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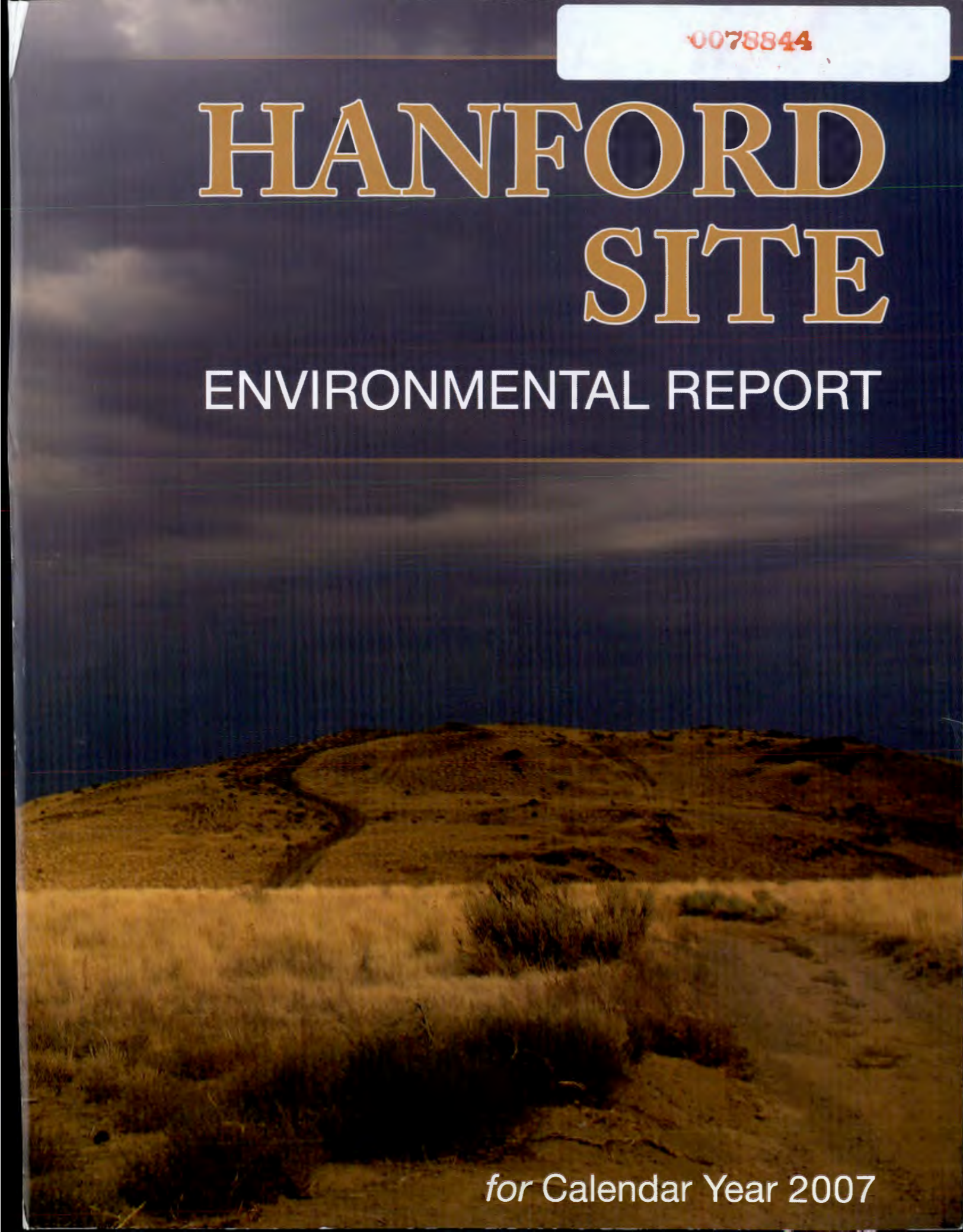
HANFORD SITE

ENVIRONMENTAL REPORT



for Calendar Year 2007

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PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

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The cover photo shows a late summer weather system passing over a shrub-steppe ecosystem that surrounds the Hanford Site. The photo was taken by AE Rakowski, Pacific Northwest National Laboratory, Richland, Washington. The cover design is by SB Colson, Pacific Northwest National Laboratory, Richland, Washington.

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08-EMD-0082

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THE HANFORD SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR (CY) 2007 (PNNL-17603), RICHLAND, WASHINGTON, SEPTEMBER 2008

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 2007 but also includes some early 2008 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 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 prime contractor for nuclear legacy cleanup; Washington Closure Hanford LLC, the environmental restoration contractor; CH2M HILL Hanford Group, Inc., the 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.

David A. Brockman, Manager
Richland Operations Office

Shirley J. Olinger, Manager
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Attachment:
Hanford Site Environmental Report for Calendar Year 2007

HANFORD SITE
ENVIRONMENTAL REPORT

for Calendar Year 2007
(Including Some Early 2008 Information)

Editors

T. M. Poston

J. P. Duncan

R. L. Dirkes

September 2008

Prepared for the U.S. Department of Energy by personnel from the Pacific Northwest National Laboratory under contract DE-AC05-76RL01830, with contributions from Bechtel National, Inc.; CH2M HILL Hanford Group, Inc.; Fluor Hanford, Inc. and its subcontractors; and Washington Closure Hanford 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 site; demonstrates the status of the site's compliance with applicable federal, state, and local environmental laws and regulations, executive orders, and DOE policies and directives; and summarizes environmental data that characterize Hanford Site environmental management performance. The report also highlights significant environmental and public protection programs and efforts. Some historical and early 2008 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 and environmentally related information to DOE managers, the public, Native Americans, public officials, regulatory agencies, Hanford Site contractors, and elected representatives. Appendix A lists scientific notation, units of measure, unit conversion information, and nomenclature that may help readers understand the report. 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 the DOE. Battelle is a non-profit, independent, 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.; and CH2M HILL Hanford Group, Inc. also prepared or provided significant input to selected sections.

Inquiries regarding this report should be directed to D. C. (Dana) Ward, DOE Richland Operations Office, P.O. Box 550, MS A5-15, Richland, Washington, 99352 (dana_c_ward@rl.gov) or to R. L. (Roger) Dirkes, Pacific Northwest National Laboratory, P.O. Box 999, MS K6-75, Richland, Washington, 99352 (rl.dirkes@pnl.gov).

Report Availability

This 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-17603-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 Consolidated Information Center in Richland, Washington. All versions of the report can be obtained from J. P. (Joanne) Duncan, Pacific Northwest National Laboratory, P.O. Box 999, MS K6-85, Richland, Washington, 99352 (joanne.duncan@pnl.gov), while supplies last.

Summary

J. P. 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 during the 2007 calendar year. Individual sections are designed to provide detail on the following:

- Describe the Hanford Site and its mission.
- Summarize the Hanford Site's compliance with all applicable DOE, federal, state, and local regulations.
- Discuss the status and results of Hanford Site cleanup and remediation activities.
- Summarize environmental management performance.
- Describe the Hanford Site environmental and groundwater monitoring programs, and summarize and describe monitoring data.
- Discuss potential radiation doses to onsite staff and the public residing in the Hanford Site vicinity.
- Describe data quality assurance methods.

The current mission of the 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 2007

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 between the Washington State Department of Ecology, the U.S. Environmental Protection Agency (EPA), and DOE to achieve compliance with the remedial action provisions of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and with treatment, storage, and disposal unit regulations and corrective action provisions of the *Resource Conservation and Recovery Act of 1976* (RCRA). The Tri-Party Agreement has evolved to meet changing conditions as cleanup requirements have progressed. During 2007, there were 41 specific Tri-Party cleanup milestones scheduled for completion; 33 were completed on or before their required due dates, 1 was completed beyond the established due date, and 7 were not yet complete at the end of 2007. During 2007, 27 negotiated change requests to the Tri-Party Agreement were approved.

Hanford Site's compliance with federal acts in 2007 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.

Table S.1. Status of Compliance with Federal Acts at the Hanford Site in 2007

Regulation	What It Covers	2007 Status
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; and *Native American Graves Protection and Repatriation Act*	Cultural resources.	During 2007, 129 cultural resource reviews were requested on the Hanford Site. DOE determined that 115 activities would not affect cultural resources and were exempt from further review; 14 requests required full reviews. Thirty-four cultural resources sites were visited in 2007 to assess the effects of erosion, weathering, and unauthorized excavation and collection. Sixteen new archaeological sites and 23 new isolated finds were recorded on the Hanford Site in 2007. Two data recovery excavations were also conducted in advance of project initiation.
Atomic Energy Act of 1954	Proper management of radioactive materials.	In 2007, five 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 underwent significant revision.
Clean Air Act	Air quality, including emissions from facilities and from unmonitored sources.	The Hanford Site air operating permit was reissued by the Washington State Department of Ecology in December 2006. Three revisions to the air operating permit were approved in 2007. The Benton Clean Air Agency regulates open-air burning and oversees asbestos regulation compliance. The Washington State Department of Health, the Washington State Department of Ecology, and the Benton Clean Air Agency conducted over 45 inspections in 2007.
Clean Water Act of 1977	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 2007.
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)	Sites already contaminated by hazardous materials.	Institutional controls are implemented and maintained in accordance with CERCLA decision documents. During 2007, there were no CERCLA institutional controls at the Central Plateau that required review. The River Corridor Project performed an inspection of remediation sites in the 100 Areas, as well as a review of events, permits, and 300 Area institutional controls implemented as a result of the 2006 review. There were several minor spills on the Hanford Site in 2007 and one spill that resulted in a penalty to DOE under the Tri-Party Agreement.
Emergency Planning & Community Right to Know Act of 1986	The public's right to information about hazardous materials in the community and the establishment of emergency planning procedures.	In early 2008, Hanford Site officials issued the *2007 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory* report (DOE/RL-2008-14, 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 *2007 Hanford Site Toxic Chemical Release Inventory* is scheduled for release in 2008.
Endangered Species Act of 1973	Rare species of plants and animals.	Numerous plants and animals at the Hanford Site are federal- or state-listed as endangered, threatened, sensitive, or candidate species. Ecological compliance reviews are conducted prior to project initiation at the Hanford Site to prevent adverse impacts to biological resources, including listed species. In 2007, 179 reviews were performed, including 99 ecological compliance reviews for general site activities and 80 reviews for environmental restoration activities.
Federal Insecticide, Fungicide, and Rodenticide Act of 1975	Storage and use of pesticides.	At the Hanford Site, pesticides are applied by commercial pesticide operators licensed by the state.
Migratory Bird Treaty Act	Migratory birds or their feathers, nests, or eggs.	All Hanford Site projects with a potential to affect federal- or state-listed species of concern were in compliance with the requirements of this act by using the ecological compliance review process to minimize adverse impacts to migratory birds.

Table S.1. (contd)

Regulation	What It Covers	2007 Status
National Environmental Policy Act of 1969 (NEPA)	Environmental impact statements for major federal projects that have the potential to significantly affect the quality of the human environment.	A draft comprehensive conservation plan and environmental impact statement for the Hanford Reach National Monument/Saddle Mountain National Wildlife Refuge was issued for review in December 2006. The public comment period ended in March 2007 and the final environmental impact statement was being finalized during 2007 for issuance in 2008. A draft environmental impact statement for Hanford Site Tank Closure and Waste Management was in process during 2007 and scheduled for issuance in 2008. In January 2007, DOE issued a notice of intent to prepare a programmatic environmental impact statement for the Global Nuclear Energy Partnership Initiative. In July 2007, DOE announced its intent to prepare an environmental impact statement for the disposal of Greater-Than-Class-C low-level radioactive waste. A draft environmental impact statement to develop and evaluate alternatives that could create additional water storage for the Yakima River Basin, 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 was issued in January 2008. DOE is preparing a supplemental analysis to the 1999 *Hanford Comprehensive Land-Use Plan Environmental Impact Statement* to evaluate whether a supplement environmental impact statement or a new environmental impact statement is required.
Resource Conservation and Recovery Act of 1976 (RCRA)	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 2007, seven revisions to the Hanford Facility RCRA Permit Part A Form and one RCRA Part B Permit application were submitted to the state for review and approval. Two revisions to the RCRA permit were issued by the Washington State Department of Ecology and three treatment, storage, and disposal units were approved for closure. Two RCRA non-compliance documents were received at the Hanford Site in 2007: 1) violations of the RCRA permit at the 183-N demolition site, and 2) violations of state and federal hazardous waste tank system regulations for operation of temporary mixed waste transfer lines in use at Hanford Site tank farms. Resolution is ongoing.
Safe Drinking Water Act of 1974	Drinking water systems.	There were nine drinking water systems on the Hanford Site in 2007. The systems were monitored for radiological and chemical contaminants and disinfection residuals and byproducts. There were no microbiological detections during 2007 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.
Toxic Substances Control Act	Hazardous chemical regulation and tracking; primarily polychlorinated biphenyls (PCBs).	During 2007, the *2006 Polychlorinated Biphenyl Annual Document Log – Report for the Hanford Site* and a 2006 PCB annual report were submitted to the EPA as required. EPA-approved risk-based disposal approvals were used in 2007 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.

Progress 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 2007, 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 2007 focused on waste burial grounds and miscellaneous waste sites in the 100-B/C, 100-K, 100-D, and 100-F Areas (Section 6.1.3). A total of 352,200 metric tons (388,200 tons) of contaminated soil from the 100 Areas remediation activities were disposed at the Environmental Restoration Disposal Facility (near the 200-West Area) during 2007. The majority of the contaminated soil was from the 100-F and 100-D Areas. Several remediated and backfilled waste sites in the 100-B/C and 100-F Areas were revegetated with native grass seed and sagebrush seedlings in 2007.

Pump-and-treat systems continued to help remove contaminants from the groundwater beneath the 100 Areas in 2007 (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 left behind sludge and debris. During 2007, K Basins cleanup continued with the removal of debris from both K-East and K-West Basins. All sludge from the K-East Basin was removed, allowing deactivation and decommissioning activities to begin. Further information concerning K Basins remediation and closure activities in 2007 are discussed in Section 6.1.3.2.

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

Location	Startup Date	Contaminant	Mass Removed 2007	Mass Removed Since Startup
100-D Area (100-DR-5 Pump-and-Treat System)	2004	Chromium	54.7 kilograms (121 pounds)	160 kilograms (353 pounds)
100-D Area (100-HR-3-D Pump-and-Treat System)	1997	Chromium	21.2 kilograms (47 pounds)	263.7 kilograms (581 pounds)
100-H Area (100-HR-3-H Pump-and-Treat System)	1997	Chromium	2.4 kilograms (5 pounds)	49 kilograms (108 pounds)
100-K Area (100-KR-4 Pump-and-Treat System)	1997	Chromium	20 kilograms (44 pounds)	312 kilograms (688 pounds)
100-K Area (Pump-and-Treat System near K-West Reactor)	2007	Chromium	15.8 kilograms (34.8 pounds)	15.8 kilograms (34.8 pounds)
200-West Area (200-ZP-1 Pump-and-Treat System)	1994	Carbon tetrachloride	755.2 kilograms (1,665 pounds)	10,950 kilograms (24,150 pounds)
200-West Area (200-UP-1 Pump-and-Treat System)	1994	Carbon tetrachloride	0.053 kilogram (0.12 pound)	34.6 kilograms (76.3 pounds)
		Nitrate	356 kilograms (785 pounds)	35,072 kilograms (77,320 pounds)
		Technetium-99	0.27 gram (0.01 ounce)	119.1 grams (0.263 pound)
		Uranium	1.13 kilograms (2.5 pounds)	212.9 kilograms (469 pounds)
Waste Management Area S-SX	2003	Technetium-99	0.04 gram (0.001 ounce)	0.31 gram (0.011 ounce)
200-West Area (Soil-Vapor Extraction System)	1991	Carbon tetrachloride	300 kilograms (661 pounds)	79,200 kilograms (175,000 pounds)

Remediation of 200 Areas Waste Sites. Remedial investigation or feasibility study activities continued on waste sites in the 200 Areas in 2007. 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 6.1.2.

Pump-and-treat systems and a soil-vapor extraction system continued to help remove contaminants from the groundwater and vadose zone beneath the 200 Areas in 2007 (Table S.2).

Remediation of 300 Area Waste Sites. Remediation efforts in 2007 focused on the 300-FF-2 Operable Unit waste sites. Remediation activities at this waste site began in 2002. In 2007, 336 metric tons (370 tons) of contaminated soil from the 300-FF-2 Operable Unit were removed and disposed at the Environmental Restoration Disposal Facility. A design solution for the cleanup of the 618-10 and 618-11 waste burial grounds was completed in December 2006 and submitted to DOE for evaluation. In 2007, DOE recommended site characterization; a characterization plan is being prepared. Discussions of these activities are provided in Section 6.1.4.

Facility Decommissioning Activities

Decommissioning of 100 Areas Facilities. During 2007, 100 Areas deactivation, decontamination, decommissioning, and demolition activities focused on the 100-N Area, where 12 buildings were demolished. In addition, a removal action work plan for the 105-K East and 105-K West Reactor facilities was approved in February 2007 by DOE and EPA (Section 6.2.4).

Decommissioning of 200 Areas Facilities. The transition and decommissioning of facilities in the 200 Areas continued in 2007. Activities at the Plutonium Finishing Plant included de-inventory of plutonium for shipment to another DOE site; continued cleanout of contaminated equipment; and upgrades to facility fire systems, fans, and electronic controls (Section 6.2.1.1). 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 the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit and buildings and waste sites in the 200-East, 200-West, and 200-North Areas in 2007. Periodic surveillances, radiation surveys, and herbicide applications were performed (Section 6.2.1.2).

Decommissioning of 300 Area Facilities. During 2007, 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. Twenty-four facilities and buildings were demolished in the 300 Area in 2007 (Section 6.2.2).

Decommissioning of 400 Area Facilities – Fast Flux Test Facility. 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 2007, fuel removal from the 400 Area Property Protected Area continued. The remaining mixed-oxide fuel assemblies were removed, processed, and placed in interim spent nuclear fuel storage casks. A RCRA treatment, storage, and disposal permit for container storage of more than 90 days was issued by the Washington State Department of Ecology in November 2007 for the storage of liquid sodium recovered from the Fast Flux Test Facility. Deactivation activities continued in 2007, including the removal or replacement of transformers containing polychlorinated biphenyls (PCBs); the shutdown of electric, water, fire suppression and ventilation systems; and the cleanout of the reactor containment building and supporting facilities (Section 6.2.3).

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. A summary of waste stored, generated, and treated at the site or received from offsite in 2007 is provided in Table S.3.

In addition to newly generated waste, significant quantities of legacy waste remain from years of nuclear materials production and waste management activities. Most legacy waste from past operations at the Hanford Site resides in RCRA-compliant waste sites or is stored in places awaiting 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 6.3 and 6.4).

Solid Waste Management. Waste management at the Hanford Site in 2007 included the treatment, storage, and disposal of solid waste at many site locations (Section 6.3.2). 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 6.3.3.1) in the 200-West Area from sources at the Hanford Site, and any offsite sources authorized by the 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 20,796 cubic meters (27,200 cubic yards) 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 of 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 7,900 cubic meters (10,300 cubic yards).

Waste destined for the Waste Receiving and Processing Facility (Section 6.3.3.2) 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 691 cubic meters (904 cubic yards) of waste offsite in 2007.

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 6.3.3.3). In 2007, eight hundred fifty-seven 208-liter (55-gallon) drum equivalents of transuranic waste were repackaged to meet offsite waste acceptance criteria.

During 2007, there were 1,460 cubic meters (1,910 cubic yards) of mixed low-level waste treated or disposed of at the Mixed Low-Level Waste Treatment and Disposal Facility (Section 6.3.3.4).

There were two defueled reactor compartments from the U.S. Navy shipped to Trench 94 in the 200-East Area in 2007, bringing the total number of U.S. Navy reactor compartments received to 117 (Section 6.3.3.5).

During 2007, approximately 398,500 metric tons (439,300 tons) of remediation waste were disposed at the Environmental Restoration Disposal Facility (Section 6.3.3.6). Approximately 6.5 million metric tons (7.2 million tons) of remediation waste have been placed in the Environmental Restoration Disposal Facility from initial operations startup through 2007. 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 in the 200-West Area (Section 6.3.3.7). Disposal to the first trench began in September 1999 and the first layer of waste packages has been completed and covered with sand and gravel. The second waste layer was started and is approximately half filled. Currently, there are approximately 4,100 cubic meters (5,360 cubic yards) of waste in the first trench. There are approximately 1,200 cubic meters (1,570 cubic yards) of waste in the second trench, which began operations in July 2004.

Table S.3. Hanford Site Waste Summary, 2007

Activity	Waste Type	Amount
Solid waste generated during onsite cleanup activities	Solid mixed waste	235,378 kilograms (259 tons)
	Radioactive waste	299,701 kilograms (330 tons)
Dangerous waste shipped off the Hanford Site	Containerized waste	47,979 kilograms (53 tons)
	Bulk solids	0 kilograms
	Bulk liquids	96,653 kilograms (107 tons)
Waste volume pumped from underground single-shell waste storage tanks to double-shell waste storage tanks	Liquid waste	4.3 million liters (1.1 million gallons)
Waste volume in underground single-shell waste storage tanks at the end of 2007	Liquid waste	113 million liters (29.8 million gallons)
Waste volume evaporated at the 242-A Evaporator	Liquid waste	4.5 million liters (1.2 million gallons)
Waste added to underground double-shell waste storage tanks	Liquid waste	5.9 million liters (1.6 million gallons)
Waste volume in underground double-shell waste storage tanks at the end of 2007	Liquid waste	101 million liters (27 million gallons)
Waste dispositioned and shipped offsite from the Waste Receiving and Processing Facility	Solid waste	691 cubic meters (904 cubic yards)
Waste treated or directly disposed of at the Mixed Low-Level Waste Treatment and Disposal Facility	Mixed low-level solid waste	1,460 cubic meters (1,910 cubic yards)
Waste disposed of at the Environmental Restoration Disposal Facility	Solid waste	398,500 metric tons (439,300 tons)
Volume of aqueous waste received at the Liquid Effluent Retention Facility	Wastewater containing low levels of organic compounds and tritium	38.3 million liters (10.1 million gallons)
Volume of liquid effluent treated at the Effluent Treatment Facility	Wastewater containing toxic metals, radionuclides, ammonia, and organic compounds	32.9 million liters (8.69 million gallons)
Volume of wastewater treated at the 242-A Evaporator	Liquid waste from single-shell tanks	7.8 million liters (2.1 million gallons)
Volume of effluent disposed of at the 200 Area Treated Effluent Disposal Facility	Uncontaminated liquid waste	1.31 billion liters (346 million gallons)
Volume of wastewater treated and disposed of at the 300 Area Treated Effluent Disposal Facility	Industrial wastewater	168 million liters (44.4 million gallons)

The low-level burial grounds (Section 6.3.3.8) consist of eight burial grounds located in the 200-East and 200-West Areas that are used for the 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, the DOE issued a record of decision for the Solid Waste Program at 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 has been disposed of in these two trenches (Section 6.3.3.7). Disposal of U.S. Navy reactor compartments (Section 6.3.3.5) in the low-level burial grounds is not affected by this record of decision.

Liquid Waste Management. Liquid effluent is managed in facilities to comply with federal and state regulations and facility permits (Section 6.3.4).

Approximately 38.3 million liters (10.1 million gallons) of liquid waste were stored at the Liquid Effluent Retention Facility at the end of 2007 (Section 6.3.4.1). The volume of wastewater received for interim storage in 2007 was approximately 56.6 million liters (15 million gallons). The volume of wastewater transferred from this facility to the Effluent Treatment Facility for treatment in 2007 was 32.9 million liters (8.69 million gallons).

The Effluent Treatment Facility (Section 6.3.4.2) 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 2007 was approximately 32.9 million liters (8.69 million gallons).

The 200 Area Treated Effluent Disposal Facility (Section 6.3.4.3) disposed of 1.31 billion liters (346 million gallons) of unregulated effluent in 2007. The major source of this effluent was uncontaminated cooling water 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 6.3.4.4). The wastewater consists of cooling water, steam condensate, and other industrial wastewater. The volume of industrial wastewater treated and disposed of during 2007 was 168 million liters (44.4 million gallons).

The 242-A Evaporator (Section 6.3.4.5) 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. The 242-A Evaporator completed two waste campaigns in 2007. The volume of waste treated was 7.8 million liters (2.1 million gallons), reducing the waste volume by 4.5 million liters (1.2 million gallons), or approximately 58% of the total volume. The volume of process condensate transferred to the Liquid Effluent Retention Facility for subsequent treatment in the Effluent Treatment Facility was 6.1 million liters (1.6 million gallons).

Underground Waste Storage Tanks. During 2007, 4.3 million liters (1.1 million gallons) of waste were pumped from single-shell tanks to the double-shell tanks, leaving 113 million liters (29.9 million gallons) of waste remaining in the single-shell tanks. At the end of 2007, there were 101 million liters (26.7 million gallons) of waste in the double-shell tanks (Section 6.4).

Hanford Tank Waste Treatment and Immobilization Plant (Waste Treatment Plant). The Hanford Tank Waste Treatment and Immobilization Plant (Waste Treatment Plant) is being built on 26 hectares (65 acres) located 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. Supporting facilities also are being constructed. Construction on these facilities resumed in September 2007, following a delay relating to seismic design criteria (Section 6.5).

Washington State Initiative 297: *Cleanup Priority Act*

Initiative 297, known as the *Cleanup Priority Act*, was passed by Washington State voters in November 2004. The *Cleanup Priority Act* sought to add a new chapter to the *Mixed Radioactive and Hazardous Waste* (RCW 70.105E) law and among other things, restricted importing offsite waste to the Hanford Site, established cleanup standards for radioactive releases, and required the DOE to pay a new mixed waste surcharge. In 2006, the federal court ruled the initiative was "invalid in its entirety" because it violated the U.S. Constitution in several areas. Washington State officials appealed the ruling, which was rejected in May 2008.

Radiological Release of Property from the Hanford Site

No property with detectable residual radioactivity was released from the Hanford Site in 2007 (Section 7.0.1).

Radiological Release of Personal Property Potentially Contaminated with 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, and real property control and release criteria 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 adjusted limits are difficult or impossible to verify with field 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 existing, approved DOE property-release guidelines. In 2007, new authorized limits were approved for use for hard-to-detect radionuclides on real property. The new limits were 50,000 dpm/100 cm^2 (average), 150,000 dpm/100 cm^2 (maximum), and 10,000 dpm/100 cm^2 (removable), which would apply to beta-gamma surface contamination only, with volumetric contamination or contamination of people excluded. Based on these limits, no property with detectable residual radioactivity was released from the Hanford Site in 2007 (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 and until 2007, guidelines for the offsite shipment and regeneration were not established as required by DOE Order 5400.5, "Radiation Protection of the Public and the Environment." During 2007, authorized limits for the ion exchange resin were established for seven radionuclides (Section 7.0.1.2). In 2007, approximately 46,000 kilograms (101,000 pounds) of resin was shipped offsite for regeneration under the new 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 and until 2007, guidelines for the offsite shipment and regeneration were not established as required by DOE Order 5400.5. During 2007, authorized limits for the granular activated carbon were established for 21 radionuclides (Section 7.0.1.3). In 2007, approximately 8,200 kilograms (18,100 pounds) of granular activated carbon was shipped offsite for regeneration under the new authorized limits.

Columbia River Corridor Baseline Risk Assessment and Groundwater 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 a draft report (Section 7.0.2.1).

In early 2007, 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).

Environmental Occurrences

Environmental releases of radioactive and regulated materials from the Hanford Site are reported to DOE and other federal and state agencies as required by law. 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 and include operational emergency, recurring, Category 1 (significant impact), Category 2 (moderate impact), Category 3 (minor impact), and Category 4 (some impact) (Section 8.0).

In 2007, there were no occurrences ranked as significance impact Category 1 or recurring. There was one operational emergency with the potential to have an immediate and severe impact on safe facility operations, worker safety and health, and environmental conditions. A range fire occurred in August 2007. Environmental sampling conducted during and after the fire indicated there was no release of radioactive materials.

There were two Category 2 occurrences with potential environmental implications on the Hanford Site in 2007. In June, contamination was identified on staff members due to a leaking plutonium-238 source. Surveys were conducted and contamination was found. A radioactive waste spill occurred in July as a result of equipment failure during waste transfer. The spill area was stabilized and posted.

In 2007, there were two Category 3 events. In May, two containers of mercury-contaminated soil were buried at the Environmental Restoration and Disposal Facility without undergoing the required mercury treatment. The contaminated soil was removed. In July, a grass fire burned 10 hectares (25 acres).

There were two Category 4 occurrences in 2007. In March, an illegal sewage dump was discovered in the Riverlands unit of the Hanford Reach National Monument. The spill was treated to kill the sewage sludge bacteria. In August, a range fire burned over 3,200 hectares (8,000 acres). Also, several areas of legacy contamination were discovered in 2007, involving contaminated tumbleweeds, rabbit feces, wind, and mud daubers.

Pollution Prevention and Waste Minimization

The Pollution Prevention and Waste Minimization 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 2007, 599 metric tons (660 tons) of sanitary and hazardous wastes were recycled through site-wide programs. The Hanford Site generated 3,115 cubic meters (4,070 cubic yards) of cleanup/stabilization waste (i.e., low-level waste, mixed low-level waste, and hazardous waste).

Environmental and Resource Protection Programs

DOE Orders require that emission, effluent, and environmental monitoring programs be conducted at the Hanford Site to verify protection of the site's environmental and cultural resources, the public, and site workers, and to comply with government regulations (Table S.4; Section 10.0).

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 to 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).

Table S.4. Summary of Contaminant Monitoring On and Around the Hanford Site, 2007

	What Was Monitored?	The Bottom Line
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 85 locations near Hanford Site facilities, at 23 locations around the Hanford 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 materials.	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 2007, 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 2007 chemical sample results were similar to those reported previously. Concentrations of volatile organic compounds were near or below their detection limits in all samples except one trichloroethene sample. 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 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 Columbia River sediment samples.
Food and Farm Products	Samples of alfalfa, grapes, milk, potatoes, tomatoes, and wine 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 whitefish, goose, and rabbit 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. Concentrations of 16 trace metals were similar to concentrations measured in samples from background locations.
Soil	Seventy routine soil samples were collected onsite near facilities and operations in 2007 to verify known radiological conditions. There were also soil samples collected to investigate potential contamination at non-routine sampling locations in 2007.	In general, radionuclide concentrations in routine samples collected from or adjacent to waste-disposal facilities in 2007 were higher than concentrations measured in distant communities in 2004. There were 17 instances of radiological contamination in soil samples investigated in 2007. Of the 17, 13 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 intact.
Vegetation	Samples of perennial vegetation were collected near Hanford Site facilities and operations in 2007 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.

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 gaseous ammonia, particulate matter, sulfur oxides, nitrogen oxides, volatile organic compounds, carbon monoxide, and lead (Section 10.1.2).

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 2007, ambient air was monitored at 85 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 2007 data indicate a large degree of variability by location.

Samples collected from locations at or directly adjacent to Hanford Site facilities had higher radionuclide concentrations than did 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.

Site-Wide and Offsite Ambient-Air Monitoring. During 2007, 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. At 20 locations, samples of atmospheric water vapor were collected every 4 weeks and analyzed for tritium. All sample results showed very low radiological concentrations in 2007. All radionuclide concentrations in air samples collected in 2007 were below the EPA *Clean Air Act* dose standard of 10 millirem (100 microsievert) per year.

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 2007, only facilities in the 200 Areas discharged radioactive liquid effluent to the ground at a single location, the State-Approved Land Disposal Site. Non-radioactive hazardous materials in liquid effluent were monitored in the 100, 200, 300, and 400 Areas. The effluent was discharged to the State-Approved Land Disposal Site and to 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.

Columbia River Water. During 2007, 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 Vernita Bridge, 100-N Area, Hanford town site, 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 2007 were less than 1/25th

of the DOE standard of 100 millirem (1 microsievert) per year. Tritium, strontium-90, 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 2007 were below regulatory limits (Section 10.4.1).

Columbia River Sediment. During 2007, 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 (Section 10.4.2). Radionuclides consistently detected in Columbia River sediment in 2007 included potassium-40, strontium-90, cesium-137, uranium-234, uranium-235, uranium-238, plutonium-238, and plutonium-239/240. 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 10.4.2.3).

Pond Water and Sediment. Two onsite ponds, West Lake and the Fast Flux Test Facility pond, were sampled in 2007. Samples were obtained quarterly and included water from both ponds and sediment 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 10.4.3.2).

Offsite Irrigation Water. In 2007, samples were collected from an irrigation canal in the Riverview area of Pasco 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-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 2007 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 2007 were less than the applicable DOE concentration guides (Section 10.5.1.2). For most locations, the 2007 chemical sample results were similar to those previously reported. Concentrations of volatile organic compounds were near or below their detection limits in all samples except one trichloroethene sample. Trace amounts of chlorinated organic compounds were observed at some locations. The concentrations of most metals measured in spring water samples in 2007 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. Shoreline springs sediment samples were collected in the 100-B, 100-F, 100-H, and 100-K 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 sediments 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 the other locations is obtained from the Columbia River. Water samples were analyzed for gross alpha, gross beta, tritium, and strontium-90. During 2007, 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 groundwater. Hazardous chemicals in the groundwater include carbon tetrachloride, chromium, and nitrate. Radioactive contaminants include tritium, uranium, strontium-90, technetium-99, and iodine-129. 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 2007, food and farm products including alfalfa, grapes, milk, potatoes, tomatoes, and wines 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 2007 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 2007, soil samples were collected near facilities and operations on 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 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 2007 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 2007 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-N Area, 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 Hanford Site plant populations, monitoring contaminants in perennial vegetation growing near facilities and operations on the site, 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 for firebreak construction and maintenance (Section 10.10.1).

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 2007 were higher than concentrations in samples collected farther away, and were significantly higher than concentrations measured offsite in prior years. 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 10.10.2.2).

Investigations of Radioactivity in Vegetation Near Hanford Site Facilities and Operations. During 2007, radiological contamination was found in 62 vegetation samples. All of the samples were tumbleweeds (Russian thistle) or tumbleweed fragments and were disposed at a licensed facility (Section 10.10.2.3).

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 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 2007 was estimated at 4,018, lower than previous years. 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. A pair of adult bald eagles returned during 2007 to occupy the historical nest site in the vicinity of the former White Bluffs town site; however, the nest was abandoned for unknown reasons. 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.

Monitoring Fish and Wildlife for Hanford-Produced Contaminants. In 2007, Canada geese, cottontail rabbits, and whitefish 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 2007. Strontium-90 was found above the analytical detection limit in the whitefish, rabbit, and goose samples collected during 2007. 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. Beryllium was not detected in any whitefish or wildlife samples. Concentrations of trace metals in whitefish samples were elevated for many samples in 2007, with the exception of nickel and selenium in fish collected from 100-N and 100-D Areas, which were similar to or less than concentrations collected in previous years. Trace metal concentrations in rabbit samples collected on the Hanford Site in 2007 were not detected or were less than or similar to concentrations from previous years; however, selenium concentrations were elevated compared with background samples from 2005.

Control of Pests and Contaminated Biota. Animal species such as the domestic pigeon (*Columbia livia*), Northern pocket gopher (*Thomomus talpoides*), house mouse (*Mus musculus*), and deer mouse (*Peromyscus maniculatus*) must be controlled when they become a nuisance, health problem, or contaminated with radioactivity. Biological control personnel responded to approximately 28,000 animal control requests (ranging from requests to remove animals within radioactive waste facilities to insect invasions of work areas) from Hanford Site employees in 2007. There were 35 contaminated animals or animal-related materials discovered during 2007.

External Radiation Monitoring

In 2007, 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 2007, external radiation fields were monitored at 124 locations near onsite facilities and operations. With the exception of the 200-West Area, measured radiation levels were similar to or lower than levels measured in 2006 (Section 10.13.1.1).

Radiological Surveys at Active and Inactive Waste-Disposal Sites. During 2007, 464 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 fire-breaks in and around the site operational areas. During 2007, the Hanford Site had approximately 593 hectares (1,465 acres) of outdoor contaminated areas of all types and approximately 600 hectares (1,482 acres) that contained underground radioactive materials, not including active facilities. No new areas of significant size were discovered during 2007. Approximately 7 hectares (18 acres) of previously posted contamination and/or underground radioactive materials areas underwent remediation action and were closed for the interim in 2007 (Section 10.13.1.2).

Potential Radiological Doses from 2007 Hanford Site Operations

During 2007, 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 (0.12 millirem [1.2 microsievert] per year at Sagemoor); 2) average dose to the collective population living within 80 kilometers (50 miles) of Hanford Site operating areas (0.9 person-rem [0.009 person-sievert] per year); 3) dose to a maximally-exposed individual for air pathways using EPA methods (0.14 millirem [1.4 microsievert] per year at Sagemoor); 4) annual dose to site workers consuming drinking water (0.1 millirem [10 microsievert] per year); 5) inhalation doses associated with measured radionuclide concentrations in air (ranging from 0.001 millirem [0.01 microsievert] in the 300 Area to 0.087 millirem [0.87 microsievert] at the site perimeter); 6) dose from non-DOE industrial sources on and near the Hanford Site (less than 0.2 millirem [2.0 microsievert] per year); and 7) absorbed dose received by animals 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 0.0039 millirem (0.039 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 maintained 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 2007, 129 cultural resource reviews were requested by Hanford Site contractors.

A monitoring program to assess the effects of weathering and erosion or unauthorized excavation and collection upon Hanford Site's cultural resources was established in

1987. In 2007, 34 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 2007, average temperature and precipitation totals were below normal. The average temperature for 2007 was 11.9°C (53.5°F), which was 0.1°C (0.1°F) below normal (12.0°C [53.6°F]). Four months during 2007 were warmer than normal; seven months were cooler than normal. Precipitation during 2007 totaled 13.9 centimeters (5.48 inches), which is 79% of normal (17.7 centimeters [6.98 inches]). Snowfall for 2007 totaled 25.4 centimeters (10.0 inches), compared to normal snowfall of 39.1 centimeters (15.4 inches).

The average wind speed during 2007 was 3.6 meters per second (8.0 miles per hour), which was 0.2 meter per second (0.4 mile per hour) above normal. The peak gust for the year was 26.8 meters per second (60 miles per hour) on November 12 and December 15. Two dust storms were recorded at the Hanford Meteorology Station during 2007, less than the five per year average for the entire period of record (1945-2007).

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 cross-checks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories.

Acknowledgments

The production of this report was managed by the Pacific Northwest National Laboratory's Public Safety and Resource Protection Project under the direction of Roger L. Dirkes.

The authors appreciate the comprehensive reviews of the draft report by George V. Last and Robert E. Peterson (Pacific Northwest National Laboratory) and would like to thank Robert W. (Bill) Hanf, who retired from Pacific Northwest National Laboratory during 2007, for his past commitment and contributions to this document.

The report was prepared by Pacific Northwest National Laboratory staff: Hope E. Matthews, text editor, with help from Wayne Cosby and Andrea J. Currie, and Kathy R. Neiderhiser, text processor, with some help from Lila M. Andor. Some of the graphics were prepared by Deborah L. Liddell (Lockheed Martin Services, Inc.), and Chris A. Newbill and Mary J. Hartman (Fluor Hanford, Inc.). Shannon B. Colson (Pacific Northwest National Laboratory) designed the report cover and layout. Duplicating and printing arrangements were managed by Lara R. Ortega, who was supported by Cindy D. Hernandez, Rosa Linda Armijo, Toni L. Dudley, Kevin M. Santo Pietro, Jeff B. Matthews, and Amber E. Dailey. This report was produced using Adobe® InDesign and formatted for the Internet by Susan J. Widener.

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1.0 Introduction

This report, published annually since 1959 (http://hanfordsite.pnl.gov/envreport), provides information and analytical data related to the Hanford Site for calendar year 2007 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 discuss 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 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 mission at the Hanford Site was the production of plutonium for national defense purposes. The current primary mission at the Hanford Site 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. Restoring the Columbia River Corridor by cleaning up Hanford Site sources of radiological and chemical contaminants that threaten the air, groundwater, or Columbia River. Most river corridor projects are estimated to be completed by 2012.
2. Ending the tank waste program by 2033 by accelerating waste retrieval, increasing the capacity of the Waste Treatment Plant (under construction in 2007), and starting the process of closing the underground waste storage tanks.
3. Cleaning up other Hanford Site facilities that are considered urgent risks.
4. Treating and disposing of mixed low-level waste, and the retrieval of transuranic waste and its shipment offsite.
5. Cleaning up excess facilities on the Central Plateau.
6. Cleaning up and protecting 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 public and worker health and safety, and the environment.

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, situated along the shore of the Columbia River in the northern portion of the site, were the location of nine nuclear reactors that have since been retired. The 100 Areas occupy approximately 11 square kilometers (4 square miles).
- **200-West and 200-East Areas** – These areas are located on the Central Plateau, approximately 8 and 11 kilometers (5 and 7 miles), respectively, south and west 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-East and 200-West Areas cover approximately 16 square kilometers (6 square miles).
- **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 at 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). It is the location of the Fast Flux Test Facility, which has not operated since 1992 and was undergoing deactivation and decommissioning during 2007. 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 at 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, managed by Fluor Hanford, Inc., and used by site contractors, federal and state agencies, tribal governments, and private industries.

Other site-related facilities (office buildings) are located within the Tri-Cities of Richland, Pasco, and Kennewick.

Non-DOE Operations and Activities on Hanford Site Leased Land – These include commercial power production by Energy Northwest at the Columbia Generating Station (4.4 square kilometers [1.6 square miles]) and operation of a commercial low-level radioactive waste burial site by US Ecology Washington, Inc. (0.4 square kilometer [0.2 square mile]). The Laser Interferometer Gravitational Wave Observatory is located west of the 400 Area, and is operated jointly by the California and Massachusetts Institutes of Technology and sponsored by the National Science Foundation.

