± 0.20	0.53 ± 0.058
	Americium-241	3	1	0.018 ± 0.048	0.046 ± 0.017	10	7	0.040 ± 0.15	0.24 ± 0.14
Perimeter	Strontium-90	13	1	0.018 ± 0.025	0.054 ± 0.026	30	16	0.038 ± 0.069	0.11 ± 0.041
	Cesium-137	13	13	0.12 ± 0.16	0.31 ± 0.031	30	29	0.19 ± 0.25	0.48 ± 0.064
	Plutonium-238	13	1	1.6E-04 ± 2.5E-04	4.6E-04 ± 2.6E-04	30	14	3.3E-04 ± 9.3E-04	1.9E-03 ± 2.2E-03
	Uranium-238	13	13	0.57 ± 0.51	1.3 ± 0.17	30	27	0.18 ± 0.29	0.81 ± 0.18
	Plutonium-239/240	13	13	4.3E-03 ± 5.4E-03	0.010 ± 1.3E-03	30	24	6.9E-03 ± 0.013	0.030 ± 4.4E-03
	Americium-241	1	0		6.8E-03 ± 8.0E-03	3	1	8.7E-04 ± 3.7E-03	3.0E-03 ± 1.5E-03
Distant	Strontium-90	9	1	0.013 ± 0.043	0.063 ± 0.025	16	6	0.041 ± 0.081	0.14 ± 0.046
	Cesium-137	9	7	0.15 ± 0.35	0.48 ± 0.031	16	14	0.14 ± 0.25	0.39 ± 0.053
	Plutonium-238	9	5	2.2E-04 ± 4.8E-04	7.0E-04 ± 2.8E-04	16	6	2.7E-04 ± 2.0E-03	2.9E-03 ± 2.4E-03
	Uranium-238	9	9	0.57 ± 0.15	0.71 ± 0.097	16	14	0.15 ± 0.14	0.34 ± 0.12
	Plutonium-239/240	9	9	4.3E-03 ± 5.4E-03	0.016 ± 2.0E-03	16	11	4.8E-03 ± 9.0E-03	0.014 ± 2.2E-03
	Americium-241	1	0		7.9E-03 ± 8.1E-03	3	3	4.1E-03 ± 7.6E-04	4.3E-03 ± 1.8E-03

(a) 1 pCi = 0.037 Bq.

(b) Detection is defined as a value reported above the minimum detectable activity or above the total analytical uncertainty.

(c) Reported mean values ± 2 standard deviations.

(d) Reported maximum values ± the total analytical uncertainty.

nuclear materials production. The sampling location “east of the 200-West Area gate” had the highest observed activities of any sampling location. This was also consistent with historical results.

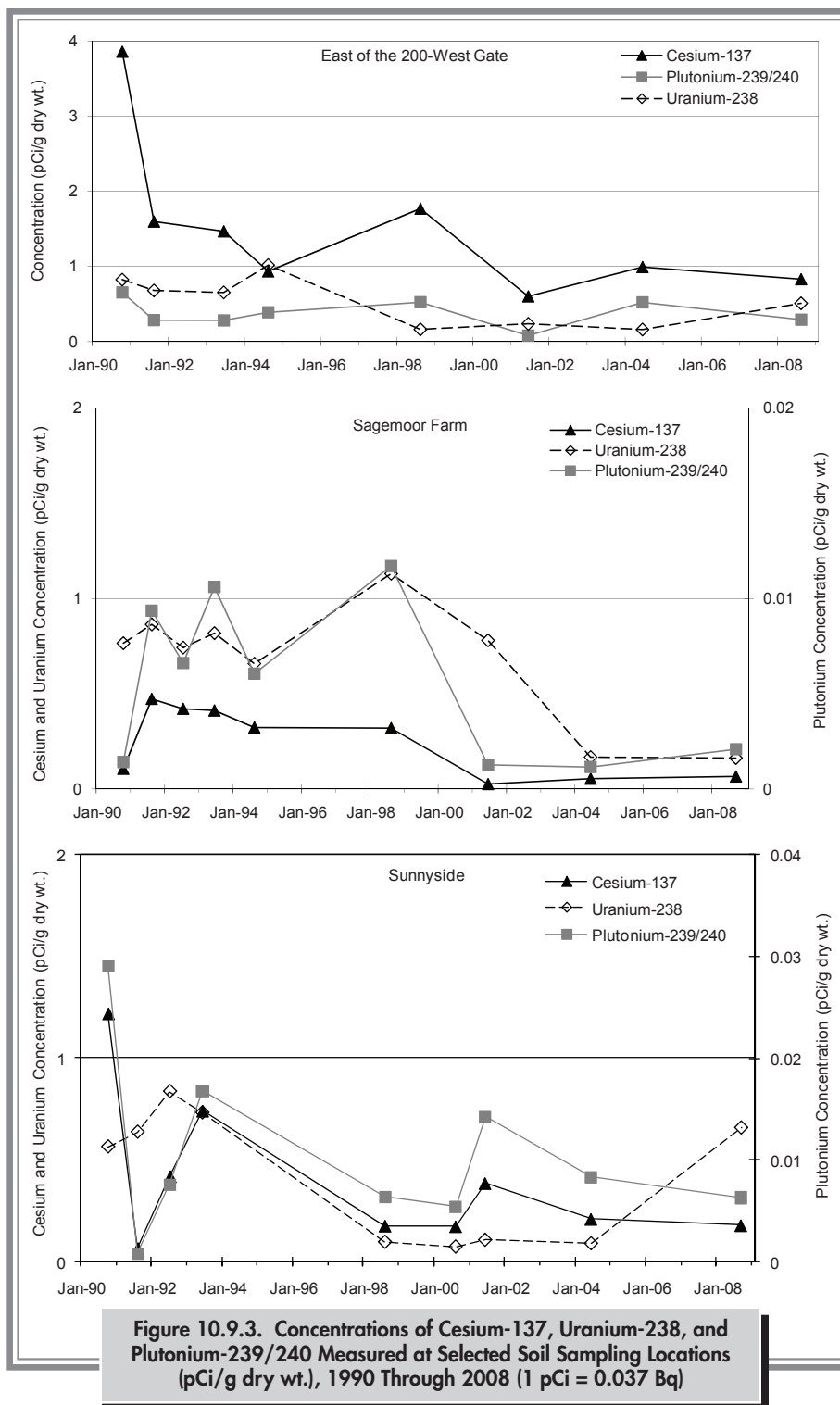
Cesium-137 and plutonium-239/240 were detected in most soil samples collected on and around the Hanford Site. The site-wide average concentration of each isotope is higher by a statistically significant amount than the average concentrations at perimeter and distant locations (two-tailed t-test, 95% confidence interval). However, for plutonium-239/240, if the result from the “east of the 200-West Area gate” sampling location is excluded, the difference between site-wide and distant concentrations is not a statistically significant difference (although the site-wide average is still higher).

In 2008, a new analytical laboratory was used for sample analysis. To evaluate the capability of the new laboratory to replicate previous results, data trends were evaluated at several sampling locations, and several results from the 2008 sampling effort were compared to analytical results from sampling conducted on the Hanford Reach National Monument in 2004 and 2005 (PNNL-14937; PNNL-16883, respectively). Historical trends for cesium-137, uranium-238,

and plutonium-239/240 at the “east of the 200-West Area gate,” Sagemoor Farm, and Sunnyside sampling locations illustrate that there did not appear to be any systematic differences in the analytical results provided by the new laboratory (Figure 10.9.3). Similarly, the concentrations of cesium-137, uranium-238, and plutonium-239/240 measured in samples collected from Berg Ranch, North end Vernita Bridge, Rattlesnake Springs, and the Fitzner/Eberhardt Arid Lands Ecology Reserve field laboratory were generally consistent with the average of concentrations measured at nearby sampling locations in 2004 and 2005 (Table 10.9.8).

Metals historically have not been analyzed in samples collected on and around the Hanford Site. There were no metals with measured concentrations onsite that were at a statistically significant higher concentration than perimeter or distant locations (Table 10.9.9). For a number of metals, the perimeter and distant concentrations were higher than the concentrations measured onsite, but not at statistically significant levels. Typically, concentrations of metals measured in samples collected in 2008 were consistent across the entire Columbia Basin, with no Hanford Site source signature. A more comprehensive evaluation of metals concentrations in Hanford Site soils can be found in PNNL-18577.





**Table 10.9.8. Comparison of Selected Radionuclide Concentrations Measured on the Hanford Site Perimeter in 2008 to Concentrations Measured Near Those Locations in 2004 and 2005**

<u>Sampling Locations</u>	<u>Cesium-137</u>	<u>Plutonium-239/240</u>	<u>Uranium-238</u>
Berg Ranch <sup>(a)</sup>	0.20	0.0064	0.51
Hanford Reach National Monument average <sup>(b)</sup>	0.15	0.0056	0.10
Rattlesnake Springs <sup>(a)</sup>	0.16	0.0057	0.48
Fitzner/Eberhardt Arid Lands Ecology Reserve average <sup>(c)</sup>	0.19	0.0076	0.13
North end of Vernita Bridge <sup>(a)</sup>	0.17	0.0059	0.45
Hanford Reach National Monument average <sup>(d)</sup>	0.12	0.0045	0.48

(a) 2008 sample result.

(b) Average of three 2005 samples closest to Berg Ranch (PNNL-16883).

(c) Average of four 2004 samples closest to Rattlesnake Springs (PNNL-14937).

(d) Average of four 2005 samples closest to north end of Vernita Bridge (PNNL-16883).

**Table 10.9.9. Concentrations of Selected Metals Analyzed in Samples Collected in 2008**

<u>Location</u>	<u>Metal</u>	<u>Concentration</u>	<u>No. of Samples</u>	<u>Maximum</u>	<u>Average</u>	<u>2 SD</u>
Distant	Arsenic	µg/kg	9	4,650	2,894	1,904
	Beryllium	µg/kg	9	504	349	182
	Calcium	g/kg	9	53	14	32
	Lead	g/kg	9	0.020	0.012	0.0093
	Mercury	µg/kg	9	20	8	11
	Potassium	g/kg	9	2.7	2.1	0.79
	Sodium	g/kg	9	0.75	0.40	0.30
	Uranium	µg/kg	9	890	577	268
Onsite	Arsenic	µg/kg	19	3,160	2,271	907
	Beryllium	µg/kg	19	410	319	78
	Calcium	g/kg	19	5	4	1
	Lead	g/kg	19	0.022	0.0084	0.0082
	Mercury	µg/kg	19	10	5	4
	Potassium	g/kg	19	2.7	2.0	0.74
	Sodium	g/kg	19	0.59	0.43	0.19
	Uranium	µg/kg	19	2,600	741	997
Perimeter	Arsenic	µg/kg	13	6,930	3,220	2,793
	Beryllium	µg/kg	13	1,050	423	532
	Calcium	g/kg	13	19	6	8
	Lead	g/kg	13	0.0147	0.0095	0.0067
	Mercury	µg/kg	13	29	7	15
	Potassium	g/kg	13	3.6	2.0	1.4
	Sodium	g/kg	13	6.81	0.81	3.6
	Uranium	µg/kg	13	2,710	873	1,409

SD = Standard deviation.



## 10.10 Vegetation Monitoring

Vegetation monitoring and control activities conducted on and around the Hanford Site in 2008 are summarized in the following sections. Included are discussions on surveys and monitoring of Hanford Site plant populations, monitoring contaminants in perennial vegetation growing near facilities and operations, and control of contaminated or unwanted vegetation.

Plant populations and habitats that occur on the Hanford Site are surveyed and monitored to assess the abundance, vigor or condition, and distribution of populations and species. These data can be integrated with contaminant monitoring results and used to help characterize potential risks or impacts to biota. Vegetation near onsite facilities and operations is monitored for radiation to determine the effectiveness of effluent monitoring and controls within facilities, assess the adequacy of containment at waste disposal sites, and detect and monitor unusual conditions. Site-wide and offsite vegetation samples are analyzed for information on atmospheric deposition of contaminants in uncultivated areas offsite and around operational areas onsite. These data provide a baseline against which unplanned releases can be compared. Vegetation management activities help prevent, limit, or clean up contaminated plants or undesirable plant species. For further information about these monitoring and control efforts, the programs that support them, and their purposes, see Section 10.0 in this report or DOE/RL-91-50, Rev. 4.

### 10.10.1 Plant Communities and Population Surveys on the Hanford Site

JL Downs, MR Sackschewsky, and  
MA Chamness

The Hanford Site contains biologically diverse shrub-steppe plant communities that have been protected from most disturbances, except for fire, for more than 55 years. This protection has allowed plant species and communities that have been displaced by agriculture and development in other parts of the Columbia Basin to thrive on the Hanford Site. Surveys and mapping efforts have documented the occurrence and extent of rare plant populations and plant community types on the Hanford Site (PNL-8942; PNNL-13688; Soll et al. 1999). Plant populations monitored on the Hanford Site include taxa listed by Washington State as endangered, threatened, or sensitive (Section 10.11) and those species listed as review group 1 (i.e., taxa in need of additional field work before status can be determined) (WNHP 2008). Data are collected for plant populations and plant communities to develop baseline information, and to monitor any changes resulting from Hanford Site operations. These data provide information for site-planning processes and land-use policy development.

#### 10.10.1.1 Vegetation Cover Types and Habitats

Monitoring plant communities and vegetation cover types on the Hanford Site is focused on two main objectives: 1) mapping the distribution and extent of major plant



cover types on uplands and riparian areas at the site, and 2) conducting periodic surveys to assess whether community composition and structure are changing and understanding underlying causes of change.

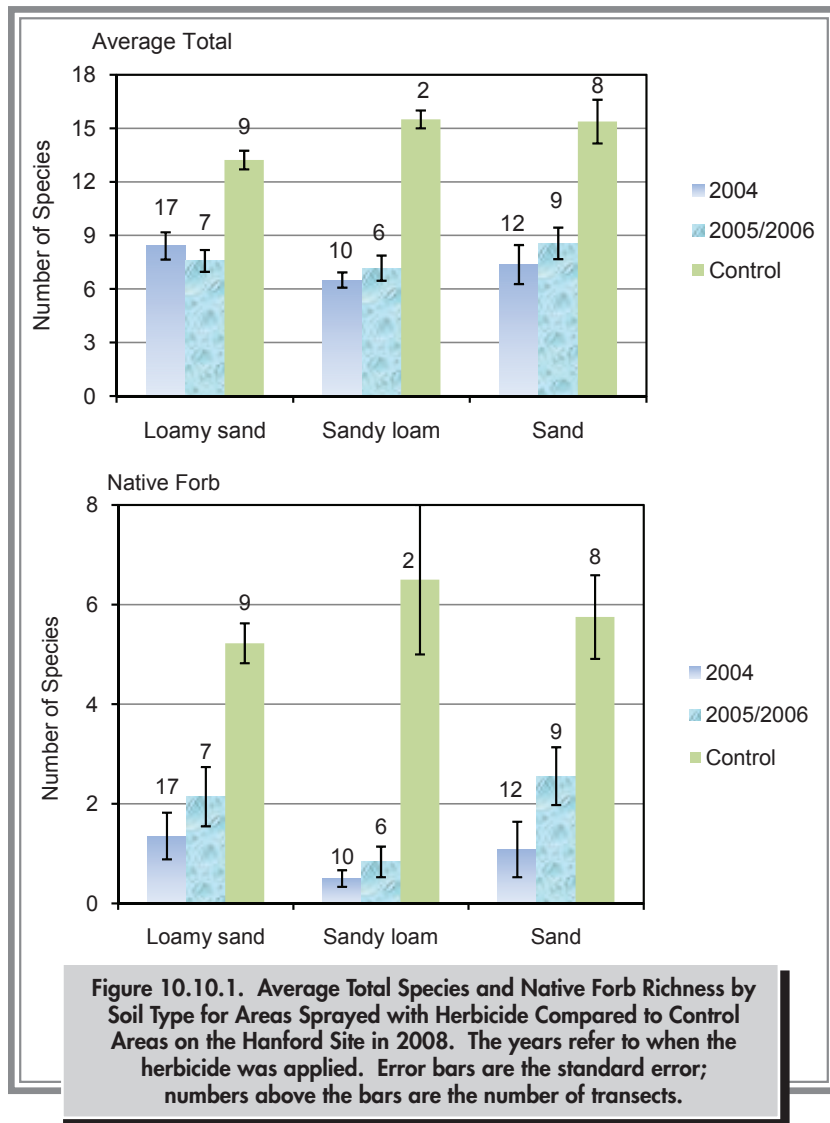
Mapping the distribution and extent of vegetation on the site provides important information on potential and existing habitats of sensitive or rare species as well as information regarding the presence of potential receptor species. Work conducted during 2008 focused on collecting data and mapping changes in habitats and vegetation associations as a result of past wildfires and land management

activities. Evaluations of satellite imagery of the Hanford Site following the 2007 Wautoma fire revealed significant changes in site vegetation in areas where herbicides were used to control noxious weeds. Herbicides are routinely used to control weeds and vegetation along roadways and on waste sites on the site (Section 10.10.4.2). When noxious weeds invade native plant communities, herbicide applications may be used across larger land areas to attempt to control or halt the invasion.

Vegetation monitoring surveys were conducted in the spring and summer of 2008 to provide information on the condition

and status of Hanford Site lands that have been aerially sprayed with herbicides to control noxious weeds. Monitoring transects were established within land areas that had been previously sprayed with herbicide and in unsprayed areas with soils and vegetation similar to that in sprayed areas. These transects were surveyed during May, June, and early July 2008 to assess canopy cover, species diversity, and frequency of occurrence of native and invasive plants. Preliminary results indicate that both total species richness and native forb richness (i.e., the number of species) are lower in areas that have been subject to aerial applications of the herbicide Tordon<sup>®(a)</sup> than in adjacent vegetation associations on the same soil types (Figure 10.10.1). These results suggest that further investigation of the impacts of herbicide on native plant communities is warranted; monitoring will continue in 2009.

Numerous activities associated with cleanup, including excavation, remediation, and restoration, have influenced vegetation cover inside the Hanford Site areas and at fenced boundaries. Information from ground-based surveys is used to update maps depicting areas with highly valued biological resources (<http://www.pnl.gov.ecomon/Veg/Veg.html>).



(a) Tordon is a registered trademark of Dow AgroSciences, LLC, Indianapolis, Indiana.

Periodic surveys of the frequency, cover, and number of species found on permanent monitoring plots provide information on trends or changes in species diversity, the presence of invasive and key species, and the overall condition of the plant community and available habitat (PNNL-16623).

### 10.10.1.2 Rare Plant Monitoring

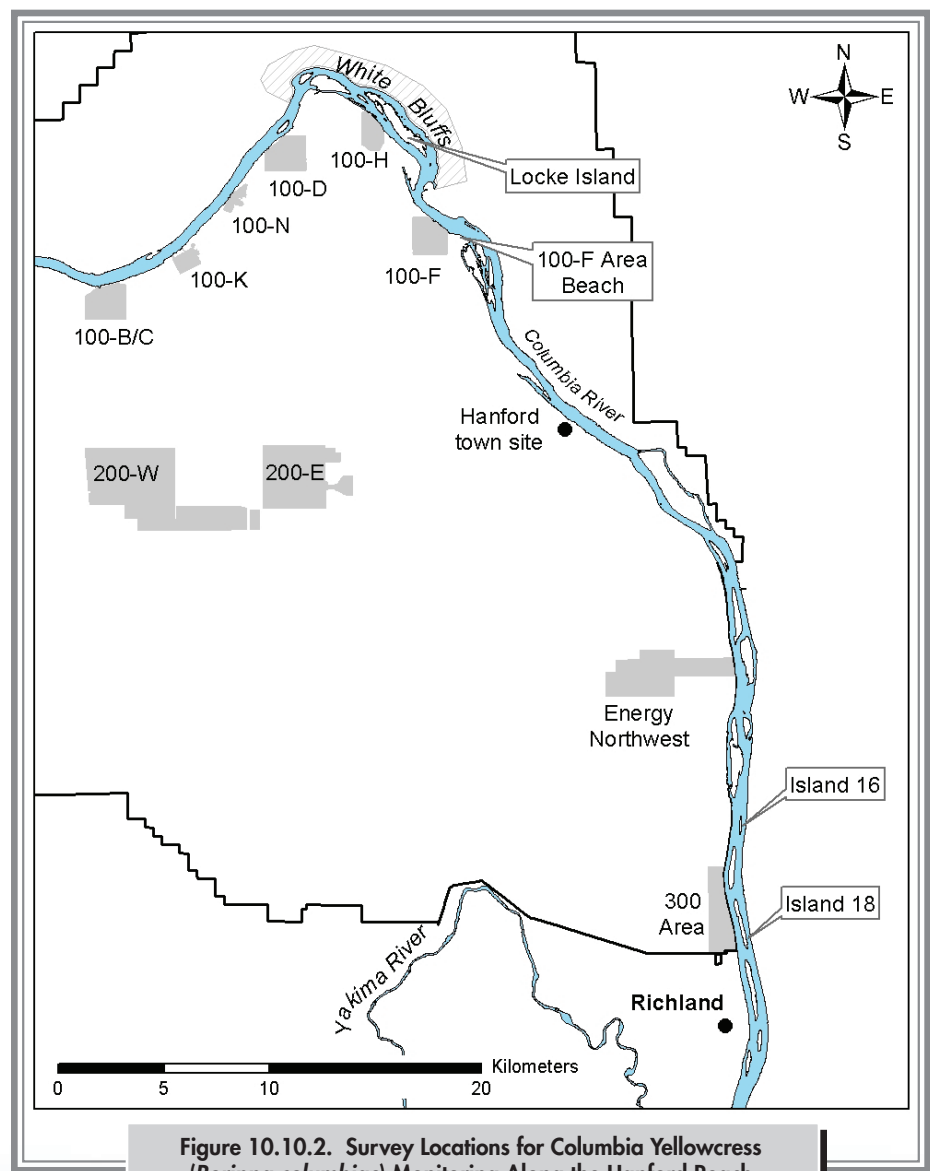
More than 100 plant populations of 53 different taxa listed by the Washington Natural Heritage program as endangered, threatened, sensitive, or on the review or watch list are found on the Hanford Site (PNNL-13688; <http://www.pnl.gov/ecomon/Veg/Habitat.html>).

The U.S. Fish and Wildlife Service has designated 4 of these 53 taxa as species of concern in the Columbia River Basin ecoregion: Columbia milkvetch (*Astragalus columbianus*), gray cryptantha (*Cryptantha leucophaea*), Hoover's desert parsley (*Lomatium tuberosum*), and Columbia yellowcress (*Rorippa columbiae*). Two species, Umtanum desert buckwheat (*Eriogonum codium*) and White Bluffs bladderpod (*Physaria douglasii* ssp. *tuplashensis*), are candidates for federal listing as endangered and threatened, respectively (<http://www1.dnr.wa.gov/nhp/refdesk/lists/planttrnk.html>). In addition, several areas on the Hanford Site are designated as special habitats with regard to potential occurrence of plant species of concern listed by Washington State. These areas potentially support populations of rare annual forbs that have been documented in adjacent habitats.

During May 2008, surveys for plant species of concern were conducted as part of annual compliance review activities. The Washington State

Natural Heritage Program also collected information on seedlings and individual Umtanum desert buckwheat plants on Umtanum Ridge.

Surveys for Columbia yellowcress were conducted during 2008 along the Columbia River shoreline and islands in the downstream section of the Hanford Reach (Figure 10.10.2). Data collected during previous years indicate the cobble habitats that supported Columbia yellowcress in the previous decade located on islands in the downstream portion of the Hanford Reach (such as Island 18 near the 300 Area) may now be inundated with silts. However, data collected in 2008 indicate a significant increase in the



**Table 10.10.1. Numbers of Columbia Yellowcress (*Rorippa columbiae*) Stems Counted Along the Hanford Reach of the Columbia River in Surveys Conducted from 1994 Through 2008**

Year	Survey Location		
	<u>100-F Beach</u>	<u>Locke Island</u>	<u>Island 18<sup>(a)</sup></u>
1994	>15,000	>10,000	>10,000
1995	70	117	0
1999	94	Not surveyed <sup>(b)</sup>	Not surveyed <sup>(b)</sup>
2000	196	1,038	19
2001	17	1,793	0
2004	Not surveyed <sup>(b)</sup>	1,800	Not surveyed <sup>(b)</sup>
2005	130	Not surveyed <sup>(b)</sup>	Not surveyed <sup>(b)</sup>
2006	639	2,220	0
2007	Not surveyed <sup>(b)</sup>	Not surveyed <sup>(b)</sup>	Not surveyed <sup>(b)</sup>
2008	1007	4,265	Not surveyed <sup>(b)</sup>

(a) Located in the Columbia River near the 300 Area.

(b) High water levels prevented access to populations.

numbers of Columbia yellowcress stems (Table 10.10.1). Data describing trends in plant numbers and the timing of growth for this species are of interest because large variations in population numbers have been observed. These variations are believed to be related to river-level fluctuations that inundate habitat for this species during a large part of the growing season.

## 10.10.2 Vegetation Monitoring Near Hanford Site Facilities and Operations

JW Wilde

Vegetation samples were collected on or adjacent to waste disposal sites and from locations downwind and near or within the boundaries of operating facilities and remedial action sites. Samples were collected to evaluate long-term trends

in environmental accumulation and potential migration of radioactive material. Contamination in vegetation can occur as the result of surface deposition of radioactive materials from other radiologically contaminated sources or by absorption of radionuclides by the roots of vegetation growing on or near former waste disposal sites.

Table 10.10.2 summarizes the number and location of vegetation samples collected near facilities and operations during 2008. Only those radionuclides with concentrations consistently above analytical detection limits are discussed in this section. A comprehensive presentation of the analytical data from these samples can be found in PNNL-18427, APP. 2.

### 10.10.2.1 Vegetation Sampling Near Hanford Site Facilities and Operations

Each sample (approximately 500 grams [17.6 ounces]) consisted of new-growth leaf cuttings taken from the available brushy, deep-rooted species (e.g., sagebrush and/or rabbit-brush) at a sampling location. Often, the sample consisted of a composite of several similar members of the sampling-site plant community to avoid decimation of any individual plant through overharvesting. Vegetation samples were dried before analysis, and analytical results were reported on a dry weight basis.

Samples were analyzed for the radionuclides expected to occur in the areas sampled (i.e., gamma-emitting radionuclides [cobalt-60 and cesium-137], strontium-90, uranium isotopes, and/or plutonium isotopes). Selected analytical results were compared to concentrations in samples collected during 2004 by Pacific Northwest National Laboratory personnel at offsite sampling locations in Yakima,

**Table 10.10.2. Number and Locations of Vegetation Samples Collected Near Hanford Site Facilities and Operations in 2008**

Number of Samples	Operational Area					
	<u>100-N</u>	<u>200-East</u>	<u>200-West<sup>(a)</sup></u>	<u>300<sup>(a)</sup></u>	<u>400</u>	<u>600<sup>(a)</sup></u>
71	3	12	25	15	1	15

(a) Number of samples includes one or more replicate samples.

Benton, and Franklin Counties (PNNL-15222). Comparisons can be used to determine the differences between contributions from site operations and remedial action sites and contributions from natural sources and worldwide fallout.

### 10.10.2.2 Analytical Results for Vegetation Samples Collected Near Hanford Site Facilities and Operations

Some degree of variability is always associated with collecting and analyzing environmental samples. Therefore, variations in sample concentrations from year to year are expected. In general, radionuclide concentrations in vegetation samples collected from, or adjacent to, waste disposal facilities in 2008 were higher than concentrations in samples collected farther away, including concentrations measured offsite. Generally, the predominant radionuclides were activation and fission products in the 100 Areas, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas.

Uranium was detected consistently, and strontium-90, cesium-137, plutonium-238, and plutonium-239/240 were detected occasionally in samples collected in 2008. Concentrations of these radionuclides were elevated near and within facility boundaries compared to historic concentrations measured at distant communities. Figure 10.10.3 shows the average concentrations of selected radionuclides in vegetation samples collected near Hanford Site facilities and operations during 2008 and the preceding 4 years, as well as results from 2004 at distant communities. The results demonstrate a high degree of variability in concentrations.

Table 10.10.3 summarizes selected radionuclides detected in vegetation samples collected and analyzed in 2008 and in previous years. The average and maximum results are reported for the six primary waste facility/operational areas of interest, along with comparative data for the preceding 5 years. A complete list of radionuclide concentrations observed in 2008, as well as sampling location maps, are provided in PNNL-18427, APP. 2.

Vegetation samples collected in 2008 at locations in the 100-N, 200-East, 200-West, 400, and 600 Areas were comparable to those collected in previous years. Vegetation samples collected in the 300 Area showed concentrations of uranium-234 and uranium-238 that were somewhat lower than historical data and higher than those measured

in the 100 and 200 Areas. The higher uranium levels in the 300 Area were expected because of uranium releases to the environment during past fuel fabrication operations in the 300 Area. Plutonium-238 and plutonium-239/240 were found at higher concentration levels in a small number of vegetation samples in the 200-West, 600, and 300 Areas. These higher levels may be a result of facility operations or a change in laboratory analytical techniques.

### 10.10.2.3 Investigations of Radioactive Contamination in Vegetation Near Hanford Site Facilities and Operations

SM McKinney and RC Roos

Investigations for radioactive contamination in vegetation were conducted in and near operational areas to monitor the presence or movement of radioactive materials around areas of known or suspected contamination, or to verify radiological conditions at specific project sites. All samples collected during investigations were field-surveyed for alpha and beta/gamma radiation.

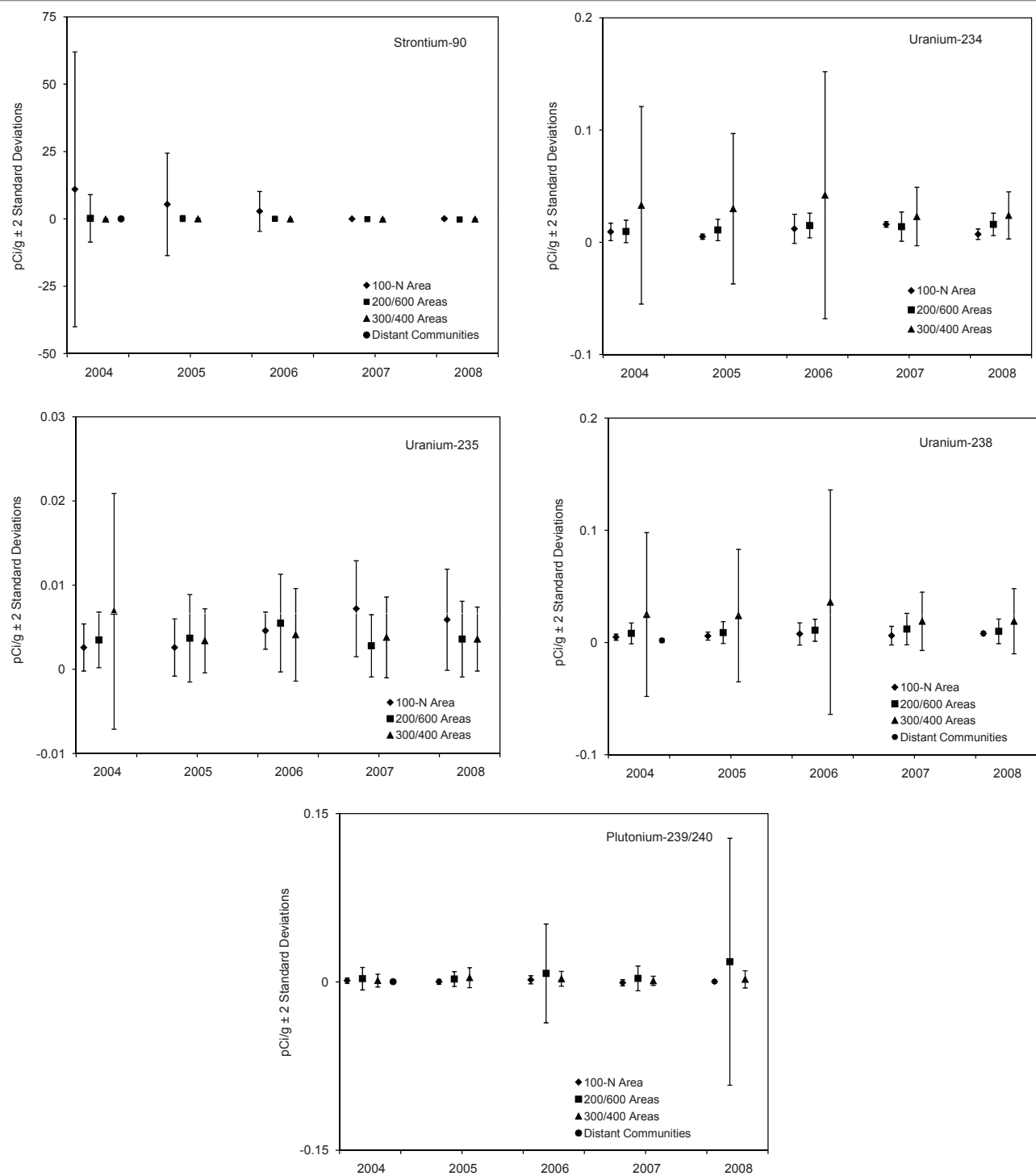
During 2008, radiological contamination was found in 127 vegetation samples collected during investigations. One hundred and twenty-five of the samples were tumbleweeds (Russian thistle) or tumbleweed fragments, and two samples were grasses. None of the samples was analyzed for specific radionuclides, and all were disposed of at a licensed facility.

Table 10.10.4 summarizes the number and general locations of vegetation contamination incidents investigated during 2008. Table 10.10.5 provides the numbers of contamination incidents investigated in 2008 and during the previous 10 years. Section 10.10.4 provides a discussion of vegetation control efforts on the Hanford Site during 2008.

## 10.10.3 Vegetation Monitoring at Hanford Site-Wide and Offsite Locations

BG Fritz

Monitoring of rabbitbrush and sagebrush leaves and stems provides information on atmospheric deposition of radioactive materials in uncultivated areas and at site-wide



**Figure 10.10.3. Average Concentrations of Selected Radionuclides in Vegetation Samples Collected Near Hanford Site Facilities and Operations Compared to Those Collected in Distant Communities, 2004 Through 2008. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.**

**Table 10.10.3. Concentrations of Selected Radionuclides (pCi/g dry wt.)<sup>(a)</sup> in Near-Facility Vegetation Samples, 2008 Compared to Previous Years**

Radionuclide	Hanford Site Area	2008				2003-2007			
		Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>
		Samples	Detections <sup>(b)</sup>			Samples	Detections <sup>(b)</sup>		
Cobalt-60	100-N	3	0	-3.9E-03 ± 6.8E-02	3.0E-02 ± 3.6E-02 <sup>(e)</sup>	21	2	2.1E-02 ± 1.2E-01	1.8E-01 ± 4.6E-02
	200-East	12	0	-3.0E-03 ± 6.8E-02	5.2E-02 ± 7.4E-02 <sup>(e)</sup>	45	0	-4.0E-03 ± 6.0E-02	3.6E-02 ± 2.2E-01 <sup>(e)</sup>
	200-West	25	0	-8.2E-03 ± 7.2E-02	1.1E-01 ± 9.5E-02 <sup>(e)</sup>	114	0	8.1E-03 ± 1.5E-01	7.2E-01 ± 3.1E+00 <sup>(e)</sup>
	300	15	0	-2.1E-02 ± 8.8E-02	7.5E-02 ± 5.8E-02 <sup>(e)</sup>	67	0	-1.5E-02 ± 1.5E-01	4.1E-02 ± 4.4E-02 <sup>(e)</sup>
	400	1	0	4.90E-03	4.9E-03 ± 4.0E-02 <sup>(e)</sup>	4	0	3.4E-03 ± 2.4E-02	2.1E-02 ± 3.6E-02 <sup>(e)</sup>
	600	15	0	-4.2E-03 ± 5.7E-02	5.3E-02 ± 1.0E-01 <sup>(e)</sup>	78	0	-2.5E-03 ± 1.0E-01	9.5E-02 ± 7.7E-02 <sup>(e)</sup>
Strontium-90	100-N	3	1	6.8E-02 ± 5.1E-01	4.1E-01 ± 2.3E-01	21	8	7.4E+00 ± 3.6E+01	6.8E+01 ± 8.2E+00
	200-East	12	2	-4.0E-02 ± 5.5E-01	6.5E-01 ± 2.6E-01	45	12	4.4E-01 ± 3.7E+00	1.2E+01 ± 1.8E+00
	200-West	25	0	-2.9E-01 ± 9.3E-01	1.2E-01 ± 2.5E-01 <sup>(e)</sup>	114	24	4.9E-01 ± 8.6E+00	2.5E+01 ± 3.8E+00
	300	15	0	-1.1E-01 ± 2.1E-01	1.7E-01 ± 2.0E-01 <sup>(e)</sup>	67	0	-8.0E-02 ± 2.3E-01	1.7E-01 ± 1.5E-01 <sup>(e)</sup>
	400	1	0	1.0E-02 ± 2.8E-06	1.0E-02 ± 1.0E-01 <sup>(e)</sup>	4	0	5.5E-02 ± 2.2E-01	1.7E-01 ± 1.4E-01 <sup>(e)</sup>
	600	15	0	-9.2E-02 ± 4.7E-01	1.6E-01 ± 2.9E-01 <sup>(e)</sup>	78	12	1.7E-01 ± 1.4E+00	4.8E+00 ± 7.2E-01
Cesium-137	100-N	3	0	-2.0E-02 ± 3.6E-02	-7.1E-03 ± 4.2E-02 <sup>(e)</sup>	21	2	3.9E-02 ± 2.3E-01	5.1E-01 ± 1.3E-01
	200-East	12	2	2.6E-02 ± 9.5E-02	1.2E-01 ± 1.1E-01	45	13	4.9E-02 ± 1.9E-01	3.3E-01 ± 9.6E-02
	200-West	25	8	6.2E-02 ± 1.4E-01	2.2E-01 ± 1.1E-01	114	20	1.3E-01 ± 1.3E+00	6.0E+00 ± 4.3E+00
	300	15	0	1.3E-02 ± 5.2E-02	6.3E-02 ± 6.3E-02 <sup>(e)</sup>	67	0	-2.6E-02 ± 2.8E-01	7.2E-02 ± 8.5E-02 <sup>(e)</sup>
	400	1	0	5.80E-04	5.8E-04 ± 5.8E-03 <sup>(e)</sup>	4	0	-2.5E-02 ± 3.6E-02	-5.8E-03 ± 2.9E-02 <sup>(e)</sup>
	600	15	2	3.6E-02 ± 1.4E-01	1.8E-01 ± 6.5E-02	78	6	4.2E-02 ± 4.1E-01	1.7E+00 ± 2.2E+00 <sup>(e)</sup>
Uranium-234	100-N	3	1	7.2E-03 ± 4.7E-03	1.0E-02 ± 7.1E-03	21	12	9.3E-03 ± 1.0E-02	2.1E-02 ± 1.1E-02
	200-East	12	12	1.4E-02 ± 6.4E-03	1.9E-02 ± 1.2E-02	45	37	1.3E-02 ± 1.3E-02	2.6E-02 ± 1.2E-02
	200-West	25	24	1.6E-02 ± 1.0E-02	2.9E-02 ± 1.3E-02	114	92	1.3E-02 ± 1.2E-02	3.5E-02 ± 1.4E-02
	300	15	14	2.4E-02 ± 2.2E-02	4.8E-02 ± 1.8E-02	67	62	3.5E-02 ± 8.9E-02	2.4E-01 ± 6.7E-02
	400	1	1	2.0E-02 ± 5.6E-06	2.0E-02 ± 1.0E-02	4	2	8.1E-03 ± 3.5E-03	1.1E-02 ± 6.9E-03
	600	15	14	1.8E-02 ± 1.1E-02	3.0E-02 ± 1.3E-02	78	58	1.0E-02 ± 9.4E-03	2.8E-02 ± 1.3E-02
Uranium-235	100-N	3	2	5.9E-03 ± 6.0E-03	1.0E-02 ± 7.5E-03	21	5	3.6E-03 ± 4.7E-03	9.9E-03 ± 7.9E-03
	200-East	12	2	3.0E-03 ± 2.4E-03	4.5E-03 ± 4.2E-03	45	12	4.1E-03 ± 5.7E-03	1.6E-02 ± 9.3E-03
	200-West	25	7	3.4E-03 ± 5.3E-03	8.6E-03 ± 6.1E-03	114	23	3.4E-03 ± 3.9E-03	8.8E-03 ± 6.3E-03
	300	15	2	3.5E-03 ± 3.9E-03	6.7E-03 ± 5.4E-03	67	22	5.1E-03 ± 9.0E-03	3.0E-02 ± 2.3E-02
	400	1	0	3.9E-03 ± 4.2E-07	3.9E-03 ± 4.9E-03 <sup>(e)</sup>	4	0	2.5E-03 ± 2.1E-03	3.6E-03 ± 4.3E-03 <sup>(e)</sup>
	600	15	7	4.2E-03 ± 4.0E-03	8.5E-03 ± 6.0E-03	78	16	3.8E-03 ± 5.8E-03	1.3E-02 ± 8.4E-03

Table 10.10.3. (contd)

Radionuclide	Hanford Site Area	2008				2003-2007			
		Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>
		Samples	Detections <sup>(b)</sup>			Samples	Detections <sup>(b)</sup>		
Plutonium-238	100-N	3	0	7.3E-04 ± 3.6E-03	2.3E-03 ± 3.5E-03 <sup>(e)</sup>	21	0	2.0E-03 ± 1.5E-02	1.9E-02 ± 1.8E-02 <sup>(e)</sup>
	200-East	12	2	4.8E-03 ± 2.6E-02	3.5E-02 ± 1.4E-02	45	0	1.8E-03 ± 1.6E-02	1.4E-02 ± 1.4E-02 <sup>(e)</sup>
	200-West	25	2	2.2E-03 ± 1.4E-02	1.9E-02 ± 9.3E-03	114	4	9.4E-04 ± 1.9E-02	6.4E-02 ± 2.9E-02
	300	15	2	8.5E-03 ± 6.3E-02	8.7E-02 ± 4.7E-02	67	2	2.3E-03 ± 1.4E-02	2.6E-02 ± 1.6E-02
	400	1	0	8.30E-03	8.3E-03 ± 1.7E-02 <sup>(e)</sup>	4	0	1.6E-03 ± 8.6E-03	5.1E-03 ± 1.5E-02 <sup>(e)</sup>
	600	15	0	7.3E-04 ± 1.9E-02	1.2E-02 ± 9.8E-03 <sup>(e)</sup>	78	0	1.3E-03 ± 1.8E-02	2.4E-02 ± 2.1E-02 <sup>(e)</sup>
Uranium-238	100-N	3	3	8.1E-03 ± 1.9E-03	9.0E-03 ± 6.1E-03	21	11	5.7E-03 ± 6.3E-03	1.4E-02 ± 8.1E-03
	200-East	12	9	9.6E-03 ± 8.0E-03	1.8E-02 ± 9.5E-03	45	33	9.7E-03 ± 9.5E-03	2.3E-02 ± 1.1E-02
	200-West	25	21	1.2E-02 ± 1.0E-02	2.3E-02 ± 1.1E-02	114	95	1.1E-02 ± 1.2E-02	3.9E-02 ± 1.6E-02
	300	15	14	1.9E-02 ± 2.9E-02	5.5E-02 ± 2.0E-02	67	60	2.9E-02 ± 7.9E-02	2.1E-01 ± 5.9E-02
	400	1	1	8.10E-03	8.1E-03 ± 6.3E-03	4	4	7.8E-03 ± 4.6E-03	9.8E-03 ± 6.7E-03
	600	15	11	8.6E-03 ± 1.2E-02	1.9E-02 ± 9.7E-03	78	55	8.0E-03 ± 8.9E-03	2.5E-02 ± 1.2E-02
Plutonium-239/240	100-N	3	0	3.4E-04 ± 1.6E-03	9.2E-04 ± 9.2E-03 <sup>(e)</sup>	21	0	5.6E-04 ± 4.0E-03	4.0E-03 ± 6.4E-03 <sup>(e)</sup>
	200-East	12	1	5.6E-03 ± 3.2E-02	5.9E-02 ± 2.2E-02	45	3	1.3E-03 ± 5.6E-03	8.8E-03 ± 7.0E-03
	200-West	25	12	3.1E-02 ± 1.5E-01	3.6E-01 ± 9.7E-02	114	23	6.2E-03 ± 3.0E-02	1.5E-01 ± 4.5E-02
	300	15	1	2.3E-03 ± 7.9E-03	9.4E-03 ± 1.6E-02 <sup>(e)</sup>	67	4	1.9E-03 ± 5.9E-03	1.6E-02 ± 1.0E-02
	400	1	0	2.8E-03 ± 1.3E-06	2.8E-03 ± 4.2E-03 <sup>(e)</sup>	4	1	4.3E-03 ± 8.7E-03	9.8E-03 ± 6.3E-03
	600	15	3	5.3E-03 ± 1.8E-02	3.6E-02 ± 1.6E-02	78	7	1.9E-03 ± 8.2E-03	2.3E-02 ± 1.1E-02

(a) 1 pCi = 0.037 Bq.

(b) Number of samples with measurable concentrations of contaminants.

(c) Average ± two standard deviations.

(d) Maximum ± analytical uncertainty.

(e) Maximum value reported is a non-detect.

**Table 10.10.4. Number of Vegetation Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 2008**

<u>Location</u>	<u>Number of Incidents</u>
200-East Area	
Tank farms	28
Burial grounds	12
Cribs, ponds, and ditches	3
Fence lines	11
Roads and railroads	1
Unplanned release sites	8
Underground pipelines	9
Miscellaneous	2
200-West Area	
Tank farms	17
Burial grounds	0
Cribs, ponds, and ditches	7
Fence lines	5
Roads and railroads	3
Unplanned release sites	2
Underground pipelines	4
Miscellaneous	13
Cross-site transfer line	0
200-BC cribs and trenches	2
200-North Area	0
100 Areas	0
300 Area	0
400 Area	0
600 Area	0
Former 1100 Area	0
<b>Total</b>	<b>127</b>

**Table 10.10.5. Annual Number of Vegetation Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 1997 Through 2008**

<u>Year</u>	<u>Number of Incidents</u>	<u>Year</u>	<u>Number of Incidents</u>
1997	46	2003	32
1998	51	2004	60
1999	85	2005	66
2000	66	2006	75
2001	31	2007	62
2002	16	2008	127

locations that could potentially be affected by contaminants from Hanford Site operations. Vegetation samples have been collected on and around the Hanford Site for more than 50 years. Data from these samples are maintained in a database to document onsite and offsite levels of manmade radionuclides in vegetation at specific locations. This database holds baseline data against which data from

unplanned contaminant releases from the Hanford Site can be compared. Vegetation samples, previously collected at site-wide and offsite locations in 2004 (Section 8.10.3 in PNNL-15222), were collected and analyzed in 2008.

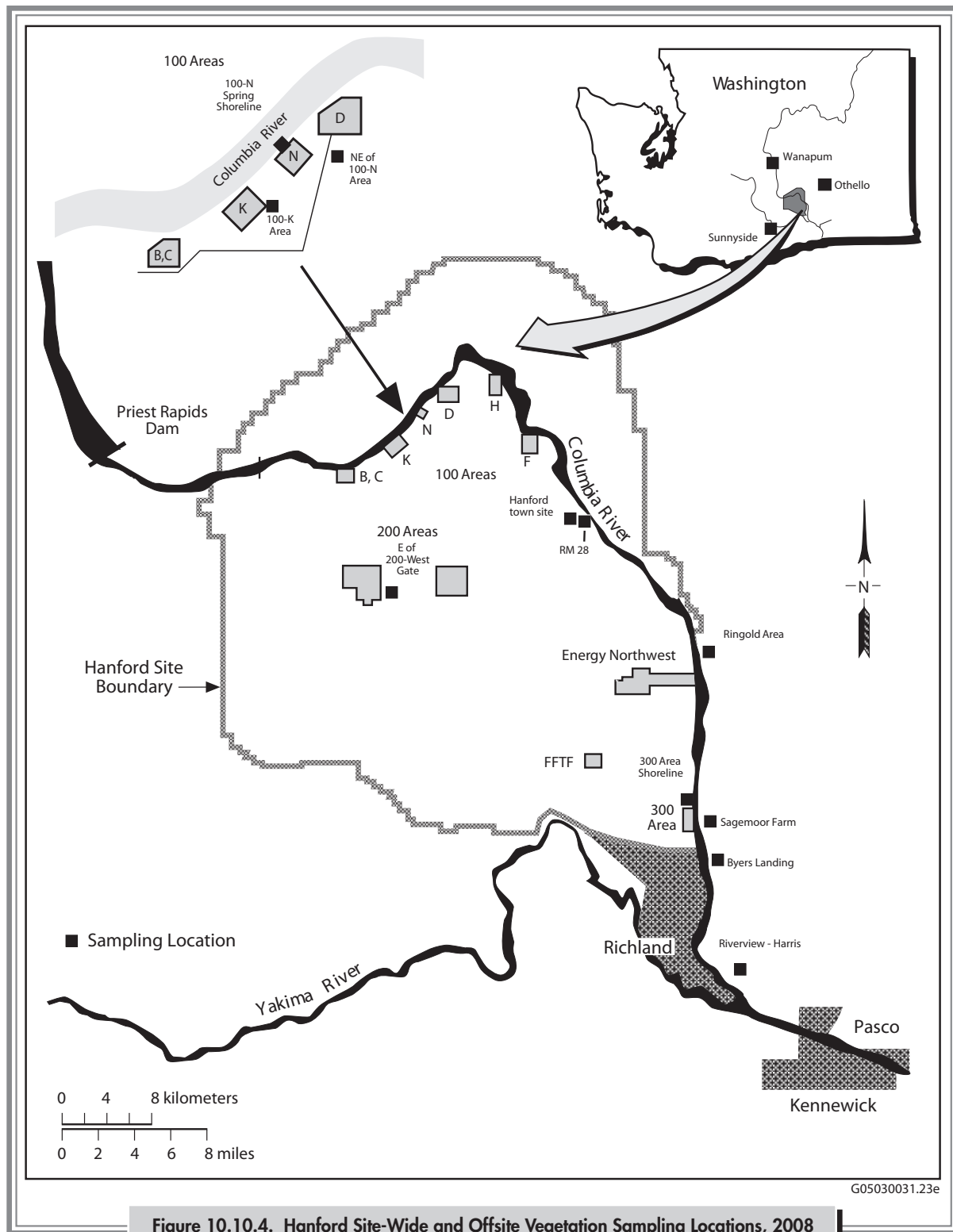
### 10.10.3.1 Vegetation Sampling at Hanford Site-Wide and Offsite Locations

Vegetation samples were collected at 14 locations on and around the Hanford Site in 2008 (Figure 10.10.4). Samples were organized into two distinct groups: site-wide (onsite) and offsite. Site-wide sampling locations were generally selected in areas around industrial development on the site.

Vegetation samples consisted of the current year's growth of leaves, stems, and new branches from sagebrush and rabbitbrush. Samples were dried before analyses, and analytical results were reported on a dry weight basis. Shoreline samples were usually taken from a predominant species at the sampling location. A contaminant was detected if the analytical result was greater than the minimum detectable activity and was larger than the total analytical error. All 14 samples collected in 2008 were analyzed for gamma-emitting radionuclides, strontium-90, uranium isotopes (uranium-234, uranium-235, and uranium-238), and plutonium isotopes (plutonium-238 and plutonium-239/40).

### 10.10.3.2 Analytical Results for Vegetation Samples Collected at Hanford Site-Wide and Offsite Locations

Vegetation sampling results in 2008 generally confirmed observations from past sampling efforts. Strontium-90, cesium-137, plutonium-238, and plutonium-239/40 concentrations were generally below nominal detection limits at offsite locations (Table 10.10.6). Uranium-238 was detected in all vegetation samples collected in 2008, and plutonium-239/240 was detected in three of the four onsite vegetation samples and in one offsite sample. The maximum uranium-238 concentration measured in vegetation during 2008 was collected at Byers Landing ( $0.032 \pm 0.013$  pCi/g [ $1.2 \pm 0.48$  mBq/g]). This result was higher than the maximum uranium-238 concentration measured along the Hanford Site perimeter between 1998 and 2004. The highest



**Table 10.10.6. Concentrations of Selected Radionuclides (pCi/g dry wt.)<sup>(a)</sup> in Hanford Site-Wide and Offsite Vegetation Samples, 2008 Compared to Previous Years**

Location	Radionuclide	2008				1998, 2001, and 2004			
		No. of Samples	No. Detected <sup>(b)</sup>	Mean <sup>(c)</sup>	Maximum <sup>(d)</sup>	No. of Samples	No. Detected <sup>(b)</sup>	Mean <sup>(c)</sup>	Maximum <sup>(d)</sup>
Site-wide (Onsite)	Strontium-90	4	0	8.3E-03 ± 0.035	0.033 ± 0.025	14	4	0.018 ± 0.064	0.094 ± 0.061
	Cesium-137	4	0	7.7E-03 ± 8.8E-03	0.013 ± 9.8E-03	14	1	9.3E-03 ± 0.032	0.055 ± 0.029
	Plutonium-238	4	0	9.4E-05 ± 4.7E-05	1.3E-04 ± 1.8E-04	14	1	2.6E-05 ± 1.3E-04	1.4E-04 ± 1.1E-04
	Uranium-238	4	3	0.016 ± 0.022	0.030 ± 0.013	14	1	1.2E-03 ± 5.0E-03	7.9E-03 ± 8.5E-03
	Plutonium-239/240	4	3	1.0E-03 ± 3.0E-03	3.2E-03 ± 8.4E-04	14	6	1.8E-03 ± 5.2E-03	7.7E-03 ± 1.3E-03
Perimeter	Strontium-90	4	0	0.021 ± 0.031	0.038 ± 0.032	12	4	0.018 ± 0.050	0.060 ± 0.11
	Cesium-137	4	0	8.6E-03 ± 0.012	0.016 ± 0.019	12	0	0.010 ± 0.016	0.027 ± 0.018
	Plutonium-238	4	0	1.1E-04 ± 7.8E-05	1.5E-04 ± 2.1E-04	12	1	6.8E-05 ± 1.5E-04	2.7E-04 ± 2.3E-04
	Uranium-238	4	4	0.023 ± 0.020	0.032 ± 0.013	12	4	7.7E-03 ± 0.011	0.018 ± 0.011
	Plutonium-239/240	4	1	2.2E-04 ± 2.5E-04	4.0E-04 ± 2.5E-04	12	6	4.1E-04 ± 9.2E-04	1.2E-03 ± 4.8E-04
Shoreline <sup>(e)</sup>	Strontium-90	3	0	0.018 ± 0.031	0.035 ± 0.031	10	4	0.11 ± 0.36	0.54 ± 0.10
	Cesium-137	3	0	0.011 ± 0.014	0.019 ± 0.022	10	2	0.033 ± 0.16	0.25 ± 0.033
	Plutonium-238	3	1	1.1E-04 ± 2.1E-04	2.1E-04 ± 2.1E-04	10	0	7.3E-05 ± 1.8E-04	2.6E-04 ± 2.7E-04
	Uranium-238	3	3	0.018 ± 9.8E-03	0.024 ± 0.024	10	2	0.065 ± 0.40	0.64 ± 0.073
	Plutonium-239/240	3	0	9.5E-05 ± 7.5E-05	1.3E-04 ± 1.8E-04	10	5	1.1E-03 ± 4.0E-03	5.9E-03 ± 1.4E-03
Distant	Strontium-90	3	0	0.022 ± 0.018	0.030 ± 0.030	9	2	0.025 ± 0.029	0.087 ± 0.10
	Cesium-137	3	0	-1.7E-03 ± 2.4E-03	-6.7E-04 ± 0.013	9	0	7.4E-03 ± 0.024	0.030 ± 0.014
	Plutonium-238	3	0	1.1E-05 ± 3.9E-05	3.3E-05 ± 1.7E-04	9	0	2.6E-05 ± 1.1E-04	1.1E-04 ± 2.3E-04
	Uranium-238	3	3	0.018 ± 0.015	0.026 ± 0.013	9	0	1.9E-03 ± 0.012	0.011 ± 0.012
	Plutonium-239/240	3	0	6.1E-05 ± 1.1E-04	9.2E-05 ± 2.2E-04	9	5	6.0E-04 ± 2.0E-03	3.1E-03 ± 7.3E-04

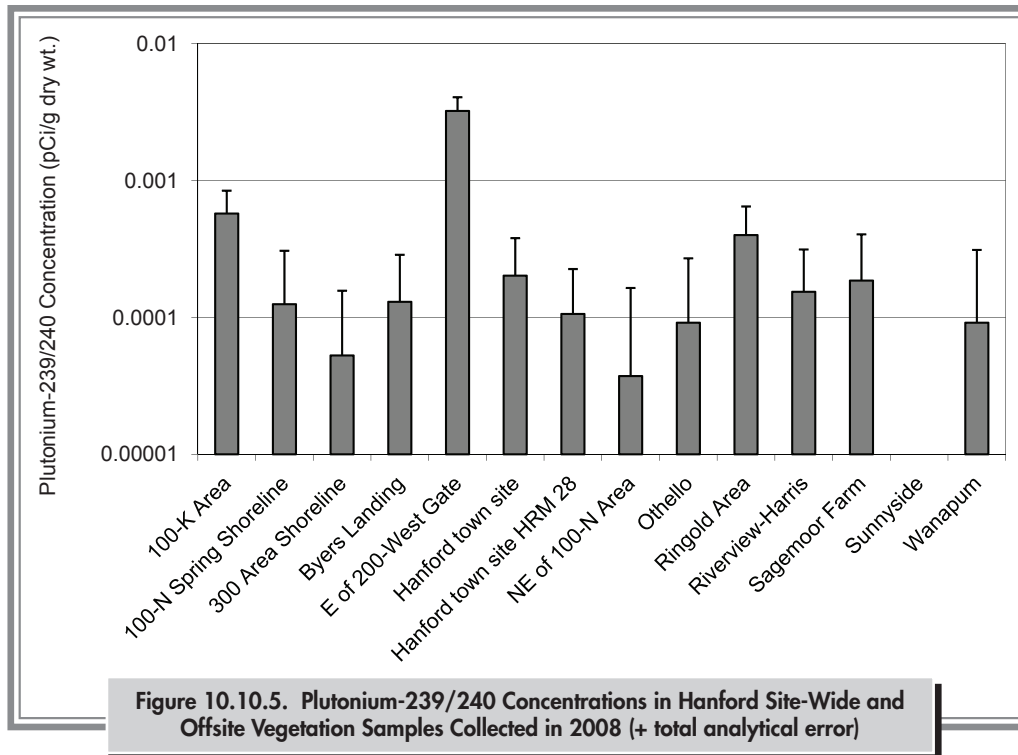
(a) To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.

(b) Detection is defined as a value reported above the minimum detectable activity or above the total analytical uncertainty.

(c) Reported mean values ± 2 standard deviations.

(d) Reported maximum values ± total analytical uncertainty.

(e) Hanford Reach of the Columbia River.



measured plutonium-239/240 concentration ( $0.0032 \pm 0.00084$  pCi/g [ $0.12 \pm 0.031$  mBq/g]) was from a vegetation sample collected at the east of the 200-West Gate sampling location (Figure 10.10.5). This concentration is consistent with historical data, which show this sampling location to have generally higher concentrations of radionuclides in vegetation and soil than other site-wide sampling locations.

## 10.10.4 Vegetation Control Activities

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Vegetation control on the Hanford Site consists of cleaning up contaminated plants that can be a threat to site workers or the public, controlling or preventing the growth or regrowth of plants in contaminated or potentially contaminated areas on the site, and monitoring and removing unwanted (noxious) plant species.

Approximately 2,230 hectares (5,500 acres) were treated with herbicides in 2008 on radiological waste sites, around operations areas, and along roadways to keep them clean of deep-rooted noxious vegetation (e.g., Russian thistle, also known as tumbleweed). Follow-up treatments are included in the total treated acres; several areas received three or four treatments per year.

### 10.10.4.1 Waste Site Remediation and Revegetation During 2008

Small sites with recurring radioactive contamination events caused by deep-rooted vegetation or burrowing animals were covered with Biobarrier® to prevent further invasion by biota.<sup>(b)</sup> Biobarrier is an engineered fabric impregnated with herbicide used to stop root penetration and serve as a physical barrier to burrowing insects. The fabric was installed at one site in 2008 that totaled approximately 3 square meters (approximately 30 square feet). Tests on the Hanford Site confirm this barrier is effective in preventing the spread of contamination. The total number

(b) Biobarrier is a registered trademark of Fiberweb plc, Old Hickory, Tennessee.

of areas on the Hanford Site covered with Biobarrier since 1999 is 39, comprising a total area of approximately 14,000 square meters (151,000 square feet).

Larger areas, including entire waste sites, were reseeded with bunchgrass to inhibit the growth of deep-rooted noxious vegetation (e.g., tumbleweed). Approximately 3,040 hectares (7,500 acres) were overseeded with bunchgrass seed in 2008, including portions of the Wautoma Fire Recovery Area where severe winds damaged areas reseeded in 2007.

#### 10.10.4.2 Noxious Weed Control

Noxious weeds are controlled on the Hanford Site to prevent their spread and eliminate populations. A noxious weed is a legal and administrative category designated by federal or state regulatory agencies (e.g., U.S. Department of Agriculture or Washington State Department of Agriculture). Noxious weeds are non-native, aggressively invasive, and hard to control. Noxious weeds alter native plant communities and degrade ecosystems unless control measures are taken. Control measures can be mechanical, chemical, cultural, or biological; approximately 20 hectares (50 acres) on the Hanford Site were treated in 2008.