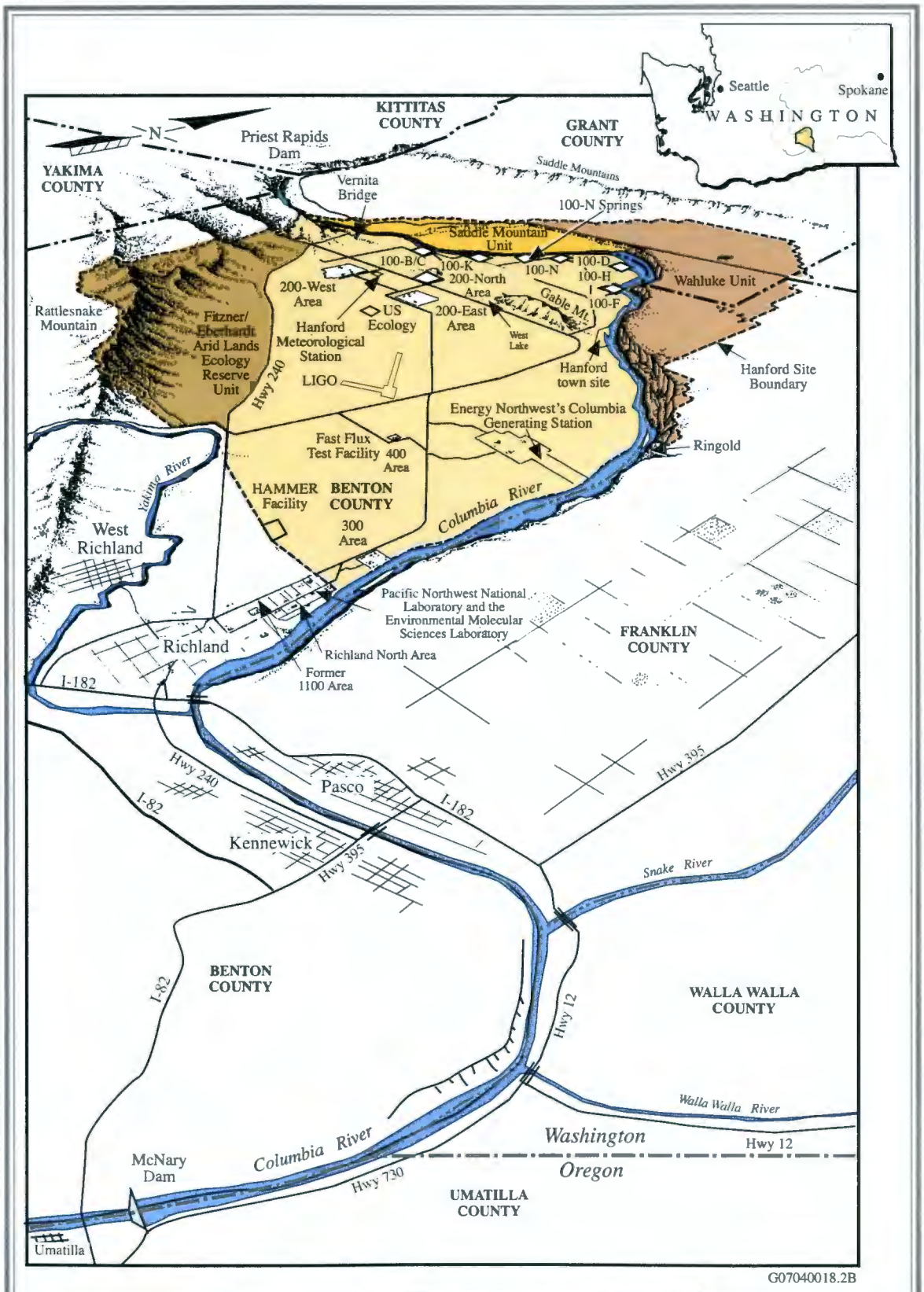

Figure 1.0.1. The Hanford Site and Surrounding Area

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, U.S. Fish and Wildlife Service, and 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 2007, the principal contractors for the DOE Richland Operations Office and their respective responsibilities included the following:

- 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. A principal subcontractor to Washington Closure Hanford LLC is Eberline Services Hanford, Inc.
- Fluor Hanford, Inc. currently manages the Project Hanford Management Contract. The purpose of this contract is to dismantle former nuclear processing facilities at 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). In 2007, Fluor Hanford, Inc.'s principal subcontractors were Energy*Solutions* Federal Services of Hanford, Inc. and Numatec Hanford Corporation, a subsidiary of AREVA Group, a world leader in the nuclear fuel industry. Other subcontractors to Fluor Hanford, Inc. included Lockheed Martin Information Technology, and the Fluor Government Group.
- AdvanceMed Hanford was the occupational health contractor at the Hanford Site in 2007. 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

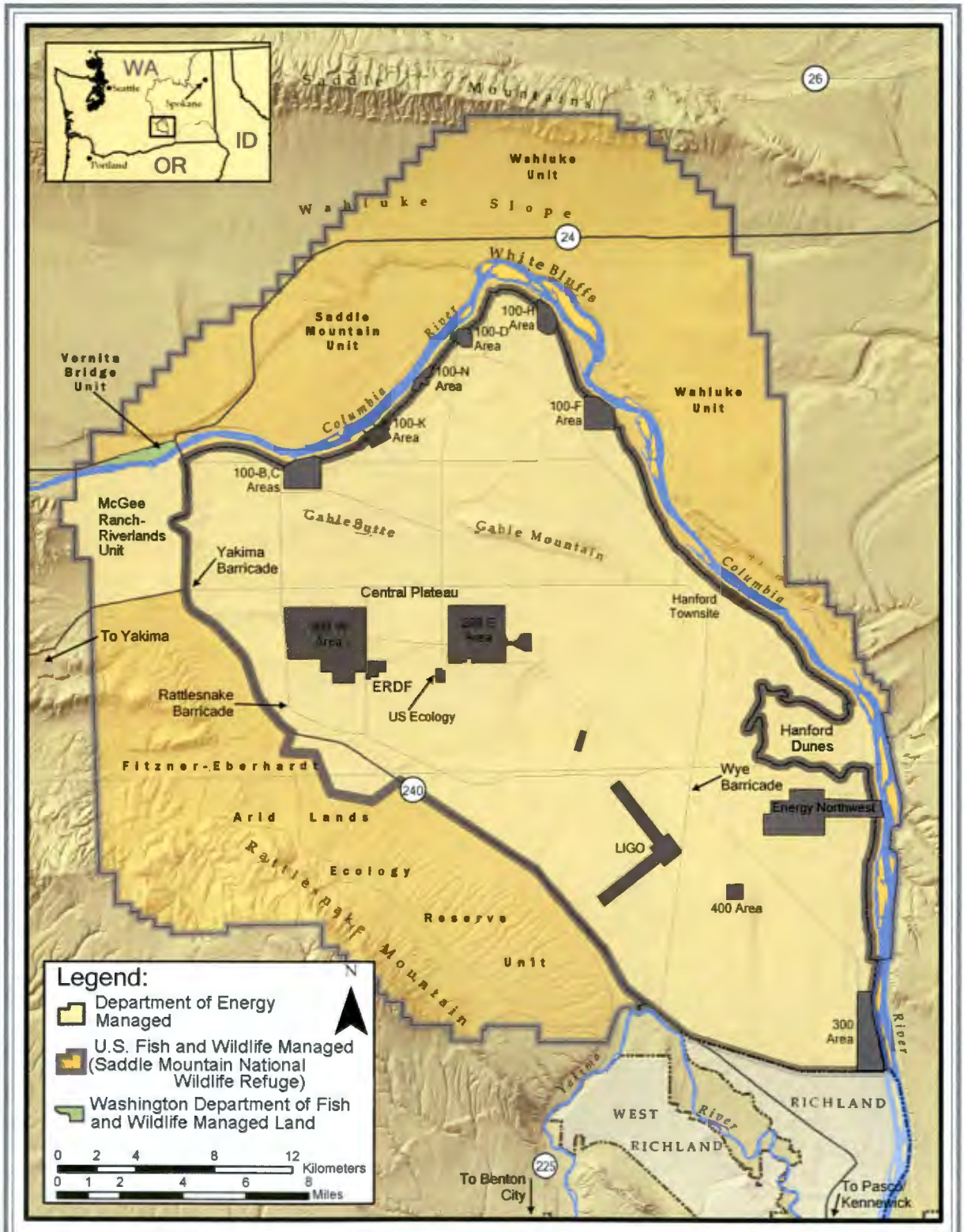

Figure 1.0.2. Management Units on the Hanford Reach National Monument (Monument boundaries are approximate.)

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 2007 and their respective responsibilities included the following:

- Bechtel National, Inc. – This contractor's mission is to design, build, and start up 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.
- CH2M HILL Hanford Group, Inc. – This contractor is responsible for storing, retrieving, and disposing of approximately 201 million liters (53 million gallons) of radioactive and chemically hazardous waste stored in 177 underground tanks at the Hanford Site. The company also maintains the tank farm infrastructure in a safe and stable configuration.
- 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. During 2007, the U.S. Fish and Wildlife Service administered three major management units (Figure 1.0.2) for the Hanford Reach National Monument 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.

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, Inc.: http://www.ch2m.com/corporate/
- CH2M HILL Hanford Group, Inc.: http://www.hanfordcleanup.info/
- 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/
- DOE Science and Technology: http://www.energy.gov/sciencetech/
- Eberline Services Hanford, Inc.: http://www.eberlineservices.com/page_field.htm
- Energy*Solutions*: 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.fluor.com/ias/gov/projects.asp
- Hanford Reach National Monument: http://www.fws.gov/hanfordreach/index-expanded.html
  - Columbia River Corridor Unit: http://www.fws.gov/hanfordreach/documents/riverfactsheet.pdf
  - Fitzner/Eberhardt Arid Lands Ecology Reserve Unit: http://www.fws.gov/hanfordreach/documents/alefactsheet.pdf
  - McGee Ranch/Riverlands Unit: http://www.fws.gov/hanfordreach/documents/mcgeefactsheet.pdf
  - Saddle Mountain National Wildlife Refuge: http://www.fws.gov/refuges/profiles/index.cfm?id=13701
  - Saddle Mountain Unit: http://www.fws.gov/hanfordreach/documents/saddlemountainfactsheet.pdf
  - Vernita Bridge Unit: http://www.fws.gov/hanfordreach/documents/vernitafactsheet.pdf
  - Wahluke Unit: http://www.fws.gov/hanfordreach/documents/wahlukefactsheet.pdf
- Hanford Tours: http://www.hanford.gov/?page=317&parent=0
- Laser Interferometer Gravitational Wave Observatory (LIGO): http://www.ligo-wa.caltech.edu/
- Lockheed Martin Information Technology: http://www.hanford.gov/?page=74&parent=62
- Numatec Hanford Corporation: http://www.hanford.gov/?page=75&parent=62
- Pacific Northwest National Laboratory: http://www.pnl.gov/
- Volpentest Hazardous Materials Management and Emergency Response Training & Education Center (HAMMER): http://www.hammertraining.com/
- Washington Division of URS Corporation (formerly Washington Group International): http://www.wgint.com/
- Washington Closure Hanford LLC: http://www.washingtonclosure.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/
- Columbia Plateau: http://www.dnr.wa.gov/ResearchScience/Topics/GeologyofWashington/Pages/columbia.aspx
- Columbia River Basin: http://www.blm.gov/education/00_resources/articles/Columbia_river_basin/article.html
- 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

1.0.4 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 Statement*. U.S. Department of Energy, Washington, D.C. Accessed on July 1, 2008, 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 July 1, 2008, at http://www.hanford.gov/rl/uploadfiles/Perf_Mang_rl-2002-47.pdf.

2.0 Public Involvement at the Hanford Site

J. P. Duncan

The U.S. Department of Energy (DOE) encourages information exchange and involvement in decisions regarding cleanup and remediation of the Hanford Site. 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 of these stakeholders are described in the following sections.

2.0.1 Role of Native American Tribes

F. A. Sijohn

The Hanford Site is located on land ceded to the United States government by the Confederated Tribes and Bands of the Yakama Indian Nation and the Confederated Tribes of the Umatilla Indian Reservation in the Treaties of 1855. These tribes, as well as the Nez Perce Tribe, have treaty fishing rights on portions of the Columbia River. Tribes reserve the right to fish at all usual and accustomed places, hunt animals and gather roots and berries, and allow horses and cattle to graze on open and unclaimed pasture land. The Wanapum are not a federally recognized tribe; however, they have historic ties to the Hanford Site as do the Confederated Tribes of the Colville Reservation, whose members are descendants of people who used the area known as the Hanford Site.

The Hanford Site environment supports a number of Native American foods and medicines and contains sacred places important to tribal cultures. The tribes want to safely use these resources in the future and have assurance that the Hanford Site is environmentally clean and safe. Native American tribal governments have a special and unique legal and political relationship with the U.S. government as defined by history, treaties, statutes, court decisions, and the U.S. Constitution. In recognition of this relationship, the DOE and each tribe interact and consult directly on Hanford Site-related matters. Tribal government representatives from the Confederated Tribes and Bands of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the 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. As part of their involvement in these DOE-supported groups, the tribes also review and comment on draft documents. Both the Wanapum and the Confederated Tribes of the Colville Reservation are also provided an opportunity to comment on documents and participate in cultural resource management activities.

The *DOE American Indian & Alaska Native Tribal Government Policy* (DOE 2006) guides the DOE's interaction with tribes for Hanford Site plans and activities. The policy states, among other things:

> "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."

In addition to the *DOE American Indian & Alaska Native Tribal Government Policy* (DOE 2006), laws such as the *American Indian Religious Freedom Act*, the *National Environmental Policy Act of 1969* (NEPA), the *Archaeological Resources Protection Act of 1979*, the *National Historic Preservation Act*, and the *Native American Graves Protection and Repatriation Act* require consultation with tribal governments. The

combination of the Treaties of 1855, federal policy, executive orders, laws, regulations, and the federal trust responsibility provides the basis for tribal participation in Hanford Site plans and activities. 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 Hanford Site environmental management activities.

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

E. P. Kennedy

Federal legislation and policies require programs such as DOE's Hanford Cultural and Historic Resources Program to formally 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* 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 conducts formal Section 106 and NEPA consultations 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 occasionally consult with parties that have expressed 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 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 focus on cultural resource reviews and issues that concern 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

D. C. Ward

Under Sections 107(a) and 120(a) of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended, federal agencies, including DOE, are 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. Native American 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). Members cooperate 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 agreements.

During 2007, the trustees met as a formal council five times to discuss CERCLA natural resource issues for the Hanford Site. The senior trustees (upper-management level representatives from each trust organization) met twice in 2007 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.

The federal trustees issued a draft conceptual design for the natural resource damage assessment at the Hanford Site with the following points:

- 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
  - Prepare an assessment plan
- Implement the assessment plan
- Initiate preliminary restoration planning
- Perform early restoration, if appropriate.

Information about the Hanford Natural Resource Trustee Council, including its history and projects, can be found at the website http://www.hanford.gov/?page=29&parent=0.

During 2007, the Hanford Natural Resource Trustee Council performed the following:

- Attended two facilitated workshops to describe the scope and content of a statement of work for a prospective contractor to develop an injury assessment plan.
- Continued to be active in all phases of the Central Plateau and River Corridor ecological risk assessments and to stay informed on groundwater projects. Attended workshops and reviewed information from DOE and its contractors. Focused DOE attention on additional topics of trustee concern.
- Produced a draft booklet titled, "Hanford Natural Resource Trustee Council, Background, History, Accomplishments (1992-2007)." The booklet is projected to be published in 2008.
- Discussed hiring a temporary administrative assistant to organize the Administrative Record (1994 to present) contained in three filing cabinets in the Federal Building (located in the city of Richland, Washington), with the goal of processing the official Natural Resource Trustee Council records to make electronic copies available in concert with the Hanford Administrative Record.
- Attended or participated in presentations concerning Borrow Area C actions on the Fitzner/Eberhardt Arid Lands Ecology Reserve; DOE Pacific Northwest Site Office's new laboratory construction adjacent to the 300 Area; and the Tank Closure Environmental Impact Statement. The trustees also attended or participated in presentations on supplemental environmental projects, Hanford Reach National Monument and 200-West Area revegetation efforts after the 2007 Wautoma wildlands fire, and the supplemental analysis for the Comprehensive Land Use Plan (DOE/EIS-0222-F).

- Discussed concerns about the funding necessary for trust organization support to the ecological risk assessments and for the Natural Resource Damage Assessment at the Hanford Site, Council governance, facilitation of Council meetings, and leadership of the injury assessment planning effort.

2.0.4 Public Participation in Hanford Site Decisions

K. E. Lutz and T. E. Olds

DOE's Richland Operations Office and Office of River Protection believe public involvement is essential to the success of Hanford Site cleanup. These offices coordinate, plan, and schedule public participation activities for DOE at 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, the U.S. Environmental Protection Agency [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 Public Involvement section. In addition, public participation guidance developed by both DOE and EPA is followed.

A key goal of public involvement is to facilitate broad-based participation and obtain Native American tribe, natural resource trustees (see Section 2.0.3), stakeholder, and public perspectives on Hanford Site cleanup decisions. DOE is committed to maintaining a government-to-government relationship with the Native American tribes that retain certain rights at the Hanford Site. DOE consults with tribal governments prior to taking action, making decisions, or implementing programs that may affect the tribes.

Stakeholders are individuals who perceive themselves affected by and/or have an interest in Hanford Site-related issues. They commit time and energy to participate in decisions. Hanford Site stakeholders include local governments, local and regional businesses, the site workforce, local and regional environmental interest organizations, and local and regional public health organizations. The public is comprised of individuals who are aware of but may choose not to be involved in decisions. It is DOE's responsibility to provide the public with meaningful information on upcoming decisions so they can choose whether or not to become involved in Hanford Site-related decisions.

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]) Hanford Site 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 newspaper notices, brochures, meeting notices, fact sheets, etc.
- **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.
- ***The Hanford Update*** – A newsletter titled *The Hanford Update*, a synopsis of Tri-Party Agreement public involvement activities and information about ongoing Hanford Site cleanup activities, is published quarterly and distributed to interested stakeholders and the general public through an established mailing list. The newsletter can also be accessed at the following website: http://www.hanford.gov/?page=102&parent=91.
- **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 current public involvement opportunities is posted at http://www.hanford.gov/public/calendar/.

- **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 in the Consolidated Information Center, 2710 University Drive, Richland, Washington.
- **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** – In an effort to provide broad and timely perspectives to the public on Hanford Site cleanup priorities and budget decisions, the Tri-Parties regularly conduct public information 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.

Cleanup documents are also made 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
- Washington State Department of Ecology's 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

K. E. Lutz and T. E. Olds

The Hanford Advisory Board is an independent, non-partisan, and 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. It provides recommendations and advice to all three Tri-Party agencies on Hanford Site cleanup decisions. The Hanford Advisory Board is comprised of 31 members and their alternates, including representatives from the Nez Perce Tribe and The Confederated Tribes and Bands of the Yakama Indian Nation tribal governments. A representative of The Confederated Tribes of the Umatilla Indian Reservation participates on the board in an ex-officio status.

The Hanford Advisory Board is intended to be an integral component for some Hanford Site tribal and general public involvement activities, but not the sole conduit for public involvement activities. Members assist the broader public in becoming more informed and meaningfully involved in Hanford Site cleanup decisions through its open public meetings. The organization provides significant advice on cleanup issues, and DOE relies on the board to provide input and advice that reflects the values of its constituents.

In 2007, the Hanford Advisory Board issued nine pieces of advice on Hanford Site cleanup during its five board meetings:

- Major cleanup contract procurement (Advice #195 and #200)
- Workers' compensation program (Advice #196)
- Groundwater values and flowchart (Advice #197)
- Hanford Site cleanup funding (Advice #198)
- Future DOE budget baselines (Advice #199)
- Tank S-102 spill investigation (Advice #201)
- Clarity and readability of technical reports (Advice #202)
- Tri-Party Agreement negotiations (Advice #203).

Information about the Hanford Advisory Board, including its charter and copies of its advice and responses, can be found at the website: http://www.hanford.gov/public/boards/hab.

2.0.6 References

43 CFR Part 11.23(f)(4). 2002. "Natural Resource Damage Assessments." *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 18, 2008, at http://www.epa.gov/lawsregs/laws/cercla.html.

DOE. 2006. *American Indian & Alaska Native Tribal Government Policy*. Office of Congressional & Intergovernmental Affairs, U.S. Department of Energy, Washington, D.C.

DOE/EIS-0222-F. 1999. *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*. U.S. Department of Energy, Washington, D.C. Accessed on July 1, 2008, at http://www.hanford.gov/doe/eis/hraeis/maintoc.htm.

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 through February 12, 2008, Olympia, Washington. Accessed April 18, 2008, 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. Accessed April 18, 2008, at http://www.gpoaccess.gov/uscode/index.html.

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

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

Native American Graves Protection and Repatriation Act. 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 22, 2008, at http://www.epa.gov/region5/defs/html/rcra.htm.

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 18, 2008, at http://www.hanford.gov/?page=113&parent=91.

3.0 Regulatory Oversight at the Hanford Site

K. A. Peterson

Several federal, state, and local regulatory agencies are responsible for monitoring and enforcing compliance with applicable environmental regulations at 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's 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)

T. W. 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 at 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 at the Hanford Site. All significant changes undergo a process of public involvement that enhances communication and addresses public concerns prior to final approvals. Revision 7, published during 2007 and current as of July 23, 2008, incorporates 92 sets of modifications (change requests) that have been approved since publication of the last revision. As new change requests are approved, 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. Copies of Revision 7 of the Tri-Party Agreement 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 Washington State Department of Ecology 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

T. W. Noland

The Tri-Party Agreement (Ecology et al. 1989) commits DOE to achieve compliance 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 2007, 984 Tri-Party Agreement milestones were completed, and 294 target dates were met. During 2007, 41 specific cleanup milestones were scheduled for completion; 33 were completed on or before their required due dates, 1 was completed beyond the established due date, and 7 were not yet complete at the end of 2007.

3.0.3 Approved Modifications to the Tri-Party Agreement

T. W. Noland

During 2007, 27 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.

3.0.4 Washington State Department of Health

J. A. Bates

The Washington State Department of Health, Office of Radiation Protection 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 Office of Radiation Protection 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 for DOE 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 conducts a program for inspecting all 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 Office of Radiation Protection maintains the majority of its staff and management offices in Richland, Washington.

3.0.5 References

40 CFR 61, Subpart A. 2007. "National Emission Standards for Hazardous Air Pollutants; General Provisions." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 61, Subpart H. 2007. "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 22, 2008, 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 through February 12, 2008, Olympia, Washington. Accessed April 18, 2008, at http://www.hanford.gov/?page=91&parent=0.

Resource Conservation and Recovery Act of 1976. 1976. Public Law 94-580, as amended, 90 Stat. 2795, 42 USC 6901 et seq. Accessed April 22, 2008, 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 18, 2008, at http://www.hanford.gov/?page=113&parent=91.

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.

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

H. T. Tilden, P. C. Miller, R. H. Engelmann, and R. J. Landon

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. The international voluntary consensus standard International Organization for Standardization (ISO) 14001, *Environmental Management Systems – Specifications with Guidance for Use*, and DOE Order 450.1, "Environmental Protection Program," were considered during the development of these systems.

DOE verified that all Hanford Site entities under DOE P 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. This included the Hanford Central Plateau Project, the Hanford River Corridor Project, the DOE Office of River Protection, and Pacific Northwest National Laboratory. Implementation dates were as follows: CH2M HILL Hanford Group, Inc. (May 2000); Fluor Hanford, Inc. (August 2000); and Pacific Northwest National Laboratory (1998). In 1996, Pacific Northwest National Laboratory established an ISO 14001 Environmental Management System; registration of that system was obtained in 2002. Re-registration to the updated ISO 14001 (2004) standard occurred in 2005. 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. Washington Closure Hanford LLC and Fluor Hanford, Inc. maintain Environmental Management Systems that are integrated with their company's Integrated Environment, Safety, and Health Management System. Washington Closure Hanford LLC completed Phase II Integrated Environment, Safety, and Health Management System verification during 2007. Efforts continued in 2007 to improve these environmental, safety, and health programs.

4.0.2 Chemical Management Systems

M. T. Jansky

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 have been reviewed periodically and improved as needed. Section 5.1.1 provides details on the inventories of hazardous chemicals stored at the Hanford Site in 2007.

4.0.3 References

29 CFR 1910, Subpart Z. 2007. "Occupational Safety and Health Standards." Subpart Z, "Toxic and Hazardous Substances." *Code of Federal Regulations*, U.S. Department of Labor.

DOE Order 450.1. 2003. "Environmental Protection Program." U.S. Department of Energy, Washington, D.C.

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

ISO 14001. 1996; updated 2004. *Environmental Management Systems – Specifications with Guidance for Use*. American Society for Testing and Materials, West Conshohocken, Pennsylvania.

5.0 Compliance Summary

J. P. Duncan

U.S. Department of Energy (DOE) policy mandates that all DOE activities at 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 at 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 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 activities are not meeting requirements.

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*

R. E. 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 facilities. These committees gather information and develop emergency plans for local planning districts. 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 themselves to the state emergency response commission and the local emergency planning committee. Facility officials must periodically provide information to support the emergency planning process. The threshold planning quantities are predetermined amounts established by state and local authorities. Facilities 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.

In early 2008, Hanford Site officials issued the *2007 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory* report (DOE/RL-2008-14, 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 *2007 Hanford Site Toxic Chemical Release Inventory* (DOE/RL-2008-16, 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 28, 2008. Table 5.1.1 provides an overview of 2007 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 at the Hanford Site in 2007.

5.1.2 *Resource Conservation and Recovery Act of 1976*

A. G. Miskho

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* reauthorized

Table 5.1.1. *Emergency Planning & Community Right to Know Act of 1986* Compliance Reporting at the Hanford Site, 2007

Sections of the Act	Yes[a]	No[a]	Not Required[a]
302-303: Planning notification	X[b]		
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 2007.

Table 5.1.2. Average Quantity of Ten Hazardous Chemicals[a] Stored on the Hanford Site, 2007

Hazardous Chemical	Average Quantity, kg (lb)
Sodium	1,240,000 (2,730,000)
Mineral oil	1,100,000 (2,430,000)
Portland cement	300,000 (661,000)
Diesel fuel (Grades 1 and 2)	248,000 (547,000)
Lead acid batteries	182,000 (401,000)
Fly ash (class F)	136,000 (300,000)
Gasoline	92,800 (205,000)
Petroleum distillates (unspecified)	86,800 (191,000)
Argon	78,600 (173,000)
Sulfuric acid	41,700 (91,900)

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

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." At the Hanford Site, RCRA applies to approximately 39 treatment, storage, and disposal units. 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

S. A. 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 seven permittees: the DOE Richland Operations Office and the DOE Office of River Protection as the owners/operators of the Hanford Site and five of their contractors 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

S. A. Thompson

The Hanford Site is considered a single facility for purposes of RCRA and WAC 173-303. The facility is comprised of 39 treatment, storage, and disposal units. The Tri-Party Agreement (Ecology et al. 1989) 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 2007, seven 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. These revisions to the Part A Form included modifications to information for the 1706-KE Waste Treatment System (100 Areas), T Plant Complex (200-West Area), Waste Receiving and Processing Facility (200-West Area), Double-Shell Tanks System (200-East and 200-West Areas), 224-T Transuranic Waste Storage and Assay Facility (200-West Area), Central Waste Complex (200-West Area), and the 400 Area Waste Management Unit (400 Area).

In 2007, 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 Permit Application for the Waste Encapsulation and Storage Facility* (DOE/RL-2006-35, Rev. 1). The closure plan submittal included the 1706-KE Waste Treatment System.

In 2007, the Washington State Department of Ecology issued two revisions to the RCRA Permit. On January 8, 2007, the Washington State Department of Ecology issued RCRA Permit Revision 8B, incorporating the 331-C Storage Unit (Operating Unit 15), 241-Z Treatment and Storage Tanks (Closure Unit 7), Plutonium Finishing Plant Treatment Unit (Closure Unit 6), and the 303-M Oxide Facility (Closure Unit 17). On October 17, 2007, the Washington State Department of Ecology issued RCRA Permit Revision 8C, incorporating the 400 Area Waste Management Unit and the 224-T Transuranic Waste Storage and Assay Facility.

The Washington State Department of Ecology approved DOE-certified closure documentation for three treatment, storage and disposal units in 2007: the 305-B Storage Facility, the 241-Z Treatment and Storage Tanks, and the 216-U-12 Crib.

5.1.2.3 RCRA Groundwater Monitoring

M. J. Hartman

RCRA groundwater monitoring is part of the Hanford Site Soil and Groundwater Remediation Project (Section 10.7). In 2007, 15 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. Twelve of the sites monitored under RCRA are scheduled for closure under the Hanford Facility RCRA Permit (Ecology 1994). The Liquid Effluent Retention Facility and low-level burial grounds (Waste Management Areas 1 through 4) will receive permits as operating RCRA facilities. The Integrated Disposal Facility received a RCRA operating permit in June 2006 and is under a unit-specific groundwater monitoring plan. A summary of groundwater monitoring activities for these sites during 2007 is provided in Section 10.7; more detailed information is available in the *Hanford Site Groundwater Monitoring Report for Fiscal Year 2007* (DOE/RL-2008-01).

5.1.2.4 RCRA Inspections

D. L. Hagel

Hanford Site contractors and DOE worked to resolve notices of violation and warning letters of non-compliance that were received from the Washington State Department of Ecology during 2007. 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 2007.

Notice of Violation of the RCRA Permit at 100-N Area. On May 8, 2007, the Washington State Department of Ecology issued a notice of violation to the DOE Richland Operations Office and Washington Closure Hanford LLC alleging violations of the RCRA permit at the 183-N demolition site.

The Washington State Department of Ecology conducted inspections of petroleum spills at the 183-N demolition site in the 100-N Area beginning on January 25, 2007. As a result of the inspections, the Washington State Department of Ecology cited two permit violations relating to notification, mitigation, and cleanup of dangerous wastes or hazardous constituents released to the environment. Five concerns were also identified regarding operations at the demolition site.

In a letter to the Washington State Department of Ecology, dated September 24, 2007, DOE responded to the notice of violation and provided release notification protocols

for contractors in the form of a supplemented contractor requirements document. The letter also requested that the Washington State Department of Ecology defer further actions until the supplemented contractor requirements document is implemented by site contractors. Resolution of implementation issues is ongoing.

Notice of Violation for Unfit-for-Use Hazardous Waste Tank System Components. On August 8, 2002, the Washington State Department of Ecology issued a notice of non-compliance to the DOE Office of River Protection and CH2M HILL Hanford Group, Inc. for alleged violations of state and federal hazardous waste tank system regulations for operating temporary mixed-waste transfer lines in use at Hanford Site tank farms. To correct the violations cited in the notice of non-compliance, the DOE Office of River Protection and CH2M HILL Hanford Group, Inc. developed a *Temporary Waste Transfer Line Management Program Plan* (RPP-12711). The Washington State Department of Ecology considered operation of the temporary mixed-waste transfer lines to be compliant as long as all requirements of the plan were met.

On May 14, 2007, the Washington State Department of Ecology issued a notice of violation to the DOE Office of River Protection and CH2M HILL Hanford Group, Inc. based on findings from a March 28, 2007, inspection at tank farms to determine if temporary transfer lines were being managed in accordance with RPP-12711. The inspection revealed that temporary mixed-waste transfer lines were not being managed according to requirements in the plan.

In August 2007, CH2M HILL Hanford Group, Inc. began submitting quarterly reports to the Washington State Department of Ecology listing all temporary transfer lines in storage or deployed for use or in use on the Hanford Site, as well as those that will exceed their service life by the end of the fiscal quarter. Developing a recovery schedule for removing out-of-service temporary transfer lines is in discussion between the DOE Office of River Protection, CH2M HILL Hanford Group, Inc., and the Washington State Department of Ecology.

5.1.3 *Washington Administrative Code* Groundwater Monitoring

M. J. Hartman

Groundwater monitoring was required for three regulated, non-RCRA waste facilities in 2007. The 200 Area Treated Effluent Disposal Facility and the State-Approved Land Disposal Site are monitored under state discharge permits (WAC 173-216). The 600 Area Central Landfill (formerly known as 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 2007 for waste constituents specified in the facility permits.

Section 10.7 summarizes groundwater monitoring activities for these sites during 2007; more detailed information is available in the *Hanford Site Groundwater Monitoring Report for Fiscal Year 2007* (DOE/RL-2008-01).

5.1.4 *Toxic Substances Control Act*

W. E. Toebe

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 at 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 maintained and serviced in accordance with 40 CFR 761.

During 2007, the DOE Richland Operations Office submitted both the 2006 PCB Annual Document Log report

for the Hanford Site (DOE/RL-2007-25) and a 2006 PCB annual report (DOE/RL-2007-26) to EPA as required by 40 CFR 761.180. These two documents describe the PCB waste management and disposal activities occurring at the Hanford Site. The *Framework Agreement for Management of Polychlorinated Biphenyls 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 (now under construction), 2) in the waste tank farms, and 3) at affected waste management units upstream and downstream of 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 2007, 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 eight tanks with seven remaining tanks identified in the Risk-Based Disposal Approval for which EPA approval has not been issued. An approval specifies which double-shell tank can supply the supernatant to the single-shell tank and to which double-shell tank the supernatant will be returned.

Other risk-based disposal approvals are being implemented at the Hanford Site. K Basins sludge continued to be managed through 2007, and a request for an extension of a risk-based disposal approval was submitted to EPA in 2007 for continued storage of two water tower tanks at the Hanford Site. The paint on the tanks' interior walls contains PCBs at 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*

W. E. Toebe

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 extensively 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 EPA's list of the most serious uncontrolled or abandoned hazardous waste sites, must enter into an interagency agreement with EPA. At the Hanford Site, the EPA is responsible for oversight of DOE's implementation of CERCLA regulations. There is significant overlap between the Washington State RCRA corrective action program (Section 5.1.2) and the CERCLA program. Many waste management units at 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 the Washington State RCRA corrective action provisions at the Hanford Site through administrative application of either program while meeting the technical requirements of both programs. There are several remediation activities ongoing at the Hanford Site pursuant to the CERCLA process.

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 at 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 site also may be employed after remediation is completed.

Section 4.2 of DOE/RL-2001-41, Rev. 2 requires DOE to conduct a site-wide assessment every 5 years coinciding with the CERCLA Five-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.

DOE is implementing the CERCLA cleanup process at the Central Plateau, which will generate decision documents. When the decision documents are approved by the Tri-Parties, institutional controls will be implemented as required. There were no CERCLA institutional controls at the Central Plateau that required review in 2007. The River Corridor project has a number of institutional controls in both interim action and final record of decision documents. An inspection of 100 Areas active remediation sites within 0.4 kilometer (0.25 mile) of the Columbia River was performed in 2007. Repair of one shoreline sign at 100-F was completed in response to this inspection. Trespass events, excavation permit use, and the status of 300 Area institutional controls were also reviewed as a result of the 2006 Institutional Controls review with no findings identified.

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

W. E. Toebe

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 2007. These spills were cleaned up, and materials were disposed of in accordance with all applicable requirements. In addition, there was one spill at single-shell Tank 241-S-102 on July 27, 2007, that was deemed by the Washington State Department of Ecology to be due to design and review inadequacies, resulting in the issuance of a penalty to DOE under the Tri-Party Agreement (Ecology et al. 1989).

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

J. M. 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 Washington 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." At 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

T. G. 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 basis for federal, state, and local air quality regulations. It 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 the 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 "Department of Energy, Radioactive Air Emission License, #FF-01" issued by the Washington State Department of Health. 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-2008-03).

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 FF-01 license issued by the Washington State Department of Health and notice of construction approval orders issued by the Washington State Department of Ecology. The air operating permit requires that semiannual reports documenting the status of required monitoring and any identified permit deviations be submitted to the regulatory agencies (DOE/RL-2007-05 and DOE/RL-2008-12). An annual report that documents the compliance status of Hanford Site emission sources against applicable *Clean Air Act* requirements is also required (DOE/RL-2008-24), as well as an annual report that documents total emissions of criteria and toxic pollutants on the Hanford Site (DOE/RL-2008-15). The air operating permit was revised three times in 2007 to incorporate new Washington State Department of Health and Washington State Department of Ecology air emission licenses, approval orders, and updated regulatory requirements. Revision A was issued on May 3, 2007, Revision B on July 26, 2007, and Revision C on December 5, 2007.

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. During 2007, the regulatory agencies conducted over 45 *Clean Air Act* inspections on the Hanford Site.

Hanford Site contractors and DOE actively work to resolve any potential compliance issues identified during these inspections.

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. At 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. Fluor Hanford, Inc. is the holder of this permit.

The Hanford Site was covered by one storm water permit during 2007. EPA's NPDES Storm Water Multi-Sector General 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 permit to replace it has not been issued. Facilities that obtained coverage under the 2000 Multi-Sector General Permit before its expiration are automatically granted an administrative continuance of permit coverage. Fluor Hanford, Inc. is the holder of this permit.

There are numerous sanitary waste discharges to the ground throughout the Hanford Site. Sanitary wastewater from the 400 Area is discharged to a treatment facility of 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 Richland is discharged to the city of Richland's treatment facility. Sanitary wastewater in the 100 and 200 Areas is primarily treated in a series of onsite sewage systems. The placement of these 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 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.

The Washington State Department of Ecology has a State Wastewater Discharge Permit Program that regulates the discharges to the ground. During 2007, the Hanford Site had five state waste discharge permits issued by the Washington State Department of Ecology (ST-4500, ST-4501, ST-4502, ST-4507, and ST-4511).

There were no permit violations during 2007.

5.3.2 *Safe Drinking Water Act of 1974*

L. M. Kelly

In 1974, Congress passed the *Safe Drinking Water Act of 1974*. The act set up a cooperative program among local, state, and federal agencies to establish 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 had to meet certain criteria, including adoption of regulations equal to or more stringent than the 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 strengthened with amendments in 1986 and 1996 (*Safe Drinking Water Act Amendments*). The 1996 amendments represent a national commitment to 1) prepare for future drinking water challenges and assure the sustainable availability of safe drinking water, 2) increase state flexibility, 3) provide for more efficient investments by water systems, 4) give better information to consumers, and 5) strengthen EPA's scientific work, including the use of risk and cost benefit analysis in establishing drinking water standards. The amendments include the development of several new drinking water regulations to be published over the next several years.

A series of these EPA regulations, known as the Microbial and Disinfection Byproduct Rules, address acute threats from microbial contamination and chronic threats from disinfectant residuals and byproducts. Two of the rules incorporated into the state drinking water regulations, WAC 246-290, "Public Water Supplies," became effective in January 2004 ("Stage 1, Disinfectants and Disinfection Byproducts Rule") and January 2005 ("Long Term 1 Enhanced Surface Water Treatment Rule"), impacting Hanford Site 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 2007, the 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 at the Hanford Site, the water systems were monitored during 2007 for microbiological, chemical, physical, and radiological constituents. There were no microbiological detections during the 2007 monitoring cycle, and all chemical concentrations in Hanford Site drinking water were well below the maximum contaminant levels established by EPA. Analytical results for 2007 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

M. R. Sackschewsky

DOE policies require that all projects with the potential to adversely affect biological resources have an ecological compliance review before starting the project. This review determines if the project will comply with the *Endangered Species Act of 1973* and the *Migratory Bird Treaty Act*. It 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 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 (the 200-East and 200-West Areas, the 100-K Area, and the 300 Area) are surveyed each spring. All habitat areas within these areas are surveyed, and each building is inspected for the 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. 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 179 reviews performed during 2007, including 99 ecological compliance reviews, to support general Hanford Site activities and 80 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). The bald eagle (*Haliaeetus leucocephalus*) was removed from the list of species protected under the *Endangered Species Act of 1973* in July 2007. Other species at 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* (see Section 5.5.1 in DOE/RL-96-32). 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

E. P. Kennedy

DOE's policy is to comply with all cultural resource-related laws and regulations (DOE P 141.1). At the Hanford Site, cultural resources are subject to the provisions of the following 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*; and *Native American Graves Protection and Repatriation Act*. Regulations applicable to cultural resources include "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 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*

M. T. Jansky

The *National Environmental Policy Act of 1969* (NEPA) requires that an environmental impact statement be prepared for major federal actions that have the potential to significantly affect the quality of the human environment. An environmental assessment is prepared when it is uncertain if a proposed action would require the preparation of an environmental impact statement. A supplement analysis is prepared to consider new information developed since issuance of an environmental impact statement and record of decision. The supplement analysis would determine if the federal action is still bounded by the original environmental impact statement and record of decision or if a supplemental environmental impact statement is required.

Additionally, certain types of actions may fall into typical classes that have already been analyzed by DOE and determined to not normally result in a significant environmental impact. These actions are called categorical exclusions, and, if eligibility criteria are met, they are exempt from NEPA environmental assessment or environmental impact statement requirements. Typically, the DOE Richland Operations Office documents more than 20 specific categorical exclusions annually, involving a variety of actions by multiple Hanford Site contractors. In addition, site-wide categorical exclusions are applied to routine, typical actions conducted daily on the Hanford Site. In 2007, there were 20 NEPA site-wide categorical exclusions at the Hanford Site.

Hanford Site NEPA documents are prepared and approved in accordance with the Council on Environmental Quality national environmental policy regulations for implementing the procedural provisions of the *National Environmental Policy Act of 1969* (40 CFR 1500-1599), DOE NEPA implementation procedures (10 CFR 1021), and DOE Order 451.1B Change 1, "National Environmental Policy Act Compliance Program – Change 1." In accordance with the Order, DOE documents prepared for CERCLA projects incorporate NEPA values such as analysis of cumulative, offsite, ecological, and socioeconomic impacts to the extent practicable in lieu of preparing separate NEPA documentation.

5.5.1 Recently Issued Environmental Impact Statements

In February 2006, DOE announced its intention to prepare a new environmental impact statement 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). The Washington State Department of Ecology will be a cooperating agency in preparing this environmental impact statement. This environmental impact statement will revise, update, and re-analyze groundwater impacts previously addressed in the *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington* (DOE/EIS-0286F). It will also include 1) a re-analysis of onsite disposal alternatives for the Hanford Site's low-level radioactive waste and mixed low-level radioactive waste and low-level radioactive waste and mixed low-level radioactive waste from other DOE sites, and 2) revisions and updates of other potential impact areas previously addressed in DOE/EIS-0286F. DOE will continue its ongoing analysis of alternatives for the retrieval, treatment, storage, and disposal of underground tank wastes and

closure of underground single-shell tanks. In addition, the scope of the ongoing *Fast Flux Test Facility Decommissioning Environmental Impact Statement* (DOE/EIS-0364, Notice of Intent issued in 69 FR 50176-50180) was also included in 71 FR 5655-5660. Projected issuance of the draft environmental impact statement is 2008.