Ten plant species are on a high-priority list for control on the Hanford Site. These species are described in the following paragraphs, along with a summary of 2008 control activities.

**Yellow Starthistle** (*Centaurea solstitialis*). Yellow starthistle represents the most rapidly expanding weed infestation in the western United States. Since 1995, yellow starthistle has been the highest priority weed for the Hanford Site noxious-weed control program because yellow starthistle has the potential to invade the entire site and have a dramatic impact on the ecology of the site and neighboring lands.

Control measures for yellow starthistle have included spot treatments and broadcast herbicide applications by ground equipment and aerial sprayers, biological control, and hand-weeding in critical locations. Major populations near the Hanford town site have been reduced to scattered individual plants, mostly near live trees where aerial herbicide applications were not made.

Yellow starthistle seeds are known to remain viable for 10 years in the soil. The small number of seedlings found over much of the area of infestation indicates the seed bank is being exhausted. Careful control efforts over the next few years should see yellow starthistle on the Hanford Site changed from a major infestation to a monitoring and eradication effort.

Biological control agents for yellow starthistle are widely distributed across the infested area and have been highly effective during the early part of the flowering season. However, the adult phase of the control agent's annual life cycle is completed before the end of the flowering season. Consequently, flowers opening late in the season are largely spared the effects of insect predation.

**Rush Skeletonweed** (*Chondrilla juncea*). Rush skeletonweed is scattered over large areas on the Hanford Site. Areas of dense rush skeletonweed infestation have largely been eliminated. Nevertheless, considerable rush skeletonweed remains as scattered individual plants. Populations of rush skeletonweed have increased in some areas burned by the 24 Command Wildland Fire in June 2000 and can be expected to increase in areas burned by the Wautoma fire in 2007.

In 2008, control of rush skeletonweed focused on individual areas between State Highway 240 and Hanford Route 10. Approximately 20 hectares (50 acres) were treated to remove an infestation that was becoming dense in this area.

The deep and extensive root system of rush skeletonweed makes it extremely difficult to eliminate. The area north of the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER) facility has been treated with herbicides in the past and will continue to be monitored for sprouts emerging from roots remaining in the ground. Additional aerial applications will likely be needed to reduce the population of rush skeletonweed to the level that ground applications will be able to control the infestation.

Biological control agents are commonly found in rush skeletonweed on the Hanford Site; however, they have not significantly reduced plant populations.



**Medusahead** (*Taeniatherum asperum*). No medusahead plants were discovered in 2008. The Hanford Site will continue to be monitored for several years to verify the seed bank has been eradicated.

**Babysbreath** (*Gypsophila paniculata*). There were no efforts to control babysbreath in 2008 at the Hanford town site. Babysbreath is resistant to control by herbicides; however, the aboveground portion of the plant can be killed by some herbicides. Using these herbicides, flowering and population growth can be prevented. It is hoped these plants will ultimately be eradicated by continually removing the top portions through herbicide use.

**Dalmatian Toadflax** (*Linaria genistifolia* ssp. *Dalmatica*). A small population of dalmatian toadflax plants was found growing east of Energy Northwest on the Hanford Site in 2008. Sprouts and seedlings of the long-lived perennial plant will be eliminated as they are identified. No biological controls have been released on the Hanford Site for dalmatian toadflax.

**Spotted Knapweed** (*Centaurea maculosa*). Spotted knapweed on the Hanford Site has been controlled so that sprouts or seedlings are rare. No sprouts or seedlings were found in 2008. The site will continue to be monitored for several years to ensure viable seeds and roots have been eliminated from the soil. Cooperative efforts with neighboring landowners continue to eliminate spotted knapweed near the Hanford Site. No biological controls have been released specifically for spotted knapweed. Most biological controls for diffuse knapweed are also effective for spotted knapweed.

**Diffuse Knapweed** (*Centaurea diffusa*). Aerial applications for control of diffuse knapweed have been effective in the past. In 2008, no areas were sprayed aerially for control of diffuse knapweed. Spot treatment of scattered individuals continues. The population of diffuse knapweed near

the high-water mark of the Columbia River has not been actively controlled by herbicides because of the biological sensitivity of the area. Biological controls are established and monitored to observe their effectiveness in controlling the weed.

**Russian Knapweed** (*Acroptilon repens*). Biological controls for Russian knapweed are limited, and their success has been poor in the arid climate of the Hanford Site. Chemicals and other control techniques are being developed that promise to be effective with this difficult-to-control species.

**Saltcedar** (*Tamarix* spp.). Several individual plants of saltcedar are found on the Hanford Site. Most are remaining from ornamental plantings near homes in the early part of the previous century. A few populations are the result of natural seed dispersal. Most individual plants south and west of the Columbia River have been eliminated. Those remaining alive continue to be treated with herbicide and will be monitored until they are eradicated.

**Purple Loosestrife** (*Lythrum salicaria*). The Columbia River riverbank and islands on the Hanford Site are monitored for purple loosestrife. Populations are found on many islands and along the north and east bank of the river. Individual plants are found along the south and west bank of the river.

Under good ecological conditions, biological controls are effective for controlling purple loosestrife. However, rapidly fluctuating water levels along the Columbia River kill the control organisms that overwinter on the ground in the weed populations. Winter mortality prevents an effective population of control agents from developing. Hanford Site personnel are working with neighboring land managers along the Columbia River to identify effective controls for purple loosestrife along the Hanford Reach. No control measures were applied for purple loosestrife in 2008.





## 10.11 Endangered and Threatened Species on the Hanford Site

MR Sackschewsky

This section describes federal and state endangered and threatened species, candidate or sensitive plant and animal species, and other species of concern potentially found on the Hanford Site. Endangered species are those in danger of extinction within all or a significant portion of their range. Threatened species are those likely to become endangered in the foreseeable future. Sensitive species are species that are vulnerable or declining and could become endangered or threatened without active management or removal of threats. The federal list of endangered and threatened species is maintained by the U.S. Fish and Wildlife Service in 50 CFR 17.11 and 50 CFR 17.12. The state lists are maintained by the Washington Natural Heritage Program (WNHP 2009) and the Washington Department of Fish and Wildlife (WDFW 2009).

The purposes of the *Endangered Species Act of 1973*, as amended, are to 1) provide a means to conserve critical ecosystems, 2) provide a program for the conservation of endangered and threatened species, and 3) ensure appropriate steps are taken to achieve the purposes of the treaties and conventions established under the act. Washington State also lists species as endangered and threatened, but such a listing does not carry the protection of the federal *Endangered Species Act of 1973*. The National Oceanic and Atmospheric Administration Fisheries (NOAA 2008) has the responsibility for the federal listing of anadromous fish (i.e., fish such as spring-run Chinook salmon [*Oncorhynchus tshawytscha*] and steelhead [*Oncorhynchus mykiss*] that require both saltwater and freshwater to complete a life cycle). The U.S. Fish and Wildlife Service has responsibility for all other federally listed species on the Hanford Site. Table 10.11.1 lists the species of plants and animals that occur or potentially occur on the Hanford Site and are listed as endangered, threatened, sensitive, or candidate by either the federal or state governments.

Two fish species (spring-run Chinook salmon and steelhead) on the federal list of endangered and threatened species are known to regularly occur on the Hanford Site (Table 10.11.1). One additional fish species (bull trout) was recorded on the Hanford Site but scientists believe this species is transient. No other plants or animals known to occur on the Hanford Site are currently on the federal list of endangered and threatened species (50 CFR 17), but two plant species, one mammal species, and one bird species are currently candidates for listing under the *Endangered Species Act of 1973* (Table 10.11.1). In addition, 13 plant species and 5 bird species have been listed as either endangered or threatened by Washington State. Numerous additional species of animals and plants are listed as candidate or sensitive species by Washington State. There are 31 state-level sensitive and candidate species of insects and animals and 14 sensitive plant species occurring or potentially occurring on the Hanford Site (Table 10.11.1). The U.S. Fish and Wildlife Service also maintains an informal list of species of concern in the Columbia Basin (USFWS 2008), which includes species that are being monitored and may be considered for federal candidate status in the future; 17 species that occur on the Hanford Site are included on this list.

Washington State officials maintain additional lower-level lists of species, including a monitor list for animals (WDFW 2009) and review and watch lists for plants (WNHP 2009). Species on the state monitor, watch, and review lists are not considered species of concern, but are monitored for status and distribution. These species are managed by the state, as needed, to prevent them from becoming endangered, threatened, or sensitive. However, an abundance of these species may be indicative of an ecosystem with relatively high native diversity. Approximately 50 Washington State

**Table 10.11.1. Federal and Washington State Listed Endangered, Threatened, Sensitive, and Candidate Species Occurring or Potentially Occurring on the Hanford Site**

<u>Common Name</u>	<u>Scientific Name</u>	<u>Federal Status<sup>(a)</sup></u>	<u>State Status<sup>(a)</sup></u>
<b>Plants</b>			
awned halfchaff sedge	<i>Lipocarpus</i> (= <i>Hemicarpus</i> ) <i>aristulata</i>		Threatened
beaked spike-rush	<i>Eleocharis rostellata</i>		Sensitive
Canadian St. John's wort	<i>Hypericum majus</i>		Sensitive
chaffweed	<i>Anagallis</i> (= <i>Centunculus</i> ) <i>minimus</i>		Threatened
Columbia milkvetch	<i>Astragalus columbianus</i>	Species of concern	Sensitive
Columbia yellowcress	<i>Rorippa columbiae</i>	Species of concern	Endangered
coyote tobacco	<i>Nicotiana attenuata</i>		Sensitive
desert dodder	<i>Cuscuta denticulata</i>		Threatened
desert evening-primrose	<i>Oenothera caespitosa</i>		Sensitive
dwarf evening primrose	<i>Camissonia</i> (= <i>Oenothera</i> ) <i>pygmaea</i>		Sensitive
fuzzytongue penstemon	<i>Penstemon eriantherus whitedii</i>		Sensitive
Geyer's milkvetch	<i>Astragalus geyeri</i>		Threatened
grand redstem	<i>Ammannia robusta</i>		Threatened
gray cryptantha	<i>Cryptantha leucophaea</i>	Species of concern	Sensitive
Great Basin gilia	<i>Aliciella</i> (= <i>Gilia</i> ) <i>leptomeria</i>		Threatened
Hoover's desert parsley	<i>Lomatium tuberosum</i>	Species of concern	Sensitive
loeflingia	<i>Loeflingia squarrosa</i> var. <i>squarrosa</i>		Threatened
lowland toothcup	<i>Rotala ramosior</i>		Threatened
desert cryptantha	<i>Cryptantha scoparia</i>		Sensitive
Piper's daisy	<i>Erigeron piperianus</i>		Sensitive
rosy pussypaws	<i>Cistanthe</i> (= <i>Calyptidium</i> ) <i>roseum</i>		Threatened
small-flowered evening-primrose	<i>Camissonia</i> (= <i>Oenothera</i> ) <i>minor</i>		Sensitive
Snake River cryptantha	<i>Cryptantha spiculifera</i> (= <i>C. interrupta</i> )		Sensitive
Suksdorf's monkey flower	<i>Mimulus suksdorfii</i>		Sensitive
Umtanum desert buckwheat	<i>Eriogonum codium</i>	Candidate	Endangered
White Bluffs bladderpod	<i>Physaria</i> (= <i>Lesquerella</i> ) <i>douglasii</i> ssp. <i>tuplashensis</i>	Candidate	Threatened
white eatonella	<i>Eatonella nivea</i>		Threatened
<b>Mollusks</b>			
California floater	<i>Anodonta californiensis</i>	Species of concern	Candidate
great Columbia River spire snail	<i>Fluminicola columbiana</i>	Species of concern	Candidate
shortfaced lanx	<i>Fisherola nuttalli</i>		Candidate
<b>Insects</b>			
Columbia River tiger beetle <sup>(b)</sup>	<i>Cicindela columbica</i>		Candidate
silver-bordered fritillary	<i>Boloria selene atrocostalis</i>		Candidate
<b>Fish</b>			
bull trout <sup>(c)</sup>	<i>Salvelinus confluentus</i>	Threatened	Candidate
leopard dace <sup>(c)</sup>	<i>Rhinichthys flacatus</i>		Candidate
mountain sucker <sup>(c)</sup>	<i>Catostomus platyrhynchus</i>		Candidate
river lamprey <sup>(c)</sup>	<i>Lampetra ayresi</i>	Species of concern	Candidate
spring-run Chinook salmon	<i>Oncorhynchus tshawytscha</i>	Endangered	Candidate
steelhead	<i>Oncorhynchus mykiss</i>	Threatened	Candidate
<b>Amphibians and Reptiles</b>			
sagebrush lizard	<i>Sceloporus graciosus</i>	Species of concern	Candidate
striped whipsnake	<i>Masticophis taeniatus</i>		Candidate
western toad	<i>Bufo boreas</i>		Candidate

Table 10.11.1. (contd)

<u>Common Name</u>	<u>Scientific Name</u>	<u>Federal Status<sup>(a)</sup></u>	<u>State Status<sup>(a)</sup></u>
<b>Birds</b>			
American white pelican	<i>Pelecanus erythrorhynchos</i>		Endangered
bald eagle	<i>Haliaeetus leucocephalus</i>	Species of concern	Sensitive <sup>(d)</sup>
burrowing owl	<i>Athene cunicularia</i>	Species of concern	Candidate
common loon	<i>Gavia immer</i>		Sensitive
ferruginous hawk	<i>Buteo regalis</i>	Species of concern	Threatened
flamulated owl <sup>(c)</sup>	<i>Otus flammeolus</i>		Candidate
golden eagle	<i>Aquila chrysaetos</i>		Candidate
greater sage grouse	<i>Centrocercus urophasianus</i>	Candidate	Threatened
Lewis's woodpecker <sup>(c)</sup>	<i>Melanerpes lewis</i>		Candidate
loggerhead shrike	<i>Lanius ludovicianus</i>	Species of concern	Candidate
merlin	<i>Falco columbarius</i>		Candidate
northern goshawk <sup>(c)</sup>	<i>Accipiter gentilis</i>	Species of concern	Candidate
olive-sided flycatcher	<i>Contopus cooperi</i>	Species of concern	
peregrine falcon	<i>Falco peregrinus</i>	Species of concern	Sensitive
sage sparrow	<i>Amphispiza belli</i>		Candidate
sage thrasher	<i>Oreoscoptes montanus</i>		Candidate
sandhill crane	<i>Grus canadensis</i>		Endangered
western grebe	<i>Aechmophorus occidentalis</i>		Candidate
<b>Mammals</b>			
black-tailed jackrabbit	<i>Lepus californicus</i>		Candidate
Merriam's shrew	<i>Sorex merriami</i>		Candidate
Townsend's ground squirrel	<i>Spermophilus townsendii</i>	Species of concern	Candidate
Washington ground squirrel <sup>(c)</sup>	<i>Spermophilus washingtoni</i>	Candidate	Candidate
white-tailed jackrabbit	<i>Lepus townsendii</i>		Candidate

- (a) Endangered = Species in danger of extinction within all or a significant portion of its range.  
 Threatened = Species likely to become endangered in the foreseeable future.  
 Candidate = Species that are believed to qualify for threatened or endangered species status, but for which listing proposals have not been prepared.  
 Sensitive = Taxa that are vulnerable or declining and could become endangered or threatened without active management or removal of threats.  
 Species of concern = Species that are not currently listed or candidates under the *Endangered Species Act*, but are of conservation concern within specific U.S. Fish and Wildlife Service regions.
- (b) Probable, but not observed, on the Hanford Site.  
 (c) Reported, but seldom observed, on the Hanford Site.  
 (d) Reclassified in January 2008.

monitor list animal and insect species occur or potentially occur on the Hanford Site (Table 10.11.2), and 24 watch or

review list plant species are potentially found on the Hanford Site (Table 10.11.3).

**Table 10.11.2. Washington State Monitor Species Occurring or Potentially Occurring on the Hanford Site**

<u>Common Name</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
<b>Mollusks</b>		<b>Birds</b>	
Oregon floater	<i>Anodonta oregonensis</i>	Arctic tern <sup>(a)</sup>	<i>Sterna paradisaea</i>
western floater	<i>Anodonta kennerlyi</i>	ash-throated flycatcher <sup>(a)</sup>	<i>Myiarchus cinerascens</i>
western pearlshell	<i>Margaritifera falcata</i>	black tern <sup>(b)</sup>	<i>Chlidonias niger</i>
<b>Insects</b>		black-crowned night-heron	<i>Nycticorax nycticorax</i>
Bonneville skipper	<i>Ochlodes sylvanoides bonnevillia</i>	black-necked stilt	<i>Himantopus mexicanus</i>
canyon green hairstreak	<i>Callophrys sheridanii neoperplexa</i>	bobolink <sup>(a)</sup>	<i>Dolichonyx oryzivorus</i>
coral hairstreak	<i>Harknclenus titus immaculosus</i>	Caspian tern	<i>Sterna caspia</i>
juba skipper	<i>Hesperia juba</i>	Clark's grebe	<i>Aechmophorus clarkii</i>
Nevada skipper	<i>Hesperia nevada</i>	Forster's tern	<i>Sterna forsteri</i>
northern checkerspot	<i>Chlosyne palla palla</i>	grasshopper sparrow	<i>Ammodramus savannarum</i>
Pasco pearl	<i>Phyciodes cocyta pascoensis</i>	gray flycatcher	<i>Empidonax wrightii</i>
Persius' duskywing	<i>Erynnis persius</i>	great blue heron	<i>Ardea herodias</i>
purplish copper	<i>Lycaena helloides</i>	great egret	<i>Ardea alba</i>
ruddy copper	<i>Lycaena rubida perkinsorum</i>	gyrfalcon <sup>(a)</sup>	<i>Falco rusticolus</i>
silver-spotted skipper	<i>Epargyreus clarus californicus</i>	horned grebe	<i>Podiceps auritus</i>
viceroy	<i>Limenitis archippus lahontani</i>	lesser goldfinch	<i>Carduelis psaltria</i>
<b>Fish</b>		long-billed curlew	<i>Numenius americanus</i>
Pacific lamprey <sup>(b)</sup>	<i>Lampetra tridentata</i>	osprey	<i>Pandion haliaetus</i>
piute sculpin	<i>Cottus beldingi</i>	prairie falcon	<i>Falco mexicanus</i>
reticulate sculpin	<i>Cottus perplexus</i>	red-necked grebe <sup>(a)</sup>	<i>Podiceps grisegena</i>
sand roller	<i>Percopsis transmontana</i>	snowy owl	<i>Nyctea scandiaca</i>
<b>Amphibians and Reptiles</b>		Swainson's hawk	<i>Buteo swainsoni</i>
night snake	<i>Hypsiglena torquata</i>	turkey vulture <sup>(a)</sup>	<i>Cathartes aura</i>
short-horned lizard	<i>Phrynosoma douglassii</i>	western bluebird	<i>Sialia mexicana</i>
Woodhouse's toad	<i>Bufo woodhousii</i>	<b>Mammals</b>	
		badger	<i>Taxidea taxus</i>
		long-legged myotis <sup>(b)</sup>	<i>Myotis volans</i>
		northern grasshopper mouse	<i>Onychomys leucogaster</i>
		pallid bat	<i>Antrozous pallidus</i>
		sagebrush vole	<i>Lagurus curtatus</i>
		small-footed myotis <sup>(b)</sup>	<i>Myotis leibii</i>
		western pipistrelle	<i>Pipistrellus hesperus</i>

(a) Reported, but seldom observed on the Hanford Site.

(b) Federal Species of Concern.

**Table 10.11.3. Washington State Review and Watch List Plant Species Potentially Found on the Hanford Site**

<u>Common Name</u>	<u>Scientific Name</u>	<u>State Listing<sup>(a)</sup></u>
annual paintbrush	<i>Castilleja exilis</i>	Watch List
annual sandwort	<i>Minuartia pusilla</i> var. <i>pusilla</i>	Review Group 1
basalt milk-vetch	<i>Astragalus conjunctus</i> var. <i>rickardii</i>	Watch List
bristly combseed	<i>Pectocarya setosa</i>	Watch List
Columbia River mugwort	<i>Artemisia lindleyana</i>	Watch List
crouching milkvetch	<i>Astragalus succumbens</i>	Watch List
false pimpernel	<i>Lindernia dubia anagallidea</i>	Watch List
giant helleborine	<i>Epipactis gigantea</i>	Watch List
hedgehog cactus	<i>Pediocactus simpsonii</i> var. <i>robustior</i> =( <i>P. nigrispinus</i> )	Review Group 1
Kittitas larkspur	<i>Delphinium multiplex</i>	Watch List
medic milkvetch	<i>Astragalus speirocarpus</i>	Watch List
pigmy-weed	<i>Crassula aquatica</i>	Watch List
porcupine sedge	<i>Carex hystericina</i>	Watch List
Robinson's onion	<i>Allium robinsonii</i>	Watch List
rosy balsamroot	<i>Balsamorhiza rosea</i>	Watch List
scilla onion	<i>Allium scilloides</i>	Watch List
shining flatsedge	<i>Cyperus bipartitus</i> ( <i>rivularis</i> )	Watch List
small-flowered nama	<i>Nama densum</i> var. <i>parviflorum</i>	Watch List
smooth cliffbrake	<i>Pellaea glabella simplex</i>	Watch List
southern mudwort	<i>Limosella acaulis</i>	Watch List
stalked-pod milkvetch	<i>Astragalus sclerocarpus</i>	Watch List
vanilla grass	<i>Hierchloe odorata</i>	Review Group 1
winged combseed	<i>Pectocarya penicillata</i>	Watch List

- (a) Review Group 1 - Taxa for which currently there are insufficient data available to support listing as threatened, endangered, or sensitive.  
 Watch List - Taxa that are more abundant and/or less threatened than previously assumed.



## 10.12 Fish and Wildlife Monitoring

The following sections summarize wildlife-related monitoring activities conducted on and around the Hanford Site in 2008. The sections include discussions on the following:

- Surveys and monitoring of Hanford Site animal populations
- Species that occur on the site that are protected by state and federal laws and regulations and other selected species
- Results of activities to measure levels of site-produced contaminants in fish and wildlife tissues
- Activities to manage organisms that may have become radiologically contaminated and could affect workers.

Hanford Site wildlife populations are monitored to assess the abundance, condition, and distribution of populations of selected species. Data collection and analyses are integrated with contaminant monitoring activities, and analytical results are used to help characterize potential risks or impact to biota. Results may also be used to support objectives for completing Hanford Site waste management and environmental restoration missions. Information on threatened, endangered, and sensitive wildlife species is collected so DOE can determine site compliance with requirements of applicable state and federal laws and regulations.

This section provides current information on the ecological monitoring of key animal species and populations found on the Hanford Site as well as results of contaminant monitoring. Population monitoring (Section 10.12.1) focuses on species of interest, including fish and wildlife potentially hunted offsite and used for food, as well as on special-status species listed by Washington State or the U.S. Fish and Wildlife Service as threatened or

endangered. Habitat and species characterization activities (Section 10.12.2) target the near-shore and riparian areas along the Columbia River. These habitats are important because of the potential for exposure to groundwater contaminants that are intersecting the Columbia River. A third area of interest includes ecological and contaminant monitoring of animal and plant populations on 35 long-term monitoring plots spread across the Hanford Site (Section 10.12.3). Data collected from surveys of these plots are used to evaluate both spatial and temporal site-wide population trends.

Fish and wildlife that inhabit the Columbia River and Hanford Site are routinely monitored for contaminants because they could potentially be exposed to site-produced materials and be adversely affected (Section 10.12.4). Subsequently, contaminated animals could be harvested and consumed by the public. When discovered, pest organisms are removed and disposed of to eliminate possible impacts to worker safety and health and to control the spread of radioactive contamination (Section 10.12.5).

See Section 10.0 of this report or DOE/RL-91-50, Rev. 4 for further information about these monitoring and pest control activities and the programs that support them.

### 10.12.1 Population Monitoring

Four fish and wildlife species on the Hanford Site are monitored annually by the Ecological Monitoring and Compliance Project: fall Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), bald eagles (*Haliaeetus leucocephalus*), and mule deer (*Odocoileus hemionus*). These species are of special interest to the public and to stakeholders. Monitoring consists of estimating numbers of fall Chinook salmon redds, surveying for

steelhead redds, assessing bald eagle nesting, and conducting an inventory of mule deer. The species are monitored to assess abundance, condition, and distribution. All have the potential to be impacted by Hanford Site operations, and yearly monitoring provides baseline data for ecological assessments.

### 10.12.1.1 Chinook Salmon

RP Mueller

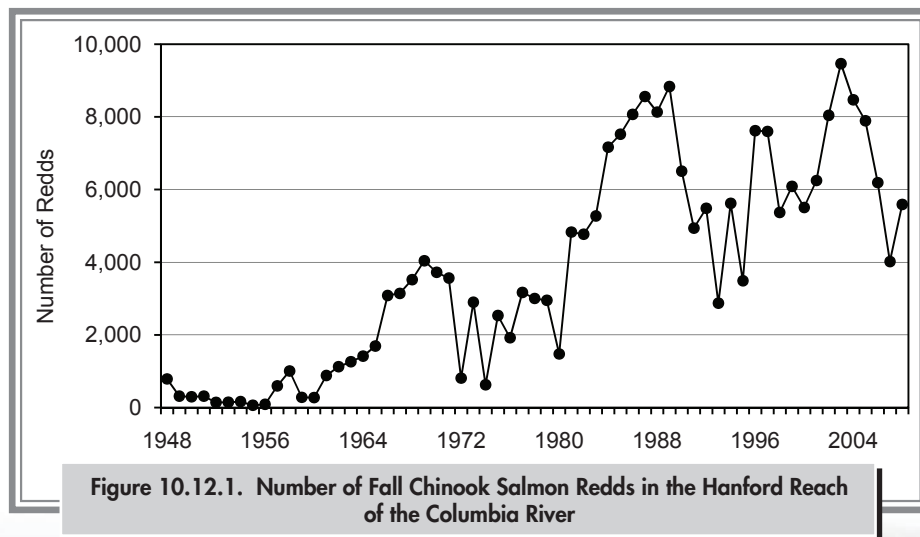
Chinook salmon are an important resource in the Pacific Northwest; they are caught commercially and for recreation. Salmon are also of cultural importance to local Native American tribes. Today, the most important natural spawning area in the mainstem Columbia River for fall Chinook salmon is found in the Hanford Reach (Dauble and Watson 1997). In the early years of the Hanford Site, only a few spawning nests (redds) were found in the Hanford Reach. Between 1943 and 1973, several dams were constructed on the Columbia River, and the formation of reservoirs behind these dams eliminated most mainstem spawning areas. These changes resulted in increased numbers of salmon spawning in the Hanford Reach. Fisheries management strategies aimed at maintaining spawning populations in the mainstem Columbia River also have contributed to the increased number of salmon redds found in the Hanford Reach.

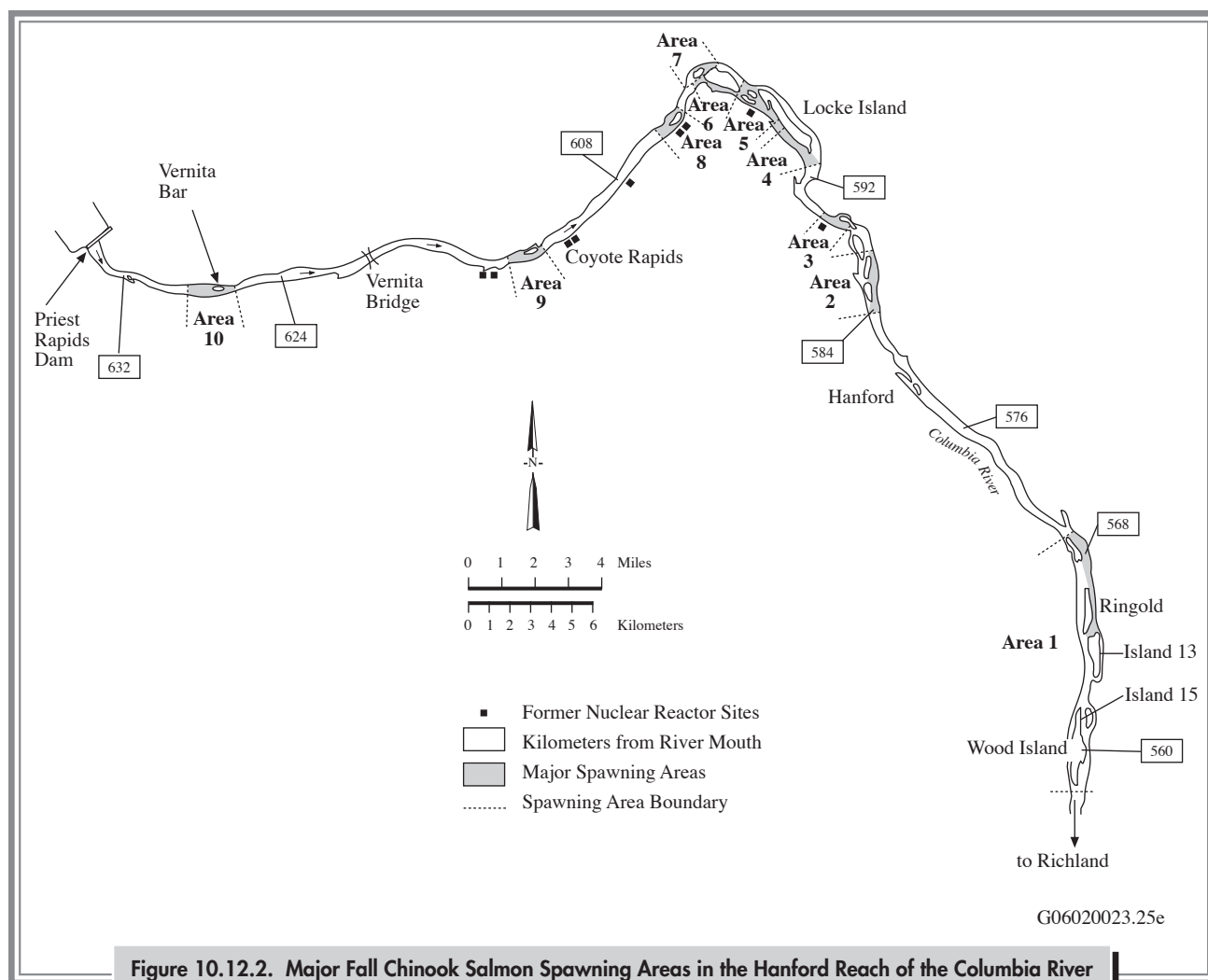
The number of fall Chinook salmon redds in the Hanford Reach is estimated by aerial surveys. Over the years, the

number of redds has increased from less than 500 in the early 1950s to nearly 8,800 in 1989 (Figure 10.12.1). In the early 1990s, redd estimates declined to approximately one-third of the 1989 peak. The number of redds peaked again in 1996 and 1997 and then declined before rising again in 2001. This trend continued through 2003 when an estimated 9,400 redds were counted, which was the highest count since monitoring began in 1948.

The peak redd count for fall Chinook salmon in the Hanford Reach during fall 2008 was estimated at 5,588 (Figure 10.12.1). This count was higher than the 2007 count of 4,018 and below the previous 5-year average of 7,206. The main spawning areas observed from the 2008 counts were located at the following sites, listed in order of abundance: Vernita Bar (Area 10), Locke Island complex (Areas 4 and 5), Island 2 (Area 7), Islands 8-10 (Areas 2 and 3), and the Ringold Area (Area 1) (Figure 10.12.2). The general locations of the spawning areas have not changed significantly over the past few years.

Aerial surveys do not yield absolute salmon redd counts because environmental conditions such as water depth, water turbidity, and sun angle vary. In addition, the number of redds in high-density locations cannot be counted with absolute accuracy while flying. However, redd survey data are highly correlated with adult salmon escapement estimates (the portion of the fish population that survives natural mortality and harvest to reach the spawning grounds) obtained by state and federal agencies within the





Columbia River Basin by using an expansion factor (1 redd = 7 to 8 adult fish) (for additional information on fish data for the Pacific Northwest, see <http://www.streamnet.org/>).

### 10.12.1.2 Steelhead

RP Mueller

Steelhead within the Hanford Reach are considered part of the upper Columbia River Evolutionarily Significant Unit and are listed as endangered under the *Endangered Species Act of 1973*. In March and May 2008, two aerial observation flights were flown on the Hanford Reach from north Richland (river kilometer 547) to near Vernita Bridge (river kilometer 624) to document the occurrence of any steelhead spawning along the shoreline regions. Flight environmental conditions were very good with clear skies, favorable

river flow (approximately 2,830 cubic meters [100,000 cubic feet] per second), clear water, and light wind. No steelhead redds were found during these surveys. Areas in which steelhead redds were found in previous years were given high priority; several passes were made over these regions to check for the presence of any disturbance of the substrates, which would indicate the possibility of spawning fish.

### 10.12.1.3 Bald Eagle

RE Durham, CA Duberstein, and  
MR Sackschewsky

Bald eagles on the Hanford Site are federally protected under the *Bald and Golden Eagle Protection Act* and the *Migratory Bird Treaty Act*. Following the federal delisting of the bald eagle and subsequent reclassification from threatened

to sensitive in Washington State, a draft revision of the *Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington* (DOE/RL-94-150, Rev 0) was produced. This draft is being reviewed by outside agencies and interested stakeholders; finalization of the revision is expected during 2009.

Washington State bald eagle management guidelines recommend 400-meter (437-yard) buffers around active nests and communal roosts (RCW 77.12.655; WAC 232-12-292). Current protective measures within the draft revision of the Hanford Site management plan follow these guidelines. In accordance with the draft revision, buffer

zones around six communal roosts were resized in the fall of 2007 (Figure 10.12.3). Access near these roosts and the active nest area near the White Bluffs boat launch will continue to be restricted annually from November 15 through March 15.

The historical nest site in the vicinity of the former White Bluffs town site was not occupied during the 2008-2009 winter season. Federal guidelines recognize a nest site as active up to 5 years beyond the last occupancy; the White Bluff's nest site was last occupied during the 2007-2008 winter season. Primary causes of eagles abandoning their nests may include 1) adverse weather, 2) food availability,

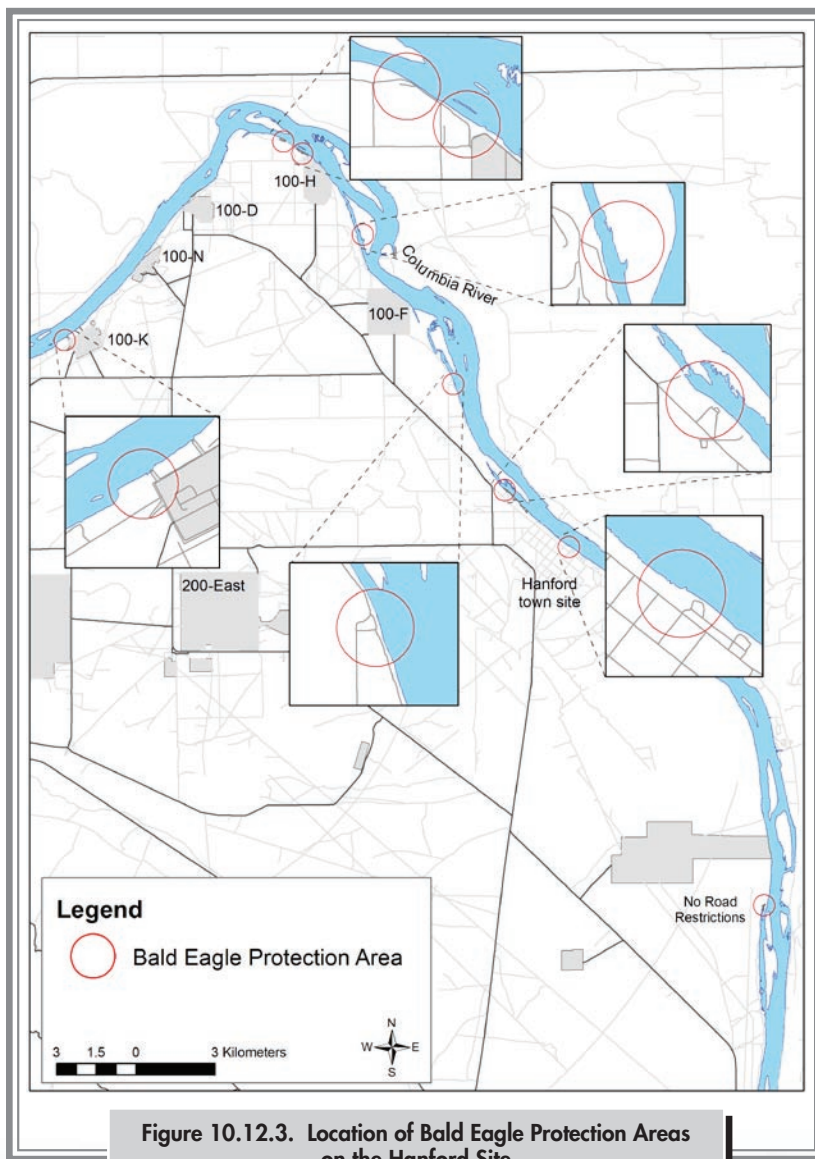
3) human activity near the nest site, and 4) avian predator interactions (such as hazing and harassment by other birds such as magpies and ravens). The causes of eagles abandoning their nests along the Hanford Reach have not been determined.

Bald eagle surveys on the Hanford Site, suspended from 2001 through 2007, resumed in 2008. Thirty-four eagles (18 adults and 16 juveniles) were observed during two surveys along the Hanford Reach from Vernita Bridge downstream to Richland. Bald eagles were counted from a boat during downstream passes through the survey area on January 30 and February 13, 2009. Bald eagles were distributed along the survey area, with the exception of a 13.7-kilometer (8.5-mile) section beginning 8 kilometers (5 miles) upstream of and ending downstream of Ringold. This count was similar to those in the late 1980s and mid-1990s (Figure 10.12.4).

#### 10.12.1.4 Mule Deer

##### KD Hand

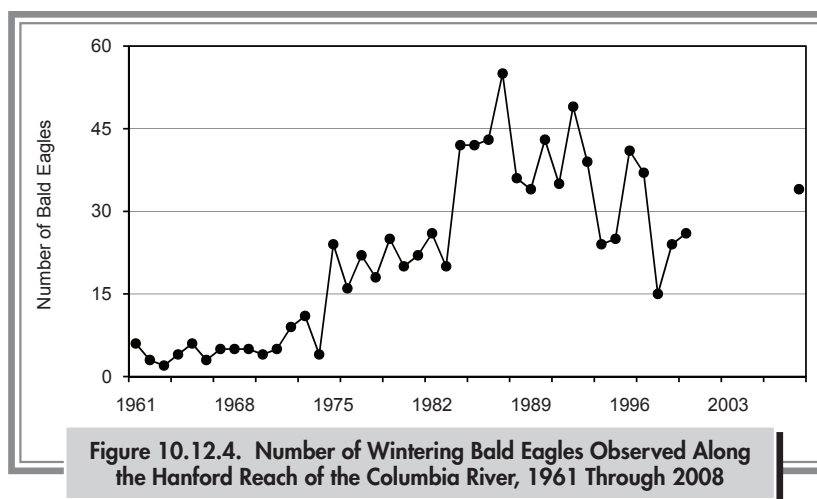
Population characteristics of mule deer on the Hanford Site have been monitored since 1994. Roadside surveys are conducted from mid-November to mid-January to assess age and sex ratios and the frequency of testicular atrophy in males. The survey route extends from near the 300 Area in the south to the



100-B/C Area in the north and is divided at the Hanford town site into northern and southern regions. Tiller and Poston (2000) found little overlap in the home ranges of deer occupying these two regions.

Five surveys were conducted between mid-November 2008 and early January 2009. A combined total of 566 deer observations were made over the five repeated surveys, which included multiple observations of the same animals in some cases. Individual animals were identified according to sex and age class (fawn or adult). For male deer, the presence of misshapen, velvet-covered antlers was used as an indicator of testicular atrophy.

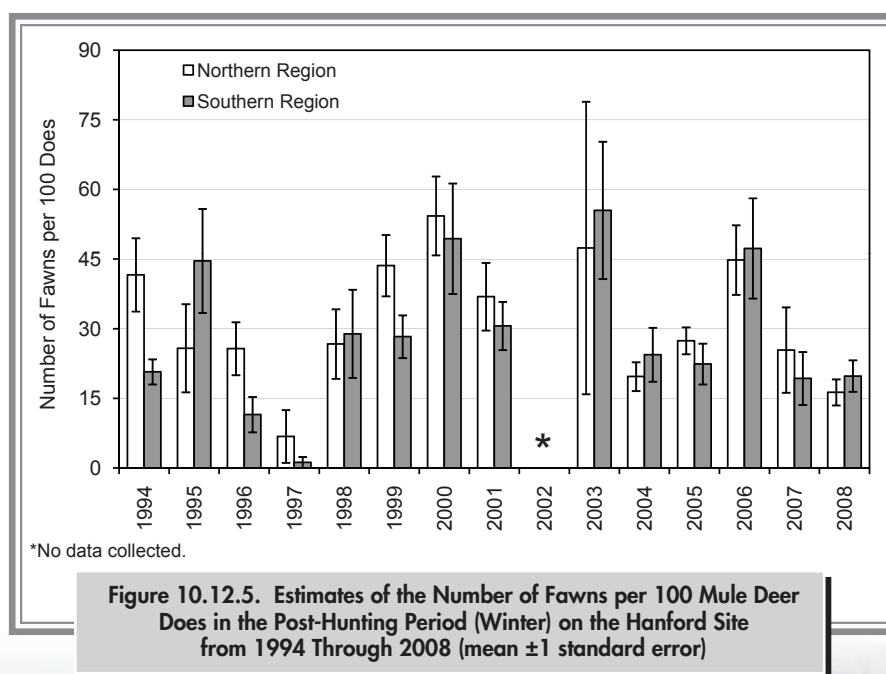
Trends in the ratios of fawns to does over time can be used to monitor changes in mule deer population size and health. The 2008 fawn-to-doe ratios were similar to those observed the previous year (Figure 10.12.5). In 2008, the northern region fawn-to-doe mean estimate was 16 fawns per 100 does, slightly lower than the 25 fawns per 100 does observed in 2007. The southern region mean estimate was 20 fawns per 100 does, which is nearly identical to the 19 fawns per 100 does observed the previous year. Fawn-to-doe estimates over all sampled years were not statistically different



**Figure 10.12.4. Number of Wintering Bald Eagles Observed Along the Hanford Reach of the Columbia River, 1961 Through 2008**

between regions ( $P > 0.05$ ). Hanford Site fawn-to-doe ratios for all survey years (1994 through 2008) are weighted averages, using the total number of fawns and does seen per survey as the weighting factors.

In the early 1990s, testicular atrophy and sterility were observed in some male mule deer on the Hanford Site (Tiller et al. 1997; PNPL-11518). Extensive investigation found no relationships between the presence of testicular atrophy and contaminant levels, diet, disease, or natural conditions such as aging or genetics (Tiller et al. 1997). Testicular atrophy in male mule deer is associated with



**Figure 10.12.5. Estimates of the Number of Fawns per 100 Mule Deer Does in the Post-Hunting Period (Winter) on the Hanford Site from 1994 Through 2008 (mean  $\pm$  1 standard error)**

abnormal antler growth manifested as misshapen, velvet-covered antlers, which can be observed in field surveys. The observed frequency of misshapen antlers in mule deer has ranged from a high of 17% in the southern region in 1998 to a low of 0% in both regions in 2003 (Figure 10.12.6). The decrease from 1998 through 2003 was reversed in 2004, when 12.5% of the northern region and 5% of the southern region male deer were affected. From 2005 to 2007, few affected bucks were observed. In 2008, observations of affected male deer rose slightly over the previous year; the observed frequency of antler abnormality was 1.6% in the northern region and 5.7% in the southern region. These frequencies need to be interpreted with caution because the small sample sizes may not fully reflect population conditions. In general, recent data indicate the health of the male mule deer on the Hanford Site has not substantially changed.

## 10.12.2 Habitat and Species Characterizations

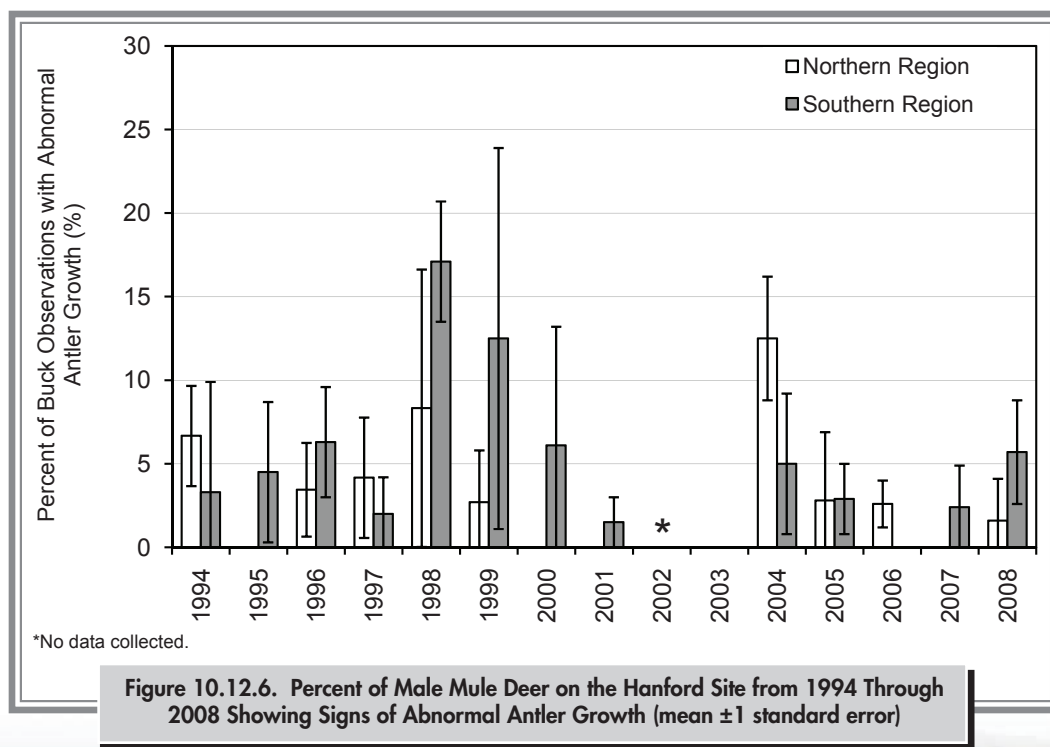
As part of work done to characterize Hanford Site biological resources, efforts in 2008 focused on assessing key wildlife: amphibians using the Columbia River corridor and the

burrowing owl (*Athene cunicularia*)—a Washington State candidate species and federal species of concern. Limited information is available concerning the breeding locations, habitat use, and distribution of amphibian species on the site. Characterization studies in 2008 focused on amphibian breeding habitats to better understand habitat use on the Hanford Site. Burrowing owls were once common during the breeding season in shrub-steppe areas of eastern Washington (Larsen et al. 2004). However, burrowing owls are believed to be declining throughout their historic range. Surveys were conducted in 2007 and 2008 to identify the distribution of burrowing owls on the Hanford Site. The information will be used to identify important breeding habitat for this species and provide DOE with information regarding burrowing owl nest locations to minimize impacts of Hanford Site operations on this priority species.

### 10.12.2.1 Amphibians

JM Becker and BF Miller

Three species of amphibians found on the Hanford Site commonly occur along the Columbia River: the eastern bullfrog (*Rana catesbeiana*), Great Basin spadefoot toad (*Spea intermontana*), and Woodhouse's toad (*Bufo woodhousii*).



Toad species are of particular interest because they are adapted to life in both terrestrial and aquatic environments. For example, work conducted in 2006 documented that breeding occurs in ephemeral pools and sloughs in the riparian zone of the Columbia River from May through July. However, relatively little was known about the location and duration of non-breeding life stages of toads. In 2008, Pacific Northwest National Laboratory staff monitored the post-breeding movements of Woodhouse's toads, a Washington State monitor list species, on the Hanford Site along the Benton County side of the Columbia River using radiotelemetry.

Sixteen adult male Woodhouse's toads were fitted with radio transmitters and tracked from July through October 2008. Movements and habitat use data were collected primarily along the 100-F Area slough of the Columbia River and along the river upstream of the 100-B/C Area, where breeding activity had been documented by Pacific Northwest National Laboratory in previous years. The toads were relocated up to 14 times per week. The majority of toad activity throughout the study period in both areas occurred within 200 meters (650 feet) of the mainstem river or high-water side channel of the slough. During daylight hours, toads spent much of the time either buried in the ground, partially buried in the ground, or sheltered in areas with litter cover accumulations of more than 88% and vegetation height averaging 0.68 meter (2.2 feet). Daily travel to and from breeding pools averaged 25 meters (82 feet). Travel areas were characterized by shorter vegetation (averaging 0.12 meter [0.40 foot] in height) and less litter cover (averaging 25%).

Six Woodhouse's toads were radio-tracked to winter hibernation areas in 2007 and one in 2008. Microhabitat data were collected from these areas and will be included in a descriptive life history analysis of the species scheduled to be published in 2009. Ongoing data collection will enable impacts by current and historical Hanford operations to be monitored and sensitive riparian ecosystems to be protected along the Hanford Reach.

## 10.12.2.2 Burrowing Owls

### KB Larson

Populations of burrowing owls are believed to be declining in several portions of their breeding range in North America (Wellicome and Holroyd 2001; Dechant et al. 2002; Klute et al. 2003), including Washington State (Smith et al. 1997; Conway and Pardieck 2006). Burrowing owls are federally listed as a Species of National Conservation Concern and listed as either endangered, threatened, or a species of concern in nine states (Klute et al. 2003). Currently in Washington State, burrowing owls are a candidate species for listing as either a state threatened or endangered species. Primary causes for population declines throughout North America include habitat loss and degradation due to land development and declines of burrowing mammal populations.

Burrowing owls have not been monitored routinely on the Hanford Site, and existing information regarding burrowing owl distribution and population status on the site was obtained incidentally through other raptor surveys (PNL-3212) and field work (BNWL-1790). The first surveys intended specifically to locate burrowing owls on the Hanford Site were conducted along a portion of the 1200-ft road on the Fitzner/Eberhardt Arid Lands Ecology Reserve between 2001 and 2004 by the U.S. Geological Survey (Conway et al. 2002, 2003, 2004, 2005). The U.S. Fish and Wildlife Service conducted additional surveys in 2004 and 2005 on the Saddle Mountain and Wahluke Units of the Hanford Reach National Monument.<sup>(a)</sup>

Pacific Northwest National Laboratory conducted roadside surveys on the Hanford Site to estimate burrowing owl nest density during the 2007 and 2008 breeding seasons. Driving surveys were conducted during 2007 because this is an efficient method for locating burrowing owls over large areas (Conway and Simon 2003). Call-broadcast point counts using pre-recorded burrowing owl calls were used in hopes of improving burrowing owl detection during 2008 (Conway and Simon 2003). Both survey techniques were designed to assess burrowing owl population changes over

(a) Newsome H. 2008. Telephone call to H Newsome (Biologist, U.S. Fish and Wildlife Service) from K Larson (Pacific Northwest National Laboratory), March 18, 2008.



time. "Nests" were defined as burrows in which one or more burrowing owls were observed on two or more occasions. Nine different driving routes were surveyed between May 4 and July 5, 2007; six were on the central Hanford Site, and three were on the Hanford Reach National Monument (Figure 10.12.7). Fourteen call-broadcast routes were surveyed between April 4 and August 23, 2008. Both driving and call-broadcast routes were surveyed at least twice during the breeding season.

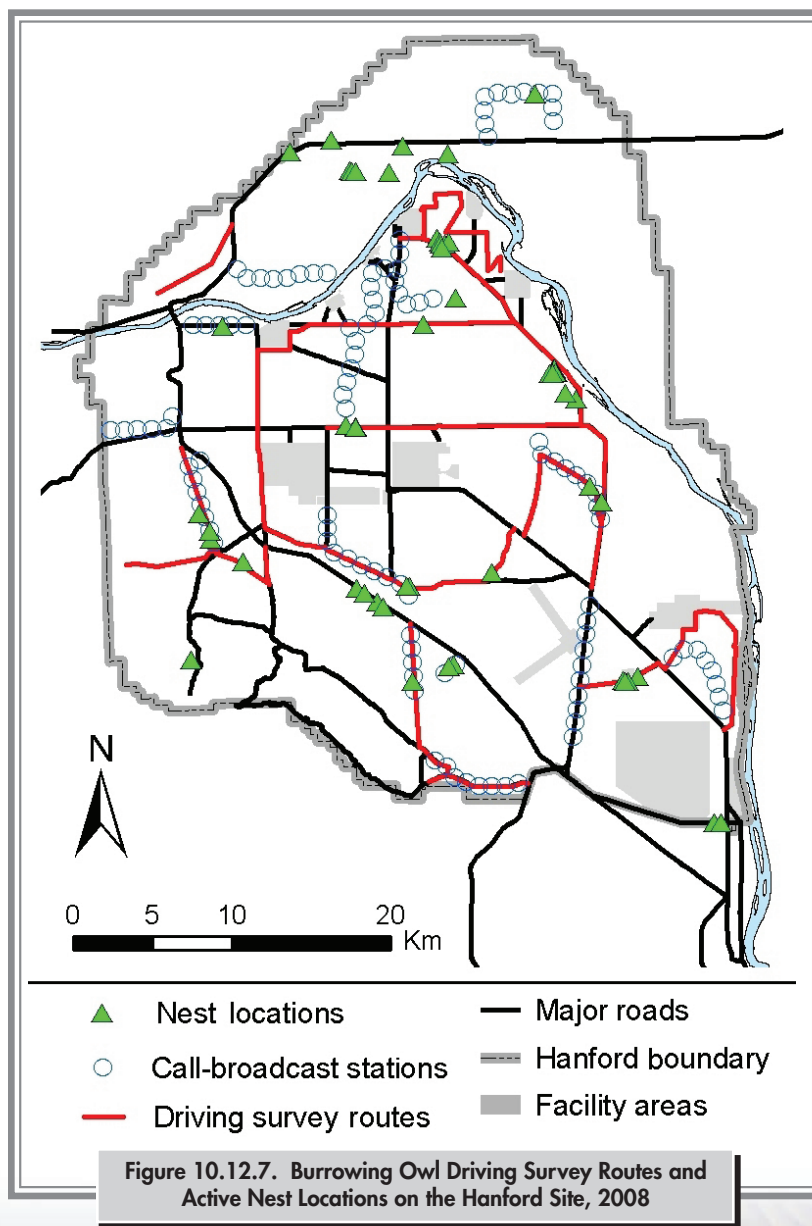
Four nests were detected in 2008 during the call-broadcast surveys, resulting in an estimated density of 0.11 burrowing

owl nests per square kilometer (0.4 square mile). This compares to seven nests detected in 2007, with a resulting estimated density of 0.22 burrowing owl nests per square kilometer (0.4 square mile). In addition to the roadside surveys, other active nests were monitored that had either been located incidentally during other surveys or were previously known nesting locations. An additional 9 nests were monitored in 2007, while 13 were observed in 2008.

In summary, a total of 53 burrowing owl nest locations were documented on the Hanford Site between 2005 and 2008 by Pacific Northwest National Laboratory and the U.S. Fish

and Wildlife Service (Figure 10.12.7). Burrowing owls appear to be widely distributed across the site and occur in a variety of habitats, including areas near roads, human facilities, and in recently burned areas. Burrowing owl nests were primarily found in abandoned badger burrows, although some nested in artificial structures such as old irrigation pipes and road culverts. There is also evidence of nest site fidelity with many nest locations being reused at least once over the 3 years. In addition, new nests were often discovered near (approximately 1.5 kilometers [0.9 mile] or less) locations that had been occupied in previous years. Although it cannot be confirmed that the same owls were present from year to year because individuals were not marked, burrowing owls are known to demonstrate high site fidelity in eastern Washington (Conway et al. 2005) and throughout their range (Klute et al. 2003).

Roadside survey results should be interpreted with caution with respect to assessing burrowing owl population change. Annual breeding season surveys would need to be continued for more than 2 years to accurately assess long-term population trends. Surveys do indicate that burrowing owls are relatively rare on the Hanford Site. Long-term results from the North American Breeding Bird Survey indicate that burrowing owls have declined 1.5% annually in eastern Washington (Conway and Pardieck 2006). However,



the breeding bird survey methods are not considered well suited for monitoring burrowing owls because of the owl's cryptic behavior and low densities. Surveys designed specifically to locate burrowing owls would provide state and federal agencies with needed information regarding the population status of this sensitive species.

### 10.12.3 Ecological Monitoring on Long-Term Plots

JL Downs

Long-term monitoring plots, established as part of the *Hanford Site Biological Resources Management Plan* (DOE/RL-96-32, Rev. 0), are surveyed periodically to determine the status of biological populations and resources on the Hanford Site. Thirty original plots, each with outside dimensions of 1 kilometer (0.62 mile) by 200 meters (0.12 mile), were initially surveyed during 1996 to characterize vegetation and bird use. Since 1996, five more plots have been added to address specific habitats, such as riparian areas and abandoned fields. Surveys also have been conducted on selected long-term monitoring plots to provide data to evaluate changes in plant and animal communities after fires and to measure the abundance and diversity of small mammals in priority habitats. As part of ongoing monitoring activities, selected plots on the Hanford Central Plateau were surveyed during 2005 (PNNL-15892). No data were collected on long-term monitoring plots during 2008 because of funding reductions.

### 10.12.4 Monitoring of Fish and Wildlife for Hanford Site-Produced Contaminants

JA Stegen and RE Durham

In 2008, several types of wildlife and fish were collected at locations on and around the Hanford Site (Figure 10.12.8) as part of routine monitoring for site-produced contaminants. Fish and wildlife were also collected at locations distant from the site to obtain reference (background) contaminant measurements. Tissue samples from these organisms were analyzed for selected radionuclides and metals that are suspected or known to be present on the

Hanford Site (Table 10.12.1). Monitoring continues to assure regulatory agencies that the consumption of fish and wildlife obtained from the site environs does not pose a threat to humans and provides long-term trends on contaminants in selected components of the ecosystem.

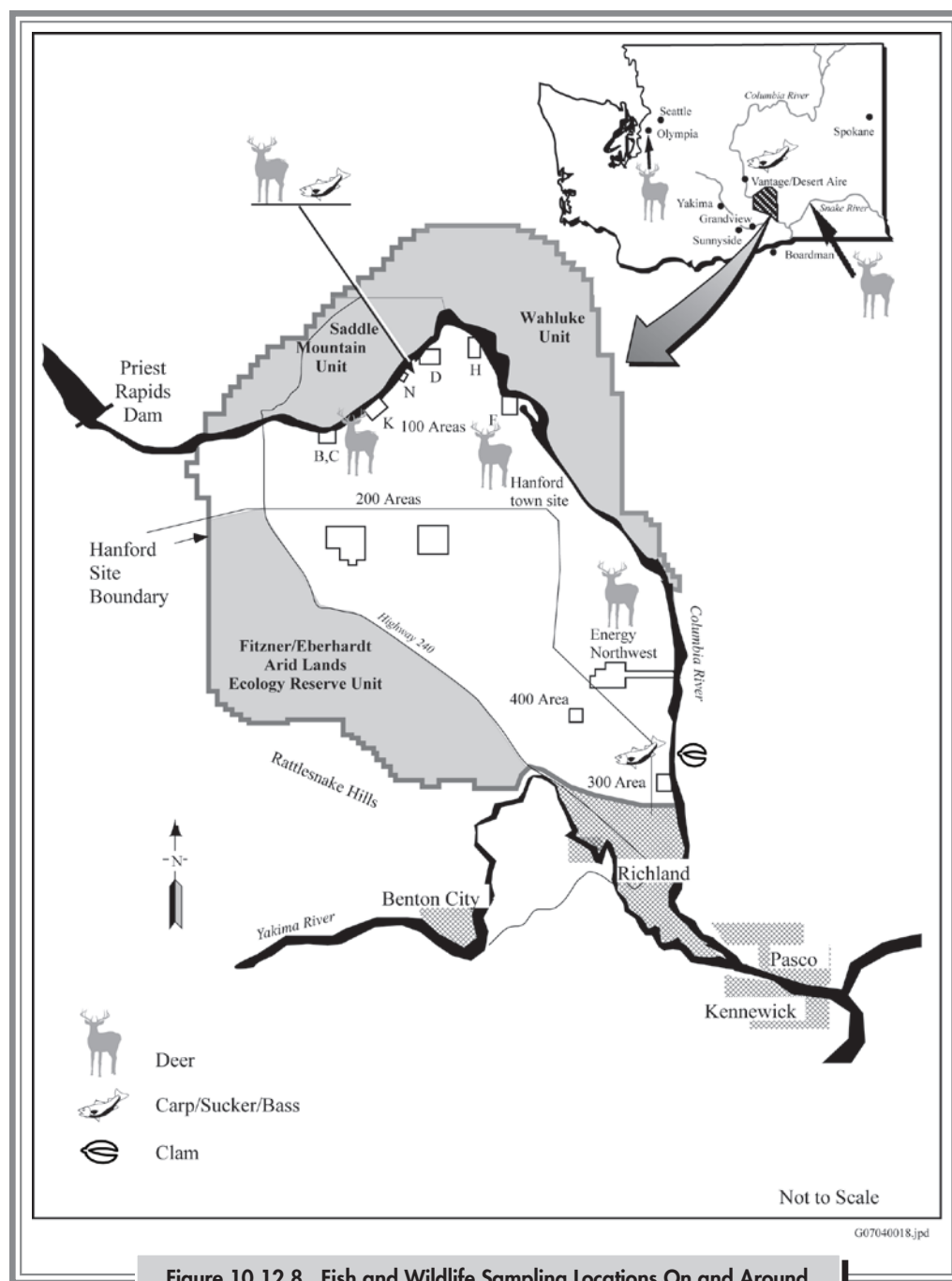
Fish and wildlife samples collected on or near the Hanford Site for routine human-exposure pathway assessments are obtained annually, but specific species are only sampled every 2 or 3 years. Samples obtained at locations believed to be unaffected by Hanford Site effluent and emissions are collected approximately every 5 years.