A draft comprehensive conservation plan and environmental impact statement for the Hanford Reach National Monument/Saddle Mountain National Wildlife Refuge has been 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 national wildlife refuge (Fitzner/Eberhardt Arid Lands Ecology Reserve, Saddle Mountain, and Wahluke Units). As co-manager of the monument, the DOE Richland Operations Office is a cooperating agency. The draft document was issued for review in December 2006 (U.S. Fish and Wildlife Service 2006). The public comment period ended March 10, 2007. Projected issuance of the final environmental impact statement is 2008.

A draft environmental impact statement for the Yakima River basin has been prepared by the U.S. Department of Interior, Bureau of Reclamation, and the Washington State Department of Ecology (with DOE as a cooperating agency). The purpose of the draft document, issued January 25, 2008, and entitled *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 their 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 supply. At this time, impacts to the Hanford Site unconfined aquifer from the Black Rock Reservoir alternative are being evaluated. The public comment period on the draft closed March 31, 2008; 292 public comments were received. The final report is in preparation.

DOE announced its intent to prepare an environmental impact statement for the 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.[a] 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).

DOE announced its intention to prepare a programmatic environmental impact statement for the Global Nuclear Energy Partnership initiative. The Global Nuclear Energy Partnership would encourage expansion of domestic and international nuclear energy production while reducing nuclear proliferation risks and reduce the volume, thermal output, and radiotoxicity of spent nuclear fuel before disposal in a geologic repository. At this time, 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. The *Notice of Intent to Prepare a Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership* was issued January 4, 2007 (72 FR 331-336).

DOE is preparing a supplement analysis to the 1999 *Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222F). DOE's NEPA regulations require periodic reviews of site-wide environmental impact statements. The primary purpose of the supplement analysis for the *Hanford Comprehensive Land-Use Plan Environmental*

(a) A state licensed by the U.S. Nuclear Regulatory Commission to regulate the use of radioactive materials within its borders.

Impact Statement is to evaluate whether a supplemental environmental impact statement, a new environmental impact statement, or neither is required. This evaluation will focus on whether further NEPA review is needed due to any changes in 1) the land-use designations in the environmental impact statement, 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 of the final *Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, or 5) impacts of the changes in items 1 through 4. The draft supplement analysis was issued for informal public comment on March 24, 2008, and closed April 23, 2008. The final supplemental analysis is scheduled to be issued in August 2008.

5.5.2 Recent Environmental Assessments

An environmental assessment titled *Environmental Assessment: Construction and Operation of a Physical Sciences Facility at the Pacific Northwest National Laboratory, Richland, Washington* (DOE/EA-1562) was prepared in January 2007. A finding of No Significant Impact was issued on January 29, 2007.

5.6 *Atomic Energy Act of 1954*

W. M. Glines

The *Atomic Energy Act of 1954* was promulgated to assure the proper management of radioactive materials. The act and its amendments have delegated 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) 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 2007, the following DOE regulations and directives that potentially impact the management and control of radioactive materials were issued or underwent significant revision:

- 10 CFR 820. 2007. "Procedural Rules for DOE Nuclear Activities." *Code of Federal Regulations*, U.S. Department of Energy.
- 10 CFR 835. 2007. "Occupational Radiation Protection." *Code of Federal Regulations*, U.S. Department of Energy.
- 72 FR 31904-31941. 2007. "Procedural Rules for DOE Nuclear Activities and Occupational Radiation Protection." *Federal Register*, U.S. Department of Energy.
- DOE O 153.1. 2007. "Departmental Radiological Emergency Response Assets." U.S. Department of Energy, Washington, D.C.
- DOE P 226.1A. 2007. "Department of Energy Oversight Policy." U.S. Department of Energy, Washington, D.C.
- DOE O 226.1A. 2007. "Implementation of Department of Energy Oversight Policy." U.S. Department of Energy, Washington, D.C.
- DOE G 441.1-1B. 2007. "Radiation Protection Programs Guide." U.S. Department of Energy, Washington, D.C.

In addition, the following DOE technical standards pertaining to the management and control of radioactive materials were issued or underwent significant revision in 2007:

- DOE-HDBK-1131-2007. 2007. *General Employee Radiological Training*. U.S. Department of Energy, Washington, D.C.
- DOE-STD-1107-97 (CN1). 2007. *Knowledge, Skills, and Abilities for Key Radiation Protection Positions at DOE Facilities*. U.S. Department of Energy, Washington, D.C.
- DOE-HDBK-1105-2002 (CN-2). 2007. *Radiological Training for Tritium Facilities*. U.S. Department of Energy, Washington, D.C.
- DOE-STD-5506-2007. 2007. *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*. U.S. Department of Energy, Washington, D.C.
- DOE-HDBK-1129-2007. 2007. *Tritium Handling and Safe Storage*. U.S. Department of Energy, Washington, D.C.
- DOE-STD-3025-2007. 2007. *Quality Assurance Inspection and Testing of HEPA Filters*. U.S. Department of Energy, Washington, D.C.

These 2007-issued documents may be accessed on the DOE Directives, Regulations, and Standards website at http://www.directives.doe.gov.

5.7 References

10 CFR 61.55. 2008. "Licensing Requirements for Land Disposal of Radioactive Waste: Waste Classification." *Code of Federal Regulations*, U.S. Department of Energy.

10 CFR 72.3. 2008. "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste: Definitions." *Code of Federal Regulations*, U.S. Department of Energy.

10 CFR 820. 2007. "Procedural Rules for DOE Nuclear Activities." *Code of Federal Regulations*, U.S. Department of Energy.

10 CFR 830. 2002. "Nuclear Safety Management." *Code of Federal Regulations*, U.S. Department of Energy.

10 CFR 835. 2007. "Occupational Radiation Protection." *Code of Federal Regulations*, U.S. Department of Energy.

10 CFR 1021. 2006. "National Environmental Policy Act Implementing Procedures." *Code of Federal Regulations*, U.S. Department of Energy.

29 CFR 1910.1200(c). 2008. "Hazard Communication;" Subsection C, "Definitions." *Code of Federal Regulations*, U.S. Occupational Safety and Health Administration.

36 CFR 60. 2002. "National Register of Historic Places." *Code of Federal Regulations*, U.S. National Park Service.

36 CFR 63. 2002. "Determinations of Eligibility for Inclusion in the National Register of Historic Places." *Code of Federal Regulations*, U.S. National Park Service.

36 CFR 65. 2002. "National Historic Landmarks Program." *Code of Federal Regulations*, U.S. National Park Service.

36 CFR 79. 2002. "Curation of Federally-Owned and Administered Archaeological Collections." *Code of Federal Regulations*, U.S. National Park Service.

36 CFR 800. 2004. "Protection of Historic Properties." *Code of Federal Regulations*, Advisory Council on Historic Preservation.

40 CFR 52. 2008. "Approval and Promulgation of Implementation Plans." *Code of Federal Regulations*, U.S. Environmental Protection Agency. Accessed April 22, 2008, at http://www.gpoaccess.gov/cfr/index.html.

40 CFR 60. 2008. "Standards of Performance for New Stationary Sources." *Code of Federal Regulations*, U.S. Environmental Protection Agency. Accessed April 22, 2008, at http://www.gpoaccess.gov/cfr/index.html.

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

40 CFR 61.92. 2008. "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities; Standard." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

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

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

40 CFR 61, Subpart M. 2008. "National Emission Standards for Hazardous Air Pollutants." Subpart M, "National Emission Standard for Asbestos." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 63. 2008. "National Emissions Standards for Hazardous Air Pollutants for Source Categories." *Code of Federal Regulations*, U.S. Environmental Protection Agency. Accessed April 22, 2008, at http://www.gpoaccess.gov/cfr/index.html.

40 CFR 68. 2004. "Chemical Accident Prevention Provisions." *Code of Federal Regulations*, U.S. Environmental Protection Agency. Accessed April 22, 2008, at http://www.gpoaccess.gov/cfr/index.html.

40 CFR 70. 2008. "State Operating Permit Programs." *Code of Federal Regulations*, U.S. Environmental Protection Agency. Accessed April 22, 2008, at http://www.gpoaccess.gov/cfr/index.html.

40 CFR 82. 2008. "Protection of Stratospheric Ozone." *Code of Federal Regulations*, U.S. Environmental Protection Agency. Accessed April 22, 2008, at http://www.gpoaccess.gov/cfr/index.html.

40 CFR 122. 2008. "EPA Administered Permit Programs: The National Pollutant Discharge Elimination System." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 300. 2008. "National Oil and Hazardous Substances Pollution Contingency Plan." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 355, Appendices A and B. 2006. "Emergency Planning and Notification; The List of Extremely Hazardous Substances and Their Threshold Planning Quantities." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 761. 2008. "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). 2008. "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions; PCB Remediation Waste; Risk-Based Disposal Approval." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 761.180. 2008. "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions; Records and Monitoring." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 1500-1599. "Protection of Environment; National Environmental Policy Act (NEPA)." *Code of Federal Regulations*, Council on Environmental Quality.

43 CFR 7. 2002. "Protection of Archaeological Resources." *Code of Federal Regulations*, U.S. Department of Interior.

43 CFR 10. 2007. "Native American Graves Protection and Repatriation Regulations." *Code of Federal Regulations*, U.S. Department of the Interior.

50 CFR 17, Subpart B. 2008. "Endangered and Threatened Wildlife and Plants." Subpart B, "Lists." *Code of Federal Regulations*, U.S. Fish and Wildlife Service.

36 FR 8921, May 13, 1971. Executive Order 11593 of May 6, 1971, "Protection and Enhancement of the Cultural Environment." *Federal Register*.

61 FR 26771-26772, May 24, 1998. Executive Order 13007, "Indian Sacred Sites." *Federal Register*.

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*.

68 FR 10635-10638, March 5, 2003. Executive Order 13287 of March 3, 2003, "Preserve America." *Federal Register*.

69 FR 50176-50180, August 13, 2004. "Notice of Intent to Prepare an Environmental Impact Statement for the Decommissioning of the Fast Flux Test Facility at the Hanford Site, Richland, Washington." *Federal Register*, U.S. Department of Energy.

71 FR 5655-5660, February 2, 2006. "Notice of Intent to Prepare the Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington." *Federal Register*. U.S. Department of Energy.

72 FR 331-336, January 4, 2007. "Notice of Intent to Prepare a Programmatic Environmental Impact Statement for the Global Nuclear Energy Partnership." *Federal Register*, U.S. Department of Energy.

72 FR 31904-31941. 2007. "Procedural Rules for DOE Nuclear Activities and Occupational Radiation Protection." *Federal Register*, U.S. Department of Energy.

72 FR 40135-40139, July 23, 2007. "Notice of Intent to Prepare an Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste." *Federal Register*. U.S. Department of Energy.

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

Antiquities Act of 1906. 1906. Ch. 3060, 34 Stat. 225, 16 USC 431 et seq.

Archaeological and Historic Preservation Act of 1974. 1974. Public Law 93-291, as amended, 16 USC 469 et seq.

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

Atomic Energy Act of 1954. 1954. Chapter 1073, Stat. 921, 42 USC 2011 et seq.

Clean Air Act. 1986. Public Law 88-206, as amended, 42 USC 7401 et seq.

Clean Air Act Amendments of 1990. 1990. Public Law 101-549, as amended, 42 USC 7401 et seq.

Clean Water Act of 1977. 1977. Public Law 95-217, as amended, 33 USC 1251 et seq.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980. 1980. Public Law 96-510, as amended, 42 USC 9601 et seq. Accessed April 22, 2008, at http://www.epa.gov/region5/defs/html/cercla.htm.

DOE/EA-1562. 2007. *Environmental Assessment: Construction and Operation of a Physical Sciences Facility at the Pacific Northwest National Laboratory, Richland, Washington*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/EIS-0222F. 1999. *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/EIS-0286F. 2004. *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/EIS-0364. 2006. *Fast Flux Test Facility Decommissioning Environmental Impact Statement*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE G 441.1-1B. 2007. "Radiation Protection Programs Guide." U.S. Department of Energy, Washington, D.C.

DOE-HDBK-1105-2002 (CN-2). 2007. *Radiological Training for Tritium Facilities*. U.S. Department of Energy, Washington, D.C.

DOE-HDBK-1129-2007. 2007. *Tritium Handling and Safe Storage*. U.S. Department of Energy, Washington, D.C.

DOE-HDBK-1131-2007. 2007. *General Employee Radiological Training*. U.S. Department of Energy, Washington, D.C.

DOE O 153.1. 2007. "Departmental Radiological Emergency Response Assets." U.S. Department of Energy, Washington, D.C.

DOE O 226.1A. 2007. "Implementation of Department of Energy Oversight Policy." U.S. Department of Energy, Washington, D.C.

DOE Order 435.1. 1999. "Radioactive Waste Management." U.S. Department of Energy, Washington, D.C.

DOE Order 451.1B, Change 1. 2001. "National Environmental Policy Act Compliance Program – Change 1." U.S. Department of Energy, Washington, D.C.

DOE Order 5400.5, Chg 2. 1993. "Radiation Protection of the Public and the Environment." U.S. Department of Energy, Washington, D.C.

DOE P 141.1. 2001. "Department of Energy Management of Cultural Resources." U.S. Department of Energy, Washington, D.C.

DOE P 226.1A. 2007. "Department of Energy Oversight Policy." U.S. Department of Energy, Washington, D.C.

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

DOE/RL-2000-27. 2000. *Threatened and Endangered Species Management Plan: Salmon and Steelhead*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2001-41, Rev 2. 2007. *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2006-35, Rev. 1 (Reissue). 2007. *Hanford Facility Dangerous Waste Permit Application, Waste Encapsulation and Storage Facility*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-05. *Hanford Site Air Operating Permit Semiannual Report for January 1, 2007 Through June 30, 2007*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-25. 2007. *2006 Polychlorinated Biphenyl Annual Document Log*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-26. 2007. *2006 Polychlorinated Biphenyl Annual Report*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-01. 2008. *Hanford Site Groundwater Monitoring Report for Fiscal Year 2007*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-03. 2008. *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2007*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-12. 2008. *Hanford Site Air Operating Permit Semiannual Report for July 1, 2007 Through December 31, 2007*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-14, Rev. 0. 2008. *2007 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-15. 2008. *Calendar Year 2007 Criteria and Toxic Air Pollutants Air Emissions Inventory*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-16, Rev. 0. 2008. *2007 Hanford Site Toxic Chemical Release Inventory*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-24. 2008. *Hanford Site Air Operating Permit Annual Compliance Certification Report for the Period January 1, 2007 Through December 31, 2007*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-STD-1107-97 (CN1). 2007. *Knowledge, Skills, and Abilities for Key Radiation Protection Positions at DOE Facilities*. U.S. Department of Energy, Washington, D.C.

DOE-STD-3025-2007. 2007. *Quality Assurance Inspection and Testing of HEPA Filters*. U.S. Department of Energy, Washington, D.C.

DOE-STD-5506-2007. 2007. *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*. U.S. Department of Energy, Washington, D.C.

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 through February 12, 2008, Olympia, Washington. Accessed April 18, 2008, at http://www.hanford.gov/?page=91&parent=0.

Ecology. 1994. *Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste*. Permit Number WA-7890008967, as amended. Washington State Department of Ecology, Olympia, Washington.

Ecology – Washington State Department of Ecology; U.S. Environmental Protection Agency, Region 10; U.S. Department of Energy, Richland Operations Office; and U.S. Department of Energy, Office of River Protection. 2000. *Framework Agreement for Management of Polychlorinated Biphenyls (PCBs) in Hanford Tank Waste.* Accessed August 21, 2008, at http://yosemite.epa.gov/r10/owcm.nsf/72b5220edcd9cf5b88256500005decf3/ce50d3fe12e371f488256a00006ffa0f!OpenDocument.

Emergency Planning & Community Right to Know Act of 1986. 1986. Public Law 99-499, as amended, 42 USC 11001 et seq.

Endangered Species Act of 1973. 1973. Public Law 93-205, as amended, 16 USC 1531 et seq.

Federal Insecticide, Fungicide, and Rodenticide Act of 1975. 1975. Public Laws 94-51, as amended, 7 USC 136 et seq.

Hazardous and Solid Waste Amendments of 1984. 1984. Public Law 98-616, as amended, 42 USC 6901 et seq.

Historic Sites, Buildings and Antiquities Act. 1935. 16 USC 461 et seq.

Migratory Bird Treaty Act. 1918. 16 USC 703 et seq.

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

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

Native American Graves Protection and Repatriation Act. 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, 42 USC 6901 et seq. Accessed April 22, 2008, at http://www.epa.gov/region5/defs/html/rcra.htm.

RPP-12711, Rev. 0. 2003. *Temporary Waste Transfer Line Management Program Plan.* CH2M HILL Hanford Group, Inc., Richland, Washington.

Safe Drinking Water Act of 1974. 1974. Public Law 93-523, as amended, 42 USC 201 et seq.

Safe Drinking Water Act Amendments of 1986. 1986. Public Law 99-339, as amended, 42 USC 201 et seq.

Safe Drinking Water Act Amendments of 1996. 1986. Public Law 104-182, as amended, 110 Stat. 1613, 42 USC 300f et seq.

Superfund Amendments and Reauthorization Act of 1986. 1986. Public Law 99-499, as amended, 42 USC 9601 et seq.

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

U.S. Department of the Interior and Ecology. 2008. *Draft Planning Report/Environmental Impact Statement Yakima River Basin Water Storage Feasibility Study, Yakima Project, Washington.* U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, and Washington State Department of Ecology, Central Regional Office, Yakima, Washington.

U.S. Fish and Wildlife Service. 2006. *Draft Hanford Reach National Monument Comprehensive Conservation Plan and Environmental Impact Statement.* U.S. Fish and Wildlife Service, Richland, Washington.

WAC 16-228. 2007. "General Pesticide Rules." *Washington Administrative Code*, Olympia, Washington.

WAC 173-216. 2006. "State Waste Discharge Permit Program." *Washington Administrative Code*, Olympia, Washington.

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

WAC 173-303-145. 2007. "Spills and Discharges into the Environment." *Washington Administrative Code*, Olympia, Washington.

WAC 173-304. 1988. "Minimum Functional Standards for Solid Waste Handling." *Washington Administrative Code*, Olympia, Washington.

WAC 173-400. 2007. "General Regulations for Air Pollution Sources." *Washington Administrative Code*, Olympia, Washington. Accessed April 22, 2008, at http://apps.leg.wa.gov/wac/.

WAC 173-400-110. 2007. "New Source Review; General Regulations for Air Pollution Sources." *Washington Administrative Code*, Olympia, Washington. Accessed April 22, 2008, at http://apps.leg.wa.gov/wac/.

WAC 173-401. 2002. "Operating Permit Regulation." *Washington Administrative Code*, Olympia, Washington. Accessed April 22, 2008, at http://apps.leg.wa.gov/wac/.

WAC 173-425. 2000. "Outdoor Burning." *Washington Administrative Code*, Olympia, Washington.

WAC 173-460. 1998. "Controls for New Sources of Toxic Air Pollutants." *Washington Administrative Code*, Olympia, Washington. Accessed April 22, 2008, at http://apps.leg.wa.gov/wac/.

WAC 173-460-040. 1998. "New Source Review; Controls for New Sources of Toxic Air Pollutants." *Washington Administrative Code*, Olympia, Washington. Accessed April 22, 2008, at http://apps.leg.wa.gov/wac/.

WAC 173-480. 2007. "Ambient Air Quality Standards and Emission Limits for Radionuclides." *Washington Administrative Code*, Olympia, Washington. Accessed April 22, 2008, at http://apps.leg.wa.gov/wac/.

WAC 173-491. 2007. "Emission Standards and Controls for Sources Emitting Gasoline Vapors." *Washington Administrative Code*, Olympia, Washington. Accessed April 22, 2008, at http://apps.leg.wa.gov/wac/.

WAC 246-247. 2005. "Radiation Protection – Air Emissions." *Washington Administrative Code*, Olympia, Washington. Accessed April 22, 2008, at http://apps.leg.wa.gov/wac/.

WAC 246-290. 2008. "Public Water Supplies." *Washington Administrative Code*, Olympia, Washington.

Washington Pesticide Control Act. RCW 15.58, as amended. *Revised Code of Washington*, Olympia, Washington.

Washington Pesticide Application Act. RCW 17.21, as amended. *Revised Code of Washington*, Olympia, Washington.

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

6.0 Environmental Restoration and Waste Management Operations

J. P. Duncan

Environmental cleanup and decommissioning activities continued at the Hanford Site during 2007. The following sections describe ongoing cleanup operations, facility decommissioning activities, 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 Cleanup Operations

This section describes ongoing cleanup and remediation activities at the Hanford Site.

6.1.1 Soil and Groundwater Remediation Project

B. H. Ford

The Fluor Hanford, Inc. Soil and Groundwater Remediation Project is focused on preventing degradation of the groundwater, and remediating and monitoring the groundwater. Early actions have been underway since the mid-1990s to address principal threats to the Columbia River and groundwater beneath the Hanford Site. These actions are focused on containment and reducing the mass of the primary contaminants of concern released from the vadose zone into the groundwater.

The Soil and Groundwater Remediation Project leads the effort to integrate all projects at the Hanford Site involved in characterization, monitoring, and remediation of groundwater and vadose zone contamination, with the overall objective of protecting the Columbia River. Information on groundwater and vadose zone remediation systems in use in 2007 is summarized in Section 10.7.

6.1.2 Waste Site Investigations and Remediation Activities in the 200 Areas

B. H. Ford

Remedial investigation/feasibility study activities continued during 2007 at waste sites in the 200 Areas. 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 2007.

200-CW-1, 200-CW-2, and 200-CW-4 Operable Units. 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, 200-CW-2, and 200-CW-4 Operable Units consist 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. In 2006, waste sites from 200-CW-2 and 200-CW-4 Operable Units were combined with the 200-CW-1 Operable Unit to form a consolidated operable unit group, which was included in a Central Plateau soil-sites supplemental characterization activity. This activity was conducted by the Tri-Party agencies (Washington State Department of Ecology, U.S. Environmental Protection Agency [EPA], and U.S. Department of Energy [DOE]). Data quality objectives workshops were conducted to determine specific additional characterization activities. Several supplemental remedial investigation activities are planned for 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.

Strontium-90, cesium-137, cadmium, mercury, lead, silver, and polychlorinated biphenyls (PCBs) were the major risk contributors identified for human and ecological receptors. 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, 2010.

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 approved in 2000 that defines planned remedial investigation activities at 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 EPA in March 2006 (Tri-Party Agreement Interim Milestone M-015-39B [Ecology et al. 1989]). Draft B of the feasibility study (DOE/RL-2005-63, Draft B) and proposed plan (DOE/RL-2005-64, Draft B) for this operable unit was submitted in fiscal year 2007.

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, PCBs, and nitrite. A feasibility study (DOE/RL-2004-24, Draft A) and proposed plan (DOE/RL-2004-26, Draft A) were issued to the regulatory agencies in October 2004 (Tri-Party Agreement Interim Milestone M-015-40C [Ecology et al. 1989]). Discussions with the Tri-Party agencies have determined that additional characterization information is not required at this operable unit. Feasibility study revisions are underway, with a Draft B version due to the agencies on July 31, 2008 (Tri-Party Agreement Interim Milestone M-015-40D [Ecology et al. 1989]).

200-CW-3 Operable Unit. Between February and September 2007, soil from 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 sampled to determine appropriate remedial actions for each waste site. These waste sites are small (approximate dimensions range from 15 to 24 meters [50 to 80 feet] in length, 3 to 6 meters [10 to 20 feet] in width and between 1.8 to 2.1 meters [6 to 7 feet] in depth). 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.

Sampling and analysis confirmed that the 216-N-2 and 216-N-3 waste sites associated with the 212-N Building did not require further action. The 216-N-5 waste site, associated with the 212-P Building, and the 216-N-7 waste site, associated with the 212-R Building, each required remediation by removal of the contaminated soil down to a depth of 4.6 meters (15 feet). Approximately 3,919 metric tons (4,320 tons) of contaminated soil was removed and disposed of in the Environmental Restoration Disposal Facility. The 216-N-5 and 216-N-7 waste sites' open excavations were sampled, the soil was analyzed to verify that remedial action goals and objectives were achieved, and the areas were backfilled, contoured, and re-vegetated.

200-SC-1 Operable Unit. Waste sites in the 200-SC-1 Operable Unit received steam condensate liquid wastes from 200-East and 200-West facilities, including the Reduction-Oxidation (REDOX) Plant, T Plant, and Plutonium-Uranium Extraction (PUREX) Plant. A supplemental characterization work plan (DOE/RL-2007-02, Rev. 0) was issued in December 2007. Supplemental remedial investigation activities began in December 2007. Supplemental characterization includes geophysical logging of shallow drive-point casings and characterization drilling to determine vadose zone contamination. Primary contaminants of concern included strontium-90, cesium-137, tritium, plutonium isotopes, uranium, fluoride, and nitrite. A feasibility study and proposed plan is scheduled in 2009 to support submission of a feasibility study and proposed plan by December 2010 (Tri-Party Agreement Milestone M-015-40E [Ecology et al. 1989]).

200-TW-1, 200-TW-2, and 200-PW-5 Operable Units. The 200-TW-1 Operable Unit consists of waste sites, which are 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. All activities in the 200-TW-1, 200-TW-2, and 200-PW-5 Operable Units were on hold in fiscal year 2007 because of other priorities. A supplemental remedial investigation work plan (DOE/RL-2007-02, Rev. 0) has been approved to collect additional data required for decision making regarding the 200-TW-1, 200-TW-2, and 200-PW-5 Operable Units. Supplemental data collection is scheduled to begin in fiscal year 2008. Revisions to the 200-TW-1, 200-TW-2, and 200-PW-5 Operable Units feasibility study and proposed plan are scheduled for fiscal year 2010.

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 the 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 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 delivered 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) was submitted to EPA in September 2007 in fulfillment of Tri-Party Agreement Interim Milestone M-015-45B (Ecology et al. 1989). Draft B of the feasibility study and proposed plan are scheduled to be complete by the end of 2008.

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. During 2006, data quality objectives workshops were conducted to determine specific future characterization strategies. These new strategies, which include supplemental characterization for the 200-PW-2 Operable Unit, were documented in a supplemental work plan (DOE/RL-2007-02, Rev. 0), which was approved by the Tri-Party agencies and published in December 2007. As a result of the supplemental work plan, site-specific sampling and analysis plans were prepared in late 2007 and will be submitted for approval in 2008 in support of conducting field work during fiscal year 2008. As specified in the site-specific sampling and analysis plan, characterization activities scheduled for 2008 include three direct-push boreholes (one at the 216-A-5 Crib and two at the 216-S-1&2 Crib) and up to two deep vadose zone boreholes (one at 216-A-5 Crib and one at 216-S1&2 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 in the 200 Areas that

supported the major chemical processing facilities and equipment decontamination at T Plant. A supplemental characterization work plan (DOE/RL-2007-02, Rev. 0) was issued in December 2007. Supplemental remedial investigation is scheduled to begin in fiscal year 2009. Supplemental characterization will include geophysical logging of shallow drive-point casings and characterization drilling to determine vadose zone contamination. Primary contaminants of concern identified include strontium-90, technetium-99, cesium-137, americium-241, plutonium isotopes, uranium, and nitrite. A feasibility study and proposed plan will be initiated in fiscal year 2010 to support submission of a feasibility study and proposed plan by December 2011 (Tri-Party Agreement Interim Milestone M-015-46B [Ecology et al. 1989]).

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. The need for additional field studies was established by data quality objectives workshops held during 2006. These workshops and associated delineation of field investigations are documented in the supplemental work plan (DOE/RL-2007-02, Rev. 0), which was approved in December 2007.

During 2007, supplemental field investigations associated with the present waste sites in the 200-MW-1 Operable Unit (i.e., 216-A-2, 216-A-4, 216-A-21 Cribs and 200-E-102 Trench) were completed. 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).

The borehole summary report for well 299-E24-23 (borehole C5301) and borehole C5302 drilled in the vicinity of the 216-A-4 Crib and the 216-E-102 Trench was released in August 2007 (SGW-33959). This report documents the drilling and sampling activities for the 216-E-102 Trench and 216-A-4 Crib. Documentation of the 216-A-2 and 216-A-21 Crib drilling and sampling activities will be completed in 2008. 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. In fiscal year 2006, a data quality objectives process (Phase I-A) for non-intrusive work was completed (D&D-27257), and a sampling and analysis instruction was issued (D&D-28283) to support preliminary remedial investigations. Non-intrusive characterization field work was completed in fiscal year 2006, including geophysical investigation, passive organic-vapor sampling, radiation surveys, and additional historical information research. Conceptual site models were revised based on historical and non-intrusive information. A second data quality objectives process (Phase I-B) was initiated in early fiscal year 2007 and later published (SGW-33253). 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 embraced 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. Upon resolution of comments, the work plan will be issued and Phase I-B investigation will commence.

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 farms contractor, CH2M HILL Hanford Group, Inc.

DOE, Washington State Department of Ecology, and EPA recently 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 Area (Central Plateau) non-tank-farm operable units. The milestones were revised to allow additional site characterization to be completed 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 Fluor Hanford, Inc. 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. The closure plan, due December 31, 2008, for the 241-CX tank system, is being prepared to meet Tri-Party Agreement Milestone M-20-54 (Ecology et al. 1989). A data quality objectives process was initiated in 2005 to identify characterization needs for completing the remedial investigation/feasibility study process for the 200-IS-1 Operable Unit pipelines. Planning for field work was initiated in 2007 for the six process waste bins identified in the data quality objective process. A phased characterization approach using direct-push technology and test pits is planned for fiscal year 2008. DOE submitted DOE/RL-2002-14, Draft B, Rev. 1, in June 2007 in accordance with Tri-Party Agreement Milestone M-013-27 (Ecology et al. 1989). The Washington State Department of Ecology reviewed the Draft B, Rev. 1 document and provided comments to DOE for resolution.

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 agree 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, containing waste sites with shallow or readily addressed contamination and for which decision making is straightforward and supplemental data are not required (Ecology et al. 2006). This model group includes 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 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 sites). Waste sites may include unplanned releases, shallow leaks from pipelines or tanks, and contamination spread by burrowing wildlife.

A Tri-Party Agreement (Ecology et al. 1989) milestone was established for submittal of a feasibility study for these sites. The majority of these sites are candidates for the removal, treatment, and disposal remedy; the no-action remedy; or the maintain-as-is existing soil cover/monitored natural attenuation/ institutional controls remedy.

Following remedy implementation for the 200-MG-1 and 200-MG-2 wastes sites, further characterization will be conducted to confirm that agreed-upon cleanup levels have been achieved. Confirmatory sampling will be needed to assure that monitored natural attenuation or no-action remedies are appropriate. Sites with the potential for groundwater impact may need a more robust monitoring scheme and/or may require a minimal cap. However, this would most likely indicate that the waste sites would no longer be considered Model Group 1 or 2 sites. If confirmation sampling or the observational approach shows that a site is more than a shallow contamination problem, the site may need to be re-evaluated and other alternatives considered.

200-UR-1 Operable Unit. The 200-UR-1 Operable Unit consists of 51 unplanned release waste sites: 2 major and 49 minor sites. The majority of these waste sites are located within the core zone boundary, the area encompassing waste management activities that will contain permanently disposed waste after site closure. 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. The more contaminated region has undergone an engineering evaluation/cost analysis, which includes an evaluation of alternative actions and selection of the preferred alternative. 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 presently being 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 edge of the pond.

The remaining 49 sites are unplanned release sites consisting of small volume spills to the ground surface or subsurface and can be grouped as follows:

- Sites currently identified as Reject or No Action. Reclassification documentation is planned for these sites (19 sites).
- Candidate sites for reassignment to another operable unit or remediation group for completion of removal action (30 sites).

BC Cribs and Trenches Area. The BC Cribs and Trenches Area was identified for accelerated closure during 2003. Two boreholes were drilled in this area in fiscal year 2004. Evaluations of these boreholes were included in a feasibility study (DOE/RL-2004-66, Draft A) and proposed plan (DOE/RL-2004-69, Draft A) that were submitted to the Tri-Party agencies in May 2005. As a result of the feasibility study, geophysical electrical resistivity characterization was conducted to delineate the extent of anomalous soil conductivity believed to result from deep, mobile contamination that is primarily nitrate, sodium, and technetium-99. Preparations to "ground-truth" the electrical resistivity characterization data were initiated to include the drilling and sampling of up to five boreholes. Also, an excavation-based treatability test, still in progress, focuses on the near-surface contamination comprised primarily of strontium-90 and cesium-137. The objective is to refine worker dose and cost estimates for removal and disposal of the highly contaminated near-surface soil. Treatability test Phase 1 field work to further characterize the 216-B-26 Trench was completed by installing 60 shallow direct-push technology holes. The holes were geophysically logged to ascertain gamma-emitting radionuclide concentration and distribution, and 24 samples were collected and analyzed. Preparations were initiated for the next phase of the treatability test that will excavate the first of three portions of the trench.

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 the 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 have been compiled and evaluated in the *Central Plateau Terrestrial Ecological Risk Assessment* report (DOE-RL-2007-50), which will support the remedial investigation/feasibility study process for the Central Plateau.

6.1.3 Cleanup and Remediation Activities in the 100 Areas

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

6.1.3.1 Remediation of Waste Sites in the 100 Areas

J. W. Golden and A. K. 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 2007 were performed in multiple locations in the 100 Areas, including the 100-B/C, 100-K, 100-D, and 100-F Areas. 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, 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 2007. Waste burial grounds require cleanup but also present a significant health and safety risk to workers due to 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 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 the 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 in the 200 Areas. 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 2007, a total of 352,200 metric tons (388,200 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:

- 38,800 metric tons (42,800 tons) from the 100-B/C Area
- 41,700 metric tons (46,000 tons) from the 100-K Area
- 128,100 metric tons (141,200 tons) from the 100-F Area
- 143,600 metric tons (158,300 tons) from the 100-D Area.

6.1.3.2 K Basins Closure Activities

M. S. Gerber

Fluor Hanford, Inc. managed the K Basins Closure Project and cleanout of the K Basins in 2007. 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 N Reactor spent fuel and a small quantity of slightly irradiated single-pass reactor fuel (fuel from older Hanford Site reactors). The fuel was removed in a major cleanup project that ended in October 2004.

Corrosion of the fuel during storage left behind up to 28 cubic meters (37 cubic yards) of sludge. The majority of the sludge—up to 18.4 cubic meters (24 cubic yards)—was in the K-East Basin. Sludge is a non-homogeneous mixture of debris including windblown sand and environmental particulates, fragments of concrete from the basin walls, corrosion products from fuel canisters and fuel racks, fuel cladding pieces, tiny bits of corroded uranium fuel (uranium oxides, hydrates, and hydrides), ion-exchange resin beads,

PCBs, and fission products. Several different forms of sludge exist in the K Basins, dependent on the basin, canister type, and pit location where the particular sludge was found. 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 to be sludge.

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

During 2007, the Fluor Hanford, Inc. K Basins Closure Project made the following progress in cleaning out the K Basins:

- Grappled, washed, and loaded out more than 90 metric tons (100 tons) of debris and fuel racks from both K Basins. The debris and fuel racks were packaged and readied for shipment to the Hanford Site's Environmental Restoration Disposal Facility as low-level nuclear waste. Waste shipments from the K Basins to the Environmental Restoration Disposal Facility were ongoing throughout the year.
- Vacuumed and containerized all sludge in the K-East Basin.
- Transferred the sludge from K-East Basin containers to K-West Basin containers using a special Hose-in-Hose Transfer System.
- Transferred out all of the "found fuel" scraps from the K-East Basin to the K-West Basin.
- Vacuumed and containerized all floor and pit sludge in the K-West Basin into underwater containers (about 3.8 cubic meters [5 cubic yards] of sludge).
- Began deactivation and decommissioning the K-East Basin, which included grouting the floor and removing sand from the sand filter.
- Re-evaluated and began re-design of a new Sludge Treatment System that will treat the bulk of the K Basins sludge.

6.1.3.3 Revegetation of Washington Closure Hanford LLC's Remediated Waste Sites in the 100 Areas

A. L. Johnson

Washington Closure Hanford LLC's Field Remediation Project revegetated several remediated and backfilled waste sites in the 100-B/C and 100-F Areas in the spring and winter of 2007. The revegetation project planted 4,000 kilograms (8,800 pounds) of native grass seed and 65,000 sagebrush seedlings across 59 hectares (145 acres). In addition to the revegetation project, Washington Closure Hanford LLC's Waste Operations Project planted 20,000 sagebrush seedlings and installed 10 artificial burrowing owl nest boxes across 25 hectares (62 acres) south of the Environmental Restoration Disposal Facility as compensatory mitigation for approximately 20 hectares (50 acres) of land utilized for staging soils during disposal cell expansion construction.

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

S. M. Hahn

The DOE Richland Operations Office made significant progress in 2007 on recommendations from the Defense Nuclear Facilities Safety Board.

The Defense Nuclear Facilities Safety Board Recommendation 2000-1 (DNFSB 2000) has one remaining commitment open related to K Basins: to complete the removal of containerized sludge from the K-West Basin and treat it to meet applicable waste acceptance criteria by November 30, 2009. Completed commitments during 2007 include the following:

- Transferred sludge from the K-East Basin to engineered containers within the K-West Basin in May
- Completed containerization of bulk sludge in the K-West Basin in July
- Removed the back-flushed filter sludge from the K-East North Load-Out Pit in July.

Additional progress in 2007 included the following:

- In June, the DOE Richland Operations Office completed the Defense Nuclear Facilities Safety Board commitment to provide a resource-loaded schedule (the linkage of scope, schedule, and budgeted cost) and a funding plan as part of implementation for Defense Nuclear Facilities Safety Board Recommendation 2005-1 (DNFSB 2005).
- The ventilation system evaluation report for the DOE Richland Operations Office facilities was completed and submitted to DOE Headquarters, fulfilling commitments in the DOE Defense Nuclear Facilities Safety Board Recommendation 2004-2 Implementation Plan (DNFSB 2004).
- The DOE Richland Operations Office completed recommended actions in response to Defense Nuclear Facilities Safety Board Recommendation 2002-3 to incorporate specific administrative controls into facility safety bases (DNFSB 2002). These actions implement *Specific Administrative Controls* (DOE-STD-1186-2004).
- The DOE Richland Operations Office performed three major assessments on Fluor Hanford, Inc. nuclear facilities' vital safety systems, verifying that these systems can and will continue to be able to perform their respective safety functions.

6.1.3.5 DOE Office of River Protection Progress on Defense Nuclear Facilities Safety Board Recommendations

N. C. Welliver

Throughout 2007, 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
- Business case study of early production of immobilized low-activity waste
- Supplemental waste treatment and its potential effect on the Hanford Tank Waste Treatment and Immobilization Plant
- Seismic hazards
- Borehole project
- Summary structural reports for the high-level waste immobilization facility
- Industry external flow sheet review team activities
- Hydrogen accumulation in pipes and ancillary vessels
- Building codes
- Fire protection
- Electrical systems
- Nuclear criticality safety program.

DOE and CH2M HILL Hanford Group, Inc. staff met with and provided information to Defense Nuclear Facilities Safety Board members and technical staff throughout 2007 to discuss the following topics:

- Authorization basis maintenance activities
- Tank farms-based pretreatment technologies
- Tank waste characterization, data use, modeling, and mission flow sheets
- Tank waste evaporator campaigns
- Tank waste process control
- Tank retrievals
- Double-shell tank corrosion control
- Double-shell tank space management
- Double-shell tank and evaporator upgrades
- Vadose zone sampling and surface barrier erection
- Fire protection
- Emergency response
- Demonstration bulk vitrification system
- Nuclear criticality safety program.

In 2007, as part of DOE's response to the Defense Nuclear Facilities Safety Board Recommendation 2007-1, *Safety-Related In Situ Nondestructive Assay of Radioactive Materials* (DNFSB 2007), DOE submitted an implementation plan addressing holdup measurements of fissionable material

in installed process equipment, ancillary equipment, and supporting facility infrastructure using in situ nondestructive assay (DOE 2007). The DOE Office of River Protection submitted a list of Environmental Management Hazard Category 2 nuclear facilities and Environmental Management Hazard Category 3 nuclear facilities with criticality safety programs to the DOE Office of Environmental Management. This action, taken to support the 2007-1 Implementation Plan, identified existing criticality safety programs and their dependence on in situ nondestructive assay. A prioritization of the identified facilities was performed based upon criticality accident risk.

6.1.4 Remediation of Waste Sites in the 300 Area

J. W. Golden, S. Parnell, and A. K. 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 efforts in 2007 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 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. Characterization 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.

The 300-FF-2 Operable Unit waste sites are authorized for remediation activities through a record of decision approved by EPA, DOE, and the Washington State Department of Ecology (EPA/ROD/R10-01-119). Waste generated from the cleanup of these waste sites is disposed at the Hanford Site's Environmental Restoration Disposal Facility located in the 200 Areas and other EPA-approved disposal facilities. The Environmental Restoration Disposal Facility is discussed in Section 6.3.3.6.

A total of 336 metric tons (370 tons) of contaminated soil from the 300-FF-2 Operable Unit was disposed at the Environmental Restoration Disposal Facility in 2007. No waste was shipped to the Waste Isolation Pilot Plant.

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 remediating these two waste sites was transferred from Fluor Hanford, Inc. to Washington Closure Hanford LLC. After the transfer, Washington Closure Hanford LLC developed a design solution for the sites, evaluating waste removal and packaging technologies and disposal pathways to determine the most cost-effective methods, which was 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 is preparing a characterization plan that will be submitted to DOE in 2008.

6.2 Facility Decommissioning Activities

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

6.2.1 Facility Decommissioning in the 200 Areas (Central Plateau)

This section provides information about the transition and decommissioning of facilities in the 200 Areas.

6.2.1.1 Plutonium Finishing Plant

M. S. Gerber

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, re-package, and/or properly dispose of nearly 18 metric tons (19.8 tons) of plutonium-bearing materials in the plant. The 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 2007, DOE directed Fluor Hanford, Inc. to begin to de-inventory Hanford Site plutonium for shipment to another DOE site.

Significant accomplishments achieved by Fluor Hanford, Inc. at the Plutonium Finishing Plant during 2007 included the following:

- Cleaned out contaminated equipment from 15 plutonium processing gloveboxes and "hoods" (open-faced enclosures used for working with plutonium), downgrading some of them to low-level waste status. Started cleanout of glovebox HA-23S. More than 90 gloveboxes and hoods in the main Plutonium Finishing Plant process building were cleaned out by the end of 2007.
- Completed cleanout of the last cell and tank beneath the 241-Z Liquid Waste Treatment Facility, and demolished the facility along with two ancillary structures. Completed rubble removal and site stabilization.
- Completed disposal of a waste container backlog that included more than 100 shipments of transuranic waste and more than 215 shipments of low-level waste out of the Plutonium Finishing Plant complex.
- Completed cleanout of the South Canyon airlock in the Plutonium Reclamation Facility.
- Completed multiple-facility "life-extension" upgrades, including improving fire systems, upgrading and re-configuring the criticality system, replacing or refurbishing large supply and exhaust fans in multiple buildings, and upgrading electronic controls in various facilities.
- Built a special robot to characterize equipment and facilities that had once been used to remove

plutonium-contaminated soil from the 216-Z-9 Crib and mine; produced hazards conditions analysis report (HNF-34723).

- Began plutonium de-inventory.

6.2.1.2 Surveillance, Maintenance, and Deactivation Activities in the 200 Areas and on the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit

G. J. LeBaron

Disposition of 200 Areas 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 Unit. 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, including former waste-disposal cribs, ponds, ditches, trenches, unplanned release sites, and waste burial grounds continued in 2007. Periodic surveillances, radiation surveys, and herbicide applications were performed at these sites 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.

6.2.1.3 Investigation of the Potential for Using the 200 Areas Chemical Separations Plants as Waste-Disposal Facilities

E. R. Jacobs

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) at 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 the 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 the fall of 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 below-ground plant process cells; the cells, galleries, and other void spaces will be backfilled with grout; the exterior walls and roof will be collapsed in place; and the site will be covered with a barrier.

Following issuance of the U Plant record of decision, the DOE began conceptual design work for its implementation. In December 2006, DOE issued the *Remedial Design/Remedial Action Work Plan for the 221-U Facility* (DOE/RL-2006-21, Draft A) for review by the regulatory agencies. Review comments from the regulatory agencies were received in July 2007, and the draft document is being revised to incorporate these comments. 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).

No waste is currently planned to be imported into U Plant as a part of the remedial action. 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 the

significant differences between each building. Planning to support development of a remedial decision on the Plutonium-Uranium Extraction (PUREX) Plant was initiated in the fall of 2006. Currently, preparation efforts for the U Plant remediation have been delayed because of budgetary restraints.

6.2.2 Decommissioning of 300 Area Facilities

M. L. Proctor

During 2007, 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) was issued, which authorizes D4 activities for the 324 and 327 Facility complexes.

The following 300 Area buildings were demolished during 2007:

- 306E Development, Fabrication, and Test Laboratory
- 306EBA Boiler Annex
- 306W Material Development Laboratory
- 328 Engineering Services and Safety Building
- 328A Sheet Metal Shop
- 328BA Boiler Annex
- 3705BA Boiler Annex
- 3706 Communications and Documentation Services
- 3706A Ventilation Equipment Room
- 3706BA Boiler Annex
- 3707H Change House
- 3709 Paint Shop
- 3718S General Storage
- 3719 Computer Facility
- 3720 Chemistry and Metal Sciences Laboratory
- 3720BA Boiler Annex
- 3731 Laboratory Equipment Central Pool
- 3731A Graphite Machine Shop
- 3745 Radiological Calibration and Standards
- 3745A Van de Graff Electron Accelerator
- 3745B Van de Graff Positive Ion Accelerator
- 3746 Irradiation Physics Building
- 3746A Radiological Physics Building
- MO-905 Mobile Office Trailer.

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

6.2.3 Deactivation of 400 Area Facilities

M. T. York

The Fast Flux Test Facility is a DOE owned, formerly operating, 400-megawatt (thermal) liquid-metal cooled (sodium) research and test reactor located in the 400 Area. Built in the late 1970s, the original purpose 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 2007, fuel removal from the 400 Area Property Protected Area continued. The remaining mixed-oxide fuel assemblies were removed, processed, and placed in interim spent nuclear fuel storage casks. Two interim storage casks were transferred to the 200 Areas Interim Storage Area at the end of 2005, and eight interim storage casks with fuel

were transferred to the 200 Areas Interim Storage Area in 2006. Three empty interim storage casks remain in storage at the 400 Area Interim Storage Area. Fuel removal has allowed the Fuel Storage Facility to be de-energized and all water sources removed and capped, placing the facility in a "cold and dark" condition. Re-certification of T-3 shipping casks was completed in 2007, prior to their use for transferring sodium-bonded fuel pins to the Idaho National Laboratory. These T-3 cask shipments will remove the last of the fuel pins from the Fast Flux Test Facility in 2008.

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 vessels and placed in two storage boxes. Each storage box contains about 757 liters (200 gallons) of contaminated sodium. The removal of the core component pots allowed the remaining sodium in interim-decay storage vessels 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., the 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. These boxes were declared hazardous mixed waste in late 2006, requiring the establishment of a RCRA storage unit. Temporary authorization was issued by the Washington State Department of Ecology. 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. A RCRA treatment, storage, and disposal permit for container storage of hazardous mixed waste for greater than 90 days was issued by the Washington State Department of Ecology and became effective in November 2007.

Deactivation activities continued through 2007 and into 2008. Workers are continuing to remove and/or replace transformers containing PCBs as their need decreases. 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 through 2009, culminating in a long-term, low-cost surveillance and maintenance condition. Final decommissioning is dependent upon an ongoing environmental impact statement activity for waste management and tank farms; the resultant record of decision will determine the final end-state for the Fast Flux Test Facility.

6.2.4 Decommissioning of Facilities in the 100 Areas

M. L. Proctor

During 2007, 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 Areas buildings were demolished during 2007:

- 105-NB (above grade)
- 1312N Liquid Effluent Retention Facility
- 1313N Change Control Building
- 1314N Liquid Waste Disposal Building
- MO-900, MO-911, MO-358, MO-055, MO-050, MO-950, MO-829, MO-390 mobile office trailers.

In addition to field activities, several planning efforts were underway to support future actions in the 100 Areas. Although clean-out activities are still ongoing at the K Basins, an engineering evaluation/cost analysis was issued to address interim safe storage of the 105-K East and 105-K West Reactors and demolition of 100-K Area ancillary facilities. The action memorandum for the 105-K East and 105-K West Reactors and the 100-K Area ancillary facilities was approved by DOE and EPA on January 4, 2007, to support the interim safe storage of the 105-K East and 105-K West Reactors by September 2011, in accordance with Tri-Party Agreement Milestone M-93-22 (Ecology et al. 1989). The *Removal Action Work Plan for 105-KE/105-KW Reactor Facilities and Ancillary Facilities* (DOE/RL-2005-26, Rev. 1) was approved by DOE and EPA on February 5, 2007.

6.3 Waste Management Operations

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

6.3.1 Waste Classifications

W. E. Toebe and J. O. 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 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-2008-06, Rev. 0, Reissue). 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 used 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 historically was disposed of at 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 sites in the 100 Areas.

6.3.2 Solid Waste Inventories

Quantities for both mixed and radioactive wastes generated onsite or received from offsite sources, and disposed of at the Hanford Site from 2003 through 2007, are provided in Table 6.3.1. Quantities of dangerous waste shipped offsite from 2003 through 2007 are shown in Table 6.3.2. Hanford Site solid waste management is discussed in Section 6.3.3.

6.3.3 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

Table 6.3.1. Quantities of Solid Waste[a] Generated on the Hanford Site, 2003 Through 2007, kg (tons)

Waste Category	2003	2004	2005	2006	2007
Mixed	421,000 (464)	144,512 (159)	349,416 (385)	315,188 (347)	235,378 (259)
Radioactive	758,000 (836)	906,591 (999)	1,188,212 (1,310)	465,340 (513)	299,701 (330)

(a) Solid waste includes containerized liquid waste.

Table 6.3.2. Quantities of Dangerous Waste[a] Shipped Off the Hanford Site, 2003 Through 2007, kg (tons)

Waste Category	2003	2004	2005	2006	2007
Containerized	83,500[b] (92)	75,296[b] (83)	71,601[b] (79)	18,700[b] (21)	47,979[b] (53)
	91,800[c] (101)	49,560[c] (55)	61,422[c] (68)	33,285[c] (37)	35,146[c] (39)
Bulk Solids	0	0	0	0	0
Bulk Liquids	48,400 (53)	35,057 (39)	49,154 (54)	917 (1)	96,653 (107)
Total	224,000 (247)	159,913 (176)	182,177 (201)	52,902 (58)	179,778 (198)

(a) Does not include *Toxic Substances Control Act* waste.
(b) Dangerous waste only.
(c) Mixed waste (radioactive and dangerous).

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

6.3.3.1 Central Waste Complex

B. M. Barnes

Waste is received at the Central Waste Complex, located in the 200-West Area, from sources at 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 on 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 7,930 cubic meters (10,370 cubic yards).

The Central Waste Complex can store as much as 20,796 cubic meters (27,200 cubic yards) 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 of each container is established at the point of origin based on process knowledge or sample analysis.

6.3.3.2 Waste Receiving and Processing Facility

H. C. 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 (21,900-square-foot) storage buildings is located north of the Central Waste Complex in the 200-West Area. The facility dispositioned and shipped offsite 691 cubic meters (904 cubic yards) of waste during calendar year 2007.

6.3.3.3 T Plant Complex

P. W. 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 2007:

- Numerous containers and boxes of waste were sampled, characterized, treated, and repackaged to meet waste acceptance criteria and land-disposal restrictions requirements.
- In the fall of 2007, a second shift was added to the 221-T Canyon Building production for repackaging of transuranic waste drums and/or process legacy waste. In 2007, eight hundred and fifty-seven, 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 is scheduled for completion in 2008. The metal roof addition will cover the existing flat asphalt roof and will be 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 will provide weather protection to workers and waste containers.
- A super-compactor, installed in the 221-T Canyon in March 2007 to crush empty waste containers, is expected to conserve landfill space in the onsite disposal units. As of December 31, 2007, the compactor had crushed 1,051 empty containers.

6.3.3.4 Mixed Low-Level Waste Treatment and Disposal Facility

D. E. Nester

On a pretreatment volume basis, 1,460 cubic meters (1,910 cubic yards) of mixed low-level waste were treated and/or directly disposed during 2007. The treated waste residues resulting from waste treatment was disposed at either the Hanford Site Mixed Waste Disposal Facility (approximately 1,100 cubic meters [1,440 cubic yards]) or the Environmental Restoration Disposal Facility (approximately 360 cubic meters [471 cubic yards]). All of this waste volume contributed to the successful completion of Tri-Party Agreement Milestones M-91-12 and M-91-42(D) (Ecology et al. 1989).

Below is a breakdown of the treated and or directly disposed mixed low-level waste:

- One thousand three hundred and eighty cubic meters (1,805 cubic yards) of mixed low-level waste, or approximately 6,635 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. All of this waste contributed toward Tri-Party Agreement Milestone M-91-42(D) (Ecology et al. 1989).

- Five cubic meters (7 cubic yards) of mixed low-level waste, or approximately 26 drum equivalents, were treated and disposed of in support of treatment objectives in Tri-Party Agreement Milestone M-91-12 (Ecology et al. 1989). This waste 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 34 and 31 at the Radioactive Mixed Waste Disposal Facility.
- Seventy-five cubic meters (98 cubic yards) of mixed low-level waste, or approximately 360 drum equivalents, were disposed at the Radioactive Mixed Waste Disposal Facility. This waste came from various Hanford Site generators and was either treated offsite by commercial waste processors, onsite by the generator, or was not treated because it met land-disposal restriction standards in the "as-generated" state. All of this waste contributed toward Tri-Party Agreement Milestone M-91-42(D) (Ecology et al. 1989).

6.3.3.5 Disposal of U.S. Navy Reactor Compartments

S. G. Arnold

Two disposal packages containing defueled U.S. Navy reactor compartments were received and placed in Trench 94 of the 218-E-12B Burial Ground in 2007, bringing the total number of reactor compartments received to 117. 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 908 and 1,362 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).

6.3.3.6 Environmental Restoration Disposal Facility

M. A. 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 in-ground facility, the Environmental Restoration Disposal Facility was constructed to RCRA Subtitle C minimum technology requirements, which include 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 cells 1 and 2 that have been brought up to ground level. Cells 3 and 4 have reached their operational capacity. Construction of cells 5 and 6 has been completed; the cells began receiving waste in January 2005. All six cells are roughly equal in size, each holding approximately 1.27 metric tons (1.4 million tons) or approximately 0.61 million cubic meter (0.8 million cubic yard).

In 2007, approximately 398,500 metric tons (439,300 tons) of remediation waste were disposed at the facility. Approximately 6.5 million metric tons (7.2 million tons) of remediation waste have been placed in the Environmental Restoration Disposal Facility from initial operations start-up through 2007. Planning for construction of cells 7 and 8 was completed in 2007 with construction scheduled to start in 2008. The total available expansion area of the Environmental Restoration Disposal Facility site 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).

6.3.3.7 Radioactive Mixed Waste Disposal Facility

D. E. Nester

The Radioactive Mixed Waste Disposal Facility is located in the 218-W-5 Low-Level Waste Burial Ground in the 200-West Area and is designated as 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 4,100 cubic meters (5,360 cubic yards) of disposed waste in 3,887 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 1,200 cubic meters (1,570 cubic yards) of waste disposed in 1,363 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 5,300 cubic meters (6,930 cubic yards); 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 in Trenches 31 and 34 is approximately 6,120 cubic meters (8,000 cubic yards).

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, 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 at the Hanford Site. Low-level waste is currently being disposed in Trenches 31 and 34.

6.3.3.8 Low-Level Burial Grounds

B. M. 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 Burial Ground 218-W-5 are lined trenches with leachate collection and removal systems (see Sections 6.3.3.4 and 6.3.3.7). Trench 94 in Burial Ground 218-E-12B is used for disposal of defueled U.S. Navy reactor compartments (Section 6.3.3.5). 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 at 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. 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 at 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.

6.3.4 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.

6.3.4.1 Liquid Effluent Retention Facility

M. D. Guthrie

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 2007 was approximately 56.6 million liters (15 million gallons). This included approximately 5.76 million liters (1.52 million gallons) of RCRA-regulated wastewater from 242-A Evaporator process condensate and approximately 3.93 million liters (1.04 million gallons) 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 44.3 million liters (11.7 million gallons) of groundwater was received direct from the originating source via pipeline, as were the above mentioned waste streams. Approximately 2.56 million liters (676,000 gallons) of wastewater were received from various facilities by tanker trucks. The wastewater volume transferred to the Effluent Treatment Facility for treatment and disposal in 2007 was 32.9 million liters (8.69 million gallons).

The volume of wastewater being stored in the Liquid Effluent Retention Facility at the end of 2007 was 38.3 million liters (10.1 million gallons).

6.3.4.2 Effluent Treatment Facility

M. D. Guthrie

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 2007 was approximately 32.9 million liters (8.69 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).

6.3.4.3 200 Area Treated Effluent Disposal Facility

M. D. Guthrie

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 facilities. 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 2007 was 1.31 billion liters (346 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.

6.3.4.4 300 Area Treated Effluent Disposal Facility

D. L. 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 ultraviolet 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 2007 was 168.0 million liters (44.4 million gallons).

6.3.4.5 242-A Evaporator

T. L. 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. The 242-A Evaporator completed two campaigns during 2007 in back-to-back operations lasting 66 days. The volume of waste treated was 7.8 million liters (2.1 million gallons), reducing the waste volume by 4.5 million liters (1.2 million gallons), a waste reduction of approximately 58% (not including flush water). The volume of process condensate transferred to the Liquid Effluent Retention Facility for subsequent treatment in the Effluent Treatment Facility was 6.1 million liters (1.6 million gallons). Also, as part of a waste minimization effort, activities required to complete the 242-A Evaporator integrity assessment were performed using flush water added to the unit at the beginning of the initial campaign, reducing the amount of raw water being added to the overall waste volume. This volume is not included in the calculation of percent waste reduction.

6.3.5 Washington State Initiative 297, The *Cleanup Priority Act*

M. K. Marvin

Initiative 297, known as the *Cleanup Priority Act*, was passed by Washington State voters in November 2004. The *Cleanup Priority Act* sought to add a new chapter to the *Mixed Radioactive and Hazardous Waste* (RCW 70.105E) law and among other things, would have restricted importing offsite waste to the Hanford Site, established cleanup standards for radioactive releases, and required the DOE to pay a new mixed-waste surcharge. In December 2004, the U.S. Department of Justice challenged the initiative, arguing it violated the U.S. Constitution. The federal district court agreed, ruling Initiative 297 was "invalid in its entirety." The state of Washington's Attorney General appealed the ruling, but in May 2008, the Ninth Circuit Court of Appeals affirmed the lower court's decision, holding the initiative was preempted by the *Atomic Energy Act of 1954*.

6.4 Underground Waste Storage Tanks

M. E. Cole

Most Hanford Site waste is stored in 177 large underground single-shell (one wall) and double-shell (two walls) tanks located in the 200 Areas 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 of which are assumed to have leaked in the past. All of the 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 prevent additional environmental releases. The following sections summarize waste tank related activities that occurred in 2007.

6.4.1 Waste Tank Status

This section provides information about the 149 single-shell and 28 double-shell tanks on the Hanford Site, and activities that occurred in fiscal year 2007 related to their operation and closure. Quantities of liquid waste generated in 2007 and stored in underground storage tanks are included in the *Hanford Facility Annual Dangerous Waste Report Calendar Year 2007* (DOE/RL-2008-06, Rev. 0, Reissue). Table 6.4.1 summarizes the liquid waste generated from 2002 through 2007 and stored in underground storage tanks.

6.4.1.1 Single-Shell Tanks

The Tri-Party Agreement (Ecology et al. 1989) formally establishes a schedule for interim stabilization, retrieval, and closure of the Hanford Site 200 Areas 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 ensure the tanks would no longer leak their contents to the environment.

Table 6.4.1. Quantities of Liquid Waste[a] Generated and Stored Within the Tank Farm System on the Hanford Site During 2007 and the Previous 5 Years, L (gal)

Type of Waste	2002[b]	2003	2004	2005	2006	2007
Volume of waste added to double-shell tanks	9,280,000 (2,452,000)	9,710,000 (2,565,000)	3,316,000 (876,000)	3,668,000 (969,000)	3,547,000 (937,000)	5,901,000 (1,559,000)
Total volume in double-shell tanks (year end)	87,683,000 (23,163,000)	92,693,000 (24,487,000)	95,275,000 (25,169,000)	98,943,000 (26,138,000)	101,411,000 (26,790,000)	101,052,000 (26,695,000)
Volume evaporated at 242-A Evaporator	1,578,000 (417,000)	4,720,000 (1,247,000)	734,000 (194,000)	707,000 (187,000)	1,052,000 (278,000)	4,500,000 (1,189,000)
Volume pumped from single-shell tanks	5,288,000[c] (1,397,000)[c]	6,185,000[c] (1,634,000)[c]	2,778,000[c] (734,000)[c]	888,000[c] (235,000)[c]	2,953,000[d] (780,000)[d]	4,342,000[d] (1,147,000)[d]

(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.

CH2M HILL Hanford Group, Inc. completed waste retrieval of one single-shell tank (241-S-112) in 2007 and made significant progress in three others (241-C-108, 241-C-109, and 241-S-102). Waste retrieval in Tank 241-S-112 required the use of two retrieval systems. Modified sluicing was used to remove the thick layer of sludge. The remaining 87,000 liters (23,000 gallons) of hardened heel was removed using the high pressure of the remote water lance system, known as the salt mantis. Tank 241-S-112 was the seventh single-shell tank retrieved. Previously completed retrievals include 241-C-106, 241-C-203, 241-C-202, 241-C-201, 241-C-103, and 241-C-204. Also during 2007, CH2M HILL Hanford Group, Inc. conducted extensive testing of the "FoldTrack" crawler at its Cold Test Facility. The "FoldTrack" is an in-tank tracked vehicle with a high pressure spray wand (3,000 pounds per square inch gauge pressure at 10 gallons per minute) and a polymer "squeegee" blade for pushing waste toward the retrieval pump. The "FoldTrack" can be collapsed, or "folded," to fit down a riser, then unfolded on the tank floor. Deployment of the "FoldTrack" in Tank 241-C-109 is planned during the spring/summer 2008 time frame.

During 2007, CH2M HILL Hanford Group, Inc. transferred approximately 4.3 million liters (1.1 million gallons) of radioactive and hazardous waste (including the water used in waste retrieval activities) from single-shell tanks to safer double-shell tanks. The waste material contained over 42,200 terabecquerels (1.14 million curies) of radioactivity.

In July 2007, during waste retrieval operations at Single-Shell Tank 241-S-102, approximately 322 liters (85 gallons) of waste leaked when waste backed up into a raw water dilution line in the pump being used to retrieve the waste. Workers were not contaminated and there was no spread of contamination beyond the spill site. A protective barrier was applied to the spill site to prevent contamination to the surrounding area. Due to recovery actions, waste retrieval throughout the tank farms were halted; however, waste retrieval will resume during 2008 focusing on Single-Shell Tanks 241-C-104, 241-C-108, 241-C-109, and 241-C-110.

At the end of 2007, there were 113 million liters (29.8 million gallons) of waste remaining in the single-shell tanks.

6.4.1.2 Single-Shell Tank Farm Vadose Zone Program

In 2007, the CH2M HILL Vadose Zone program completed initial investigations to understand the major radioactive and chemical contaminants in the soil in the single-shell tank farms and interim actions to mitigate the impact to groundwater. Results of vadose zone investigations and interim measures conducted during the last 10 years are documented in the *RCRA Facility Investigations Report for Hanford Single-Shell Tank Waste Management Areas* (DOE/ORP-2008-01, Rev. 0).

In 2007, the CH2M HILL Vadose Zone program used the following technologies to mitigate groundwater impact and characterize subsurface contamination.

Interim Surface Barrier. Project teams began construction of an interim surface barrier over a known plume in the T Tank Farm. The barrier, completed in March 2008, covers 6,000 square meters (65,000 square feet) of the T Tank Farm surface, including all or part of nine tanks and a contamination plume resulting from the 1973 release of 435,000 liters (115,000 gallons) from Tank 241-T-106. The barrier features a sprayed-on polyurea liner that prevents moisture from infiltrating into the ground and driving contaminants down to the groundwater.

Direct-Push Technology. Direct-push technology was deployed in four tank farms during 2007. This technology uses a hydraulic hammer to drive a hollow rod deep into the soil either vertically or at an angle. A variety of sensors can be deployed inside the rod to detect radioactive contaminants and soil moisture, allowing the targeted collection of soil samples or monitoring of soil moisture and radiation without bringing contaminated soils to the ground surface.

Several pushes were made in the B Tank Farm to investigate unplanned release sites associated with diversion boxes in that farm. Direct-push technology was deployed in the T Tank Farm in support of the T Tank Farm interim barrier placement and monitoring. In the U Tank Farm, direct-push technology was deployed at 10 sites and a multilevel sampler was used to collect samples of potentially contaminated sediments for laboratory analysis. In addition, direct-push technology was used to place deeply buried electrodes at each of the 10 investigation sites for future resistivity

investigations. Analytical results for samples collected from direct-push technology deployments were included in the RCRA facility investigations report (DOE/ORP-2008-01, Rev. 0). In addition, direct-push technology was used to obtain samples from a pipeline leak just outside of C Tank Farm, the first characterization of the next phase of the Tank Farm Vadose Zone Program.

Surface Geophysical Exploration. Surface geophysical exploration uses the electrical properties in the soil to map potential contamination plumes. Surface geophysical exploration was applied in Waste Management Area B-BX-BY during fiscal year 2007 (RPP-RPT-34690) and is currently being applied in Waste Management Area TX-TY. Results for the fiscal year 2006 field application of surface geophysical exploration in Waste Management Areas C and U were included in the RCRA facility investigations report (DOE/ORP-2008-01, Rev. 0). The surface geophysical exploration results will be used to guide the locations of direct-push technology deployments and groundwater monitoring wells to be drilled during fiscal year 2008 and beyond.

6.4.1.3 Double-Shell Tanks

The 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 (i.e., bulk vitrification), and includes emergency pumping space available at all times for 3.8 million liters (1 million gallons). In 2007, the Washington State Department of Ecology approved the *Double-Shell Tank Emergency Pumping Guide* revision as part of its overall management of the double-shell tank space (HNF-3484).

In 2007, significant multi-year projects required by the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) were completed. Double-shell tank system integrity assessment reports were issued, including completion of the ultrasonic re-examination of six double-shell tanks (RPP-28538; RPP-27591; RPP-25153; RPP-25299; RPP-27097; RPP-22604; RPP-20556). In addition, the integrity assessments incorporated the results of recently completed upgrades and installation of new tank system components to support future treatment of the double-shell tank waste at the Hanford Tank Waste Treatment and Immobilization Plant.

Structural integrity assessments of the double-shell tanks in the AP Tank Farm support increasing operational fill levels of the AP tanks upon successful completion of a leak test for each tank. In 2007, Tank 241-AP-108 was leak tested and the operational level was increased. Increases in operational fill levels will allow more waste to be transferred from the aging single-shell tanks into the newer double-shell tanks, pending startup of the Hanford Tank Waste Treatment and Immobilization Plant.

At the end of 2007, there were 101 million liters (26.7 million gallons) of waste in the double-shell tanks.

6.4.2 Demonstration Bulk Vitrification System

The Demonstration Bulk Vitrification System was designed as a full-scale test facility for treatment of Hanford Site tank waste using in-container vitrification. The facility was designed to receive waste from Single-Shell Tank 241-S-109, mix the waste with glass-forming materials, and feed it into a metal container lined with a refractory and sand. The blended material would then be heated to approximately 1300°C (2370°F) to produce a vitrified waste product. The Demonstration Bulk Vitrification System design was approved in July 2006 by the Washington State Department of Ecology under a RCRA Research Development and Demonstration Permit issued in December 2004. The waste product will be sampled and tested to verify it is suitable and meets the Waste Acceptance Criteria for near-surface land disposal at the Integrated Disposal Facility. The Demonstration Bulk Vitrification System will treat the process off-gas to ensure it is compliant with applicable state and federal regulations, and is protective of human health and the environment. Secondary liquid wastes will be sent to the Effluent Treatment Facility for proper treatment and disposal.

CH2M HILL Hanford Group, Inc. commissioned a panel of 16 independent experts and consultants to review the approved design to help ensure facility construction and operations will be successful. During fiscal year 2007, the design was modified to incorporate recommendations from the expert panel, as well as input received from the Defense Nuclear Facilities Safety Board during its nuclear safety review. Project personnel have conducted an extensive set of process tests ranging from laboratory crucible melts of both simulants and radioactive tank wastes, cold (non-radioactive) and hot (radioactive) engineering scale melts, and a series of full-scale tank waste simulant tests. The Demonstration Bulk Vitrification System also conducted supporting activities that focused on glass formulation and performance of the melter system.

Containers of low-activity waste produced by the Demonstration Bulk Vitrification System will be placed in the new Integrated Disposal Facility, which was completed in 2006. The facility, located in the 200-East Area near the center of the Hanford Site, is the site's first RCRA compliant disposal facility. The Integrated Disposal Facility is fully lined and has a leachate collection system to intercept any leachate and liquids that percolate through the waste before they reach the groundwater.

6.5 Hanford Tank Waste Treatment and Immobilization Plant

J. F. 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: the Pretreatment Facility, High-Level Waste Vitrification Facility, Low-Activity Waste Vitrification Facility, and Analytical Laboratory, along with 20 supporting facilities and underground utilities.

A significant turnaround for the Hanford Tank Waste Treatment and Immobilization Plant project occurred in 2007. Challenges in 2005 and 2006, such as revising the seismic design criteria, led to a 2-year construction hiatus on the Pretreatment and High-Level Waste Vitrification facilities. The seismic criteria were finalized in August 2007, and the High-Level Waste Vitrification Facility returned to full construction in September. The Pretreatment Facility returned to full construction in December.

During 2007, progress continued on construction of the Low-Activity Waste Vitrification Facility, Analytical Laboratory, and Balance of Facilities. The Low-Activity Waste Vitrification Facility's final structural concrete, the north annex and west import bay structural steel, and the east export bay walls were placed. The Analytical Laboratory's structural steel and exterior siding were completed, the steel monorail installed, and the hot cell walls were stainless-steel lined and coated. Five air-drying units, the last major equipment needed to complete the chiller compressor plant, were delivered and installed in the Balance of Facilities. System completion activities were initiated for the fire water system, and the facility received the first 2 of 13 glass former silos that will store and dispense the materials to be mixed with the waste to form glass.

The overall project is approximately 41% complete, including the following:

- 70% design complete
- 56% construction complete on the Low-Activity Waste Vitrification Facility
- 44% construction complete on the Analytical Laboratory
- 61% construction complete on the Balance of Facilities
- 17% construction complete on the High-Level Waste Vitrification Facility
- 23% construction complete on the Pretreatment Facility.

Design and procurement activities were completed for the Pretreatment Engineering Platform, a one-quarter-scale test facility that will demonstrate the Pretreatment Facility capacity and capability. Pacific Northwest National Laboratory will perform the integrated testing. When operating, the Pretreatment Engineering Platform will be the Hanford Site's second largest processing system.

From project inception through 2007, the Hanford Tank Waste Treatment and Immobilization Plant placed 138,400 cubic meters (181,000 cubic yards) of concrete; erected 10,070 metric tons (11,100 tons) of steel; installed 81,700 meters (268,000 linear feet) of pipe; installed 4,900 meters (16,200 linear feet) of cable tray; installed 120,700 meters (396,000 linear feet) of conduit; and installed 124,050 meters (407,000 linear feet) of wire and cable.

6.6 Scientific and Technical Contributions to Hanford Cleanup

T. Walton

In 2007, Pacific Northwest National Laboratory and Battelle, which operates the Laboratory for DOE, contributed to the efforts of DOE and its contractors by providing scientific innovation and leadership to solve challenges in subsurface science and remediation and chemical and nuclear waste processing. Specifically, Pacific Northwest National Laboratory researchers provided analyses, reviews, tests, and new technologies to assist DOE in solving its complex scientific issues, contributing to critical cleanup decisions, reducing technical uncertainty, and aiding in the protection of human health and the environment.

Pacific Northwest National Laboratory provided scientific and engineering data and analysis to support the processing of high-level radioactive waste for the DOE Office of River Protection. Paramount to high-level waste disposition at the Hanford Site is the construction of the Hanford Tank Waste Treatment and Immobilization Plant. Construction stalled in 2005 when the design basis for a seismic event was revised. Pacific Northwest National Laboratory researchers led the Waste Treatment Plant Seismic Boreholes Project to reduce the uncertainty associated with shear-wave velocities of sediments and basalts below the Hanford Tank Waste Treatment and Immobilization Plant. This uncertainty was the main issue related to the adequacy of seismic design. Data and analyses delivered by Pacific Northwest National Laboratory in 2007 resolved the seismic issues, which allowed the Secretary of Energy to restart construction of the Hanford Tank Waste Treatment and Immobilization Plant. Pacific Northwest National Laboratory researchers resolved several technical issues impacting design by performing scaled and prototypic testing of Hanford Tank Waste Treatment and Immobilization Plant process components, including tank mixers and piping systems. Testing helped resolve technical uncertainties related to mixing, pipe plugging, and hydrogen gas retention.

Researchers also performed extensive tests examining the consequences of pulsed jet mixer overblows on waste processing tank internal structures. An overblow occurs when all waste is expelled from a pulse jet mixer and large volumes of pressurized air are released into the tank. The resulting hydrodynamic forces can lead to fatigue failures in tank internal structures over its 40-year operating life. Results will support structural analyses to determine if modifications to the internal structures of the tanks are required.

In 2007, construction of a large slurry piping test loop to confirm the adequacy of slurry transport design criteria for the Hanford Tank Waste Treatment and Immobilization Plant was completed. In addition, a 464.5-square-meter (5,000-square-foot) high-bay facility was selected to contain a large pretreatment engineering platform to evaluate the adequacy of the plant's high-level waste sludge leaching and filtration processes.

Pacific Northwest National Laboratory researchers also supported DOE's efforts to develop and evaluate low-activity tank waste immobilization options that could supplement the treatment capacity of the Hanford Tank Waste Treatment and Immobilization Plant. Pacific Northwest National Laboratory developed and tested a method to resolve migration of mobile (leachable) technetium in the bulk vitrification waste form. Researchers verified conceptual model data with laboratory tests and full-scale test data, identified a strategy to reduce migration, and demonstrated the effectiveness of that strategy through bench-scale testing and full-scale test data. The method successfully minimized technetium migration and was adopted as a processing baseline for the bulk vitrification supplemental treatment option.

In support of DOE Richland Operations Office and its contractors, Pacific Northwest National Laboratory researchers provided additional scientific understanding of the behavior of subsurface contaminants, developing new technologies to treat uranium, strontium-90, chromium, technetium-99, and carbon tetrachloride in the vadose zone and groundwater. In the 300 Area, researchers evaluated uranium stabilization using polyphosphate. This work supports final remediation of the uranium plume in 300 Area groundwater.

In 2007, evaluation of strontium-90 remediation continued, including the injection of a long-lasting apatite barrier to sequester the contamination before it reaches the Columbia River. Researchers also evaluated phytoremediation, involving the use of plants to remove strontium from the groundwater following apatite sequestration. Microbial treatment of chromium, combined with a downstream in-situ reduction and oxidation manipulation barrier, was examined for chromium plume reduction and to extend the longevity of the reduction and oxidation manipulation barrier.

Technetium-99 remediation focused on evaluating technologies that can be used to treat contamination deep in the vadose zone before it reaches the groundwater. Pacific Northwest National Laboratory assisted Fluor Hanford, Inc. in evaluating a soil desiccation technology and assisted with the development of a test plan. Efforts to remediate carbon tetrachloride have focused on reduction of flux through the vadose zone and the revision of conceptual and numerical models of carbon tetrachloride transport.

The Pacific Northwest National Laboratory has created research sites to investigate field-scale issues related to uranium transport in the vadose zone and groundwater and to evaluate remediation concepts. At the Hanford Site's 300 Area, research has focused on the processes controlling uranium behavior and mass transfer (exchange between the mobile and immobile phases in the subsurface).

Several grants awarded through the DOE Office of Science Scientific Discovery through Advanced Computing program have contributed to the development of the next generation of subsurface models for groundwater analysis. The first effort focused on resolving the "issue of scale" for subsurface models that are implemented at different scales. Researchers developed pore-scale models and scaled up the models to the continuum (meter) scale. The second phase of the project focused on developing high-performance computational tools that built on advanced technologies in grid generation, linear and non-linear solvers, component architectures, visualization, and scientific workflow and data management tools. For testing and benchmarking, researchers are developing a prototype application focused on flow and transport of uranium in the 300 Area.

6.7 References

40 CFR 264.301. 2007. "Design and Operating Requirements." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

69 FR 39449-39456, June 30, 2004. "Record of Decision for the Solid Waste Program, Hanford Site, Richland, WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant." *Federal Register*, U.S. Department of Energy.

Atomic Energy Act of 1954. 1954. Chapter 1073, Stat. 921, 42 USC 2011 et seq.

Cleanup Priority Act. 2004. Washington State Initiative Measure No. 297, as amended. Accessed April 22, 2008, at http://www.secstate.wa.gov/elections/guide/text/297.pdf.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980. 1980. Public Law 96-510, as amended, 42 USC 9601 et seq. Accessed April 22, 2008, at http://www.epa.gov/region5/defs/html/cercla.htm.

D&D-27257. 2006. *Data Quality Objectives Summary Report for Nonintrusive Characterization of Bin 3A and Bin 3B Waste Sites in the 200-SW-2 Operable Unit*. Fluor Hanford, Inc., Richland, Washington.

D&D-28283. 2006. *Sampling and Analysis Instruction for Nonintrusive Characterization of Bin 3A and Bin 3B Waste Sites in the 200-SW-2 Operable Unit*. Fluor Hanford, Inc., Richland, Washington.

D&D-33135. 2007. *Disposition of Waste from Process Vessel in Cell 30 of 221-U*. Fluor Hanford, Inc., Richland, Washington.

D&D-33637. 2007. *U Canyon Railroad Tunnel Reactivation Study*. Fluor Hanford, Inc., Richland, Washington.

D&D-33945. 2007. *U Canyon Structure Void Fill Analysis and Installation Plan*. Fluor Hanford, Inc., Richland, Washington.

D&D-35827. 2009. *Project Experience Report, Canyon Disposition Initiative (221-U Facility)*. Fluor Hanford, Inc., Richland, Washington.

DNFSB. 2000. *Recommendation 2000-1, Prioritization for Stabilizing Nuclear Materials*. Defense Nuclear Facilities Safety Board to the Secretary of Energy, Washington, D.C. Accessed April 22, 2008, at http://www.dnfsb.gov/pub_docs/dnfsb/rec_2000_01.pdf.

DNFSB. 2002. *Recommendation 2002-3, Requirements for the Design, Implementation, and Maintenance of Administrative Controls*. Defense Nuclear Facilities Safety Board to the Secretary of Energy, Washington, D.C. Accessed April 22, 2008, at http://www.dnfsb.gov/pub_docs/dnfsb/rec_2002_03.pdf.

DNFSB. 2004. *Recommendation 2004-2, Active Confinement Systems*. Defense Nuclear Facilities Safety Board to the Secretary of Energy, Washington, D.C. Accessed April 22, 2008, at http://www.dnfsb.gov/pub_docs/dnfsb/rec_2004_02.pdf.

DNFSB. 2005. *Recommendation 2005-1, Nuclear Material Packaging*. Defense Nuclear Facilities Safety Board to the Secretary of Energy, Washington, D.C. Accessed April 22, 2008, at http://www.dnfsb.gov/pub_docs/dnfsb/rec_2005_01.pdf.

DNFSB. 2007. *Recommendation 2007-1, Safety-Related In Situ Nondestructive Assay of Radioactive Materials*. Defense Nuclear Facilities Safety Board to the Secretary of Energy, Washington, D.C. Accessed April 22, 2008, at http://www.dnfsb.gov/pub_docs/dnfsb/rec_2007_01.pdf.

DOE. 2007. *Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2007-1, Safety-Related In Situ Nondestructive Assay of Radioactive Materials*. U.S. Department of Energy to the Defense Nuclear Facilities Safety Board, Washington, D.C. Accessed August 22, 2008, at http://www.hss.doe.gov/deprep/2007/AttachedFile/tb07o24a_enc.pdf.

DOE and EPA. 2005. *Memorandum #1 for the 300 Area Facilities*. U.S. Department of Energy, Richland Operations Office, Richland, Washington, and U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

DOE and EPA. 2006a. *Memorandum #2 for the 300 Area Facilities*. U.S. Department of Energy, Richland Operations Office, Richland, Washington, and U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

DOE and EPA. 2006b. *Memorandum #3 for the 300 Area Facilities*. U.S. Department of Energy, Richland Operations Office, Richland, Washington, and U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

DOE, EPA, and Ecology. 2005. *Final Record of Decision for the 221-U Facility (Canyon Disposition Initiative and Responsiveness Summary*. U.S. Department of Energy, Richland Operations Office, Richland, Washington; U.S. Environmental Protection Agency, Region 10, Seattle, Washington; and Washington State Department of Ecology, Olympia, Washington.

DOE/ORP-2008-01, Rev. 0. 2008. *RCRA Facility Investigation Report for Hanford Single-Shell Tank Waste Management Areas*. U.S. Department of Energy, Office of River Protection, Richland, Washington.

DOE/RL-98-28, Rev. 0. 1999. *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-99-44, Rev. 0. 2000. *200-CS-1 Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling Plan*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2001-01, Rev. 1. 2004. *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan: Includes 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2001-11, Rev. 1. 2004. *Final Feasibility Study for the Canyon Disposition Initiative (221-U Facility)*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2001-29, Rev. 0. 2004. *Proposed Plan for Remediation of the 221-U Facility (Canyon Disposition Initiative)*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2001-65, Rev. 0. 2002. *200-MW-1 Miscellaneous Waste Group Operable Unit RI/FS Work Plan*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2002-14, Rev. 1, Draft B. 2007. *Tanks/Lines/Pits/Boxes/Septic Tank and Drain Fields Waste Group Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling Plan; Includes: 200-IS-1 and 200-ST-1 Operable Units*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2002-69, Draft A. 2003. *Feasibility Study for the 200-CW-1 and 200-CW-3 Operable Units and the 200 North Area Waste Sites*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2003-06, Draft A. 2003. *Proposed Plan for the 200-CW-1 and 200-CW-3 Operable Units and the 200 North Area Waste Sites*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2004-24, Draft A. 2004. *Feasibility Study for the 200-CW-5 (U Pond/Z Ditches Cooling Water Waste Group), 200-CW-2 (S Pond and Ditches Cooling Water Waste Group), 200-CW-4 (T Pond and Ditches Cooling Water Waste Group), and 200-SC-1 (Steam Condensate Waste Group) Operable Units*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2004-26, Draft A. 2004. *Proposed Plan for 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2004-60, Draft B. 2007. *200-SW-1 Nonradioactive Landfills and Dumps Group Operable Unit and 200-W-2 Radioactive Landfills and Dumps Group Operable Units Remedial Investigation/Feasibility Study Work Plan*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2004-66, Draft A. 2005. *Focused Feasibility Study for the BC Cribs and Trenches Area Waste Sites*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2004-69 Draft A. 2005. *Proposed Plan for the BC Cribs and Trenches Area Waste Sites*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2005-26, Rev. 1. 2007. *Removal Action Work Plan for 105-KE/105-KW Reactor Facilities and Ancillary Facilities*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2005-63, Draft A. 2006. *Feasibility Study for the 200-CS-1 Chemical Sewer Group Operable Unit*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2005-63, Draft B. 2006. *Feasibility Study for the 200-CS-1 Chemical Sewer Group Operable Unit*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2005-64, Draft A. 2007. *Proposed Plan for the 200-CS-1 Chemical Sewer Group Operable Unit*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2005-64, Draft B. 2007. *Proposed Plan for the 200-CS-1 Chemical Sewer Group Operable Unit*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2006-21, Draft A. 2006. *Remedial Design/Remedial Action Work Plan for the 221-U Facility*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2006-51, Draft A. 2006. *Remedial Investigation Report for the Plutonium/Organic Rich Process Condensate/Process Waste Group Operable Unit: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2006-51, Rev. 0. 2007. *Remedial Investigation Report for the Plutonium/Organic Rich Process Condensate/Process Waste Group Operable Unit: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-02, Rev. 0. 2007. *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-22, Rev. 0. 2007. *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid (DNAPL) Source Term Characterization Report Addendum*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-50. 2007. *Central Plateau Terrestrial Ecological Risk Assessment*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-27, Draft A. 2007. *Feasibility Study for the Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-40, Draft A. 2007. *Proposed Plan for the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-06, Rev. 0, Reissue. 2008. *Hanford Facility Annual Dangerous Waste Report Calendar Year 2007*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-STD-1186-2004. 2004. *Specific Administrative Controls*. U.S. Department of Energy, Washington, D.C.