In 2008, all routine fish and wildlife samples collected were monitored for strontium-90 contamination and were analyzed by gamma spectrometry to detect a number of gamma emitters (Appendix F), including cesium-137. Since the 1990s, strontium-90 and cesium-137 have been the most frequently measured radionuclides in fish and wildlife samples collected on the Hanford Site.

Strontium-90 is chemically similar to calcium; consequently, it accumulates in hard tissues rich in calcium such as bones and antlers. Strontium-90 has a biological half-life in hard tissue of 14 to 600 days (PNL-9394). Hard-tissue concentrations may profile an organism's long-term exposure to strontium-90. However, strontium-90 generally does not contribute much to human dosage because it does not accumulate in edible portions of fish and wildlife. Strontium-90 is present in the Hanford Site environs as a result of atmospheric fallout from nuclear weapons testing and past site operations and waste disposal practices. Currently, contaminated groundwater entering the Columbia River via shoreline springs in the 100-N and 100-H Areas is the primary source of site-produced strontium-90 measurable in the Columbia River; however, the current contaminant contribution relative to historical fallout from atmospheric weapons testing is small (<2%) (PNL-8817).

Cesium-137 is particularly important to the human food chain because it is chemically similar to potassium and is found in the muscle tissues of fish and wildlife. Having a relatively short biological half-life (<200 days in muscle and <20 days in the gastrointestinal tract [PNL-9394]), cesium-137 is an indicator of recent exposure to radioactive materials. Cesium-137 is present in the environment as a





**Figure 10.12.8. Fish and Wildlife Sampling Locations On and Around the Hanford Site, 2008**

result of past Hanford Site operations and waste disposal practices as well as historical worldwide fallout from nuclear weapons testing.

Gamma spectrometry results for most radionuclides are not discussed here because concentrations were too low

to be detected by the analytical laboratory, or measured concentrations were considered artifacts of low background counts. Low background counts occur at random intervals during sample counting and can produce false-positive results.

**Table 10.12.1. Routine Site-Wide and Offsite Fish and Wildlife Sampling Locations and Analyses, 2008**

<b>Biota</b>	<b>No. of Offsite Locations</b>	<b>No. of Onsite Locations</b>	<b>No. of Analyses</b>		
			<b>Gamma</b>	<b>Strontium-90</b>	<b>Trace Metals</b>
Fish (carp and sucker)	1 <sup>(a)</sup>	2	15	15	10
Fish (bass)	1 <sup>(a)</sup>	2	14	14	14
Big game (deer)	2 <sup>(b)</sup>	3	12	12	3

(a) Samples collected near the Desert Aire/Vantage, Washington.  
(b) Black-tailed deer collected near Olympia, Washington, and white-tailed deer collected near Pasco, Washington.

Several trace metals associated with Hanford Site operations have the potential to accumulate in certain fish and wildlife tissues. These metals are potential contaminants of concern (e.g., cadmium, chromium, lead, mercury, and uranium), particularly along Hanford's Columbia River shoreline where contaminated groundwater flows into the river (PNNL-14295). The metals analyzed in the 2008 biota samples are consistent with those identified in the 100 Areas and 300 Area sampling and analysis plan (DOE/RL-2005-42, Rev. 1) and associated data-quality objective summary report (BHI-01757, Rev. 0).

Historical operations on the Hanford Site resulted in the production of both radiological and non-radiological wastes containing metals. Liquid and solid wastes harboring metals were placed in various disposal sites on the Hanford Site, including trenches, cribs, ditches, ponds, and underground storage tanks (PNNL-13487). Fly ash, produced by burning coal to fuel steam/power plants associated with each reactor, contained trace metals and naturally occurring radionuclides that were released to the atmosphere and may have been deposited on the soil around the reactors. Other sources of metals related to Hanford Site operations include those used in the treatment of water used in the reactors (e.g., chromium for treating pipe corrosion; iron or aluminum flocculants for removing dissolved solids), and metals released from studies (e.g., animal testing in the 100-F Area).

Other sources have contributed trace metals to the Hanford Site environment. Trace metals generated from upriver mining and smelting have been transported down the Columbia River (Johnson et al. 1990) into the Hanford Reach. Also, contaminants associated with past and

present agricultural practices have added to the metals inventory on the Hanford Site (Yokel and Delistraty 2003). For example, arsenic is likely associated with historical applications of lead arsenate on fruit orchards prior to World War II. Lead arsenate was once the most commonly used insecticide in fruit orchards. Studies that examined the extent of arsenic contamination in pre-World War II orchard soil near the 100 Areas showed elevated levels of arsenic compared to levels in soil from background locations (Yokel and Delistraty 2003).

Organisms can accumulate metals through incidental soil ingestion, by drinking contaminated water, and by consuming contaminated foods. The spatial variability of concentrations of metals in the environment is influenced by both natural background sources and the industrial sources described above. Consequently, organism exposures and thus tissue concentrations can vary between locations. This variability can produce some uncertainty as to the source of the metals within the sampled organism. To evaluate the Hanford Site's contribution to levels of metals in biota collected onsite or in the Hanford Reach, background samples were also collected from the Columbia River upstream of the site and from other areas distant from the site. Differences between metals concentrations in background samples and concentrations in Hanford Reach or Hanford Site samples are indicative of the contribution of Hanford Site activities.

Fish and wildlife species sampled and analyzed during 2008 for radionuclides and trace metals included sucker (*Catostomus* species), common carp (*Cyprinus carpio*), smallmouth bass (*Micropterus dolomieu*), and mule deer

(*Odocoileus hemionus*) (Figure 10.12.8). In addition, Asiatic clam (*Corbicula fluminea*) samples were collected near the 300 Area for uranium analysis. Data results are summarized in the following sections. Individual results and their associated analytical uncertainties are provided in PNNL-18427, APP. 1.

#### 10.12.4.1 Analytical Results for Fish Samples

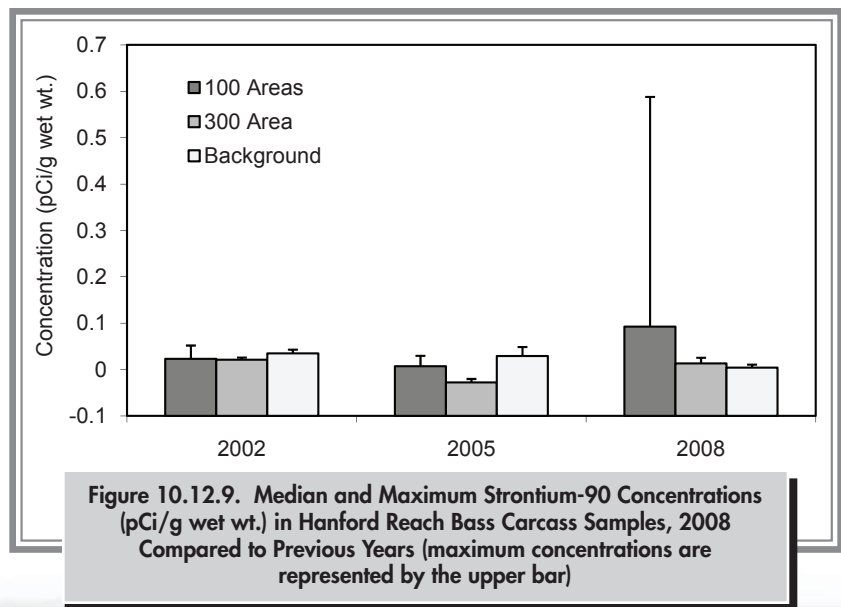
Fishing is a popular activity along the Hanford Reach of the Columbia River. Fish, such as bass, carp, and suckers, are occasionally harvested for food and could potentially contribute to human exposure to contaminants. When possible, carp were sampled; however, when carp could not be collected, suckers were collected instead. Suckers and carp are both bottom feeders that are likely moving up and down the Hanford Reach. Bass are carnivorous and mainly feed on invertebrates and fish. Carp, suckers, and bass may be exposed to metals and persistent radionuclides in the Columbia River environment.

During 2008, four carp and six suckers were collected from two locations in the Hanford Reach: five from the region between the 100-N and 100-D Areas and five from near the 300 Area (Figure 10.12.8). Additionally, five carp were collected at an upstream background location near Desert Aire, Washington, in 2008. Five smallmouth bass were collected in 2008 in the region between the 100-N and 100-D Areas, four were collected near the 300 Area, and five were collected from an upstream reference area near Desert Aire, Washington (Figure 10.12.8). Fillets and the eviscerated remains (carcasses) of the fish were analyzed for a variety of radiological contaminants, and liver samples were analyzed for 17 trace metals.

**Cesium-137.** Cesium-137 results were below the analytical detection limit (0.03 pCi/g [0.001 Bq/g] wet weight) in all fish-fillet samples collected in 2008. These results are consistent with those reported throughout the past 10 years that indicated a gradual decline in cesium-137 levels in fish both at background locations and near the Hanford Site.

**Strontium-90.** Strontium-90 was not detected in carp or sucker carcass samples collected onsite or at the background location. Strontium-90 was detected in three bass samples collected between the 100-N and 100-D Areas. The maximum strontium-90 concentration in bass carcass samples collected between the 100-N and 100-D Areas (0.588 pCi/g [0.022 Bq/g] wet weight) in 2008 was elevated compared to maximum strontium-90 concentrations in bass collected in previous years (Figure 10.12.9).

**Trace Metals.** Liver samples from five bass collected between the 100-N and the 100-D Areas and four collected near the 300 Area were analyzed for 17 trace metals in 2008. Concentrations in these samples were compared to concentrations in five bass samples collected upstream of the Hanford Site near Desert Aire, Washington, during 2008 and bass samples collected near Desert Aire in 2005. Antimony and beryllium were not detected above method detection limits in samples collected from anywhere in the Hanford Reach in 2008 (Appendix C, Table C.12; PNNL-18427, APP. 1). Maximum concentrations of aluminum, arsenic, cadmium, mercury, and selenium were elevated in samples collected from the 300 Area compared to maximum concentrations of these metals in bass collected in the 300 Area in 2005 and in bass collected near Desert Aire in 2005 and 2008 (PNNL-15892, APP. 1; Appendix C, Table C.12). Maximum concentrations of aluminum, arsenic, cadmium, chromium, copper, lead, manganese,



mercury, nickel, selenium, silver, thallium, thorium, uranium, and zinc in bass collected between the 100-N and 100-D Areas were similar to or less than maximum concentrations of these metals in bass collected near Desert Aire in 2008.

Liver samples from two carp and one sucker collected near the 300 Area and two carp collected between the 100-N and 100-D Areas on the Hanford Reach were analyzed for 17 trace metals during 2008. Liver samples from five carp collected at a reference location upstream of Priest Rapids Dam near Desert Aire, Washington, were also analyzed in 2008. Trace metal concentrations measured in samples collected in the Hanford Reach in 2008 were compared to concentrations in carp samples collected at the reference site in 2008 and 2006 (Appendix C, Table C.13; PNNL-16623, APP. 1). For most trace metals, the maximum and median concentrations in samples collected on the Hanford Site were the same as or below concentrations in samples collected at the reference location near Desert Aire in 2006 and 2008. Antimony, beryllium, and thorium were not detected above the analytical detection limit in carp/sucker samples at any location in 2008 (Appendix C, Table C.13). Maximum concentrations of copper, silver, and zinc in liver samples from fish collected near the 300 Area were elevated compared to maximum concentrations in liver samples from fish collected from the reference location in 2006 and 2008. The maximum concentration of cadmium in liver samples from fish collected between the 100-N and 100-D Areas was elevated compared to concentrations in liver samples from fish collected from the reference location in 2006 and 2008.

As the above discussion indicates, the surveillance data set for metals in fish on and near the Hanford Site is relatively small and results are variable. In addition, no established state or federal adverse-effects values (i.e., benchmark criteria) are available for metals concentrations in fish tissue. Therefore, it is difficult to draw conclusions regarding relative contributions of sources of contamination and effects on the species sampled.

#### 10.12.4.2 Analytical Results for Deer Samples

Studies of mule deer populations residing on the Hanford Site indicate their division into three relatively distinct

populations (Tiller and Poston 2000): north (deer that live in the 100 Areas); south (deer that reside from the Hanford town site south to the 300 Area); and central (deer living around the 200 Areas, away from the Columbia River). Deer can be exposed to metals and persistent radionuclides when they forage on plants whose roots have access to contaminated groundwater or soil, drink contaminated water, or incidentally ingest contaminated soil. Deer hunting is not allowed above the high water mark on the Benton County side of the Columbia River (on the Hanford Site), but the river is not a barrier to deer movements. Deer captured and tagged on the Hanford Site have been legally killed by hunters on the Hanford Reach shoreline below the high water mark and across the Columbia River in Franklin County. Harvesting deer for food could potentially contribute to human exposure to contaminants.

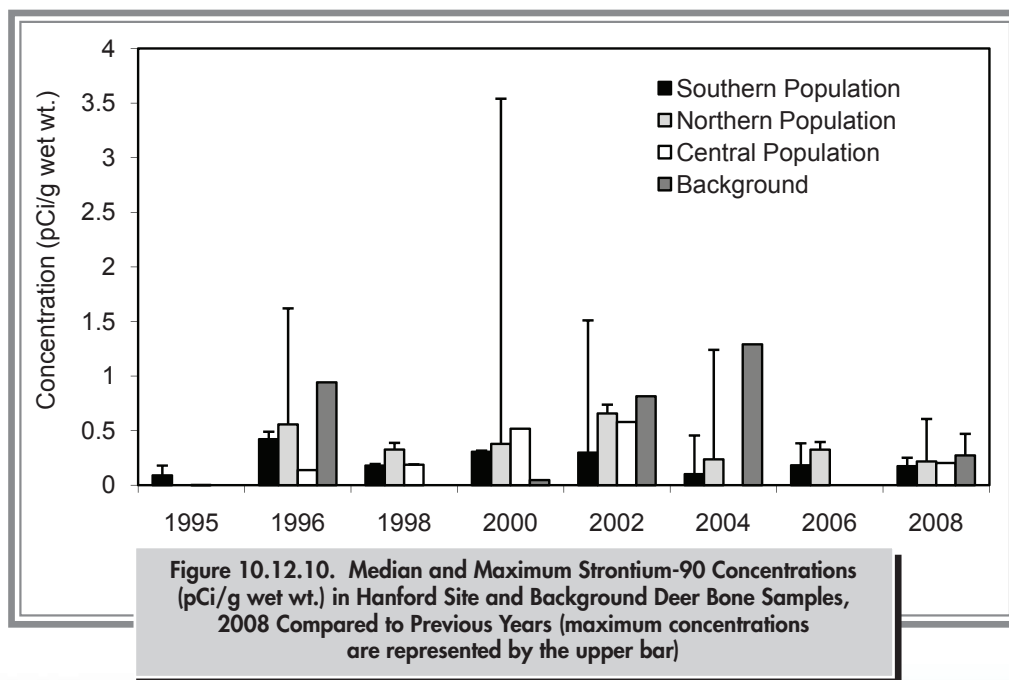
Radionuclide levels in 10 deer collected on the Hanford Site in 2007 and 2008 were compared to concentrations in a black-tailed deer collected from Olympia, Washington, by the Washington Department of Fish and Wildlife and a white-tailed deer donated by a hunter outside of Pasco, Washington, in 2008. In 2008, three deer were collected from the northern-area population, one deer was from the central-area population, and five were collected from the southern-area population. One deer was opportunistically collected near the 100-N Area in 2007. Results from deer collected in 2008 were also compared to deer samples collected in previous years from reference locations that are distant from the site and to results reported for the preceding 10-year period. The comparisons with samples from distant locations are useful in evaluating the Hanford Site's relative contribution of radionuclides in deer.

**Cesium-137.** Cesium-137 was not detected (at or  $<0.03$  pCi/g [0.001 Bq/g] wet weight) in any of the 10 deer muscle samples collected on the Hanford Site in 2007 and 2008. These results are consistent with a decline in cesium-137 levels in wildlife examined from the preceding 15 years. In this time period, the highest level of cesium-137 was measured in the background deer sample collected in 1996 from Vail, Washington. The deer collected in Vail inhabited mountain regions that received more rainfall (and more atmospheric fallout) than the Hanford Site, which increased background levels of fallout radionuclides in the mountain (Tiller and Poston 2000).

**Strontium-90.** Concentrations of strontium-90 measured in the deer samples collected onsite in 2007 and 2008 ranged from 0.121 pCi/g (0.004 Bq/g) wet weight to 0.607 pCi/g (0.02 Bq/g) wet weight. The highest concentration of strontium-90 (0.607 pCi/g [0.02 Bq/g] wet weight) reported onsite in 2007 and 2008 was from a deer collected from the northern population near the 100-N Area. In general, concentrations of strontium-90 appear to be elevated in deer collected from the northern population, when compared to deer collected elsewhere onsite. In 1992, the highest concentration of strontium-90 measured in deer bone onsite (20.8 pCi/g [0.77 Bq/g] wet weight) was reported from a deer collected near the 100-N Area (PNNL-13487, Section 4.5). The apparently higher concentrations reported in deer bone from the northern area may indicate some exposure to localized, low-level contamination in the 100-N Area. The black-tailed deer sample collected near Olympia, Washington, in 2008 had a strontium-90 concentration of 0.471 pCi/g (0.018 Bq/g) wet weight. The concentration of strontium-90 reported for the white-tailed deer sample collected near Pasco, Washington, in 2008 was 0.07 pCi/g (0.003 Bq/g) wet weight. The highest concentration of strontium-90 in the background samples from deer collected before 2008 was 2.06 pCi/g (0.08 Bq/g) wet weight (Figure 10.12.10).

**Trace Metals.** Liver samples from two mule deer collected from the northern population, one mule deer collected from the central population, and one black-tailed deer collected near Olympia, Washington, were analyzed for trace metals in 2008. Concentrations measured in Hanford Site deer were compared to concentrations in black-tailed deer collected in 2002, 2004, and 2008 near Olympia (PNNL-15222, APP. 1; PNNL-16623, APP. 1; Appendix C, Table C.14).

Most trace metal concentrations in liver samples collected from deer on the Hanford Site in 2008 were similar to or less than concentrations measured in a liver sample from the deer collected near Olympia (Appendix C, Table C.14). Antimony, beryllium, nickel, thallium, and uranium were not detected above analytical detection limits in samples collected on the Hanford Site in 2008. The maximum concentrations of aluminum, copper, and lead measured in the deer liver samples collected from the northern population were elevated compared to the concentrations measured in reference samples collected in 2002, 2004, and 2008 and previous onsite samples. Cadmium and selenium levels were elevated in samples collected onsite compared to concentrations in reference samples collected in 2002, 2004, and 2008. These results are consistent with deer samples



collected onsite in 2004 and 2006 (PNNL-15222, APP. 1; PNNL-16623, APP. 1). The maximum concentration of cadmium and selenium measured in the samples collected onsite in 2008 was at least two times higher than the maximum concentrations measured in all reference samples (Appendix C, Table C.14; PNNL-15222, APP. 1; PNNL-16623, APP. 1).

### 10.12.4.3 Analytical Results for Clam Samples, 300 Area Special Study

Uranium concentrations were measured in clam soft tissue and shell samples collected in situ (i.e., resident clams) near Spring 9, Spring 10, and at a control site in the 300 Area (Figure 10.12.11), as well as in “clean” clams transplanted from the Priest Rapids Hatchery upstream of the Hanford Site on the Columbia River. The control site, located approximately 800 meters (2,625 feet) upstream of Spring 9, was outside of the influence of the 300 Area uranium groundwater plume (Figure 10.12.11). Clams transplanted from the background location had no known history of exposure to elevated concentrations of uranium or other Hanford Site contaminants.

Nine clam enclosures were placed in groups of three at Spring 9, Spring 10, and the control site near the 300 Area in January 2008. Natural substrate, consisting of small- to medium-size cobble, was placed into each enclosure before stocking each enclosure with approximately 100 clams (size class greater than 22 millimeters [0.9 inch]) collected from the background location. Enclosures at each location were placed 1.5 to 3 meters (5 to 10 feet) apart at similar riverbed elevations.

Clams were collected from January 25 through February 8, 2008 (day 1 through day 14). Samples of soft tissue and shell were collected from resident clams and enclosure clams throughout the 2-week period. Each sample of soft tissue or shell taken throughout the study was a composite from two to five individual clams. Approximately equal numbers of clam samples were collected during low and high river stages, which were considered uranium pulse and non-pulse events, respectively. Samples of soft tissue and shell were also collected from resident clams and enclosure clams on September 8, 2008 (day 224).

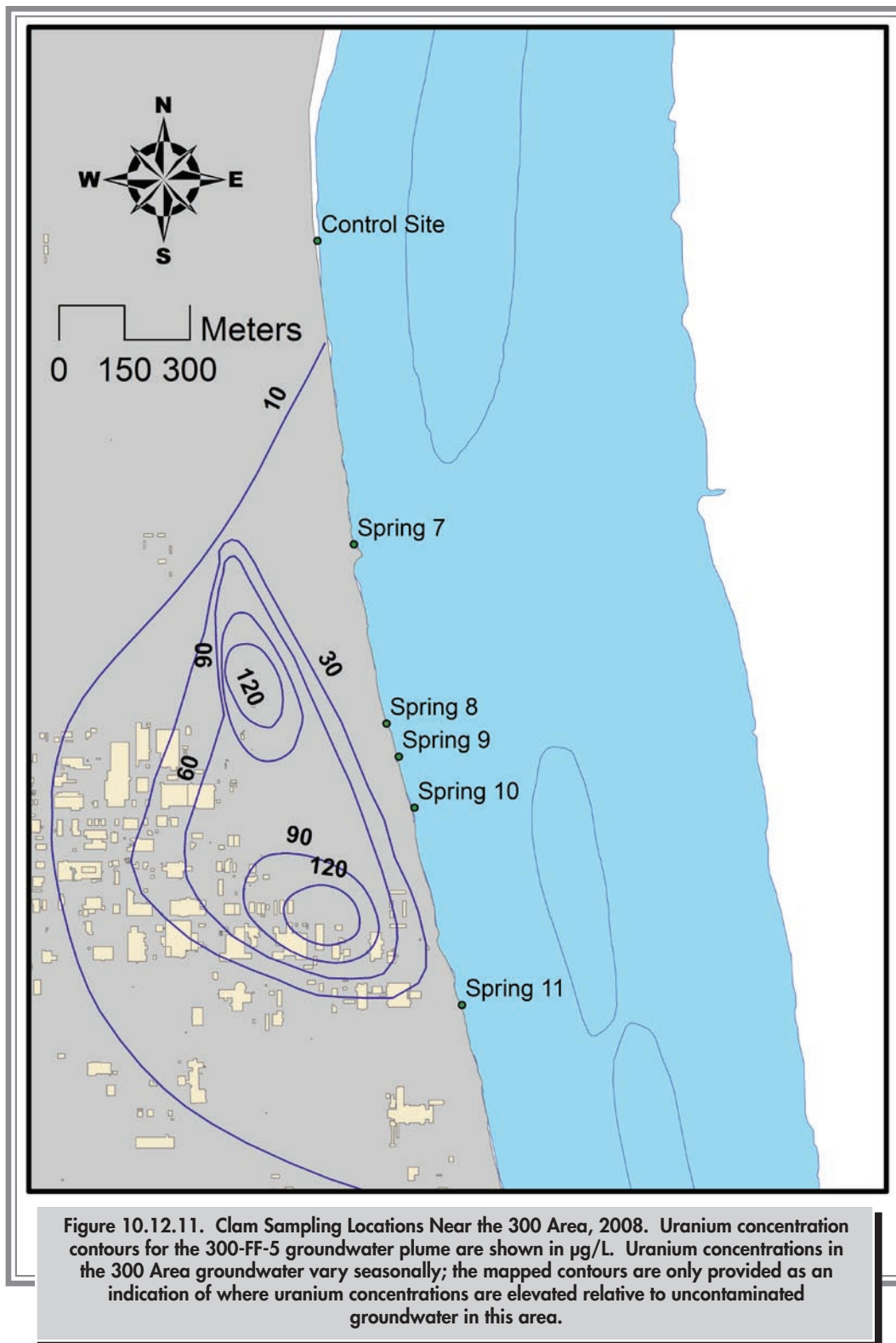
### Soft Tissue

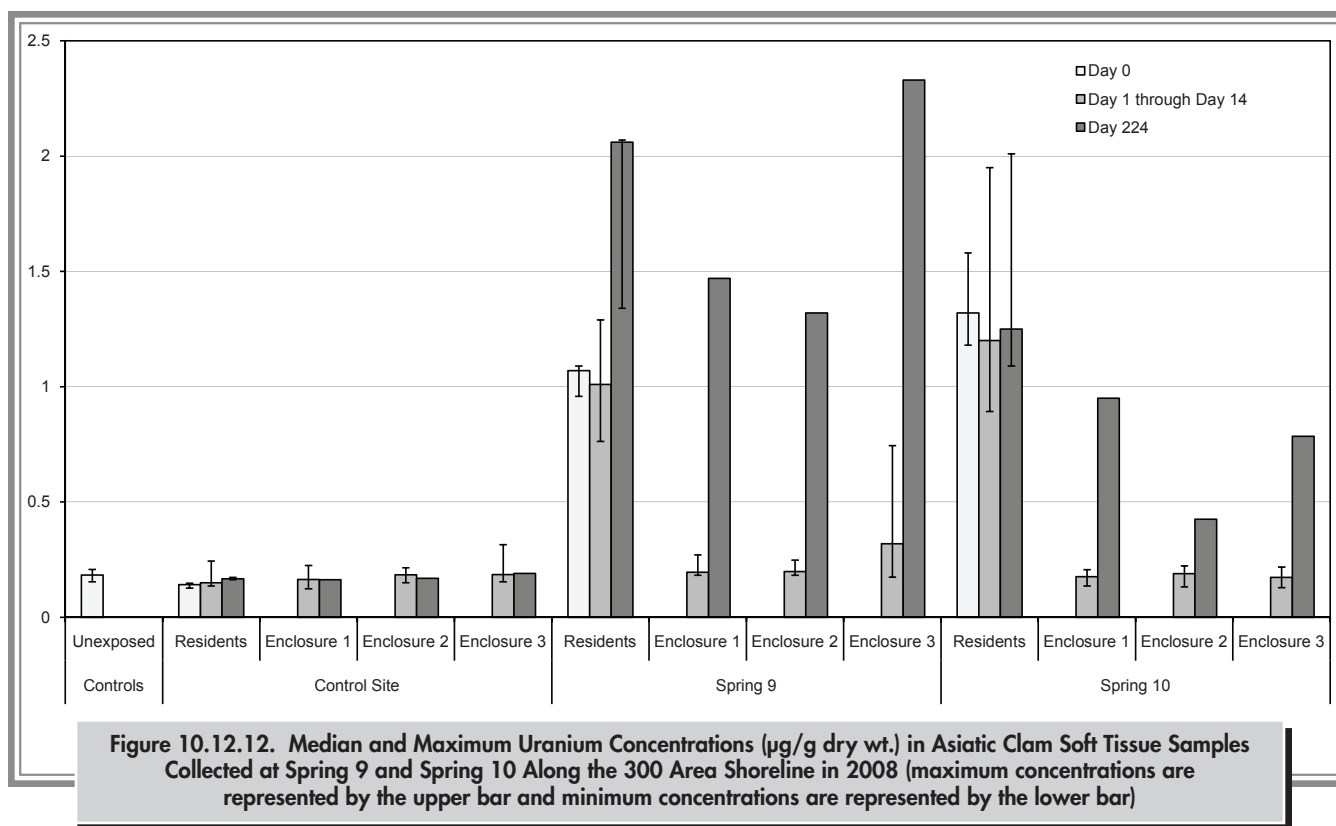
Median and maximum uranium concentrations in soft tissue samples collected from resident clams at the control site during the 2-week period were similar to the median and maximum concentrations observed for enclosure clam samples at the control site during the same period and “unexposed background” clams at day 0 (Figure 10.12.12 and Table C.15). Median and maximum soft tissue concentrations in resident clams near Spring 9 and Spring 10 were three to nine times higher than the median and maximum concentrations in resident clams at the control site. Concentrations in soft tissue clam samples from enclosures 1 and 2 at Spring 9 and all enclosures at Spring 10 were similar to concentrations observed from enclosure clams at the control site. However, median and maximum concentrations in samples from enclosure 3 at Spring 9 were elevated compared to concentrations observed in enclosure samples at the control site. Uranium concentrations observed in the soft tissue of resident and enclosure samples collected at the control site in September 2008 were less than or similar to concentrations in soft tissue samples collected at the control site in January and February 2008 (Figure 10.12.12 and Table C.15). Concentrations measured in soft tissue samples from all resident and enclosure clams from Spring 9 and Spring 10 in September 2008 ranged from being comparable to those collected in January and February to more than five times greater. Uranium concentrations observed in soft tissue samples obtained from resident clams at Spring 9 and Spring 10, as well as all enclosure clams at Spring 9, were elevated compared to soft tissue sample concentrations from the Spring 10 enclosures.

### Shells

Uranium concentrations observed in shell samples from Spring 9 and Spring 10 resident clams were elevated throughout the study compared to shell sample concentrations from the control site (Figure 10.12.13 and Table C.15). Uranium concentrations in samples collected in February 2008 from all enclosures were comparable to concentrations observed in exposure clams from the control site and in “unexposed” clams from the background location, with the exception of enclosure 3 at Spring 9, which was elevated. In September 2008, concentrations observed in shell samples from all enclosures at Spring 9 and







Spring 10 were 1.5 to 10 times higher than shell samples measured in February. Concentrations of uranium in shells from enclosure 1 and enclosure 2 at Spring 9 were less than that observed in resident clams collected from the same location in September. Concentrations in the shells from enclosure 3 at Spring 9 were elevated compared to those observed in resident clams at the same location, but it was similar to the resident clam maximum concentration measured in January and February. Uranium concentrations in shell samples from the Spring 10 enclosures were less than half the concentrations observed in shells from resident clams collected at the same location.

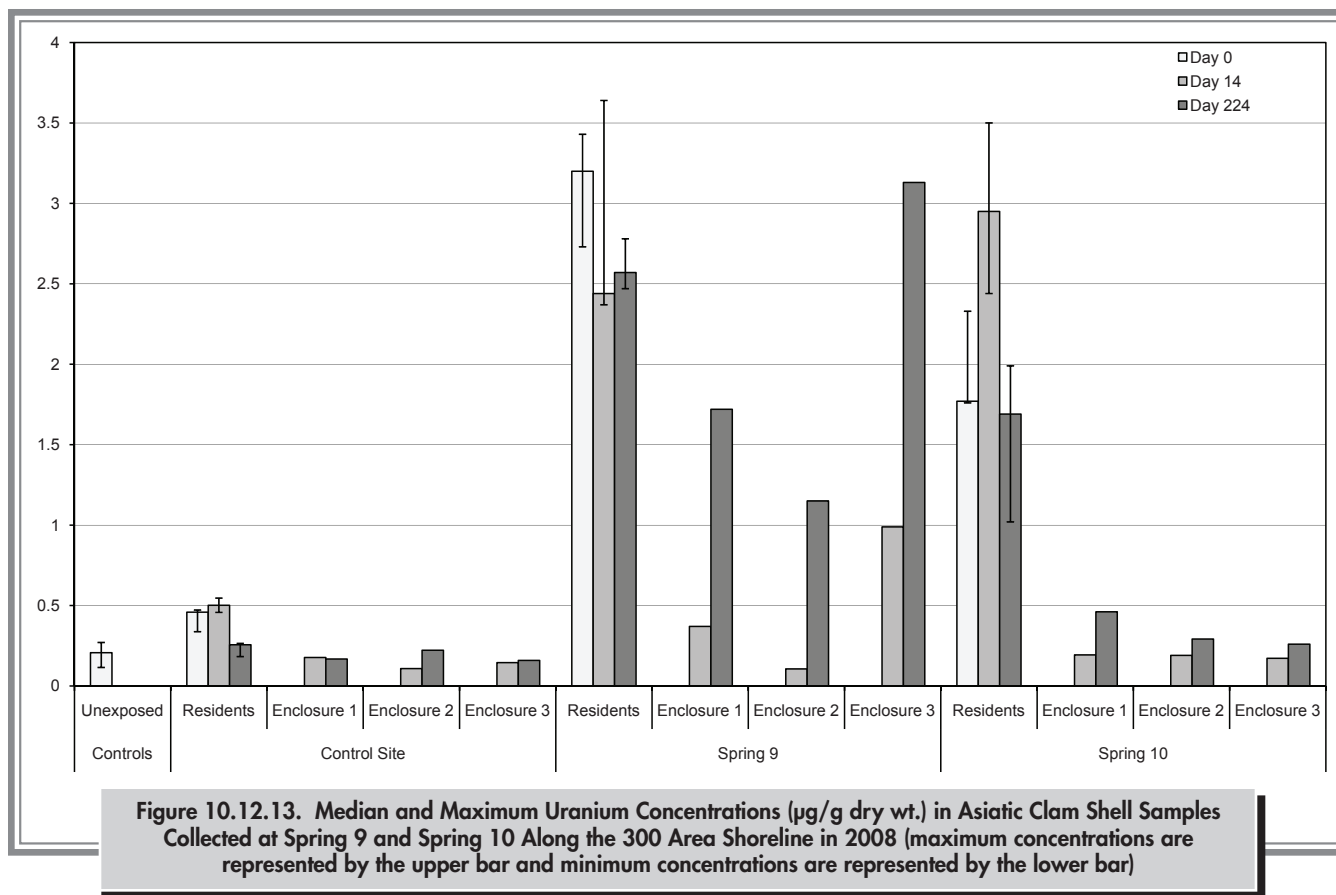
### 10.12.5 Control of Pests and Contaminated Biota

AR Johnson, RC Roos, JG Caudill,  
JM Rodriguez, RF Giddings, NP Daniel,  
JW Wilde, and TM Kilpatrick

Animal species such as the domestic pigeon (*Columba livia*), Northern pocket gopher (*Thomomys talpoides*), house mouse

(*Mus musculus*), and deer mouse (*Peromyscus maniculatus*) must be controlled when they become a nuisance or a health problem, or if they become contaminated with radioactivity. Biological control personnel responded to approximately 33,000 animal control requests (ranging from requests to remove animals within radioactive waste facilities to insect invasions of work areas) from Hanford Site employees in 2008. Approximately 3,100 trap or bait stations were used to control populations of animals in and near site facilities and offices.

During 2008, 33 contaminated animals or animal-related materials were discovered. This is approximately 28% less than the peak number of 46 in 1999 and 2 less than the total for 2007. Flying insects and insect-related materials (e.g., harvester ants and mud-dauber wasp nests) collected during operations on the Hanford Site are monitored for radiological contaminants. None of the contaminated animal samples collected in 2008 were related to insects.





## 10.13 External Radiation Monitoring

External radiation is defined as radiation originating from a source external to the human body. In 2008, external radiation on the Hanford Site was monitored onsite in relative proximity to known, suspected, or potential radiation sources. Sources of external radiation on the Hanford Site include waste materials associated with the historical production of plutonium for defense; residual nuclear inventories in former production and processing facilities; radioactive-waste handling, storage, and disposal activities; waste cleanup and remediation actions; atmospheric fallout from historical nuclear weapons testing; and natural sources such as cosmic radiation. During any given year, external radiation levels can vary from 15% to 25% at any location because of changes in soil moisture and snow cover (National Council on Radiation Protection and Measurements 1975).

The Harshaw<sup>TM(a)</sup> thermoluminescent dosimeter (TLD) system is used to measure external radiation on the Hanford Site. This system includes the Harshaw 8800-series dosimeter and the Harshaw 8800 reader. The Harshaw 8800-series environmental dosimeter consists of two TLD-700 chips and two TLD-200 chips and provides both shallow- and deep-dose measurement capabilities using filters in the dosimeter. Data obtained from the two TLD-700 chips were used to determine the average total environmental dose at each location during 2008. The two TLD-200 chips were included to determine doses in the event of a radiological emergency and were not used in calculating average total environmental dose. The average daily dose rate was determined by dividing the average total environmental dose by the number of days the dosimeter was exposed. Daily dose equivalent rates (millirem per day) at each location

were converted to annual dose equivalent rates (millirem per year) by averaging the daily dose rates and multiplying by 365 days per year. The TLDs were positioned approximately 1 meter (3.3 feet) above the ground and were collected and read quarterly.

Radiation surveys with portable instruments are conducted to monitor and detect contamination and to provide a coarse screening for external radiation fields. The types of areas surveyed in 2008 included underground radioactive material areas, contamination areas, soil contamination areas, high-contamination areas, roads, and fence lines.

### 10.13.1 External Radiation Monitoring Near Hanford Site Facilities and Operations

CJ Perkins

During 2008, external radiation fields were monitored with TLDs at 124 locations near onsite facilities and operations. The TLD results were used individually or averaged to determine dose rates in a given area for a specific sampling period. Table 10.13.1 compares 2007 and 2008 results for TLDs located near waste-handling facilities on the Hanford Site. Individual TLD results and detailed maps of monitoring locations are provided in PNNL-18427, APP. 2.

(a) Harshaw is a trademark of Thermo Fisher Scientific, Waltham, Massachusetts.

**Table 10.13.1. Thermoluminescent Dosimeter Results (mrem/yr)<sup>(a)</sup> Near Hanford Site Operations in 2007 and 2008**

Hanford Site Locations	No. of Dosimeters	2007		2008		% Change <sup>(e)</sup>
		Maximum <sup>(b)</sup>	Average <sup>(c,d)</sup>	Maximum <sup>(b)</sup>	Average <sup>(c,d)</sup>	
100-B/C Area	4	89 ± 12	85 ± 7	83 ± 3	79 ± 6	-6
100-K Area	14	590 ± 15	206 ± 273	574 ± 42	192 ± 255	-6
100-N Area	6	142 ± 153	102 ± 48	106 ± 9	88 ± 25	-13
200-East Area	42	305 ± 148	110 ± 95	280 ± 37	103 ± 80	-5
200-West Area	24	241 ± 287	110 ± 77	259 ± 135	105 ± 77	-3
200-North Area (212-R) <sup>(f)</sup>	1	1,700 ± 268	1,700 ± 81	1,663 ± 250	1,647 ± 26	-2
300 Area	8	109 ± 6	87 ± 20	103 ± 7	83 ± 17	-3
300 Area TEDF	6	87 ± 12	84 ± 4	83 ± 7	81 ± 3	-3
300-FF-2	4	88 ± 11	85 ± 5	81 ± 8	79 ± 4	-6
400 Area	7	98 ± 8	85 ± 12	94 ± 9	81 ± 12	-3
CVDF	4	306 ± 13	154 ± 205	302 ± 18	151 ± 203	-1
ERDF	3	93 ± 6	88 ± 8	80 ± 10	79 ± 4	-10
IDF <sup>(f)</sup>	1	99 ± 15	91 ± 13	87 ± 13	85 ± 5	-5

(a) To convert to international metric system units, multiply mrem/yr by 0.01 to obtain mSv/yr.

(b) Maximum values are ± analytical uncertainty.

(c) ±2 standard deviations.

(d) Each dosimeter is collected and read quarterly.

(e) Numbers indicate a decrease from the 2007 mean.

(f) Maximum value represents highest quarterly value ± analytical uncertainty.

CVDF = Cold Vacuum Drying Facility (100-K Area).

ERDF = Environmental Restoration Disposal Facility (200-West Area).

IDF = Integrated Disposal Facility (200-East Area).

TEDF = Treated Effluent Disposal Facility.

### 10.13.1.1 External Radiation Measurements Onsite Near Facilities and Operations

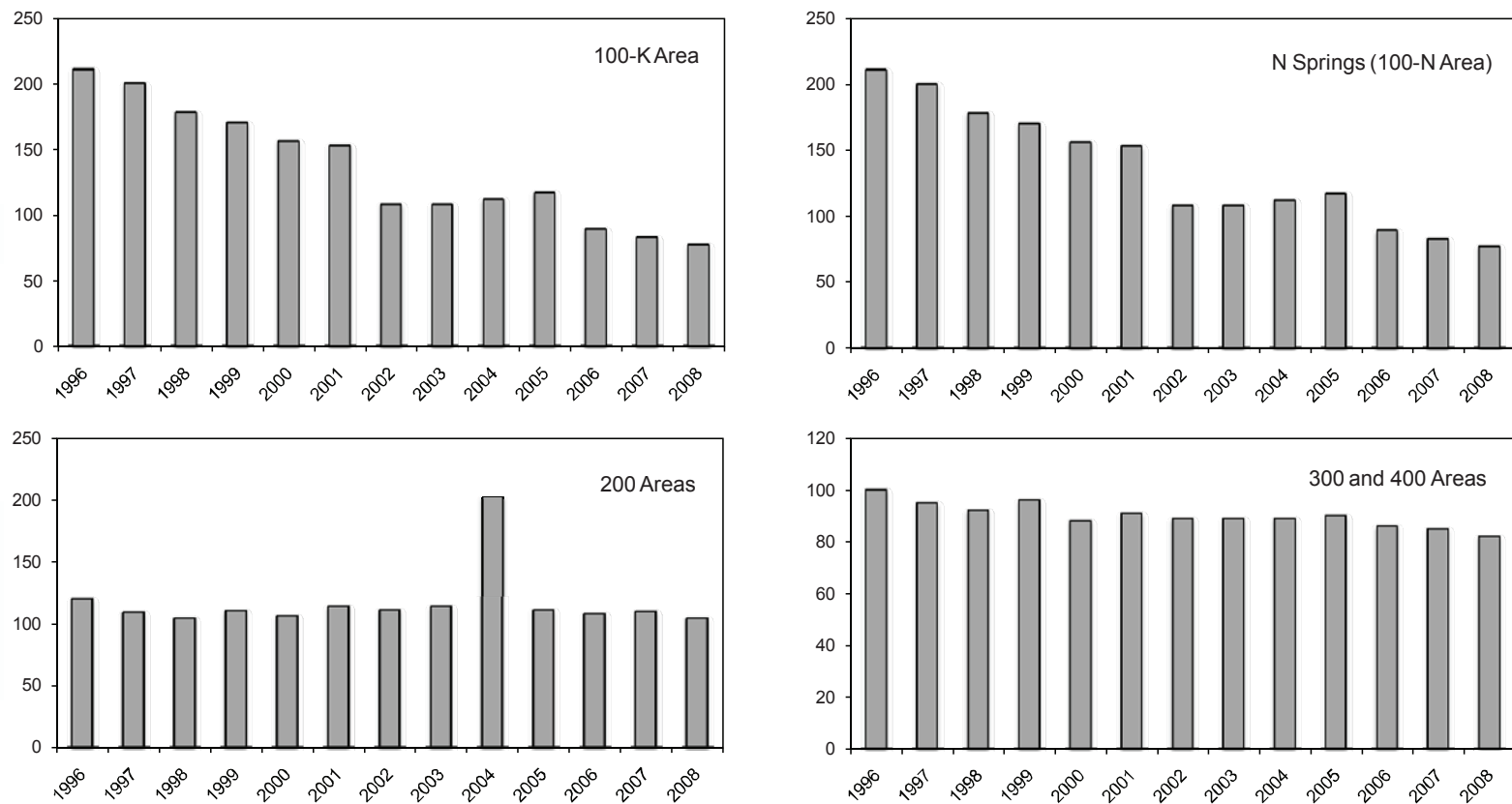
**100-B/C Area.** At the former 116-B-11 and 116-C-1 liquid waste disposal facilities (located in the 100-B/C Area), dose rate levels in 2008 were slightly lower than those measured in previous years.

**100-K Area.** Major cleanup activities at the 100-K Area fuel storage basins and adjacent retired reactor buildings were completed in 2007, and overall average dose rates measured in both the 100-K East and 100-K West Areas in 2008 were comparable to the 2007 values. Similarly, dose-rate levels measured in 2008 at monitoring stations around the 100-K Area Cold Vacuum Drying Facility were comparable to 2007 levels. The Hose-in-Hose Project was completed in May 2007 and dose-rate levels measured at the

monitoring location situated adjacent to the sludge transfer route decreased to typical Hanford Site baseline levels in 2008.

**100-N Area.** Average dose-rate levels observed in the 100-N Area during 2008 showed a decrease of 13% compared to 2007 levels.

**100-N Area Shoreline (N Springs).** Dose rates were measured along the Columbia River shoreline in the 100-N Area (N Springs) to determine potential external radiation doses to onsite workers and to the public accessing the river. Cleanup activities at the retired 116-N-1 and 116-N-3 Trenches (located near the Columbia River) have decreased dose rates notably over the past few years (Figure 10.13.1). The 2008 dose rates were approximately 7% lower than the 2007 dose rates and averaged less than 100 millirem (1 millisievert) per year.



**Figure 10.13.1. Annual Average Thermoluminescent Dosimeter Results in Selected Areas Near Facilities and Operations on the Hanford Site, 1996 Through 2008**

**200-East and 200-West Areas.** Dose rates measured during 2008 in the 200-East and 200-West Areas were similar to those measured in 2007.

Average dose rates measured in 2008 at the Environmental Restoration Disposal Facility (located near the 200-West Area) were approximately 10% lower than 2007 levels (Table 10.13.1).

**200-North Area.** One TLD monitoring site, located in the 200-North Area at the contaminated 212-R Railroad Car Disposition Area, showed annual average dose rates in 2008 to be comparable to 2007 levels. This TLD location was established in 2000 to monitor expected high radiation levels emitted from contaminated railroad cars.

**300 and 400 Areas.** The average dose rates in the 300 Area, at the 300 Area Treated Effluent Disposal Facility, and in the 400 Area in 2008 were comparable to 2007 levels (Figure 10.13.1). Average dose rates at the 300-FF-2 field remediation project site were approximately 6% lower in 2008 than in 2007.

### 10.13.1.2 Radiological Surveys at Active and Inactive Waste Disposal Sites

#### SM McKinney

During 2008, 473 environmental radiological surveys were conducted at active and inactive waste disposal sites and the surrounding terrain to detect and characterize radioactive surface contamination. Vehicles equipped with radiation detection devices and global positioning systems were used to accurately measure the extent of contamination. Area measurements were entered into the Hanford Geographical Information System, a computer database maintained by Fluor Hanford, Inc. Routine radiological survey locations included former waste disposal cribs and trenches, retention basin perimeters, ditch banks, solid waste disposal sites (e.g., burial grounds), unplanned release sites, tank farm perimeters, stabilized waste disposal sites, roads, and firebreaks in and around the site operational areas. These sites were posted as underground radioactive material areas, contamination areas, and soil contamination areas. It was estimated the external dose rate at 80% of the outdoor contamination

areas was less than 1 millirem (0.01 millisievert) per hour, although direct dose-rate readings from isolated radioactive specks could have been higher.

Underground radioactive material areas are areas where radioactive materials occur below the soil surface. These areas are typically stabilized cribs, burial grounds, covered ponds, trenches, and ditches. Barriers over the contamination sources are used to inhibit radionuclide transport to the surface. These areas are surveyed at least annually to assess the effectiveness of the barriers.

Contamination areas and soil contamination areas may or may not be associated with an underground structure containing radioactive material. A breach in the surface barrier of a contaminated underground area may result in the growth of contaminated vegetation. Insects or animals may burrow into the soil and bring contamination to the surface. Vent pipes or risers from an underground structure may be sources of speck contamination (particles with a diameter less than 0.6 centimeter [0.25 inch]). Areas of contamination not related to subsurface structures can include sites contaminated with fallout from effluent stacks or with materials from unplanned releases (e.g., contaminated tumbleweeds and animal feces).

All contaminated areas may be susceptible to contaminant migration and are surveyed at least annually to assess their current radiological status (locations of posted contamination areas are illustrated in PNNL-18427, APP. 2). In addition, onsite paved roadways are surveyed annually, and the intersections along the Environmental Restoration Disposal Facility haul routes are surveyed quarterly.

During 2008, the Hanford Site had approximately 3,583 hectares (8,853 acres) of outdoor contaminated areas of all types and approximately 584 hectares (1,443 acres) that contained underground radioactive materials, not including active facilities. Table 10.13.2 provides a list of contamination areas, underground radioactive material areas, and interim-closed waste sites as well as their status and general locations. No new areas of significant size were discovered during 2008. Waste sites are “interim-closed” and released from radiation posting when the remedial actions meet the record of decision cleanup requirements for the operable unit. During 2008, approximately



9 hectares (22 acres) of previously posted contamination and/or underground radioactive material areas underwent remediation action and were interim-closed. Table 10.13.3 summarizes the change in status of outdoor contamination areas during 2008.

## 10.13.2 External Radiation Monitoring at Hanford Site-Wide and Offsite Locations

External radiation monitoring and radiation surveys at site-wide, offsite, and Columbia River shoreline locations were discontinued by Pacific Northwest National Laboratory at the end of calendar year 2005 because of funding reductions. Data collected at these locations for many years indicate that current radiation levels are at or near background levels and are stable or decreasing as onsite cleanup activities progress. Readers interested in reviewing measurement and survey readings obtained in 2005 or earlier should refer to previous Hanford Site environmental reports and their data appendices (see <http://hanford-site.pnl.gov/envreport>).

**Table 10.13.2. Status of Outdoor Contamination Areas on the Hanford Site, 2008**

<u>Area</u>	<u>Contamination Areas,<sup>(a)</sup> ha (acres)</u>		<u>Underground Radioactive Materials Areas,<sup>(b)</sup> ha (acres)</u>		<u>Interim Closed, ha (acres)</u>	
100-B/C	0	(0)	29	(72)	17	(42)
100-D/DR	0	(0)	22	(54)	6	(15)
100-F	0	(0)	3	(7)	19	(47)
100-H	0	(0)	7	(17)	7	(17)
100-K	5	(12)	45	(111)	20	(49)
100-N	2	(5)	16	(40)	25	(62)
200-East <sup>(c)</sup>	71	(175)	141	(348)	0	(0)
200-West <sup>(c)</sup>	27	(67)	224	(554)	0	(0)
300	0	(0)	42	(104)	22	(54)
400	0	(0)	0	(0)	0	(0)
600 <sup>(d)</sup>	3,478	(8,594)	55	(136)	0	(0)
<b>Totals</b>	<b>3,583</b>	<b>(8,853)</b>	<b>584</b>	<b>(1,443)</b>	<b>116</b>	<b>(287)</b>

(a) Includes areas posted as contamination/soil contamination or as radiologically controlled and areas that had both underground radioactive material and contamination/soil contamination.

(b) Includes areas with only underground contamination.

(c) Includes tank farms.

(d) Includes BC Controlled Area, Environmental Restoration Disposal Facility, and waste disposal facilities outside the 200-East and 200-West Areas boundaries.

**Table 10.13.3. Change in Status of Outdoor Contamination Areas on the Hanford Site, 2008**

<u>Areas</u>	<u>Changes</u>	<u>Area, ha (acres)</u>	
100	CA/URM to interim closed <sup>(a)</sup>	9	(22)
200-East	None to report	0	(0)
200-West	None to report	0	(0)
300	None to report	0	(0)
400	None to report	0	(0)
600	CA/URM to interim closed <sup>(a)</sup>	<1	(<1)

(a) Changes due to remediation activities.

CA = Contamination/soil contamination area.

URM = Underground radioactive material area.



## 10.14 Potential Radiological Doses from 2008 Hanford Site Operations

EJ Antonio and K Rhoads

Potential radiological doses to the public and biota from Hanford Site operations were evaluated in detail during 2008 to determine compliance with pertinent regulations and limits. Potential sources of radionuclide contamination included gaseous emissions from stacks and ventilation exhausts, liquid effluent from operating wastewater treatment facilities, contaminated groundwater seeping into the Columbia River, and fugitive emissions from contaminated soil areas and facilities. The methods used to calculate the potential doses are detailed in Appendix E.

The radiological impacts of 2008 Hanford Site operations were assessed in terms of the following:

- Dose to a hypothetical, maximally exposed individual at an offsite location, evaluated by using a multimedia pathway assessment (DOE Order 5400.5; Section 10.14.1)
- Collective dose to the population residing within 80 kilometers (50 miles) of Hanford Site operating areas (Section 10.14.2)
- Doses for air pathways, evaluated using EPA methods, for comparison to the *Clean Air Act* standards in 40 CFR 61, Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities” (Section 10.14.3)
- Dose to a worker consuming drinking water on the site (Section 10.14.4.2)
- Doses from non-DOE industrial sources on and near the Hanford Site (Section 10.14.5)
- Absorbed dose received by organisms exposed to radionuclide releases to the Columbia River and to radionuclides in onsite surface-water bodies (Section 10.14.6).

Radiological dose assessments are generally based on direct measurements of radiation dose rates and radionuclide concentrations. However, amounts of most radioactive materials released in 2008 from Hanford Site sources were generally too small to be measured directly after they were dispersed in the offsite environment. For many of the radionuclides present in measurable amounts, it was difficult to separate Hanford Site source contributions from contributions due to fallout and naturally occurring uranium and its decay products. Therefore, in nearly all instances, offsite doses were estimated using *GENII – The Hanford Environmental Radiation Dosimetry Software System, Version 1.485* (PNL-6584) and the Hanford Site-specific parameters listed in Appendix E and DOE/RL-2007-53.

Radiological doses from the water pathway were calculated based on known releases to the Columbia River from the 100 Areas (see Table 10.3.2) and the differences in radionuclide concentrations between upstream and downstream sampling points on the Columbia River (considered the contribution from the 200 Areas). Tritium and two uranium isotopes were found during 2008 in the Columbia River downstream of the Hanford Site at greater levels than predicted, based on direct discharges from the 100-K Area (Section 10.3 and Appendix C). All other radionuclide concentrations in river water were lower than those predicted from known releases. Columbia River shoreline spring water containing radionuclides is known to enter the river along the portion of the site shoreline extending from the 100-B/C Area downstream to the 300 Area (Sections 10.5 and 10.7). No direct discharge of radioactive materials from the 300 Area to the Columbia River was reported during 2008.

## 10.14.1 Maximally Exposed Individual Dose (Offsite Resident)

The maximally exposed individual is a hypothetical person who lives at a specific location and has a lifestyle that makes it unlikely that any member of the public would have received a higher radiological dose from Hanford Site releases during 2008. This individual's exposure pathways were chosen to maximize the combined doses from all reasonable environmental routes of exposure to radionuclides in Hanford Site effluents and emissions using a multimedia pathway assessment (DOE Order 5400.5). In reality, such a combination of maximized exposures to radioactive materials is highly unlikely to apply to any single individual.

The location of the hypothetical, maximally exposed individual varies depending on the relative contributions of the several sources of radioactive emissions to the air and of liquid effluents released to the Columbia River from Hanford Site facilities (Figure 10.14.1). During 2008, the dose assessment determined that the maximally exposed individual was located across the Columbia River (east of the Hanford Site) at the Sagemoor area in Franklin County

(Figure 10.14.1). For the calculation, it was assumed this individual did the following:

- Inhaled and was immersed in airborne radionuclides
- Received external exposure to radionuclides deposited on the ground
- Ingested locally grown food products irrigated with Columbia River water and/or containing radionuclides deposited from the air
- Used the Columbia River near the Hanford Site for recreational purposes, resulting in direct exposure from radionuclides in water and radionuclides deposited on the shoreline
- Consumed locally caught Columbia River fish.

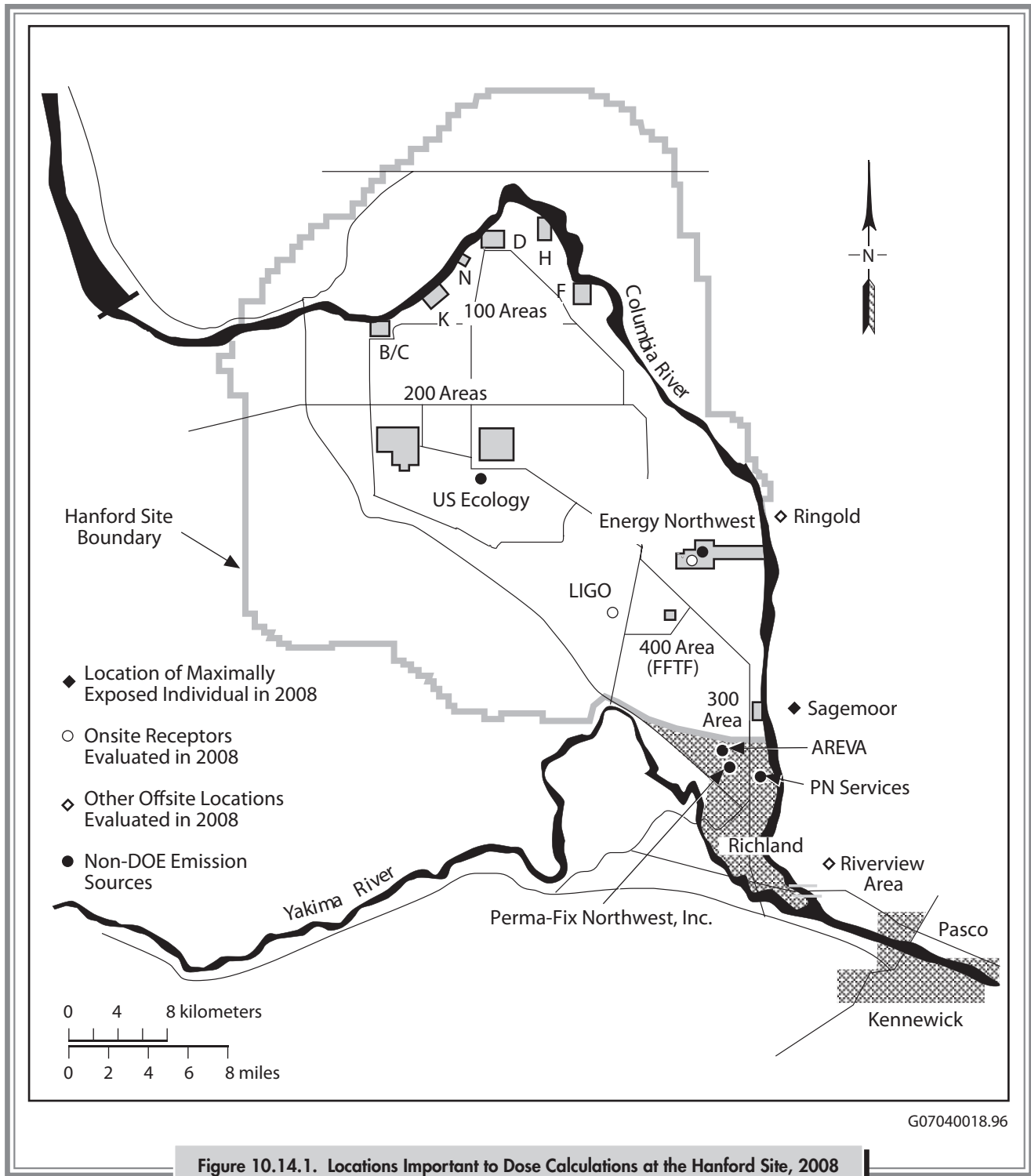
Doses were calculated using Hanford Site air emissions and effluent data (Tables 10.1.1 and 10.3.2) and the calculated quantities of radionuclides assumed to be present in the Columbia River from spring discharges along the site shoreline. The estimated radionuclide releases to the Columbia River from these sources were derived from the difference between the upstream and downstream radionuclide concentrations in river water. These radionuclides were assumed to originate from historical releases of contaminants to the ground in the 100 and 200 Areas and to have entered the

Historically at the Hanford Site, there has been one primary expression of radiological risk to an offsite individual—this is the maximally exposed individual dose. However, the maximally exposed individual dose is currently calculated by two different methods in response to two different requirements. One maximally exposed individual dose computation is required by DOE Order 5400.5 and is calculated using the GENII computer code. This calculation considers all reasonable environmental pathways (e.g., air, water, and food) that maximize a hypothetical individual's offsite exposure to Hanford's radiological effluent and emissions. A second estimate of maximally exposed individual dose is required by the *Clean Air Act* and is calculated using an EPA dose modeling computer code (CAP88-PC) or other methods accepted by the EPA for estimating offsite exposure. This offsite dose is based solely on an airborne radionuclide emissions pathway and considers the site's stack emissions and emissions from diffuse and unmonitored sources (e.g., windblown dust).

Because the DOE and EPA computer codes use different input parameters, the location and predicted dose of each agency's maximally exposed individual may be different. However, the estimated doses from both methods have historically been significantly lower than health-based exposure criteria.

Recently, the DOE has allowed private businesses to locate their activities and personnel on the Hanford Site. This has created the need to calculate a maximum dose for an onsite individual who is employed by a non-DOE business and works within the boundary of the Hanford Site. This dose is based on a mix of air-emission modeling data, the individual's exposure at an onsite work location, and the individual's potential offsite exposure.

Another way to estimate risk is to calculate the collective dose. This dose is estimated using the GENII computer code based on exposure to Hanford Site radiological contaminants through food, water, and air pathways. It is calculated for the population residing within 80 kilometers (50 miles) of the Hanford Site operation areas. The collective dose is reported in units of person-rem (person-sievert), which is the sum of doses to all individuals in an exposed population.



Columbia River through shoreline groundwater springs between the 100-B/C Area and the 300 Area.

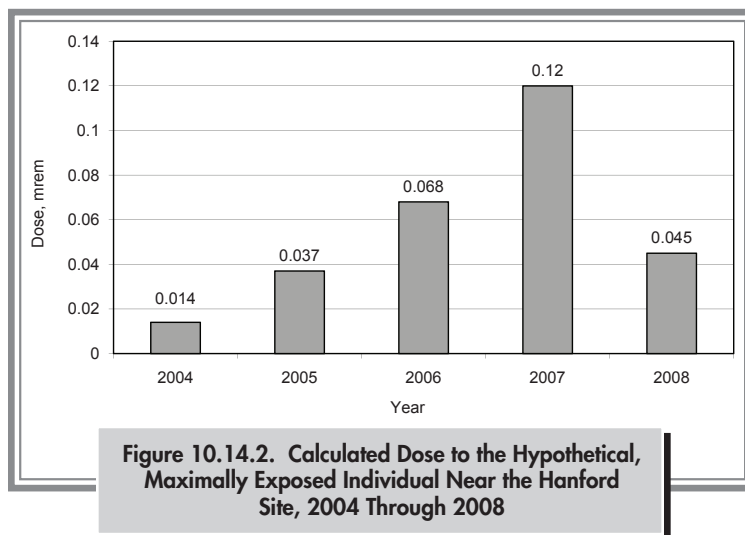
During 2008, the total dose to the maximally exposed individual at Sagemoor (Figure 10.14.1) was calculated to be 0.045 millirem (0.45 microsievert) per year (Table 10.14.1; Figure 10.14.2). This dose was 0.045% of the 100-millirem (1,000-microsievert) per-year standard specified in DOE Order 5400.5. The primary pathways (Appendix E,

Tables E.1, E.2, and E.4) contributing to this dose and the percentage of each pathway were as follows:

- The inhalation of air downwind from the Hanford Site (17%) and the consumption of food products grown downwind from the Hanford Site (approximately 71%), resulting in exposure to tritium and radon released to air from the 300 Area.

**Table 10.14.1. Dose to the Hypothetical, Maximally Exposed Individual Residing at Sagemoor from 2008 Hanford Site Operations**

		Dose Contributions from Operating Areas, mrem				
<u>Effluent</u>	<u>Pathway</u>	<u>100 Areas</u>	<u>200 Areas</u>	<u>300 Area</u>	<u>400 Area</u>	<u>Pathway Total</u>
Air	External	$2.8 \times 10^{-10}$	$3.1 \times 10^{-7}$	$5.3 \times 10^{-4}$	$2.6 \times 10^{-8}$	$5.3 \times 10^{-4}$
	Inhalation	$2.3 \times 10^{-5}$	$3.6 \times 10^{-5}$	$7.4 \times 10^{-3}$	$1.6 \times 10^{-5}$	$7.5 \times 10^{-3}$
	Foods	$6.5 \times 10^{-7}$	$2.3 \times 10^{-4}$	$3.2 \times 10^{-2}$	$5.2 \times 10^{-7}$	$3.2 \times 10^{-2}$
	<b>Subtotal air</b>	<b><math>2.4 \times 10^{-5}</math></b>	<b><math>2.7 \times 10^{-4}</math></b>	<b><math>4.0 \times 10^{-2}</math></b>	<b><math>1.7 \times 10^{-5}</math></b>	<b><math>4.0 \times 10^{-2}</math></b>
Water	Recreation	$1.3 \times 10^{-9}$	$3.6 \times 10^{-5}$	0.0	0.0	$3.6 \times 10^{-5}$
	Foods	$6.6 \times 10^{-7}$	$2.7 \times 10^{-3}$	0.0	0.0	$2.7 \times 10^{-3}$
	Fish	$5.7 \times 10^{-7}$	$2.0 \times 10^{-3}$	0.0	0.0	$2.0 \times 10^{-3}$
	<b>Subtotal water</b>	<b><math>1.2 \times 10^{-6}</math></b>	<b><math>4.7 \times 10^{-3}</math></b>	<b>0.0</b>	<b>0.0</b>	<b><math>4.7 \times 10^{-3}</math></b>
<b>Combined total</b>		<b><math>2.5 \times 10^{-5}</math></b>	<b><math>5.0 \times 10^{-3}</math></b>	<b><math>4.0 \times 10^{-2}</math></b>	<b><math>1.7 \times 10^{-5}</math></b>	<b><math>4.5 \times 10^{-2}</math></b>



- The consumption of food irrigated with Columbia River water withdrawn downstream from the Hanford Site (6.0%) and consumption of fish from the Columbia River (4.4%), resulting in exposure to uranium isotopes and tritium in the river.

## 10.14.2 Collective Dose

Collective dose is defined as the sum of doses to all individual members of the public within 80 kilometers (50 miles) of Hanford Site operating areas. The regional collective dose from 2008 Hanford Site operations was estimated by calculating the radiological dose to the population residing within an 80-kilometer (50-mile) radius of onsite operating areas. The collective dose calculated during 2008 for the population was 0.44 person-rem (0.0044 person-sievert) per

year (Table 10.14.2; Figure 10.14.3), which is about half of the 2007 collective dose (0.90 person-rem [0.0090 person-sievert] per year) (Appendix E, Tables E.5 to E.10).

Primary pathways contributing to the 2008 collective dose and the percentage of each pathway included the following:

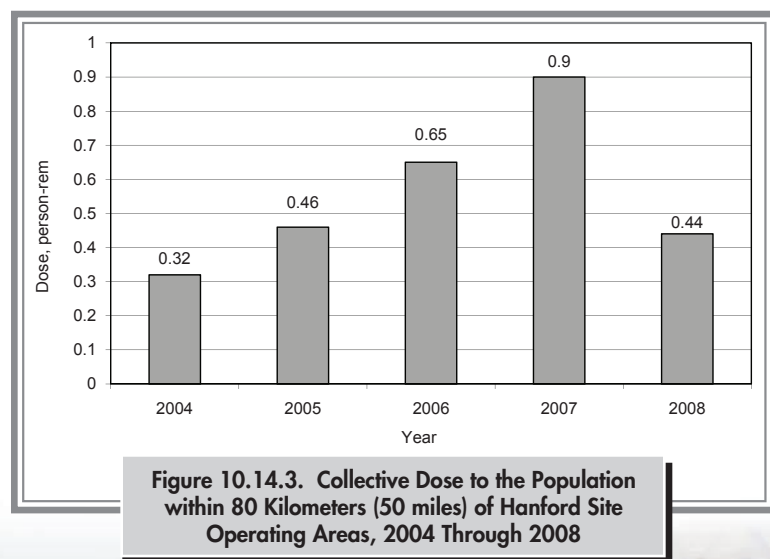
- Consumption of food grown downwind of the Hanford Site (approximately 55%) and inhalation of radionuclides (23%) that were released to the air, principally tritium and radon from the 300 Area and iodine-129 from the 200 Areas.

- The consumption of water withdrawn from the Columbia River downstream of the Hanford Site (21%) and foods irrigated with water withdrawn from the Columbia River downstream of the site (approximately 0.7%) containing tritium, uranium-234, and uranium-238.

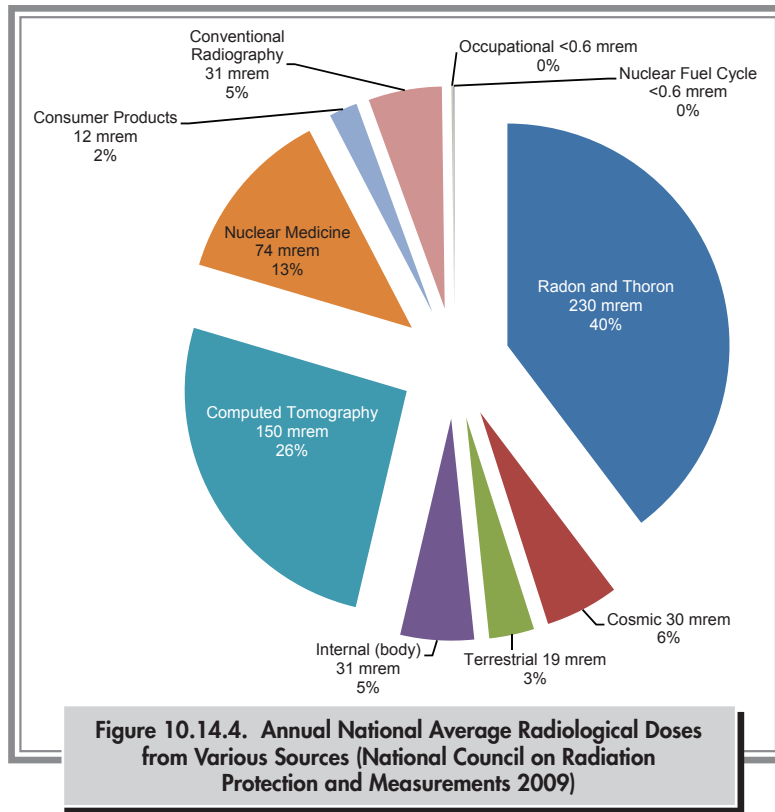
Collective doses reported for 2008 are based on population data from the 2000 census. The collective dose is reported in units of person-rem (person-sievert), which is the sum of doses to members of the exposed population. Between 1990 and 2000, the population within 80 kilometers (50 miles) of the major Hanford Site operating areas increased between 24% and 29%.

**Table 10.14.2. Collective Dose to the Population from 2008 Hanford Site Operations**

		Dose Contributions from Operating Areas, person-rem				Pathway Total
Effluent	Pathway	100 Areas	200 Areas	300 Area	400 Area	
Air	External	$5.6 \times 10^{-8}$	$2.7 \times 10^{-5}$	$5.9 \times 10^{-3}$	$1.3 \times 10^{-6}$	$5.9 \times 10^{-3}$
	Inhalation	$7.1 \times 10^{-3}$	$4.8 \times 10^{-3}$	$8.6 \times 10^{-2}$	$1.2 \times 10^{-3}$	$9.9 \times 10^{-2}$
	Foods	$9.7 \times 10^{-5}$	$2.2 \times 10^{-2}$	$2.2 \times 10^{-1}$	$2.4 \times 10^{-5}$	$2.4 \times 10^{-1}$
	<b>Subtotal air</b>	<b><math>7.2 \times 10^{-3}</math></b>	<b><math>2.7 \times 10^{-2}</math></b>	<b><math>3.1 \times 10^{-1}</math></b>	<b><math>1.2 \times 10^{-3}</math></b>	<b><math>3.5 \times 10^{-1}</math></b>
Water	Recreation	$1.0 \times 10^{-8}$	$1.8 \times 10^{-4}$	0.0	0.0	$1.8 \times 10^{-4}$
	Foods	$7.0 \times 10^{-7}$	$2.9 \times 10^{-3}$	0.0	0.0	$2.9 \times 10^{-3}$
	Fish	$2.1 \times 10^{-7}$	$7.4 \times 10^{-4}$	0.0	0.0	$7.4 \times 10^{-4}$
	Drinking water	$3.3 \times 10^{-6}$	$9.0 \times 10^{-2}$	0.0	0.0	$9.0 \times 10^{-2}$
	<b>Subtotal water</b>	<b><math>4.2 \times 10^{-6}</math></b>	<b><math>9.4 \times 10^{-2}</math></b>	<b>0.0</b>	<b>0.0</b>	<b><math>9.4 \times 10^{-2}</math></b>
<b>Combined total</b>		<b><math>7.2 \times 10^{-3}</math></b>	<b><math>1.2 \times 10^{-1}</math></b>	<b><math>3.1 \times 10^{-1}</math></b>	<b><math>1.2 \times 10^{-3}</math></b>	<b><math>4.4 \times 10^{-1}</math></b>



The average individual dose from Hanford Site operations, based on a population of 486,000 within 80 kilometers (50 miles) of the site, was approximately 0.0009 millirem (0.009 microsievert) in 2008. To place this estimated dose into perspective, it may be compared with doses received from other routinely encountered sources of radiation, such as natural terrestrial and cosmic background radiation, medical treatment and x-rays, natural radionuclides in the body, and inhalation of naturally occurring radon (Figure 10.14.4). In March 2009, the National Council on Radiation Protection and Measurements issued NCRP Report No. 160 (National



Council on Radiation Protection and Measurements 2009), which concluded that Americans were exposed to more than seven times as much ionizing radiation from medical procedures as was the case in the 1980s, causing the overall average exposure to ionizing radiation for the average American to rise from 360 to 620 millirem (3,600 to 6,200 microsievert) per year. The estimated annual average individual dose to members of the public from Hanford Site sources in 2008 was approximately 0.0003% of the estimated annual individual dose received from natural background sources (approximately 310 millirem [3,100 microsievert]). The calculated radiological doses from Hanford Site operations in 2008 were a small percentage of the federal standards and of doses from natural background sources (Table 10.14.3).

### 10.14.3 Compliance with *Clean Air Act* Standards

In addition to complying with the all-pathways dose limits established by DOE Order 5400.5, officials managing DOE facilities are required to demonstrate that their facilities

comply with standards established by the EPA for airborne radionuclide emissions under the *Clean Air Act* in 40 CFR 61, Subpart H. This regulation specifies that no member of the public shall receive a dose greater than 10 millirem (100 microsievert) per year from exposure to airborne radionuclide emissions (other than radon) released at DOE facilities. Whereas DOE uses the GENII computer code (PNL-6584) at the Hanford Site to determine dose to the all-pathways maximally exposed individual, EPA requires the use of the CAP88-PC computer code (Rosnick 2007) or other EPA-approved computer models to demonstrate compliance with the requirements in 40 CFR 61, Subpart H. The assumptions and dosimetry models embodied in the CAP88-PC computer code differ from standard assumptions used with the GENII computer code. Therefore, air-pathway doses calculated by the two codes may differ. In addition, the maximally exposed individual for air pathways may be evaluated at a different location from the all-pathways maximally exposed individual because of the relative contributions from each exposure pathway (Section 10.14.1).

**Table 10.14.3. Comparison of 2008 Doses to the Public from Hanford Site Effluent and Emissions to Federal Standards and Natural Background Levels**

<b>Federal Standard</b>	<b>Hanford Site Dose<sup>(a)</sup></b>	<b>Percent of Standard or of Background Dose</b>
DOE - 100 mrem/yr all pathways MEI <sup>(b)</sup>	0.045 mrem/yr	0.045
EPA - 10 mrem/yr air pathway MEI <sup>(c)</sup>	0.041 mrem/yr	0.41
<b>Background Dose</b>		
310 mrem/yr average from natural background U.S. individual <sup>(d)</sup>	0.0009 mrem/yr	0.0003
150,700 person-rem/yr to population within 80 km (50 mi)	0.44 person-rem/yr	0.0003

(a) To convert the dose values to millisievert or person-sievert, divide by 100.

(b) DOE Order 5400.5.

(c) 40 CFR 61.

(d) National Council on Radiation Protection and Measurements (2009).

DOE = U.S. Department of Energy.

EPA = U.S. Environmental Protection Agency.

MEI = Maximally exposed individual.

The EPA regulation also requires that an annual report for each DOE facility be submitted to EPA that supplies information about atmospheric emissions for the preceding year and their potential contributions to offsite dose. For more detailed information about 2008 air emissions at the Hanford Site, refer to DOE's report to EPA, *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2008* (DOE/RL-2009-14).

### 10.14.3.1 Dose to an Offsite Maximally Exposed Individual

Using EPA-specified methods, the maximally exposed offsite individual for air pathways in 2008 was in the Sagemoor area, approximately 1.4 kilometers (0.8 mile) east of the 300 Area, across the Columbia River (Figure 10.14.1). The potential air-pathway dose from stack emissions (excluding radon) to a maximally exposed individual at that location, calculated using the CAP88-PC computer code, was determined to be 0.041 millirem (0.41 microsievert) per year, which represented less than 1% of the EPA standard.

The dose from radon-220 and radon-222 amounted to 0.021 millirem (0.21 microsievert) in 2008. Radon is not included in the dose calculated for compliance with the EPA standard in 40 CFR 61, but is regulated by the 10-millirem (100-microsievert) per year standard established by Washington State in WAC 246-247. The total dose from stack emissions was therefore 0.062 millirem (0.62 microsievert) per year, including radon, which represented less than 1% of the Washington State standard. This is similar to the offsite individual doses calculated in previous years and to the air-pathway doses for stack emissions in Table 10.14.1.

### 10.14.3.2 Maximum Dose to Non-U.S. Department of Energy Workers on the Hanford Site

The DOE Richland Operations Office received guidance from the EPA Region 10 office and the Washington State Department of Health that, in demonstrating compliance with 40 CFR 61 standards, it should evaluate potential doses to non-DOE employees who work at facilities within the

Hanford Site but who are not under direct DOE management. Accordingly, doses to members of the public employed at non-DOE facilities who were outside access-controlled areas on the Hanford Site (those requiring DOE-access authorization for entry) were evaluated for the 2008 EPA air emissions report (DOE/RL-2009-14). These locations included the Columbia Generating Station operated by Energy Northwest and the Laser Interferometer Gravitational-Wave Observatory operated by the University of California (Figure 10.14.1). Of those locations, an employee at the Laser Interferometer Gravitational-Wave Observatory received the highest dose for non-DOE employees who worked at the Hanford Site. The dose from stack emissions calculated using the CAP88-PC computer code was 0.0055 millirem (0.055 microsievert) per year, assuming full-time occupancy.

EPA guidance does not currently allow for adjustment of doses calculated using the CAP88-PC computer code to account for less than full-time occupancy at locations within the Hanford Site boundary. However, if an occupancy period of 2,000 hours per year was assumed for employees at onsite non-DOE facilities, the doses to employees at any of the locations evaluated would be lower than the dose reported for the Laser Interferometer Gravitational-Wave Observatory. In 2008, the estimated doses to all non-DOE onsite workers were lower than the dose to an offsite maximally exposed individual.

### 10.14.3.3 Dose from Diffuse and Fugitive Radionuclide Emissions

The December 15, 1989, revisions to the *Clean Air Act* (40 CFR 61, Subpart H) required DOE facilities to estimate the dose to a member of the public for radionuclides released from all potential sources of airborne radionuclides. DOE and EPA interpreted the regulation to include diffuse (widespread) and fugitive (unintended) emissions, as well as emissions from monitored point sources (i.e., stacks). EPA has not specified or approved standardized methods to estimate diffuse air emissions because of the wide variety of sources at DOE sites. The method developed at the Hanford Site to estimate potential diffuse emissions is based on environmental monitoring measurements of airborne radionuclides at the site perimeter (DOE/RL-2009-14).

The estimated dose from diffuse emissions to a maximally exposed individual at a location in the Sagemoor area was calculated during 2008 using the CAP88-PC computer code to be 0.052 millirem (0.52 microsievert) per year. This is similar to results for recent years, where the dose from diffuse emissions has been comparable to the dose from stack emissions. Doses for 2007 and 2008 were calculated using CAP88-PC, Version 3.0 (Rosnick 2007), which has a different basis for the dosimetry system and other parameters compared to that in CAP88-PC, Version 1.0 used in previous years (EPA 402-B-92-001). The dose to an onsite non-DOE worker from diffuse and fugitive emissions would be similar to, or lower than, the dose at the site perimeter. Therefore, the potential combined dose from stack emissions and diffuse emissions during 2008 was well below the EPA 10-millirem (100-microsievert) per year standard for either onsite or offsite members of the public.

## 10.14.4 Special Case Dose Estimates

The parameters used to calculate the dose to the maximally exposed individual were selected to provide a scenario yielding a reasonable upper (or bounding) dose estimate. However, such a scenario may not have necessarily resulted in the highest conceivable radiological dose. Other low-probability exposure scenarios exist that could have resulted in somewhat higher doses. Two scenarios that could have potentially led to larger doses include 1) a person who consumed contaminated wildlife that migrated from the Hanford Site, and 2) a person who consumed water at the Fast Flux Test Facility in the 400 Area. The potential doses resulting from these scenarios are examined in the following sections. A third scenario where an individual would spend time at the Hanford Site boundary location with the maximum external radiological dose rate was not evaluated for 2008 because external radiation surveillance around the site was discontinued in December 2005.

### 10.14.4.1 Outdoor Recreationalist Dose

Wildlife, with access to Hanford Site areas that are contaminated with radioactive materials, has the potential to acquire radioactive contamination and migrate off the



site. Wildlife sampling was conducted on the site to estimate the maximum contamination levels that might have existed in animals from the site that were hunted or fished offsite. Because this scenario had a relatively low probability of occurrence, this pathway was not considered in the maximally exposed individual calculation.

Radionuclides detected in routinely collected wildlife samples during 2008 included potassium-40, a primordial radioisotope not of Hanford Site origin. Strontium-90 was detected only in fish carcass or deer bone samples (Sections 10.12.4.1 and 10.12.4.2), which are not routinely consumed; therefore, they are not considered further here. Uranium-234 and uranium-238 were detected in fish muscle samples collected along the Hanford Reach and at an upstream background location (PNNL-18427, APP. 1). The maximum detectable concentration of uranium-234 (0.0211 pCi/g [0.00078 Bq/g]) was measured in a background bass muscle sample collected upstream of the Hanford Site at Desert Aire, Washington. The maximum detectable uranium-238 concentration (0.0148 pCi/g [0.00055 Bq/g]) was measured in the muscle portion of a carp also collected upstream of the Hanford Site at Desert Aire. The calculated effective dose equivalent from consuming 1 kilogram (2.2 pounds) of muscle from the background bass sample would be about 0.0055 millirem (0.055 microsievert). The calculated effective dose equivalent from consuming 1 kilogram (2.2 pounds) of the background carp muscle would be about 0.0034 millirem (0.034 microsievert).

#### 10.14.4.2 Onsite Drinking Water

Drinking water was sampled and analyzed throughout 2008 in accordance with applicable regulations (40 CFR 141). Tap water samples were collected from the 100-K, 100-N, 200-West, and 400 Areas. The annual average radionuclide concentrations measured during 2008 were below applicable drinking water standards. However, tritium in the 400 Area was detected at levels above the minimum detectable concentration, gross alpha was identified in one of four quarterly 100-N samples, and gross beta was detected in one of four quarterly samples collected from both the 100-K and 200-West Areas drinking water (Section 10.6). Gross beta was also detected in all four quarterly samples collected at the 400 Area.

Based on annual average concentrations (Table 10.6.2), the potential annual dose to a worker at the Fast Flux Test Facility (400 Area) in 2008 would be approximately 0.1 millirem (1 microsievert). This dose estimate was derived by assuming a consumption rate of 1 liter (0.26 gallon) per day for 250 working days and is well below the drinking water dose limit of 4 millirem (40 microsievert) per year for public drinking water supplies. Doses from the 100-K, 100-N, and 200-West Areas tap water supplies would be lower than at the Fast Flux Test Facility. Results are tabulated in Appendix E, Table E.11.

### 10.14.5 Doses from Non-U.S. Department of Energy Sources

DOE Order 5400.5, Chapter II, paragraph 7, has a reporting requirement for a combined dose due to DOE and other manmade sources that exceeds 100 millirem (1,000 microsievert) per year. During 2008, various non-DOE industrial sources of public radiation exposure existed on or near the Hanford Site. Onsite sources included a commercial, low-level, radioactive waste burial ground operated by US Ecology and a nuclear power generating station operated by Energy Northwest. Sources near the Hanford Site included a nuclear fuel production plant operated by AREVA NP; a commercial, low-level, radioactive waste treatment facility operated by Perma-Fix Northwest, Inc.; and a commercial decontamination facility operated by PN Services (Figure 10.14.1).

DOE maintains an awareness of these other sources of radiation, which, if combined with the DOE sources, might have the potential to cause a dose exceeding 10 millirem (100 microsievert) per year to any member of the public. With information gathered from these companies via personal communication and annual reporting, it was conservatively estimated that the total 2008 individual dose from their combined activities was less than 0.003 millirem (0.03 microsievert) per year. Therefore, the combined annual dose from non-DOE and DOE sources on and near the Hanford Site to a member of the public for 2008 was well below any regulatory dose limit.



## 10.14.6 Dose to Non-Human Biota

Upper estimates of the radiological dose to aquatic organisms were made in accordance with the DOE Order 5400.5 interim requirement for managing and controlling liquid discharges. The current dose limit for native aquatic animal organisms is 1 rad (10 mGy) per day. The proposed dose limit for terrestrial biota is 0.1 rad (1 mGy) per day.

Concentration guides for assessing doses to biota are very different from the DOE-derived concentration guides used to assess radiological doses to humans. A screening method is used to estimate radiological doses to aquatic and terrestrial biota. This method uses the RESRAD-BIOTA computer

code (DOE/EH-0676; DOE/STD-1153-2002) to compare radionuclide concentrations measured by routine monitoring programs to a set of conservative biota concentration guides (e.g., the water concentration of a radionuclide that would produce 1 rad [10 mGy] per day for aquatic biota). For samples containing multiple radionuclides, a sum of fractions is calculated to account for the contribution to dose from each radionuclide relative to the dose guideline. If the sum of fractions exceeds 1.0, then the dose guideline has been exceeded. If the initial estimated screening value (Tier 1) exceeds the guideline (sum of fractions more than 1.0), another screening calculation is performed (Tier 2) to more accurately evaluate exposure of the biota to the radionuclides. The process may culminate in a site-specific assessment requiring additional sampling and study of exposure. Biota dose screening assessments were conducted using surveillance data collected in 2008 from on and around the Hanford Site.

Maximum concentrations of radionuclides measured in sediment, onsite pond water, and Columbia River shoreline spring water as tabulated in Appendix C were evaluated using the RESRAD-BIOTA computer code. Riverbank springs carry groundwater contaminants into the Columbia River at greater concentrations than observed in river water and provide another level of conservatism in the biota dose assessment process. The results of the screening calculations show that the concentrations in all water and sediment samples passed the Tier 1 screen, indicating that the calculated doses were below the dose limits and guidelines (sum of fractions less than 1.0) (Table 10.14.4).

## 10.14.7 Radiological Dose in Perspective

Scientific studies (National Research Council 1980, 1990; United Nations Science Committee on the Effects of Atomic Radiation 1988) have been conducted to estimate the possible risk from exposure to low levels of radiation. These studies provided information to government and scientific organizations and are used to recommend radiological dose limits and standards for public and occupational safety.

**Table 10.14.4. Results of Using the RESRAD-BIOTA<sup>(a)</sup> Computer Code to Estimate Radiological Doses to Biota On and Around the Hanford Site, Using 2008 Onsite Pond Water, Columbia River Shoreline Spring Water, and River and Pond Sediment, as Available**

<u>Location</u>	<u>Tier 1 Screen, Sum of Fractions<sup>(b)</sup></u>	<u>Pass or Fail</u>
100-B Area	0.104	Pass
100-D Area	0.000401	Pass
100-F Area	0.0393	Pass
100-F Slough sediment	0.106	Pass
100-H Area	0.0310	Pass
100-K Area	0.262	Pass
100-N Area	0.00482	Pass
300 Area Springs	0.484	Pass
Hanford town site	0.0247	Pass
Hanford Slough sediment	0.145	Pass
McNary Dam	0.255	Pass
Priest Rapids Dam	0.254	Pass
Priest Rapids Dam sediment	0.232	Pass
Richland Spring/River	0.0496	Pass
West Lake	0.602	Pass
White Bluffs Slough	0.144	Pass

(a) A screening method to estimate radiological doses to aquatic and terrestrial biota.

(b) A sum of fractions is calculated to account for the contribution to dose from each radionuclide. If the sum of fractions exceeds 1.0, then the dose guideline has been exceeded and further screening (Tier 2) is required.

Although no increase in the incidence of health effects from low doses of radiation has actually been confirmed by the scientific community, regulatory agencies cautiously assume that the probability of these types of health effects occurring because of exposure to low doses (down to zero dose) is the same per unit dose as the health effects observed after an exposure to much higher doses (e.g., in atomic bomb survivors, individuals receiving medical exposure, or painters of radium dials). This concept is known as the linear no-threshold hypothesis. Under these assumptions, even natural background radiation, which is hundreds of times greater than radiation from current Hanford Site releases, increases each individual's probability or chance of developing a detrimental health effect.

Scientists do not fully agree on how to translate the available data on health effects into the numerical probability (risk) of detrimental effects from low radiological doses. Some scientific studies have indicated that low radiological doses result in beneficial effects (Sagan 1987). Because cancer and hereditary diseases in the general population are caused by many sources (e.g., genetic defects, sunlight, chemicals, and background radiation), some scientists doubt that the risk from low-level radiation exposure can ever be proven conclusively. In developing *Clean Air Act* regulations, EPA used a probability value of approximately 4 per 10 million ( $4 \times 10^{-7}$ ) for the risk of developing a fatal cancer after receiving a dose of 1 millirem (10 microsievert) (EPA 520/1-89-005). Additional data (National Research Council 1990) support the reduction of even this small risk value, possibly to zero, for certain types of radiation

when the dose is spread over an extended time. Guidance from the Interagency Steering Committee on Radiation Standards (ISCORS 2002) recommends that agencies assign a risk factor of 6 per 10 million ( $6 \times 10^{-7}$ ) for the risk of developing a fatal cancer after receiving a dose of 1 millirem (10 microsievert).

Government agencies are trying to determine what exposure level is safe for members of the public exposed to pollutants from industrial operations (e.g., DOE facilities, nuclear power plants, chemical plants, and hazardous waste sites). All of these industries are considered beneficial to the public in some way, such as providing electricity, national defense, waste disposal, and consumer products. Government agencies have a complex task to establish environmental regulations that control levels of risk to the public without unnecessarily reducing needed benefits from industry.

One perspective on risks from industry is to compare them to risks involved in other typical activities. For instance, two risks that an individual experiences when flying on an airplane are added radiological dose (from a stronger cosmic radiation field that exists at higher altitudes) and the possibility of being in an airplane accident. Table 10.14.5 compares the estimated risks from various radiological doses to the risks of some activities encountered in everyday life. Some activities that are estimated to be approximately equal in risk to that from the dose received by the maximally exposed individual from monitored Hanford Site effluents and emissions during 2008 are shown in Table 10.14.6.



**Table 10.14.5. Estimated Risk from Various Activities and Exposures<sup>(a)</sup>**

<b>Activity or Exposure Per Year</b>	<b>Risk of Fatality</b>
Smoking 1 pack of cigarettes per day (lung/heart/other diseases)	$3,600 \times 10^{-6}$
Home accidents	$100 \times 10^{-6(b)}$
Taking contraceptive pills (side effects)	$20 \times 10^{-6}$
Drinking 1 can of beer or 0.12 L (4 oz) of wine per day (liver cancer/cirrhosis)	$10 \times 10^{-6}$
Firearms (sporting accidents)	$10 \times 10^{-6(b)}$
Flying as an airline passenger (cross-country roundtrip – accidents)	$8 \times 10^{-6(b)}$
Eating ~54 g (4 Tbsp) of peanut butter per day (liver cancer)	$8 \times 10^{-6}$
Recreational boating (accidents)	$6 \times 10^{-6}$
Drinking chlorinated tap water (trace chloroform – cancer)	$3 \times 10^{-6}$
Riding or driving 483 km (300 mi) in a passenger vehicle	$2 \times 10^{-6(b)}$
Eating 41 kg (90 lb) of charcoal-broiled steaks (gastrointestinal tract cancer)	$1 \times 10^{-6}$
Natural background radiological dose (310 mrem [3.1 mSv])	0 to $180 \times 10^{-6}$
Flying as an airline passenger (cross-country roundtrip – radiation)	0 to $5 \times 10^{-6}$
Dose of 1 mrem (10 $\mu$ Sv) for 70 yr	0 to $6 \times 10^{-7}$
Dose to the hypothetical, maximally exposed individual living near the Hanford Site	0 to $3 \times 10^{-8}$

(a) These values are generally accepted approximations with varying levels of uncertainty; there can be significant variation as a result of differences in individual lifestyles and biological factors (Atallah 1980; Dinman 1980; Ames et al. 1987; Wilson and Crouch 1987; Travis and Hester 1990).

(b) Real actuarial values. Other values are predicted from statistical models. For radiological dose, the values are reported in a possible range from the least conservative (0) to the currently accepted most conservative value.

**Table 10.14.6. Activities Comparable in Risk to the 0.045-mrem (0.00045-mSv) Dose Calculated for the Hanford Site Maximally Exposed Individual in 2008**

Driving or riding 6.6 km (4 mi) in a car	Eating one 17.8-kg (39.4-lb) charcoal-broiled steak
Smoking less than 1/1,000 of a cigarette	Drinking 6.6 L (1.73 gal) of chlorinated tap water
Flying 16.8 km (10 mi) on a commercial airliner	Drinking 333 mL (11.8 oz) of beer or 111 mL (3.9 oz) of wine
Eating 5 Tbsp (75 mL) of peanut butter	Exposed to the U.S. national average background dose for 1.3 hours



## 10.15 Cultural and Historic Resources Monitoring

EP Kennedy and TE Marceau

Cultural and historic resources monitoring on DOE-managed portions of the Hanford Site is conducted under the auspices of the DOE Richland Operations Office's Hanford Cultural and Historic Resources Program to ensure site compliance with federal cultural resources laws and regulations (see Section 5.4.2). Program activities in 2008 included the following:

- Performing cultural resources reviews for all federal activities conducted at the Hanford Site in accordance with Section 106 of the *National Historic Preservation Act of 1966* and the *National Environmental Policy Act of 1969*
- Monitoring cultural resources conditions to ensure important resources were protected
- Maintaining a database of cultural resources site records, project records, and regional ethnohistory
- Maintaining archaeological and historical collections
- Identifying and evaluating new cultural resources so they could be appropriately managed
- Consulting with Native American tribes and stakeholders to gather input on the identification, documentation, and management of cultural resources important to them.

The DOE Hanford Cultural and Historic Resources Program oversees all cultural resource activities at the Hanford Site. The majority of technical work is performed for DOE by Pacific Northwest National Laboratory; Washington Closure Hanford, LLC; and the Columbia River Exhibition of History, Science, and Technology Museum.

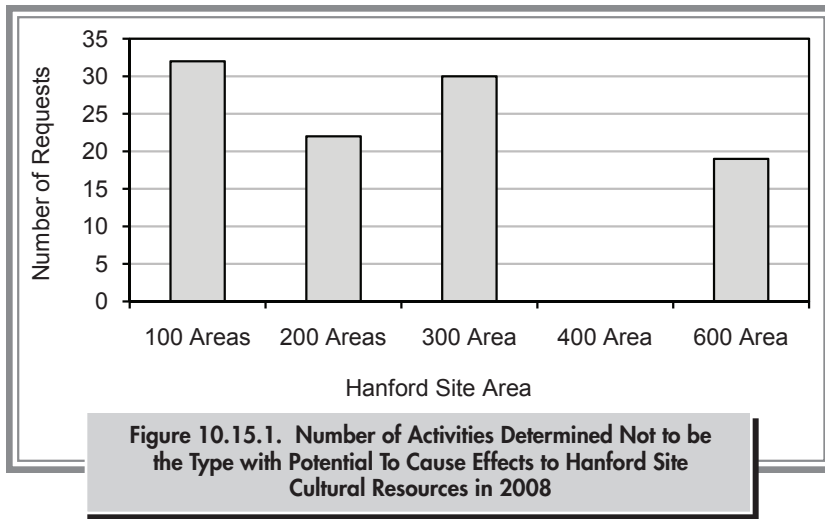
### 10.15.1 Cultural Resources Reviews

Pursuant to the *National Environmental Policy Act of 1969* and Section 106 of the *National Historic Preservation Act of 1966*, DOE conducts cultural resources reviews of all federal activities at the Hanford Site. Cultural resources reviews ensure that important cultural resources are identified and impacts to those resources are evaluated so that mitigation measures can be conducted.

During 2008, 113 requests were received for Hanford Site cultural resources reviews. Pacific Northwest National Laboratory received 57 review requests, and Washington Closure Hanford, LLC received 56 review requests. Upon initial review, DOE determined that 103 of the 113 activities were not the type that had the potential to cause adverse effects and therefore were exempt from full review. Examples of these activities included small excavations, such as routine maintenance activities in previously disturbed areas, particularly those located within the fence lines of existing operable units. The largest number of activities determined to not have the potential to cause adverse effects were located in the 300 Area in 2008 (Figure 10.15.1).

The remaining 10 activities required full reviews because these activities involved undisturbed ground, areas that had not been surveyed in the past, or locations in proximity to known cultural resources. Seven were completed by Pacific Northwest National Laboratory and three were completed by Washington Closure Hanford, LLC. The full reviews involved efforts to identify cultural resources that might





be affected by the activity, assess potential impacts, and develop mitigation measures if necessary (Table 10.15.1). Some full reviews required new areas (approximately 70.4 hectares [174 acres]) to be surveyed for cultural resources. Others required determinations of eligibility evaluations from the National Register of Historic Places, archaeological data recovery, or cultural resources monitoring of project excavations.

## 10.15.2 Cultural Resources Protections

Activities to ensure protection of Hanford Site cultural resources are conducted to comply with Section 110 of the *National Historic Preservation Act of 1966*, the *Native American Graves Protection and Repatriation Act of 1990*, and the *Archaeological Resources Protection Act of 1979*. The Hanford Site has had a monitoring program since 1987 to assess the effects of weathering and erosion or unauthorized excavation and collection upon the site's significant cultural resources. Activities include onsite inspections of important cultural resource sites to monitor site conditions, assess impacts (if any), and identify protective measures when an impact is significant. In 2008, 45 cultural resource sites were inspected on the Hanford Site.

Cultural resources site visits were conducted with the participation of tribal cultural resources personnel.

Although no major impacts were noted at the sites inspected in 2008, minor impacts as a result of recreation, natural erosion, and animal activity were recorded. DOE also visited Locke Island in the Hanford Reach of the Columbia River to measure river-caused erosion so protective measures could be taken if erosion rates began to increase. In 2008, the rate of erosion increased on the island relative to that of 2007. Water levels were higher than any since 1996 and 1997 levels, with a corresponding high in erosion measurements. One feature each from archaeological sites 45GR303 and 45GR304 were eroded completely from the cutbank within which they were exposed,

and several new features were exposed by the same erosive forces. A new concentration of archaeological material was noted during monitoring, also exposed through erosion. Examination of eroded areas has revealed there may be two separate causal variables: high water levels and periods of water fluctuation.

The DOE Richland Operations Office made a concerted effort to protect culturally sensitive areas within two highly significant traditional cultural properties containing multiple significant archaeological sites. Protection efforts include signage, access control, and cultural resources sensitivity and awareness training for federal agency and Hanford Site contractor staff. A land-use history report was completed for Gable Mountain to support these protection efforts.<sup>(a)</sup> Cultural resources survey documentation was completed for the Wautoma fire reseeding effort during 2008, which included documentation of 15 newly recorded archaeological sites and 15 newly recorded isolated finds. This project was initiated in 2007 and described in the *Hanford Site Environmental Report for Calendar Year 2007* (PNNL-17603). In 2008, two newly recorded archaeological sites were inadvertently driven over by contractor staff; the effects of this incident were documented.

(a) Document not publicly available.

**Table 10.15.1. Full Cultural Resources Reviews Conducted on the Hanford Site in 2008**

<b>Reviewing Organization</b>	<b>Proposed Activity</b>	<b>Field Activity</b>	<b>Survey Size (hectares [acres])</b>	<b>Review Finding</b>
PNNL	NoaNet fiber-optic cable installation at Midway Station, 600 Area	Field reconnaissance	0	No effect to historic properties
PNNL	Installation of aquifer tubes at six locations along the 100-K Area Terrace to support 100-KR-4 Pump-and-Treat Project	Field reconnaissance	0	No effect to historic properties. Archaeological excavation mitigation plan followed.
PNNL	Installation of four new injection wells to support the 100-KR-4 Pump-and-Treat Project, 100-K Area	Field reconnaissance	0	No effect to historic properties. Archaeological excavation mitigation plan followed.
PNNL	Interim Pretreatment System Facility to support treatment of tank wastes and Waste Treatment Plan, 200-East Area	Field survey	8 [20]	No effect to historic properties
PNNL	Phase 1 of CERCLA Treatability Test for 200-BC-1 Operable Unit, 600 Area	Field survey	24 [59]	Adverse effect to 216-B-26 Trench. Mitigation in form of documentation on Expanded Historic Property Inventory Form.
PNNL	Remediation of Zone A of the BC Control Area Waste Site UPR-200-E-83, 600 Area	Field survey	140 [346]	No effect to historic properties
PNNL	Demolition of 212-N, 212-P, and 212-R and remediation, 200-North Area	Field reconnaissance	0	Adverse effect to the 212-N, P and R. Mitigation in form of documentation on Expanded Historic Property Inventory Form and artifact assessment. No adverse effect to the White Bluffs Road, due to avoidance measures.
PNNL	Geophysical characterization and monitoring strategy for determining hydrogeologic processes in the hyporheic corridor in the 300 Area	Update archaeological site recording documentation and National Register determination of eligibility completed for 45BN162	0	No adverse effect to historic properties
WCH	300 Area Utility Relocation: Sanitary water improvements for the 331 Building	Field reconnaissance	0	No effect to historic properties. Monitoring conducted during trenching operations. No cultural resources observed.
WCH	Remediation of waste site 600-149 (Hanford Firing Range) in the 600 Area	Field reconnaissance	0	No effect to historic properties. Monitoring conducted during trenching operations. No cultural resources observed.
WCH	Installation of power poles and road crossings at 100-KR-4 Pump-and-Treat Project	Archaeological data recovery	0	No effect to historic properties. Archaeological excavation mitigation plan followed.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*

NoaNet = Northwest Open Access Network.

PNNL = Pacific Northwest National Laboratory.

WCH = Washington Closure Hanford, LLC.

### 10.15.2.1 Identification and Evaluation Activities

Identification and evaluation activities are performed to comply with Sections 106 and 110 of the *National Historic Preservation Act of 1966*. In 2008, no new archaeological sites or isolated finds were recorded. A determination of eligibility for listing in the National Register of Historic Places was completed for archaeological site 45BN162 that contained intact deposits dating between 2,000 to 8,000 radiocarbon years before the present. An addendum was completed to the *Mooli Mooli* National Register determination of eligibility, adding another contributing area to the traditional cultural property documentation.

### 10.15.2.2 Data Recovery Activities

No data recovery activities occurred during 2008.

### 10.15.2.3 Management of Artifact and Data Collections

Pacific Northwest National Laboratory, under a DOE contract, manages Hanford Site archaeological collections, DOE cultural resources records, a reference library, an electronic database of cultural resources reviews, geographic information system data of cultural sites and surveys, and an assortment of supporting documentations required to facilitate compliance efforts for the DOE Hanford Cultural and Historic Resources Program. Files from more than 1,500 cultural sites and curated archaeological collections from more than 80 sites are stored in an archive room. During 2008, temperature and humidity levels within the archive room remained within limits for storage of numerous types of archived materials. During 2008, the database and geographic information system continued to be used and updated. The Pacific Northwest National Laboratory's Total Records Information Management database (accessible to Pacific Northwest National Laboratory Cultural Resources staff) continues to be used for efficient retrieval of representative site photos, site monitoring photos, historic photos, and archived electronic documents produced by project activities.

The Columbia River Exhibition of History, Science, and Technology Museum manages the Hanford Site Manhattan Project and Cold War artifact collection. Efforts to generate new collections are conducted as stipulated in the programmatic agreement for the built environment on the Hanford Site (DOE/RL-96-77, Rev. 0), which directs DOE to assess the contents of site historical buildings and structures prior to the commencement of deactivation, decontamination, or decommissioning activities. The purpose of the assessments is to identify and preserve any artifacts (e.g., control panels, signs, scale models, and machinery) that may have value as interpretive or educational exhibits within national, state, or local museums. No walkthrough assessments were conducted in 2008.

### 10.15.3 Cultural Resources Consultations and Public Involvement

The DOE conducts formal consultations with the Washington State Historic Preservation Office, Native American tribes, and interested parties for cultural resources reviews to comply with Section 106 of the *National Historic Preservation Act of 1966* and the *National Environmental Policy Act of 1969* (see Section 2.0.2). In 2008, DOE consulted with the Washington State Historic Preservation Office and Native American tribes on 10 full cultural reviews (Table 10.15.1).

Hanford Cultural and Historic Resources Program staff held 12 meetings in 2008 with tribal cultural resources staff from the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Indian Nation, the Confederated Tribes of the Colville Reservation, the Nez Perce Tribe, and the Wanapum. Discussions focused on the 10 full cultural resources reviews initiated in 2008; development of a cultural resources management plan for Rattlesnake Mountain; and approaches to protecting threatened archaeological sites and places containing Native American human remains. No cultural resources meetings were held with non-tribal interested parties in 2008.





## 10.16 Climate and Meteorology

KW Burk

Meteorological measurements are taken to support Hanford Site emergency preparedness and response, operations, and atmospheric dispersion calculations for dose assessments (Appendix E, Tables E.5, E.7, E.9, and E.10). Support is provided through weather forecasting and by maintaining and distributing climatological data. Forecasting is provided to help manage weather-dependent operations. Climatological data are provided used to help plan weather-dependent activities and as a resource to assess the environmental effects of site operations.

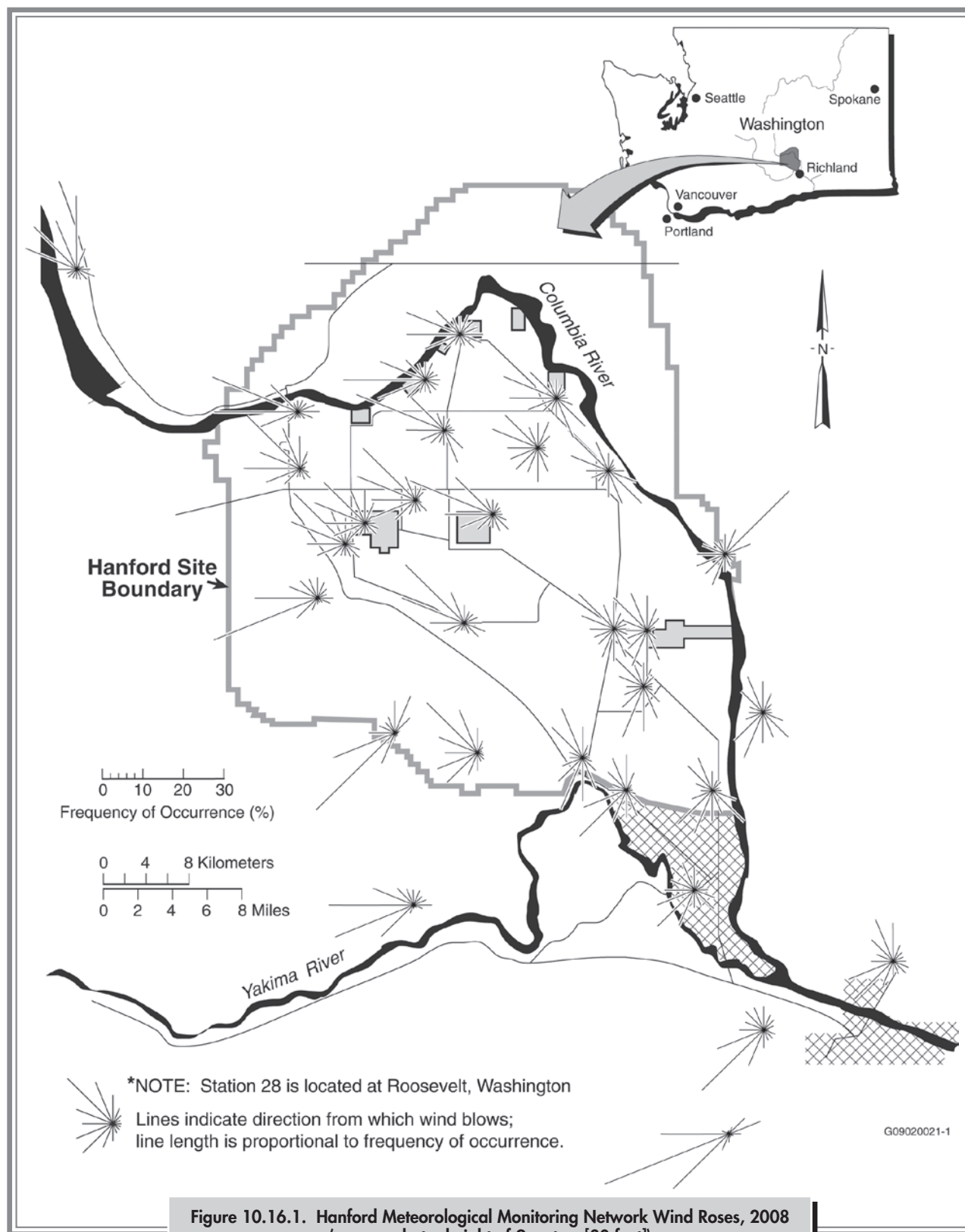
The Hanford Meteorology Station relies on data provided by the Hanford Meteorological Monitoring Network. This network consists of 30 remote monitoring stations that transmit data to the Hanford Meteorology Station via radio telemetry every 15 minutes. There are twenty-seven 9-meter (30-foot) towers and three 61-meter (200-foot) towers. Meteorological information collected at these stations includes wind speed, wind direction, temperature, precipitation, atmospheric pressure, and relative humidity; however, not all of these data are collected at all stations.

Regional temperatures, precipitation, and winds are affected by mountain barriers. The Cascade Range, beyond Yakima to the west, greatly influences the climate of the Hanford Site because of its rain-shadow effect. The Rocky Mountains and ranges in southern British Columbia protect the region from severe, cold polar air masses moving southward across Canada and winter storms associated with them.

Real-time and historical data from the Hanford Meteorology Station can be obtained at <http://hms.pnl.gov>. Data on this website include hourly weather observations, 15-minute data from the Hanford Meteorological Monitoring Network, monthly climatological summaries, and historical data.

The Hanford Meteorology Station is located on the Hanford Site Central Plateau, where the prevailing wind direction is from the northwest during all months of the year. The secondary wind direction is from the southwest. Summaries of wind directions indicate that winds from the northwestern quadrant occur most often during winter and summer. During spring and fall, the frequency of southwesterly winds increases, with a corresponding decrease in the northwesterly flow. Monthly average wind speeds are lowest during winter months, averaging about 3 meters per second (6 to 7 miles per hour), and highest during summer, averaging about 4 meters per second (8 to 9 miles per hour). Wind speeds well above average are usually associated with southwesterly winds. However, summertime drainage winds are generally northwesterly and frequently exceed 13 meters per second (30 miles per hour). These winds are most prevalent over the northern portion of the Hanford Site. Figure 10.16.1 shows the 2008 wind roses (i.e., diagrams showing direction and frequencies of wind) measured at a height of 9 meters (30 feet) for the 30 meteorological monitoring stations on and around the Hanford Site.

Atmospheric dispersion is a function of wind speed, wind duration and direction, atmospheric stability, and mixing depth. Dispersion conditions are generally good if winds are moderate to strong, the atmosphere is of neutral or unstable stratification, and there is a deep mixing layer. Good dispersion conditions associated with neutral and unstable stratification exist approximately 57% of the time during summer. Less-favorable conditions may occur when wind speed is light and the mixing layer is shallow. These conditions are most common during winter, when moderate to extremely stable stratification exists (approximately 66% of the time). Occasionally, there are extended periods of



**Figure 10.16.1. Hanford Meteorological Monitoring Network Wind Roses, 2008  
(measured at a height of 9 meters [30 feet])**

poor dispersion conditions, primarily during winter, that are associated with stagnant air in stationary high-pressure systems.

## 10.16.1 Historical Climatological Information

Daily and monthly averages and extremes of temperature, dew point temperature, and relative humidity for 1945 through 2004 are reported in PNNL-15160. From 1945 through 2008, the record maximum temperature was 45°C (113.0°F) recorded in August 1961, July 2002, and July 2006. The record minimum temperature was -30.6°C (-23.1°F) in February 1950. Normal monthly average temperatures ranged from a low of -0.2°C (31.7°F) in December to a high of 24.6°C (76.3°F) in July. During winter, the highest monthly average temperature at the Hanford Meteorology Station was 6.9°C (44.4°F) in February 1991, and the record lowest was -11.1°C (12.1°F) in January 1950. During summer, the record maximum monthly average temperature was 27.9°C (82.2°F) in July 1985, and the record minimum was 17.2°C (63.0°F) in June 1953. The normal annual relative humidity at the Hanford Meteorology Station is 54%. Humidity is highest during winter, averaging approximately 76%, and lowest during summer, averaging approximately 36%. Normal annual precipitation at the Hanford Meteorology Station is 17.7 centimeters (6.98 inches). The wettest year on record, 1995, received 31 centimeters (12.31 inches) of precipitation; the driest, 1976, received 7.6 centimeters (2.99 inches). Most precipitation occurs during late autumn and winter, with more than half of the annual amount occurring from November through February. The snowiest winter on record, 1992-1993, received 142.5 centimeters (56.1 inches) of snow.

## 10.16.2 Results of 2008 Monitoring

The 2008 average temperature and precipitation totals were below normal.

The average temperature for 2008 was 11.3°C (52.4°F), which was 0.7°C (1.2°F) below normal (12.0°C [53.6°F]). Five months during 2008 were warmer than normal; seven months were cooler than normal. February had the greatest positive departure, 1.5°C (2.7°F); December, at 3.7°C (6.7°F) below normal, had the greatest negative departure.

Precipitation during 2008 totaled 13.9 centimeters (5.49 inches), which is 79% of normal (17.7 centimeters [6.98 inches]). Snowfall for 2008 totaled 77.7 centimeters (30.6 inches), compared to normal snowfall of 39.1 centimeters (15.4 inches).

The average wind speed during 2008 was 3.6 meters per second (8.1 miles per hour), which was 0.2 meter per second (0.5 mile per hour) above normal. The peak gust for the year was 26.4 meters per second (59 miles per hour) on February 7.

Two dust storms were recorded at the Hanford Meteorology Station during 2008. There has been an average of five dust storms per year at the Hanford Meteorology Station during the entire period of record (1945–2008).

Table 10.16.1 provides monthly and annual climatological data collected at the Hanford Meteorology Station during 2008.



Table 10.16.1. Monthly and Annual Climatological Data for 2008 from the Hanford Meteorology Station

Hanford Meteorology Station, 40 kilometers (25 miles) northwest of Richland, Washington,  
latitude 46° 34'N, longitude 119° 35'W, elevation 223 meters (733 feet)

Month	Temperatures, °C								Precipitation (cm)				Relative Humidity (%)		15-m Wind <sup>(a)</sup>				
	Averages				Extremes				Total	Departure <sup>(b)</sup>	Snowfall		Average	Departure <sup>(b)</sup>	Average Speed, m/sec	Departure <sup>(b)</sup>	Peak Gusts		
	Daily Maximum	Daily Minimum	Monthly	Departure <sup>(b)</sup>	Highest	Date	Lowest	Date			Total	Departure <sup>(b)</sup>					Speed, m/sec	Direction	Date
J	1.4	-6.7	-2.7	-2.6	9.4	4	-16.7	22	3.3	+1.1	42.4	+31.7	80.7	+3.1	3.2	+0.4	22.8	SSW	5
F	10.1	-0.5	4.8	+1.5	18.3	28	-6.1	18	1.4	-0.3	10.2	+3.6	72.0	+1.3	3.5	+0.4	26.4	WSW	7
M	13.2	-0.6	6.3	-1.5	17.2	8	-5.6	22 <sup>(c)</sup>	0.5	-1.0	T <sup>(d)</sup>	-1.0	53.6	-3.0	3.7	+0.2	20.1	SW	23 <sup>(c)</sup>
A	17.1	1.6	9.3	-2.6	28.3	13	-5.6	3	0.2	-0.9	T <sup>(d)</sup>	0	44.2	-3.3	4.1	+0.2	19.7	SW	4
M	25.3	9.8	17.6	+1.0	37.2	17	-0.6	2	1.4	0	0	0	45.1	+2.1	4.2	+0.2	19.7	NW	11
J	28.3	11.8	20.1	-0.6	41.7	30	7.2	12 <sup>(c)</sup>	1.0	0	0	0	38.5	-1.1	4.6	+0.5	24.1	SW	29
J	33.9	16.2	25.1	+0.5	38.3	21 <sup>(c)</sup>	9.4	31	T <sup>(d)</sup>	-0.7	0	0	31.8	-1.5	4.2	+0.4	22.8	NW	10
A	32.2	15.3	23.7	-0.4	42.2	17	8.9	22	1.2	+0.5	0	0	38.9	+3.2	4.0	+0.5	22.3	SW	8
S	27.4	10.3	18.9	+0.1	33.3	12	2.2	23	0.1	-0.7	0	0	40.3	-1.8	3.3	0	18.8	WSW	25
O	18.4	4.1	11.3	-0.4	28.9	1	-2.8	29	0.6	-0.6	0	-0.3	53.2	-2.9	3.0	+0.1	16.5	WNW	13 <sup>(c)</sup>
N	10.4	1.1	5.7	+1.2	22.2	12	-4.4	25 <sup>(c)</sup>	1.9	-0.6	0	-5.8	79.3	+5.7	2.7	-0.2	17.4	SW	20
D	0.2	-7.9	-3.9	-3.7	11.7	8	-19.4	16	2.4	-0.4	25.1	+10.4	78.7	-1.7	2.9	+0.2	21.0	SW	12
Y <sup>(e)</sup>	18.2	4.5	11.3	-0.6	42.2	Aug 17	-19.4	Dec 16	13.9	-3.8	77.7	+38.6	54.7	+0.1	3.6	+0.2	26.4	WSW	Feb 7

NOTE: See Table A.2, Conversion Table in the Helpful Information section for unit conversion information.

(a) Measured on a tower 15 meters (50 feet) above the ground.

(b) Departure columns indicate positive or negative departure of meteorological parameters from 30-year (1971-2000) climatological normals.

(c) Latest of several occurrences.

(d) Trace.

(e) Yearly averages, extremes, and totals.



## 10.17 Quality Assurance

Quality assurance and quality control practices encompass all aspects of Hanford Site environmental monitoring and surveillance programs. This section provides information on specific measures taken in 2008 to ensure quality in project management, sample collection, and analytical results.

Samples were collected and analyzed according to documented standard analytical procedures. Analytical data quality was verified by a continuing program of internal laboratory quality control, participation in interlaboratory crosschecks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories.

Quality assurance/quality control for Hanford Site environmental monitoring and surveillance programs also include procedures and protocols to perform the following:

- Document instrument calibrations.
- Conduct program-specific activities in the field.
- Maintain groundwater wells to ensure representative samples are collected.
- Avoid cross-contamination by using dedicated well sampling pumps.

### 10.17.1 Hanford Site-Wide and Offsite Environmental Surveillance and Environmental Monitoring EA Lepel

During 2008, comprehensive quality assurance programs, including various quality control practices, were maintained

to assure the quality of data collected through the Pacific Northwest National Laboratory Surface Environmental Surveillance Project. The samples collected by project staff were submitted to General Engineering Laboratories, LLC, Charleston, South Carolina, for radiochemical and chemical analyses.

Samples for inorganic analyses were submitted primarily to the Battelle Marine Sciences Laboratory, located at the Pacific Northwest National Laboratory Sequim Marine Research Operations in Washington State.

#### 10.17.1.1 Project Management Quality Assurance

Site environmental monitoring and related activities (such as performing dose calculations) were subject to an overall quality assurance program. This program implements the requirements of DOE Order 414.1C, "Quality Assurance." Quality assurance plans are maintained by the project and these plans describe the specific quality assurance elements that apply to each project. These plans were approved by the Pacific Northwest National Laboratory quality assurance organizations that monitor compliance with the plans. Work performed through contracts, such as sample analyses, must meet the same quality assurance requirements. Potential equipment and service suppliers are audited before service contracts are approved and awarded, or materials are purchased that could have a significant impact on quality within the projects.

#### 10.17.1.2 Sample Collection Quality Assurance and Quality Control

Surface Environmental Surveillance Project samples were collected by personnel trained to conduct sampling

**Relative percent difference (RPD)** – A measure of the precision of the measurement of a sample (S) and its duplicate (D). The formula is as follows:

$$RPD = \left( \frac{|S - D|}{\frac{(S + D)}{2}} \right) \times 100$$

according to approved and documented procedures (PNNL-16744). Continuity of all sampling location identities was maintained through careful documentation. Field duplicate samples were collected for air, biota, soil, and water (Table 10.17.1). The water duplicates consisted of three Columbia River water samples and one onsite pond water sample. The biota duplicates were samples of cow's milk. Thirteen duplicate air samples were collected for tritium analyses; results for eight are available. A field duplicate

is used to assess sampling and measurement precision. Analytical results were reviewed against the criterion that the result must be greater than the minimum detectable activity value to be evaluated. To be an acceptable result, the relative percentage difference of the two duplicates must be less than 30%. Of the evaluated results, 84% of the total 2008 field duplicates were acceptable.