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 through February 12, 2008, Olympia, Washington. Accessed April 18, 2008, at http://www.hanford.gov/?page=91&parent=0.

Ecology, EPA, and DOE. 2006. *Hanford Federal Facility Agreement and Consent Order Changes to Central Plateau Waste Site and Groundwater Remediation Milestones (including Tentative Agreement on Negotiations, Introduction, Federal Facilities Agreement and Consent Order Change Control Form M-15-16-02, M-13-06-01, P-11-06-01, C-06-2), September 14, 2006*. Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA. 2007. *Amended Record of Decision, Decision Summary and Responsiveness Summary for U.S. Department of Energy Environmental Restoration Disposal Facility Hanford Site – 200 Area Benton County, Washington*. U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

EPA/ROD/R10-01-119. 2001. *Declaration of the Record of Decision for the 300-FF-2 Operable Unit*. U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Richland Operations Office, Richland, Washington. Accessed July 16, 2008, at http://www.epa.gov/superfund/sites/rods/fulltext/r1001119.pdf.

EPA/ROD/R10-95/100. 1995. *Record of Decision for the USDOE Hanford Environmental Restoration Disposal Facility Remedial Action*. U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

HNF-3484. 2007. *Double-Shell Tank Emergency Pumping Guide, Revision 7*. CH2M HILL Hanford Group, Inc., Richland, Washington.

HNF-34169. 2007. *Canyon Waste Acceptance Study*. Fluor Hanford, Inc., Richland, Washington.

HNF-34723. 2007. *Facility Condition Analysis for the 216-Z-9 Crib and Cover Slab to Support Removal of the Above-Grade Soil Mining Structures*. Fluor Hanford, Inc., Richland, Washington.

Mixed Radioactive and Hazardous Waste. RCW 70.105E, as amended, *Revised Code of Washington*, Olympia, Washington.

NUREG-1575, Rev. 1. 2000. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*. U.S. Nuclear Regulatory Commission; EPA 402-R-97-016, U.S. Environmental Protection Agency, Washington, D.C.

Resource Conservation and Recovery Act of 1976. 1976. Public Law 94-580, as amended, 42 USC 6901 et seq. Accessed April 22, 2008, at http://www.epa.gov/region5/defs/html/rcra.htm.

RPP-20556. 2007. Volume 7: *IQRPE DST System Integrity Assessment – Evaluation of the Dome Loading Program for Double-Shell Tanks, Revision 1*. CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-22604. 2007. Volume 6: *IQRPE DST System Integrity Assessment – Evaluation and Documentation of DST Secondary Liner Issues, Revision 1*. CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-25153. 2007. Volume 3: *IQRPE DST System Integrity Assessment – Waste Compatibility, Revision 2*. CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-25299. 2007. Volume 4: *IQRPE DST System Integrity Assessment – Cathodic Protection for DST Transfer Lines, Revision 1*. CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-27097. 2007. Volume 5: *IQRPE DST System Integrity Assessment – Waste Transfer Line Encasement Integrity Technology Study, Revision 1*. CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-27591. 2007. Volume 2: *IQRPE DST System Integrity Assessment – Pipeline Integrity, Revision 1*. CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-28538. 2007. Volume 1: *Independent Qualified Registered Professional Engineer (IQRPE) Double-Shell Tank (DST) System Integrity Assessment, Revision 3*. CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-RPT-34690. 2007. *Surface Geophysical Exploration of the B, BX, BY Tank Farms at the Hanford Site*. CH2M HILL Hanford Group, Inc., Richland, Washington.

SGW-33253. 2007. *Data Quality Objectives Summary Report for Phase I-B Characterization of the 200-SW-2 Operable Unit Landfills*. Fluor Hanford, Inc., Richland, Washington.

SGW-33959. 2007. *Borehole Summary Report for Well 299-E24-23 (Borehole C5301) and Borehole C5302 Drilled in the Vicinity of the 216-A-4 Crib and the 216-E-102 Trench*. Fluor Hanford, Inc., Richland, Washington.

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

WAC 173-240. 2007. "Submission of Plans and Reports for Construction of Wastewater Facilities." *Washington Administrative Code*, Olympia, Washington.

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

WAC 173-303-070(3). 2007. "Designation of Dangerous Waste; Designation Procedures." *Washington Administrative Code*, Olympia, Washington.

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 possible transfer of land to other entities.

7.0.1 Radiological Release of Property from the Hanford Site

W. M. Glines

Principal requirements for the control and release of DOE property containing residual radioactivity are in DOE Order 5400.5, "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 2007.

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

W. M. Glines

Washington Closure Hanford LLC, the prime contractor for the River Corridor Closure Contract, performs Hanford Site decontamination and decommissioning activities. In the process of performing these activities, Washington Closure Hanford LLC encounters 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. Personal property that has contamination levels below approved DOE control and release guidelines are considered for release if the property can be reused. Washington Closure Hanford LLC routinely encounters 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, and the control and release criteria 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.

Accordingly, in May 2006, Washington Closure Hanford LLC 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 excluded 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 in May 2007.

Table 7.0.1. Approved Authorized Limits for Select Hard-to-Detect Radionuclides[a] for Residual Beta-Gamma Surface Contamination

Average (dpm/100 cm²)	Maximum (dpm/100 cm²)	Removable (dpm/100 cm²)
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.

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

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

W. M. 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 exceed the U.S. Environmental Protection Agency's (EPA) ambient water quality criterion of 10 mg/L 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 being utilized 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 returned to the aquifer using injection wells. Once saturated, the spent resin is removed from the system and the resin is prepared for shipment to an offsite facility for regeneration and reuse. Regeneration of the resin requires chemical washing to release the bound hexavalent chromium.

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 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. Accordingly, 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 regeneration of the resin.

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 considered to be 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-Sv) 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." 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)" exposure to any individual and a minimal collective dose. The analyses performed for these authorized limits show that any actual releases would meet these criteria. Following review by the DOE Richland Operations Office and DOE Headquarters personnel, these authorized limits (Table 7.0.2) were approved for use in August 2007.

In 2007, approximately 46,000 kilograms (101,000 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

Radionuclide	Authorized Limit (pCi/g)
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

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

W. M. Glines

Carbon tetrachloride was found in the unconfined aquifer beneath the 200-West Area at 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 utilizes 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 made ready for shipment to an offsite facility for regeneration and reuse. Regeneration of the granular activated carbon requires heating it in a hearth furnace to drive off 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 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 use scenario was considered to be 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-Sv) 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." 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)" exposure to any individual and a minimal collective dose. The analyses performed for these authorized limits show that any actual releases would meet these criteria. Following review by the DOE Richland Operations Office and DOE Headquarters personnel, these authorized limits were approved for use in August 2007 (Table 7.0.3).

In 2007, approximately 8,200 kilograms (18,100 pounds) of granular activated carbon was shipped offsite for regeneration under these approved authorized limits.

7.0.2 Columbia River Corridor Mission Completion

E. T. Feist

The Hanford Site's River Corridor includes the 100 and 300 Areas, which border the Columbia River shoreline. 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 Hanford 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

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

Radionuclide	Authorized Limit (pCi/g)
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

- 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 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 2007 as work progressed in these areas. An Internet website (http://www.washingtonclosure.com/Projects/endstate.htm) provides current information on these associated activities. The website includes the planned dates of public involvement opportunities, documents available for review and comment, administrative information, and links to related projects.

7.0.2.1 Assessment and Integration

J. A. Lerch

River Corridor Baseline Risk Assessment. DOE's cleanup plans for the 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 2013. The current focus of Washington Closure Hanford LLC 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 results of this assessment will be used to evaluate the adequacy of cleanup actions within the River Corridor.

The River Corridor Baseline Risk Assessment uses a multi-step process. The process began with researchers compiling and summarizing existing data; then, the data quality objectives process was used 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 have been 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 and 300 Areas component was initiated in 2005 and completed in 2006. Sampling for the riparian and near-shore environments of the River Corridor between reactor/operational areas (the "Inter-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 Report (Draft B), which is scheduled for regulatory and stakeholder review in late 2008. At the Tri-Parties' direction and in response to stakeholder feedback, an enhanced characterization of risks associated with groundwater is being included in the Draft B report. The River Corridor Baseline Risk Assessment will support recommendations for final cleanup decisions at source and groundwater units within the River Corridor. The results will be presented by the Tri-Parties to the public for consideration in a River Corridor source unit proposed plan in the future.

Remedial Investigation of Hanford Site Releases to the Columbia River. A CERCLA remedial investigation, including a baseline risk assessment, 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. The risk assessment will be performed as a component of the River Corridor Baseline Risk Assessment. Project scoping and preparation of a work plan for field sampling and risk assessment is underway.

Integration with Groundwater Actions. Cleanup actions for source and groundwater operable units in the Hanford Site River Corridor have been programmatically separated between the 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. The DOE Richland Operations Office updated the interface control agreement in early 2007 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 to support closure of the River Corridor (07-AMCP-0037). DOE has directed Hanford Site contractors to support these integration activities. Specific integration activities supported by Washington Closure Hanford LLC in 2007 include participation in integrated project team meetings, development of the strategy for development of final records of decision for the River Corridor, and participation in the systematic planning/data quality objective process to support an integrated work plan for the 100-D, 100-H, and 100-K Areas.

7.0.2.2 Columbia River Corridor Long-Term Stewardship

C. S. 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 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 2007, the draft *Planning for the Transition to Long-Term Stewardship Under the River Corridor Closure Contract* (WCH-134) was issued. The report provides a proposed approach to meet the requirements for long-term stewardship to maintain protectiveness of the source unit cleanup remedies performed for the River Corridor. Also in 2007, orphan site evaluations continued for the 100-IU-2 and 100-IU-6 Operable Units, and evaluations were initiated for the 100-H and 100-K Areas.

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

07-AMCP-0037. 2007. *Interface Control Agreement for Integrating Groundwater and Vadose Zone Remediation Activities in the River Corridor*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980. 1980. Public Law 96-510, as amended, 42 USC 9601 et seq. Accessed April 22, 2008, at http://www.epa.gov/region5/defs/html/cercla.htm.

DOE Order 5400.5, Chg 2. 1993. "Radiation Protection of the Public and the Environment." U.S. Department of Energy, Washington, D.C.

WCH-134. 2007. *Planning for the Transition to Long-Term Stewardship Under the River Corridor Closure Contract*. Washington Closure Hanford LLC, Richland, Washington.

8.0 Environmental Occurrences

B. G. 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 M 231.1-2). The following sections summarize occurrences that occurred in 2007 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 2007, there were no Hanford Site environmental occurrences ranked as recurring or Category 1.

8.0.1 Operational Emergency

Operational emergencies are emergencies with the potential to have an immediate and severe impact on safe facility operations, worker safety and health, or environmental conditions. One operational emergency occurred in 2007.

Range Fire on the Hanford Site and Fitzner/Eberhardt Arid Lands Ecology Reserve. On August 16, 2007, a fire that began offsite crossed the Hanford Site boundary. High winds and dry fuel resulted in more than 26,000 hectares (64,000 acres) being burned; nearly 19,000 hectares (47,000 acres) on the Fitzner/Eberhardt Arid Lands Ecology Reserve, over 3,600 hectares (9,000 acres) on the DOE-operated portion of the Hanford Site, and more than 3,000 hectares (8,000 acres) offsite. No Hanford Site facilities were directly affected by the fire, although the fire burned over three former process ponds that had previously been capped with clean soil. Environmental sampling conducted during and after the fire indicated there was no release of radioactive materials. Details about the ecological impacts of the fire can be found in Section 10.10.1 of this report.

8.0.2 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. Two Category 2 occurrences with potential environmental implications occurred on the Hanford Site in 2007.

Personnel and Offsite Contamination from a Leaking Source. On June 14, 2007, an exit survey from a radiological buffer area identified alpha contamination on a Hanford Site worker. Follow-up surveys conducted by a radiological control technician identified three additional workers with some level of contamination. The contamination source was a leaking plutonium-238 source. Surveys were conducted in other Pacific Northwest National Laboratory facilities, and workers' homes, vehicles, and clothing. Contamination was found at two residences, in three personal vehicles, on computer keyboards, chairs, and tools. The worker most severely contaminated in this event received an estimated dose of 320-millirem (3,200-microsievert) committed effective dose equivalent. Two members of the public (family of

workers involved in the incident) also received doses of 25- and 33-millirem (250- and 330-microsievert) committed effective dose equivalent (50-year total dose).

Tank 241-S-102 Waste Spill. On July 27, 2007, approximately 322 liters (85 gallons) of radioactive waste spilled inside of the S Tank Farm. The spill occurred as a result of equipment failure during waste transfer from a single-shell tank into a double-shell tank. The spill area was stabilized with two coats of fixative and posted as a high radiation area. Air sampling and perimeter surveys detected no contamination at the facility boundary.

8.0.3 Category 3 – Minor Impact

Category 3 occurrences are defined as having a minor impact on safe facility operations, worker or public safety and health, regulatory compliance, or public and business interests. Two Category 3 occurrences with potential environmental implications occurred in 2007 at the Hanford Site.

Mercury Contaminated Soil Inadvertently Placed into the Environmental Restoration Disposal Facility Prior to Required Treatment. On May 17, 2007, two containers of mercury contaminated soil were buried at the Environmental Restoration Disposal Facility without undergoing the required mercury treatment. When teamsters identified the mistake, the area where the mercury had been buried was isolated with ropes and flags. Entry was restricted and a soil fixative was placed on the surface to limit dust suspension or moisture intrusion. The contaminated soil was removed from the landfill on June 16, 2007, and confirmatory sampling demonstrated that all the mercury contaminated soil was removed.

Range Fire. On July 19, 2007, a grass fire started near the 100-K Area of the Hanford Site. The fire was ignited by either a lightning strike or equipment failure at a 230-kV transmission tower. The fire burned 10 hectares (25 acres) before being extinguished.

8.0.4 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. The two Category 4 occurrences with potential environmental implications that occurred at the Hanford Site in 2007 are discussed in the following paragraphs. Other discoveries of legacy contamination are also summarized, but not in detail.

Illegal Dumping at Riverlands Unit. On March 2, 2007, a groundwater operations operator reported finding an illegal sewage dump site on the Riverlands Unit, which is part of the Hanford Reach National Monument. The dump site was estimated to be 96 meters (105 yards) long and 1.2 to 2.4 meters (4 to 8 feet) wide. The quantity of the spill was estimated in excess of 22,700 liters (6,000 gallons) of wastewater and sewage sludge. It appeared that the dump site had been used several times. Because the dump was not part of Hanford Site land or operations, the Benton County Sheriff's office was notified. In addition, prior to taking any actions to clean the spill, the Washington State Department of Ecology and the Benton-Franklin Health Department were notified and consulted. The spill was treated with 1,900 liters (500 gallons) of chlorinated water to kill the sewage sludge bacteria. The distance to the Columbia River is sufficient that there should be no impacts to surface water as a result of this illegal dumping.

Arid Lands Ecology Reserve, Highway 240, Milepost 17, Range Fire. On August 13, 2007, the Hanford Fire Department responded to a report of a wildland fire on State Route 240 between mileposts 17 and 18 on the Fitzner/Eberhardt Arid Lands Ecology Reserve. The fire spread from 2 hectares (5 acres) to 81 hectares (200 acres) within an hour of the Hanford Fire Department arriving at the scene. The fire was contained by August 14, with an estimated burn footprint of over 3,200 hectares (8,000 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 that can result in the spread of contamination include

tumbleweeds, rabbits, and mud daubers (wasps). Tumbleweeds have a deep taproot that can sequester contamination from below the soil surface into the plant body. Rabbits can 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 the original location. High winds are another vector that may result in the spread of legacy contamination beyond posted areas.

8.0.5 Reference

DOE M 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 and Waste Minimization

This section provides information on Hanford Site policies regarding pollution prevention and waste minimization.

9.0.1 Pollution Prevention Program

C. E. Marple

The U.S. Department of Energy (DOE) Richland Operations Office is responsible for the Hanford Site pollution prevention program and provides program guidance to Hanford Site contractors.

DOE Order 450.1, Change 2, "Environmental Protection Program," established new pollution prevention and environmental stewardship goals that enhanced the pollution prevention and environmental management system provisions in DOE Order 450.1 and Executive Orders 13148, "Greening the Government Through Leadership in Environmental Management" (65 FR 24595-24607), and 13101, "Greening the Government Through Waste Prevention, Recycling and Federal Acquisition" (63 FR 49643-49651). These goals are implemented by Hanford Site contractors.

In 2007, 599 metric tons (660 tons) of sanitary and hazardous wastes were recycled through 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 2007 goal. The Hanford Site Solid Waste Information Tracking System indicates that 3,115 cubic meters (4,074 cubic yards) 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 2007, along with 68 metric tons (75 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 2007

Waste	Metric Tons	(tons)
Sanitary Waste		
Appliances and furniture	107.91	(118.95)
Ballasts	0.97	(1.07)
Computers and electronics	7.16	(7.89)
Copper	34.14	(37.63)
Engine oils	61.41	(67.69)
Fire extinguishers	0.23	(0.25)
Iron, steel, and lead	147.20	(162.26)
Mixed office paper and corrugated cardboard	120.42	(132.74)
Non-ferrous metal	59.32	(65.39)
Tires	24.28	(26.76)
Toner cartridges	8.32	(9.17)
Hazardous Waste		
Antifreeze	2.69	(2.97)
Batteries	20.20	(22.27)
Lamps	2.73	(3.01)
PCB oil[a]	1.81	(2.00)
Shop towels	0.60	0.66

(a) Less than 2 ppm PCB oil burned for energy recovery.
PCB = Polychlorinated biphenyl.

9.0.2 References

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

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

DOE Order 450.1. 2003. "Environmental Protection Program." U.S. Department of Energy, Washington, D.C.

DOE Order 450.1, Change 2. 2005. "Environmental Protection Program." U.S. Department of Energy, Washington, D.C.

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 and 5400.5 require that environmental monitoring programs be conducted at 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 at 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:

- Routinely conducting pre-operational environmental characterization and assessment activities
- Monitoring effluent and emissions
- Performing environmental monitoring and surveillance (as defined in DOE Order 5400.5 and in Appendix B of this report, "Glossary")
- Monitoring cultural resources
- Periodically sampling Hanford Site drinking water
- Monitoring and controlling 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 impact 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, the nearby population, 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 collection of duplicative environmental data
- Ensuring 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 at the Hanford Site
- Providing information to assure 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

J. J. Dorian

Effluent and near-facility environmental monitoring at 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. Information on effluent discharged from site facilities in 2007 is summarized in Section 10.3 and in an annual environmental release report (e.g., HNF-EP-0527-17). Emissions data for 2007 are summarized in Section 10.1 and in other reports (e.g., DOE/RL-2008-03).

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 100-K Area fuel storage basins; 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, 450.1, and 5400.5; DOE M 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 2007 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 frozen and stored for possible laboratory analysis in 2008. 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 2007 are provided in a separate appendix (PNNL-17603, APP. 2).

Information on contaminant concentrations or radiation levels measured onsite near facilities and operations during 2007 is summarized in Sections 10.2, 10.9, 10.10, 10.12, and 10.13. Additional data may be found in PNNL-17603, APP. 2. The type and general locations of samples collected for near-facility monitoring during 2007 are summarized in Table 10.0.1. Information on contamination incidents investigated during 2007 is summarized in Sections 10.9, 10.10, and 10.12.

10.0.2 Public Safety and Resource Protection Program Projects

J. P. 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

Table 10.0.1. Routine Environmental Monitoring Samples and Locations Near Hanford Site Facilities and Operations, 2007

Sample Type	Number of Sampling Locations	Operational Area								
		100-B/C	100-D	100-F	100-H	100-K	100-N	200/600	300/400	ERDF[a]
Air	85	5	4	5	0	10	3	48[b]	7	3
Soil	70	0	0	0	0	0	0	55	14	1
Vegetation	59	0	0	0	0	0	3	42	14	0
External radiation	124	4	0	0	0	18	6	68	25	3

(a) Environmental Restoration Disposal Facility in the 200-West Area.
(b) Includes two stations in the 200-North Area and one station at the Wye Barricade.

Project, the Meteorological and Climatological Services Project, the Surface Environmental Surveillance Project, and the Cultural Resources Project. These projects are designed to monitor the Hanford Site environment; provide assurance to 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 at 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 assure 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. Meteorological data for 2007, including some historical climatological information, are summarized in Section 10.16.

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, to assess doses to members of the public, to monitor potential impacts of contaminants on other biota, and to alert DOE to the possible need for corrective action (DOE Orders 450.1 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:

- Collect and analyze samples, review and interpret analytical data, and maintain a long-term computer database for trend analysis.
- Determine compliance with applicable environmental quality standards, public exposure limits, and applicable laws and regulations; the requirements of DOE Orders; and the environmental commitments made in environmental impact statements, environmental assessments, safety analysis reports, or other official DOE documents.
- Conduct pre-operational assessments.

- Assess radiological doses to the public and environment.
- Assess doses from other local sources.
- Report alarm levels and potential doses exceeding reporting limits.
- Determine contaminant background levels and site contributions of contaminants in the environment.
- Determine long-term accumulations of site-related contaminants in the environment and predict trends.
- Characterize and define trends in the physical, chemical, and biological conditions of environmental media.
- Determine the effectiveness of treatments and controls in reducing effluents and emissions.
- Determine the validity and effectiveness of models to predict concentrations of pollutants in the environment.
- Detect and quantify unplanned releases.
- Identify and quantify new environmental quality problems.
- Maintain the capability to assess the consequence of accidental contaminant releases.
- Provide public assurance and address issues of concern to the public, stakeholders, regulatory agencies, and business community.
- Enhance the public understanding of site environmental issues, primarily through public involvement and providing environmental information to the public.
- Provide 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 at 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).

Information on contaminant concentrations in project samples collected at site-wide and offsite locations during 2007 is summarized in Sections 10.2, 10.4, 10.5, 10.8, and 10.12. Other project information is summarized in Sections 10.11, 10.14, and 10.17. More detailed contaminant data are provided in the *Hanford Site Environmental Surveillance Data Report for Calendar Year 2007* (PNNL-17603, APP. 1). The types and general locations of samples collected for site-wide and offsite environmental surveillance during 2007 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 ensure 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 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 completion of the Hanford Site waste management and environmental restoration mission through the following activities:

- Verify 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*.
- Identify biotic contaminant transport pathways and characterize risks.
- Provide data for environmental impact and ecological risk assessments.
- Provide maps and information useful for mitigating the impact on biological resources during facility expansions and decommissioning activities.
- Support Hanford Site land-use planning and stewardship.

Table 10.0.2. Types and General Locations of Samples Collected for Site-Wide and Offsite Environmental Surveillance in 2007

Type	Total Number of Locations	Sampling Locations						
		Onsite[a]	Site Perimeter[b]	Nearby[c]	Distant[c]	Columbia River		
						Upstream[c]	Hanford Reach[b]	Downstream[c]
Air	42	23	11	7	1			
Spring water	18						17	1
Spring sediment	11						10	1
Columbia River water	47					5	31	11
Irrigation water	2			2				
Drinking water	4	4						
River sediment	8					2	3	3
Ponds	2	2						
Pond sediment	1	1						
Foodstuffs	9		3	4	2			
Wildlife	5	4			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).

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 2007 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 2007 is provided in Section 10.15.

10.0.3 Soil and Groundwater Remediation Project

T. L. Watson

The Soil and Groundwater Remediation Project is responsible for assessing the distribution and movement of existing contamination (both radiological and chemical) in the soil and groundwater beneath the Hanford Site. The project identifies and characterizes potential and emerging groundwater contamination problems. Monitoring activities are conducted to comply with requirements of the *Resource Conservation and Recovery Act of 1976* (RCRA), 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 monitoring is also performed during cleanup investigations under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). Groundwater samples were collected from 947 monitoring wells and shoreline aquifer tubes during 2007. A summary of groundwater monitoring activities and analytical results for 2007 is provided in Section 10.7.

10.0.4 Drinking Water Monitoring Project

G. W. Patton and L. M. 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 2007.

10.0.5 Biological Control Program

A. R. 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 contaminated biota and soil, 2) control of undesirable plants and animals, 3) cleanup of legacy and new contamination related to biota, and 4) remediation, following cleanup, of sites affected by radioactive contamination spread by plants and animals.

The control of weeds and pests is an important part of the Biological Control Program. Weeds on industrial sites at the Hanford Site threaten to accumulate radionuclides, become fire hazards, or interfere with work or machinery. At the Hanford Site, weed control occurs at tank farms (clusters 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), 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, restoration is necessary following cleanup and removal of contamination. Restoration is a common activity on the Hanford Site but has specific meanings and limitations when applied to biological control. Restoration may include removal and replacement of soil, revegetation of the soil surface, or placement of engineered barriers to stop biological intrusion (biological barriers). Such restoration on radioactive waste sites is typically performed to prevent recurrence of surface radioactive contamination or colonization by unwanted biota. Activities conducted for the Biological Control Program in 2007 are discussed in Sections 10.10 and 10.12.

10.0.6 Washington State Department of Health Oversight Monitoring

J. J. 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 2007, the contractors were Pacific Northwest National Laboratory, Energy*Solutions*, 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. Analysis of Washington State Department of Health samples is performed by the Washington State Public Health Laboratory, 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 320-047).

10.1 Air Emissions

D. J. Rokkan

Hanford Site contractors monitor airborne emissions from site facilities to assess the effectiveness of emission control equipment and pollution management practices, and to 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 manufacturer's specifications. Most facility radioactive air emission units are actively ventilated stacks at which sampling is performed 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 instance, DOE annually submits to EPA and the Washington State Department of Health a report of radionuclide air emissions from the site (DOE/RL-2008-03), 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). Isotopes mostly commonly measured in the emissions are tritium (i.e., hydrogen-3), strontium-90, iodine-129, cesium-137, plutonium-238, plutonium-239/240, plutonium-241, and americium-241. 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. The cessation of nuclear materials processing at the Hanford Site is largely responsible for the decrease in its radioactive emissions.

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. The selection of the specific radionuclides sampled, analyzed, and reported is 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 2007, the prime sources of emissions and the number of emission points by operating area are as follows:

- In the 100 Areas, nine radioactive emission points were active. Emissions originated from normal evaporation and cleanup activities at two water-filled storage basins (100-K East and 100-K West Fuel Storage Basins [also known as the K Basins], which previously contained irradiated nuclear fuel); 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, 44 radioactive emission points were active. The primary sources of these emission points were the Plutonium Finishing Plant, T Plant, 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, 14 radioactive emission points were active. The primary sources of these emissions were laboratories and research facilities, such as the 324 Waste Technology Engineering Laboratory, 325 Applied Chemistry Laboratory, 327 Post-Irradiation Laboratory, and 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 shutdown—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 at which low-level radiological and chemical analyses are performed on various types of samples (e.g., particulate air filters, liquids, soil, and vegetation).

A summary of Hanford Site radioactive airborne emissions in 2007 is provided in Table 10.1.1.

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 at the Hanford Site during 2007. (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, AP Tank Farm, and 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. During 2007, the 200 Areas tank farms and the 242-A Evaporator produced reportable ammonia emissions, also summarized in Table 10.1.2.

Onsite diesel-powered electric-generating plants emitted particulate matter, sulfur oxides, nitrogen oxides, volatile organic compounds, carbon monoxide, and lead. The 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).

Should activities result in chemical emissions in excess of quantities reportable under CERCLA, the release totals are immediately reported to EPA. 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 at the Hanford Site, 2007

		Release, Ci[a]				
Radionuclide	**Half-Life**	**100 Areas**	**200-East Area**	**200-West Area**	**300 Area**	**400 Area**
Tritium (as HT)	12.3 yr	NM	NM	NM	1.76×10^{2}	NM
Tritium (as HTO)	12.3 yr	NM	NM	NM	3.99×10^{2}	2.5×10^{-1}
Strontium-90	29.1 yr	3.2×10^{-5}[b]	6.9×10^{-5}[b]	2.2×10^{-5}[b]	6.7×10^{-6}[b]	NM
Iodine-129	16,000,000 yr	NM	1.6×10^{-3}	NM	NM	NM
Xenon-131m	11.8 d	NM	NM	NM	2.0×10^{-10}	NM
Xenon-133	5.2 d	NM	NM	NM	3.0×10^{-9}	NM
Cesium-137	30 yr	NM	1.9×10^{-5}	2.4×10^{-7}	1.4×10^{-7}	5.9×10^{-6}[c]
Radon-220	55.6 s	NM	NM	NM	1.83×10^{1}	NM
Radon-222	3.8235 d	NM	NM	NM	2.23×10^{-2}	NM
Plutonium-238	87.74 yr	3.6×10^{-6}	1.2×10^{-7}	5.1×10^{-7}	ND	NM
Plutonium-239/240	24,110 yr	2.6×10^{-5}[d]	1.5×10^{-6}[d]	2.6×10^{-5}[d]	5.6×10^{-7}[d]	8.9×10^{-7}[d]
Plutonium-241	14.4 yr	8.7×10^{-5}	ND	1.9×10^{-5}	ND	NM
Americium-241	432.2 yr	2.0×10^{-5}	2.9×10^{-7}	5.3×10^{-6}	3.8×10^{-9}	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 = 3.7×10^{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 at the Hanford Site, 2007

Constituent	Release, kg (lb)	
Particulate matter-total	4,500	(10,000)
Particulate matter-10	2,700	(6,000)
Particulate matter-2.5	900	(2,000)
Nitrogen oxides	13,000	(28,000)
Sulfur oxides	2,700	(6,000)
Carbon monoxide	14,000	(30,000)
Lead	0.45	(1)
Volatile organic compounds[a,b]	10,000	(22,000)
Ammonia[c]	12,000	(26,000)
Other toxic air pollutants[d]	5,600	(12,300)
Total criteria pollutants[e]	**44,000**	**(96,000)**

(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, operation of the 242-A Evaporator, 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, the 242-A Evaporator, 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, operation of the 242-A Evaporator, 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

B. G. Fritz and C. J. Perkins

Atmospheric releases of radioactive materials from Hanford Site facilities and operations to the surrounding region are potential sources of human exposure. At 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, and in nearby and distant communities. Information about these ambient-air monitoring efforts, including detailed descriptions of air-sampling and analysis techniques, is provided in the DOE's Hanford Site environmental monitoring plan (DOE/RL-91-50, Rev. 4). Brief summaries of the ambient-air monitoring objectives and the projects that support them are provided in Section 10.0 of this report.

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-17603, APP. 1; PNNL-17603, 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

C. J. Perkins

During 2007, a network of continuously operating samplers at 85 locations across the site (Table 10.2.1) (sampling locations illustrated in PNNL-17603, APP. 2) was used to monitor radioactive materials in air near Hanford 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 prior to the 2007 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

Table 10.2.1. Monitoring Locations and Analyses for Ambient-Air Monitoring Samples Collected Near Hanford Site Facilities and Operations, 2007

Site	Number of Samplers	EDP Code[a]	Analyses	
			Biweekly	Composite[b]
100-B/C Area Field Remediation Project	5	N464, N465, N466, N496, N497	Gross alpha, gross beta	GEA, ^{90}Sr, Pu-iso, U-iso
100-D Area Field Remediation Project	4	N467, N468, N514, N515	Gross alpha, gross beta	GEA, ^{90}Sr, Pu-iso, U-iso
100-F Area Field Remediation Project	5	N519, N520, N521, N552, N553	Gross alpha, gross beta	GEA, ^{90}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, ^{90}Sr, Pu-iso, U-iso, ^{241}Pu, ^{241}Am
118-K-1 Field Remediation Project (100-K Area)	3	N403, N534, N535	Gross alpha, gross beta	GEA, ^{90}Sr, Pu-iso, U-iso
100-N Area D4 Project	3	N102, N103, N106	Gross alpha, gross beta	GEA, ^{90}Sr, Pu-iso, U-iso
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, ^{90}Sr, Pu-iso, U-iso
Canister Storage Building (200-East Area)	2	N480, N481	Gross alpha, gross beta	GEA, ^{90}Sr, Pu-iso, U-iso, ^{241}Pu, ^{241}Am
Integrated Disposal Facility (200-East Area)	2	N532, N559	Gross alpha, gross beta	GEA, ^{90}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, ^{90}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, ^{90}Sr, Pu-iso, U-iso
200-North Decontamination and Demolition Project	2	N563, N564	Gross alpha, gross beta	GEA, ^{90}Sr, Pu-iso, U-iso
300 Area Decontamination and Demolition Project	1	N557	Gross alpha, gross beta	GEA, ^{90}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, ^{90}Sr, Pu-iso, U-iso
Environmental Restoration Disposal Facility	4	N482, N517, N518, N963	Gross alpha, gross beta	GEA, ^{90}Sr, Pu-iso, U-iso
600 Area (Wye Barricade)	1	N981	Gross alpha, gross beta	GEA, ^{90}Sr, Pu-iso, U-iso

(a) Environmental data point (EDP) Code = Sampler location code. See PNNL-17603, APP. 2.
(b) GEA = Gamma spectroscopy; strontium-90; Pu-iso = isotopic plutonium (^{238}Pu, $^{239/240}$Pu); U-iso = isotopic uranium (^{234}U, ^{235}U, ^{238}U).

period was too small to be measured accurately. To increase the accuracy of the analysis, the samples were combined into either quarterly or semiannual composite samples for each location. 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, analyses were conducted for americium-241 and plutonium-241 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 (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 2007 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 did those 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 2007. Concentrations of radionuclides in air in the 300 and 400 Areas, near some onsite remediation projects, and offsite at distant locations were collected by Pacific Northwest National Laboratory personnel. Results for Pacific Northwest National Laboratory air samples are summarized in Section 10.2.2.

At the remedial action project site in the 100-B/C Area during 2007, ambient-air monitoring was conducted at five locations through July, when cleanup activity in the northern portion of the site was completed. For the remainder of the year, air monitoring was conducted at three locations. The radionuclides uranium-234 and uranium-238 were consistently detected, while plutonium-239/240 was detected in 30% of the composited samples.

Beginning in February 2007, ambient-air monitoring was initiated at four locations at the 100-D Field Remediation Project. Only uranium-234 and uranium-238 were consistently detected.

Air monitoring was conducted at five locations at the 100-F Area in 2007. Results were similar to those observed during 2005 and 2006; uranium-234 and uranium-238 were detected consistently in approximately 80% of the samples.

During 2007, 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). Overall, airborne contaminant levels in the 100-K Area were similar to those measured over the previous years. Strontium-90, detected in approximately 40% of historic samples, was not detected during 2006 or 2007. Americium-241 concentrations were somewhat lower during 2007 than in previous years; however, this radionuclide was detected in more than 90% of the samples.

Air sampling to support the 118-K-1 Field Remediation Project (100-K Area) was conducted at three locations during 2007. 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 2007 were similar to those measured in previous years. Uranium-234 and uranium-238 were detected in approximately 90% of the composite samples, and plutonium-239/240 was detected in 33% of the samples.

Air sampling was conducted at 21 locations in the 200-East Area during 2007. Radionuclide levels measured in the 200-East Area ambient-air composite samples in 2007 were generally similar to those measured over the previous years. Uranium-234 and uranium-238 were detected in 90% of the samples, uranium-235 was detected in approximately 25% of the samples, and cesium-137 and plutonium-239/240 were detected in approximately 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.

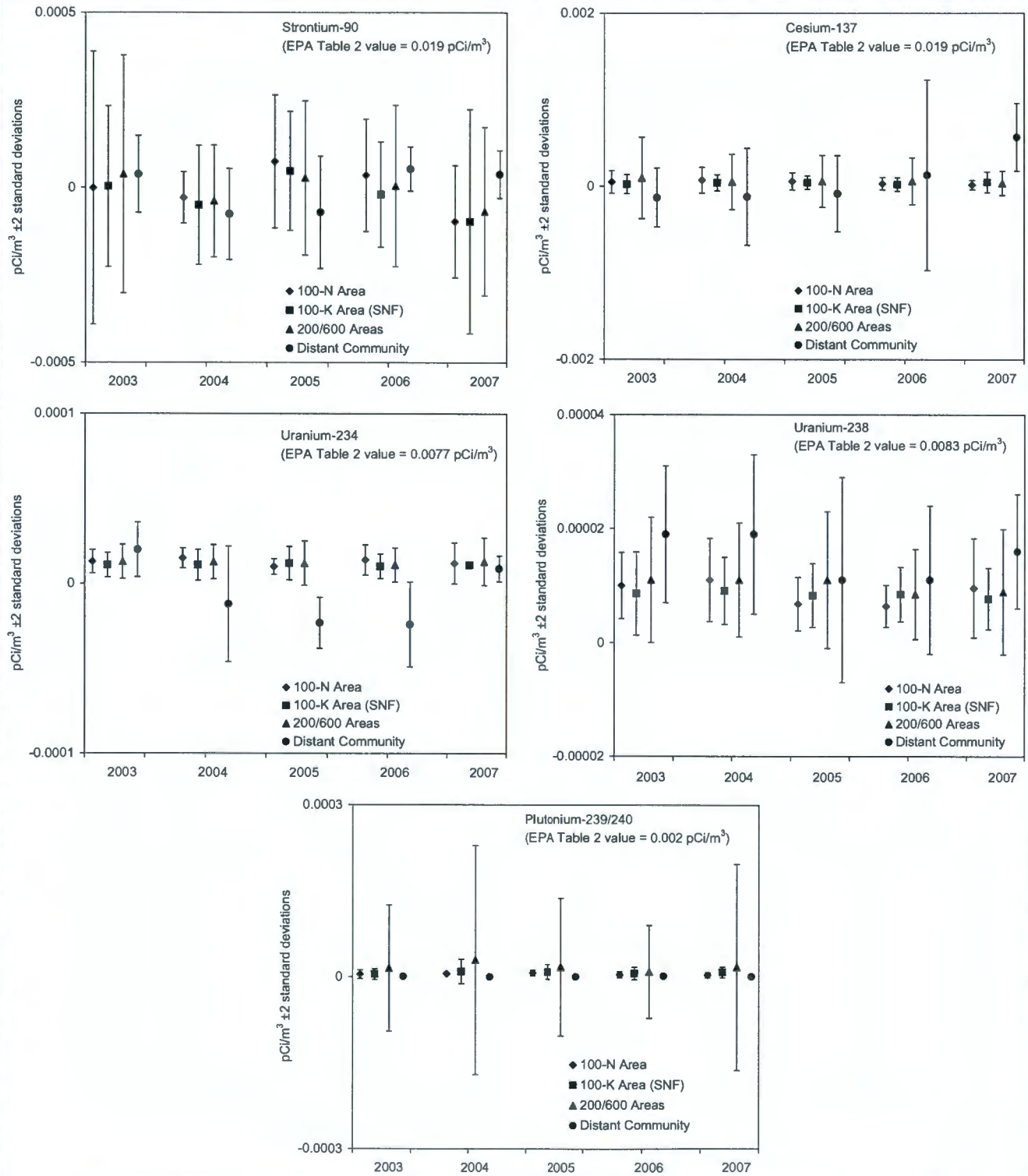

Figure 10.2.1. Average Concentrations of Selected Radionuclides in Ambient-Air Samples Collected on the Hanford Site Near Facilities and Operations Compared to Those Collected in Distant Communities, 2003 Through 2007. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol. Source: 40 CFR 61, Appendix E, Table 2.

Air sampling was conducted at 24 locations in the 200-West Area during 2007. 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 85% of the samples. Plutonium-239/240 was detected in approximately 40% of the samples, and uranium-235 in less than 20%. Plutonium-239/240 concentrations at air-sampling location N165 (near the 216-Z-9 Trench) were greater than 10% of the EPA value (40 CFR 61, Appendix E, Table 2) for both 6-month composite samples collected in 2007. 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 deactivation and decontamination activities in the 200-North Area was conducted at two ambient-air monitoring stations from February through September during 2007. Only uranium-234 and uranium-238 were consistently detected.

During 2007, air sampling in support of deactivation and decontamination activities at the 200-UW-1 site was conducted at four ambient-air monitoring stations. Uranium-234 and uranium-238 were detected in 100% of the samples, and plutonium-239/240 was detected in approximately 60% of the samples.

Air sampling in support of decontamination and decommissioning activities in the 300 Area continued at one location in 2007. 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 in support of remediation work in the 300-FF-2 Operable Unit (near the 300 Area) during 2007 was conducted at six ambient-air monitoring stations. Uranium-234 and uranium-238 were detected in approximately 90% of the samples.

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 2007 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. Detected in only one sample in 2007, the strontium-90 concentration observed during the second-half of the year at station N482 was statistically elevated compared to its historic levels. The concentration was, however, below 10% of the EPA value (40 CFR 61, Appendix E, Table 2).

The near-facility ambient-air monitoring network is occasionally utilized to supply information during and after some environmental occurrences. In 2007, analytical data from selected near-facility air sampling stations were used to help determine impacts from the following events (details of the occurrences are available in Section 8.0):

- On July 27, 2007, approximately 322 liters (85 gallons) of radioactive tank waste spilled onto the ground in the vicinity of the 241-S-102 retrieval pump discharge in the 200-West Area as tank waste was being retrieved from the 241-S-102 Tank. The spill was cleaned up, and no measurable increases in radiological concentrations were detected in samples collected by nearby near-facility monitoring ambient air monitors.
- On August 16, 2007, the Wautoma wildland fire that started in northwestern Benton County reached the Hanford Site and ultimately burned about 3,359 hectares (8,300 acres). Hanford Site and Washington State Department of Health personnel collected air samples from locations across the site as well as from many off-site locations. Analytical results of the samples indicated that there were no releases of radiological contamination from the incident.

Analytical results from 10 near-facility environmental air sampling stations in the 200-West Area that were collected immediately after the fire was contained are provided in PNNL-17603, APP. 2.

10.2.2 Site-Wide and Offsite Ambient-Air Monitoring

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During 2007, airborne radionuclide samples were collected by 42 continuously operating samplers. 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 of the site. 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 prior to the monitoring year (PNNL-16369) 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 was 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 for accurate analysis of individual radionuclides of concern. To increase the sensitivity and accuracy of the analysis, biweekly samples were combined into quarterly composite samples. 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.

Samples have historically been collected for iodine-129 analysis at four locations by drawing air through a cartridge containing a charcoal adsorbent material. Samples were previously collected monthly and combined to form quarterly composite samples for each location. In 2007, samples were not collected because of continued difficulties with the analytical equipment used for iodine-129 analysis. Instead, the measured annual iodine-129 emissions were simulated using the CAP88-PC computer model (EPA 402-R-00-004) to estimate concentrations at the historical monitoring locations. Previous work has shown CAP88-PC to provide accurate estimates of annual average iodine concentrations on the Hanford Site when stack-specific parameters are used (Rhoads et al. 2005).

Atmospheric water vapor was collected for tritium analysis at 20 locations in 2007 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.

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 2007. All 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 radiological material. All radionuclide concentrations in air samples collected in

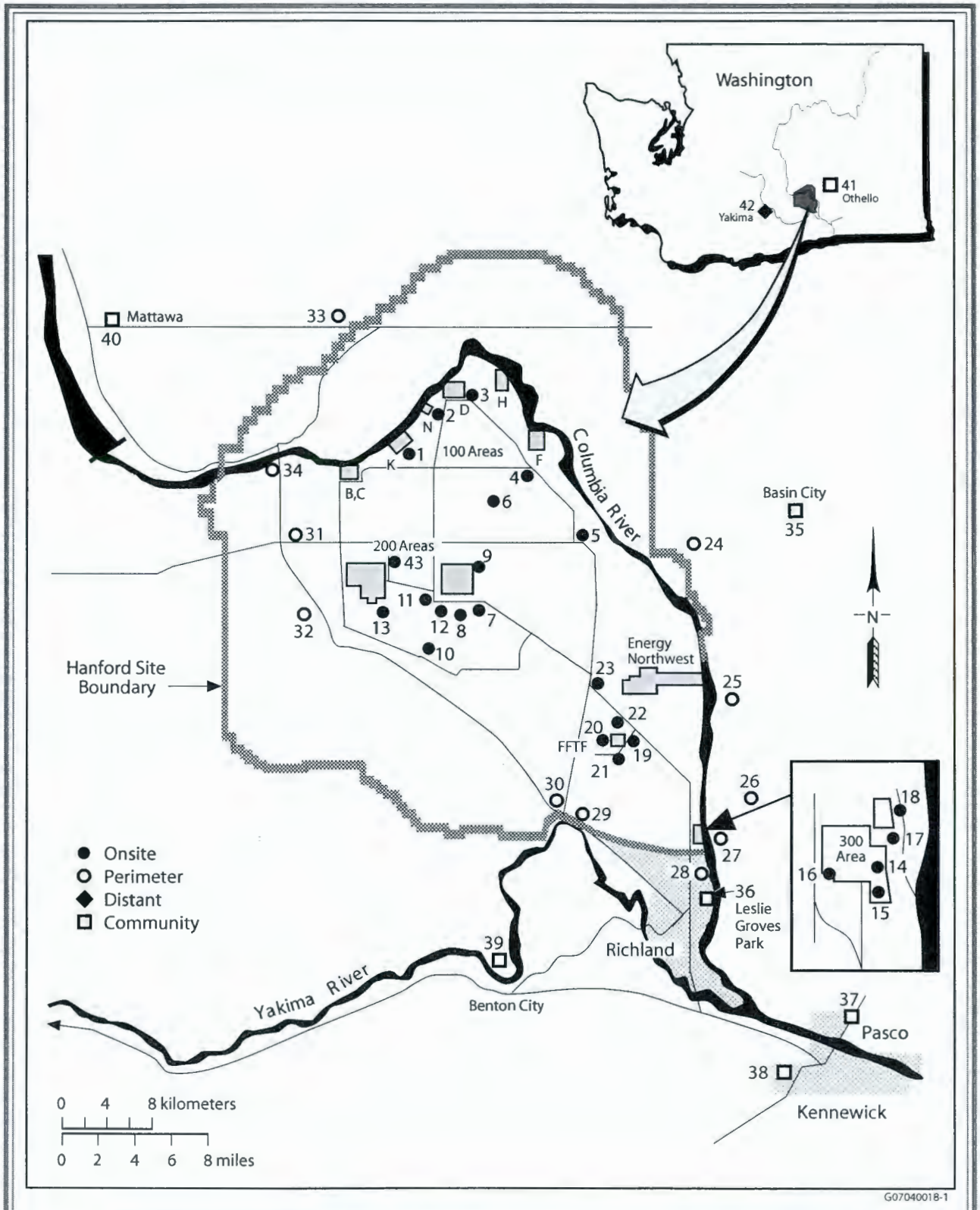


Figure 10.2.2. Hanford Site-Wide and Offsite Ambient-Air Sampling Locations During 2007 (see Table 10.2.2 for location names)

Table 10.2.2. Site-Wide and Offsite Ambient-Air Sampling Locations, Sample Composite Groups, and Analytes, 2007

Map[a] Location	Sampling Location	Analytes[b]	Composite Group	Analytes[c]
Site-Wide (Onsite)				
1	100 K Area	Alpha, Beta, ^{3}H	100 Areas	Gamma, Sr, Pu
2	100 N-1325 Crib	Alpha, Beta, ^{3}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, ^{3}H, ^{129}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, ^{3}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, ^{3}H	300 Area	Gamma, Sr, Pu, U
15	300 South Gate	Alpha, Beta, ^{3}H		
16	300 South West	Alpha, Beta, ^{3}H		
17	300 Trench	Alpha, Beta, ^{3}H U, Gamma	300 NE	Sr, Pu
18	300 NE	Alpha, Beta, ^{3}H U, Gamma		
19	400 E	Alpha, Beta, ^{3}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
Perimeter				
24	Ringold Met Tower	Alpha, Beta, ^{3}H, ^{129}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, ^{3}H	Dogwood Met Tower	Gamma, Sr, Pu, U
27	Byers Landing	Alpha, Beta, ^{3}H, ^{129}I	Byers Landing	Gamma, Sr, Pu, U
28	Battelle Complex	Alpha, Beta, ^{3}H	Battelle Complex	Gamma
29	Horn Rapids Substation	Alpha, Beta	Prosser Barricade	Gamma, Sr, Pu, U
30	Prosser Barricade	Alpha, Beta, ^{3}H		
31	Yakima Barricade	Alpha, Beta	Yakima Barricade	Gamma, Sr, Pu
32	Rattlesnake Springs	Alpha, Beta		
33	Wahluke Slope	Alpha, Beta, ^{3}H	Wahluke Slope	Gamma, Sr, Pu
34	S End Vernita Bridge	Alpha, Beta		

Table 10.2.2. (contd)

Map[a] Location	Sampling Location	Analytes[b]	Composite Group	Analytes[c]
Nearby Communities				
35	Basin City School	Alpha, Beta, ^{3}H	Basin City School	Gamma, Sr, Pu, U
36	Leslie Groves-Richland	Alpha, Beta, ^{3}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
Distant Communities				
42	Yakima	Alpha, Beta, ^{3}H, ^{129}I	Yakima	Gamma, Sr, Pu, U
Non-Radiological Monitoring				
43	Hanford Meteorology Station	PM_{10}, $PM_{2.5}$[d]		

(a) See Figure 10.2.2.
(b) Alpha (gross) and beta (gross) samples were collected and analyzed every 2 weeks, ^{3}H samples were collected and analyzed every 4 weeks, and ^{129}I samples were collected every 4 weeks but were not analyzed because of an equipment problem at the analytical laboratory.
(c) Gamma spectroscopy, strontium-90, isotopic plutonium (^{238}Pu, $^{239/240}Pu$), and isotopic uranium (^{234}U, ^{235}U, ^{238}U) analyses were performed on quarterly composite samples.
(d) See Section 10.2.2.3.

2007 were low enough to meet the EPA standard; no air samples were collected in 2007 with concentrations high enough to result in a 10-millirem (100-microsievert) annual dose.

Gross alpha concentrations were essentially the same at site-wide and offsite locations during 2007 (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 2007 was observed at a site-wide location near the 300 Area (3,000 aCi/m^3 [110 µBq/m^3]). The average gross alpha concentrations observed in individual location groups during 2007 were slightly higher than the 10-year average concentrations observed from 1996 through 2005 (Table 10.2.3).

Gross beta concentrations in air peaked during the fall and winter months in 2007 (Figure 10.2.4), repeating a pattern of natural radioactivity fluctuations (Eisenbud 1987). The annual average gross beta concentrations at site-wide locations during 2007 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 2007 were the same as concentrations measured from 1996 through 2005 (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 2007 (Figure 10.2.4).

Tritium concentrations measured at all locations during 2007 were similar but slightly higher than average values reported for 1997 through 2006 (Table 10.2.3). The annual average concentrations for the 300 Area, perimeter, and community were higher than the annual average concentration measured at the distant location; although

Table 10.2.3. Airborne Radionuclide Concentrations in the Environs of the Hanford Site, 2007 Compared to Previous Years

Radionuclide (approximate detection limit)	Location Group[a]	2007 No. of Samples	2007 No. of Detections[b]	2007 Maximum[c]	2007 Average[d]	1997-2006 No. of Samples	1997-2006 No. of Detections[b]	1997-2006 Maximum[c]	1997-2006 Average[d]	Derived Concentration Guide[e]
				pCi/m³[f]	pCi/m³[f]			pCi/m³[f]	pCi/m³[f]	pCi/m³[f]
Tritium (1.0 pCi/m³)	300 Area	77	74	29 ± 4.1	8.0 ± 10	603	492	25 ± 3.0	4.3 ± 7.6	100,000
	Site-wide	63	53	15 ± 2.2	3.1 ± 5.0	581	376	16 ± 2.4	2.3 ± 4.8	
	Perimeter	90	81	64 ± 8.3	5.9 ± 18	634	384	74 ± 10	3.4 ± 12	
	Nearby communities	26	20	30 ± 3.1	6.6 ± 15	345	215	61 ± 8.5	3.6 ± 12	
	Distant communities	13	10	10 ± 1.8	3.2 ± 5.9	235	98	24 ± 3.8	1.8 ± 5.0	
Gross beta (0.001 pCi/m³)	Site-wide	592	591	0.072 ± 0.012	0.016 ± 0.022	5,166	5,156	0.14 ± 0.0089	0.016 ± 0.019	No standard
	Perimeter	287	287	0.055 ± 0.0092	0.016 ± 0.020	2,279	2,276	0.098 ± 0.010	0.016 ± 0.018	
	Nearby communities	179	179	0.056 ± 0.0093	0.016 ± 0.021	1,887	1,885	0.059 ± 0.0059	0.016 ± 0.018	
	Distant communities	25	25	0.036 ± 0.0062	0.015 ± 0.016	501	499	0.061 ± 0.0024	0.015 ± 0.018	
				aCi/m³[g]	aCi/m³[g]			aCi/m³[g]	aCi/m³[g]	aCi/m³[g]
Gross alpha (350 aCi/m³)	Site-wide	577	471	3,000 ± 950	700 ± 760	4,965	3,403	6,300 ± 3,300	600 ± 880	No standard
	Perimeter	282	243	2,400 ± 960	720 ± 730	2,188	1,577	5,100 ± 1,300	590 ± 810	
	Nearby communities	79	64	2,600 ± 870	690 ± 910	991	722	6,300 ± 1,700	630 ± 930	
	Distant communities	24	18	1,500 ± 650	620 ± 630	501	327	5,500 ± 1,900	550 ± 920	
Strontium-90 (80 aCi/m³)	Site-wide	36	0	84 ± 72	-2.4 ± 53	274	67	1,300 ± 280	23 ± 190	9,000,000
	Perimeter	28	0	37 ± 64	-7.5 ± 47	189	24	390 ± 79	6.5 ± 100	
	Nearby communities	12	0	49 ± 78	-16 ± 77	108	13	220 ± 190	13 ± 110	
	Distant communities	4	0	6.4 ± 58	-34 ± 94	57	4	300 ± 100	-0.053 ± 130	
Iodine-129 (0.01 aCi/m³)	Site-wide					36	36	47 ± 7.1	22 ± 16	70,000,000
	Perimeter		Data not available for 2007			72	72	1.9 ± 0.20	0.64 ± 0.80	
	Distant communities					37	37	0.22 ± 0.015	0.050 ± 0.073	
Plutonium-238 (3 aCi/m³)	Site-wide	44	3	2.5 ± 2.7	0.23 ± 1.5	274	16	13 ± 3.9	0.095 ± 2.3	30,000
	Perimeter	24	1	13 ± 4.0	0.67 ± 5.6	189	1	1.9 ± 1.4	-0.11 ± 1.1	
	Nearby communities	12	1	2.0 ± 6.3	0.28 ± 1.4	108	2	3.7 ± 3.6	0.0061 ± 1.5	
	Distant communities	4	0	1.2 ± 2.2	0.11 ± 1.6	57	0	0.98 ± 1.4	-0.32 ± 1.1	
Plutonium-239/240 (3 aCi/m³)	Site-wide	44	5	11 ± 5.6	0.75 ± 3.8	274	74	36 ± 6.4	1.4 ± 7.0	20,000
	Perimeter	24	1	8.8 ± 4.2	0.64 ± 3.7	189	13	5.2 ± 2.5	0.31 ± 1.7	
	Nearby communities	12	0	0.78 ± 2.3	-0.13 ± 1.4	108	7	3.2 ± 4.6	0.39 ± 1.4	
	Distant communities	4	0	1.1 ± 2.5	0.36 ± 1.5	57	2	3.2 ± 2.9	0.29 ± 1.7	

Table 10.2.3. (contd)

Radionuclide (approximate detection limit)	Location Group[a]	2007 No. of Samples	2007 No. of Detections[b]	2007 Maximum[c] aCi/m³[g]	2007 Average[d] aCi/m³[g]	1997-2006 No. of Samples	1997-2006 No. of Detections[b]	1997-2006 Maximum[c] aCi/m³[g]	1997-2006 Average[d] aCi/m³[g]	Derived Concentration Guide[e] aCi/m³[g]
Uranium-234 (10 aCi/m³)	Site-wide	32	8	43 ± 11	6.1 ± 34	217	188	150 ± 52	21 ± 44	90,000
	Perimeter	16	4	32 ± 10	4.4 ± 33	108	96	135 ± 32	25 ± 47	
	Nearby communities	8	2	29 ± 10	5.6 ± 32	81	71	58 ± 21	22 ± 37	
	Distant communities	4	1	13 ± 6.8	-3.1 ± 23	57	48	41 ± 15	14 ± 29	
Uranium-235 (10 aCi/m³)	Site-wide	32	0	12 ± 17	0.064 ± 5.4	217	10	6.5 ± 8.5	0.32 ± 3.0	100,000
	Perimeter	16	0	1.9 ± 2.9	-0.32 ± 3.0	108	7	6.0 ± 6.0	0.58 ± 3.3	
	Nearby communities	8	0	5.5 ± 14	0.35 ± 5.7	81	5	6.2 ± 5.6	0.25 ± 3.9	
	Distant communities	4	0	1.9 ± 15	-0.48 ± 3.6	57	0	7.0 ± 9.3	-0.18 ± 4.2	
Uranium-238 (10 aCi/m³)	Site-wide	32	32	38 ± 10	21 ± 17	217	201	160 ± 37	22 ± 40	100,000
	Perimeter	16	16	45 ± 13	23 ± 22	108	105	140 ± 32	27 ± 37	
	Nearby communities	8	8	39 ± 12	24 ± 13	81	78	56 ± 18	24 ± 22	
	Distant communities	4	3	24 ± 11	15 ± 12	57	56	33 ± 15	17 ± 13	
Cobalt-60 (1,400 aCi/m³)	Site-wide	48	0	1,000 ± 960	-16 ± 660	471	5	3,800 ± 2,500	73 ± 740	80,000,000
	Perimeter	32	0	1,400 ± 1,100	60 ± 670	320	2	1,000 ± 530	18 ± 730	
	Nearby communities	24	0	1,000 ± 1,400	170 ± 950	262	1	1,800 ± 3,600	43 ± 830	
	Distant communities	4	0	660 ± 1,000	170 ± 1,200	88	2	730 ± 1,000	100 ± 580	
Cesium-137 (1,100 aCi/m³)	Site-wide	48	0	490 ± 450	-38 ± 450	471	6	3,500 ± 1,500	11 ± 670	400,000,000
	Perimeter	32	0	700 ± 550	21 ± 800	320	3	4,600 ± 1,300	36 ± 800	
	Nearby communities	24	0	610 ± 600	-27 ± 730	262	2	2,100 ± 3,100	31 ± 650	
	Distant communities	4	0	360 ± 620	-220 ± 1,300	88	1	520 ± 520	-4.9 ± 520	

(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).

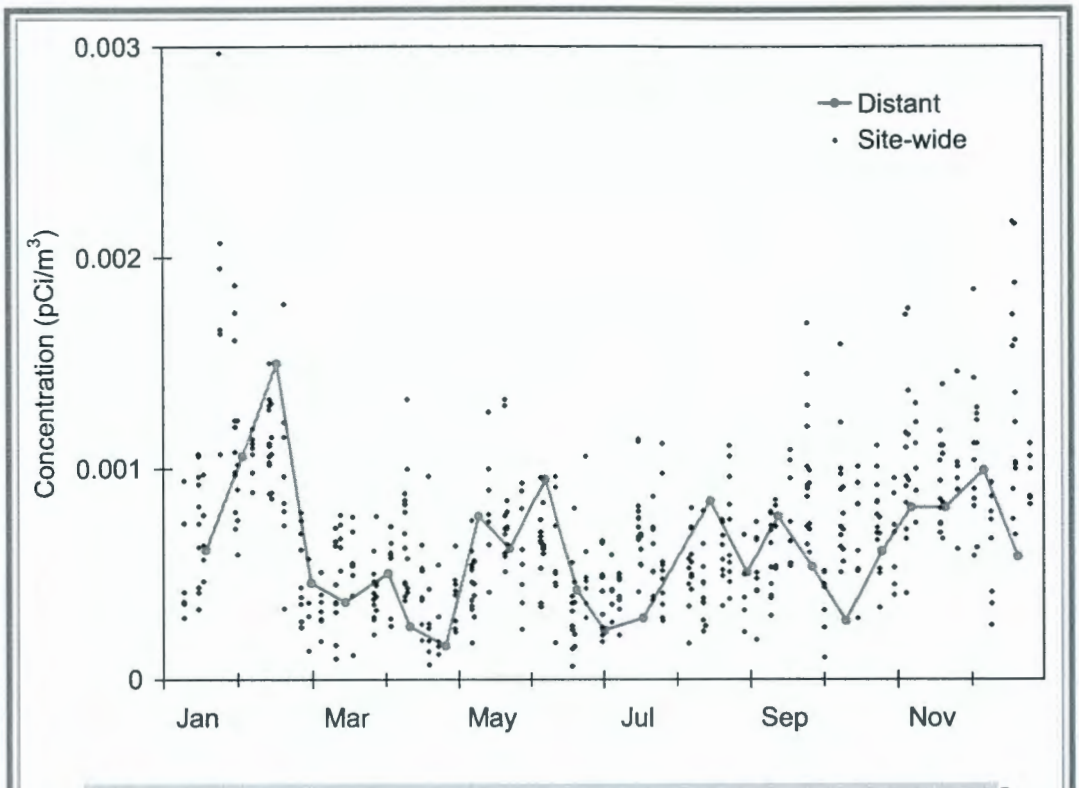


Figure 10.2.3. Gross Alpha Concentrations in Airborne Particulate Samples Collected at Hanford Site-Wide and Distant Locations During 2007 (1 pCi = 0.037 Bq)

the differences were not statistically significant (two-sample means t-test, 95% confidence level). The highest tritium concentration measured during 2007 (64 pCi/m^3 [2.4 Bq/m^3]) was collected at the Dogwood Met Tower sampling location during January. This concentration was 0.064% of the DOE-derived concentration guide for tritium (Appendix D, Table D.2).

Iodine-129 samples were not collected in 2007 (Table 10.2.3) because the mass spectrometer used to analyze samples for iodine-129 was not operational. Concentrations of iodine-129 at the historic monitoring locations and reported iodine emissions (see Section 10.1.1) were modeled using CAP88-PC. The concentrations modeled at the Byers Landing location for 2007 were consistent with concentrations measured between 1996 and 2005 (Figure 10.2.5).

Plutonium-238 was detected in five air samples collected during 2007 (Table 10.2.3). The maximum reported plutonium-238 concentration in 2007 was 13 aCi/m^3 (0.48 μBq/m^3) or 2,000 times below the DOE-derived concentration guide for plutonium-238.

The annual average plutonium-239/240 concentration in air samples collected in 2007 at site-wide locations was 0.75 aCi/m^3 (0.028 μBq/m^3). Of the 44 site-wide samples analyzed for plutonium-239/240, 5 had detectable concentrations (Table 10.2.3). The maximum reported concentration (11 aCi/m^3 [0.41 μBq/m^3]) was 1,800 times less than the DOE-derived concentration guide (20,000 aCi/m^3 [740 μBq/m^3]) for plutonium-239/240.

Average isotopic uranium concentrations (uranium-234, uranium-235, and uranium-238) in airborne particulate matter in 2007 were lower than average concentrations measured from 1996 through 2005 for all location groups (Table 10.2.3). The 2007 annual average uranium-238 concentration at the site perimeter was 23 aCi/m^3 (0.85 μBq/m^3), which is 0.023% of the DOE-derived concentration guide (100,000 aCi/m^3 [3,700 μBq/m^3]). The annual average site-wide and perimeter uranium-238 concentrations were not different from the concentration measured at the distant location by a statistically significant amount (two-sample means t-test, 95% confidence level).

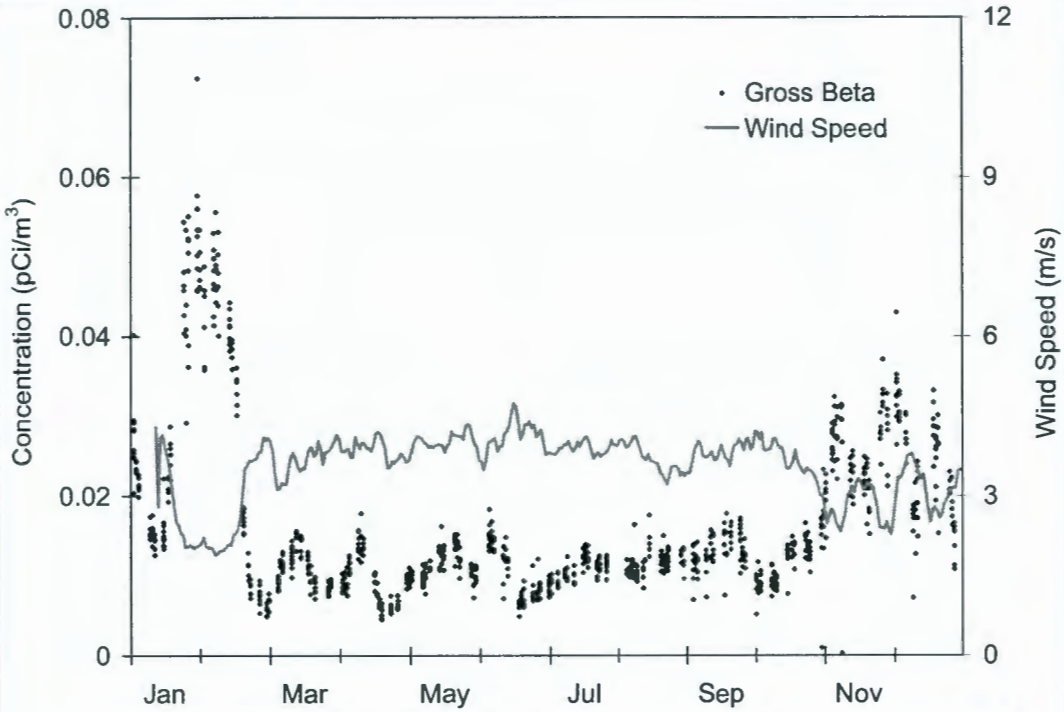


Figure 10.2.4. Gross Beta Concentrations in Airborne Particulate Samples for all Hanford Site-Wide and Offsite Sampling Locations in 2007 and Continuous 14-day Average Wind Speeds at the Hanford Meteorology Station (1 pCi = 0.037 Bq)

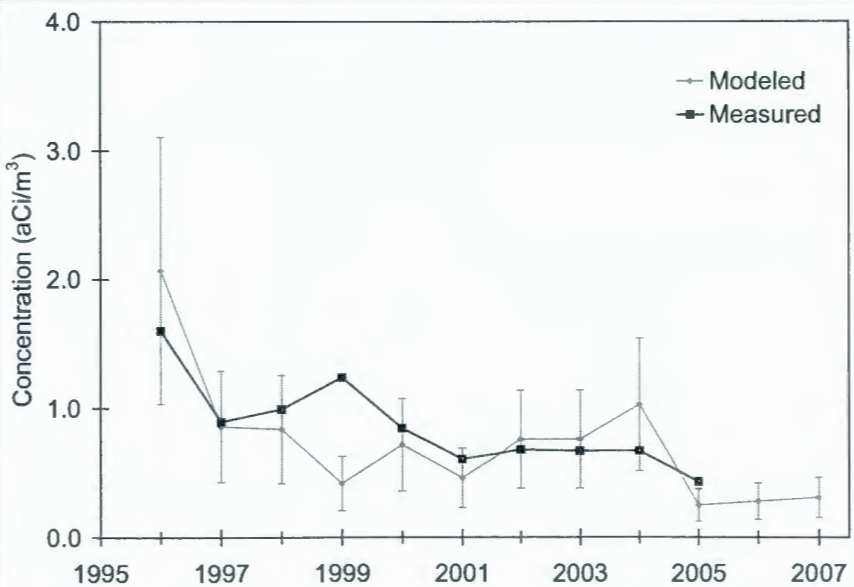


Figure 10.2.5. Modeled and Measured Iodine-129 Concentrations at the Byers Landing Location, 1996 to 2007 (Modeled concentrations based on PUREX stack-specific emission data; error bars represent assumed model accuracy of ±50%.)

The nine highest uranium-238 concentrations measured in 2007 were for samples collected near the 300 Area (Figure 10.2.2). The maximum uranium-238 concentration measured in 2007 (45 aCi/m^3 [1.7 μBq/m^3]) was only 0.045% of the DOE-derived concentration guide for uranium-238.

Eighty-one airborne-particulate samples were analyzed for strontium-90 in 2007 (Table 10.2.3). No samples had detectable concentrations.

Gamma spectroscopy was conducted on all quarterly composite samples collected in 2007. Naturally occurring beryllium-7 and potassium-40 were occasionally measured with detectable concentrations. The potential Hanford Site-origin gamma-emitting radionuclides cobalt-60 and cesium-137 were not detected in any air samples collected in 2007.

10.2.2.3 Monitoring of Airborne Particulate Matter on the Hanford Site

Airborne particulate matter (dust) is an EPA criteria pollutant. The EPA classifies particulate matter by particle size. PM_{10} is an air pollutant consisting of small particles with aerodynamic diameters less than or equal to 10 micrometers. Similarly, $PM_{2.5}$ is an air pollutant consisting of small particles with aerodynamic diameters less than or equal to 2.5 micrometers (PM_{10} particles can include $PM_{2.5}$). The EPA "National Primary and Secondary Ambient Air Quality Standards" (40 CFR 50) for PM_{10} require a 24-hour average concentration of less than 150 μg/m^3. The newly established EPA standards for $PM_{2.5}$ are 35 μg/m^3 for a 24-hour average concentration and 15 μg/m^3 for an annual average concentration. Health-risk studies have shown a positive correlation between increases in concentrations of airborne particulate matter and increased hospital admissions for pulmonary and heart conditions (Schwartz 1994; Morgan et al. 1998; Ostro et al. 1999). Studies have indicated that a 100-μg/m^3 increase in PM_{10} concentrations results in a 17% increase in hospital admissions for pneumonia and chronic obstructive pulmonary disorder (Schwartz 1994). Similar relationships were found between PM_{10} concentrations and daily human mortality in areas where windblown dust was the main contributor to high PM_{10} concentrations (Ostro et al. 1999).

Monitoring of particulate matter mass concentrations in air at the Hanford Site began during February 2001 following the decrease in vegetative cover on a large portion of the site after the 24 Command Wildland Fire in 2000 (PNNL-13487) as well as information requests from the public. Researchers expected the decrease in vegetative cover would result in increased wind erosion and subsequent increased particulate matter (dust) concentrations in air. Particulate monitoring occurs at the Hanford Meteorology Station (location 43, Figure 10.2.2 and Table 10.2.2) using a tapered element oscillating microbalance. This instrument measures the difference in mass collected on a filter by measuring the change in oscillation frequency of the filter. The instrument records an hourly average concentration, but daily average concentration data were calculated for this report. The PM_{10} concentration data have been collected at the Hanford Meteorology Station since February 2001, while $PM_{2.5}$ concentration data collection began at the Hanford Meteorology Station in October 2001.

In 2007, the tapered element oscillating microbalance PM_{10} instrument operated 60% of the time. Although Hanford Site measurements are not used to determine compliance with air quality standards (Section 5.2.1), EPA standards were not exceeded at the measurement locations on the Hanford Site. The observed annual average PM_{10} concentration at the Hanford Meteorology Station during 2007 (14 μg/m^3) was typical of annual average PM_{10} concentrations measured in recent years. Daily average PM_{10} concentrations on the Hanford Site did not exceed the EPA 24-hour average standard during any of the days when monitoring occurred in 2007. The highest measured 24-hour average PM_{10} concentration in 2007 (143 μg/m^3) occurred on October 2, a day with wind gusts measured at 22 m/s (50 mph) at the Hanford Meteorology Station, approximately 6 weeks after the range fires on the Fitzner/Eberhardt Arid Lands Ecology Reserve (see Section 8.0). The dust concentrations measured after the fires in 2007 were dramatically lower than the dust concentrations measured onsite after the 24 Command Fire in 2000 (PNNL-13910).

In 2007, $PM_{2.5}$ monitoring occurred for only about 2-1/2 months (mid-August through October) because of instrument problems. The average $PM_{2.5}$ concentration during this period was 6.3 μg/m^3, 2.5 times lower than the EPA annual average standard of 15 μg/m^3.

10.3 Liquid Effluents from Hanford Site Facilities

D. J. Rokkan

Liquid effluents are discharged from a few facilities at 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-0527-17). 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 the 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 2007, 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. A summary of this effluent is provided in Table 10.3.1.

Table 10.3.1. Radionuclides in 200 Areas Liquid Effluent Discharged to the State-Approved Land Disposal Site at the Hanford Site, 2007

Radionuclide	Half-Life	Release, Ci[a]
Tritium	12.35 yr	29

(a) 1 Ci = 3.7×10^{10} Bq.

Liquid effluent discharged in the 100 Areas are summarized in Table 10.3.2. Generally, this effluent consists 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, 2007

Radionuclide	Half-Life	Release, Ci[a]
Strontium-90	29.12 yr	3.2×10^{-4}
Cesium-137	30 yr	7.5×10^{-5}
Plutonium-239/240	24,065 yr	3.3×10^{-6}

(a) 1 Ci = 3.7×10^{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 permits and the state waste discharge permits (WAC 173-216) for the Hanford Site. Should chemicals in liquid effluent exceed quantities reportable under CERCLA, the release totals are immediately reported to the EPA. If chemical levels in effluent remain stable at predicted levels, they may, with EPA permission, be reported annually. Section 5.3.1 provides a brief synopsis of the NPDES and state waste discharge permits.

10.4 Surface-Water and Sediment Monitoring

G. W. 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 2007. This section describes the monitoring efforts and summarizes the results for these aquatic environments. Detailed analytical results are reported in PNNL-17603, 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, in part, 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. The flow of the river is regulated by 3 dams in Canada and 11 dams in the United States; 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 2007, the Columbia River had normal flows; the average daily flow rate downstream of Priest Rapids Dam was 3,300 cubic meters (116,500 cubic feet) per second. The peak monthly average flow rate occurred during May (4,910 cubic meters [173,400 cubic feet] per second) (Figure 10.4.2). The lowest monthly average flow rate occurred during September (1,780 cubic meters [62,900 cubic feet] per second), based on mean daily flows. Daily average flow rates varied from 1,085 to 6,315 cubic meters (38,310 to 223,000 cubic feet) per second during 2007. 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 measured at the 300 Area

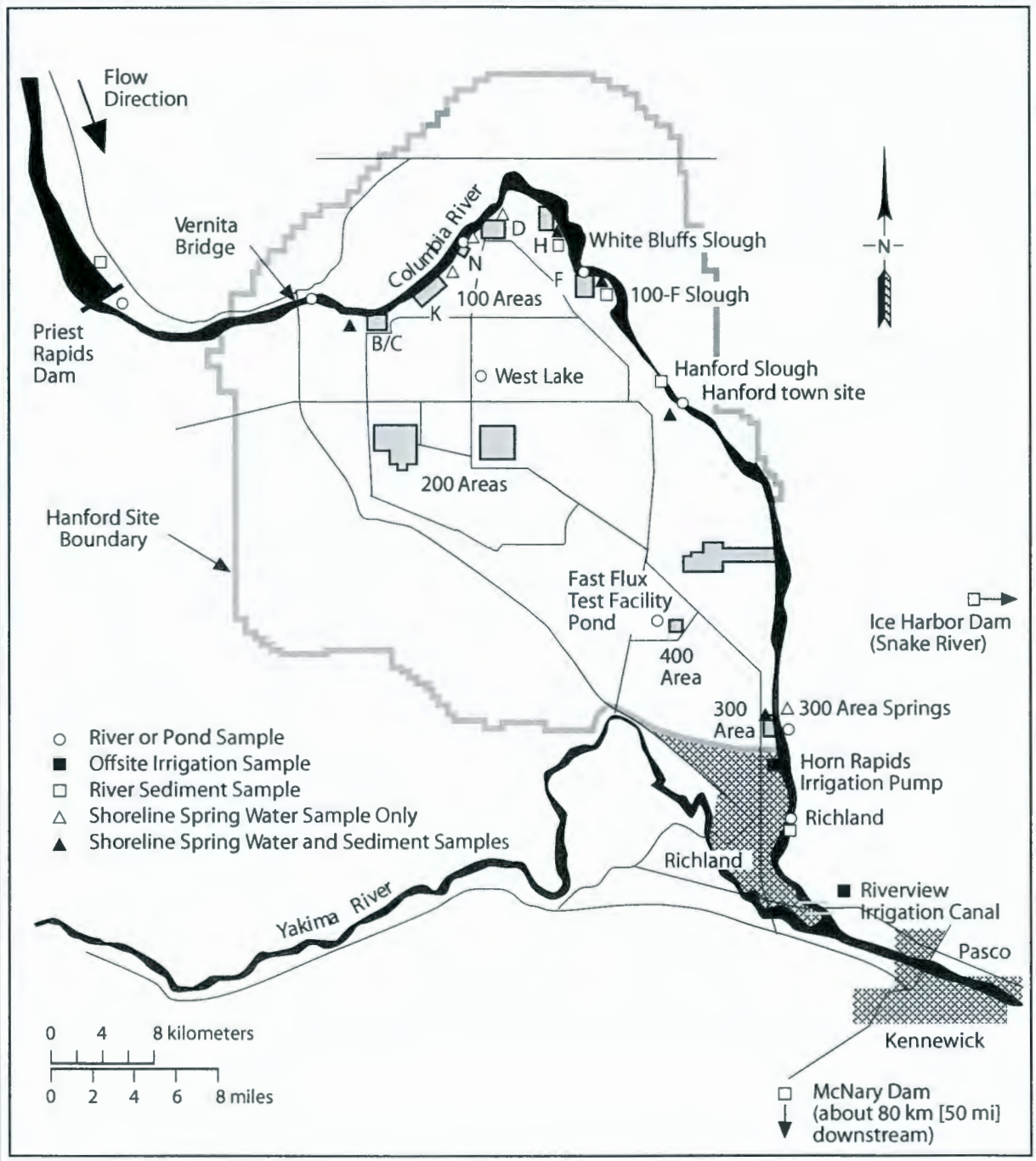


Figure 10.4.1. Surface-Water and Sediment Sampling Locations On and Around the Hanford Site, 2007

Table 10.4.1. Surface-Water Surveillance On and Near the Hanford Site, 2007

Location	Sample Type	Frequency	Analyses
Columbia River - Radiological			
Priest Rapids Dam and Richland	Cumulative	M Comp[a]	Alpha, beta, low ^{3}H,[b] ^{90}Sr, ^{99}Tc, U[c]
	Particulate (filter)	M Cont[d]	Gamma energy analysis
		Q Cont[e]	Pu[f]
	Soluble (resin)	M Cont	Gamma energy analysis
		Q Cont	Pu
Vernita Bridge and Richland	Grab (transects)	Quarterly	Low ^{3}H, ^{90}Sr, U
100-N and 300 Areas and Hanford town site	Grab (transects)	Annually	Low ^{3}H, ^{90}Sr, U
Columbia River - Chemical			
Vernita Bridge and Richland[g]	Grab	3/year	Temperature, dissolved oxygen, turbidity, pH, alkalinity, anions, suspended solids, dissolved solids, specific conductance, hardness (as $CaCO_3$), Ca, P, Cr, Mg, N, Fe, NH_3, $NO_3 + NO_2$
	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
Onsite Ponds			
West Lake[h]	Grab	Quarterly	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma energy analysis
Fast Flux Test Facility pond	Grab	Quarterly	Alpha, beta, ^{3}H, gamma energy analysis
Offsite Irrigation Water			
Riverview irrigation canal	Grab	3/year	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma energy analysis
Horn Rapids	Grab	3/year	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma energy analysis

(a) M Comp indicates river water was collected hourly and composited monthly for analysis.
(b) Low ^{3}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 to 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.

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 National Pollutant Discharge Elimination System in compliance with the *Clean Water Act of 1977*

Table 10.4.2. Columbia River Sediment Surveillance, 2007

Location[a]	Frequency	Analyses
Columbia River		River-sediment analyses included gamma energy analysis, ^{90}Sr, U,[b] Pu,[c] 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.

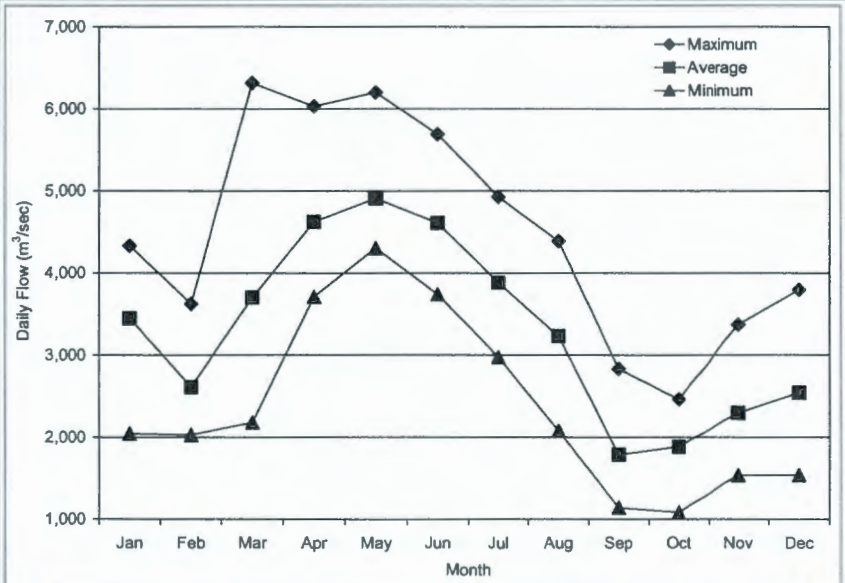


Figure 10.4.2. Monthly Average, Maximum, and Minimum Columbia River Flow Rates at Priest Rapids Dam, Washington, 2007 (multiply m³/sec by 35.31 to obtain ft³/sec)

(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 2007, Columbia River water samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the city of Richland (analyzed for radionuclides), as well as from cross-river transects and near-shore locations near the Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and Richland (analyzed for both radionuclides and chemicals, Figure 10.4.1). Samples were collected upstream from Hanford Site facilities at Priest Rapids Dam and the 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 site facilities or in near-river groundwater underlying the Hanford 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, uranium-238, plutonium-238, and plutonium-239/240. River water samples to be analyzed for iodine-129 were not collected in 2007 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 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 2007 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. The Vernita Bridge and city of Richland transects and near-shore locations were sampled quarterly during 2007. 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 2007 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). All radiological and chemical analyses of transect samples were performed on grab samples of unfiltered water, except for metals analyses, which were performed on both filtered and unfiltered samples.