### 10.17.1.3 Analytical Results Quality Assurance and Quality Control

Routine chemical analyses of water samples were performed at General Engineering Laboratories, LLC for the Surface Environmental Surveillance Project. The laboratory participated in the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation Studies conducted by Environmental Resource Associates in Arvada, Colorado. General Engineering Laboratories, LLC maintained an internal quality control program that met the

**Table 10.17.1. Summary of Field Duplicate Sample Results for Samples Submitted to General Engineering Laboratories, LLC, Charleston, South Carolina, for the Surface Environmental Surveillance Project, 2008**

Media (Number of Samples)	Radionuclides	Number of Results Reported for Each Radionuclide <sup>(a)</sup>	Number Within Control Limits for Each Radionuclide <sup>(b)</sup>
Air (13)	<sup>3</sup> H	8	1
Water (4)	<sup>3</sup> H	4	4
	<sup>90</sup> Sr	1	1
	<sup>234</sup> U, <sup>238</sup> U	3	3
	Gross beta	1	1
Biota <sup>(c)</sup> (1)	<sup>3</sup> H	2	2
	<sup>40</sup> K	2	2
	<sup>90</sup> Sr	0	0
Soil <sup>(d)</sup> (2)	<sup>40</sup> K	4	4
	<sup>90</sup> Sr	1	0
	<sup>134</sup> Cs	2	2
	<sup>137</sup> Cs	4	4
	<sup>234</sup> U, <sup>235</sup> U, <sup>238</sup> U	4	4
	<sup>239/240</sup> Pu	4	4

(a) Number of reported results are those results greater than the minimum detectable activity.

(b) Number of reported results within control limits are those results with the relative percent difference value less than 30%, and the result is greater than the minimum detectable activity.

(c) Cow milk samples collected in triplicate, resulting in two duplicates.

(d) Two soil samples collected in triplicate. Each triplicate was considered two duplicates.

requirements in EPA (1986). The program was audited by the DOE Consolidated Audit Program.

Routine metals analyses were performed by the Battelle Marine Sciences Laboratory. The Battelle Marine Sciences Laboratory participated in the NSI Solutions, Inc. Proficiency Testing Program. NSI Solutions, Inc. in Raleigh, North Carolina, supplied spiked soil and water samples for analyses. Analytical results were provided to NSI Solutions, Inc. and compared to the known concentrations of the spikes. Water sample results from three (two for inductively coupled plasma-optical emission spectroscopy) studies in 2008 were reported. The acceptance criteria were met by 99% of the reported results from the water samples. Results also reported from two soil studies in 2008; 100% of these results were acceptable. Results are summarized in Table 10.17.2.

Routine radiochemical analyses of samples for the Environmental Surveillance Monitoring Project were performed by General Engineering Laboratories, LLC, who also participated in the DOE Mixed Analyte Performance Evaluation Program (DOE 2004). A quality control blind-spiked sample program was also conducted by the Pacific Northwest National Laboratory. General Engineering Laboratories, LLC maintains an internal quality control program. Additional information on these quality control efforts is provided in the following sections.

**Blind-spiked sample** – A sample of known activity and/or concentration submitted to the analytical laboratory but not necessarily in the same physical geometry as the typical samples submitted.

#### 10.17.1.4 U.S. Department of Energy and U.S. Environmental Protection Agency Comparison Studies

Blind-spiked water samples were distributed to participating laboratories as part of the EPA performance evaluation program. These blind-spiked samples contained specific organic and inorganic analytes that had concentrations unknown to the analyzing laboratories. After analysis, the results were submitted to Environmental Resource Associates, the EPA performance evaluation program sponsor, for comparison with known values and results from other participating laboratories. Results from seven different studies were reported. The acceptance criteria were met by 94.5% of the results; however, General Engineering Laboratories, LLC did not meet acceptance criteria for any chromium measurements (Table 10.17.3).

The DOE Mixed Analyte Performance Evaluation Program conducted by the Radiological and Environmental Sciences Laboratory in Idaho Falls, Idaho, provided standard samples of environmental media (e.g., air filters, soil, vegetation, and water) containing specific amounts of one or more radionuclides unknown to the participating laboratory. After analysis, the results were forwarded to

**Table 10.17.2. Summary of Battelle's Marine Sciences Laboratory Performance on NSI Solutions, Inc. Proficiency Testing Program Samples (five studies), 2008**

<u>Media</u>	<u>Analytes</u>	<u>Number of Results Reported for Each Analyte</u>	<u>Number Within Control Limits for Each Analyte</u>
Soil	Al, Sb, As, Ba, Be, B, Cd, Cr, Co, Cu, Pb, Mn, Hg, Mo, Ni, Se, Ag, Sr, Sn, Tl, V, Zn	2	2
	Ca, Fe, Mg, Na, K, Ti	1	1
Water	Hg	2	2
	B, Ca, Fe, Mg, K, Ti	2	2
	Na	2	1
	Al, Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Ag, Sr, Tl, V, Zn	3	3

**Table 10.17.3. Summary of Chemical Results for General Engineering Laboratories, LLC, Charleston, South Carolina, Performance on Seven Environmental Resource Associates' Proficiency Testing Samples, 2008**

Analyte	Number of Results Reported for Each Analyte	Number Within Control Limits for Each Analyte
Manganese	13	10
Aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, copper, iron, lead, molybdenum, nickel, selenium, silver, and thallium	10	10
Zinc	9	9
Turbidity	8	4
Vanadium	8	8
Chromium	6	0
Strontium, total hardness as CaCO <sub>3</sub>	6	6
2-Amino-4,6-dinitrotoluene; 4-amino-2,6-dinitrotoluene	5	5
1,3-Dinitrobenzene	5	4
1,3,5-Trinitrobenzene; 2,4,6-trinitrotoluene; 2,4-dinitrotoluene; 2,6-dinitrotoluene; 2-nitrotoluene; 4-nitrotoluene; bromide; calcium; chemical oxygen demand (COD); octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX); nitrobenzene; tetryl; total residual chlorine	4	4
3-Nitrotoluene, calcium hardness as CaCO <sub>3</sub>	4	3
Hexavalent chromium; hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	4	2
Aroclor 1016, Aroclor 1242, Aroclor 1254, Aroclor 1260, magnesium, mercury	3	3
Dissolved organic carbon (DOC)	3	0
Aroclor 1221, Aroclor 1232, Aroclor 1248, biological oxygen demand (BOD), carbonaceous biological demand (CBOD), cyanide, cyanide total, diesel range organics (DRO), non-filterable residue (TSS), pH, phenolics total, silica as SiO <sub>2</sub> , sodium, total organic carbon (TOC), total phosphorus as phosphorus, total petroleum hydrocarbons (TPH) (gravimetric), volatile solids	2	2
Total organic halides (TOX)	2	1
Total organic carbon (TOC)	2	0
2,6-Dinitrotoluene; alkalinity as CaCO <sub>3</sub> ; chlorate; chloride; conductivity at 25°C; fluoride; gasoline range organics (GRO); hexane extracted material (HEM), nitrate+nitrite as nitrogen; nitrate as nitrogen; nitrite as nitrogen; oil and grease (gravimetric); ortho-phosphate as phosphorus; potassium; silica gel treated hexane extractable material (SGT-HEM); sulfate; total dissolved solids at 180°C; total Kjeldahl nitrogen; total solids at 105°C	1	1

the Radiological and Environmental Sciences Laboratory (two studies) or Environmental Resource Associates (three studies) for comparison with known values and results from other laboratories. The Radiological and Environmental Sciences Laboratory and Environmental Resource Associates established criteria for evaluating the accuracy of results as defined by the *National Standards for Water Proficiency Testing Studies, Criteria Document* (NERL-Ci-0045). The Radiological and Environmental Sciences Laboratory evaluated the DOE Mixed Analyte Performance Evaluation Program radiological and inorganic samples results for accuracy by determining if each result was within  $\pm 30\%$  of a reference value. Summaries of the 2008 results are provided in Tables 10.17.4 and 10.17.5. The DOE Mixed Analyte Performance Evaluation Program provided General Engineering Laboratories, LLC with two sets of performance evaluation samples for analysis consisting of air filters, soil, vegetation, and water. Acceptable control limits, as defined by the DOE Mixed Analyte Performance Evaluation Program, were met by 97% of the DOE performance assessment sample results. The acceptable control limit range (NERL-Ci-0045) was met by 85% of the Environmental Resource Associates samples.

**Double-blind spiked sample** – A sample of known activity and/or concentration prepared to look like a typical sample submitted to the analytical service laboratory.

### 10.17.1.5 Pacific Northwest National Laboratory Evaluations

Eight double-blind spiked samples were submitted for analyses by the Surface Environmental Surveillance Project. The samples included air filters, soil, vegetation, and water (Table 10.17.6). For all media, 85% of General Engineering Laboratories, LLC radiochemistry blind-spiked determinations were within the control limit ( $\pm 30\%$  of the known value). In 2008, all of the air filter blind-spiked analysis results were within the control limit. Two vegetation blind-spiked analysis results were outside the control limit, manganese-54 (a gamma-emitter) and uranium-234. Analysis results for four blind-spiked soil samples were outside the control limit: one for zinc-65 (a gamma-emitter); one for plutonium-238; and two for plutonium-239/240.

**Table 10.17.4. Summary of General Engineering Laboratories, LLC, Charleston, South Carolina, Performance on Eight Performance Evaluation Program Samples Provided by the DOE Mixed Analyte Performance Evaluation Program, 2008**

<u>Media</u>	<u>Radionuclides</u>	<u>Number of Results Reported for Each Radionuclide</u>	<u>Number of Results Within Control Limits for Each Radionuclide<sup>(a)</sup></u>
Air filters	Gross alpha, gross beta, <sup>54</sup> Mn, <sup>57</sup> Co, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, <sup>241</sup> Am	2	2
Soil	<sup>40</sup> K, <sup>54</sup> Mn, <sup>57</sup> Co, <sup>60</sup> Co, <sup>63</sup> Ni, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>99</sup> Tc, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, <sup>241</sup> Am	2	2
	<sup>55</sup> Fe	2	1
	<sup>125</sup> Sb	1	1
Vegetation	<sup>54</sup> Mn, <sup>57</sup> Co, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>137</sup> Cs, <sup>234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu	2	2
	<sup>134</sup> Cs, <sup>241</sup> Am	2	1
Water	Gross alpha, gross beta, <sup>3</sup> H, <sup>54</sup> Mn, <sup>55</sup> Fe, <sup>57</sup> Co, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>99</sup> Tc, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, <sup>241</sup> Am	2	2
	<sup>63</sup> Ni	2	1

(a) Control limits are from DOE (2004).

**Table 10.17.5. Summary of General Engineering Laboratories, LLC, Charleston, South Carolina, Performance on One Water Supply Sample and One Multimedia Radiochemistry Performance Evaluation Sample Provided by the Environmental Resource Associates Proficiency Testing Program, 2008**

<u>Media</u>	<u>Radionuclides</u>	<u>Number of Results Reported for Each Radionuclide</u>	<u>Number of Results Within Control Limits for Each Radionuclide<sup>(a)</sup></u>
Water	Gross alpha	5	5
	Gross beta	4	4
	<sup>60</sup> Co, <sup>65</sup> Zn, <sup>131</sup> I, <sup>134</sup> Cs, <sup>137</sup> Cs	4	2
	<sup>90</sup> Sr, <sup>228</sup> Ra	3	3
	<sup>226</sup> Ra	3	2
	<sup>3</sup> H, <sup>54</sup> Mn, <sup>89</sup> Sr, U (natural), U (natural) mass	2	2
	<sup>133</sup> Ba	2	0
	<sup>234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239</sup> Pu, total U	1	1
Soil	<sup>90</sup> Sr, <sup>241</sup> Am	2	2
	<sup>40</sup> K, <sup>54</sup> Mn, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>212</sup> Bi, <sup>212</sup> Pb, <sup>214</sup> Bi, <sup>214</sup> Pb, <sup>228</sup> Ac, <sup>234</sup> Th, <sup>234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239</sup> Pu, total U	1	1
Vegetation	<sup>90</sup> Sr	2	2
	<sup>40</sup> K, <sup>54</sup> Mn, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239</sup> Pu, total U	1	1

(a) Control limits are from NERL-Ci-0045.

Three blind-spiked water analysis results were outside the control limit: one tritium and two gamma-emitters, cobalt-60 and cesium-134. No consistent pattern was observed.

### 10.17.1.6 Laboratory Internal Quality Assurance Programs

Analytical laboratories are required to maintain an internal quality assurance and control program. Laboratories are audited at least annually for compliance to the quality assurance and control programs. At General Engineering Laboratories, LLC, the quality control program met the quality assurance and control criteria as specified in EPA (1986). The laboratory was also required to maintain a system to review and analyze the results of the quality control samples to detect problems that may have arisen from contamination, inadequate calibrations, calculation errors, or improper procedure performance. Detection levels for each analytical method were determined at least annually.

The internal quality control program at General Engineering Laboratories, LLC involved routine calibrations of counting instruments, yield determinations of radiochemical procedures, frequent radiation-check sources and background counts, replicate and spiked sample analyses, the use of matrix and reagent blanks, and maintenance of control charts to indicate analytical deficiencies. Available calibration standards traceable to the National Institute of Standards and Technology were used for radiochemical calibrations. Calculation of minimum detectable concentrations involved the use of factors such as the average counting efficiencies and background counts for detection instruments, length of time for background and sample counts, sample volumes, radiochemical yields, and a pre-designated uncertainty multiplier (EPA 520/1-80-012).

The internal quality control program at the Battelle Marine Sciences Laboratory involved routine daily calibrations of analytical instruments, analysis of certified reference

**Table 10.17.6. Summary of General Engineering Laboratories, LLC, Charleston, South Carolina, Performance on Double-Blind Spiked Samples Submitted by Pacific Northwest National Laboratory for the Surface Environmental Surveillance Project, 2008**

<u>Media</u>	<u>Radionuclides</u>	<u>Number of Results Reported for Each Radionuclide</u>	<u>Number of Results Within the Control Limit for Each Radionuclide<sup>(a)</sup></u>
Air filters	$^{60}\text{Co}$ , $^{90}\text{Sr}$ , $^{137}\text{Cs}$ , $^{238}\text{Pu}$	2	2
	$^{54}\text{Mn}$ , $^{57}\text{Co}$ , $^{134}\text{Cs}$ , $^{234}\text{U}$ , $^{238}\text{U}$ , $^{239/240}\text{Pu}$	1	1
Soil	$^{40}\text{K}$ , $^{137}\text{Cs}$ , $^{234}\text{U}$ , $^{241}\text{Am}$	2	2
	$^{238}\text{Pu}$	2	1
	$^{239/240}\text{Pu}$	2	0
	$^{54}\text{Mn}$ , $^{90}\text{Sr}$ , $^{212}\text{Pb}$ , $^{214}\text{Bi}$ , $^{214}\text{Pb}$ , $^{238}\text{U}$	1	1
	$^{65}\text{Zn}$	1	0
	$^{60}\text{Co}$ , $^{90}\text{Sr}$ , $^{137}\text{Cs}$ , $^{238}\text{Pu}$	2	2
Vegetation	$^{54}\text{Mn}$	2	1
	$^{134}\text{Cs}$ , $^{238}\text{U}$ , $^{239/240}\text{Pu}$	1	1
	$^{234}\text{U}$	1	0
	$^{238}\text{Pu}$ , $^{239/240}\text{Pu}$	2	2
Surface water	$^3\text{H}$	2	1
	$^{137}\text{Cs}$ , $^{234}\text{U}$ , $^{238}\text{U}$	1	1
	$^{60}\text{Co}$ , $^{134}\text{Cs}$	1	0

(a) Control limit  $\pm 30\%$ .

materials, replicate and spiked sample analyses, and the use of matrix and reagent blanks. Acceptable results were achieved for more than 95% of quality control analyses. Most failures were attributed to the results for certified reference materials that were certified at or near the achieved detection limit for that analyte. Available calibration standards traceable to the National Institute of Standards and Technology were used for calibrating instruments used in metal analyses. Calculations of method detection limits are performed annually according to 40 CFR 136, Appendix B. The Battelle Marine Sciences Laboratory maintained strict adherence to in-house sample handling and chain-of-custody procedures, and all data were fully validated prior to release.

Periodically, inspections of services were performed, and conformance of the analytical facility with its contractual requirements was documented. These inspections provided the framework within which to identify and resolve potential performance problems. Responses to inspection findings

were documented by written communication, and corrective actions were verified by follow-up audits and inspections. In 2008, an audit of General Engineering Laboratories, LLC was conducted by the DOE Consolidated Audit Program.

The scope of DOE Consolidated Audit Program audits included the following specific functional areas: 1) quality assurance management systems and general laboratory practices; 2) data quality for organic analyses; 3) data quality for inorganic and wet chemistry analyses; 4) data quality for radiochemistry analyses; 5) laboratory information management systems (electronic data management); 6) hazardous and radioactive materials management; and 7) verification of corrective-action implementation from previous audit findings.

A total of 4 new Priority II findings (requiring some corrective action by the laboratory) and 13 observations were noted during the DOE Consolidated Audit Program audit

of General Engineering Laboratories, LLC. A Priority II finding is defined as the following:

“...factual statement issued from a DOECAP [DOE Consolidated Audit Program] audit to document a deficiency which in of itself does not represent a concern of sufficient magnitude to render the audited facility unacceptable to provide services to DOE. An observation is defined as a factual statement resulting from a DOECAP audit to document an isolated deficiency, deviation from Best Management Practices, or an opportunity for improvement, which does not warrant issuance of a Priority II finding.”

Thirteen previous Priority II finding were closed and one remains open.

The four new Priority II findings are as follows:

1. Data Quality for Organic Analyses – The organic extraction standard operating procedure for semivolatile organics analysis compounds from soil does not provide sufficient information related to the method blank.
2. Data Quality for Inorganic and Wet Chemistry Analyses – Performance analysis of selenium on recent Mixed Analyte Performance Evaluation Program soil studies has not been acceptable.
3. Data Quality for Radiochemistry Analyses – Spectral data references are not documented.
4. Laboratory Information Management Systems/Electronic Data Management – Spreadsheets were identified that lacked write protection (a software protection mechanism that prevents modification or erasure of data).

The open Priority II finding is as follows:

1. The temperature of refrigerators and freezers is tracked each work day instead of each calendar day.

Corrective actions for all the audit findings were accepted, and verification of the corrective actions will be performed in future audits.

The DOE Consolidated Audit Program audit<sup>(a)</sup>

“found that GEL [General Engineering Laboratories, LLC] meets established requirements necessary to produce data of acceptable and documented quality through analytical operations that follow approved and technically sound methods. DOE samples and analysis-derived waste are handled in a manner that is protective of human health and the environment.”

Internal laboratory quality control program data were reported with analytical results. Pacific Northwest National Laboratory scientists summarized results quarterly. General Engineering Laboratories, LLC met contract-specified requirements for each quarter of 2008 (for the Surface Environmental Surveillance Project).

#### 10.17.1.7 Media Audits and Comparisons

Additional audits and comparisons were conducted on several specific types of samples. The Washington State Department of Health routinely analyzed co-samples of various environmental media during 2008 as part of its oversight monitoring program (see Section 3.0.4). Media that were analyzed for radionuclides included irrigation water from 2 locations, water from 14 locations along and across the Columbia River, water from 10 Columbia River shoreline springs, water from 1 onsite drinking water location, sediment from 11 Columbia River sites extending from Priest Rapids Dam (upriver from the Hanford Site) to McNary Dam (downriver from the Hanford Site), and surface soil from 9 locations. Biota samples analyzed for radionuclides were four samples of cherries, two samples of potato tubers, and seven samples of perennial vegetables. Four deer samples were obtained for bone and muscle analysis.

Data from the measurement of gross beta in air samples collected at several co-located sites were also reported by the Washington State Department of Health and Pacific Northwest National Laboratory. The Washington State Department of Health and Pacific Northwest National Laboratory collected samples on a biweekly basis. Data

(a) Document not publicly available.

were compared for sites at the Pacific Northwest National Laboratory Complex, Prosser Barricade, Wye Barricade, and Yakima Barricade (Figure 10.2.2). Comparison of gross beta concentrations at the Pacific Northwest National Laboratory Complex is shown in Figure 10.17.1. Laboratory data are presented with two sigma error bars (2 standard deviation confidence level), and the values are in mutual agreement with those reported by the Washington State Department of Health. The Washington State Department of Health and Pacific Northwest National Laboratory reported tritium data in air (collected on silica gel) at the 300 Area water intake location (Figure 10.17.2). The tritium value obtained from samples collected September 25 through October 22, 2008, was significantly elevated. This was brought to the attention of General Engineering Laboratories, LLC, which determined the cause of the elevated results was contaminated hardware from a previous analysis. Pacific Northwest National Laboratory determined that nine silica gel samples were elevated due to contamination, based on a review of past analyses at the measurement location and concurrently reported tritium measurements. Identified samples were flagged in the database.

The U.S. Food and Drug Administration received co-samples provided by Pacific Northwest National Laboratory from sampling locations around the Hanford Site and analyzed cherries and potato tubers for radionuclides (Table 10.17.7). Potassium-40 concentrations measured

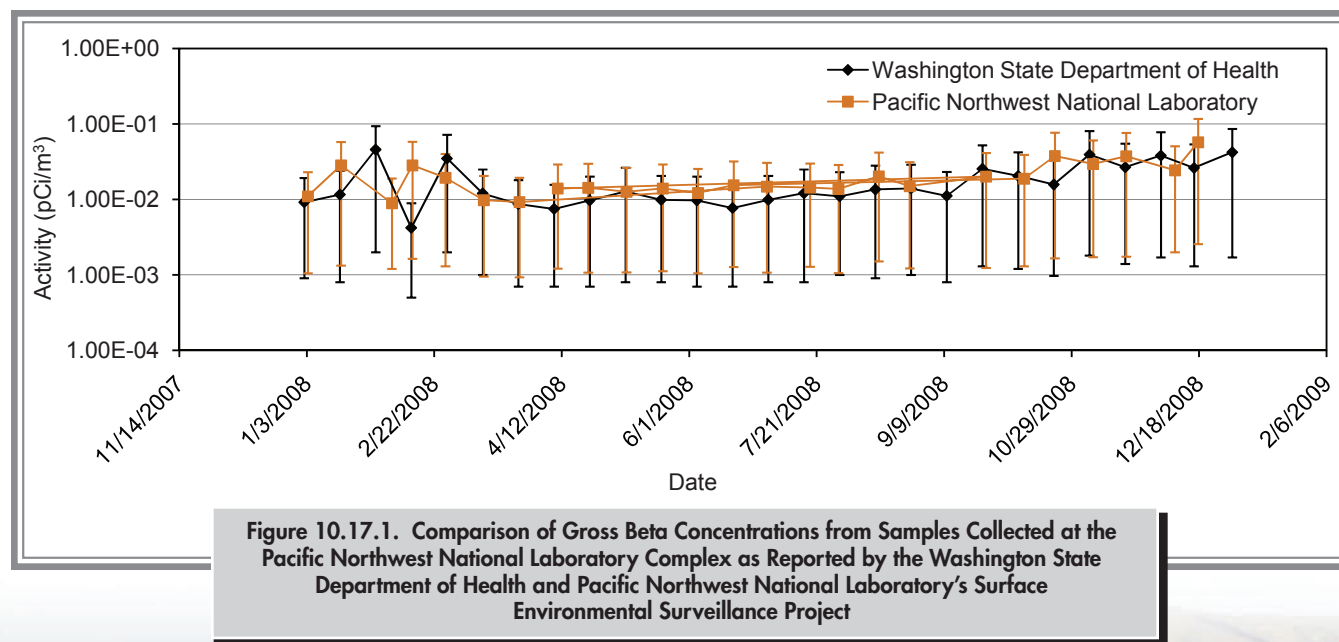
by the U.S. Food and Drug Administration and General Engineering Laboratories, LLC in cherries and potato tubers were in mutual agreement.

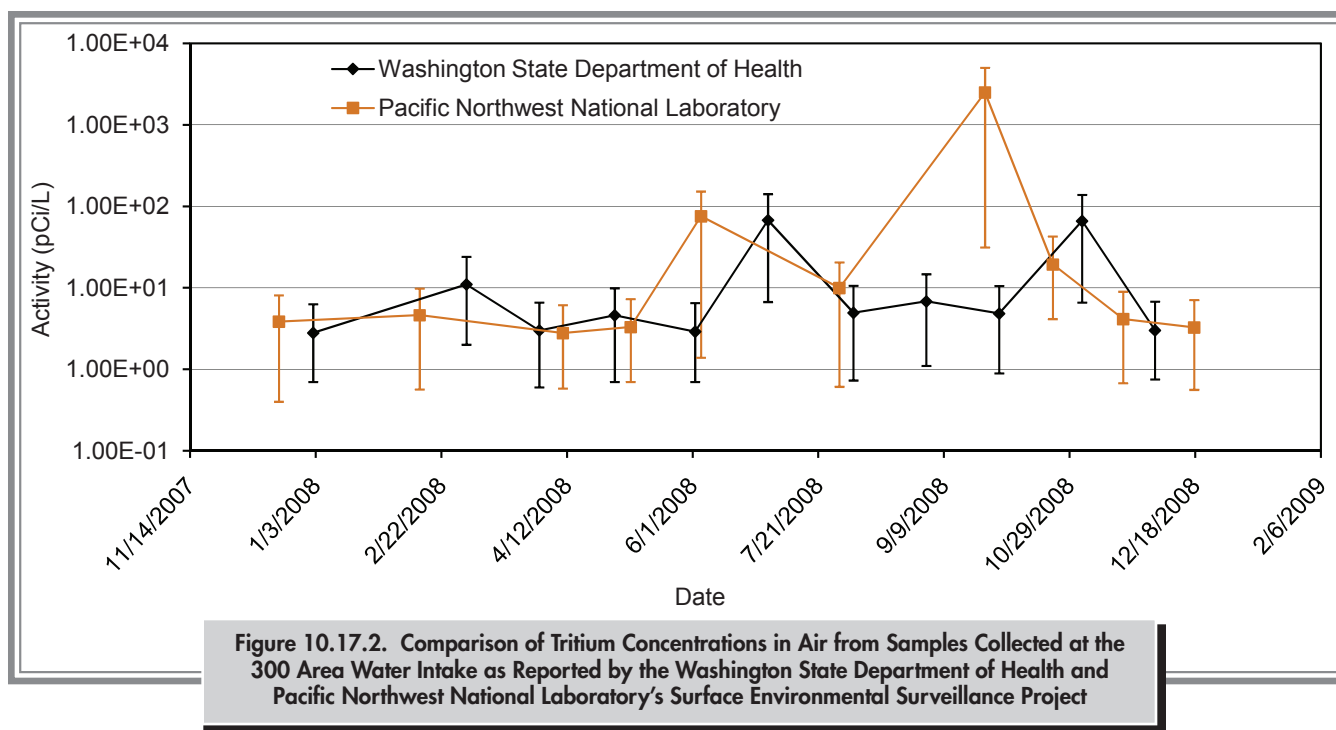
Samples of bone and muscle from a mule deer collected in December 2007 were submitted to the previous analytical laboratory (TestAmerica Richland Laboratory) and to General Engineering Laboratories, LLC for strontium-90 analysis in bone and gamma analysis of muscle tissue. The strontium-90 concentration measured by TestAmerica Richland Laboratory was  $0.19 \pm 0.04$  pCi/g; General Engineering Laboratories, LLC reported  $0.24 \pm 0.02$  pCi/g. These results show remarkable agreement between the laboratories. Samples of red and white wines were also compared between the laboratories. Potassium-40 was the only significant nuclide measured in the wines; results indicated very good agreement between the two laboratories.

## 10.17.2 Effluent Monitoring and Environmental Monitoring Near Facilities and Operations Quality Assurance Programs

JJ Dorian

The Effluent Monitoring and Near-Facility Environmental Monitoring Programs were subject to the quality assurance





**Table 10.17.7. Comparison of U.S. Food and Drug Administration and Pacific Northwest National Laboratory<sup>(a)</sup> Results for Food and Farm Product Samples Collected Near the Hanford Site, 2008<sup>(b)</sup>**

Media	Sampling Area <sup>(c)</sup>	Organization	Potassium-40 pCi/g <sup>(d,e)</sup>
Cherries	Sagemoor	FDA	2.0 ± 1.6
		FDA	2.6 ± 0.5
		GEL	3.6 ± 0.6
Potato tuber	Sunnyside	FDA	3.6 ± 0.6
		FDA	3.2 ± 0.7
		GEL	3.9 ± 0.4

(a) Samples analyzed by General Engineering Laboratories, LLC, Charleston, South Carolina.

(b) Sample results are wet weight.

(c) Sampling areas are illustrated in Figure 10.8.1.

(d) To convert pCi/g to Bq/g, multiply by 0.037.

(e) Errors reported as ±2 standard deviations.

FDA = U.S. Food and Drug Administration.

GEL = General Engineering Laboratories, LLC, Charleston, South Carolina.

requirements specified in DOE/RL-96-68, Rev. 2. These quality assurance programs complied with DOE Order 414.1C, using standards from the American Society of Mechanical Engineers (ASME NQA-1-2000) as their basis. The program also adhered to the guidelines and objectives in *Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA QA/R-5).

The Effluent Monitoring and Near-Facility Monitoring Programs each have a quality assurance project plan describing applicable quality assurance elements. These plans were approved by contractor quality assurance groups, who monitored compliance with the plans. Work, such as sample analyses performed through contracts, had to meet plan requirements. Suppliers were audited before the contract selection was made for equipment and services that may have significantly affected project quality.

### 10.17.2.1 Sample Collection Quality Assurance

Samples for the Effluent Monitoring and Near-Facility Environmental Monitoring Programs were collected by

personnel trained in accordance with the approved procedures. Established sampling locations were accurately identified and documented to ensure continuity of data for those sites and are described in PNNL-18427, APP. 2.

### 10.17.2.2 Analytical Results Quality Assurance

#### HK Meznarich and EJ Wyse

Samples for the Effluent Monitoring and Near-Facility Environmental Monitoring Programs were analyzed by up to three different analytical laboratories. Use of these laboratories was dependent on the Hanford Site contractor collecting the samples. Table 10.17.8 provides a summary of the analytical laboratories used for analyzing Hanford Site effluent monitoring and near-facility monitoring samples in 2008.

Analytical data quality was ensured by several means. For instance, counting room instruments were verified to perform within calibration limits through daily checks, the results of which were stored in computer databases. Radiochemical standards used in analyses were measured regularly,

**Table 10.17.8. A Summary of Hanford Site Laboratories Used by Site Contractors and Types of Effluent Monitoring and Near-Facility Monitoring Samples Analyzed, 2008**

Analytical Laboratory	Effluent Monitoring Samples						Near-Facility Environmental Monitoring Samples		
	Fluor Hanford, Inc.		Pacific Northwest National Laboratory	CH2M HILL Hanford Group, Inc.		Bechtel Hanford, Inc. and Washington Closure Hanford, LLC	Fluor Hanford, Inc.		
	Air	Water	Air	Water	Air	Water	Air	Water	Other
Waste Sampling and Characterization Facility <sup>(a)</sup>	X	X				X	X	X	X
Advanced Technologies and Laboratories International, Inc.				X					X
General Engineering Laboratories, LLC, Charleston, South Carolina	X	X	X		X	X			
Radiochemical Processing Laboratory <sup>(b)</sup>	X	X	X						

(a) Operated by Fluor Hanford, Inc.

(b) Operated by Pacific Northwest National Laboratory.

and the results were reported and tracked. Formal, written laboratory procedures were followed to analyze samples. Analytical procedural control was ensured through administrative procedures. Chemical technologists at the laboratories are qualified to perform analyses through formal classroom and on-the-job training.

The participation of the Hanford Site analytical laboratories in EPA and DOE laboratory performance evaluation programs also served to ensure the quality of data produced. Samples formerly provided by the EPA are now available only from National Institute of Standards and Technology-approved private contractors.

Performance of the Waste Sampling and Characterization Facility was evaluated by its participation in the following laboratory performance intercomparison studies in 2008: the EPA studies (i.e., soil and water pollution), the DOE Mixed Analyte Performance Evaluation Program studies, and the National Institute of Standards and Technology Radiochemistry Intercomparison Program study. The Waste Sampling and Characterization Facility Laboratory received and analyzed samples containing 414 different analytes and compounds during participation in the EPA Water Pollution Studies Nos. 156 and 162 and EPA Soil Studies Nos. 61 and 63. Of the 414 reported analytes, 409 results were acceptable while 5 were unacceptable, for a total acceptable rate of 99%. In the DOE Mixed Analyte Performance Evaluation Program study (MAPEP-07-Study 18 and MAPEP-08-Study 19), samples containing 409 different radionuclides and analytes were submitted to the Waste Sampling and Characterization Facility for analysis. Of the 409 reported radionuclide analytes, 390 results were acceptable while 19 were unacceptable, for a total acceptable rate of 95%. In the National Institute of Standards and Technology Radiochemistry Intercomparison Program study, samples containing strontium-90, americium-241, isotopic plutonium, and isotopic uranium in filters and soils were submitted to the Waste Sampling and Characterization Facility for different analyses (i.e., five samples of each radionuclide for each medium). All radionuclide results for both filters and soils were acceptable, for a total acceptable rate of 100%. Performance evaluation results for the Waste Sampling and Characterization Facility are presented in Table 10.17.9.

Advanced Technologies and Laboratories International, Inc., the Analytical Services Production Contractor at the 222-S Laboratory in the 200-West Area of the Hanford Site, received accreditation from the American Industrial Hygiene Association and the Washington State Department of Ecology in 2007, receiving additional scope from each in 2008. Analytical performance was evaluated by its participation in six different laboratory proficiency testing studies in 2008. The laboratory participated in one round of the Environmental Resource Associates' MRaD study, a radiological performance evaluation study that was added when the DOE Mixed Analyte Performance Evaluation Program was temporarily suspended. The Mixed Analyte Performance Evaluation Program resumed in early 2008; however, Advanced Technologies and Laboratories International, Inc. continued using Environmental Resource Associates' MRaD study for the first half of 2008, returning to the DOE Mixed Analyte Performance Evaluation Program for the remainder of the year.

The laboratory's 2008 studies included Environmental Resource Associates' water pollution studies 159 and 165 and soil studies 62 and 64; Mixed Analyte Performance Evaluation Program study 19; and Environmental Resource Associates' MRaD study 008. In addition, Advanced Technologies and Laboratories International, Inc. participated in the American Industrial Hygiene Association Industrial Hygiene Proficiency Analytical Testing, Beryllium Proficiency Analytical Testing, and Workplace Analysis Scheme for Proficiency testing programs to maintain its accreditation.

Advanced Technologies and Laboratories International, Inc. reported 336 different analytes and compounds during participation in the Environmental Resource Associates water pollution studies conducted in 2008. Of the 336 reported analytes, 294 results were acceptable while 42 were unacceptable, for a total acceptable rate of 87.5%. The vast majority of unacceptable results were due to a reporting error during water pollution study WP-165, in which all metal results (37) were reported in incorrect units. These results would have been acceptable had they been properly reported as analyzed (i.e., score would have been 331 acceptable out of 336, or 98.5%, which is more in sync with historical scores for this study). Because Advanced Technologies and



**Table 10.17.9. The Hanford Site's Waste Sampling and Characterization Facility<sup>(a)</sup> Performance on DOE Mixed Analyte Performance Evaluation Program Samples and National Institute of Standards and Technology Radiochemistry Intercomparison Program Samples, 2008**

<b>Media</b>	<b>Program</b>	<b>Radionuclide</b>	<b>Number of Results Reported</b>	<b>Number of Results Within Control Limits</b>
Air filters	MAPEP	<sup>54</sup> Mn, <sup>57</sup> Co, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>233/234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, <sup>241</sup> Am, gross alpha, gross beta	28	27 ( <sup>90</sup> Sr failed once. Sample preparation method used for paper filters performed less efficiently with glass filters, as glass fiber filters do not ash completely.) <sup>(b)</sup>
	NRIP	<sup>90</sup> Sr, <sup>233/234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, <sup>241</sup> Am	6	6
Soil	MAPEP	<sup>40</sup> K, <sup>54</sup> Mn, <sup>57</sup> Co, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>99</sup> Tc, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>233/234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, <sup>241</sup> Am	29	26 <sup>(c)</sup> ( <sup>40</sup> K, <sup>125</sup> Sb, and <sup>239/240</sup> Pu each failed once.)
	NRIP	<sup>90</sup> Sr, <sup>233/234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, <sup>241</sup> Am	6	6
Vegetation	MAPEP	<sup>54</sup> Mn, <sup>57</sup> Co, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>233/234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, <sup>241</sup> Am	24	24 <sup>(d)</sup>
Water	MAPEP	<sup>3</sup> H, <sup>54</sup> Mn, <sup>57</sup> Co, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>99</sup> Tc, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>233/234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, <sup>241</sup> Am, gross alpha, gross beta	32	32 <sup>(e)</sup>

(a) Onsite laboratory operated by Fluor Hanford, Inc.

(b) Since the Hanford Site does not use glass fiber filters as specified by MAPEP, the Waste Sampling and Characterization Facility's method (ashing for paper filters) does not work as efficiently.

(c) Acceptable <sup>90</sup>Sr and <sup>99</sup>Tc in remedial sample.

(d) Acceptable <sup>90</sup>Sr in remedial sample.

(e) Acceptable gamma energy analysis and alpha energy analysis in remedial sample.

MAPEP = Mixed Analyte Performance Evaluation Program.

NRIP = National Institute of Standards and Technology Radiochemistry Intercomparison Program.

Laboratories International, Inc.'s Washington State Department of Ecology accreditation is based primarily on the results of the soil study, the reporting error did not impact accreditation. For the 2 soil studies, a total of 314 analytes were reported, of which 312 were acceptable, for an overall score of 99.4%. For the MRaD-008 study, 42 of 44 results were acceptable, for an acceptable rate of 95.5%. For the Mixed Analyte Performance Evaluation Program-19 study,

37 of 40 radiological results were acceptable, for an acceptable rate of 92.5%; 96 of 97 non-radiological (i.e., inorganic and organic) results reported on the same study were acceptable, for a score of 99.0%. Performance evaluation results for Advanced Technologies and Laboratories International, Inc. are presented in Tables 10.17.10 and 10.17.11.

**Table 10.17.10. The Hanford Site's Advanced Technologies and Laboratories International, Inc. Performance on Environmental Resource Associates' MRaD and DOE's Mixed Analyte Performance Evaluation Program Samples, 2008**

<u>Media</u>	<u>Radionuclide</u>	<u>Number of Results Reported</u>	<u>Number of Results Within Control Limits</u>
<b>MAPEP-19</b>			
Air filters	<sup>54</sup> Mn, <sup>57</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>134</sup> Cs, <sup>235</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, total U, gross alpha, gross beta	12	11 <sup>(a)</sup>
Soil	<sup>40</sup> K, <sup>54</sup> Mn, <sup>57</sup> Co, <sup>60</sup> Co, <sup>134</sup> Cs, <sup>241</sup> Am	6	6
Vegetation	<sup>54</sup> Mn, <sup>57</sup> Co, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>134</sup> Cs, <sup>235</sup> U, <sup>238</sup> U, <sup>239/240</sup> Pu, <sup>241</sup> Am, total U	10	9 <sup>(b)</sup>
Water	<sup>3</sup> H, <sup>54</sup> Mn, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>99</sup> Tc, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>235</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239/240</sup> Pu, total U	12	11 <sup>(c)</sup>
<b>MRaD-008</b>			
Air filters	<sup>54</sup> Mn, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>234</sup> U, <sup>238</sup> U, total U, gross alpha, gross beta	11	11
Soil	<sup>40</sup> K, <sup>54</sup> Mn, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>212</sup> Bi, <sup>212</sup> Pb, <sup>214</sup> Bi, <sup>214</sup> Pb, <sup>228</sup> Ac, <sup>234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239</sup> Pu, <sup>241</sup> Am, total U	18	16 <sup>(d)</sup>
Water	<sup>3</sup> H, <sup>54</sup> Mn, <sup>60</sup> Co, <sup>65</sup> Zn, <sup>90</sup> Sr, <sup>134</sup> Cs, <sup>137</sup> Cs, <sup>234</sup> U, <sup>238</sup> Pu, <sup>238</sup> U, <sup>239</sup> Pu, <sup>241</sup> Am, total U, gross alpha, gross beta	15	15

(a) Incorrect value for <sup>90</sup>Sr.

(b) Incorrect value for <sup>134</sup>Cs.

(c) Incorrect value for <sup>99</sup>Tc.

(d) Incorrect values for <sup>212</sup>Bi and <sup>228</sup>Ac.

MAPEP = Mixed Analyte Performance Evaluation Program.

MRaD = Environmental Resource Associates Multi-Media Radiochemistry Study.

**Table 10.17.11. The Hanford Site's Advanced Technologies and Laboratories International, Inc. Performance on EPA Laboratory Water Pollution Inorganic and Organic Studies, 2008**

<u>Laboratory</u>	<u>Water Pollution Study (WP-159)</u>	<u>Water Pollution Study (WP-165)</u>
	<u>June 2008</u>	<u>December 2008</u>
	<u>% Acceptable</u>	<u>% Acceptable</u>
Advanced Technologies and Laboratories International, Inc.	98.7 <sup>(a)</sup>	77.5 <sup>(b)</sup>

(a) 156 of 158 analytes were evaluated as acceptable.

(b) 138 of 178 analytes were evaluated as acceptable. All 37 metals were unacceptable because of reporting in incorrect units; score would have otherwise been 175 of 178 (98.3%) based on analytical performance.



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# Appendix A

## Helpful Information

JP Duncan

The following information is provided to assist the reader in understanding this report. Included here is information on scientific notation, units of measure, radioactivity units, radiological dose units, chemical and elemental nomenclature, understanding data tables and data uncertainty, understanding graphs, and greater than or less than symbols. Definitions of technical terms can be found in Appendix B.

### Scientific Notation

Scientific notation is used to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, by using scientific or E notation, written as  $1 \times 10^9$  or 1.0E+09. Translating from scientific notation to a more traditional number requires moving the

decimal point either left or right from its current location. If the value given is  $2.0 \times 10^3$  (or 2.0E+03), the decimal point should be moved three places to the **right** so that the number would then read 2,000. If the value given is  $2.0 \times 10^{-5}$  (or 2.0E-05), the decimal point should be moved five places to the **left** so that the result would be 0.00002.

### Units of Measure

The primary units of measure used in this report follow the International System of Units and are metric. Table A.1 summarizes and defines the terms and corresponding symbols (metric and non-metric). A conversion table is also provided in Table A.2.

**Table A.1. Names and Symbols for Units of Measure**

<u>Symbol</u>	<u>Name</u>	<u>Symbol</u>	<u>Name</u>
<b>Temperature</b>		<b>Concentration</b>	
°C	degree Celsius	ppb	parts per billion
°F	degree Fahrenheit	ppm	parts per million
<b>Time</b>		ppmv	parts per million by volume
d	day	<b>Length</b>	
hr	hour	cm	centimeter ( $1 \times 10^{-2}$ m)
min	minute	ft	foot
sec	second	in.	inch
yr	year	km	kilometer ( $1 \times 10^3$ m)
<b>Rate</b>		m	meter
cfs (or ft <sup>3</sup> /sec)	cubic feet per second	mi	mile
cpm	counts per minute	mm	millimeter ( $1 \times 10^{-3}$ m)
gpm	gallon per minute	µm	micrometer ( $1 \times 10^{-6}$ m)
mph	mile per hour	<b>Area</b>	
mR/hr	milliroentgen per hour	ha	hectare ( $1 \times 10^4$ m <sup>2</sup> )
mrem/yr	millirem per year	km <sup>2</sup>	square kilometer
<b>Volume</b>		mi <sup>2</sup>	square mile
cm <sup>3</sup>	cubic centimeter	ft <sup>2</sup>	square foot
ft <sup>3</sup>	cubic foot	<b>Mass</b>	
gal	gallon	g	gram
L	liter	kg	kilogram ( $1 \times 10^3$ g)
m <sup>3</sup>	cubic meter	mg	milligram ( $1 \times 10^{-3}$ g)
mL	milliliter ( $1 \times 10^{-3}$ L)	µg	microgram ( $1 \times 10^{-6}$ g)
yd <sup>3</sup>	cubic yard	lb	pound

Table A.2. Conversion Table

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>	<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
cm	0.394	in.	in.	2.54	cm
m	3.28	ft	ft	0.305	m
km	0.621	mi	mi	1.61	km
kg	2.205	lb	lb	0.454	kg
L	0.2642	gal	gal	3.785	L
m <sup>2</sup>	10.76	ft <sup>2</sup>	ft <sup>2</sup>	0.093	m <sup>2</sup>
ha	2.47	acres	acre	0.405	ha
km <sup>2</sup>	0.386	mi <sup>2</sup>	mi <sup>2</sup>	2.59	km <sup>2</sup>
m <sup>3</sup>	35.31	ft <sup>3</sup>	ft <sup>3</sup>	0.0283	m <sup>3</sup>
m <sup>3</sup>	1.308	yd <sup>3</sup>	yd <sup>3</sup>	0.7646	m <sup>3</sup>
pCi	1,000	nCi	nCi	0.001	pCi
μCi/mL	10 <sup>9</sup>	pCi/L	pCi/L	10 <sup>-9</sup>	μCi/mL
Ci/m <sup>3</sup>	10 <sup>12</sup>	pCi/m <sup>3</sup>	pCi/m <sup>3</sup>	10 <sup>-12</sup>	Ci/m <sup>3</sup>
mCi/cm <sup>3</sup>	10 <sup>15</sup>	pCi/m <sup>3</sup>	pCi/m <sup>3</sup>	10 <sup>-15</sup>	mCi/cm <sup>3</sup>
nCi/m <sup>2</sup>	1.0	mCi/km <sup>2</sup>	mCi/km <sup>2</sup>	1.0	nCi/m <sup>2</sup>
Ci	3.7 x 10 <sup>10</sup>	Bq	Bq	2.7 x 10 <sup>-11</sup>	Ci
pCi	0.037	Bq	Bq	27	pCi
rad	0.01	Gy	Gy	100	rad
rem	0.01	Sv	Sv	100	rem
ppm	1,000	ppb	ppb	0.001	ppm
°C	(°C x 9/5) + 32	°F	°F	(°F - 32) ÷ 9/5	°C
oz	28.349	g	g	0.035	oz
ton	0.9078	tonne	tonne	1.1	ton

## Radioactivity Units

Much of this report deals with levels of radioactivity in various environmental media. Radioactivity in this report is usually discussed in units of **curies (Ci)**, with conversions to **becquerels (Bq)**, the International System of Units measure (Table A.3). The curie is the basic unit used to describe the amount of activity present, and activities are generally expressed in terms of curies per mass or volume (e.g., picocuries per liter). One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radio-nuclide that decays at the rate of 37 billion disintegrations

per second. One becquerel is equivalent to one disintegration per second. Nuclear disintegrations produce spontaneous emissions of alpha or beta particles, gamma radiation, or combinations of these. Table A.4 includes selected conversions from curies to becquerels.

## Radiological Dose Units

Radiological dose in this report is usually written in terms of effective dose equivalent and reported numerically in units of millirem (mrem), with the metric units millisievert (mSv) or microsievert (μSv) following in parenthesis or footnoted.

Table A.3. Names and Symbols for Units of Radioactivity

<u>Symbol</u>	<u>Name</u>	<u>Symbol</u>	<u>Name</u>
Ci	curie	Bq	becquerel (2.7 x 10 <sup>-11</sup> Ci)
mCi	millicurie (1 x 10 <sup>-3</sup> Ci)	kBq	kilobecquerel (1 x 10 <sup>3</sup> Bq)
μCi	microcurie (1 x 10 <sup>-6</sup> Ci)	MBq	megabecquerel (1 x 10 <sup>6</sup> Bq)
nCi	nanocurie (1 x 10 <sup>-9</sup> Ci)	mBq	millibecquerel (1 x 10 <sup>-3</sup> Bq)
pCi	picocurie (1 x 10 <sup>-12</sup> Ci)	GBq	gigabecquerel (1 x 10 <sup>9</sup> Bq)
fCi	femtocurie (1 x 10 <sup>-15</sup> Ci)	TBq	terabecquerel (1 x 10 <sup>12</sup> Bq)
aCi	attocurie (1 x 10 <sup>-18</sup> Ci)		

**Table A.4. Conversions for Radioactivity Units**

aCi	fCi	fCi	pCi	pCi	nCi	nCi	μCi	μCi	mCi	mCi	Ci	Ci	kCi
27	1	27	1	27	1	27	1	27	1	27	1	27	1
1	37	1	37	1	37	1	37	1	37	1	37	1	37
μBq	μBq	mBq	mBq	Bq	Bq	kBq	kBq	MBq	MBq	GBq	GBq	TBq	TBq

New unit of quantity = Becquerel (Bq) (formerly curie [Ci]) ( $1 \text{ Ci} = 3.7 \times 10^{10} \text{ dps}$ ).

1 Becquerel = 1 disintegration/sec (dps).

Millirem (millisievert) is a term that relates a given amount of absorbed radiation energy to its biological effectiveness or risk (to humans). For perspective, a dose of 0.01 millirem (1 millisievert) would have a biological effect roughly the same as received from 1 day's exposure to natural background radiation. An acute (short-term) dose to the whole body of 100 rem (1 sievert) would likely cause temporary radiation sickness in some exposed individuals. An acute dose of over 500 rem (5 sievert) would soon result in death in approximately 50% of those exposed. Exposure to lower amounts of radiation (10 mrem [100 μSv] or less) produces no immediate observable effects, but long-term (delayed) effects are possible. The average person in the United States receives an annual dose from exposure to naturally produced radiation of approximately 300 mrem (3 mSv). Medical and dental x-rays and air travel add to this total. Table A.5 includes selected conversions from rem to sievert.

Also used in this report is the term **rad**, with the corresponding unit **gray (Gy)** in parenthesis or footnoted. The rad (gray) is a measure of the energy absorbed by any material, whereas a rem relates to both the amount of radiation energy absorbed by humans and its consequence. The gray can be converted to rad by multiplying by 100. The conversions in Table A.5 can also be used to convert grays to rads.

A **roentgen (R)** is a measure of exposure to electromagnetic radiation (i.e., gamma and x-radiation). One roentgen is equivalent to a charge release of 258 microcoulombs per kilogram of air.

**Table A.5. Conversions for Radiological Dose Units**

μSv	μSv	μSv	μSv	μSv	mSv	mSv	mSv	Sv
0.01	0.1	1	10	100	1	10	100	1
1	10	100	1	10	100	1	10	100
μrem	μrem	μrem	mrem	mrem	mrem	rem	rem	rem

Unit of absorbed dose – Gray (Gy) (formerly rad).

Unit of dose equivalent – Sievert (Sv) (formerly rem).

Table also converts Gy to rad.

The names and symbols for units of radiation dose used in this report are listed in Table A.6

Additional information on radiation and dose terminology can be found in Appendix B. A list of the radionuclides discussed in this report, their symbols, and their half-lives are included in Table A.7.

**Table A.6. Names and Symbols for Units of Radiation Dose or Exposure**

<u>Symbol</u>	<u>Name</u>
mrad	millirad ( $1 \times 10^{-3} \text{ rad}$ )
mrem	millirem ( $1 \times 10^{-3} \text{ rem}$ )
μrem	microrem ( $1 \times 10^{-6} \text{ rem}$ )
Sv	sievert (100 rem)
mSv	millisievert ( $1 \times 10^{-3} \text{ Sv}$ )
μSv	microsievert ( $1 \times 10^{-6} \text{ Sv}$ )
R	roentgen
mR	milliroentgen ( $1 \times 10^{-3} \text{ R}$ )
μR	microroentgen ( $1 \times 10^{-6} \text{ R}$ )
Gy	gray (100 rad)
mGy	milligray ( $1 \times 10^{-3} \text{ rad}$ )

**Table A.7. Radionuclides and Their Half-Lives<sup>(a)</sup>**

<u>Symbol</u>	<u>Radionuclide</u>	<u>Half-Life</u>	<u>Symbol</u>	<u>Radionuclide</u>	<u>Half-Life</u>
<sup>3</sup> H	tritium	12.35 yr	<sup>137m</sup> Ba	barium-137m	2.552 min
<sup>7</sup> Be	beryllium-7	53.3 d	<sup>152</sup> Eu	europium-152	13.33 yr
<sup>14</sup> C	carbon-14	5,730 yr	<sup>154</sup> Eu	europium-154	8.8 yr
<sup>40</sup> K	potassium-40	1.28 x 10 <sup>9</sup> yr	<sup>155</sup> Eu	europium-155	4.96 yr
<sup>51</sup> Cr	chromium-51	27.704 d	<sup>212</sup> Pb	lead-212	10.64 h
<sup>54</sup> Mn	manganese-54	312.5 d	<sup>220</sup> Rn	radon-220	55.6 sec
<sup>55</sup> Fe	iron-55	2.7 yr	<sup>222</sup> Rn	radon-222	3.8235 d
<sup>59</sup> Fe	iron-59	44.529 d	<sup>232</sup> Th	thorium-232	1.405 x 10 <sup>10</sup> yr
<sup>59</sup> Ni	nickel-59	7.5 x 10 <sup>4</sup> yr	U or uranium	natural uranium	~4.5 x 10 <sup>9(b)</sup>
<sup>60</sup> Co	cobalt-60	5.271 yr	<sup>233</sup> U	uranium-233	1.585 x 10 <sup>5</sup> yr
<sup>63</sup> Ni	nickel-63	96 yr	<sup>234</sup> U	uranium-234	2.445 x 10 <sup>5</sup> yr
<sup>65</sup> Zn	zinc-65	243.9 d	<sup>235</sup> U	uranium-235	7.038 x 10 <sup>8</sup> yr
<sup>85</sup> Kr	krypton-85	10.72 yr	<sup>237</sup> Np	neptunium-237	2.14 x 10 <sup>6</sup> yr
<sup>90</sup> Sr	strontium-90	29.12 yr	<sup>238</sup> U	uranium-238	4.468 x 10 <sup>9</sup> yr
<sup>90</sup> Y	yttrium-90	64.0 h	<sup>238</sup> Pu	plutonium-238	87.74 yr
<sup>95</sup> Zr	zirconium-95	63.98 d	<sup>239</sup> Pu	plutonium-239	2.4065 x 10 <sup>4</sup> yr
<sup>99</sup> Tc	technetium-99	2.13 x 10 <sup>5</sup> yr	<sup>240</sup> Pu	plutonium-240	6.537 x 10 <sup>3</sup> yr
<sup>103</sup> Ru	ruthenium-103	39.28 d	<sup>241</sup> Pu	plutonium-241	14.4 yr
<sup>106</sup> Ru	ruthenium-106	368.2 d	<sup>242</sup> Pu	plutonium-242	3.763 x 10 <sup>5</sup> yr
<sup>113</sup> Sn	tin-113	115.1 d	<sup>241</sup> Am	americium-241	432.2 yr
<sup>125</sup> Sb	antimony-125	2.77 yr	<sup>243</sup> Am	americium-243	7,380 yr
<sup>129</sup> I	iodine-129	1.57 x 10 <sup>7</sup> yr	<sup>243</sup> Cm	curium-243	28.5 yr
<sup>131</sup> I	iodine-131	8.04 d	<sup>244</sup> Cm	curium-244	18.11 yr
<sup>134</sup> Cs	cesium-134	2.062 yr	<sup>245</sup> Cm	curium-245	8,500 yr
<sup>137</sup> Cs	cesium-137	30.0 yr			

(a) From EPA 402-R-99-01.

(b) Natural uranium is a mixture dominated by uranium-238; thus, the half-life is ~4.5 x 10<sup>9</sup> years.

## Chemical and Elemental Nomenclature

Many of the chemical contaminants discussed in this report are listed in Table A.8 along with their chemical (or elemental) names and their corresponding symbols.

## Understanding the Data Tables

Some degree of variability, or uncertainty, is associated with all analytical measurements. This uncertainty is the consequence of random or systematic inaccuracies related to collecting, preparing, and analyzing the samples. These inaccuracies could include errors associated with reading or recording the result, handling or processing the sample,

calibrating the counting instrument, and numerical rounding. With radionuclides, inaccuracies can also result from the randomness of radioactive decay. In this report, the uncertainties used include standard deviation, total propagated analytical uncertainty, and standard error of the mean.

## Standard Deviation

The standard deviation (SD) of sample data relates to the variation around the mean of a set of individual sample results. If differences in analytical results occur among samples, then two times the standard deviation (or  $\pm 2$  SD) implies that 95% of the time, a re-count or re-analysis of the same sample would give a value somewhere between the mean result minus two times the standard deviation and the mean result plus two times the standard deviation.

**Table A.8. Elemental and Chemical Constituent Nomenclature**

<u>Symbol</u>	<u>Constituent</u>	<u>Symbol</u>	<u>Constituent</u>
Ag	silver	K	potassium
Al	aluminum	LiF	lithium fluoride
As	arsenic	Mg	magnesium
B	boron	Mn	manganese
Ba	barium	Mo	molybdenum
Be	beryllium	NH <sub>3</sub>	ammonia
Br	bromine	NH <sub>4</sub> <sup>+</sup>	ammonium
C	carbon	N	nitrogen
Ca	calcium	Na	sodium
CaF <sub>2</sub>	calcium fluoride	Ni	nickel
CCl <sub>4</sub>	carbon tetrachloride	NO <sub>2</sub> <sup>-</sup>	nitrite
Cd	cadmium	NO <sub>3</sub> <sup>-</sup>	nitrate
CHCl <sub>3</sub>	trichloromethane	Pb	lead
Cl <sup>-</sup>	chloride	PO <sub>4</sub> <sup>3-</sup>	phosphate
CN <sup>-</sup>	cyanide	P	phosphorus
Cr <sup>+6</sup>	chromium (hexavalent)	Sb	antimony
Cr	chromium (total)	Se	selenium
CO <sub>3</sub> <sup>2-</sup>	carbonate	Si	silicon
Co	cobalt	Sr	strontium
Cu	copper	SO <sub>4</sub> <sup>2-</sup>	sulfate
F <sup>-</sup>	fluoride	Ti	titanium
Fe	iron	Tl	thallium
HCO <sub>3</sub> <sup>-</sup>	bicarbonate	V	vanadium
Hg	mercury		

## Total Propagated Analytical Uncertainty

For samples that are prepared or manipulated in the laboratory prior to counting (counting the rate of radioactive emissions from a sample), the total propagated analytical uncertainty includes both the counting uncertainty and the uncertainty associated with sample preparation and chemical separations. For samples that are not manipulated (e.g., ashed, dried, or chemically treated) in the laboratory before counting, the total propagated analytical uncertainty only accounts for the uncertainty associated with counting the sample. The uncertainty associated with samples that are analyzed but not counted (e.g., chemical or water quality measurements) includes only the analytical process uncertainty. In this situation, the total propagated analytical uncertainty is assumed to be the nominal detection limit.

## Standard Error of the Mean

Just as individual values are accompanied by counting uncertainties, the mean of mean values (averages) is accompanied by  $\pm 2$  times the standard error of the calculated mean (or  $\pm 2$  SEM). Two times the standard error of the mean implies that approximately 95% of the time the next calculated mean will fall somewhere between the reported value minus two times the standard error and the reported value plus two times the standard error.

## Median, Maximum, and Minimum Values

Median, maximum, and minimum values are reported in some sections of this report. A median value is the middle value of an odd numbered set and the average of the two central values in an even numbered set. For example, the

median value in the odd numbered series of numbers — 1, 2, 3, 3, 4, 5, 5, 5, 6 is 4. The maximum value would be 6 and the minimum value would be 1. Median, maximum, and minimum values are reported when there are too few analytical results to accurately determine the average with a  $\pm$  statistical uncertainty or when the data do not follow a bell-shape (i.e., normal) distribution. Figure A.1 provides a graphical representation of median, maximum, and minimum values. The upper line is the maximum value, the center dot is the median value, and the lower line is the minimum value.

## Negative Concentrations

Instruments used in the laboratory to measure radioactivity in Hanford Site environmental samples are sensitive enough to measure natural, or background, radiation along with any contaminant radiation in a sample. To obtain a true measure of the contaminant level in a sample, the background radiation level must be subtracted from the total amount of radioactivity measured by an instrument. Because of the randomness of radioactive emissions, the very low activities of some contaminants, or the presence of undesirable materials, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is

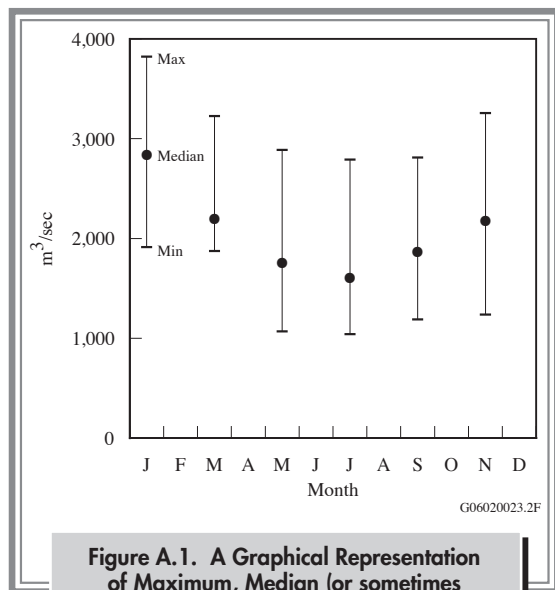
generated. The negative results are reported because they are essential when conducting statistical evaluations of the data.

## Understanding Graphs

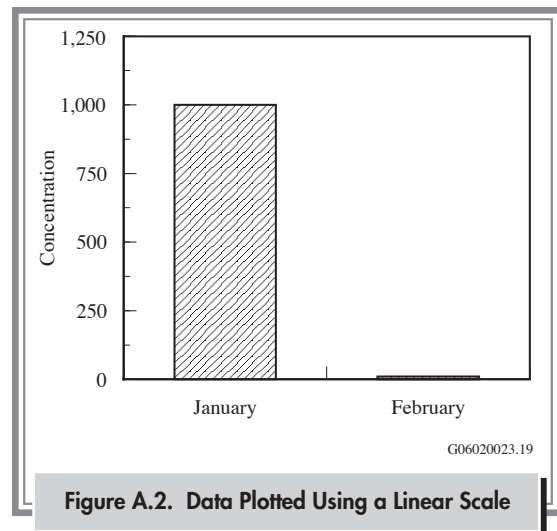
Graphs are useful when comparing numbers collected at several locations or at one location over time. Graphs often make it easy to visualize differences in data where they exist. However, careful consideration should be given to the scale (linear or logarithmic) and units.

Some of the data graphed in this report may be plotted using logarithmic, or compressed, scales. Logarithmic scales are useful when plotting two or more numbers that differ greatly in size or are very close together. For example, a sample with a concentration of 5 grams per liter would get lost at the bottom of the graph if plotted on a linear scale with a sample having a concentration of 1,000 grams per liter (Figure A.2). A logarithmic plot of these same two numbers allows the reader to see both data points clearly (Figure A.3).

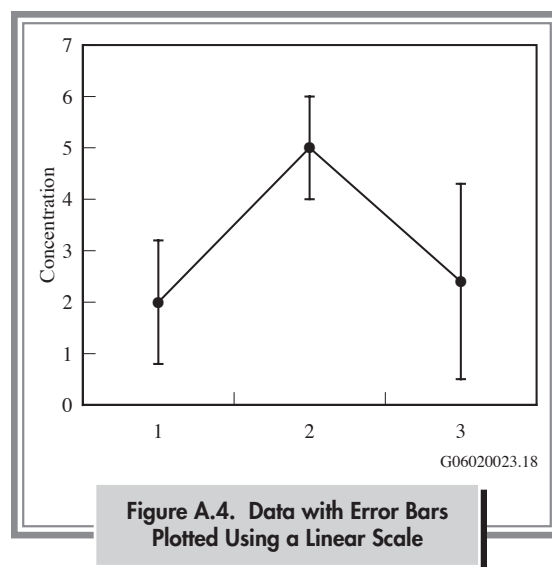
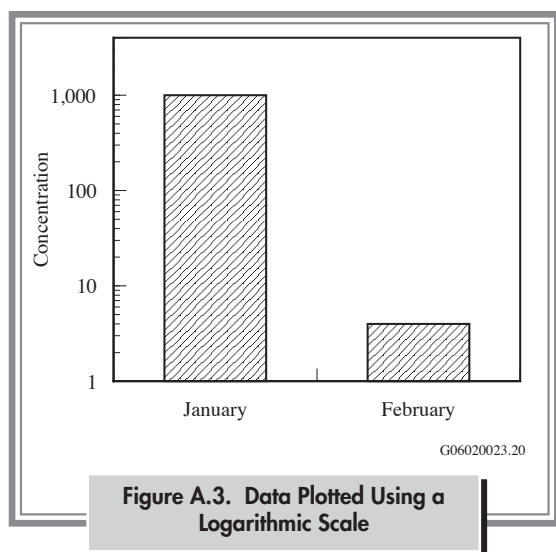
The mean (average) and median (defined earlier) values graphed in this report have vertical lines extending above and below the data point. When used with a value, these lines (called error bars) indicate the amount of uncertainty (standard deviation, total propagated analytical uncertainty, or two standard error of the mean) in the reported value.



**Figure A.1. A Graphical Representation of Maximum, Median (or sometimes average), and Minimum Values**



**Figure A.2. Data Plotted Using a Linear Scale**



The error bars in this report represent a 95% chance that the value is between the upper and lower ends of the error bar and a 5% chance that the true value is either lower or higher than the error bar.<sup>(a)</sup> For example, in Figure A.4, the first plotted value is  $2.0 \pm 1.1$ , so there is a 95% chance that the true value is between 0.9 and 3.1, a 2.5% chance that it is less than 0.9, and a 2.5% chance that it is greater than 3.1. Error bars are computed statistically, employing all of the information used to generate the value. These bars provide a quick, visual indication that one value may be statistically similar to or different from another value. If the error bars of two or more values overlap, as is the case with values 1 and 3 and values 2 and 3, the values may be statistically similar. If the error bars do not overlap (values 1 and 2), the values may be statistically different. Values that appear to be very different visually (values 2 and 3) may actually be quite similar when compared statistically.

When vertical lines are used with median values, the lower end of each bar represents the minimum concentration measured; the upper end of each bar represents the maximum concentration measured (Figure A.1).

## Greater Than (>) or Less Than (<) Symbols

Greater than (>) or less than (<) symbols are used to indicate that the actual value may either be larger than the number given or smaller than the number given. For example,  $>0.09$  would indicate that the actual value is greater than 0.09. A symbol pointed in the opposite direction ( $<0.09$ ) would indicate that the number is less than the value presented. A symbol used with an underscore ( $\leq$  or  $\geq$ ) indicates that the actual value is less than or equal to or greater than or equal to the number given, respectively.

## Reference

EPA 402-R-99-01. 1999. "Cancer Risk Coefficients for Environmental Exposure to Radionuclides." Appendix G in *Federal Guidance Report 13*, KF Eckerman, RW Leggett, CB Nelson, JS Puskin, and ACB Richardson, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C.

(a) Assuming the data are normally distributed.



## Appendix B

### Glossary

This glossary contains selected words and phrases used in this report that may not be familiar to the reader. Words appearing in *italic* within a definition are also defined in this glossary.

**absorbed dose** - Energy absorbed per unit mass from any kind of ionizing *radiation* in any kind of matter. Units: *rad*, which is equal to the absorption of 100 ergs per gram of material irradiated, or *gray*, which is the International System of Units (SI) equivalent.

**activation product** - Material made radioactive by *exposure* to *radiation*, principally by neutron radiation as in metals in a nuclear reactor (e.g., cobalt-60 from cobalt-59 in stainless steel).

**adsorption** - The accumulation of gases, liquids, or solutes on the surface of a solid or liquid.

**alpha particle** - A positively charged particle composed of two protons and two neutrons ejected spontaneously from the nuclei of some *radionuclides*. It has low penetrating power and short range. The most energetic alpha will generally fail to penetrate the skin. Alpha particles are hazardous when an alpha-emitting *isotope* is introduced into the body.

**anion** - A negatively charged ion.

**apatite** - A mineral that has the capability to capture and retain radioactive metal contaminants.

**aquifer** - Underground sediment or rock that stores and/or transmits water.

**aquifer tube** - A small-diameter, flexible plastic tube used to sample shallow *aquifers*, natural seepage areas, or springs.

**background radiation** - *Radiation* in the natural environment, including cosmic rays from space and *radiation* from naturally occurring radioactive elements in the air, in the earth, and in human bodies. It also includes *radiation* from global *fallout* from historical atmospheric nuclear weapons testing. In the United States, the average person receives approximately 300 *millirem* of background radiation per year.

**bank storage** - Hydrologic term that describes river water that flows into and is retained in permeable stream banks during periods of high river stage. Flow is reversed during periods of low river stage.

**becquerel (Bq)** - Unit of activity or amount of a radioactive substance (also *radioactivity*) equal to one nuclear transformation per second (1 Bq = 1 disintegration per second). Another unit of *radioactivity*, the *curie*, is related to the becquerel: 1 Ci =  $3.7 \times 10^{10}$  Bq.

**beta particle** - A negatively charged particle (essentially an electron) emitted from a nucleus during radioactive *decay*. Large amounts of beta particles may cause skin burns and are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal or plastic.

**biological half-life** - The time required for one-half of the amount of a *radionuclide* to be expelled from the body by natural metabolic processes, excluding radioactive *decay*, following ingestion, inhalation, or absorption.

**black cell** - A section of the Hanford Tank Waste Treatment and Immobilization Plant where high-level nuclear waste will be routed that will never be accessible because of the high *radiation* levels.

**cation** - A positively charged ion.

**clean closed** - A facility is classified as “clean closed” under Resource Conservation and Recovery Act of 1976 regulations when all dangerous waste has been removed and *groundwater* monitoring is no longer required.

**collective total effective dose equivalent** - Sum of the *total effective dose equivalents* for individuals composing a defined population. The units for this are *person-rem* or *person-sievert*.

**committed dose equivalent** - The *dose equivalent* to organs or tissues that will be received from an intake of radioactive material by an individual during the 50-year period following intake.

**committed effective dose equivalent** - The sum of the *committed dose equivalent* to various tissues in the body, each multiplied by the appropriate weighting factor.

**composite sample** - Sample formed by mixing discrete samples taken at different times or from different locations.

**confined aquifer** - An *aquifer* bounded above and below by less-permeable layers. *Groundwater* in the confined aquifer is under a pressure greater than atmospheric pressure.

**continuous sample** - Sample formed by the continuous collection of the medium or contaminants within the medium during the entire sampling period.

**cosmic radiation** - High-energy subatomic particles and electromagnetic *radiation* from outer space that bombard the earth. Cosmic radiation is part of natural *background radiation*.

**crib** - An underground structure designed to receive liquid waste that percolates into the soil directly or percolates into the soil after having traveled through a connected tile field. These structures are no longer used at the Hanford Site.

**curie (Ci)** - A unit of *radioactivity* equal to 37 billion ( $3.7 \times 10^{10}$ ) nuclear transformations per second (*becquerels*).

**decay** - The decrease in the amount of any radioactive material (disintegration) with the passage of time. See *radioactivity*.

**decay product** - The atomic nucleus or nuclei that are left after radioactive transformation of a radioactive material. Decay products may be radioactive or non-radioactive (stable). They are informally referred to as daughter products. See *radioactivity*.

**deep-dose equivalent** - The *dose equivalent* at a tissue depth of 1 centimeter from *radiation* originating outside of the body.

**derived concentration guide (DCG)** - Concentrations of *radionuclides* in air and water that an individual could continuously consume, inhale, or be immersed in at average annual rates and not receive an *effective dose equivalent* of greater than 100 *millirem* per year.

**desiccation** - A process whereby water or moisture is removed, resulting in dryness.

**detection level (or limit)** - Minimum amount of a substance that can be measured with a specified or implied confidence that the analytical result is greater than a specific value (e.g., zero).

**direct-push technology** - A cost-effective means of collecting subsurface samples; this technology uses a hydraulic hammer to drive a hollow rod into the soil either vertically or at an angle. Sensors can be deployed within the rod to detect radioactive contaminants, soil moisture, and other sampling criteria.

**dispersion** - Process whereby *effluent* or *emissions* are spread or mixed when they are transported by *groundwater*, surface water, or air.

**dose equivalent** - Product of the *absorbed dose*, a quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of *radiation* on a common scale. The unit of dose equivalent is the *rem*.

**dose rate** - The rate at which a dose is delivered over time (e.g., *dose equivalent* rate in *millirem* per hour [*mrem/hr*]).

**dosimeter** - Portable device for measuring the accumulated *exposure* or *absorbed dose* from specific types or energies of ionizing *radiation* fields.

**effective dose** - See *effective dose equivalent*.

**effective dose equivalent** - The sum of products of *dose equivalent* to selected tissues of the body and appropriate tissue weighting factors. The tissue weighting factors put doses to various tissues and organs on an equal basis in terms of health risk.

**effluent** - Liquid material released from a facility.

**effluent monitoring** - Sampling or measuring specific liquid *effluent* streams for the presence of pollutants.

**emission** - Gaseous stream released from a facility.

**exposure** - The interaction of an organism with a physical agent (e.g., *radiation*) or a chemical agent (e.g., arsenic) of interest. Also used as a term for quantifying x- and *gamma-radiation* fields. See *roentgen*.

**external radiation** - *Radiation* originating from a source outside the body.

**fallout** - Typically refers to radioactive materials that are released into the earth's atmosphere following a nuclear explosion or atmospheric release and that eventually fall to earth.

**fission** - The splitting or breaking apart of a nucleus into at least two other nuclei, accompanied with a release of a relatively large amount of energy.

**fission products** - *Nuclides* formed from fissioning. Many fission products are radioactive.

**found fuel** - Incomplete pieces of spent nuclear fuel elements too small to have been located and removed during previous debris removal.

**fully institutionalized** - To incorporate into a formalized, structured system and be implemented and fully functional.

**gamma radiation** - High-energy electromagnetic *radiation* (*photons*) originating in the nucleus of decaying *radionuclides*. Gamma radiation is substantially more penetrating than *alpha* or *beta particles*.

**grab sample** - A short-duration sample (e.g., air, water, and soil) that is grabbed from the collection site.

**ground truth** - Direct physical observations that are used to test indirect interpretations.

**groundwater** - Subsurface water that is in the pores of sand and gravel or in the cracks of fractured rock.

**gray (Gy)** - Unit of *absorbed dose* in the International System of Units (SI) equal to the absorption of 1 joule per kilogram. The common unit of *absorbed dose*, the *rad*, is equal to 0.01 Gy.

**half-life** - Length of time in which a radioactive substance will lose one half of its *radioactivity* by *decay*. Half-lives range from a fraction of a second to billions of years, and each *radionuclide* has a unique half-life.

**high-activity waste** - See *high-level waste*.

**high-level waste** - Highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains *fission products* and other *radioisotopes* in sufficient concentrations to require permanent isolation.

**institutional controls** - Long-term actions or restrictions including *monitoring*, periodic sampling, access controls, and land-use restrictions designed to mitigate any *risks* posed by contamination following *remediation*. Institutional controls alone may be sufficient to reduce *risks* posed by low levels of contamination.

**internal radiation** - *Radiation* from radioactive material inside the body.

**ion exchange** - The reversible exchange of one species of ion for a different species of ion within a medium.

**ion exchange resin** - High molecular weight insoluble polymers containing functional groups that are capable of undergoing exchange reactions with ions in a solution with which it is in contact.

**irradiation** - *Exposure* to *radiation*.

**isotopes** - *Nuclides* of the same chemical element with the same number of protons but a differing number of neutrons.

**isotopic plutonium** - Any of two or more atoms of the chemical element *plutonium* with the same atomic number and position in the periodic table and nearly identical chemical behavior but with differing atomic mass number and different physical properties. Plutonium-239 is produced by neutron *irradiation* of uranium-238.

**isotopic uranium** - Any of two or more atoms of the chemical element uranium with the same atomic number and position in the periodic table and nearly identical chemical behavior but with differing atomic mass number and different physical properties. Uranium exists naturally as a mixture of three *isotopes* of mass 234, 235, and 238 in the proportions of 0.006%, 0.71%, and 99.27%, respectively.

**legacy waste** - Waste that was generated before the Hanford Site's nuclear materials production mission was terminated.

**low-activity waste** - See *low-level waste*.

**low-level waste** - Radioactive waste that is not high-level radioactive waste, spent nuclear fuel, *transuranic waste*, byproduct material, or naturally occurring radioactive material.

**material at risk** - The inventory of radioactive material that could potentially be released to the environment from an accident.

**maximally exposed individual** - A hypothetical member of the public residing near the Hanford Site who, by virtue of location and living habits, would reasonably receive the highest possible *radiation* dose from materials originating from the site.

**mean (or average)** - Average value of a series of measurements. The mean is computed as:

$$\text{mean} = \frac{\sum x}{n}$$

where *n* is the number of measurements, and  $\sum x$  is the sum of all measurements.

**median** - Middle value in an odd-numbered set of results when the data are ranked in increasing or decreasing order or the *average* of two central values in an even number set of results.

**millirem** - A unit of *radiation dose equivalent* that is equal to one one-thousandth (1/1000) of a *rem*.

**minimum detectable amount or concentration** - Smallest amount or concentration of a chemical or radioactive material that can be reliably detected in a sample.

**mitigation** - Prevention or reduction of expected *risks* to workers, the public, or the environment.

**mixed waste** - A U.S. Environmental Protection Agency or state-designated dangerous, extremely hazardous, or acutely hazardous waste that contains both a non-radioactive hazardous component and a radioactive component.

**monitoring** - As defined in DOE Order 5400.5, the collection and analysis of samples or measurements of liquid *effluent* and gaseous *emissions* for purposes of characterizing and quantifying contaminants, assessing *radiation exposure* to the public, and demonstrating compliance with regulatory standards.

**noble gas** - Any of a group of chemically and biologically inert gases that includes argon, krypton, and xenon. These gases are not retained in the body following inhalation. The principal *exposure* pathway for radioactive noble gases is direct external dose from the surrounding air.

**nuclide** - A particular combination of neutrons and protons. A *radionuclide* is a radioactive nuclide.

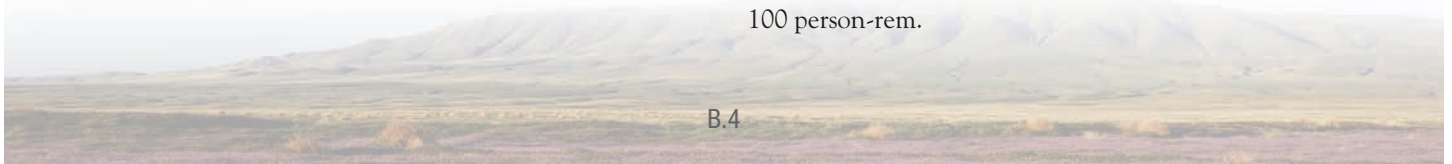
**offsite locations** - Sampling and measurement locations outside the Hanford Site boundary.

**onsite locations** - Sampling and measurement locations within the Hanford Site boundary.

**operable unit** - A discrete area for which an incremental step can be taken toward comprehensively addressing site problems. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site.

**outfall** - End of a drain or pipe that carries wastewater or other *effluent* into a ditch, pond, or river.

**person-rem or person-sievert (person-Sv)** - Unit of *collective total effective dose equivalent*. 1 person-Sv = 100 person-rem.



**photon** - A quantum of radiant energy. *Gamma radiation* and x-radiation (x-rays) are both composed of photons of varying energy.

**plume** - The cloud of a pollutant in air, surface water, or *groundwater* formed after the pollutant is released from a source.

**plutonium** - A heavy, radioactive, metallic element consisting of several *isotopes*. One important *isotope* is plutonium-239, which is produced by the *irradiation* of uranium-238. Routine analysis cannot distinguish between the plutonium-239 and plutonium-240 *isotopes*; hence, the term plutonium-239/240 as used in this report is symbolic of the presence of one or both of these *isotopes* in the analytical results.

**primordial radionuclide** - A radioactive material in the earth's crust that has a very long *half-life* and has existed since the beginning of the planet.

**quality assurance** - Actions that provide confidence that an item or process meets or exceeds a user's requirements and expectations.

**quality control** - Comprises all those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements. Quality control is an element of *quality assurance*.

**rad** - The unit of *absorbed dose*. 1 rad = 0.01 gray (Gy).

**radiation** - The energy emitted in the form of *photons* or particles (e.g., *alpha* and *beta particles*) such as that from transforming *radionuclides*. For this report, radiation refers to ionizing types of radiation; not radiowaves, microwaves, radiant light, or other types of non-ionizing radiation.

**radioactivity** - Property possessed by *radioisotopes* emitting *radiation* (such as *alpha* or *beta particles*, or high-energy *photons*) spontaneously in their *decay* process also, the *radiation* emitted.

**radioisotope** - An unstable *isotope* of an element that *decays* or disintegrates spontaneously, emitting *radiation* (Shleien 1992).

**radiologically controlled area** - An area to which access is controlled to protect individuals from *exposure* to *radiation* or radioactive materials.

**radionuclide** - A species of atoms having a particular number of protons (Z), a particular number of neutrons (A), and a particular atomic weight ( $N = Z + A$ ) that happens to emit *radiation*. Carbon-14 is a radionuclide but carbon-12, which is not radioactive, is referred to simply as a *nuclide*.

**recruitment** - Survival from one life form or stage to the next or from one age class to the next.

**redox** - A chemical reaction involving oxidation and reduction.

**refractory** - A material that has a high melting point (i.e., heat resistant).

**rem** - A unit of *dose equivalent* and *effective dose equivalent*.

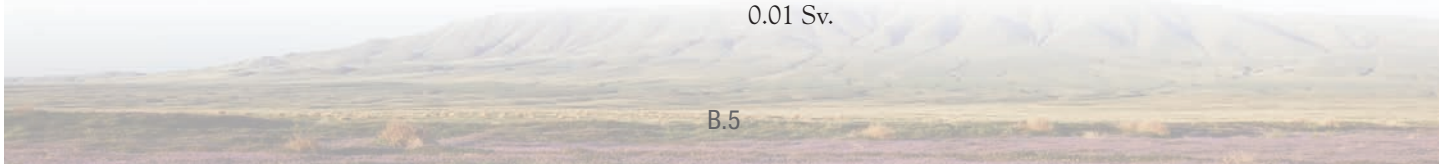
**remediation** - Reduction (or cleanup) of known *risks* to the public and environment to an agreed-upon level.

**risk** - The probability that a detrimental health effect will occur.

**risk-based disposal approval** - A written application to the U.S. Environmental Protection Agency intended to manage and dispose of Toxic Substances Control Act-regulated polychlorinated biphenyl waste not addressed suitably within the regulations. The risk-based disposal approval process applies to any person wishing to sample, clean up, or dispose of waste in a manner other than as prescribed in 40 CFR 761. For polychlorinated biphenyl *remediation* waste, the requirements for a risk-based disposal approval are specified in 40 CFR 761.61(c). A written approval from the U.S. Environmental Protection Agency is required before waste management activities are performed.

**roentgen (R)** - The unit of x-ray or gamma *photon exposure* as measured in air, historically used to describe *external radiation* levels. An *exposure* of 1 roentgen typically causes an *effective dose* of 1 rem.

**sievert (Sv)** - The unit of *dose equivalent* and its variants in the International System of Units (SI). The common unit for *dose equivalent* and its variants, the *rem*, is equal to 0.01 Sv.



**special case waste** - Waste for which there is an undetermined disposal path because of high levels of *radioactivity* and difficulties in characterization, classification, and packaging.

**specific retention facilities** - Historical structures consisting of *cribs*, ditches, trenches, or holes in the ground that received relatively small volumes of high concentration liquid radioactive waste. The small volume of liquid waste was designed to prevent flushing of the contaminants through the soil column to the *groundwater*.

**spent fuel** - Uranium metal or oxide and its metal container that have been used to power a nuclear reactor and for one reason or another has reached the end of its useful life. It is highly radioactive and typically contains *fission products*, *plutonium*, and residual uranium.

**standard error of the mean** - A measure of the precision of a *mean* of observed values; that is, an estimate of how close a *mean* of observed values is expected to be to the true *mean*.

**surveillance** - As defined in DOE Order 5400.5, the collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media, and the measurement of *external radiation* for purposes of demonstrating compliance with applicable standards, assessing *exposures* to the public, and assessing effects, if any, on the local environment.

**tank farm** - A group of underground waste storage tanks.

**transuranic element** - An element with an atomic number greater than 92 (92 is the atomic number of uranium).

**transuranic waste** - Waste containing more than 100 nanocuries ( $10^{-9}$  curies) per gram of alpha-emitting transuranic isotopes (*half-lives* greater than 20 years).

**thermoluminescent dosimeter** - A device containing a material that, after being exposed to beta and/or *gamma radiation*, emits light when heated. The amount of light emitted is proportional to the *absorbed dose* to the thermoluminescent dosimeter.

**total effective dose equivalent** - The sum of *committed effective dose equivalent* from the intake of radioactive material and *dose equivalent* from exposure to *external radiation*. Unit: *rem* or *sievert*.

**unconfined aquifer** - An *aquifer* containing *groundwater* that is not confined above by relatively impermeable rocks. The pressure at the top of the unconfined aquifer is equal to that of the atmosphere. At the Hanford Site, the unconfined aquifer is the uppermost *aquifer* and is most susceptible to contamination from site operations.

**vadose zone** - Underground area from the ground surface to the top of the *water table* or *aquifer*.

**volatile organic compounds** - Lightweight organic compounds that vaporize easily; used in solvents and degreasing compounds as raw materials.

**water table** - The top of the *unconfined aquifer*.

**wind rose** - A diagram showing how often winds of various speeds blow from different directions, usually based on yearly averages.

## References

40 CFR 761. "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 761.61(c). "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions; PCB Remediation Waste." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

DOE Order 5400.5. 1990. "Radiation Protection of the Public and the Environment." U.S. Department of Energy, Washington, D.C.

Shleien B. (ed.). 1992. *The Health Physics and Radiological Health Handbook, Revised Edition*. Scinta, Inc., Silver Spring, Maryland.

*Resource Conservation and Recovery Act of 1976*. 1976. Public Law 94-580, as amended, 90 Stat. 2795, 42 USC 6901 et seq. Accessed on April 9, 2009, at <http://www.epa.gov/lawsregs/laws/rcra.html>.

*Toxic Substances Control Act*. 1976. Public Law 94-469, as amended, 90 Stat. 2003, 15 USC 2601 et seq.





# Appendix C

## Additional Monitoring Results for 2008

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This appendix contains additional information on 2008 monitoring results, supplementing data summarized in the main body of the report. More detailed information is available in *Hanford Site Environmental Surveillance Data Report*

*for Calendar Year 2008* (PNNL-18427, APP. 1) and *Hanford Site Near-Facility Monitoring Data Report for Calendar Year 2008* (PNNL-18427, APP. 2).



Table C.1. Concentrations of Selected Radionuclides (pCi/m<sup>3</sup>)<sup>(a)</sup> in Near-Facility Air Samples, 2008 Compared to Previous Years

Radionuclide	Site	2008				Sampler Number	2003-2007				EPA Table 2 <sup>(e,f)</sup>
		Number of Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>		Number of Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	
Gross alpha	100-B/C FR	9	6	9.3E-04 ± 1.3E-03	1.8E-03 ± 6.3E-04	N466	591	530	1.1E-03 ± 1.2E-03	3.9E-03 ± 1.0E-03	2.0E-02
	100-D FR	104	93	1.2E-03 ± 1.2E-03	3.1E-03 ± 8.5E-04	N514	119	106	1.1E-03 ± 9.8E-04	2.6E-03 ± 9.3E-04	
	100-F FR	87	70	9.1E-04 ± 1.1E-03	2.6E-03 ± 7.5E-04	N907	590	493	9.8E-04 ± 1.3E-03	4.0E-03 ± 1.4E-03	
	100-H FR	71	67	1.3E-03 ± 1.2E-03	2.8E-03 ± 8.1E-04	N574	130	95	6.3E-04 ± 8.2E-04	2.8E-03 ± 1.0E-03	
	100-IU-2/6	34	32	1.1E-03 ± 1.1E-03	3.1E-03 ± 1.1E-03	N922	129	98	7.0E-04 ± 8.9E-04	2.1E-03 ± 8.3E-04	
	100-K SNF	211	198	1.7E-03 ± 3.0E-03	1.5E-02 ± 3.9E-03	N404	1,041	913	1.2E-03 ± 1.6E-03	1.4E-02 ± 1.6E-02	
	118-K-1 FR	37	30	1.0E-03 ± 1.1E-03	2.7E-03 ± 7.9E-04	N534	248	216	1.2E-03 ± 1.6E-03	7.5E-03 ± 1.6E-03	
	100-N	78	75	1.3E-03 ± 1.3E-03	3.3E-03 ± 9.0E-04	N102	393	369	1.2E-03 ± 1.3E-03	4.1E-03 ± 1.1E-03	
	200-East	542	501	1.3E-03 ± 1.3E-03	4.8E-03 ± 1.5E-03	N019	2,611	2,377	1.2E-03 ± 1.3E-03	6.7E-03 ± 1.6E-03	
	200-West	644	587	1.4E-03 ± 1.7E-03	1.2E-02 ± 4.6E-03	N165	3,086	2,803	1.2E-03 ± 1.4E-03	1.1E-02 ± 1.6E-02	
	200-UW-1	104	94	1.3E-03 ± 1.2E-03	3.2E-03 ± 2.0E-03	N168	510	460	1.2E-03 ± 1.5E-03	6.5E-03 ± 1.6E-03	
	300 Area D&D	26	23	1.3E-03 ± 1.3E-03	2.8E-03 ± 8.3E-04	N557	75	69	1.2E-03 ± 1.9E-03	7.3E-03 ± 1.7E-03	
	300-FF-2 FR	156	145	1.2E-03 ± 1.1E-03	3.0E-03 ± 8.5E-04	N538	408	371	1.2E-03 ± 1.5E-03	6.3E-03 ± 7.8E-03	
	BCCA	137	122	1.2E-03 ± 1.4E-03	4.7E-03 ± 3.6E-03	N570	391	328	1.0E-03 ± 1.3E-03	4.7E-03 ± 1.3E-03	
	ERDF	104	88	1.1E-03 ± 1.2E-03	3.0E-03 ± 8.3E-04	N482	531	451	1.1E-03 ± 1.3E-03	5.4E-03 ± 1.5E-03	
Gross beta	100-B/C FR	9	8	1.6E-02 ± 2.9E-02	3.8E-02 ± 3.6E-03	N497	591	591	1.6E-02 ± 2.0E-02	5.8E-02 ± 5.1E-03	9.0E+00
	100-D FR	104	104	1.9E-02 ± 2.1E-02	4.9E-02 ± 4.6E-03	N468	119	119	1.4E-02 ± 1.4E-02	4.2E-02 ± 4.3E-03	
	100-F FR	87	87	1.7E-02 ± 2.1E-02	5.4E-02 ± 5.8E-03	N907	590	590	1.6E-02 ± 2.0E-02	7.1E-02 ± 7.6E-03	
	100-H FR	71	71	2.2E-02 ± 2.2E-02	5.4E-02 ± 5.8E-03	N907	130	130	1.5E-02 ± 1.7E-02	6.3E-02 ± 1.2E-02	
	100-IU-2/6	34	34	2.0E-02 ± 2.2E-02	5.0E-02 ± 5.5E-03	N922	129	129	1.7E-02 ± 2.2E-02	6.9E-02 ± 1.4E-02	
	100-K SNF	211	211	2.1E-02 ± 3.9E-02	2.2E-01 ± 3.9E-02	N402	1,041	1,041	1.8E-02 ± 2.3E-02	1.2E-01 ± 1.1E-02	
	118-K-1 FR	37	37	1.4E-02 ± 2.0E-02	3.7E-02 ± 3.6E-03	N403	248	248	1.7E-02 ± 2.1E-02	7.8E-02 ± 7.9E-03	
	100-N	78	78	1.8E-02 ± 2.0E-02	4.1E-02 ± 4.4E-03	N102	393	393	1.7E-02 ± 1.9E-02	6.8E-02 ± 6.1E-03	
	200-East	542	542	1.8E-02 ± 2.1E-02	5.2E-02 ± 4.9E-03	N498	2,611	2,611	1.6E-02 ± 2.0E-02	9.6E-02 ± 7.8E-03	
	200-West	644	643	1.9E-02 ± 2.7E-02	1.7E-01 ± 2.0E-02	N165	3,086	3,085	1.6E-02 ± 1.9E-02	7.4E-02 ± 6.9E-03	
	200-UW-1	104	104	1.8E-02 ± 2.2E-02	4.9E-02 ± 4.4E-03	N963	510	510	1.7E-02 ± 2.1E-02	7.4E-02 ± 6.9E-03	
	300 Area D&D	26	26	1.9E-02 ± 2.3E-02	4.4E-02 ± 4.8E-03	N557	75	75	1.7E-02 ± 2.3E-02	6.4E-02 ± 6.8E-03	
	300-FF-2 FR	156	156	1.9E-02 ± 2.3E-02	5.3E-02 ± 5.8E-03	N539	408	407	1.7E-02 ± 2.2E-02	8.1E-02 ± 1.0E-02	
	BCCA	137	137	1.8E-02 ± 2.0E-02	5.1E-02 ± 4.8E-03	N978	391	391	1.6E-02 ± 1.9E-02	6.2E-02 ± 5.8E-03	
	ERDF	104	103	1.6E-02 ± 2.2E-02	4.9E-02 ± 4.4E-03	N963	531	530	1.5E-02 ± 1.9E-02	7.1E-02 ± 6.8E-03	

Table C.1. (contd)

Radionuclide	Site	2008					Sampler Number	2003-2007				EPA Table 2 <sup>(e,f)</sup>
		Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>			
		Samples	Detections <sup>(b)</sup>			Samples				Detections <sup>(b)</sup>		
Cobalt-60	100-B/C FR	3	0	-7.8E-06 ± 5.0E-04	2.9E-04 ± 6.1E-04	O466	53	0	8.1E-06 ± 8.2E-05	1.2E-04 ± 4.8E-04	1.7E-02	
	100-D FR	8	0	-2.0E-08 ± 1.2E-04	7.8E-05 ± 8.6E-05	O515	14	0	3.2E-05 ± 3.1E-04	5.6E-04 ± 1.3E-03		
	100-F FR	12	0	9.1E-07 ± 7.8E-04	1.0E-03 ± 9.8E-04	O906	69	0	1.2E-04 ± 3.5E-04	6.6E-04 ± 7.1E-04		
	100-H FR	8	0	2.5E-05 ± 2.2E-04	1.5E-04 ± 2.0E-04	O574	20	0	1.6E-04 ± 2.3E-04	5.4E-04 ± 4.3E-06		
	100-IU-2/6	5	0	-5.8E-05 ± 2.9E-04	1.2E-04 ± 2.6E-04	O565	21	0	1.9E-04 ± 2.9E-04	5.5E-04 ± 6.5E-04		
	100-K SNF	16	0	2.0E-05 ± 6.8E-05	9.3E-05 ± 7.1E-05	O476	88	0	7.2E-06 ± 9.0E-05	1.2E-04 ± 8.5E-05		
	118-K-1 FR	3	0	-8.0E-06 ± 1.9E-05	1.0E-07 ± 1.0E-06	O535	23	0	4.4E-05 ± 2.7E-04	5.5E-04 ± 5.7E-04		
	100-N	6	0	-1.7E-05 ± 7.9E-05	5.1E-05 ± 8.9E-05	O102	33	8	7.1E-05 ± 2.0E-04	2.8E-04 ± 1.5E-04		
	200-East	42	0	-8.9E-06 ± 1.2E-04	1.4E-04 ± 1.7E-04	O977	219	2	7.9E-06 ± 9.0E-05	1.7E-04 ± 2.7E-04		
	200-West	50	0	4.5E-07 ± 9.8E-05	1.1E-04 ± 1.3E-04	O456	259	1	3.0E-06 ± 8.9E-05	1.6E-04 ± 9.0E-05		
	200-UW-1	8	0	9.0E-06 ± 7.3E-05	5.1E-05 ± 8.7E-05	O963	43	0	9.3E-06 ± 9.0E-05	1.4E-04 ± 2.6E-04		
	300 Area D&D	4	0	-1.1E-05 ± 1.2E-04	8.3E-05 ± 1.5E-04	O557	12	0	-6.7E-05 ± 2.5E-04	8.2E-05 ± 1.6E-04		
	300-FF-2 FR	12	0	-7.2E-06 ± 1.0E-04	7.1E-05 ± 1.0E-04	O539	48	0	-4.0E-05 ± 4.7E-04	1.1E-03 ± 1.3E-03		
	BCCA	15	0	6.4E-05 ± 6.2E-04	1.2E-03 ± 6.8E-04	O920	42	1	7.3E-05 ± 2.3E-04	4.8E-04 ± 4.8E-04		
	ERDF	8	0	8.0E-07 ± 8.8E-05	7.1E-05 ± 1.1E-04	O482	44	0	6.9E-06 ± 1.1E-04	1.5E-04 ± 1.2E-04		
Strontium-90	100-B/C FR	3	0	-1.2E-03 ± 1.2E-03	-7.5E-04 ± 7.6E-04	O496	53	6	-1.4E-05 ± 3.1E-04	5.8E-04 ± 7.5E-04	1.9E-02	
	100-D FR	8	0	-1.5E-04 ± 2.7E-04	7.0E-06 ± 7.0E-05	O467	14	2	-4.5E-05 ± 5.0E-04	2.9E-04 ± 2.4E-04		
	100-F FR	12	0	-8.1E-05 ± 3.1E-04	7.7E-05 ± 6.1E-05	O907	68	5	-5.7E-06 ± 1.9E-04	2.7E-04 ± 1.3E-04		
	100-H FR	8	0	-1.2E-04 ± 2.8E-04	7.7E-05 ± 6.1E-05	O907	19	1	1.7E-05 ± 2.4E-05	4.2E-05 ± 4.9E-05		
	100-IU-2/6	5	0	-2.4E-04 ± 5.1E-04	-9.1E-06 ± 9.1E-07	O922	21	1	1.5E-05 ± 3.0E-05	4.5E-05 ± 5.2E-05		
	100-K SNF	16	2	-6.0E-05 ± 3.0E-04	2.9E-04 ± 1.7E-04	O402	88	10	-1.3E-05 ± 2.4E-04	2.7E-04 ± 1.2E-04		
	118-K-1 FR	3	0	-1.8E-04 ± 4.8E-05	-1.6E-04 ± 1.6E-04	O403	23	4	3.9E-06 ± 6.5E-04	9.5E-04 ± 4.3E-04		
	100-N	6	0	-1.8E-04 ± 2.9E-04	-1.9E-05 ± 2.0E-05	O106	33	5	-3.3E-06 ± 2.7E-04	4.5E-04 ± 1.8E-04		
	200-East	42	1	-1.5E-04 ± 2.8E-04	2.1E-04 ± 1.5E-04	O977	219	31	1.3E-05 ± 3.0E-04	1.0E-03 ± 3.3E-04		
	200-West	50	0	-2.0E-04 ± 2.6E-04	9.7E-05 ± 1.6E-04	O304	259	22	-1.5E-05 ± 2.2E-04	6.2E-04 ± 2.2E-04		
	200-UW-1	8	0	-2.2E-04 ± 2.7E-04	-7.3E-05 ± 7.5E-05	O956	43	5	-4.5E-06 ± 2.9E-04	6.6E-04 ± 2.6E-04		
	300 Area D&D	4	0	-8.6E-05 ± 2.1E-04	8.4E-05 ± 3.0E-04	O557	12	0	-1.2E-04 ± 4.4E-04	3.8E-04 ± 4.7E-04		
	300-FF-2 FR	2	0	-2.3E-04 ± 5.2E-05	-2.0E-04 ± 2.1E-04	O130	11	1	-2.4E-05 ± 1.9E-04	1.3E-04 ± 8.5E-05		
	BCCA	15	2	-7.8E-06 ± 5.5E-04	7.8E-04 ± 3.0E-04	O570	42	4	9.3E-06 ± 1.2E-04	2.1E-04 ± 1.2E-04		
	ERDF	8	0	-1.3E-04 ± 1.6E-04	9.0E-06 ± 9.0E-05	O482	44	3	9.0E-06 ± 2.7E-04	6.7E-04 ± 2.7E-04		

Table C.1. (contd)

Radionuclide	Site	2008					Sampler Number	2003-2007					EPA Table 2 <sup>(e,f)</sup>
		Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	Number of		Average <sup>(c)</sup>	Maximum <sup>(d)</sup>				
		Samples	Detections <sup>(b)</sup>			Samples				Detections <sup>(b)</sup>			
Cesium-137	100-B/C FR	3	0	7.7E-05 ± 2.9E-04	2.8E-04 ± 3.6E-04	O497	53	0	1.3E-05 ± 8.9E-05	1.5E-04 ± 2.0E-04	1.9E-02		
	100-D FR	8	0	1.0E-05 ± 6.7E-05	6.5E-05 ± 7.0E-05	O467	14	0	2.0E-06 ± 2.0E-04	1.9E-04 ± 3.5E-04			
	100-F FR	12	0	-2.5E-06 ± 3.8E-04	3.5E-04 ± 1.1E-03	O906	69	1	1.3E-04 ± 4.6E-04	1.6E-03 ± 6.8E-04			
	100-H FR	8	0	-5.8E-05 ± 3.5E-04	2.3E-04 ± 5.0E-04	O907	20	0	2.7E-04 ± 6.4E-04	1.6E-03 ± 6.8E-04			
	100-IU-2/6	5	0	-3.1E-05 ± 3.7E-04	2.5E-04 ± 6.6E-04	O922	21	0	1.8E-04 ± 3.4E-04	5.3E-04 ± 4.3E-04			
	100-K SNF	16	4	6.5E-04 ± 3.6E-03	7.4E-03 ± 2.5E-03	O403	88	5	3.5E-05 ± 1.0E-04	1.7E-04 ± 1.2E-04			
	118-K-1 FR	3	1	4.2E-05 ± 1.3E-04	1.3E-04 ± 9.3E-05	O535	23	5	6.7E-05 ± 2.9E-04	6.6E-04 ± 2.6E-04			
	100-N	6	0	-3.3E-06 ± 6.1E-05	4.9E-05 ± 7.1E-05	O102	33	4	4.5E-05 ± 1.2E-04	1.9E-04 ± 1.1E-04			
	200-East	42	3	2.6E-05 ± 1.2E-04	2.0E-04 ± 1.3E-04	O976	219	28	6.9E-05 ± 4.1E-04	2.3E-03 ± 7.6E-04			
	200-West	50	2	2.5E-05 ± 1.0E-04	1.8E-04 ± 1.2E-04	O433	259	25	5.8E-05 ± 2.5E-04	1.3E-03 ± 5.1E-04			
	200-UW-1	8	0	3.1E-05 ± 9.0E-05	1.2E-04 ± 1.3E-04	O956	43	11	1.2E-04 ± 2.6E-04	4.8E-04 ± 1.9E-04			
	300 Area D&D	4	0	-1.8E-05 ± 2.6E-05	-5.2E-06 ± 5.2E-05	O557	12	0	2.1E-05 ± 1.3E-04	1.2E-04 ± 3.1E-04			
	300-FF-2 FR	12	0	1.2E-05 ± 7.7E-05	1.0E-04 ± 7.7E-05	O538	48	0	2.1E-05 ± 2.6E-04	4.6E-04 ± 7.8E-04			
	BCCA	15	1	2.3E-04 ± 1.2E-03	2.5E-03 ± 8.1E-04	O570	42	1	8.9E-05 ± 2.5E-04	4.4E-04 ± 4.4E-04			
	ERDF	8	1	5.3E-05 ± 1.3E-04	1.5E-04 ± 1.1E-04	O517	44	2	5.4E-05 ± 1.1E-04	2.8E-04 ± 1.7E-04			
Uranium-234	100-B/C FR	3	3	5.9E-05 ± 3.6E-06	6.1E-05 ± 3.7E-05	O466	53	47	1.3E-05 ± 2.4E-05	6.7E-05 ± 3.6E-05	7.7E-03		
	100-D FR	8	8	1.4E-05 ± 4.9E-06	1.7E-05 ± 9.5E-06	O514	14	10	1.9E-05 ± 3.0E-05	6.3E-05 ± 7.5E-05			
	100-F FR	8	5	2.5E-05 ± 3.0E-05	4.6E-05 ± 1.7E-05	O906	50	33	2.0E-05 ± 6.2E-05	2.3E-04 ± 2.0E-03			
	100-H FR	4	4	2.7E-05 ± 1.6E-05	4.0E-05 ± 2.1E-05	O510	1	0	2.3E-04 ± 9.4E-09	2.3E-04 ± 2.0E-03			
	100-IU-2/6	2	1	1.5E-05 ± 1.7E-05	2.4E-05 ± 1.5E-05	O566			Not applicable				
	100-K SNF	16	16	1.5E-05 ± 7.9E-06	2.4E-05 ± 1.2E-05	O401	88	76	1.1E-05 ± 8.7E-06	2.2E-05 ± 1.2E-05			
	118-K-1 FR	3	3	1.3E-05 ± 7.5E-07	1.3E-05 ± 7.9E-06	O535	23	19	1.8E-05 ± 3.3E-05	8.4E-05 ± 4.3E-05			
	100-N	6	6	1.4E-05 ± 7.8E-06	1.7E-05 ± 1.0E-05	O103	33	33	1.3E-05 ± 8.4E-06	2.2E-05 ± 1.1E-05			
	200-East	42	41	1.3E-05 ± 9.1E-06	3.2E-05 ± 1.7E-05	O019	219	200	1.2E-05 ± 1.1E-05	3.9E-05 ± 1.8E-05			
	200-West	50	50	1.4E-05 ± 9.2E-06	2.4E-05 ± 1.3E-05	O550	259	226	1.2E-05 ± 1.2E-05	6.0E-05 ± 2.6E-05			
	200-UW-1	8	8	1.7E-05 ± 1.1E-05	2.4E-05 ± 1.3E-05	O550	43	38	1.8E-05 ± 2.4E-05	6.3E-05 ± 2.8E-05			
	300 Area D&D	4	4	2.1E-05 ± 1.2E-05	3.0E-05 ± 1.7E-05	O557	12	12	3.4E-05 ± 4.9E-05	1.1E-04 ± 5.3E-05			
	300-FF-2 FR	12	12	2.4E-05 ± 1.9E-05	4.7E-05 ± 2.1E-05	O539	48	44	4.4E-05 ± 9.7E-05	1.9E-04 ± 9.7E-05			
	BCCA	15	15	2.8E-05 ± 2.6E-05	5.3E-05 ± 1.9E-05	O920	42	24	1.7E-01 ± 2.2E+00	7.2E+00 ± 7.2E-01			
	ERDF	8	8	3.0E-05 ± 3.1E-05	5.4E-05 ± 3.0E-05	O518	44	42	1.7E-05 ± 1.6E-05	4.8E-05 ± 2.2E-05			

Table C.1. (contd)

Radionuclide	Site	2008				Sampler Number	2003-2007				EPA Table 2 <sup>(e,f)</sup>
		Number of Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>		Number of Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	
Uranium-235	100-B/C FR	3	0	8.9E-06 ± 8.4E-06	1.4E-05 ± 2.2E-05	O466	53	14	4.0E-06 ± 7.5E-06	2.1E-05 ± 1.6E-05	7.1E-03
	100-D FR	8	1	2.3E-06 ± 1.7E-06	3.7E-06 ± 3.5E-06	O467	14	2	9.4E-06 ± 3.3E-05	6.7E-05 ± 6.8E-05	
	100-F FR	7	2	3.9E-06 ± 6.0E-06	8.2E-06 ± 7.3E-06	O520	50	8	3.3E-06 ± 7.6E-06	2.4E-05 ± 1.2E-04	
	100-H FR	4	0	2.4E-06 ± 1.2E-06	2.9E-06 ± 3.5E-06	O509	1	0	2.40E-05	2.4E-05 ± 1.2E-04	
	100-IU-2/6	2	1	1.1E-05 ± 6.9E-06	1.4E-05 ± 1.2E-05	O565	Not applicable				
	100-K SNF	16	5	3.2E-06 ± 2.7E-06	5.3E-06 ± 4.8E-06	O476	88	14	2.5E-06 ± 3.7E-06	1.2E-05 ± 7.9E-06	
	118-K-1 FR	3	0	1.9E-06 ± 2.3E-06	3.5E-06 ± 3.9E-06	O403	23	3	4.7E-06 ± 9.7E-06	2.3E-05 ± 2.3E-05	
	100-N	6	5	4.6E-06 ± 1.8E-06	6.0E-06 ± 4.8E-06	O106	33	9	2.3E-06 ± 3.9E-06	8.2E-06 ± 6.9E-06	
	200-East	42	10	2.5E-06 ± 3.0E-06	6.8E-06 ± 5.2E-06	O019	219	51	2.8E-06 ± 4.2E-06	1.4E-05 ± 1.7E-05	
	200-West	50	12	3.2E-06 ± 4.2E-06	1.1E-05 ± 8.8E-06	O165	259	64	2.9E-06 ± 5.0E-06	1.9E-05 ± 1.2E-05	
	200-UW-1	8	2	3.2E-06 ± 4.1E-06	7.2E-06 ± 5.5E-06	O168	43	13	3.3E-06 ± 4.5E-06	9.7E-06 ± 7.3E-06	
	300 Area D&D	4	0	1.1E-06 ± 3.4E-06	2.9E-06 ± 4.3E-06	O557	12	1	4.6E-06 ± 5.2E-06	8.8E-06 ± 9.8E-06	
	300-FF-2 FR	12	4	2.6E-06 ± 4.9E-06	7.8E-06 ± 5.7E-06	O539	48	14	1.1E-05 ± 4.2E-05	1.3E-04 ± 8.9E-05	
	BCCA	15	1	3.3E-06 ± 5.0E-06	9.5E-06 ± 1.2E-05	O571	42	4	2.1E-06 ± 4.1E-06	1.0E-05 ± 6.8E-06	
	ERDF	8	1	5.0E-06 ± 5.3E-06	1.0E-05 ± 7.4E-06	O517	44	9	2.6E-06 ± 3.7E-06	7.8E-06 ± 5.7E-06	
Plutonium-238	100-B/C FR	3	0	2.1E-05 ± 2.4E-05	3.1E-05 ± 4.5E-05	O497	53	1	1.7E-06 ± 1.7E-05	2.9E-05 ± 2.1E-05	2.1E-03
	100-D FR	8	0	3.4E-06 ± 1.6E-05	5.2E-06 ± 9.2E-06	O468	14	0	9.5E-06 ± 5.5E-05	1.1E-04 ± 1.9E-04	
	100-F FR	12	0	4.5E-07 ± 3.1E-06	2.6E-06 ± 1.8E-05	O552	67	0	2.3E+00 ± 2.7E+01	1.1E+02 ± 1.1E+01	
	100-H FR	8	0	1.4E-06 ± 3.2E-06	5.6E-07 ± 6.8E-07	O907	19	0	2.3E+00 ± 6.4E+00	9.3E+00 ± 9.3E-01	
	100-IU-2/6	5	0	1.3E-06 ± 7.0E-06	8.0E-06 ± 2.3E-05	O565	20	1	2.1E+00 ± 6.3E+00	8.6E+00 ± 8.6E-01	
	100-K SNF	16	5	2.3E-05 ± 7.5E-05	1.1E-04 ± 5.6E-05	O403	88	0	1.2E-06 ± 2.1E-05	3.0E-05 ± 3.7E-05	
	118-K-1 FR	3	0	3.6E-06 ± 1.4E-05	1.0E-05 ± 1.5E-05	O535	23	1	3.1E-06 ± 2.6E-05	3.3E-05 ± 6.0E-05	
	100-N	6	0	3.2E-06 ± 1.1E-05	1.1E-05 ± 1.1E-05	O102	33	0	1.1E-07 ± 1.5E-05	2.2E-05 ± 1.5E-05	
	200-East	41	2	5.0E-06 ± 5.9E-05	1.9E-04 ± 6.8E-05	O977	219	1	4.4E-07 ± 1.4E-05	3.7E-05 ± 2.8E-05	
	200-West	50	1	1.2E-06 ± 1.1E-05	2.0E-05 ± 1.5E-05	O987	259	2	2.1E-06 ± 1.5E-05	4.0E-05 ± 2.5E-05	
	200-UW-1	8	0	4.7E-06 ± 8.5E-06	1.2E-05 ± 1.1E-05	O956	43	1	1.7E-06 ± 1.0E-05	1.4E-05 ± 1.4E-05	
	300 Area D&D	4	1	1.9E-06 ± 2.4E-05	1.8E-05 ± 1.1E-05	O557	12	1	5.5E-06 ± 3.8E-05	5.5E-05 ± 4.4E-05	
	300-FF-2 FR	12	0	3.1E-06 ± 8.0E-06	8.7E-06 ± 1.3E-05	O539	31	2	5.5E-06 ± 6.4E-05	1.4E-04 ± 1.6E-04	
	BCCA	15	0	2.3E-06 ± 3.7E-05	5.6E-05 ± 9.4E-05	O571	42	0	2.3E-01 ± 2.4E+00	7.6E+00 ± 7.6E-01	
	ERDF	8	0	1.7E-06 ± 9.1E-06	2.9E-06 ± 4.3E-06	O963	44	1	2.1E-06 ± 1.2E-05	1.6E-05 ± 1.5E-05	

Table C.1. (contd)

Radionuclide	Site	2008				Sampler Number	2003-2007				EPA Table 2 <sup>(e,f)</sup>
		Number of Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>		Number of Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	
Uranium-238	100-B/C FR	3	1	3.1E-05 ± 4.0E-05	5.6E-05 ± 3.6E-05	O466	53	45	9.7E-06 ± 9.6E-06	2.8E-05 ± 1.3E-05	8.3E-03
	100-D FR	8	8	8.6E-06 ± 3.8E-06	1.2E-05 ± 7.7E-06	O467	14	10	1.4E-05 ± 3.6E-05	7.8E-05 ± 7.3E-05	
	100-F FR	8	5	1.7E-05 ± 2.2E-05	3.4E-05 ± 1.4E-05	O906	50	38	1.3E-05 ± 3.0E-05	1.1E-04 ± 8.2E-05	
	100-H FR	4	4	1.9E-05 ± 8.6E-06	2.4E-05 ± 1.5E-05	O510	1	1	1.10E-04	1.1E-04 ± 8.2E-05	
	100-IU-2/6	2	1	1.2E-05 ± 1.0E-05	1.7E-05 ± 1.2E-05	O566	Not applicable				
	100-K SNF	16	15	1.1E-05 ± 1.3E-05	2.7E-05 ± 1.4E-05	O401	88	80	8.5E-06 ± 6.0E-06	1.8E-05 ± 1.0E-05	
	118-K-1 FR	3	2	8.4E-06 ± 5.7E-06	1.1E-05 ± 6.9E-06	O403	23	20	1.4E-05 ± 1.6E-05	3.9E-05 ± 2.6E-05	
	100-N	6	6	1.1E-05 ± 4.8E-06	1.6E-05 ± 9.0E-06	O106	33	28	8.9E-06 ± 7.1E-06	1.7E-05 ± 9.2E-06	
	200-East	42	39	9.4E-06 ± 7.5E-06	2.0E-05 ± 1.1E-05	O984	219	190	9.7E-06 ± 1.0E-05	4.0E-05 ± 1.9E-05	
	200-West	50	46	1.1E-05 ± 8.0E-06	2.3E-05 ± 1.2E-05	O550	259	226	1.0E-05 ± 1.1E-05	4.7E-05 ± 2.1E-05	
	200-UW-1	8	8	1.3E-05 ± 1.1E-05	2.3E-05 ± 1.2E-05	O550	43	40	1.5E-05 ± 2.1E-05	4.7E-05 ± 2.1E-05	
	300 Area D&D	4	3	1.2E-05 ± 8.2E-06	1.8E-05 ± 1.3E-05	O557	12	8	1.7E-05 ± 2.1E-05	3.6E-05 ± 2.0E-05	
	300-FF-2 FR	12	12	1.9E-05 ± 1.8E-05	3.8E-05 ± 1.8E-05	O539	48	42	3.4E-05 ± 7.6E-05	1.5E-04 ± 1.0E-04	
	BCCA	15	12	1.6E-05 ± 1.7E-05	3.7E-05 ± 1.5E-05	O920	42	39	1.2E-05 ± 1.2E-05	2.9E-05 ± 1.4E-05	
	ERDF	8	8	2.4E-05 ± 2.2E-05	3.7E-05 ± 1.7E-05	O482	44	41	1.5E-05 ± 1.7E-05	4.9E-05 ± 2.2E-05	
Plutonium-239/240	100-B/C FR	3	1	7.6E-06 ± 2.7E-05	2.4E-05 ± 1.9E-05	O497	53	8	2.3E-06 ± 6.7E-06	1.9E-05 ± 1.6E-05	2.0E-03
	100-D FR	8	0	1.9E-06 ± 2.4E-06	4.5E-06 ± 6.6E-06	O514	14	2	7.4E-06 ± 3.5E-05	6.7E-05 ± 6.3E-05	
	100-F FR	12	0	9.0E-09 ± 2.2E-06	1.5E-06 ± 5.2E-06	O553	65	2	3.5E-01 ± 3.2E+00	9.0E+00 ± 9.0E-01	
	100-H FR	8	0	1.0E-06 ± 5.3E-06	8.0E-07 ± 1.6E-06	O907	16	0	1.4E+00 ± 5.9E+00	9.0E+00 ± 9.0E-01	
	100-IU-2/6	4	1	3.4E-06 ± 7.2E-06	8.7E-06 ± 4.7E-06	O922	21	2	7.9E-01 ± 4.1E+00	6.9E+00 ± 6.9E-01	
	100-K SNF	16	10	1.5E-04 ± 5.2E-04	9.4E-04 ± 3.6E-04	O403	88	21	7.1E-06 ± 1.4E-05	4.1E-05 ± 2.4E-05	
	118-K-1 FR	3	0	3.5E-06 ± 3.6E-06	5.9E-06 ± 6.9E-06	O535	23	7	9.7E-06 ± 2.9E-05	5.4E-05 ± 3.3E-05	
	100-N	6	1	5.0E-06 ± 1.1E-05	1.8E-05 ± 1.1E-05	O103	33	12	4.7E-06 ± 6.0E-06	1.2E-05 ± 8.0E-06	
	200-East	42	2	4.4E-05 ± 5.5E-04	1.8E-03 ± 6.5E-04	O977	219	25	3.2E-06 ± 1.6E-05	7.2E-05 ± 3.2E-05	
	200-West	50	19	2.2E-05 ± 1.4E-04	4.6E-04 ± 1.8E-04	O165	259	105	2.9E-05 ± 1.9E-04	7.1E-04 ± 2.7E-04	
	200-UW-1	8	2	1.5E-05 ± 5.8E-05	9.1E-05 ± 3.8E-05	O956	43	20	1.0E-05 ± 4.1E-05	1.3E-04 ± 5.2E-05	
	300 Area D&D	4	1	9.3E-06 ± 2.5E-05	3.1E-05 ± 2.0E-05	O557	12	1	5.3E-06 ± 2.1E-05	3.9E-05 ± 2.8E-05	
	300-FF-2 FR	12	0	1.8E-06 ± 3.0E-06	4.3E-06 ± 4.9E-06	O540	31	2	2.3E-05 ± 2.2E-04	6.2E-04 ± 2.5E-04	
	BCCA	13	0	2.4E-06 ± 1.0E-05	1.4E-05 ± 1.6E-05	O569	42	2	3.0E-01 ± 2.2E+00	5.3E+00 ± 5.3E-01	
	ERDF	8	2	3.1E-06 ± 3.8E-06	6.8E-06 ± 5.5E-06	O517	44	16	9.3E-06 ± 4.2E-05	1.3E-04 ± 5.2E-05	

Table C.1. (contd)

Radionuclide	Site	2008				Sampler Number	2003-2007				EPA Table 2 <sup>(e,f)</sup>
		Number of Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>		Number of Samples	Detections <sup>(b)</sup>	Average <sup>(c)</sup>	Maximum <sup>(d)</sup>	
Americium-241	100-D FR	8	4	5.6E-06 ± 2.1E-06	6.9E-06 ± 5.0E-06	O515			Not applicable		1.9E-03
	100-IU-2/6	2	1	1.3E-05 ± 6.9E-06	1.6E-05 ± 1.2E-05	O566			Not applicable		
	100-K SNF	16	15	2.0E-04 ± 6.9E-04	1.2E-03 ± 4.4E-04	O403	88	33	1.4E-05 ± 9.3E-05	4.4E-04 ± 1.7E-04	
	118-K-1 FR	1	1	9.10E-06	9.1E-06 ± 5.8E-06	O403	11	6	5.2E-05 ± 2.5E-04	4.4E-04 ± 1.7E-04	
	100-N	6	3	5.1E-06 ± 4.7E-06	7.7E-06 ± 5.1E-06	O103	12	1	5.2E-06 ± 1.1E-05	1.4E-05 ± 1.0E-05	
	200-East	4	3	7.4E-06 ± 6.4E-06	1.0E-05 ± 6.1E-06	O480	22	4	4.6E-06 ± 7.3E-06	1.3E-05 ± 1.6E-05	
	200-West	2	1	1.7E-04 ± 2.8E-04	3.1E-04 ± 1.1E-04	O165			Not applicable		
	BCCA	6	2	1.6E-05 ± 1.9E-05	3.0E-05 ± 1.9E-05	O571			Not applicable		
Plutonium-241	100-K SNF	16	4	1.3E-03 ± 3.6E-03	5.8E-03 ± 1.8E-03	O403	88	10	1.4E-04 ± 1.4E-03	1.8E-03 ± 8.8E-04	1.0E-01
	118-K-1 FR	1	0	5.20E-04	5.2E-04 ± 6.7E-04	O403	11	0	1.6E-04 ± 1.2E-03	1.0E-03 ± 8.4E-04	
	200-East	4	0	1.9E-04 ± 9.5E-04	7.7E-04 ± 8.4E-04	O480	22	3	-2.9E-05 ± 1.5E-03	1.7E-03 ± 8.7E-04	
	200-West	2	1	1.4E-03 ± 5.9E-04	1.7E-03 ± 1.5E-03	O165			Not applicable		
	BCCA	6	0	2.9E-04 ± 1.4E-03	1.2E-03 ± 2.1E-03	O570			Not applicable		

(a) 1 pCi = 0.037 Bq.

(b) Number of samples with measurable concentrations of contaminant.

(c) Average ± two standard deviations of all samples analyzed.

(d) Maximum ± analytical uncertainty.

(e) DOE-derived concentration guides are shown for gross alpha and gross beta.

(f) EPA values are based on an effective dose equivalent of 10 mrem/yr (40 CFR 61, Appendix E, Table 2).

BCCA = BC Controlled Area.

D&amp;D = Decontamination and decommissioning.

DOE = U.S. Department of Energy.

EPA = U.S. Environmental Protection Agency.

ERDF = Environmental Restoration Disposal Facility.

FR = Field Remediation Project.

SNF = Spent nuclear fuel.