In addition to water monitoring conducted by Pacific Northwest National Laboratory for potential Hanford Site contaminants, monitoring for basic water-quality parameters (e.g., pH, dissolved oxygen, turbidity) and some chemical constituents was performed by the U.S. Geological Survey under contract to the Pacific Northwest National Laboratory. Samples were collected by the U.S. Geological Survey three times per year along Columbia River transects at the Vernita Bridge and the city of Richland (Appendix C, Table C.2). Sample analyses were performed 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. Results of the radiological analyses of Columbia River water samples collected at Priest Rapids Dam and the city of Richland during 2007 are reported in PNNL-17603, APP. 1 and summarized in Appendix C (Tables C.3 and C.4). The Appendix C tables list the maximum and average concentrations of selected radionuclides detected in Columbia River water in 2007 and for the previous 5 years. All individual radiological contaminant concentrations measured in Columbia River water during 2007 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 2007. Tritium, strontium-90, technetium-99, uranium-234, uranium-238, plutonium-239/240, and naturally occurring beryllium-7 and potassium-40 were measured consistently in river water at levels greater than their reported minimum detectable concentrations. The 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 2007 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

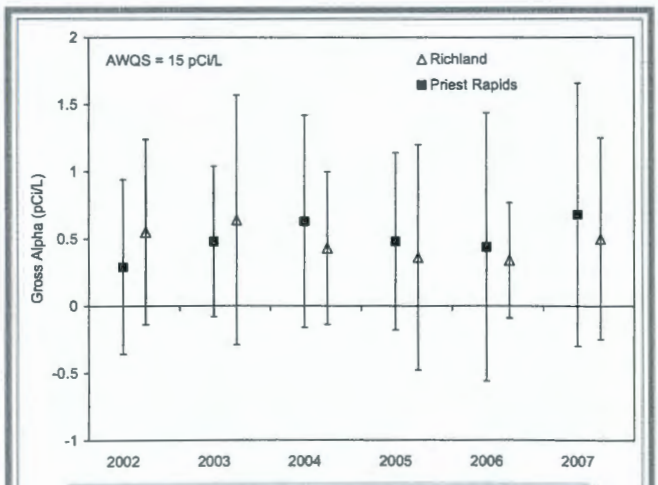


Figure 10.4.3. Annual Average Gross Alpha Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2002 Through 2007 (AWQS = ambient-water quality standard)

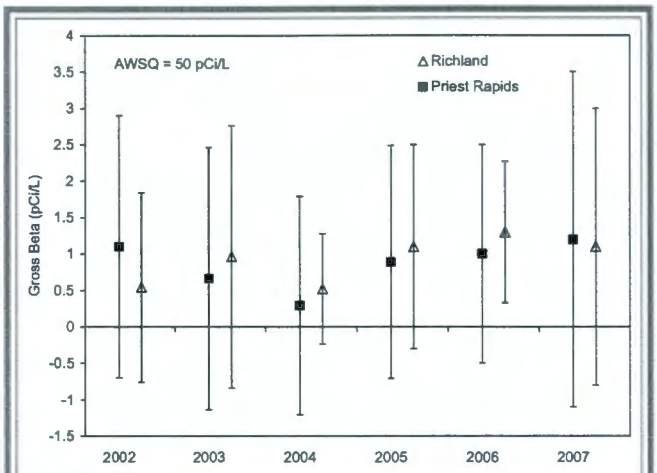


Figure 10.4.4. Annual Average Gross Beta Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2002 Through 2007 (AWQS = ambient-water quality standard)

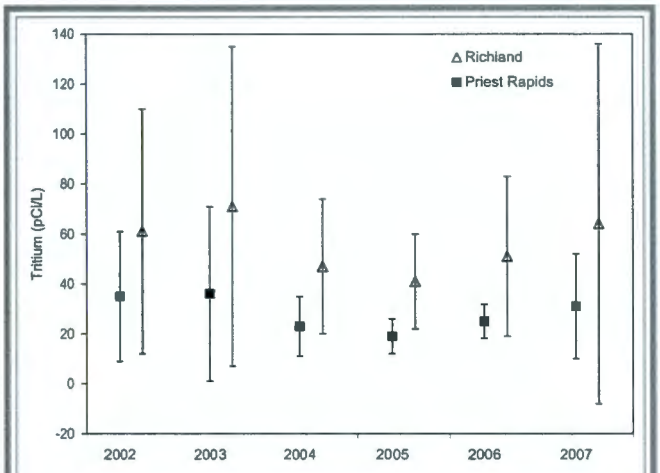


Figure 10.4.5. Annual Average Tritium Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2002 Through 2007 (AWQS = ambient-water quality standard)

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 2007 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 2007 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, 2007 average tritium concentrations in Columbia River water collected at the city of Richland were only 0.3% 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 2007 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.

The average strontium-90 levels measured in Columbia River water collected upstream and downstream of the Hanford Site during 2007 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. Despite the Hanford Site source, there were no statistical differences between monthly strontium-90 concentrations at Priest Rapids Dam and the city of Richland. Average strontium-90 concentrations in Columbia River water at

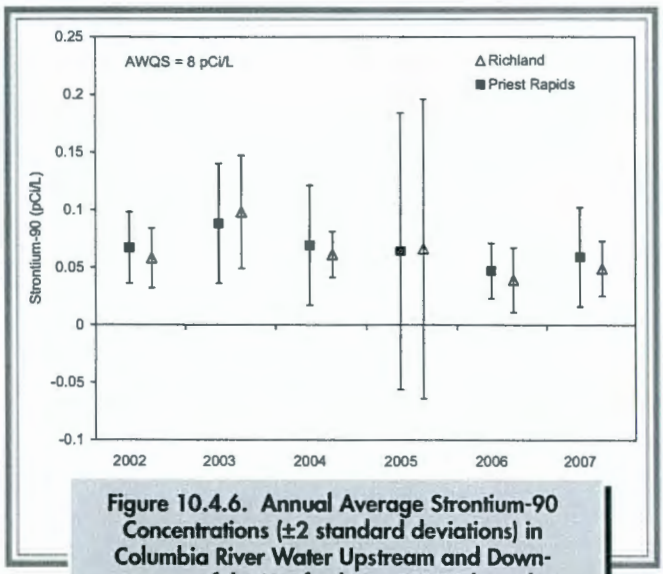


Figure 10.4.6. Annual Average Strontium-90 Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2002 Through 2007 (AWQS = ambient-water quality standard)

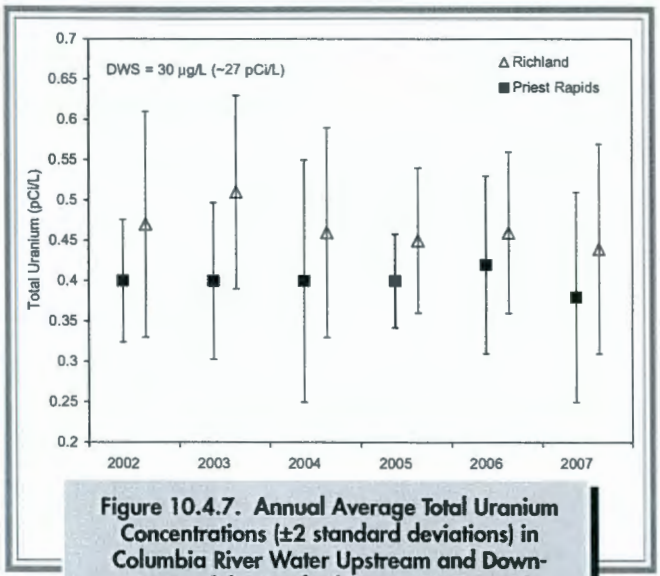


Figure 10.4.7. Annual Average Total Uranium Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2002 Through 2007 (DWS = drinking water standard)

the city of Richland were less than 0.6% 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 2007 were similar to those observed during recent years (Figure 10.4.7). Monthly total uranium concentrations measured at the city of Richland during 2007 were significantly higher than those measured at Priest Rapids Dam. Although there is no direct process discharge of uranium to the river, 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 river across from the Hanford Site via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia 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 2007 were well below the EPA drinking water standard of 30 µg/L (approximately 27 pCi/L [1.0 Bq/L], Appendix D, Table D.4).

Columbia River water samples were collected but not analyzed for iodine-129 in 2007 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 stage; 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 2002 through 2005 shown in Figure 10.4.8.

Plutonium-239/240 concentrations for filtered river-water samples at the city of Richland were extremely low during 2007. All plutonium concentrations for dissolved fractions were reported as undetected by the analytical laboratory.

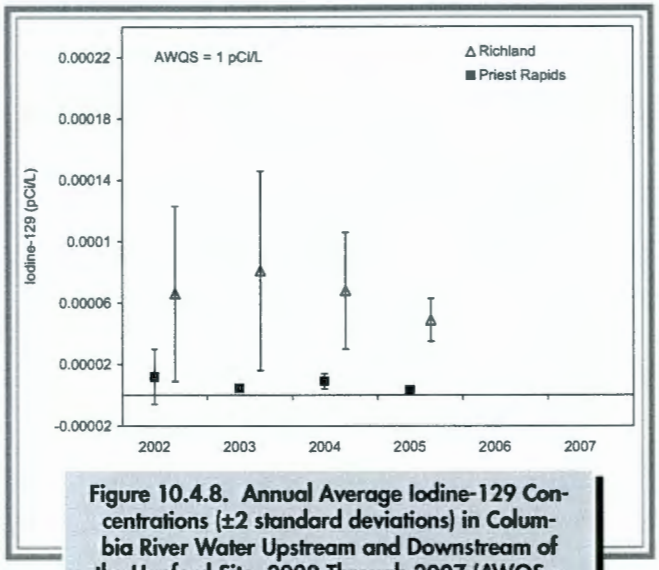


Figure 10.4.8. Annual Average Iodine-129 Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2002 Through 2007 (AWQS = ambient-water quality standard) (River water samples were not analyzed for iodine-129 in 2006 and 2007.)

Plutonium concentrations for material collected on the filters were above the detection limits in one of four samples at the city of Richland (0.000024 ± 0.000018 pCi/L [0.89 ± 0.67 µBq/L]). Plutonium was detected in three of four filter samples from Priest Rapids Dam with a maximum concentration of 0.000046 ± 0.000016 pCi/L (0.17 ± 0.59 µBq/L). 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. Statistical comparisons for dissolved plutonium concentrations at Priest Rapids Dam and the city of Richland were not performed 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 the Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland during 2007 are presented in Appendix C (Tables C.5 and C.6) and PNNL-17603, 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, strontium-90, uranium-234, and uranium-238. 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 the Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland pump house during August 2007 are depicted in Figure 10.4.9. The transect at the 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 during 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 2007, the highest tritium concentration measured in cross-river transect water was 860 ± 150 pCi/L (32 ± 5.6 Bq/L) at the Hanford town site. The highest concentrations measured in near-shore water samples were from samples collected at the 300 Area and Hanford town site; both reported 1,200 ± 210 pCi/L (44 ± 7.8 Bq/L) (Appendix C, Table C.5).

During 2007, 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 2007 was 0.30 ± 0.073 pCi/L (0.011 ± 0.0027 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.

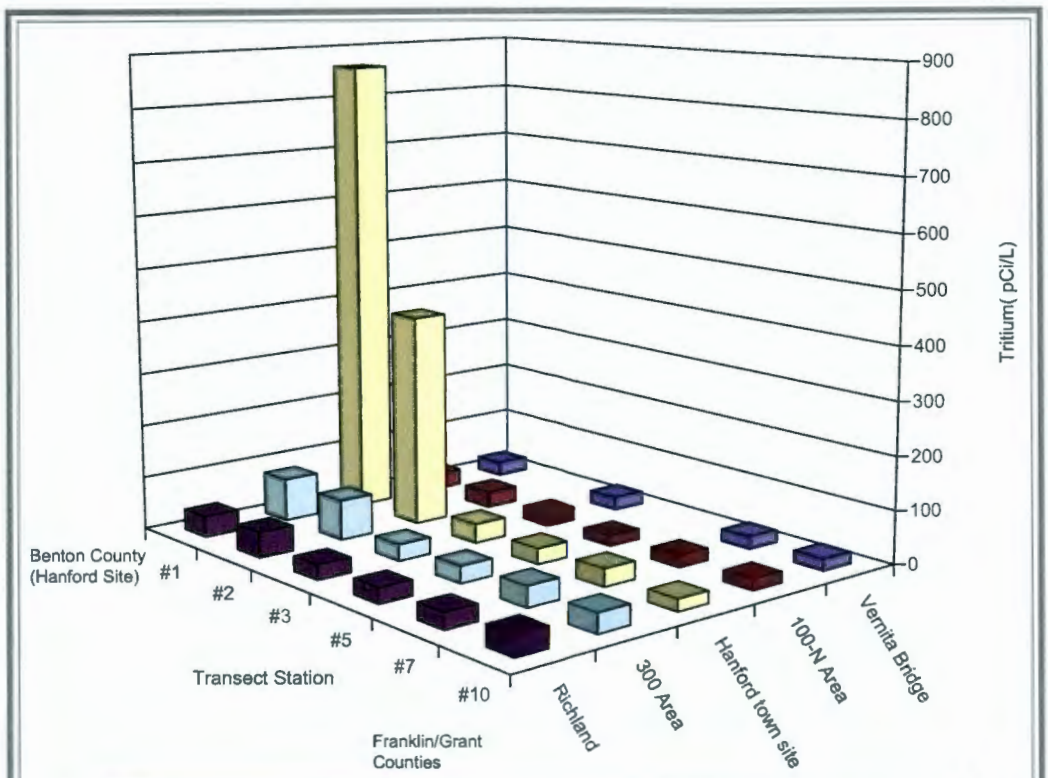


Figure 10.4.9. Tritium Concentrations in Cross-River Transect Water Samples from the Hanford Reach of the Columbia River, September 2007. The Washington State ambient-water quality standard for tritium is 20,000 pCi/L (740 Bq/L).

Total uranium concentrations in Hanford Reach water during 2007 were elevated along both the Benton and Grant–Franklin Counties shorelines for the transect and near-shore samples. For August 2007, the highest total uranium concentration was measured for the sample from the Franklin County shore of the 300 Area transect (1.7 ± 0.22 pCi/L [0.063 ± 0.0081 Bq/L]) (Appendix C, Table C.6; PNNL-17603, 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

The Pacific Northwest National Laboratory and the U.S. Geological Survey (under contract to the Pacific Northwest National Laboratory) compiled chemical and physical water-quality data for the Columbia River during 2007. 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 the Pacific Northwest National Laboratory on water collected at Columbia River transect and near-shore locations at the Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland are provided in PNNL-17603, APP. 1. The concentrations of metals and anions observed in river water during 2007 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 detected occasionally. 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 the 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 2007 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 the Vernita Bridge and the city of Richland.

For samples collected on the cross-river transects, concentrations of nitrate, chloride, and sulfate were elevated at the Hanford town site, and nitrate was slightly elevated at the 100-N Area along the Grant County shore. Elevated nitrate concentrations at the Hanford town site shoreline are from the contaminated groundwater plume in the 200 Areas. 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. 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 the 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. The one exception was acetone, detected for one water sample collected near the middle of the river at the city of Richland pump house, with a 2.1-µg/L concentration just above the 2.0-µg/L detection limit.

Concentrations of chromium in the Hanford Reach are of interest because groundwater contaminated with chromium above the ambient-water quality criterion intersects the river at several Hanford Site locations (Section 10.7). All Columbia River transect and near-shore filtered water samples for 2007 had 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, and 300 Area had slightly elevated chromium levels compared to upstream samples at the 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 the Vernita Bridge and the city of Richland for 2002 through 2007 (WDR-US-2007). Results for 2007 are also tabulated in PNNL-17603, APP. 1 and summarized in Appendix C (Table C.2). The 2007 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 2007, there was no indication of any deterioration of water quality along the Hanford Reach of the Columbia River (Appendix D, Table D.3). For 2007, median concentrations of dissolved chromium were similar for water samples collected from near the Vernita Bridge and the city of Richland and were well below the ambient-water quality criterion.

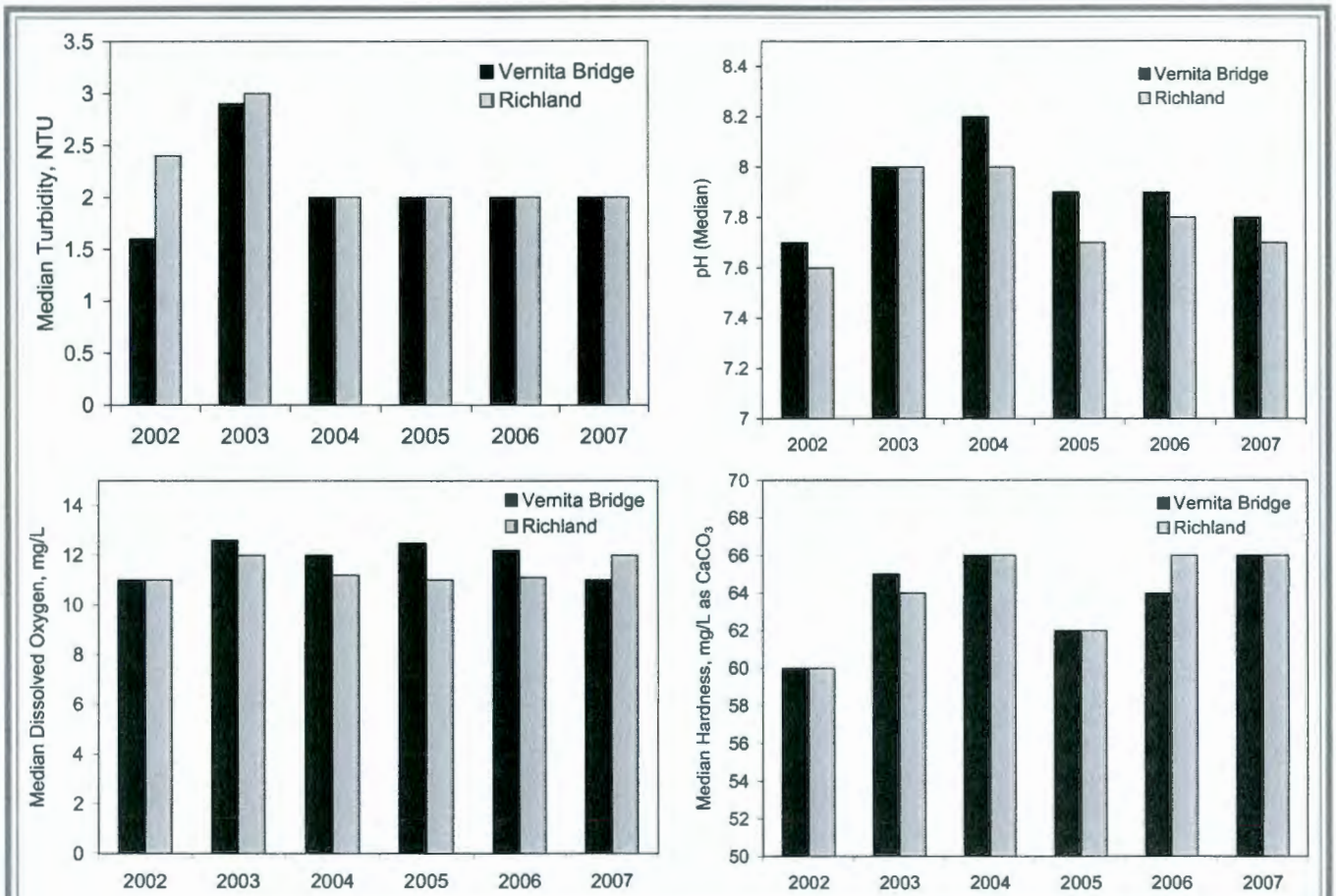


Figure 10.4.10. U.S. Geological Survey Water Quality Measurements for the Columbia River Upstream and Downstream of the Hanford Site, 2002 Through 2007

10.4.2 Monitoring of Columbia River Sediment

During the peak operating years at 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 the 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; PNL-8148; PNL-10535; Cox et al. 2004; 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 at the Hanford Site during 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 White Bluffs Slough on the Hanford Reach.

10.4.2.1 Collection of Columbia River Sediment Samples and Analytes of Interest

During 2007, 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 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 weapons testing, also may 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, uranium-238, and metals (DOE/RL-91-50, Rev. 4). Selected samples were also analyzed for plutonium-238 and plutonium-239/240. 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 2007 included potassium-40, strontium-90, cesium-137, uranium-234, uranium-235, uranium-238, plutonium-238, and plutonium-239/240. The concentrations of all other radionuclides were below the reported minimum detectable concentrations for most samples (PNNL-17603, APP. 1). Strontium-90, 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 2007 were similar to those reported for previous years (Appendix C, Table C.8), and there were no obvious differences between locations. The only unusual values for sediment samples for 2004 through 2007 have been for cesium-137 at the White Bluffs Slough, which were roughly two times higher than values from locations above Priest Rapids Dam. 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 (2002 through 2007) 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-17603, 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, mercury, 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 2007. 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 2007, 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

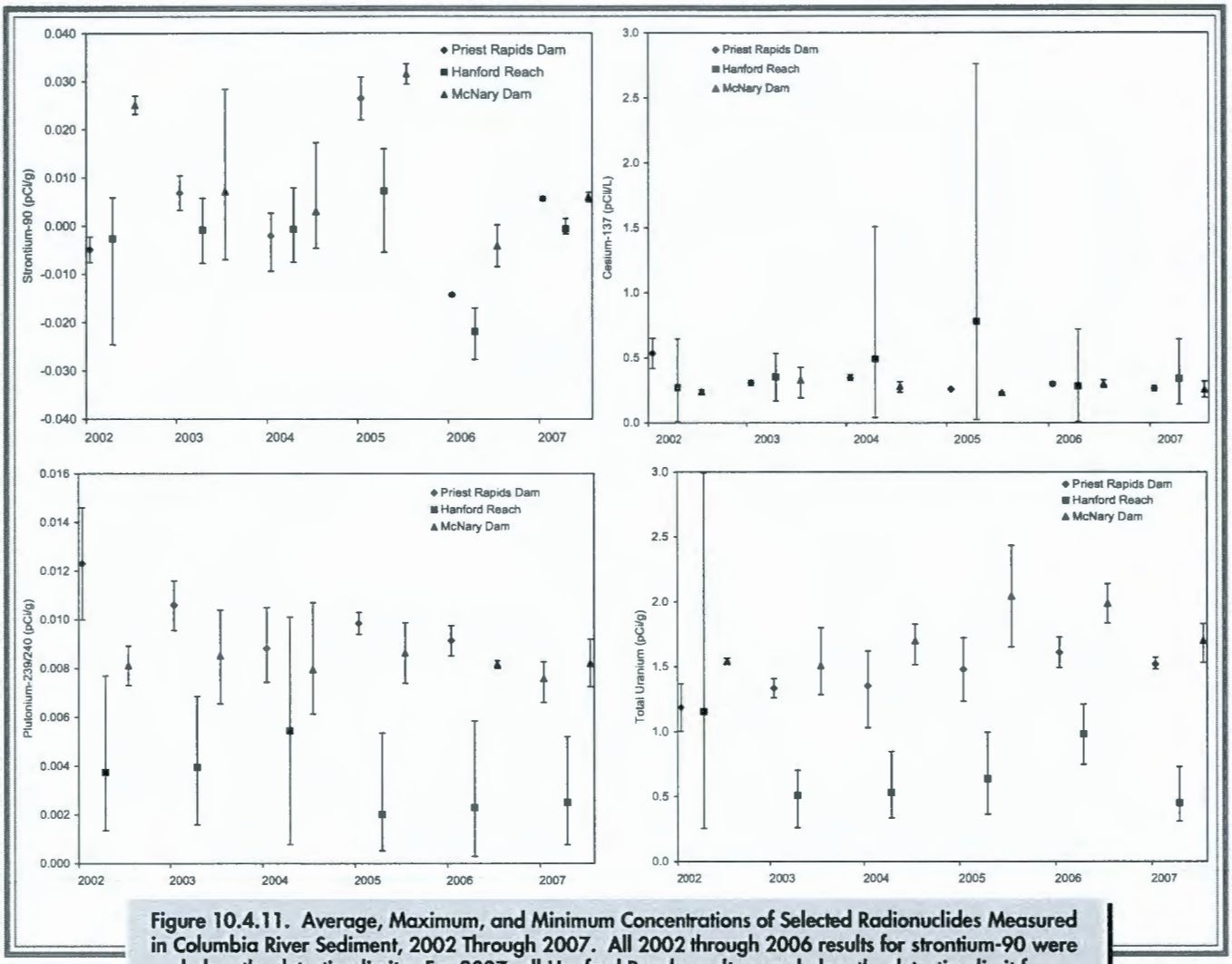


Figure 10.4.11. Average, Maximum, and Minimum Concentrations of Selected Radionuclides Measured in Columbia River Sediment, 2002 Through 2007. All 2002 through 2006 results for strontium-90 were below the detection limits. For 2007, all Hanford Reach results were below the detection limit for strontium, with detected values at McNary Dam (2 of 2) and Priest Rapids Dam (1 of 2).

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-17603, 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 2002 through 2007. Average levels of both constituents have remained stable or decreased slightly in recent years. The average tritium concentration in Fast Flux Test Facility pond water during 2007 was 13% 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.

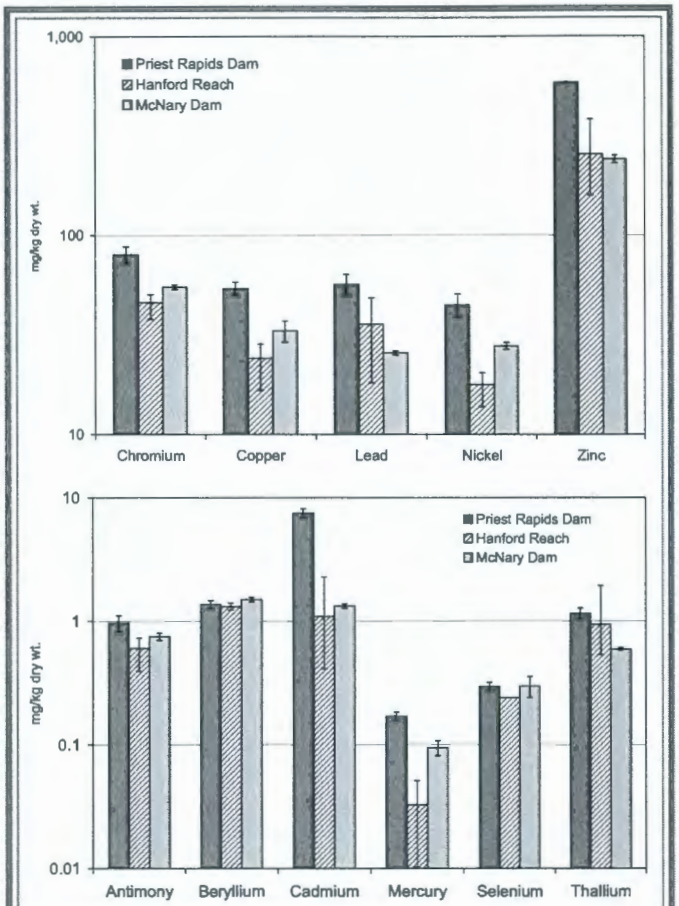


Figure 10.4.12. Average, Maximum, and Minimum Concentrations of Selected Metals Measured in Columbia River Sediment (Washington and Oregon), 2007. The upper and lower bars represent maximum and minimum values. For some metals, the maximum results are similar to the average and are not visible on the figure.

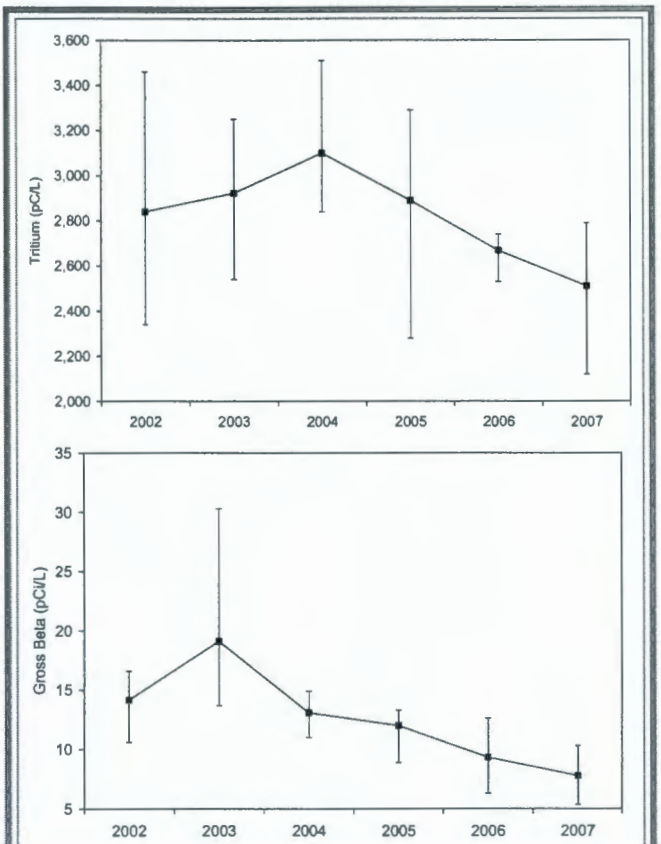


Figure 10.4.13. Average, Maximum, and Minimum Gross Beta and Tritium Concentrations in Water Samples from the Fast Flux Test Facility Pond on the Hanford Site, 2002 Through 2007

Tritium concentrations in West Lake water during 2007 were similar to those observed in the past (Figure 10.4.14). All results for 2007 are below the laboratory-reported detection limits.

Samples of West Lake upper layer sediment in 2007 had the following ranges of values:

- Gross alpha – 2.0 to 6.4 pCi/g (0.074 to 0.24 Bq/g)
- Gross beta – 19 to 24 pCi/g (0.70 to 0.89 Bq/g)
- Potassium-40 – 12 to 16 pCi/g (0.44 to 0.59 Bq/g)
- Strontium-90 – 0.050 to 0.29 pCi/g (0.0018 to 0.011 Bq/g)
- Cesium-137 – 0.88 to 1.0 pCi/g (0.033 to 0.037 Bq/g)
- Uranium-234 – 1.1 to 1.8 pCi/g (0.041 to 0.067 Bq/g)
- Uranium-235 – 0.038 to 0.047 pCi/g (0.0014 to 0.0017 Bq/g)
- Uranium-238 – 0.94 to 1.7 pCi/g (0.035 to 0.063 Bq/g).

West Lake sediment samples were collected near the shoreline as grab samples of upper-layer material using a hand-scoop. The radionuclide levels in West Lake surface sediments are similar to previous measurements reported (PNL-7662). Uranium concentrations are most likely a result from naturally occurring uranium in the surrounding soil (BNWL-1979).

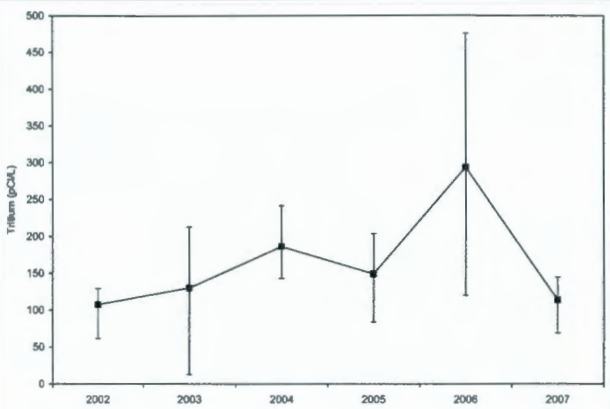


Figure 10.4.14. Average, Maximum, and Minimum Concentrations of Tritium in Water Samples from West Lake on the Hanford Site, 2002 Through 2007

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 2007 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 2007, 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 2007 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 2007, radionuclide concentrations measured in irrigation water were at the same levels detected in Columbia River water samples collected upstream of the Hanford Site (PNNL-17603, 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

G. W. 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 to 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. River stage in the Hanford Reach is controlled by upriver conditions and operations at upriver dams. As water levels fluctuate, groundwater levels and, thus, the presence of shoreline springs in the Hanford Reach, vary. At the 300 Area, the river stage is also influenced by the elevation of the McNary Dam pool. 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.

Because of the effect of bank storage on groundwater discharges and contaminant concentrations, as well as variations in aquifer thickness, porosity, and plume concentrations, it is 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 (PNNL-11933; 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, and sample types and analyses included in shoreline springs monitoring during 2007. This section describes the monitoring efforts and summarizes the results for these aquatic environments. Detailed analytical results are reported in PNNL-17603, 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 2007 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. Riverbank spring water samples collected in 2005 and 2006 were not analyzed for iodine-129 because the unique instrument used for this assay was not operational; an alternative for this ultra-trace measurement capability was not available. For 2007 samples, the ultra-trace analysis was not available so a traditional gamma spectroscopy method (which has a higher detection limit) was used to analyze the samples for iodine-129. Most samples were analyzed for metals and anions. Samples from selected locations were analyzed for volatile organic compounds. All analyses were conducted on unfiltered samples except for metals analyses, which were conducted on both filtered and unfiltered samples (Appendix C, Table C.10; PNNL-17603, 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 2007. 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 2007 were below the laboratory reported detection limit. All radiological contaminant concentrations measured in shoreline springs during 2007 were less than applicable DOE-derived concentration guides, but exceeded the Washington State ambient-water quality criteria for tritium and 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 2002 through 2007. Concentrations of radionuclides in 300 Area shoreline springs in 2007 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 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).

Concentrations of selected radionuclides in shoreline spring water near the Hanford town site (Spring 28-2) from

Table 10.5.1. Hanford Reach Shoreline Springs Water Monitoring, 2007

Springs Locations[a]	Sample Type	Sampling Frequency	Analyses
100-B Area	Grab	Annually	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, gamma energy analysis, metals (filtered and unfiltered), anions, VOC[b]
100-K Area	Grab	Annually	Alpha, beta, ^{3}H, ^{90}Sr, gamma energy analysis, metals (filtered and unfiltered), anions, VOC[b]
100-N Area	Grab	Annually	Alpha, beta, ^{3}H, ^{90}Sr, gamma energy analysis, metals (filtered and unfiltered), anions
100-D Area	Grab	Annually	Alpha, beta, ^{3}H, ^{90}Sr, gamma energy analysis, metals (filtered and unfiltered), anions
100-H Area	Grab	Annually	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U,[c] gamma energy analysis, metals (filtered and unfiltered), anions
100-F Area	Grab	Annually	Alpha, beta, ^{3}H, ^{90}Sr, U,[c] gamma energy analysis, metals (filtered and unfiltered), anions, VOC[b]
Hanford town site	Grab	Annually	Alpha, beta, ^{3}H, ^{129}I, ^{99}Tc, U,[c] gamma energy analysis, metals (filtered and unfiltered), anions
300 Area	Grab	Annually	Alpha, beta, ^{3}H, ^{129}I, ^{90}Sr, U,[c] gamma energy analysis, metals (filtered and unfiltered), anions, VOC[b]

(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, 2007

Springs Locations[a]	Sampling Frequency	Analyses
100-B Area	Annually	Gamma energy analysis, ^{90}Sr, U,[b] metals
100-H Area	Annually	Gamma energy analysis, ^{90}Sr, U,[b] metals
100-F Area	Annually	Gamma energy analysis, ^{90}Sr, U,[b] metals
Hanford town site	Annually	Gamma energy analysis, ^{90}Sr, U,[b] metals
300 Area	Annually	Gamma energy analysis, ^{90}Sr, U,[b] metals

(a) See Figure 10.4.1.
(b) U = Isotopic uranium-234, uranium-235, and uranium-238 analyzed by alpha spectrometry (alpha energy analysis).

2002 through 2007 are provided in Figure 10.5.2. 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 Hanford town site, 300 Area, 100-B Area, and 100-H Area.

Tritium concentrations varied widely with location. The highest tritium concentration measured in shoreline springs was at the Hanford town site (53,000 ± 3,000 pCi/L [2,000 ± 110 Bq/L]), which was above the Washington State ambient surface-water quality criterion of 20,000 pCi/L (740 Bq/L) (WAC 173-201A; 40 CFR 141), followed by 10,000 ± 760 pCi/L (370 ± 28 Bq/L) in the 300 Area (Spring 41-9), and 7,900 ± 600 pCi/L (290 ± 22 Bq/L) in the 100-N Area. Tritium concentrations in most shoreline spring water samples were elevated compared to the 2007 Columbia River water concentrations at Priest Rapids Dam.

Water samples from shoreline springs were analyzed for strontium-90 in the 100-B, 100-D, 100-F, 100-H, 100-K,

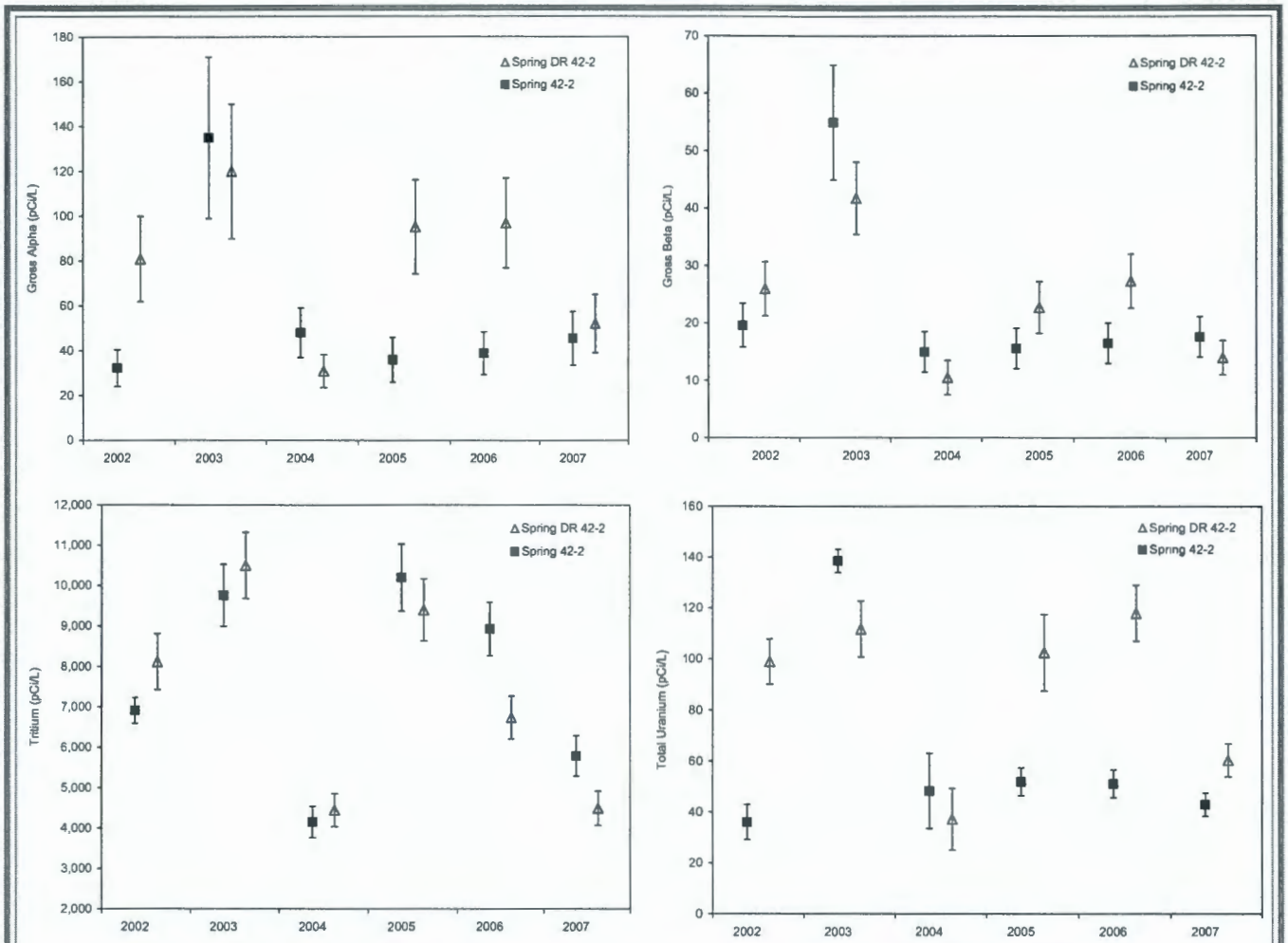


Figure 10.5.1. Concentrations (results ±2 total propagated analytical uncertainty) of Selected Radionuclides in Water from Columbia River Shoreline Springs Near the Hanford Site's 300 Area, 2002 Through 2007. Note: DR refers to downriver; thus, DR 42-2 is a spring located downriver from Hanford Site Spring 42-2. Spring 42-7 (not shown) had the highest concentrations of tritium, gross alpha, and total uranium for the 300 Area in 2007.

100-N, and 300 Areas. The highest strontium-90 concentration detected in shoreline spring water was at the 100-H Area (6.2 ± 0.89 pCi/L [0.23 ± 0.033 Bq/L]). This value was 78% 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 (68 ± 3.9 pCi/L [2.5 ± 0.14 Bq/L]).

Water samples from shoreline springs at the Hanford town site and 300 Area were collected in 2005 and 2006 and submitted to a laboratory for iodine-129 analyses. However, these samples could not be analyzed for iodine-129 because the unique instrument used for this assay was not operational, and an alternative for this ultra-trace measurement capability was not available. From 2000 through 2004, the highest concentrations were measured in water samples from the Hanford town site springs, with all values below the state's surface-water quality criterion of 1 pCi/L (0.037 Bq/L)

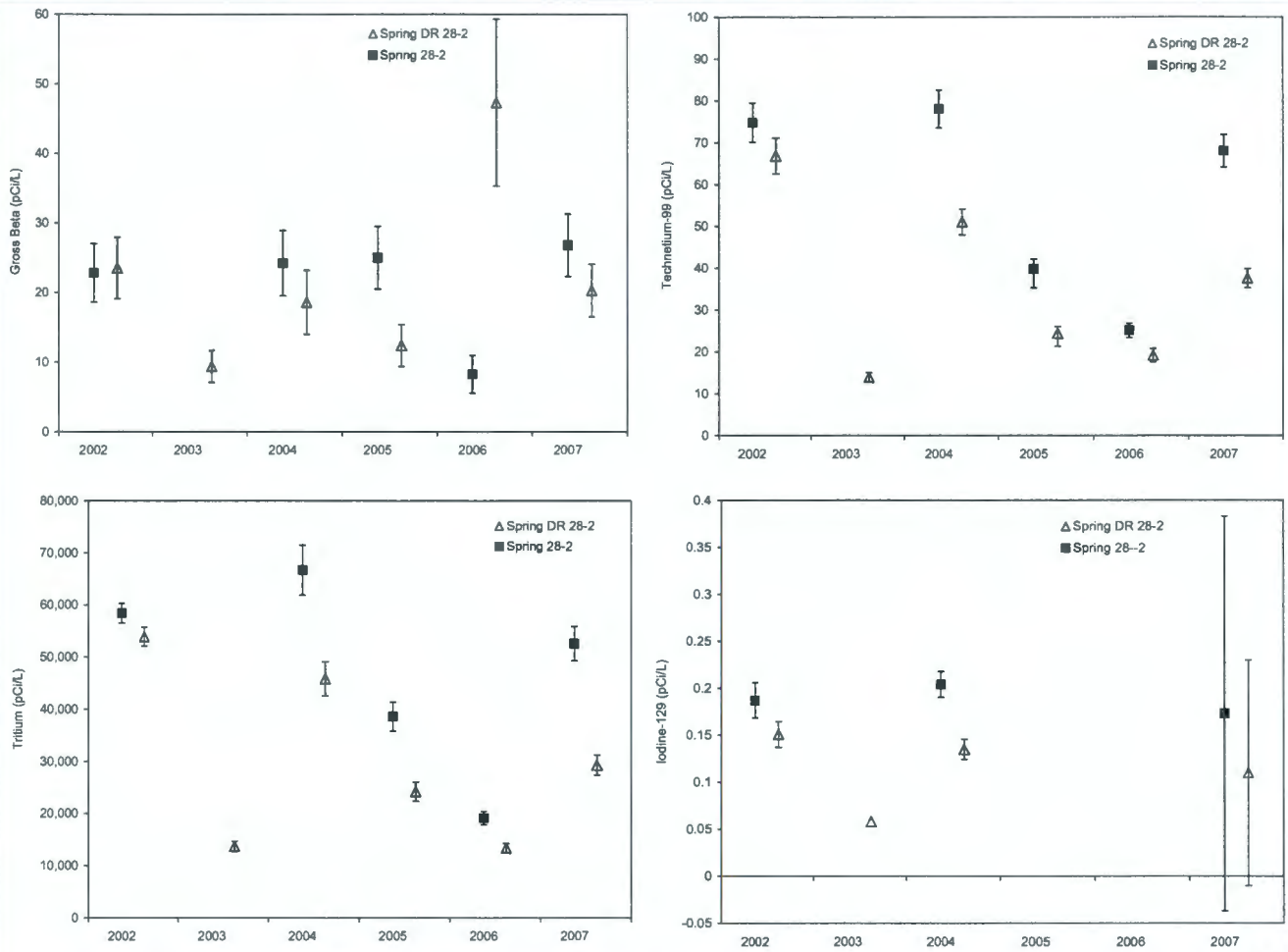


Figure 10.5.2. Concentrations (results ±2 total propagated analytical uncertainty) of Selected Radionuclides in Columbia River Shoreline Springs Water at the Hanford Town Site (Spring 28-2 and Spring 28-2 DR), 2002 Through 2007. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol. Note: DR refers to downriver; thus, DR 28-2 is a spring located downriver from Hanford town site Spring 28-2. Samples for iodine-129 from 2005 and 2006 were not analyzed; samples for 2007 were analyzed using a method with a higher detection limit than the previous samples.