Table C.2. Selected U.S. Geological Survey Columbia River Water Quality Data for Vernita Bridge and Richland, Washington, 2008

Analysis	Units	Vernita Bridge (upstream)			Richland (downstream)			Washington Ambient Surface Water Quality Standard <sup>(a)</sup>
		No. of Samples	Maximum	Minimum	No. of Samples	Maximum	Minimum	
Temperature	°C	2	19	9.8	2	19	11	20 (maximum)
Dissolved oxygen	mg/L	2	13	9.5	2	12	9.6	8 (minimum)
Turbidity	NTU	2	5.3	1.1 <sup>(b)</sup>	2	3.3	1.0 <sup>(b)</sup>	5 + background
pH	pH units	2	7.9	7.8	2	7.8	7.7	6.5 - 8.5
Sulfate, dissolved	mg/L	2	10	8.3	2	10	8.6	-- <sup>(c)</sup>
Dissolved solids, 180°C (356°F)	mg/L	2	120	78	2	130	79	--
Specific conductance	µS/cm	2	149	133	2	150	134	--
Total hardness, as CaCO <sub>3</sub>	mg/L	2	69	61	2	69	61	--
Alkalinity	mg/L	2	58	54	2	61	54	--
Phosphorus, total	mg/L	2	<0.04	0.04	2	<0.04	<0.04	--
Chromium, dissolved	µg/L	2	0.07 <sup>(b)</sup>	0.07 <sup>(b)</sup>	2	<0.12	0.08 <sup>(b)</sup>	10
Dissolved organic carbon	mg/L	2	1.5	1.4	2	2.0	1.5	--
Iron, dissolved	µg/L	2	<8	5 <sup>(b)</sup>	2	<8	5 <sup>(b)</sup>	--
Ammonia, dissolved, as nitrogen	mg/L	2	<0.02	<0.02	2	<0.02	<0.02	--
Nitrite + nitrate, dissolved, as nitrogen	mg/L	2	0.20	0.07	2	0.20	0.08	--
Calcium, dissolved	mg/L	2	20	17	2	19	17	--
Magnesium, dissolved	mg/L	2	4.9	4.2	2	4.9	4.2	--
Potassium, dissolved	mg/L	2	0.83	0.69	2	0.84	0.71	--
Sodium, dissolved	mg/L	2	2.6	2.2	2	2.6	2.3	--
Chloride, dissolved	mg/L	2	1.3	0.86	2	1.3	0.94	--
Suspended sediment	mg/L	2	2	2	2	6	2	--

(a) From WAC 173-201A.

(b) Estimated value.

(c) Dashes indicate no standard available.

NTU = Nephelometric turbidity units.

**Table C.3. Radionuclide Concentrations in Columbia River Water Samples Collected at Priest Rapids Dam, Washington, 2008 Compared to Previous 5 Years**

Radionuclide <sup>(a)</sup>	2008				2003-2007				Ambient Surface Water Quality Standard, pCi/L
	No. of Samples	Concentration, <sup>(b)</sup> pCi/L		No. of Samples	Concentration, <sup>(b)</sup> pCi/L				
		Maximum	Average		Maximum	Average			
Composite System									
Tritium	12	48 ± 19	23 ± 22	58	80 ± 9.0	29 ± 25	20,000 <sup>(c)</sup>		
Alpha (gross)	12	2.1 ± 1.7	0.45 ± 1.4	60	1.4 ± 1.2	0.53 ± 0.81	15 <sup>(d,e)</sup>		
Beta (gross)	12	6.8 ± 1.6	1.9 ± 3.4	60	4.2 ± 1.8	0.83 ± 1.8	50 <sup>(d,e)</sup>		
Strontium-90	12	0.090 ± 0.040	0.035 ± 0.051	60	0.24 ± 0.085	0.065 ± 0.070	8 <sup>(d,e)</sup>		
Technetium-99	12	0.46 ± 0.50 <sup>(f)</sup>	5.3E-04 ± 0.56	60	1.1 ± 0.43	0.14 ± 0.51	900 <sup>(c)</sup>		
Uranium-234	12	0.30 ± 0.097	0.26 ± 0.058	60	0.28 ± 0.057	0.22 ± 0.066	-- <sup>(g)</sup>		
Uranium-235	12	0.15 ± 0.086	0.028 ± 0.077	60	0.014 ± 0.014 <sup>(f)</sup>	3.8E-03 ± 0.013	--		
Uranium-238	12	0.27 ± 0.072	0.19 ± 0.081	60	0.25 ± 0.058	0.18 ± 0.054	--		
Uranium (total)	12	0.58 ± 0.13	0.47 ± 0.12	60	0.54 ± 0.087	0.40 ± 0.11	--		
Continuous System									
Cesium-137	P	11	2.2E-03 ± 6.1E-03 <sup>(f)</sup>	3.2E-04 ± 2.3E-03 <sup>(f)</sup>	60	8.9E-03 ± 6.0E-03 <sup>(f)</sup>	7.3E-04 ± 2.6E-03	200 <sup>(c)</sup>	
	D	12	7.8E-03 ± 7.0E-03 <sup>(f)</sup>	7.0E-04 ± 6.0E-03 <sup>(f)</sup>	60	4.7E-03 ± 3.1E-03 <sup>(f)</sup>	8.2E-04 ± 2.3E-03 <sup>(f)</sup>		
Plutonium-238	P	4	6.2E-05 ± 7.3E-05 <sup>(f)</sup>	1.8E-06 ± 9.1E-05 <sup>(f)</sup>	19	8.2E-05 ± 4.2E-05	6.6E-06 ± 4.9E-05	600 <sup>(c)</sup>	
	D	4	2.3E-04 ± 4.1E-04 <sup>(f)</sup>	7.4E-05 ± 2.2E-04 <sup>(f)</sup>	20	4.9E-05 ± 5.7E-05 <sup>(f)</sup>	2.2E-04 ± 4.6E-04 <sup>(f)</sup>		
Plutonium-239/240	P	4	7.1E-05 ± 1.1E-04 <sup>(f)</sup>	2.2E-05 ± 8.8E-05 <sup>(f)</sup>	19	1.2E-04 ± 4.9E-05	2.7E-05 ± 5.6E-05	--	
	D	4	3.2E-04 ± 4.4E-04 <sup>(f)</sup>	1.2E-04 ± 2.8E-04 <sup>(f)</sup>	20	5.5E-05 ± 5.7E-05 <sup>(f)</sup>	2.2E-05 ± 3.2E-05 <sup>(f)</sup>		

(a) Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately. Other radionuclides are based on unfiltered samples collected by the composite system (see Section 10.4).

(b) Maximum values are ± total propagated analytical uncertainty (2 sigma). Averages are ±2 standard deviations of the mean. To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(c) WAC 173-201A-250 and EPA-570/9-76-003.

(d) WAC 246-290.

(e) 40 CFR 141.

(f) Less than the laboratory reported detection limit.

(g) Dashes indicate no concentration guides available.

**Table C.4. Radionuclide Concentrations in Columbia River Water Samples Collected at Richland, Washington, 2008 Compared to Previous 5 Years**

Radionuclide <sup>(a)</sup>	2008				2003-2007				Ambient Surface Water Quality Standard, pCi/L
	No. of Samples	Concentration, <sup>(b)</sup> pCi/L		No. of Samples	Concentration, <sup>(b)</sup> pCi/L				
		Maximum	Average		Maximum	Average			
Composite System									
Tritium	12	66 ± 23	37 ± 30	58	140 ± 14	54 ± 48	20,000 <sup>(c)</sup>		
Alpha (gross)	12	1.5 ± 1.5 <sup>(d)</sup>	0.54 ± 1.4	60	1.6 ± 1.1	0.44 ± 0.74	15 <sup>(e,f)</sup>		
Beta (gross)	12	5.3 ± 2.6	1.4 ± 3.4	60	3.3 ± 1.5	1.0 ± 1.5	50 <sup>(e,f)</sup>		
Strontium-90	12	0.081 ± 0.029	0.035 ± 0.037	60	0.26 ± 0.059	0.063 ± 0.075	8 <sup>(e,f)</sup>		
Technetium-99	12	0.50 ± 0.42 <sup>(d)</sup>	0.015 ± 0.57 <sup>(d)</sup>	60	1.2 ± 0.57	0.22 ± 0.56	900 <sup>(c)</sup>		
Uranium-234	12	0.32 ± 0.11	0.27 ± 0.081	60	0.32 ± 0.11	0.26 ± 0.066	-- <sup>(g)</sup>		
Uranium-235	12	0.045 ± 0.045	0.019 ± 0.021	60	0.020 ± 0.011	5.3E-03 ± 0.014	--		
Uranium-238	12	0.27 ± 0.11	0.22 ± 0.075	60	0.30 ± 0.066	0.20 ± 0.062	--		
Uranium (total)	12	0.63 ± 0.16	0.50 ± 0.15	60	0.61 ± 0.093	0.46 ± 0.12	--		
Continuous System									
Cesium-137	P	11	2.7E-03 ± 2.0E-03 <sup>(f)</sup>	1.7E-04 ± 2.6E-03 <sup>(f)</sup>	59	9.1E-03 ± 4.8E-03 <sup>(d)</sup>	5.3E-04 ± 2.6E-03 <sup>(d)</sup>	200 <sup>(f)</sup>	
	D	11	7.9E-03 ± 5.6E-03 <sup>(f)</sup>	6.8E-04 ± 8.0E-03 <sup>(f)</sup>	59	3.7E-03 ± 2.4E-03 <sup>(d)</sup>	6.7E-04 ± 2.2E-03 <sup>(d)</sup>		
Plutonium-238	P	4	4.3E-05 ± 8.4E-05 <sup>(f)</sup>	4.1E-06 ± 9.5E-05 <sup>(f)</sup>	19	6.0E-05 ± 6.8E-05 <sup>(d)</sup>	1.4E-07 ± 3.7E-05	600 <sup>(f)</sup>	
	D	4	3.3E-04 ± 9.6E-04 <sup>(f)</sup>	-2.5E-05 ± 6.9E-04 <sup>(f)</sup>	20	4.1E-05 ± 8.7E-05 <sup>(d)</sup>	-2.6E-04 ± 4.4E-04 <sup>(d)</sup>		
Plutonium-239/240	P	4	6.8E-05 ± 1.3E-04 <sup>(f)</sup>	-6.6E-05 ± 3.5E-04 <sup>(f)</sup>	19	8.9E-05 ± 4.6E-05	2.4E-05 ± 4.5E-05	--	
	D	4	1.6E-04 ± 2.5E-04 <sup>(f)</sup>	4.5E-05 ± 1.7E-04	20	7.3E-05 ± 8.6E-05 <sup>(d)</sup>	1.7E-05 ± 6.4E-05 <sup>(d)</sup>		

(a) Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately. Other radionuclides are based on unfiltered samples collected by the composite system (see Section 10.4).

(b) Maximum values are ± total propagated analytical uncertainty (2 sigma). Averages are ±2 standard deviations of the mean. To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(c) WAC 173-201A-250 and EPA-570/9-76-003.

(d) Less than the laboratory reported detection limit.

(e) WAC 246-290.

(f) 40 CFR 141.

(g) Dashes indicate no concentration guides available.

**Table C.5. Radionuclide Concentrations Measured in Columbia River Water Samples Collected Along Transects of the Hanford Reach, 2008**

<u>Transect/Radionuclide</u>	<u>No. of Samples</u>	<u>Concentration,<sup>(a)</sup> pCi/L</u>	
		<u>Maximum</u>	<u>Minimum</u>
<b>Vernita Bridge (HRM 0.3)</b>			
Tritium	16	35 ± 10	11 ± 6.8
Strontium-90	16	0.058 ± 0.040 <sup>(b)</sup>	0.0078 ± 0.030 <sup>(b)</sup>
Uranium (total)	16	0.54 ± 0.14	0.32 ± 0.12
<b>100-N Area (HRM 9.5)</b>			
Tritium	7	130 ± 19	19 ± 5.7
Strontium-90	7	0.20 ± 0.054	0.0019 ± 0.023 <sup>(b)</sup>
Uranium (total)	7	0.67 ± 0.15	0.43 ± 0.12
<b>Hanford town site (HRM 28.7)</b>			
Tritium	6	560 ± 200	15 ± 7.8
Strontium-90	6	0.18 ± 0.046	0.0075 ± 0.024 <sup>(b)</sup>
Uranium (total)	6	0.54 ± 0.14	0.37 ± 0.10
<b>300 Area (HRM 43.1)</b>			
Tritium	6	86 ± 16	22 ± 8.5
Strontium-90	6	0.13 ± 0.058	0.0030 ± 0.031 <sup>(b)</sup>
Uranium (total)	6	1.1 ± 0.22	0.46 ± 0.13
<b>Richland (HRM 46.4)</b>			
Tritium	26	72 ± 13	13 ± 7.6
Strontium-90	24	0.098 ± 0.044	-0.0090 ± 0.023 <sup>(b)</sup>
Uranium (total)	26	1.0 ± 0.20	0.34 ± 0.078

(a) Maximum and minimum values are ± total propagated analytical uncertainty (2 sigma). To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(b) Less than the laboratory-reported detection limit.

HRM = Hanford river marker.

**Table C.6. Radionuclide Concentrations Measured in Columbia River Water Samples Collected at Near-Shore Locations in the Hanford Reach, 2008**

<u>Near-Shore/Radionuclide</u>	<u>No. of Samples</u>	<u>Concentration,<sup>(a)</sup> pCi/L</u>	
		<u>Maximum</u>	<u>Minimum</u>
<b>Vernita Bridge (HRM 0.3)</b>			
Tritium	4	21 ± 6.5	15 ± 5.9
Strontium-90	4	0.058 ± 0.040 <sup>(b)</sup>	0.021 ± 0.027 <sup>(b)</sup>
Uranium (total)	4	0.47 ± 0.12	0.33 ± 0.071
<b>100-N Area (HRM 8.4 to 9.8)</b>			
Tritium	6	130 ± 19	25 ± 4.9
Strontium-90	6	0.20 ± 0.054	0.062 ± 0.032
Uranium (total)	6	0.51 ± 0.13	0.38 ± 0.11
<b>Hanford town site (HRM 26 to 30)</b>			
Tritium	5	2,900 ± 610	15 ± 8.6
Strontium-90	5	0.12 ± 0.041	0.019 ± 0.030 <sup>(b)</sup>
Uranium (total)	5	0.51 ± 0.13	0.42 ± 0.11
<b>300 Area (HRM 41.5 to 43.1)</b>			
Tritium	5	1,100 ± 290	60 ± 12
Strontium-90	5	0.052 ± 0.033	0.0030 ± 0.031 <sup>(b)</sup>
Uranium (total)	5	1.1 ± 0.22	0.51 ± 0.13
<b>Richland (HRM 43.5 to 46.4)</b>			
Tritium	22	72 ± 13	21 ± 13
Strontium-90	22	0.040 ± 0.035 <sup>(b)</sup>	-0.015 ± 0.023 <sup>(b)</sup>
Uranium (total)	22	0.78 ± 0.17	0.33 ± 0.13

(a) Maximum and minimum values are ± total propagated analytical uncertainty (2 sigma). To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(b) Less than the laboratory-reported detection limit.

HRM = Hanford river marker.

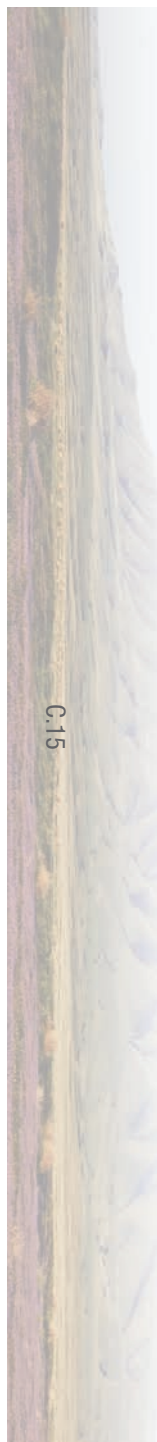
**Table C.7. Concentrations (µg/L) of Dissolved Metals in Columbia River Transect and Near-Shore Water Samples Collected Near the Hanford Site, September 2008**

<u>Location</u>	<u>Metal</u>	<u>No. of Samples</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average (±2SD)</u>	
Vernita Bridge	Antimony	4	0.27	0.24	0.25	(0.025)
	Arsenic	4	0.77	0.75	0.76	(0.018)
	Beryllium <sup>(a)</sup>	4	0.009 <sup>(a)</sup>	0.009 <sup>(a)</sup>	0.009 <sup>(a)</sup>	(0.0)
	Cadmium	4	0.010	0.0092	0.010	(0.0011)
	Chromium <sup>(a)</sup>	4	0.12	0.1 <sup>(a)</sup>	0.11 <sup>(a)</sup>	(0.022)
	Copper	4	0.82	0.74	0.79	(0.072)
	Lead	4	0.056	0.034	0.042	(0.019)
	Nickel	4	0.33	0.26	0.30	(0.066)
	Selenium	4	0.23	0.2 <sup>(a)</sup>	0.21	(0.030)
	Silver	4	0.0062	0.005 <sup>(a)</sup>	0.0053	(0.0012)
	Thallium	4	0.014	0.013	0.014	(0.0007)
	Zinc	4	1.4	1.2	1.3	(0.23)
100-N Area	Antimony	10	0.34	0.23	0.27	(0.067)
	Arsenic	10	0.81	0.76	0.79	(0.034)
	Beryllium	10	0.009 <sup>(a)</sup>	0.009 <sup>(a)</sup>	0.009 <sup>(a)</sup>	(0.0)
	Cadmium	10	0.011	0.0096	0.010	(0.0011)
	Chromium	10	0.30	0.1 <sup>(a)</sup>	0.16	(0.12)
	Copper <sup>(b)</sup>	10	0.78	0.70	0.74	(0.054)
	Lead	10	0.037	0.025	0.030	(0.0072)
	Nickel	10	0.63	0.22	0.36	(0.25)
	Selenium	10	0.2 <sup>(a)</sup>	0.2 <sup>(a)</sup>	0.2 <sup>(a)</sup>	(9.9E-09)
	Silver <sup>(a)</sup>	10	0.005 <sup>(a)</sup>	0.005 <sup>(a)</sup>	0.005 <sup>(a)</sup>	(2.2E-10)
	Thallium	10	0.014	0.013	0.013	(0.00090)
	Zinc	10	1.4	1.0	1.2	(0.27)
Hanford town site	Antimony	10	0.31	0.20	0.24	(0.082)
	Arsenic	10	1.1	0.73	0.79	(0.20)
	Beryllium <sup>(a)</sup>	10	0.009 <sup>(a)</sup>	0.009 <sup>(a)</sup>	0.009 <sup>(a)</sup>	(0.0)
	Cadmium	10	0.011	0.0077	0.0094	(0.0019)
	Chromium	10	0.35	0.11 <sup>(a)</sup>	0.16	(0.14)
	Copper	10	0.70	0.66	0.68	(0.025)
	Lead	10	0.032	0.013	0.021	(0.012)
	Nickel	10	0.51	0.16	0.32	(0.21)
	Selenium	10	0.29	0.2 <sup>(a)</sup>	0.22	(0.066)
	Silver	10	0.005 <sup>(a)</sup>	0.005 <sup>(a)</sup>	0.005 <sup>(a)</sup>	(2.2E-10)
	Thallium	10	0.015	0.013	0.014	(0.0010)
	Zinc	10	1.7	0.96	1.3	(0.44)
300 Area	Antimony <sup>(a)</sup>	10	0.31	0.20	0.27	(0.062)
	Arsenic	10	1.3	0.72	0.88	(0.41)
	Beryllium <sup>(a)</sup>	10	0.009 <sup>(a)</sup>	0.009 <sup>(a)</sup>	0.009 <sup>(a)</sup>	(0.0)
	Cadmium	10	0.011	0.0071	0.0091	(0.0025)
	Chromium	10	0.43	0.12	0.23	(0.22)
	Copper	10	0.94	0.64	0.72	(0.23)
	Lead	10	0.031	0.017	0.022	(0.0096)
	Nickel	10	0.39	0.26	0.32	(0.085)
	Selenium	10	0.56	0.2 <sup>(a)</sup>	0.29	(0.23)
	Silver <sup>(a)</sup>	10	0.005 <sup>(a)</sup>	0.005 <sup>(a)</sup>	0.005 <sup>(a)</sup>	(2.2E-10)
	Thallium	10	0.015	0.012	0.014	(0.0018)
	Zinc	10	1.2	0.87	1.0	(0.22)

**Table C.7. (contd)**

<u>Location</u>	<u>Metal</u>	<u>No. of Samples</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average (<math>\pm 2SD</math>)</u>	
Richland	Antimony	10	0.22	0.19	0.21	(0.020)
	Arsenic	10	1.0	0.71	0.80	(0.20)
	Beryllium <sup>(a)</sup>	10	0.009 <sup>(a)</sup>	0.009 <sup>(a)</sup>	0.009 <sup>(a)</sup>	(0.0)
	Cadmium	10	0.010	0.0069	0.0087	(0.0021)
	Chromium <sup>(a)</sup>	10	0.35 <sup>(a)</sup>	0.16 <sup>(a)</sup>	0.22 <sup>(a)</sup>	(0.13)
	Copper	10	2.4	0.65	0.85	(1.1)
	Lead	10	0.043	0.019	0.029	(0.016)
	Nickel	10	1.5	0.26	0.49	(0.75)
	Selenium	10	0.28	0.2 <sup>(a)</sup>	0.22	(0.064)
	Silver	10	0.005 <sup>(a)</sup>	0.005 <sup>(a)</sup>	0.005 <sup>(a)</sup>	(2.2E-10)
	Thallium	10	0.015	0.012	0.014	(0.0015)
	Zinc	10	1.4	1.1	1.2	(0.21)

(a) Values shown were below the limit of detection.  
SD = Standard deviation.



**Table C.8. Radionuclide and Total Organic Carbon Concentrations in Sediment from the Columbia River Near the Hanford Site, 2008 Compared to Previous 5 Years**

Location and Total Organic Carbon Concentrations		Radionuclide	2008		No. of Samples	2003-2007			
			No. of Samples	Concentration, pCi/g <sup>(a)</sup>		No. of Samples	Concentration, pCi/g <sup>(a)</sup>		
				Average <sup>(b)</sup>			Maximum <sup>(c)</sup>	Average <sup>(b)</sup>	Maximum <sup>(c)</sup>
(2008 TOC Value)									
Priest Rapids Dam (16,800-24,400 mg/kg)	Cobalt-60	2	8.2E-03 ± 6.7E-03 <sup>(d)</sup>	0.011 ± 0.019	10	2.0E-03 ± 9.7E-3 <sup>(d)</sup>	0.010 ± 0.015 <sup>(d)</sup>		
	Strontium-90	2	4.1E-03 ± 4.5E-03 <sup>(d)</sup>	5.7E-03 ± 0.028 <sup>(d)</sup>	10	5.3E-03 ± 0.028	0.031 ± 0.029 <sup>(d)</sup>		
	Cesium-137	2	0.30 ± 4.2E-03	0.30 ± 0.041	10	0.30 ± 0.080	0.37 ± 0.059		
	Europium-152	2	-0.014 ± 0.049 <sup>(d)</sup>	3.3E-03 ± 0.061 <sup>(d)</sup>	10	-7.8E-03 ± 0.058 <sup>(d)</sup>	0.026 ± 0.032 <sup>(d)</sup>		
	Europium-155	2	0.067 ± 0.019 <sup>(d)</sup>	0.074 ± 0.051 <sup>(d)</sup>	10	0.058 ± 0.038 <sup>(d)</sup>	0.093 ± 0.045 <sup>(d)</sup>		
	Uranium-234	2	1.1 ± 0.13	1.1 ± 0.14	10	0.78 ± 0.26	0.95 ± 0.16		
	Uranium-235	2	0.091 ± 0.013	0.096 ± 0.026	10	0.027 ± 0.015	0.038 ± 0.017		
	Uranium-238	2	1.0 ± 0.25	1.1 ± 0.14	10	0.65 ± 0.19	0.78 ± 0.15		
	Plutonium-239/240	2	7.6E-03 ± 2.8E-03	8.6E-03 ± 3.0E-03	10	9.2E-03 ± 2.9E-03	0.012 ± 2.3E-03		
White Bluffs Slough (6,860 mg/kg)	Cobalt-60	1		0.017 ± 9.5E-03 <sup>(d)</sup>	5	0.021 ± 0.024	0.038 ± 0.028		
	Strontium-90	1		-3.1E-05 ± 0.025 <sup>(d)</sup>	5	-2.4E-03 ± 0.032 <sup>(d)</sup>	0.016 ± 0.015 <sup>(d)</sup>		
	Cesium-137	1		0.42 ± 0.042	5	1.2 ± 1.9	2.8 ± 0.33		
	Europium-152	1		0.10 ± 0.034 <sup>(d)</sup>	4	0.25 ± 0.31	0.51 ± 0.099		
	Europium-155	1		0.039 ± 0.035 <sup>(d)</sup>	5	0.062 ± 3.4E-03 <sup>(d)</sup>	0.086 ± 0.032 <sup>(d)</sup>		
	Uranium-234	1		0.64 ± 0.088	5	0.41 ± 0.14	0.51 ± 0.090		
	Uranium-235	1		0.061 ± 0.020	5	0.017 ± 0.013	0.027 ± 9.8E-03		
	Uranium-238	1		0.61 ± 0.084	5	0.38 ± 0.16	0.46 ± 0.081		
	Plutonium-239/240	1		6.0E-03 ± 2.6E-03	5	6.7E-03 ± 4.0E-03	0.010 ± 1.9E-03		
100-F Slough (786 mg/kg)	Cobalt-60	1		0.011 ± 8.6E-03 <sup>(d)</sup>	5	6.6E-03 ± 6.8E-03 <sup>(d)</sup>	0.012 ± 0.010 <sup>(d)</sup>		
	Strontium-90	1		9.3E-03 ± 0.029 <sup>(d)</sup>	5	-3.0E-03 ± 0.020 <sup>(d)</sup>	7.9E-03 ± 0.017 <sup>(d)</sup>		
	Cesium-137	1		0.27 ± 0.022	5	0.28 ± 0.14	0.39 ± 0.055		
	Europium-152	1		0.047 ± 0.028 <sup>(d)</sup>	5	0.032 ± 0.047 <sup>(d)</sup>	0.072 ± 0.044 <sup>(d)</sup>		
	Europium-155	1		0.026 ± 0.020 <sup>(d)</sup>	5	0.039 ± 0.038 <sup>(d)</sup>	0.064 ± 0.028 <sup>(d)</sup>		
	Uranium-234	1		0.49 ± 0.072	5	0.24 ± 0.40	0.60 ± 0.11		
	Uranium-235	1		0.061 ± 0.020	5	5.5E-03 ± 0.013	0.015 ± 9.0E-03		
	Uranium-238	1		0.42 ± 0.064	5	0.25 ± 0.39	0.60 ± 0.13		
	Plutonium-239/240	1		5.6E-04 ± 1.4E-03 <sup>(d)</sup>	4	1.4E-03 ± 1.3E-03	2.0E-03 ± 1.2E-03		
Hanford Slough (11,800 mg/kg)	Cobalt-60	1		4.2E-03 ± 0.012 <sup>(d)</sup>	5	0.019 ± 0.053	0.055 ± 0.020		
	Strontium-90	1		-9.3E-04 ± 0.018 <sup>(d)</sup>	5	-4.7E-03 ± 0.023 <sup>(d)</sup>	5.8E-03 ± 0.018 <sup>(d)</sup>		
	Cesium-137	1		0.060 ± 0.021	5	0.13 ± 0.30	0.32 ± 0.046		
	Europium-152	1		9.5E-04 ± 0.028	5	0.043 ± 0.16 <sup>(d)</sup>	0.18 ± 0.049 <sup>(d)</sup>		
	Europium-155	1		0.091 ± 0.044	5	0.055 ± 0.021 <sup>(d)</sup>	0.070 ± 0.034 <sup>(d)</sup>		
	Uranium-234	1		0.74 ± 0.11	5	0.34 ± 0.28	0.56 ± 0.11		
	Uranium-235	1		0.031 ± 0.017	5	0.013 ± 0.013	0.021 ± 0.016		
	Uranium-238	1		0.73 ± 0.10	5	0.33 ± 0.24	0.53 ± 0.13		
	Plutonium-239/240	1		-1.9E-04 ± 8.4E-04 <sup>(d)</sup>	5	1.9E-03 ± 4.2E-03	5.3E-03 ± 2.6E-03		

Table C.8. (contd)

Location and Total Organic Carbon Concentrations (2008 TOC Value)	Radionuclide	2008			2003-2007		
		No. of Samples	Concentration, pCi/g <sup>(a)</sup>		No. of Samples	Concentration, pCi/g <sup>(a)</sup>	
			Average <sup>(b)</sup>	Maximum <sup>(c)</sup>		Average <sup>(b)</sup>	Maximum <sup>(c)</sup>
Richland (1,570 mg/kg)	Cobalt-60	1		5.5E-03 ± 0.011 <sup>(d)</sup>	5	3.8E-03 ± 8.0E-03 <sup>(d)</sup>	9.2E-03 ± 0.011 <sup>(d)</sup>
	Strontium-90	1		2.4E-03 ± 0.028 <sup>(d)</sup>	5	-3.3E-03 ± 0.023 <sup>(d)</sup>	0.015 ± 0.020 <sup>(d)</sup>
	Cesium-137	1		0.17 ± 0.020	5	0.15 ± 0.062	0.19 ± 0.033
	Europium-152	1		0.037 ± 0.024 <sup>(d)</sup>	5	0.041 ± 0.027 <sup>(d)</sup>	0.057 ± 0.033 <sup>(d)</sup>
	Europium-155	1		0.045 ± 0.028 <sup>(d)</sup>	5	0.078 ± 0.049 <sup>(d)</sup>	0.010 ± 0.053 <sup>(d)</sup>
	Uranium-234	1		0.41 ± 0.073	5	0.25 ± 0.15	0.36 ± 0.089
	Uranium-235	1		0.026 ± 0.016	5	7.4E-03 ± 9.3E-03	0.014 ± 9.1E-03
	Uranium-238	1		0.47 ± 0.080	5	0.25 ± 0.16	0.38 ± 0.11
Plutonium-239/240	1		1.4E-03 ± 1.3E-03 <sup>(d)</sup>	4	1.4E-03 ± 7.9E-04	1.6E-03 ± 9.1E-04	
McNary Dam (10,100-15,500 mg/kg)	Cobalt-60	2	0.019 ± 1.8E-03 <sup>(d)</sup>	0.020 ± 0.014 <sup>(d)</sup>	10	0.013 ± 0.025 <sup>(d)</sup>	0.029 ± 0.011 <sup>(d)</sup>
	Strontium-90	2	-5.5E-03 ± 0.053 <sup>(d)</sup>	0.013 ± 0.024 <sup>(d)</sup>	10	0.012 ± 0.029	0.034 ± 0.047 <sup>(d)</sup>
	Cesium-137	2	0.28 ± 0.082	0.31 ± 0.032	10	0.26 ± 0.11	0.33 ± 0.054
	Europium-152	2	0.061 ± 0.16 <sup>(d)</sup>	0.12 ± 0.047 <sup>(d)</sup>	10	0.079 ± 0.15 <sup>(d)</sup>	0.17 ± 0.068 <sup>(d)</sup>
	Europium-155	2	0.055 ± 0.035 <sup>(d)</sup>	0.067 ± 0.048 <sup>(d)</sup>	10	0.057 ± 0.045 <sup>(d)</sup>	0.082 ± 0.055 <sup>(d)</sup>
	Uranium-234	2	1.2 ± 0.30	1.3 ± 0.17	10	1.0 ± 0.31	1.4 ± 0.24
	Uranium-235	2	0.10 ± 0.057	0.12 ± 0.030	10	0.034 ± 0.020	0.052 ± 0.015
	Uranium-238	2	1.1 ± 0.21	1.1 ± 0.14	10	0.78 ± 0.22	1.0 ± 0.19
Plutonium-239/240	2	8.9E-03 ± 8.1E-03	0.012 ± 3.3E-03	10	7.8E-03 ± 2.2E-03	9.9E-03 ± 3.2E-03	

(a) To convert to the International System of Units, multiply pCi/g by 0.037 to obtain Bq/g. All values are dry weight.

(b) Average values are not provided when only one sample was analyzed.

(c) Values are ± total propagated analytical uncertainty (2 sigma).

(d) Below detection limit.

TOC = Total organic carbon.

**Table C.9. Range of Metal Concentrations (mg/kg dry wt.) in Sediment Samples Collected from the Columbia River Near the Hanford Site, 2008**

<b>Metal</b>	<b>(n=2) Priest Rapids Dam</b>	<b>(n=4) Hanford Reach<sup>(a)</sup></b>	<b>(n=2) McNary Dam</b>	<b>(n=8) Shoreline Springs<sup>(b)</sup></b>
Antimony	0.99 - 1.0	0.56 - 0.81	0.79 - 0.86	0.18 - 1.4
Arsenic	9.1 - 9.4	4.2 - 6.5	7.7 - 9.2	1.6 - 15
Beryllium	1.4 - 1.5	1.4 - 1.5	1.5 - 1.7	0.50 - 1.7
Cadmium	4.8 - 7.4	0.34 - 0.87	1.5 - 3.0	0.19 - 1.6
Chromium	72 - 80	45 - 60	55 - 55	17 - 130
Copper	44 - 51	16 - 23	30 - 33	6.7 - 36
Lead	45 - 46	16 - 42	24 - 29	7.3 - 100
Mercury	0.13 - 0.14	0.012 - 0.030	0.081 - 0.12	0.0078 - 0.044
Nickel	40 - 46	15 - 22	26 - 29	6.2 - 24
Selenium	1.4 - 1.6	0.30 - 1.2	1.5 - 2.2	0.086 - 0.59
Silver	0.25 - 0.37	0.013 - 0.11	0.30 - 0.35	0.013 - 0.033
Thallium	0.89 - 1.5	0.51 - 0.71	0.66 - 0.72	0.15 - 0.58
Zinc	440 - 540	98 - 230	220 - 320	48 - 440

(a) White Bluffs Slough, 100-F Slough, Hanford Slough, and Richland.

(b) 100-B Area (n=1), 100-K Area (n=1), 100-F Area (n=1), 100-H Area (n=1), Hanford town site (n=2), and 300 Area (n=2).

n = Number of samples.

**Table C.10. Radionuclide Concentrations Measured in Columbia River Water Samples Collected from Shoreline Springs Along the Hanford Site, 2008 Compared to Previous 5 Years**

Location/Radionuclide	No. of Samples	2008		No. of Samples	2003-2007		Washington State Ambient Surface Water Quality Standard, <sup>(b)</sup> pCi/L
		Concentration, <sup>(a)</sup> pCi/L			Concentration, <sup>(a)</sup> pCi/L		
		Maximum	Average		Maximum	Average	
100-B Area							
Alpha (gross)	2	1.6 ± 1.9 <sup>(c)</sup>	1.3 ± 0.75	8	14 ± 5.6	3.1 ± 9.2	15
Beta (gross)	2	10 ± 2.4	7.8 ± 6.3	8	23 ± 5.1	10 ± 12	50
Strontium-90	2	2.2 ± 0.37	1.1 ± 3.0	8	4.0 ± 0.59	1.5 ± 3.3	8
Technetium-99	2	7.8 ± 1.0	4.7 ± 8.7	8	12 ± 0.95	5.5 ± 8.1	900 <sup>(d)</sup>
Tritium	2	2,700 ± 560	2,500 ± 480	8	5,800 ± 500	3,900 ± 3,100	20,000
100-K Area							
Alpha (gross)	1	3.0 ± 2.3 <sup>(c)</sup>		7	13 ± 4.8	2.5 ± 9.3	15
Beta (gross)	1	11 ± 2.6		7	19 ± 5.2	6.9 ± 11	50
Strontium-90	1	0.022 ± 0.034 <sup>(c)</sup>		7	2.8 ± 0.41	1.6 ± 2.3	8
Tritium	1	3,200 ± 670		7	4,200 ± 370	810 ± 3,100	20,000
100-N Area							
Alpha (gross)	1	2.3 ± 1.6		5	4.9 ± 2.7	1.8 ± 3.6	15
Beta (gross)	1	5.9 ± 1.7		5	9.3 ± 2.4	4.5 ± 6.1	50
Strontium-90	1	1.4E-03 ± 0.033 <sup>(c)</sup>		7	0.043 ± 0.020	0.022 ± 0.039	8
Technetium-99	0			2	0.64 ± 0.40	0.61 ± 0.089	900 <sup>(d)</sup>
Tritium	1	5,800 ± 1,200		7	11,000 ± 430	9,400 ± 4,100	20,000
Uranium (total)	1	1.0 ± 0.19		0			-- <sup>(e)</sup>
100-D Area							
Alpha (gross)	2	1.9 ± 1.6 <sup>(c)</sup>	1.7 ± 0.71 <sup>(c)</sup>	10	7.6 ± 2.9	2.7 ± 6.0	15
Beta (gross)	2	5.4 ± 2.0	4.2 ± 3.5	10	10 ± 2.8	4.3 ± 6.7	50
Strontium-90	2	0.11 ± 0.052	0.087 ± 0.029	10	0.40 ± 0.074	0.17 ± 0.29	8
Tritium	2	45 ± 130 <sup>(c)</sup>	8.0 ± 100 <sup>(c)</sup>	10	4,800 ± 250	630 ± 2,900	20,000
Uranium (total)	0			8	3.2 ± 0.43	1.1 ± 1.9	-- <sup>(e)</sup>
100-H Area							
Alpha (gross)	2	2.1 ± 1.9 <sup>(c)</sup>	1.7 ± 1.2	9	3.9 ± 2.2	2.1 ± 3.0	15
Beta (gross)	2	22 ± 3.0	13 ± 24	9	25 ± 4.2	10 ± 16	50
Strontium-90	2	6.8 ± 1.1	3.4 ± 9.6	8	14 ± 2.0	3.8 ± 9.8	8
Technetium-99	2	0.45 ± 0.48 <sup>(c)</sup>	0.26 ± 0.52	9	0.52 ± 0.42 <sup>(c)</sup>	0.26 ± 0.25 <sup>(c)</sup>	900 <sup>(d)</sup>
Tritium	2	2,100 ± 460	1,400 ± 1,900	9	4,100 ± 250	1,500 ± 2,800	20,000
Uranium (total)	2	2.2 ± 0.31	1.4 ± 2.2	9	5.0 ± 0.56	1.8 ± 3.4	-- <sup>(e)</sup>

Table C.10. (contd)

Location/Radionuclide	No. of Samples	2008		No. of Samples	2003-2007		Washington State Ambient Surface Water Quality Standard, <sup>(b)</sup> pCi/L
		Concentration, <sup>(a)</sup> pCi/L			Concentration, <sup>(a)</sup> pCi/L		
		Maximum	Average		Maximum	Average	
100-F Area							
Alpha (gross)	1	4.4 ± 1.9		5	28 ± 8.8	12 ± 20	15
Beta (gross)	1	3.5 ± 1.4		5	43 ± 9.6	16 ± 31	50
Strontium-90	1	3.8E-03 ± 0.030 <sup>(c)</sup>		5	0.12 ± 0.050	0.044 ± 0.10	8
Tritium	1	1,200 ± 280		5	1,400 ± 190	880 ± 1,000	20,000
Uranium (total)	1	5.5 ± 0.89		5	20 ± 2.1	6.8 ± 15	-- <sup>(e)</sup>
Hanford town site							
Alpha (gross)	3	3.5 ± 2.1	2.6 ± 2.9	14	14 ± 5.6	2.4 ± 6.9	15
Beta (gross)	3	20 ± 3.6	15 ± 11	14	47 ± 12	17 ± 23	50
Iodine-129 <sup>(f)</sup>	3	0.25 ± 0.39 <sup>(c)</sup>	0.11 ± 0.23 <sup>(c)</sup>	3	0.65 ± 0.27 <sup>(c)</sup>	0.31 ± 0.59 <sup>(c)</sup>	1
Technetium-99	3	23 ± 2.8	16 ± 13	14	78 ± 4.5	31 ± 45	900 <sup>(d)</sup>
Tritium	3	14,000 ± 2,800	12,000 ± 4,500	14	67,000 ± 4,800	28,000 ± 36,000	20,000
Uranium (total)	3	2.6 ± 0.43	1.6 ± 1.7	14	5.6 ± 0.69	1.8 ± 2.7	-- <sup>(e)</sup>
300 Area							
Alpha (gross)	4	54 ± 8.4	34 ± 46	16	140 ± 36	57 ± 84	15
Beta (gross)	4	40 ± 3.6	31 ± 20	16	55 ± 10	22 ± 25	50
Iodine-129 <sup>(f)</sup>	2	-0.053 ± 0.23	-0.092 ± 0.11 <sup>(c)</sup>	2	0.045 ± 0.10 <sup>(c)</sup>	0.014 ± 0.089 <sup>(c)</sup>	1
Strontium	4	0.17 ± 0.058	0.092 ± 0.14	16	0.32 ± 0.058	0.13 ± 0.18	8
Tritium	4	9,100 ± 1,800	7,000 ± 4,100	17	12,000 ± 920	7,400 ± 6,700	20,000
Uranium (total)	4	99 ± 15	62 ± 82	17	140 ± 15	61 ± 87	-- <sup>(e)</sup>

(a) Maximum values are ± total propagated analytical uncertainty. Averages are ±2 standard deviations of the mean. To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

(b) WAC 246-290, 40 CFR 141, and Appendix D, Table D.4.

(c) Value below the laboratory-reported detection limit.

(d) WAC 173-201A-250 and EPA-570/9-76-003.

(e) Dashes indicate no concentration guides available.

(f) 2001 - 2004 results; no results were available for 2005 and 2006. Note: For 2007, iodine-129 was analyzed by the gamma spectroscopy method, which has higher detection limits than the previous method.

Table C.11. Radionuclide Concentrations in Columbia River Shoreline Sediment for 2008 Compared to Previous 5 Years

Location	Radionuclide	2008		2003-2007	
		No. of Samples	Concentration, pCi/g <sup>(a)</sup>	No. of Samples	Concentration, pCi/g <sup>(a)</sup>
			Average <sup>(b)</sup> Maximum <sup>(c)</sup>		Average <sup>(b)</sup> Maximum <sup>(c)</sup>
100-B Spring	Cobalt-60	1	0.010 ± 8.9E-03 <sup>(d)</sup>	4	2.2E-03 ± 0.014 <sup>(d)</sup> 7.6E-03 ± 0.012 <sup>(d)</sup>
	Strontium-90	1	8.0E-03 ± 0.020 <sup>(d)</sup>	4	-4.2E-03 ± 0.030 <sup>(d)</sup> 6.8E-03 ± 0.016 <sup>(d)</sup>
	Cesium-137	1	0.055 ± 0.012	4	0.048 ± 0.032      0.068 ± 0.023
	Europium-152	1	-9.2E-03 ± 0.021 <sup>(d)</sup>	3	-0.011 ± 0.039 <sup>(d)</sup> 9.7E-03 ± 0.045 <sup>(d)</sup>
	Europium-155	1	0.068 ± 0.036 <sup>(d)</sup>	4	0.075 ± 0.037 <sup>(d)</sup> 0.095 ± 0.037 <sup>(d)</sup>
	Uranium-234	1	0.47 ± 0.093	4	0.25 ± 0.22      0.41 ± 0.077
	Uranium-235	1	0.034 ± 0.022	4	7.3E-03 ± 9.3E-03      0.014 ± 8.0E-03
	Uranium-238	1	0.49 ± 0.094	4	0.22 ± 0.19      0.35 ± 0.067
100-K Spring	Cobalt-60	1	-1.8E-03 ± 9.9E-03 <sup>(d)</sup>	2	8.6E-03 ± 0.012 <sup>(d)</sup> 0.013 ± 8.5E-03 <sup>(d)</sup>
	Strontium-90	1	-4.2E-03 ± 0.022 <sup>(d)</sup>	2	9.8E-03 ± 0.020 <sup>(d)</sup> 0.017 ± 0.019 <sup>(d)</sup>
	Cesium-137	1	0.094 ± 0.016	2	0.10 ± 0.028      0.11 ± 0.024
	Europium-152	1	0.025 ± 0.028 <sup>(d)</sup>	2	-0.012 ± 0.017 <sup>(d)</sup> -5.9E-03 ± 0.023 <sup>(d)</sup>
	Europium-155	1	0.057 ± 0.035 <sup>(d)</sup>	2	0.033 ± 0.036 <sup>(d)</sup> 0.046 ± 0.025 <sup>(d)</sup>
	Uranium-234	1	1.3 ± 0.17	2	0.25 ± 0.024      0.26 ± 0.052
	Uranium-235	1	0.12 ± 0.031	2	9.0E-03 ± 2.1E-04      9.1E-03 ± 6.4E-03
	Uranium-238	1	1.3 ± 0.17	2	0.21 ± 0.066      0.24 ± 0.048
100-H Spring	Cobalt-60	1	-4.1E-03 ± 0.013 <sup>(d)</sup>	5	8.3E-03 ± 6.0E-03 <sup>(d)</sup> 0.012 ± 0.012 <sup>(d)</sup>
	Strontium-90	1	0.044 ± 0.030 <sup>(d)</sup>	5	0.020 ± 0.091      0.10 ± 0.017
	Cesium-137	1	0.18 ± 0.027	5	0.14 ± 0.076      0.20 ± 0.029
	Europium-152	1	0.066 ± 0.037 <sup>(d)</sup>	5	0.039 ± 0.032 <sup>(d)</sup> 0.061 ± 0.047 <sup>(d)</sup>
	Europium-155	1	0.030 ± 0.030 <sup>(d)</sup>	5	0.058 ± 0.030 <sup>(d)</sup> 0.074 ± 0.034 <sup>(d)</sup>
	Uranium-234	1	1.0 ± 0.14	5	0.34 ± 0.12      0.43 ± 0.10
	Uranium-235	1	0.067 ± 0.025	5	0.010 ± 5.4E-03      0.013 ± 0.012
	Uranium-238	1	0.93 ± 0.13	5	0.30 ± 0.11      0.39 ± 0.12
100-F Spring	Cobalt-60	1	5.3E-03 ± 0.011 <sup>(d)</sup>	5	3.9E-03 ± 9.0E-03 <sup>(d)</sup> 8.5E-03 ± 0.014 <sup>(d)</sup>
	Strontium-90	1	0.014 ± 0.027 <sup>(d)</sup>	5	-3.8E-03 ± 0.018 <sup>(d)</sup> 5.0E-03 ± 4.8E-03 <sup>(d)</sup>
	Cesium-137	1	0.11 ± 0.021	5	0.13 ± 0.15      0.26 ± 0.051
	Europium-152	1	0.038 ± 0.031 <sup>(d)</sup>	5	0.038 ± 0.10 <sup>(d)</sup> 0.13 ± 0.060 <sup>(d)</sup>
	Europium-155	1	0.036 ± 0.036 <sup>(d)</sup>	5	0.053 ± 0.035 <sup>(d)</sup> 0.073 ± 0.033 <sup>(d)</sup>
	Uranium-234	1	0.98 ± 0.13	5	0.48 ± 0.28      0.60 ± 0.13
	Uranium-235	1	0.081 ± 0.024	5	0.019 ± 8.4E-03      0.026 ± 0.011
	Uranium-238	1	1.0 ± 0.13	5	0.41 ± 0.22      0.50 ± 0.13

Table C.11. (contd)

Location	Radionuclide	2008				2003-2007			
		No. of Samples	Concentration, pCi/g <sup>(a)</sup>		No. of Samples	Concentration, pCi/g <sup>(a)</sup>			
			Average <sup>(b)</sup>	Maximum <sup>(c)</sup>		Average <sup>(b)</sup>	Maximum <sup>(c)</sup>		
Hanford Spring	Cobalt-60	2	0.013 ± 1.4E-03 <sup>(d)</sup>	0.014 ± 0.026 <sup>(d)</sup>	7	0.012 ± 0.018 <sup>(d)</sup>	0.025 ± 0.013 <sup>(d)</sup>		
	Strontium-90	2	-0.016 ± 2.8E-03 <sup>(d)</sup>	-0.016 ± 0.015 <sup>(d)</sup>	7	6.5E-03 ± 0.062	0.074 ± 0.013		
	Cesium-137	2	0.16 ± 0.20	0.23 ± 0.090	7	0.15 ± 0.13	0.26 ± 0.041		
	Europium-152	2	0.062 ± 0.056 <sup>(d)</sup>	0.082 ± 0.19 <sup>(d)</sup>	7	0.078 ± 0.092 <sup>(d)</sup>	0.15 ± 0.058 <sup>(d)</sup>		
	Europium-155	2	0.094 ± 0.073 <sup>(d)</sup>	0.12 ± 0.11 <sup>(d)</sup>	7	0.072 ± 0.041 <sup>(d)</sup>	0.098 ± 0.033 <sup>(d)</sup>		
	Uranium-234	2	1.2 ± 0.25	1.3 ± 0.19	7	0.52 ± 0.18	0.66 ± 0.12		
	Uranium-235	2	0.059 ± 0.022	0.066 ± 0.021	7	0.014 ± 5.9E-03	0.019 ± 8.8E-03		
	Uranium-238	2	1.1 ± 0.085	1.1 ± 0.16	7	0.41 ± 0.12	0.51 ± 0.11		
300 Area Spring	Cobalt-60	4	4.2E-03 ± 5.4E-03 <sup>(d)</sup>	8.1E-03 ± 0.010 <sup>(d)</sup>	16	2.8E-03 ± 0.011 <sup>(d)</sup>	0.014 ± 0.011 <sup>(d)</sup>		
	Strontium-90	2	-6.2E-04 ± 7.1E-03 <sup>(d)</sup>	1.9E-03 ± 0.023 <sup>(d)</sup>	10	5.5E-03 ± 0.030	0.027 ± 0.021 <sup>(d)</sup>		
	Cesium-137	4	0.13 ± 0.27	0.33 ± 0.029	16	0.10 ± 0.14	0.23 ± 0.035		
	Europium-152	4	0.043 ± 0.085 <sup>(d)</sup>	0.11 ± 0.037 <sup>(d)</sup>	16	0.023 ± 0.061 <sup>(d)</sup>	0.082 ± 0.049 <sup>(d)</sup>		
	Europium-155	4	0.039 ± 0.051 <sup>(d)</sup>	0.059 ± 0.040 <sup>(d)</sup>	16	0.057 ± 0.030 <sup>(d)</sup>	0.083 ± 0.032 <sup>(d)</sup>		
	Uranium-234	4	0.94 ± 0.85	1.6 ± 0.19	16	1.6 ± 2.2	4.1 ± 0.66		
	Uranium-235	4	0.078 ± 0.049	0.11 ± 0.027	16	0.071 ± 0.11	0.21 ± 0.042		
	Uranium-238	4	0.91 ± 0.77	1.5 ± 0.18	16	1.4 ± 2.0	3.8 ± 0.61		

(a) To convert to the International System of Units, multiply pCi/g by 0.037 to obtain Bq/g. All values are dry weight.

(b) Averages are ±2 standard deviations of the mean. Average values are not provided when only one sample was analyzed.

(c) Values are ± total propagated analytical uncertainty (2 sigma).

(d) Below detection limit.

**Table C.12. Concentrations (µg/g dry wt.) of Metals in Livers from Bass Collected from the Hanford Reach of the Columbia River and at a Reference Location Near Desert Aire, Washington, in 2008<sup>(a)</sup>**

<b>Metal</b>	<b>100-N to 100-D Area (n=5)</b>			<b>300 Area (n=4)</b>			<b>Desert Aire, Washington (n=5)</b>		
	<b>Maximum</b>	<b>Minimum</b>	<b>Median</b>	<b>Maximum</b>	<b>Minimum</b>	<b>Median</b>	<b>Maximum</b>	<b>Minimum</b>	<b>Median</b>
Aluminum	1.1 <sup>(b)</sup>	0.5 <sup>(c)</sup>	0.5	11	0.5 <sup>(c)</sup>	1.0	1.6 <sup>(b)</sup>	0.5 <sup>(c)</sup>	0.91
Antimony	0.02 <sup>(c)</sup>	0.02 <sup>(c)</sup>	0.02	0.02 <sup>(c)</sup>	0.02 <sup>(c)</sup>	0.02	0.02 <sup>(c)</sup>	0.02 <sup>(c)</sup>	0.02
Arsenic	0.85	0.32	0.69	1.4	1.1	1.3	1.2	0.73	0.93
Beryllium	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>	0.01	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>	0.01	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>	0.01
Cadmium	1.0	0.44	0.48	6.2	1.8	2.0	2.7	0.51	0.79
Chromium	0.26	0.18	0.22	0.3	0.17	0.23	0.20	0.14	0.19
Copper	11	6.8	7.7	54	8.8	17	85	7.1	12
Lead	0.022 <sup>(b)</sup>	0.0066 <sup>(b)</sup>	0.0089	0.043	0.019 <sup>(b)</sup>	0.032	0.080	0.011 <sup>(b)</sup>	0.024
Manganese	4.7	3.5	4.5	5.4	2.8	5.3	4.8	2.2	4.3
Mercury	0.12	0.098	0.11	2.3	0.077	0.24	0.53	0.12	0.14
Nickel	0.066	0.043	0.057	0.28	0.072	0.081	0.28	0.049 <sup>(b)</sup>	0.060
Selenium	8.8	7.1	7.9	15	7.1	8.3	8.5	5.7	6.2
Silver	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>	0.01	0.028	0.01 <sup>(c)</sup>	0.016	0.72	0.01 <sup>(c)</sup>	0.01
Thallium	0.21	0.13	0.16	0.23	0.13	0.16	0.31	0.018	0.17
Thorium	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>	0.01	0.012	0.01 <sup>(c)</sup>	0.01	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>	0.01
Uranium	0.002 <sup>(c)</sup>	0.002 <sup>(c)</sup>	0.002	0.038	0.0028 <sup>(b)</sup>	0.0038	0.046	0.002 <sup>(c)</sup>	0.002
Zinc	110	88	92	140	87	92	1,200	73	100

(a) Data are not blank corrected.

(b) Value less than required detection limit and greater than method detection limit.

(c) Analyte not detected above the method detection limit.

n = Number of samples.

**Table C.13. Concentrations ( $\mu\text{g/g}$  dry wt.) of Metals in Livers from Carp and Suckers Collected from the Hanford Reach of the Columbia River and at a Reference Location Near Desert Aire, Washington, in 2008<sup>(a)</sup>**

<b>Metal</b>	<b>Reference Site, Near Desert Aire, Washington (n=5)</b>			<b>100-N to 100-D Area, Hanford Reach (n=2)</b>		<b>300 Area, Hanford Site (n=3)</b>		
	<b>Maximum</b>	<b>Minimum</b>	<b>Median</b>	<b>Maximum</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Minimum</b>	<b>Median</b>
Aluminum	11	0.5 <sup>(b)</sup>	1.8	4.2 <sup>(c)</sup>	2.9 <sup>(c)</sup>	13	0.67 <sup>(c)</sup>	2.1
Antimony	0.12	0.02 <sup>(b)</sup>	0.02	0.02 <sup>(b)</sup>	0.02 <sup>(b)</sup>	0.02 <sup>(b)</sup>	0.02 <sup>(b)</sup>	0.02
Arsenic	1.7	0.57	1.1	1.4	0.86	0.94	0.68	0.84
Beryllium	0.01 <sup>(b)</sup>	0.01 <sup>(b)</sup>	0.01	0.01 <sup>(b)</sup>	0.01 <sup>(b)</sup>	0.01 <sup>(b)</sup>	0.01 <sup>(b)</sup>	0.01
Cadmium	16	2.9	11	53	11	15	1.2	2.7
Chromium	0.46	0.14	0.18	0.24	0.21	0.24	0.16	0.20
Copper	110	74	85	120	46	160	35	83
Lead	0.39	0.12	0.13	0.27	0.19	0.15	0.077	0.11
Manganese	9.1	3.7	6.7	23	3.6	6.2	4.8	5.5
Mercury	0.29	0.12	0.19	NA	NA	0.24	0.12	0.17
Nickel	0.33	0.030 <sup>(c)</sup>	0.061	0.19	0.062	0.26	0.086	0.10
Selenium	11	4.4	5.4	5.2	4.2	6.5	4.5	4.7
Silver	0.87	0.40	0.63	0.820	0.31	1.7	0.090	0.67
Thallium	0.059	0.016	0.039	0.063	0.025	0.046	0.019	0.029
Thorium	0.01 <sup>(b)</sup>	0.01 <sup>(b)</sup>	0.01	0.01 <sup>(b)</sup>	0.01 <sup>(b)</sup>	0.01 <sup>(b)</sup>	0.01 <sup>(b)</sup>	0.01
Uranium	0.12	0.037	0.11	0.11	0.03	0.11	0.046	0.058
Zinc	1,400	380	1,100	1,100	940	3,300	130	1,100

(a) Data are not blank corrected.

(b) Analyte not detected above the method detection limit.

(c) Value less than required detection limit and greater than method detection limit.

n = Number of samples.

NA = Not analyzed.

**Table C.14. Concentrations ( $\mu\text{g/g}$  dry wt.) of Metals in Livers from Deer Collected from the Hanford Site and at a Background Location Near Olympia, Washington, in 2008<sup>(a)</sup>**

<b>Metal</b>	<b>Background Location Near Olympia, Washington (n=1)</b>	<b>North Population, Hanford Site (n=2)</b>		<b>Central Population, Hanford Site (n=1)</b>
	<b>Maximum</b>	<b>Maximum</b>	<b>Minimum</b>	<b>Maximum</b>
Aluminum	0.87 <sup>(b)</sup>	4.4 <sup>(b)</sup>	2.2 <sup>(b)</sup>	1.4 <sup>(b)</sup>
Antimony	0.02 <sup>(c)</sup>	0.02 <sup>(c)</sup>	0.02 <sup>(c)</sup>	0.02 <sup>(c)</sup>
Arsenic	1 <sup>(c)</sup>	0.20	0.15	0.17
Beryllium	0.0079 <sup>(c)</sup>	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>
Cadmium	0.17	0.56	0.2	0.48
Chromium	0.14	0.20	0.17	0.19
Copper	31	120	45	49
Lead	0.026 <sup>(b)</sup>	0.12	0.11	0.018 <sup>(b)</sup>
Manganese	19	14	12	9.7
Mercury	NA	0.028	0.027	NA
Nickel	0.035 <sup>(b)</sup>	0.04 <sup>(c)</sup>	0.04 <sup>(c)</sup>	0.04 <sup>(c)</sup>
Selenium	0.2 <sup>(c)</sup>	1.5 <sup>(d)</sup>	1.0 <sup>(d)</sup>	1.4
Silver	0.058	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>	0.014
Thallium	0.0062 <sup>(b)</sup>	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>
Thorium	0.02 <sup>(c)</sup>	0.012	0.01 <sup>(c)</sup>	0.01 <sup>(c)</sup>
Uranium	0.003 <sup>(c)</sup>	0.002 <sup>(c)</sup>	0.002 <sup>(c)</sup>	0.002 <sup>(c)</sup>
Zinc	180	150	120	100

(a) Data are not blank corrected.

(b) Value less than required detection limit and greater than method detection limit.

(c) Analyte not detected above the method detection limit.

(d) Analyte detected in both the sample and associated quality control blank, and the sample concentration was less than or equal to 5 times the blank concentration.

n = Number of samples.

NA = Not analyzed.

**Table C.15. Maximum, Minimum, and Median Uranium Concentrations ( $\mu\text{g/g}$  dry wt.) in 300 Area Spring 9 and Spring 10 Asiatic Clam Samples, 2008<sup>(a)</sup>**

Sample Site	Soft Tissue Composites								
	Day 0 <sup>(b)</sup>			Days 1 through 14 <sup>(c)</sup>			Day 224 <sup>(d)</sup>		
	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
Unexposed Controls	0.21	0.15	0.18						
Control Site Residents	0.15	0.13	0.14	0.24	0.14	0.15	0.17	0.16	0.17
Control Enclosure 1				0.23	0.12	0.16	0.16		
Control Enclosure 2				0.22	0.15	0.18	0.17		
Control Enclosure 3				0.32	0.15	0.19	0.19		
Spring 9 Resident Controls	1.1	0.96	1.1	1.3	0.76	1.0	2.1	1.3	2.1
Spring 9 Enclosure 1				0.27	0.18	0.20	1.5		
Spring 9 Enclosure 2				0.25	0.18	0.20	1.3		
Spring 9 Enclosure 3				0.75	0.17	0.32	2.3		
Spring 10 Resident Controls	1.6	1.2	1.3	2.0	0.89	1.2	2.0	1.1	1.3
Spring 10 Enclosure 1				0.21	0.14	0.18	0.95		
Spring 10 Enclosure 2				0.22	0.13	0.19	0.43		
Spring 10 Enclosure 3				0.22	0.13	0.17	0.79		
Sample Site	Shell Composites								
	Day 0 <sup>(b)</sup>			Day 14 <sup>(d)</sup>			Day 224 <sup>(d)</sup>		
	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
Unexposed Controls	0.27	0.12	0.21						
Control Site Residents	0.47	0.34	0.46	0.55	0.46	0.50	0.27	0.18	0.26
Control Enclosure 1				0.18			0.17		
Control Enclosure 2				0.11			0.22		
Control Enclosure 3				0.15			0.16		
Spring 9 Resident Controls	3.4	2.7	3.2	3.6	2.4	2.4	2.8	2.5	2.6
Spring 9 Enclosure 1				0.37			1.7		
Spring 9 Enclosure 2				0.11			1.2		
Spring 9 Enclosure 3				0.99			3.1		
Spring 10 Resident Controls	2.3	1.8	1.8	3.5	2.4	3.0	2.0	1.0	1.7
Spring 10 Enclosure 1				0.19			0.46		
Spring 10 Enclosure 2				0.19			0.29		
Spring 10 Enclosure 3				0.17			0.26		

(a) Data not blank corrected.

(b) Unexposed controls (N=9 composites); resident controls (N=3 composites).

(c) N=9 composites from each location.

(d) Resident controls (N=3 composites); enclosures (N=1 composite).

## References

40 CFR 61, Appendix E, Table 2. 2008. "Compliance Procedures Methods for Determining Compliance with Subpart I; Concentration Levels for Environmental Compliance." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 141. 2008. "National Primary Drinking Water Regulations; Radionuclides; Proposed Rule." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

EPA-570/9-76-003. 1976. *National Interim Primary Drinking Water Regulations*. Office of Water Supply, U.S. Environmental Protection Agency, Washington, D.C.

PNNL-18427, APP. 1. 2009. *Hanford Site Environmental Surveillance Data Report for Calendar Year 2008*. LE Bisping, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-18427, APP. 2. 2009. *Hanford Site Near-Facility Monitoring Data Report for Calendar Year 2008*. CJ Perkins, MC Dorsey, SM McKinney, and RC Roos, EnergySolutions, LLC for Pacific Northwest National Laboratory, Richland, Washington.

WAC 173-201A. "Water Quality Standards for Surface Waters of the State of Washington." *Washington Administrative Code*, Olympia, Washington.

WAC 173-201A-250. "Radioactive Substances." *Washington Administrative Code*, Olympia, Washington.

WAC 246-290. "Group A Public Water Supplies." *Washington Administrative Code*, Olympia, Washington.





## Appendix D

# Standards and Permits

GW Patton and JP Duncan

Permits required for regulated releases to water and air have been issued by the U.S. Environmental Agency (EPA) under the National Pollutant Discharge Elimination System of the *Clean Water Act of 1977* and the “Prevention of Significant Deterioration” requirements of the *Clean Air Act*. Also, under authority granted by the *Clean Air Act*, the Washington State Department of Health issued a permit for Hanford Site radioactive air emissions. Permits to collect wildlife for environmental sampling are issued by the Washington Department of Fish and Wildlife and the U.S. Fish and Wildlife Service. Current permits are discussed in Table D.1.

U.S. Department of Energy (DOE) Order 5400.5 established derived concentration guides that reflect the concentrations of radionuclides in water and air that an individual could continuously consume, inhale, or be immersed in at average annual levels without exceeding an effective dose equivalent of 100 mrem (1 mSv) per year. Derived concentration guides are not exposure limits but are simply reference values that are provided to allow for comparisons of radionuclide concentrations in environmental media. Table D.2 lists selected DOE-derived concentration guides for radionuclides of particular interest at the Hanford Site. These guides are useful reference values but do not generally represent concentrations in the environment that assure compliance with DOE, *Clean Air Act*, or drinking water dose standards.

Hanford Site operations must conform to a variety of government standards and permits. The primary environmental quality standards and permits applicable to Hanford Site operations in 2008 are listed in the following tables. Washington State has water quality standards for the Columbia River, as defined in WAC 173-201A, “Water

Quality Standards for Surface Waters of the State of Washington.” The Hanford Reach of the Columbia River has been designated as Class A (Excellent). This designation requires that the water be usable for substantially all needs, including drinking water, recreation, and wildlife. In 2003, the Washington State Department of Ecology revised the surface-water quality standards and submitted them to the EPA for approval. As the new standards are approved, the Class A (Excellent) designation uses are being replaced by other-use designations. Four use-designations have been identified for water bodies in Washington State: 1) Aquatic Life Uses, 2) Recreational Uses, 3) Water Supply Uses, and 4) Miscellaneous Uses. Within each designation are categories that apply to specific bodies of water. For the Hanford Reach of the Columbia River, the category for Aquatic Life Uses is noncore salmon and trout; for the protection of spawning, noncore rearing and migration of salmon and trout, and other associated aquatic life. The category for Recreational Uses is primary contact, which refers to the amount of fecal-coliform bacteria allowed in the water. Designated water-supply uses and miscellaneous uses include domestic water, industrial water, agricultural water, stock water, wildlife habitat, harvesting, commerce and navigation, boating, and aesthetics. Some of the new-use designations and associated criteria have been approved and some have not. For those not yet approved, the old criteria are still in effect. A summary of currently applicable Hanford Reach water criteria is provided in Table D.3. Table D.4 summarizes federal and state drinking water standards in 40 CFR 141, “National Primary Drinking Water Regulations” and WAC 246-290, “Group A Public Water Systems.” Select surface freshwater quality criteria for toxic pollutants are included in Table D.5.

**Table D.1. Environmental Permits****Clean Air Act Permits**

Prevention of Significant Deterioration Permit No. PSD-X80-14, issued to the U.S. Department of Energy, Richland Operations Office by the U.S. Environmental Protection Agency, Region 10, covers emission of  $\text{NO}_x$  to the atmosphere from the Plutonium Uranium Extraction Plant and the Uranium-Trioxide Plant. No expiration date.

Hanford Site Air Operating Permit 00-05-006, Renewal 1, covers operations on the Hanford Site having a potential to emit airborne emissions. This permit was effective on January 1, 2007, and expires January 1, 2012. The permit is intended to provide a compilation of applicable *Clean Air Act* requirements both for radioactive and non-radioactive emissions at the Hanford Site. It will be implemented through federal and state programs.

State License FF-01 was incorporated into the Hanford Site Air Operating Permit.

**Clean Water Act of 1977 – National Pollutant Discharge Elimination System Permits**

Permit WA-002591-7 (governing effluent discharges to the Columbia River) includes the outfall for the 300 Area Treated Effluent Disposal Facility and two outfalls in the 100-K Area.

Permit WAR05A57F governs storm water discharges. This permit expired October 30, 2005, and a new permit has not yet been issued. However, facilities covered by this permit are automatically granted an administrative continuance of permit coverage until a new permit is issued.

Permit CR-IU005 allows wastewater from the Environmental Molecular Sciences Laboratory to be discharged to the city of Richland's wastewater treatment facility.

**Washington State Department of Ecology – State Wastewater Permits**

Permit ST 4500 allows treated wastewater from the Effluent Treatment Facility to be discharged to the State-Approved Land Disposal Site. This permit expired August 1, 2005, and has not been reissued. The old permit will remain in effect until the new permit is issued.

Permit ST 4501 allows for the discharge of cooling water and other primarily uncontaminated wastewater from 400 Area facilities to two ponds located north-northeast of the 400 Area perimeter fence. This permit was effective October 1, 2003, and expired on October 1, 2008. It will remain in effect until a new permit is issued.

Permit ST 4502 allows treated effluent from the 200-East and 200-West Areas to be discharged to the 200 Area Treated Effluent Disposal Facility. This permit expired in May 2005 and has not been reissued. The old permit will remain in effect until the new permit is issued.

Permit ST 4507 allows domestic wastewater to be discharged to the 100-N Area sewage lagoon. This permit expired in May 2002. A renewal application has been submitted. The old permit will remain in effect until a new permit is issued.

Permit ST 4511 is a consolidation of permits: ST 4508, ST 4509, and ST 4510. This Categorical State Waste Discharge Permit authorizes the discharge of wastewater from maintenance, construction, and hydrotesting activities and allows for cooling water, condensate, and industrial storm water discharges at the Hanford Site. This permit was issued February 16, 2005, and expires February 16, 2010.

Permit WAG-50-5180 (General Sand and Gravel) for the Concrete Batch Plant in the 200-East Area. Reissued in May 2006.

Permit WAG-50-5181 for Gravel Pit 30 in the 200-East Area. Reissued in May 2006.

**Wildlife Sampling Permits**

Scientific Collection Permit 07-391, issued by the Washington Department of Fish and Wildlife to Pacific Northwest National Laboratory for 2008; covered the collection of food fish, shellfish, game fish, and wildlife for research purposes. This permit is renewed annually.

Federal Fish and Wildlife Permit No. MB671877-0, issued by the U.S. Fish and Wildlife Service to Pacific Northwest National Laboratory; covers the collection of migratory wildlife. Expires March 31, 2012.

Copies of the regulations concerning these permits may be obtained from the following organizations:

State of Washington  
Department of Ecology  
P.O. Box 47600  
Olympia, WA 98504-7600

U.S. Environmental Protection Agency  
Region 10  
1200 Sixth Avenue  
Seattle, WA 98101

U.S. Department of Energy  
Richland Operations Office  
825 Jadwin Avenue  
Richland, WA 99352

**Table D.2. Selected DOE-Derived Concentration Guides<sup>(a,b,c)</sup>**

<b>Radionuclide</b>	<b>Consumed Water, pCi/L (Bq/L)</b>		<b>Inhaled Air, pCi/m<sup>3</sup> (Bq/m<sup>3</sup>)</b>	
Tritium	2,000,000	(74,000)	100,000	(3,700)
Carbon-14	70,000	(2,590)	500,000	(18,500)
Chromium-51	1,000,000	(37,000)	60,000	(2,220)
Cobalt-60	5,000	(185)	80	(2.96)
Strontium-90	1,000	(37)	9	(0.333)
Technetium-99	100,000	(3,700)	2,000	(74)
Ruthenium-103	50,000	(1,850)	2,000	(74)
Ruthenium-106	6,000	(222)	30	(1.11)
Iodine-129	500	(18.5)	70	(2.59)
Iodine-131	3,000	(111)	400	(14.8)
Cesium-137	3,000	(111)	400	(14.8)
Uranium-234	500	(18.5)	0.09	(0.00333)
Uranium-235	600	(22.2)	0.1	(0.0037)
Uranium-238	600	(22.2)	0.1	(0.0037)
Plutonium-238	40	(1.48)	0.03	(0.00111)
Plutonium-239	30	(1.11)	0.02	(0.00074)
Plutonium-240	30	(1.11)	0.02	(0.00074)
Americium-241	30	(1.11)	0.02	(0.00074)

- (a) Concentration of a specific radionuclide in water or air that could be continuously consumed or inhaled at average annual rates and not exceed an effective dose equivalent of 100 mrem (1 mSv) per year.
- (b) Values in this table represent the lowest, most-conservative, derived concentration guides considered potentially applicable to Hanford Site operations and may be adjusted upward (larger) if accurate solubility information is available.
- (c) From DOE Order 5400.5.

**Table D.3. Washington State Water Quality Criteria for the Hanford Reach of the Columbia River<sup>(a)</sup>**

<b><u>Parameter</u></b>	<b><u>Permissible Levels</u></b>
Fecal coliform	(1) Geometric mean value less than or equal to 100 colonies/100 milliliters (0.026 gallons) (2) Not more than or equal to 10% of samples may exceed the geometric mean value of 200 colonies/100 milliliters (0.026 gallons)
Dissolved oxygen	Greater than 8 mg/L (8 ppm)
Temperature	(1) Less than or equal to 18°C (64°F) as a result of human activities (2) When natural conditions exceed 18°C (64°F), no temperature increases will be allowed that will raise the temperature of the receiving water by more than 0.3°C (0.54°F) (3) Incremental temperature increases resulting from point sources shall not at any time exceed $t = 28/(T + 7)$ , where $t$ = maximum permissible temperature increase measured at a mixing zone boundary and $T$ = background temperature. Incremental temperature increases resulting from non-point sources shall not exceed 2.8°C (5.04°F).
pH	(1) 6.5 to 8.5 range (2) Less than 0.5-unit induced variation
Turbidity	Turbidity shall be less than or equal to 5 nephelometric turbidity units over background turbidity when the background turbidity is 50 nephelometric units or less, and shall not increase more than 10% when the background turbidity is >50 nephelometric units
Aesthetic value	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste
Radioactive substances	Deleterious concentrations of radioactive materials for all classes shall be as determined by the lowest practicable level attainable and in no case shall exceed 1/12.5 of the values listed in WAC 246-221-290 or exceed EPA drinking water regulations for radionuclides, as published in EPA-570/9-76-003 or subsequent revisions thereto (see Table D.2)
Toxic substances	Shall not be introduced above natural background levels in waters of the state that have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic toxicity to the most sensitive biota dependent on those waters, or adversely affect public health, as determined by the department (see Table D.5)

(a) WAC 173-201A.

EPA = U.S. Environmental Protection Agency.

WAC = Washington Administrative Code.

Table D.4. Selected Drinking Water Standards

Constituent	DWS		Agency <sup>(a)</sup>
Antimony	6 µg/L	(0.006 ppm)	EPA, DOH
Arsenic	10 µg/L	(0.01 ppm)	EPA, DOH
Barium	2,000 µg/L	(2 ppm)	EPA, DOH
Cadmium	5 µg/L	(0.005 ppm)	EPA
Carbon tetrachloride	5 µg/L	(0.005 ppm)	EPA, DOH
Chloroform (THM) <sup>(b)</sup>	80 µg/L	(0.08 ppm)	EPA
Chromium	100 µg/L	(0.1 ppm)	EPA, DOH
cis-1,2-Dichloroethene	70 µg/L	(0.07 ppm)	EPA, DOH
Copper	1,300 µg/L	(1.3 ppm)	EPA
Cyanide	200 µg/L	(0.2 ppm)	EPA, DOH
Fluoride	4 mg/L	(4 ppm)	EPA, DOH
Lead	15 µg/L	(0.015 ppm)	EPA
Mercury (inorganic)	2 µg/L	(0.002 ppm)	EPA, DOH
Methylene chloride	5 µg/L	(0.005 ppm)	EPA, DOH
Nitrate, as NO <sub>3</sub> <sup>-</sup>	45 mg/L	(45 ppm)	EPA, DOH
Nitrite, as NO <sub>2</sub> <sup>-</sup>	3.3 mg/L	(3.3 ppm)	EPA, DOH
Selenium	50 µg/L	(0.05 ppm)	EPA, DOH
Tetrachloroethene	5 µg/L	(0.005 ppm)	EPA, DOH
Thallium	2 µg/L	(0.002 ppm)	EPA, DOH
Trichloroethene	5 µg/L	(0.005 ppm)	EPA, DOH
Antimony-125	300 pCi/L <sup>(c)</sup>	(11.1 Bq/L)	EPA
Beta particle and photon activity	4 mrem/yr <sup>(d)</sup>	(40 µSv/yr)	EPA, DOH
Carbon-14	2,000 pCi/L <sup>(c)</sup>	(74.1 Bq/L)	EPA
Cesium-137	200 pCi/L <sup>(c)</sup>	(7.4 Bq/L)	EPA
Cobalt-60	100 pCi/L <sup>(c)</sup>	(3.7 Bq/L)	EPA
Iodine-129	1 pCi/L <sup>(c)</sup>	(0.037 Bq/L)	EPA
Ruthenium-106	30 pCi/L <sup>(c)</sup>	(1.11 Bq/L)	EPA
Strontium-90	8 pCi/L <sup>(c)</sup>	(0.296 Bq/L)	EPA, DOH
Technetium-99	900 pCi/L <sup>(c)</sup>	(33.3 Bq/L)	EPA
Total alpha (excluding uranium)	15 pCi/L <sup>(c)</sup>	(0.56 Bq/L)	EPA, DOH
Tritium	20,000 pCi/L <sup>(c)</sup>	(740 Bq/L)	EPA, DOH
Uranium	30 µg/L	(0.03 ppm)	EPA, DOH

(a) DOH = Washington State Department of Health at WAC 246-290.

EPA = U.S. Environmental Protection Agency at 40 CFR 141, 40 CFR 143, and EPA 822-R-96-001.

(b) Standard is for total trihalomethanes (THM).

(c) EPA drinking water standards for radionuclides were derived based on a 4-mrem/yr dose standard using maximum permissible concentrations in water specified in *National Bureau of Standards Handbook 69* (U.S. Department of Commerce, August 1963, as amended).

(d) Beta and gamma radioactivity from anthropogenic radionuclides. Annual average concentration shall not produce an annual dose from anthropogenic radionuclides equivalent to the total body or any internal organ dose >4 mrem/yr. If two or more radionuclides are present, the sum of their annual dose equivalents shall not exceed 4 mrem/yr. Compliance may be assumed if annual average concentrations of total beta, tritium, and strontium-90 are <50, 20,000, and 8 pCi/L, respectively.

DWS = Drinking water standard (maximum contaminant level for drinking water supplies).

Table D.5. Selected Surface Freshwater Quality Criteria for Toxic Pollutants

Compound	Level that Yields Acute Toxicity, $\mu\text{g/L}$ (ppm) <sup>(a)</sup>	Level that Yields Chronic Toxicity, $\mu\text{g/L}$ (ppm) <sup>(a)</sup>	Level to Protect Human Health for the Consumption of Water and Organisms, $\mu\text{g/L}$ (ppm) <sup>(b)</sup>
<b>Dissolved Metals</b>			
Antimony	--	--	14 (0.014)
Arsenic	360.0 (0.360)	190.0 (0.19)	0.018 (0.000018)
Cadmium	1.6 (0.0016) <sup>(c)</sup>	0.59 (0.00059) <sup>(d)</sup>	--
Chromium(VI)	15 (0.015)	10 (0.01)	--
Copper	8.4 (0.0084) <sup>(e)</sup>	6.0 (0.006) <sup>(f)</sup>	--
Lead	28 (0.028) <sup>(g)</sup>	1.1 (0.0011) <sup>(h)</sup>	--
Mercury	2.1 (0.0021)	--	0.14 (0.00014)
Nickel	750 (0.75) <sup>(i)</sup>	83 (0.083) <sup>(j)</sup>	610 (0.61)
Silver	0.94 (0.00094) <sup>(k)</sup>	--	--
Thallium	--	--	1.7 (0.0017)
Zinc	60 (0.060) <sup>(l)</sup>	55 (0.055) <sup>(m)</sup>	--
<b>Total Recoverable Metals</b>			
Chromium(III) <sup>(n)</sup>	300 (0.30) <sup>(o)</sup>	96 (0.096) <sup>(p)</sup>	--
Mercury	--	0.012 (0.000012)	--
Selenium	20 (0.02)	5.0 (0.005)	--
<b>Anions</b>			
Cyanide <sup>(q)</sup>	22.0 (0.022)	5.2 (0.0052)	700 (0.70)
Chloride <sup>(r)</sup>	860,000 (860)	230,000 (230)	--
<b>Organic Compounds</b>			
Benzene	--	--	1.2 (0.0012)
Carbon tetrachloride	--	--	0.25 (0.00025)
Chloroform	--	--	5.7 (0.0057)
1,2-Dichloroethane	--	--	0.38 (0.00038)
Methylene chloride	--	--	4.7 (0.0047)
Toluene	--	--	6,800 (6.80)
Tetrachloroethene	--	--	0.8 (0.0008)
1,1,2-Trichloroethane	--	--	0.60 (0.0006)
Trichloroethene	--	--	2.7 (0.0027)
Vinyl chloride	--	--	2 (0.002)
1,4-Dichlorobenzene	--	--	400 (0.40)

(a) WAC 173-201A-240. For hardness-dependent criteria, the minimum value of 47 mg  $\text{CaCO}_3/\text{L}$  for 1992-2000 water samples collected near the Vernita Bridge by the U.S. Geological Survey is used.

(b) 40 CFR 131.36.

(c)  $(1.1367 - [\ln(\text{hardness})] 0.04184) \exp(1.128[\ln(\text{hardness})]-3.828)$ . Hardness expressed as mg  $\text{CaCO}_3/\text{L}$ .

(d)  $(1.1017 - [\ln(\text{hardness})] 0.04184) \exp(0.7852[\ln(\text{hardness})]-3.490)$ .

(e)  $(0.960) \exp(0.9422[\ln(\text{hardness})]-1.464)$ .

(f)  $(0.960) \exp(0.8545[\ln(\text{hardness})]-1.465)$ .

(g)  $(1.4620 - [\ln(\text{hardness})] 0.1457) \exp(1.273[\ln(\text{hardness})]-1.460)$ .

(h)  $(1.4620 - [\ln(\text{hardness})] 0.1457) \exp(1.273[\ln(\text{hardness})]-4.705)$ .

(i)  $(0.998) \exp(0.8460[\ln(\text{hardness})]+3.3612)$ .

(j)  $(0.997) \exp(0.8460[\ln(\text{hardness})]+1.1645)$ .

(k)  $(0.85) \exp(1.72[\ln(\text{hardness})]-6.52)$ .

(l)  $(0.978) \exp(0.8473[\ln(\text{hardness})]+0.8604)$ .

(m)  $(0.986) \exp(0.8473[\ln(\text{hardness})]+0.7614)$ .

(n) Where methods to measure trivalent chromium are unavailable, these criteria are to be represented by total recoverable chromium.

(o)  $(0.316) \exp(0.8190[\ln(\text{hardness})]+3.688)$ .

(p)  $(0.860) \exp(0.8190[\ln(\text{hardness})]+1.561)$ .

(q) Criteria based on weak and dissociable method.

(r) Dissolved in association with sodium.

**Table D.6. Radiation Standards (Dose Limits<sup>(a)</sup>) for Protection of the Public From All Routine DOE Concentrations**

**All Pathways** (limits from DOE Order 5400.5)

The effective dose equivalent for any member of the public from all routine DOE operations<sup>(b)</sup> shall not exceed the values given below.

	<u>Effective Dose Equivalent<sup>(c)</sup></u>	
	<u>mrem/yr</u>	<u>mSv/yr</u>
Routine public dose	100	1
Potential authorized temporary public dose <sup>(d)</sup>	500	5

**Dose to Native Aquatic Animal Organisms from Liquid Discharges** (interim limits from DOE Order 5400.5)

Radioactive material in liquid waste discharged to natural waterways shall not cause an absorbed dose<sup>(e)</sup> to native aquatic animal organisms that exceeds 1 rad (10 mGy) per day.

**Drinking Water Pathway Only** (limits from 40 CFR Parts 9, 141, and 142; WAC 246-290; and DOE Order 5400.5)

Radionuclide concentrations in DOE-operated public drinking water supplies shall not cause persons consuming the water to receive an effective dose equivalent greater than 4 mrem (0.04 mSv) per year. DOE operations shall not cause private or public drinking water systems downstream of the facility discharge to exceed the radiological drinking water limits in 40 CFR Parts 9, 141, and 142 (see Table D.2).

**Air Pathways Only** (limits from 40 CFR 61)

	<u>Effective Dose Equivalent<sup>(c)</sup></u>	
	<u>mrem/yr</u>	<u>mSv/yr</u>
Public dose limit at location of maximum annual air concentration as a consequence of routine DOE operations <sup>(b)</sup>	10	0.1

- (a) Radiation doses received from natural background, residual weapons testing and nuclear accident fallout, medical exposure, and consumer products are excluded from the implementation of these dose limits.
- (b) "Routine DOE operations" implies normal, planned activities and does not include actual or potential accidental or unplanned releases.
- (c) Effective dose equivalent is expressed in rem (or millirem) and sievert (or millisievert).
- (d) Authorized temporary annual dose limits may be greater than 100 mrem (1 mSv) per year (but cannot exceed 500 mrem [5 mSv]) per year if unusual circumstances exist that make avoidance of doses greater than 100 mrem (1 mSv) per year to the public impracticable. The DOE Richland Operations Office is required to request and receive specific authorization from DOE Headquarters for an increase from the routine public dose limit to a temporary annual dose limit.
- (e) Absorbed dose is expressed in rad (or millirad) with the corresponding value in gray (or milligray) in parentheses.

## References

- 40 CFR 61. 2008. "National Emission Standards for Hazardous Air Pollutants." *Code of Federal Regulations*, U.S. Environmental Protection Agency.
- 40 CFR 131.36. 2008. "Toxics Criteria for Those States not Complying with the Clean Water Act Section 303(c) (2)(B)." *Code of Federal Regulations*, U.S. Environmental Protection Agency.
- 40 CFR 141. 2008. "National Primary Drinking Water Regulations." *Code of Federal Regulations*, U.S. Environmental Protection Agency.
- 40 CFR 143. 2008. "National Secondary Drinking Water Regulations." *Code of Federal Regulations*, U.S. Environmental Protection Agency.
- 40 CFR Parts 9, 141, and 142. 2008. "National Primary Drinking Water Regulations; Radionuclides; Final Rule." *Code of Federal Regulations*, U.S. Environmental Protection Agency, and 65 FR 76708, December 7, 2000, *Federal Register*, U.S. Environmental Protection Agency.
- Clean Air Act*. 1986. Public Law 88-206, as amended, 42 USC 7401 et seq.
- Clean Water Act of 1977*. 1977. Public Law 95-217, as amended, 91 Stat. 1566 and Public Law 96-148, as amended.
- DOE Order 5400.5. 1990. "Radiation Protection of the Public and the Environment." U.S. Department of Energy, Washington, D.C.
- EPA-570/9-76-003. 1976. *National Interim Primary Drinking Water Regulations*. Office of Water Supply, U.S. Environmental Protection Agency, Washington, D.C.
- EPA 822-R-96-001. 1996. *Drinking Water Regulations and Health Advisories*. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.
- U.S. Department of Commerce. 1959, as amended 1963. "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure." In *National Bureau of Standards Handbook 69*, National Bureau of Standards, Washington, D.C. (This document is available from the Hilton M. Briggs Library, South Dakota State University, Brookings, South Dakota.)
- WAC 173-201A. "Water Quality Standards for Surface Waters of the State of Washington." *Washington Administrative Code*, Olympia, Washington.
- WAC 173-201A-240. "Toxic Substances." *Washington Administrative Code*, Olympia, Washington.
- WAC 246-221-290. "Appendix A - Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sanitary Sewerage." *Washington Administrative Code*, Olympia, Washington.
- WAC 246-290. "Group A Public Water Systems." *Washington Administrative Code*, Olympia, Washington.





## Appendix E

# Dose Calculations

EJ Antonio

The radiological dose that the public could have received in 2008 from Hanford Site cleanup operations was calculated in terms of the “total effective dose equivalent.” The total effective dose equivalent is the sum of the effective dose equivalent from external sources and the committed effective dose equivalent for internal exposure. Effective dose equivalent is a weighted sum of doses to organs and tissues that accounts for the sensitivity of the tissue and the nature of the radiation causing the dose. It is expressed in units of rem (sievert), or, more typically, the sub-unit millirem (millisievert)<sup>(a)</sup> for individuals, and in units of person-rem for the collective dose received by the total population within an 80-kilometer (50-mile) radius of the Hanford Site operations areas. This appendix describes how the doses in this report were calculated.

Calculating the effective dose equivalent takes into account the long-term (50 years) internal exposure from radionuclides taken into the body during the current year. The effective dose equivalent is the sum of individual committed (50 years) organ doses multiplied by weighting factors that represent the proportion of the total health effect risk that each organ would contribute following uniform irradiation of the whole body. Internal organs may also be irradiated from external sources of radiation. The external exposure received during the current year is added to the committed internal dose to obtain the total effective dose equivalent. The transfer factors used for pathway and dose calculations are documented in PNL-6584 and PNL-3777, Rev. 2.

Releases of radionuclides from Hanford Site facilities are usually too small to be measured. Therefore, the air dose calculations were based on measurements made at the point

of release (stacks and vents). The water-pathway dose calculations were based on measurements of releases to the Columbia River (from the 100 Areas) and the difference in detectable radionuclide concentrations measured upstream and downstream of the site. Environmental radionuclide concentrations were estimated from the effluent measurements by using environmental transport models.

The transport of radionuclides in the environment to the point of exposure is predicted by empirically derived models of exposure pathways. These models calculate radionuclide levels in air, water, and foods. Radionuclides taken into the body by inhalation or ingestion may be distributed among different organs and retained for various times. In addition, long-lived radionuclides deposited on the ground become possible sources for long-term external exposure and uptake by agricultural products. Dietary and exposure parameters were applied to calculate radionuclide intakes and radiological doses to the public. Standardized computer programs were used to perform the calculations. These programs contain internally consistent mathematical models that use site-specific dispersion and uptake parameters. These programs are incorporated in a master code, *GENII – The Hanford Environmental Radiation Dosimetry Software System, Version 1.485* (PNL-6584), which employs the dosimetry methodology described in International Commission on Radiological Protection reports (1979a, 1979b, 1980, 1981a, 1981b, 1982a, 1982b, 1988). The assumptions and data used in these calculations are in the following paragraphs.

The RESRAD-BIOTA computer code was used to screen the 2008 radionuclide concentrations in water and sediment to see if they exceeded established biota concentration guides

(a) 1 rem (0.01 sievert) = 1,000 millirem (10 millisievert).

(e.g., concentrations that could result in a dose rate of 1 rad per day for aquatic biota or 0.1 rad per day for terrestrial organisms). Both internal and external doses to aquatic, riparian, and terrestrial animals, as well as to terrestrial plants, are included in the screening process. For analyses with multiple media and multiple radionuclides, a sum of fractions is calculated to account for the contribution to dose from each radionuclide relative to its corresponding biota concentration guide. The maximum measured concentrations are compared to the biota concentration guides in the initial screening assessment. If the sum of fractions does not exceed 1, no further analysis is required. However, if the sum of fractions does exceed 1, a second analysis is performed using average concentrations. The screening process is further described in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2002).

The computer program, CAP88-PC, was used to calculate an air pathway dose to a maximally exposed individual (as required by the U.S. Environmental Protection Agency [EPA] through 40 CFR 61, Subpart H) from airborne radionuclide effluent (other than radon) released at U.S. Department of Energy (DOE) facilities. Technical details of the CAP88-PC calculations are provided in the 2008 air emissions report (DOE/RL-2009-14).

## Types of Dose Calculations Performed

Radiological doses to the public from radionuclides released into the environment are calculated to demonstrate compliance with applicable standards and regulations.

DOE Order 5400.5 requires the following:

- Effective dose equivalent must be used in estimating public doses.
- Calculations of doses to the public from exposures resulting from both routine and unplanned activities must be performed using EPA or DOE dose conversion factors, or analytical models prescribed in regulations applicable to DOE operations.
- Doses to the public must be calculated using facility effluent data when environmental concentrations are too low to measure accurately.

The following types of radiological doses were estimated.

### Maximally Exposed Individual Dose (mrem [ $\mu$ Sv]).

The maximally exposed individual is a hypothetical member of the public who lives at a location and has a lifestyle that makes it unlikely that other members of the public would receive higher doses. All potentially significant exposure pathways to this hypothetical individual were considered, including the following:

- Inhalation of airborne radionuclides
- Submersion in airborne radionuclides
- Ingestion of foodstuffs contaminated by radionuclides deposited on vegetation and the ground by both airborne deposition and irrigation water drawn from the Columbia River downstream of the 100-K Area
- Exposure to ground contaminated by both airborne deposition and irrigation water
- Consumption of fish taken from the Hanford Reach of the Columbia River
- Recreation along the Hanford Reach of the Columbia River, including boating, swimming, and shoreline activities.

### Determination of the Location of the Maximally Exposed Individual.

The location of the hypothetical, maximally exposed individual can vary yearly, depending on the relative contributions of the several sources of radioactive emissions released to the air and effluent released to the Columbia River from Hanford Site facilities. Based on experience since 1990, three separate locations (Figure 10.13.1) have been used to assess the dose to the maximally exposed individual: 1) the Ringold area, along the east shoreline of the Columbia River 26 kilometers (16 miles) east of the separations facilities in the 200 Areas; 2) the Sagemoor area, across the Columbia River from the 300 Area; and 3) the Riverview area, across the Columbia River from the city of Richland. Although the Ringold area is closer than the Riverview area to Hanford Site facilities that historically released airborne emissions, at Riverview the maximally exposed individual receives a higher dose rate from radionuclides in the Columbia River than a Ringold resident. The applicable exposure pathways for Ringold and Sagemoor are described in the following paragraphs. In 2002, the maximally exposed

individual was located in the Riverview area. However, from 2003 through 2008, the hypothetical, maximally exposed individual was located across the Columbia River from the 300 Area in the Sagemoor area (Figure 10.14.1).

**Ringold Maximally Exposed Individual.** Because of its location, an individual in the Ringold area has the potential to receive the maximum exposure to airborne emissions from the 200 Areas, including direct exposure to a contaminated plume, inhalation, external exposure to radionuclides that deposit on the ground, and ingestion of contaminated locally grown food products. In addition, it is assumed that individuals in the Ringold area irrigate their crops with water taken from the Columbia River downstream of where contaminated groundwater originating from the 100 and 200-East Areas enters the river. This results in additional exposure from ingestion of potentially contaminated irrigated food products and potential external irradiation from radionuclides deposited on the ground by irrigation. Recreational use of the Columbia River is also considered for this individual, resulting in direct exposure from water, radionuclides deposited on the shoreline, and doses from consumption of locally caught Columbia River fish.

**Riverview Maximally Exposed Individual.** Because of its location, an individual in the Riverview area has the potential to receive the maximum exposure to waterborne effluent from Hanford Site facilities. For the calculation, it was assumed the Riverview area maximally exposed individual obtained domestic water from a local water treatment system pumped from the Columbia River just downstream of the Hanford Site. In addition, it was assumed that individuals in the Riverview area irrigate their crops with water from the Columbia River. This results in additional exposure from ingesting potentially contaminated irrigated food products and potential external irradiation from radionuclides deposited on the ground by irrigation. Recreational use of the Columbia River was also considered, resulting in direct exposure from water, radionuclides deposited on the shoreline, and doses from ingestion of locally caught Columbia River fish. This individual also receives exposure via the air pathways, including direct exposure to a contaminated plume, inhalation, external exposure to radionuclides that deposit on the ground, and ingestion of locally grown food products contaminated by air deposition.

**Sagemoor Maximally Exposed Individual.** The significance of air emissions from production facilities in the 200 Areas has decreased compared to emissions from research facilities in the 300 Area because of the shift in Hanford Site operations from nuclear weapons production to the current mission of managing waste products, cleaning up the site, and researching new, innovative ideas and technologies for waste disposal and cleanup.

An individual in the Sagemoor area, located approximately 1.4 kilometers (0.87 mile) directly across the Columbia River from the 300 Area, receives the maximum exposure to airborne emissions from the 300 Area. However, domestic water at this location comes from wells rather than from the river, and wells in this region are not directly contaminated by radionuclides of Hanford Site origin (EPS-87-367A). Because the farms located across from the 300 Area obtain irrigation water from the Columbia River upstream of the Hanford Site, the conservative assumption was made that the diet of an individual from the Sagemoor area consisted totally of foods purchased from the Riverview area, which could contain radionuclides present in both the liquid effluent and air emissions pathways. The added contribution of radionuclides in the Riverview area irrigation water maximizes the calculated dose from the air and water pathways combined.

**80-kilometer (50-mile) Collective Population Doses (person-rem [person-sievert]).** Regulatory limits have not been established for population doses. However, DOE Order 5400.5 requires that the collective population doses to all residents within an 80-kilometer (50-mile) radius of Hanford Site operations be evaluated. The radiological dose to the collective population within 80 kilometers (50 miles) of the site operations areas was calculated to confirm adherence to DOE environmental protection policies and provide information to the public. The 80-kilometer (50-mile) collective dose is the sum of doses to all individual members of the public within 80 kilometers (50 miles) of Hanford Site operations areas.

Pathways similar to those used for the maximally exposed individual were used to calculate doses to the offsite population. In calculating the effective dose, the fraction



of the offsite population expected to be affected by each pathway was estimated. The exposure pathways for the population are as follows:

- **Drinking water** – The cities of Richland and Pasco obtain all or part of their municipal water directly and Kennewick indirectly from the Columbia River downstream from the Hanford Site. Approximately 130,000 people in the three cities are assumed to obtain all their drinking water directly from the Columbia River or from wells adjacent to the river.
- **Irrigated food** – Columbia River water is withdrawn to irrigate small vegetable gardens and farms in the Riverview area of Pasco in Franklin County. It is assumed that enough food is grown in this area to feed an estimated 2,000 people. Commercial crops are also irrigated by Columbia River water in the Horn Rapids area of Benton County. These crops are widely distributed.
- **Columbia River recreation** – These activities include swimming, boating, and shoreline recreation. Specific pathways include external exposure from radionuclides in the water or on the shoreline and ingestion of river water while swimming. An estimated 125,000 people who reside within 80 kilometers (50 miles) of the Hanford Site operations areas are assumed to be affected by these pathways.
- **Fish consumption** – Population doses from the consumption of fish obtained locally from the Columbia River were calculated from an estimated total annual catch of 15,000 kilograms (33,075 pounds) per year without reference to a specified human group of consumers.

## Data for Dose Calculations

The data that are needed to perform dose calculations are based on either measured upstream/downstream differences or measured effluent releases and include information on initial transport through the atmosphere or Columbia River, transfer or accumulation in terrestrial and aquatic pathways, and public exposure. By comparison, radiological dose calculations based on measured activities of radionuclides in food require data describing only dietary and recreational activities and exposure times. These data are discussed below.

## Population Distribution and Atmospheric Dispersion

Geographic distributions of the population residing within an 80-kilometer (50-mile) radius of the Hanford Site operating areas are shown in PNNL-18427, APP. 1. These distributions are based on 2000 Bureau of the Census data (PNNL-14428). These data influence the population dose by providing estimates of the number of people exposed to radioactive effluent and their proximity to the points of release.

## Terrestrial and Aquatic Pathways

Important parameters affecting the movement of radionuclides within exposure pathways such as irrigation rates, growing periods, and holdup periods are listed in Table E.1. Certain parameters are specific to the lifestyles of either the DOE or EPA maximally exposed individuals or individuals for whom average parameter values were used.

## Public Exposure

The offsite radiological dose is related to the extent of external exposure to or intake of radionuclides released from Hanford Site operations. Tables E.2 through E.4 provide the parameters describing the diet, residency, and river recreation parameters assumed for maximally exposed and average individuals.

## Dose Calculation Documentation

DOE established the Hanford Dose Overview Panel to promote consistency and defensibility of environmental dose calculations at the Hanford Site. The panel was responsible for defining standard, documented computer codes and input parameters used to calculate radiological doses to the public in the vicinity of the site. This panel is no longer functional. Only those procedures, models, and parameters previously defined by the panel were used to calculate the radiological doses (PNL-3777, Rev. 2). The calculations were then reviewed by a former panel member.



**Table E.1. Food Pathway Parameters Used in Hanford Site Dose Calculations, 2008**

<b>Medium</b>	<b>Holdup (days)<sup>(a)</sup></b>		<b>Growing Period (days)</b>	<b>Yield kg/m<sup>2</sup> (lb/yr)<sup>2</sup></b>		<b>Irrigation Rate L/m<sup>2</sup>/mo (gal/yr<sup>2</sup>/mo)</b>	
	<b>Maximally Exposed Individual</b>	<b>Average Individual</b>					
Leafy vegetables	1	14	90	1.5	(3.3)	150	(40)
Other vegetables	5	14	90	4	(8.2)	170	(45)
Fruit	5	14	90	2	(4.41)	150	(40)
Cereal	180	180	90	0.8	(1.76)	0	
Eggs	1	18	90	0.8	(1.76)	0	
Milk	1	4	--	--	--	--	--
Hay	[100] <sup>(b)</sup>	[100]	45	2	(4.41)	200	(53)
Pasture	0	0	30	1.5	(3.3)	200	(53)
Red meat	15	34	--	--	--	--	--
Hay	[100]	[100]	45	2	(4.41)	200	(53)
Grain	[180]	[180]	90	0.8	(1.76)	0	
Poultry	1	34	90	0.8	(1.76)	0	
Fish	1	1	--	--	--	--	--
Drinking water <sup>(c)</sup>	1	1	--	--	--	--	--

(a) Holdup is the time between harvest and consumption.

(b) Values in [ ] are the holdup in days between harvest and consumption by farm animals.

(c) Drinking water holdup in calculations is 1.5 days for 100 Areas releases and 1.0 day for 200 Areas releases.

Summaries of dose calculation technical details for this report are shown in Tables E.5 through E.10 and in PNNL-18427, APP. 1.

## 400 Area Drinking Water

Drinking water at the Fast Flux Test Facility contained slightly elevated levels of tritium. The potential doses to 400 Area workers consuming this water in 2008 are given in Table E.11.

**Table E.2. Dietary Parameters Used in Hanford Site Dose Calculations, 2008**

<b>Medium</b>	<b>Consumption</b>			
	<b>Maximally Exposed Individual</b>		<b>Average Individual</b>	
Leafy vegetables	30 kg/yr	(66 lb/yr)	15 kg/yr	(33 lb/yr)
Other vegetables	220 kg/yr	(485 lb/yr)	140 kg/yr	(310 lb/yr)
Fruit	330 kg/yr	(728 lb/yr)	64 kg/yr	(140 lb/yr)
Grain	80 kg/yr	(180 lb/yr)	72 kg/yr	(160 lb/yr)
Eggs	30 kg/yr	(66 lb/yr)	20 kg/yr	(44 lb/yr)
Milk	270 L/yr	(71 gal/yr)	230 L/yr	(61 gal/yr)
Red meat	80 kg/yr	(180 lb/yr)	70 kg/yr	(150 lb/yr)
Poultry	18 kg/yr	(40 lb/yr)	8.5 kg/yr	(19 lb/yr)
Fish	40 kg/yr	(88 lb/yr)	-- <sup>(a)</sup>	--
Drinking water	730 L/yr	(193 gal/yr)	440 L/yr	(116 gal/yr)

(a) Average individual consumption not identified; radiation doses were calculated based on estimated total annual catch of 15,000 kg/yr (33,075 lb/yr).

**Table E.3. Residency Parameters Used in Hanford Site Dose Calculations, 2008**

<u>Parameter</u>	<u>Exposure (hr/yr)</u>	
	<u>Maximally Exposed Individual</u>	<u>Average Individual</u>
Ground contamination	4,383	2,920
Air submersion	8,766	8,766
Inhalation <sup>(a)</sup>	8,766	8,766

(a) Inhalation rates: adult 270 cm<sup>3</sup>/sec (16.5 in.<sup>3</sup>/sec).

**Table E.4. Columbia River Recreational Parameters Used in Hanford Site Dose Calculations, 2008**

<u>Parameter</u>	<u>Exposure (hr/yr)<sup>(a)</sup></u>	
	<u>Maximally Exposed Individual</u>	<u>Average Individual</u>
Shoreline	500	17
Boating	100	5
Swimming	100	10

(a) Transit times for water to irrigation and recreation sites vary by release and receptor locations.

**Table E.5. Technical Details of Airborne Release Dose Calculations for the 100-K Area of the Hanford Site, 2008**

Facility name	100-K Area
Releases (Ci [Bq])	<sup>90</sup> Sr ( $1.3 \times 10^{-5}$ [ $4.8 \times 10^5$ ]), <sup>238</sup> Pu ( $1.1 \times 10^{-6}$ [ $4.1 \times 10^4$ ]), <sup>239</sup> Pu ( $8.6 \times 10^{-6}$ [ $3.2 \times 10^5$ ]), <sup>241</sup> Pu ( $2.0 \times 10^{-5}$ [ $7.4 \times 10^5$ ]), <sup>241</sup> Am ( $7.1 \times 10^{-6}$ [ $2.6 \times 10^5$ ])
Meteorological conditions	2008 annual average, calculated using the GENII Joint Frequency Data (GENJFD) computer code from data collected at the 100-K Area and the Hanford Meteorology Station from January through December 2008
$\bar{X}/Q'$ dispersion factors	Maximally exposed individual, $1.4 \times 10^{-8}$ sec/m <sup>3</sup> at 41 km (25 mi) SE; 80-km (50-mi) population, $4.2 \times 10^{-3}$ person-sec/m <sup>3</sup>
Release height	10-m (33-ft) effective stack height
Population distribution	~482,000 (PNNL-14428)
Computer code	GENII, Version 1.485, December 3, 1990 (PNL-6584)
Doses calculated	Chronic, 1-yr exposure, 50-yr committed internal dose equivalent, and annual effective dose equivalent to individual and population
Pathways considered	External exposure to contaminant plume and atmospheric contaminants deposited on the ground Inhalation Ingestion of foods produced locally at Riverview
Files addressed	Radionuclide Library, Rev. 7-1-92 Food Transfer Library, Rev. 8-29-88 External Dose Factor Library, Rev. 5-9-88 Internal Dose Factor Library, Rev. 12-3-90

**Table E.6. Technical Details of Liquid Release Dose Calculations for the 100-K Area of the Hanford Site, 2008**

Facility name	100-K Area
Releases (Ci [Bq])	$^{90}\text{Sr}$ ( $2.1 \times 10^{-4}$ [ $7.8 \times 10^6$ ]), $^{239}\text{Pu}$ ( $7.7 \times 10^{-6}$ [ $2.9 \times 10^5$ ])
Mean river flow	3,070 m <sup>3</sup> /sec (108,385 ft <sup>3</sup> /sec)
Shore width factor	0.2
Population distribution	130,000 for drinking water pathway 125,000 for aquatic recreation pathway 2,000 for consumption of irrigated foodstuffs pathway
Computer code	GENII, Version 1.485, December 3, 1990 (PNL-6584)
Doses calculated	Chronic, 1-yr exposure, 50-yr committed internal dose equivalent, and annual effective dose equivalent to individual and population
Pathways considered	External exposure to irrigated soil, river water, and shoreline sediments Ingestion of aquatic foods, assuming a 15,000 kg/yr (33,075 lb/yr) total harvest of Columbia River fish, and irrigated farm products
Files addressed	Radionuclide Library, Rev. 7-1-92 Food Transfer Library, Rev. 8-29-88 External Dose Factor Library, Rev. 5-9-88 Internal Dose Factor Library, Rev. 12-3-90

**Table E.7. Technical Details of Airborne Release Dose Calculations for the 200 Areas of the Hanford Site, 2008**

Facility name	200 Areas
Releases (Ci [Bq])	<p>200-East Area</p> <p><math>^{90}\text{Sr}</math> (<math>8.5 \times 10^{-5}</math> [<math>3.2 \times 10^6</math>]), <math>^{129}\text{I}</math> (<math>1.3 \times 10^{-3}</math> [<math>4.8 \times 10^7</math>]), <math>^{137}\text{Cs}</math> (<math>3.1 \times 10^{-5}</math> [<math>1.2 \times 10^6</math>]), <math>^{239}\text{Pu}</math> (<math>1.9 \times 10^{-6}</math> [<math>7.0 \times 10^4</math>]), <math>^{241}\text{Am}</math> (<math>2.1 \times 10^{-7}</math> [<math>7.8 \times 10^3</math>])</p> <p>200-West Area</p> <p><math>^{90}\text{Sr}</math> (<math>1.4 \times 10^{-5}</math> [<math>5.2 \times 10^5</math>]), <math>^{137}\text{Cs}</math> (<math>8.1 \times 10^{-7}</math> [<math>3.0 \times 10^4</math>]), <math>^{238}\text{Pu}</math> (<math>1.1 \times 10^{-8}</math> [<math>4.1 \times 10^2</math>]), <math>^{239}\text{Pu}</math> (<math>1.8 \times 10^{-5}</math> [<math>6.7 \times 10^5</math>]), <math>^{241}\text{Pu}</math> (<math>1.2 \times 10^{-5}</math> [<math>4.4 \times 10^5</math>]), <math>^{241}\text{Am}</math> (<math>3.6 \times 10^{-6}</math> [<math>1.3 \times 10^5</math>])</p>
Meteorological conditions	2008 annual average, calculated using the GENII Joint Frequency Data (GENJFD) computer code from data collected at the Hanford Meteorology Station from January through December 2008
$\bar{X}/Q'$ dispersion factors	Maximally exposed individual, $1.6 \times 10^{-8} \text{ sec/m}^3$ at 28 km (17 mi) SE; 80-km (50-mi) population, $2.2 \times 10^{-3} \text{ person-sec/m}^3$
Release height	89-m (292-ft) effective stack height
Population distribution	~486,000 (PNNL-14428)
Computer code	GENII, Version 1.485, December 3, 1990 (PNL-6584)
Doses calculated	Chronic, 1-yr exposure, 50-yr committed internal dose equivalent, and annual effective dose equivalent to individual and population
Pathways considered	<p>External exposure to contaminant plume and atmospheric contaminants deposited on the ground</p> <p>Inhalation</p> <p>Ingestion of foods produced locally at Riverview</p>
Files addressed	<p>Radionuclide Library, Rev. 7-1-92</p> <p>Food Transfer Library, Rev. 8-29-88</p> <p>External Dose Factor Library, Rev. 5-9-88</p> <p>Internal Dose Factor Library, Rev. 12-3-90</p>

**Table E.8. Technical Details of Liquid Release Dose Calculations for the 200 Areas of the Hanford Site Calculated as Difference in Upstream and Downstream Concentrations, 2008**

Facility name	200 Areas
Releases (Ci [Bq])	$^3\text{H}$ ( $1.4 \times 10^3$ [ $5.2 \times 10^{13}$ ]), $^{234}\text{U}$ ( $9.7 \times 10^{-1}$ [ $3.6 \times 10^{10}$ ]), $^{238}\text{U}$ ( $2.9 \times 10^0$ [ $1.1 \times 10^{11}$ ])
Mean river flow	3,070 m <sup>3</sup> /sec (108,385 ft <sup>3</sup> /sec)
Shore width factor	0.2
Population distribution	130,000 for drinking water pathway 125,000 for aquatic recreation pathway 2,000 for consumption of irrigated foodstuffs pathway
Computer code	GENII, Version 1.485, December 3, 1990 (PNL-6584)
Doses calculated	Chronic, 1-yr exposure, 50-yr committed internal dose equivalent, and annual effective dose equivalent to individual and population
Pathways considered	External exposure to irrigated soil, river water, and shoreline sediments Ingestion of aquatic foods, assuming 15,000 kg/yr (33,075 lb/yr) total harvest of Columbia River fish, and irrigated farm products
Files addressed	Radionuclide Library, Rev. 7-1-92 Food Transfer Library, Rev. 8-29-88 External Dose Factor Library, Rev. 5-9-88 Internal Dose Factor Library, Rev. 12-3-90

**Table E.9. Technical Details of Airborne Release Dose Calculations for the 300 Area of the Hanford Site, 2008**

Facility name	300 Area
Releases (Ci [Bq])	$^3\text{H}$ (as HT) <sup>(a)</sup> ( $7.3 \times 10^1$ [ $2.7 \times 10^{12}$ ]), $^3\text{H}$ (as HTO) <sup>(a)</sup> ( $1.8 \times 10^2$ [ $6.7 \times 10^{12}$ ]), $^{85}\text{Kr}$ ( $1.1 \times 10^{-5}$ [ $4.1 \times 10^5$ ]), $^{90}\text{Sr}$ ( $5.7 \times 10^{-6}$ [ $2.1 \times 10^5$ ]), $^{131}\text{mXe}$ ( $1.0 \times 10^{-10}$ [ $3.7 \times 10^0$ ]), $^{133}\text{Xe}$ ( $5.4 \times 10^{-8}$ [ $2.0 \times 10^3$ ]), $^{135}\text{Xe}$ ( $3.0 \times 10^{-10}$ [ $1.1 \times 10^1$ ]), $^{137}\text{Cs}$ ( $5.2 \times 10^{-7}$ [ $1.9 \times 10^4$ ]), $^{220}\text{Rn}$ ( $7.4 \times 10^1$ [ $2.7 \times 10^{12}$ ]), $^{222}\text{Rn}$ ( $1.7 \times 10^0$ [ $6.3 \times 10^{10}$ ]), $^{239}\text{Pu}$ ( $4.2 \times 10^{-7}$ [ $1.6 \times 10^4$ ]), $^{241}\text{Am}$ ( $4.2 \times 10^{-8}$ [ $1.6 \times 10^3$ ]), $^{243}\text{Am}$ ( $7.4 \times 10^{-9}$ [ $2.7 \times 10^2$ ])
Meteorological conditions	2008 annual average, calculated using the GENII Joint Frequency Data (GENJFD) computer code from data collected at the 300 Area and the Hanford Meteorology Station from January through December 2008
$\bar{X}/Q'$ dispersion factors	Maximally exposed individual at residence, $7.7 \times 10^{-7}$ sec/m <sup>3</sup> at 1.4 km (0.87 mi) E; 80-km (50-mi) population, $8.7 \times 10^{-3}$ person-sec/m <sup>3</sup>
Release height	10-m (33-ft) effective stack height
Population distribution	~349,000 (PNNL-14428)
Computer code	GENII, Version 1.485, December 3, 1990 (PNL-6584)
Doses calculated	Chronic, 1-yr exposure, 50-yr committed internal dose equivalent, and annual effective dose equivalent to individual and population
Pathways considered	External exposure to contaminant plume and atmospheric contaminants deposited on the ground Inhalation Ingestion of foods produced locally at Riverview
Files addressed	Radionuclide Library, Rev 7-1-92 Food Transfer Library, Rev. 8-29-88 External Dose Factor Library, Rev. 5-9-88 Internal Dose Factor Library, Rev. 12-3-90

(a) HT = Elemental tritium; HTO = Tritiated water vapor.

**Table E.10. Technical Details of Airborne Release Dose Calculations for the 400 Area of the Hanford Site, 2008**

Facility name	400 Area
Releases (Ci [Bq])	$^3\text{H}$ (as HTO) <sup>(a)</sup> ( $1.7 \times 10^{-2}$ [ $6.3 \times 10^8$ ]), $^{137}\text{Cs}$ ( $9.0 \times 10^{-6}$ [ $3.3 \times 10^5$ ]), $^{239}\text{Pu}$ ( $2.4 \times 10^{-6}$ [ $8.9 \times 10^4$ ])
Meteorological conditions	2008 annual average, calculated using the GENJFD computer code from data collected at the 400 Area and the Hanford Meteorology Station from January through December 2008
$\bar{X}/Q'$ dispersion factors	Maximally exposed individual at residence, $7.9 \times 10^{-8}$ sec/m <sup>3</sup> at 11 km (7 mi) SE; 80-km (50-mi) population, $5.8 \times 10^{-3}$ person-sec/m <sup>3</sup>
Release height	10-m (33-ft) effective stack height
Population distribution	~354,000 (PNNL-14428)
Computer code	GENII, Version 1.485, December 3, 1990 (PNL-6584)
Doses calculated	Chronic, 1-yr exposure, 50-yr committed internal dose equivalent, and annual effective dose equivalent to individual and population
Files addressed	Radionuclide Library, Rev. 7-1-92 Food Transfer Library, Rev. 8-29-88 External Dose Factor Library, Rev. 5-9-88 Internal Dose Factor Library, Rev. 12-3-90

(a) HTO = Tritiated water vapor.

GENJFD = GENII Joint Frequency Data

**Table E.11. Annual Dose to Workers from Ingestion of Onsite Drinking Water, 2008**

<u>Location</u>	<u>Radionuclide</u>	<u>Average Drinking Water Activity (pCi/L)</u>	<u>Intake (pCi/yr)</u>	<u>Ingestion Dose Factor (µrem/pCi)</u>	<u>Ingestion Dose (µrem/yr)</u>
100-K Area	Gross alpha	0.58	145	0.283	41.035
	Gross beta	2.2	550	$5.00 \times 10^{-2}$	27.5
	Tritium	320	80,000	$6.30 \times 10^{-5}$	5.04
	Strontium-90	0.38	95	$1.30 \times 10^{-1}$	12.35
	<b>Total</b>				<b>85.925</b>
100-N Area	Gross alpha	1	250	0.283	70.75
	Gross beta	1.5	375	$5.00 \times 10^{-2}$	18.75
	Tritium	280	70,000	$6.30 \times 10^{-5}$	4.41
	Strontium-90	0.27	67.5	$1.30 \times 10^{-1}$	8.775
	<b>Total</b>				<b>102.685</b>
200-West Area	Gross alpha	0.26	65	0.283	18.395
	Gross beta	2	500	$5.00 \times 10^{-2}$	25
	Tritium	110	27,500	$6.30 \times 10^{-5}$	1.7325
	Strontium-90	0.19	47.5	$1.30 \times 10^{-1}$	6.175
	<b>Total</b>				<b>51.3025</b>
400 Area	Gross alpha	0.58	145	0.283	41.035
	Gross beta	6.1	1,525	$5.00 \times 10^{-2}$	76.25
	Tritium	2,100	525,000	$6.30 \times 10^{-5}$	33.075
	Strontium-90	0.68	170	$1.30 \times 10^{-1}$	22.1
	<b>Total</b>				<b>172.46</b>

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# Appendix F Radionuclides Measured by Gamma Spectroscopy (Gamma Scan)

EJ Antonio

Gamma rays are a form of high energy electromagnetic radiation that originate from the nucleus of an atom. They have very short wavelengths and can easily penetrate all but the most dense materials. Gamma-emitting radionuclides may be natural in origin, result from Hanford Site operations, or be related to fallout from historic nuclear weapons testing.

Gamma rays can be detected and quantified by inorganic scintillators, which convert energy into visible light. Scintillators may include thallium-activated sodium iodide crystals (NaI(Tl)) or germanium semiconductor detectors and their associated electronics (gamma spectroscopy). A partial list of radionuclides whose activity is measurable using gamma spectroscopy is provided in Table F.1.

**Table F.1. Radionuclides Measured by Gamma Spectroscopy**

<u>Radionuclide</u>	<u>Symbol</u>	<u>Principal Source</u>
Beryllium-7 <sup>(a)</sup>	<sup>7</sup> Be	Natural - cosmogenic
Sodium-22	<sup>22</sup> Na	Fission product
Sodium-24	<sup>24</sup> Na	Fission product
Potassium-40 <sup>(a)</sup>	<sup>40</sup> K	Natural - primordial
Manganese-54	<sup>54</sup> Mn	Fission product
Cobalt-58	<sup>58</sup> Co	Fission product
Cobalt-60 <sup>(a)</sup>	<sup>60</sup> Co	Fission product
Iron-59	<sup>59</sup> Fe	Fission product
Zinc-65	<sup>65</sup> Zn	Fission product
Zirconium/niobium-95	<sup>95</sup> Zr/Nb	Activation product and fission product
Molybdenum-99	<sup>99</sup> Mo	Activation product and fission product
Ruthenium-103	<sup>103</sup> Ru	Activation product and fission product
Ruthenium-106 <sup>(a)</sup>	<sup>106</sup> Ru	Fission product
Antimony-125 <sup>(a)</sup>	<sup>125</sup> Sb	Activation product
Iodine-131	<sup>131</sup> I	Fission product
Cesium-134 <sup>(a)</sup>	<sup>134</sup> Cs	Activation product
Cesium-137 <sup>(a)</sup>	<sup>137</sup> Cs	Fission product
Barium/lanthanum-140	<sup>140</sup> Ba/La	Fission product
Cerium-141	<sup>141</sup> Ce	Activation product and fission product
Cerium/praseodymium-144	<sup>144</sup> Ce/Pr	Fission product
Europium-152 <sup>(a)</sup>	<sup>152</sup> Eu	Activation product
Europium-154 <sup>(a)</sup>	<sup>154</sup> Eu	Activation product
Europium-155 <sup>(a)</sup>	<sup>155</sup> Eu	Activation product

(a) Routinely reported by contracting laboratory for Pacific Northwest National Laboratory environmental monitoring samples.



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Rick G. McCain (CD)	B2-62	Amanda Stegen (CD)	K3-66
Adrian L. McCall (P/CD)	K1-68	Robert D. Stenner (CD)	K3-54
John P. McDonald (CD)	R3-50	Scott D. Stubblebine (CD)	H6-60
Steve M. McKinney (CD)	E6-28	Monte J. Sula (CD)	Sequim
Geoffrey A. McMichael (CD/S)	K6-85	L. Craig Swanson (CD)	R3-50
Huei K. Mezmarich (CD)	S3-30	Mark D. Sweeney (CD)	K6-75
William J. Millsap (CD)	A1-14	Alex E. Teimouri (CD)	A3-04
Ron D. Morrison (CD)	A5-11	William Thackaberry (CD)	R3-60
John G. Morse (CD)	A5-11	K. Mike Thompson (CD)	A6-38
Robert P. Mueller (CD/S)	K6-85	Suzette A. Thompson (CD)	E6-28
Ellyn M. Murphy (CD)	K9-02	Harold T. Tilden II (CD)	K3-75
Bruce A. Napier (CD)	K3-54	Wayne E. Toebe (CD)	H8-12
Susan M. Narbutovskih (CD)	R3-50	Arlene C. Tortoso (CD)	A6-38
Gay M. Neath (CD)	H6-60	Steve Trent (CD)	R3-50
Kathy R. Neiderhiser (P/S)	K6-90	Wooyong Um (CD)	P7-22
Dean E. Nester (CD)	T4-09	Barry L. Vedder (CD)	H4-21
Darrell R. Newcomer (CD)	K6-96	Jeffrey A. Voogd (CD)	R1-51
Karin L. Nickola (CD)	H8-75	Curt B. Walker (CD)	T4-35
Terry W. Noland (CD)	E6-28	Dana C. Ward (30P/50CD/50S)	A5-15
Steve M. O'Toole (CD)	S7-90	Christine R. Webb (CD)	H8-51
Shirley J. Olinger (CD)	H6-60	Kriss E. Weeks (CD)	S5-31
Brian E. Opitz (P/CD/S)	K6-75	Regan S. Weeks (CD)	K3-75
Gregory W. Patton (P)	K6-75	Michael J. Weis (P/CD/S)	K9-42
Craig J. Perkins (CD)	E6-28	Dana L. Widrig (CD)	R3-50
Jon K. Perry (CD)	R3-32	Debra J. Wilcox (CD)	A4-52
Scott W. Petersen (CD)	R3-50	Justin Wilde (CD)	E6-28
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Marcus I. Wood (CD)	H8-51	Martin E. Zizzi (CD)	G3-70
Robin K. Woodford (CD)	P7-28	DOE Public Reading Room (2P/2CD/2S)	H2-53
Joan G. Woolard (CD)	H4-21	Hanford Site Administrative	
Signe K. Wurstner (CD)	K9-36	Record (2P/2CD/2S)	H6-08
Eric J. Wyse (CD)	T6-10	Hanford Technical Library (2P/2CD/2S)	P8-55
Robert M. Yasek (CD)	H6-60	Historical File—J. P. Duncan (P/CD/S)	K6-85



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