(Appendix D, Table D.4). For 2007, samples were analyzed for iodine-129 with traditional gamma spectrometry, which has a higher detection limit than the ultra-trace method. All samples analyzed for iodine-129 for 2007 were below the detection limit of 1 pCi/L (0.037 Bq/L).

Uranium was monitored in shoreline spring-water samples from the 100-H Area, 100-F Area, Hanford town site, and 300 Area in 2007 (Figure 10.4.1). The highest total uranium level was found in 300 Area Spring water (110 ± 11 pCi/L [4.1 ± 0.41 Bq/L] or approximately 120 ± 12 µg/L), which was collected at Spring 42-7 downgradient 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 27 pCi/L [1.0 Bq/L]). Spring 42-7 in the 300 Area had an elevated gross alpha concentration (120 ± 28 pCi/L [4.4 ± 1.0 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 2002 through 2007 parallel

uranium and are likely associated with its presence. Concentrations of radionuclides in 300 Area shoreline springs in 2007 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 2007. Metals and anions of interest (chloride, fluoride, nitrate, and sulfate) were detected in spring water. Concentrations of volatile organic compounds were near or below their detection limits in all samples except for one at the 100-K Area with a trichloroethene concentration of 4.6 µg/L. Trace amounts (<1 µg/L) of chlorinated organic compounds were observed for the following locations: trichloroethene for the 300 Area, trichloroethene and chloroform at the 100-B Area, and chloroform at the 100-F and 100-K Areas. 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.

Concentration ranges of selected chemicals measured in shoreline spring water during 2002 through 2007 are presented in Table 10.5.3. For most locations, the 2007 chemical sample results were similar to those reported previously (PNNL-14687). Nitrate concentrations in 2007 were highest in spring-water samples from the 100-F Area. Dissolved chromium concentrations were highest in the 100-D, 100-H, and 100-K Areas shoreline springs. Hanford Site groundwater monitoring results for 2007 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. The concentrations of most metals measured in water collected from springs along the Hanford Site shoreline during 2002 through 2007 were below Washington State ambient surface-water chronic toxicity levels (WAC 173-201A). However, for 2002 through 2007, the maximum concentrations of dissolved chromium in shoreline spring water from the 100-B, 100-D, 100-F, 100-H, 100-K, and 100-N Areas were above the Washington State ambient surface-water chronic and acute toxicity levels (Appendix D, Table D.5). Dissolved chromium was above the Washington State ambient surface-water level for chronic and acute toxicity levels at the 100-D, 100-H, and 100-K Areas for riverbank spring-water samples in 2007. 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-F, and 100-K Areas began during 1995 and in the 100-H Area in 2003. Substrates at the shoreline springs in the 100-D and 100-N Areas consist predominantly of large cobble, which are unsuitable for sampling. During 2007, sediment samples were collected at shoreline springs in the 100-B, 100-F, 100-H, 100-K, 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 at the Hanford Site, 2002 Through 2007

	Ambient-Water Quality Criterion Level[a]	100-B Area	100-K Area	100-N Area	100-D Area	100-H Area	100-F Area	Hanford Town Site	300 Area
No. of Samples		13	9	10	12	10	6	16	14
Dissolved Metals (µg/L)									
Antimony	NA	0.11 - 0.31	0.094 - 0.29	0.16 - 0.46	0.17 - 0.30	0.13 - 0.27	0.096 - 0.22	0.15 - 0.26	0.14 - 0.26
Arsenic	190	0.32 - 1.6	0.35 - 2.1	1.5 - 2.7	0.54 - 2.5	0.33 - 2.9	0.38 - 2.3	0.99 - 4.0	0.87 - 5.6
Cadmium	0.59	0.0056 - 0.025	0.012 - 0.037	0.013 - 0.031	0.0074 - 0.12	0.0020 - 0.040	0.013 - 0.12	0.010 - 0.087	0.014 - 0.077
Chromium	10[b]	1.8 - 18	0.59 - 72	6.0 - 17	0.49 - 150	0.76 - 37	0.83 - 19	0.52 - 2.7	1.5 - 5.0
Copper	6	0.20 - 0.52	0.25 - 1.1	0.18 - 0.43	0.32 - 1.5	0.40 - 0.62	0.31 - 1.1	0.24 - 0.88	0.30 - 0.60
Lead	1.1	0.0040 - 0.60	0.0040 - 0.38	0.0052 - 0.24	0.016 - 0.91	0.011 - 1.0	0.0082 - 0.36	0.0040 - 0.29	0.0040 - 0.41
Nickel	83	0.028 - 1.6	0.11 - 1.3	0.042 - 1.7	0.22 - 6.4	0.099 - 1.5	0.14 - 1.7	0.046 - 1.4	0.31 - 2.1
Silver	0.94[c]	0.0017 - 0.0097	0.0017 - 0.0095	0.0017 - 0.0085	0.0017 - 0.0098	0.0017 - 0.010	0.0017 - 0.0084	0.0017 - 0.0022	0.0017 - 0.021
Thallium	NA	0.0035 - 0.0098	0.0038 - 0.023	0.0039 - 0.017	0.0066 - 0.059	0.0042 - 0.017	0.0066 - 0.013	0.0073 - 0.028	0.0040 - 0.038
Zinc	55	0.14 - 2.1	0.43 - 3.7	1.2 - 2.3	1.2 - 12	1.1 - 4.8	0.66 - 4.2	0.54 - 2.7	0.78 - 4.1
No. of Samples		9	9	11	12	10	6	16	14
Total Recoverable Metals (µg/L)									
Chromium	96[d]	7.2 - 89	0.83 - 74	4.6 - 17	5.9 - 270	0.89 - 63	2.3 - 37	0.88 - 24	1.8 - 30
Mercury	0.012	0.00038 - 0.11	0.00075 - 0.050	0.00040 - 0.0094	0.00047 - 0.30	0.00062 - 0.064	0.0016 - 0.029	0.00073 - 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	0.45 - 1.7	1.2 - 3.8
No. of Samples		11	8	5	10	9	5	16	17
Anions (mg/L)									
Nitrate	45[e]	0.10 - 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 2007 samples were similar to those observed for previous years (PNNL-17603, APP. 1; Appendix C, Table C.11). Beryllium-7 (in 1 of 10 samples), potassium-40, strontium-90, cesium-137, and uranium isotopes were the only radionuclides reported above the minimum detectable concentrations. During 2007, 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 2007 were similar to concentrations in Hanford Reach Columbia River sediment samples (PNNL-17603, APP. 1; Appendix C, Table C.9). 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

G. W. Patton and L. M. Kelly

During 2007, Pacific Northwest National Laboratory scientists conducted radiological monitoring of drinking water supplied to Hanford Site facilities by DOE-owned pumps and water-treatment facilities. 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 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-17603, 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 drinking water systems on the Hanford Site were in compliance with drinking water standards for radiological, chemical, and microbiological contaminant levels during 2007. Contaminant concentrations measured during the year were similar to those observed in recent years (see Section 10.6 in PNNL-16623 and Section 10.6 in PNNL-15892).

10.6.1 Hanford Site Drinking Water Systems

During 2007, drinking water was supplied to DOE facilities on the 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 systems. Two systems were operated by Washington Closure Hanford LLC. The system in the 300 Area 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 Hazardous Materials Management and Emergency Response (HAMMER) Training and Education Center in 2007.

Table 10.6.1. Hanford Site Drinking Water Systems and Systems Operators

System[a]	Operator
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 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. During 2007, wells P-14 and P15 did not supply water to the 400 Area.

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 HAMMER Training and Education Center 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 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. The 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 2007 were analyzed for gross alpha, gross beta, tritium, and strontium-90. Results for radiological monitoring of Hanford Site drinking water during 2007 are summarized in Table 10.6.2. Individual analytical results are reported in PNNL-17603, 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 uranium and radon) 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), 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).

During 2007, annual average concentrations of all monitored radionuclides in Hanford Site drinking water were below state and federal maximum allowable contaminant levels. All 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 detected in all three of the river-water samples analyzed for strontium. 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

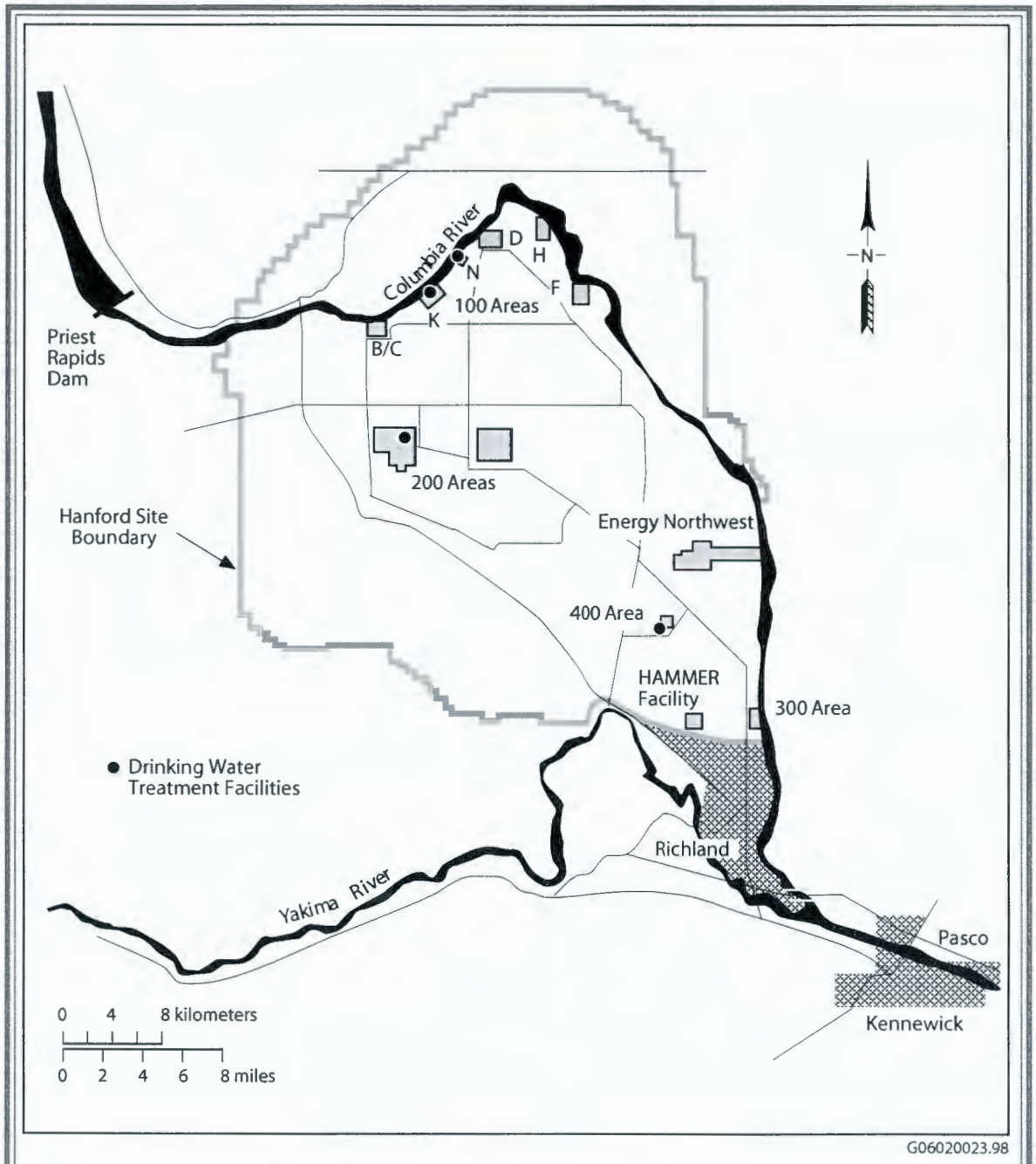


Figure 10.6.1. Hanford Site Drinking Water Treatment Facilities and Sampling Locations, 2007

drinking water wells. During 2007, 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).

Table 10.6.2. Annual Average Concentrations (pCi/L)[a] of Selected Radiological Constituents in Hanford Site Drinking Water, 2007

Constituent	No. of Samples Analyzed From Each Location	Systems				Standards
		100-K Area	100-N Area	200-West Area	400 Area	
Gross alpha[b]	4[c]	0.071 ± 0.79[d]	0.18 ± 0.37[d]	0.094 ± 0.66[d]	0.61 ± 0.93[d]	15[e,f]
Gross beta[b]	4[g]	1.25 ± 1.38[d]	1.16 ± 1.97[d]	1.36 ± 0.674[d]	6.56 ± 3.00	50[f]
Tritium	1[h]	70 ± 140[d,i]	60 ± 140[d,i]	2.48 ± 140[d,i]	2,500 ± 210[b,c]	20,000[f]
Strontium-90	1[h]	0.049 ± 0.037[i]	0.067 ± 0.037[i]	0.092 ± 0.039[i]	-0.0032 ± 0.036[d,i]	8[e,f]

(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.

Table 10.6.3. Tritium Concentrations (pCi/L)[a] in Hanford Site 400 Area Drinking Water Wells, 2007[b]

Sampling Date	Primary Drinking Water Well 499-S1-8J (P-16)	Backup Drinking Water Well 499-S0-8 (P-14)	Backup Drinking Water Well 499-S0-7 (P-15)
January 29, 2007	2,100 ± 460	2,400 ± 530	9,200 ± 1,800
April 25, 2007	2,400 ± 530	2,400 ± 530	11,000 ± 2,200
July 11, 2007	2,510 ± 240	2,540 ± 250	10,400 ± 550
October 22, 2007	2,500 ± 550	2,300 ± 510	9,700 ± 1,900

(a) Multiply pCi/L by 0.037 to convert to Bq/L.
(b) Reported concentration ±2 total propagated analytical error.

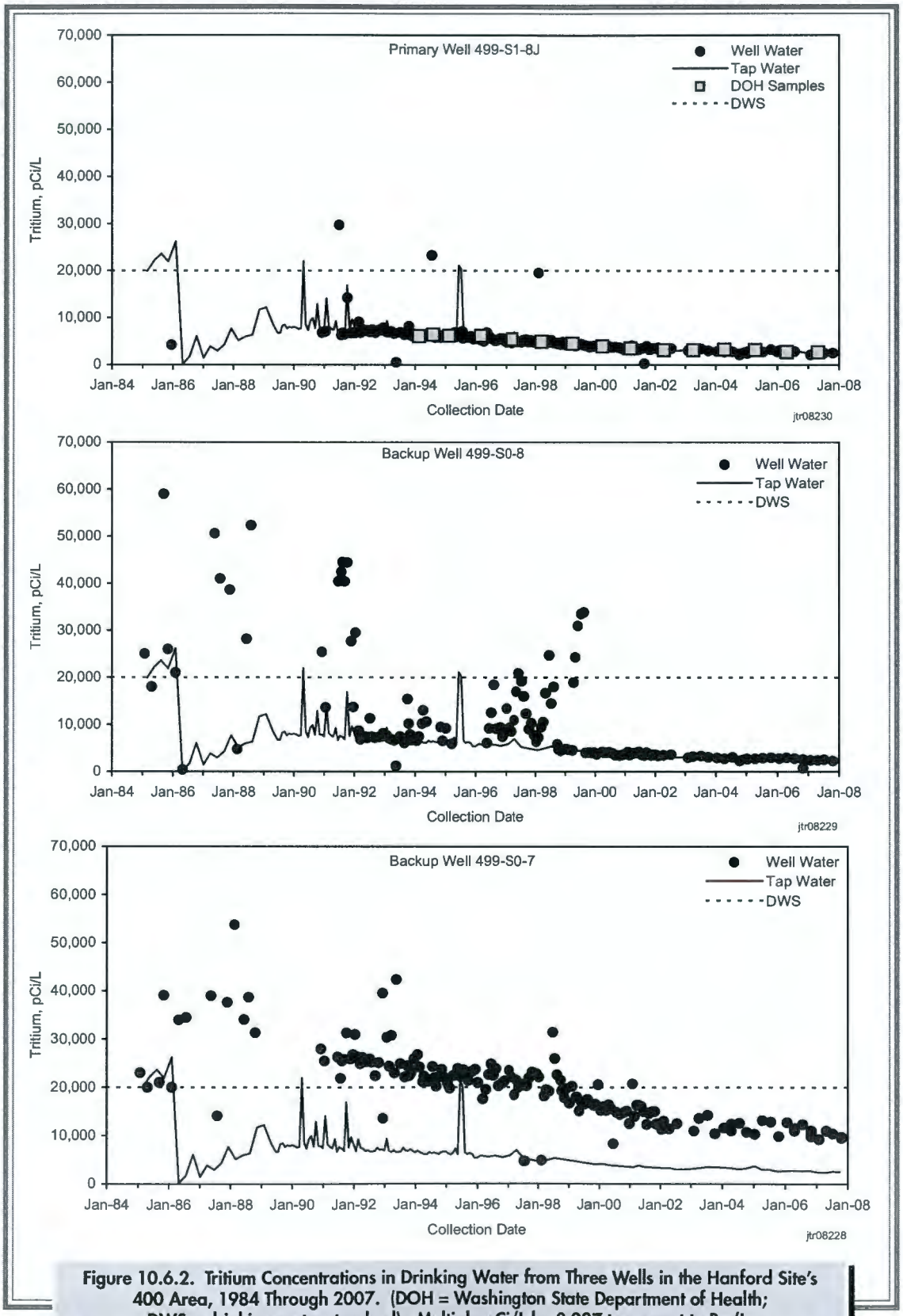


Figure 10.6.2. Tritium Concentrations in Drinking Water from Three Wells in the Hanford Site's 400 Area, 1984 Through 2007. (DOH = Washington State Department of Health; DWS = drinking water standard). Multiply pCi/L by 0.037 to convert to Bq/L.

10.7 Groundwater Monitoring

M. J. Hartman

Groundwater is a supply of fresh water found in layers beneath the earth's surface. At 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). Some of the associated contaminants have reached the groundwater. Hazardous chemicals in the groundwater include carbon tetrachloride, chromium, and nitrate. Radioactive contaminants include strontium-90, technetium-99, iodine-129, tritium, and uranium. Currently, groundwater contaminant levels are greater than drinking water standards beneath 12% of the Hanford Site area (DOE/RL-2008-01).

Groundwater beneath the Hanford Site is not currently used extensively as a water supply for drinking water and 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.

DOE works with regulatory agencies such as the EPA and the Washington State Department of Ecology to make cleanup decisions to protect the Columbia River. The Soil and Groundwater Remediation Project is largely responsible for implementing cleanup decisions. The following sections are summarized from the Hanford Site groundwater monitoring report for fiscal year 2007 (DOE/RL-2008-01).

10.7.1 Highlights and Items of Interest

Integrating Hanford's Groundwater and Vadose Zone Activities. DOE has instituted a series of business processes to enhance integration across the projects engaged in groundwater and vadose zone activities at the Hanford Site. *The Hanford Integrated Groundwater and Vadose Zone Management Plan* was published in 2007 (DOE/RL-2007-20). Integrated project teams have been formed to ensure effective coordination of field investigations and timely communication of emerging data.

K-West Reactor Chromium Plume. In 1998, chromium concentrations in groundwater near the K-West Reactor began to rise. A new pump-and-treat system began operations in 2007.

100-N Apatite Barrier. Workers injected a calcium citrate phosphate solution into a line of wells along the 100-N Area shoreline in spring and summer 2007. The chemicals create a permeable reactive barrier containing the mineral apatite, which binds strontium-90 to the sediment. Strontium-90 concentrations initially increased in many wells but then declined to levels below those observed before treatment began.

100-HR-3 Characterization and Testing. DOE installed 41 wells in the 100-HR-3 Operable Unit in 2007. The objectives of this work were to 1) characterize the chromium plume between 100-D and 100-H Areas; 2) locate the source of the chromium plume in the south 100-D Area; 3) characterize deep chromium contamination; 4) test biostimulation, an in situ remediation method for chromium; 5) test micron-size iron injection, a method to increase effectiveness of the redox barrier in the 100-D Area; and 6) test electrocoagulation, a water-treatment process.

200-ZP-1 Pump-and-Treat Expansion. DOE issued a draft feasibility study and proposed plan for groundwater remediation in September 2007. The goal is to design

a remediation system to remove carbon tetrachloride throughout the vertical extent of the aquifer. The expanded system will affect groundwater flow and contaminant movement through much of the operable unit.

Treatability Test for Technetium-99 in 200-ZP-1 Extraction Wells. Groundwater in two of the carbon tetrachloride extraction wells west of Waste Management Area TX-TY has increasing technetium-99 concentrations. In 2007, DOE conducted a treatability test to remove technetium-99 prior to carbon tetrachloride treatment so the radionuclide would not contaminate the groundwater around injection wells. The treatability test ran through October 2007, and results will be used to determine further actions.

Technetium-99 Extraction at Waste Management Area T. Two wells downgradient (east) of Waste Management Area T, in the 200-West Area, were converted to extraction wells in May 2007. The technetium-99 concentration in one of the wells was 113,000 pCi/L (4,181 Bq/L) before extraction began and declined to 18,000 pCi/L (666 Bq/L) during extraction.

200-UP-1 Pump-and-Treat. DOE restarted the pump-and-treat system for technetium-99 and uranium after a 2-year hiatus. The remedial action goal for uranium was 480 µg/L, 10 times the "Washington State Model Toxics Control Act – Cleanup" (WAC 173-340) cleanup standard (48 µg/L) at the time the record of decision was issued. The uranium concentration in monitoring wells remained below 480 µg/L for the past 2 years. However, EPA has established a drinking water standard for uranium of 30 µg/L. In expectation that the cleanup goal for uranium will be revised to 300 µg/L (10 times the drinking water standard), DOE resumed groundwater extraction.

300-FF-5 Studies. In 2007, scientists continued an aggressive campaign to investigate the uranium plume in the 300 Area. They updated computer simulations of groundwater flow and uranium transport, conducted a limited field investigation involving multiple characterization boreholes, updated the human health and ecological risk assessment, and assessed potential remedial action technologies for the uranium plume. DOE also continued to investigate the distribution of organic contaminants in groundwater beneath the 300 Area.

DOE's Office of Environmental Management Technology. In 2006, the U.S. Congress authorized $10 million for "...analyzing contaminant migration to the Columbia River, and for the introduction of new technology approaches to solving contamination migration issues." DOE's Office of Environmental Management (EM-22) administers these funds. The following projects were active in 2007:

- 100-D Area south chromium plume
  - Inject micron-size iron into the deteriorating portions of the redox barrier.
  - Refine location of the chromium source.
- 100-D Area north chromium plume
  - Field-test electrocoagulation for accelerated cleanup.
- Characterize chromium geochemistry in 100 Areas vadose zone sediment.
- Test biostimulation for remediation of chromium in 100-D Area.
- Investigate phytoremediation for strontium-90 in 100-N Area.
- Treat vadose zone strontium-90 in 100-N Area with surface infiltration of apatite.
- Study carbon tetrachloride and chloroform attenuation parameters.
- Immobilize uranium in the aquifer beneath the 300 Area using in situ treatment with polyphosphate.

More information on DOE's Office of Environmental Management (EM-22) projects is available at http://www.hanford.gov/cp/gpp/science/em21.cfm.

CERCLA Five-Year Review. Whenever contaminants remain in the environment following a remedial action decision, CERCLA regulations require that the regulatory agency conduct a review of the decision at least every 5 years. DOE released *The Second CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20) in November 2006. The purposes of the review were to determine whether the selected remedies are protective of human health and the environment and to recommend appropriate corrective actions if the remedy is not achieving

the established goals. The report made the following conclusions regarding groundwater operable units:

- ***100-KR-4 and 100-HR-3 Groundwater Operable Units***: Because the groundwater interim actions in the 100 Areas are not designed to be remedial actions, the protectiveness of the selected remedies could not be assessed. There may be contaminants other than the selected principal threat contaminants addressed in the interim actions that may need to be addressed in the final records of decision.
- ***100-NR-2 and 300-FF-5 Groundwater Operable Units***: The interim remedies have not achieved their objectives. Institutional controls are effective in protecting human health. However, determinations of protectiveness are being deferred until a final remedy is selected through the CERCLA remedial investigation/feasibility study process.
- ***100-BC-5 and 100-FR-3 Groundwater Operable Units***: Records of decision for groundwater remediation have not been established for these areas. Previous assessments have not identified groundwater conditions that warrant interim remedial measures, assuming that the source control measures will meet established remedial action objectives designed to reduce contaminant recharge to the aquifer.
- ***200-BP-5 and 200-PO-1 Groundwater Operable Units***: Records of decision for groundwater remediation have not been established for these areas.
- ***200-ZP-1 Groundwater Operable Unit***: Protectiveness determinations for the pump-and-treat and vapor extraction systems are being deferred until a final remedy is selected through the CERCLA remedial investigation/feasibility study process.
- ***200-UP-1 Groundwater Operable Unit***: This system has met the remedial action objectives identified in the record of decision for interim action (ROD 1997). The need for additional work will be assessed through the CERCLA remedial investigation/feasibility study process.
- ***1100-EM-1 Groundwater Operable Unit***: The remedial actions selected for the 1100 Area operable unit have been completed, and the remedy remains protective.

The review identified 20 issues and associated corrective actions that are recommended such that the selected remedies remain protective of human health and the environment. Actions that pertain to individual groundwater operable units are discussed in the applicable subsections below. Three actions pertain to the river corridor and thus cut across operable unit boundaries. Table 10.7.1 describes their current status.

Table 10.7.1. Status of Five-Year Review Action Items that Pertain to Multiple Operable Units

Issue	Action	Status
1. Additional risk assessment information is needed to evaluate the interim actions prescribed within the records of decision and to develop final cleanup decisions.	1-1. Submit Draft A of the *River Corridor Baseline Risk Assessment Report*.	Completed; DOE/RL-2007-21, Draft A, June 2007
	1-2. Submit draft sampling and analysis plan for Inter-Areas Shoreline Assessment.	Completed August 2006[a]
2. A strategy has not been developed and agreed upon to obtain the final records of decision and integrate the waste sites, deep vadose zone, and groundwater.	2-1. Submit Draft A of the *River Corridor Strategy for Achieving Final Cleanup Decision in the River Corridor*. The document will identify issues for integration and provide alternatives for future discussion between the Tri-Parties on milestones for final records of decision in the river corridor.	Completed; WCH-71, February 2007

(a) Letter 06-AMRC-0317 from JR Franco (U.S. Department of Energy, Richland Operations Office) to N Ceto (U.S. Environmental Protection Agency) and J Hedges (Washington State Department of Ecology), *Transmittal of the Sampling and Analysis Plan for the Inter-Areas Shoreline Assessment*, dated August 2, 2006.

More information on the 5-year review is available at http://www.hanford.gov, "CERCLA Five-Year Review."

Groundwater Data. Workers sampled 1,123 monitoring wells and aquifer tubes in 2007. Aquifer tubes are small-diameter, flexible tubes used to sample shallow groundwater near the Columbia River. Many wells were sampled more than once, resulting in 4,093 sampling events. Laboratories analyzed more than 30,000 samples of Hanford Site groundwater. Tables 10.7.2 and 10.7.3 list the number of wells and analyses by groundwater interest area and monitoring purpose.

Table 10.7.2. A Summary of the Hanford Site Groundwater Monitoring by Groundwater Interest Area, 2007

	Hanford Site	100-BC-5	100-FR-3	100-HR-3-D	100-HR-3-H	100-KR-4	100-NR-2
Number of wells and aquifer tubes	1,123	42	45	195	98	74	81
Number of sampling events	4,093	68	61	1,221	312	534	288
Number of analyses	36,648	708	675	6,488	1,361	2,505	3,332
Number of results	112,157	1,642	3,065	10,068	2,709	5,712	8,025
Percent of results non-detected	46	27	44	15	24	29	37
	1100-EM-1	**200-BP-5**	**200-PO-1**	**200-UP-1**	**200-ZP-1**	**300-FF-5**	
Number of wells	55	136	138	77	100	82	
Number of sampling events	67	312	301	225	458	246	
Number of analyses	576	6,307	4,472	2,764	4,999	2,461	
Number of results	1,731	17,814	16,801	12,093	20,732	11,765	
Percent of results non-detected	55	46	54	54	53	60	

Table 10.7.3. A Summary of the Hanford Site Groundwater Monitoring by Monitoring Purpose,[a] 2007

	Restoration[b]	Waste Management[c]	Environmental Surveillance[d]
Number of wells and aquifer tubes	662	287	472
Number of sampling events	2,817	1,026	1,678
Number of analyses	18,985	15,771	16,762
Number of results	53,969	53,341	50,548
Percent of results non-detected	42	48	47

(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.
(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.

10.7.2 Groundwater Flow

General directions of groundwater flow are illustrated on the water-table map for March 2007 (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 the 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.

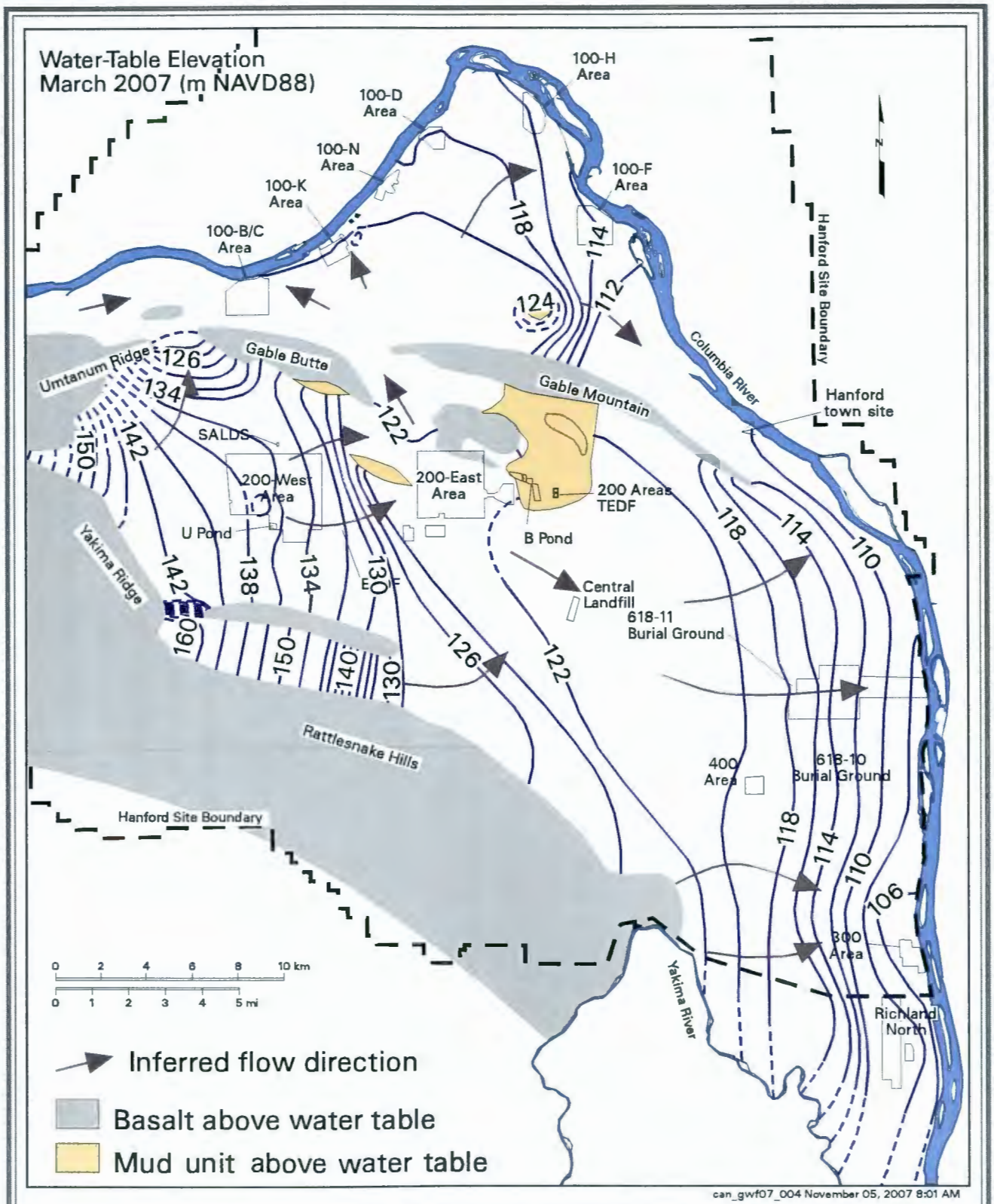


Figure 10.7.1. Water-Table Elevation (meters) and Inferred Flow Direction for the Unconfined Aquifer at the Hanford Site, March 2007 (DOE/RL-2008-01)

In the part of the site north of Gable Mountain and Gable Butte, unconfined groundwater flows generally toward the Columbia River. 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 vicinity of the 200-East Area from the west and divides, with some migrating to the north through a gap between Gable Butte and Gable Mountain (Gable Gap) and some moving southeast toward the central part of the site. This groundwater divide is located near the northwest 200-East Area, but its precise location is not known. Ongoing studies will help determine the direction of groundwater flow in this region. In the south 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 Hanford Site 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 200 Area Treated Effluent Disposal Facility, east of 200-East Area, affecting groundwater flow locally.

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 located 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 below by basalt and above by the lower mud unit. East of the 200-East Area, where the water-table map is shaded tan (Figure 10.7.1), there is no unconfined aquifer, and groundwater in the Ringold Formation confined aquifer is still influenced by a residual recharge mound.

A deeper system of confined aquifers occurs within basalt fractures and sedimentary interbeds. Several wells north and east of the 200-East Area have shown evidence of intercommunication between the unconfined and confined aquifers (PNL-10817; RHO-RE-ST-12P). The intercommunication has been attributed to erosion of the upper Saddle Mountains Basalt and a downward hydraulic gradient. An upward gradient exists elsewhere in the 200-East Area/Gable Gap region, so it is expected that the upper basalt-confined aquifer discharges to the overlying unconfined aquifer, especially within Gable Gap where the Elephant Mountain Basalt was removed by erosion.

10.7.3 Groundwater Monitoring and Remediation

DOE monitors groundwater at 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 450.1, "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 has been divided into operable units, or groupings of similar waste units within a geographic area so that the CERCLA process can be implemented efficiently. Forty-six are source operable units, and 11 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 in accordance with remedial investigation/feasibility study work plans 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

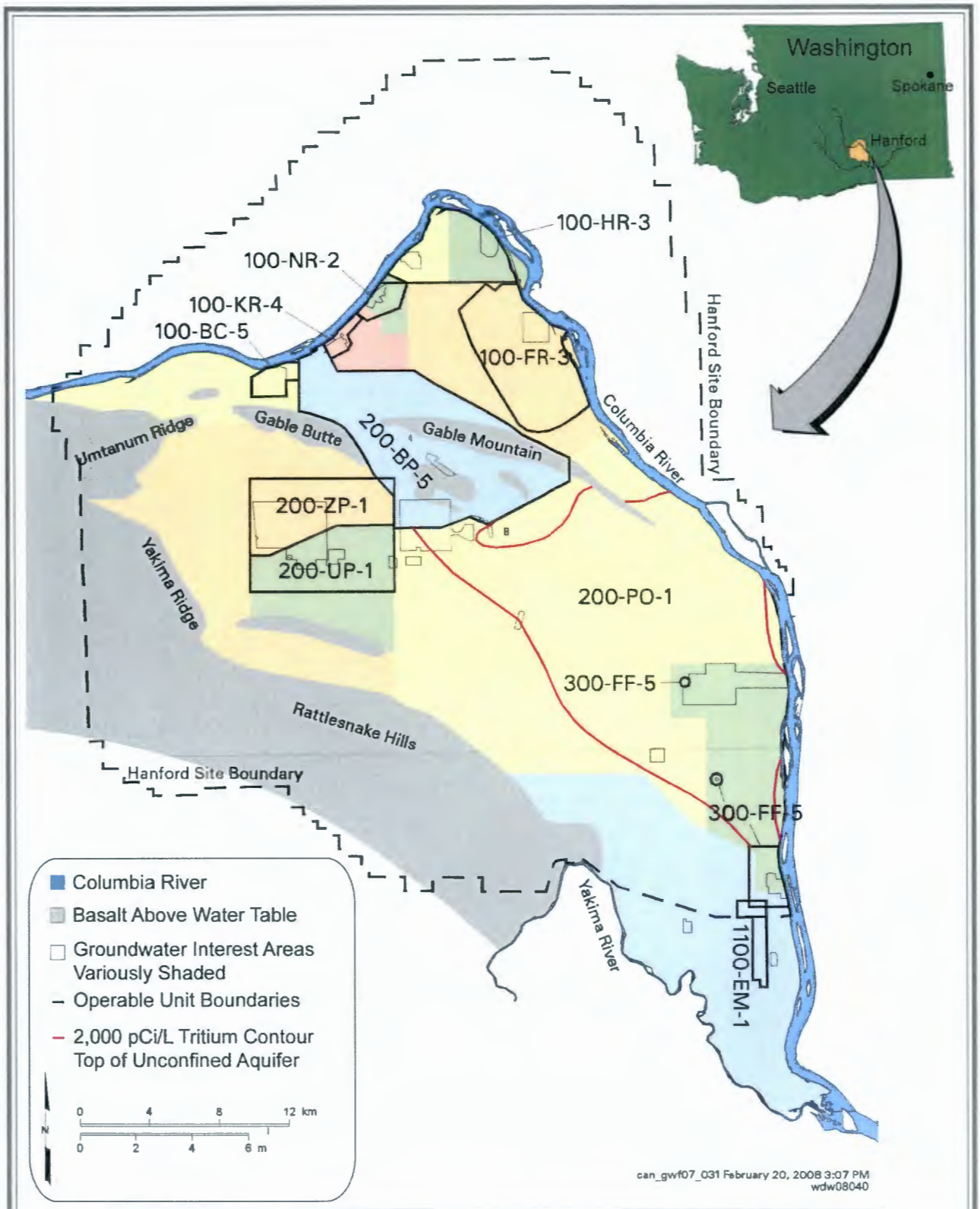


Figure 10.7.2. Groundwater Operable Units and Groundwater Interest Areas at the Hanford Site

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, then 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, then the Washington State Department of Ecology may require corrective action. Groundwater is monitored to determine if the corrective action is effective.

Table 10.7.4 lists Hanford Site RCRA units, the phase of groundwater monitoring, and 2007 highlights; Figure 10.7.3 shows their locations.

10.7.3.1 Overview

DOE developed a plan (DOE/RL-2007-20) that lays out steps for cleaning up groundwater and the vadose zone. Key elements include the following:

- Continue to implement remedies that are working.
- Gather characterization data to help make informed decisions.
- Address emerging problems.
- Work with regulatory agencies to make remediation decisions.
- Identify new cleanup technologies.
- Continue to monitor groundwater to detect emerging problems and determine how well remedies are working.

Figures 10.7.4 and 10.7.5 show the principal groundwater contaminant plumes. The total area of contaminant plumes with concentrations above drinking water standards was about 183 square kilometers (70.7 square miles) in 2007 (Table 10.7.5). This area is about 12% of the total area of the Hanford Site. Table 10.7.6 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 (see Figure 10.7.4). The dominant plumes had sources in the 200-East Area and extend toward the east and southeast. Less extensive tritium and iodine-129 plumes are also present in the 200-West Area. Technetium-99 exceeds standards in plumes within both the 200-East and 200-West Areas. One technetium-99 plume extends northward from the 200-East Area. Uranium is less mobile than tritium, iodine-129, or technetium-99; 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 200 Areas and from offsite industry and agriculture (see Figure 10.7.5). Carbon tetrachloride, the most widespread organic contaminant on the Hanford Site, forms a large plume beneath the 200-West Area. Other organic contaminants include chloroform, found in 200-West Area, and trichloroethene. Trichloroethene plumes that exceed the drinking water standard are found in the 100-F and 200-West Areas; a single well exceeded the standard in the 100-K Area. Wells completed at depth in the aquifer in the 300 Area also detected trichloroethene at levels above the drinking water standard. Chromium at levels above the

Table 10.7.4 Regulated Units Requiring Groundwater Monitoring on the Hanford Site, 2007

Site or Waste Management Area	Type of Monitoring Program	Regulated Under	2007 Highlights
		RCRA Regulated Units	
116-N-1 (1301-N) Facility	Final status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
116-N-3 (1325-N) Facility	Final status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
120-N-1, 120-N-2 (1324-N/NA) Facilities	Final status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
116-H-6 (183-H) Evaporation Basins	Final status corrective action	WAC 173-303-645(11)(g)	Monitoring during CERCLA interim action: chromium, nitrate, technetium-99, uranium
216-A-29 Ditch	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
216-B-3 Pond	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
216-S-10 Pond and Ditch	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection;[a] only two shallow and one deep downgradient wells remain
216-U-12 Crib	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Reclassified as past-practice unit; RCRA monitoring discontinued October 2007
316-5 Process Trenches	Final status corrective action	WAC 173-303-645(11)(g)	Monitoring during CERCLA natural attenuation interim action: uranium and organics
Integrated Disposal Facility	Establishing background	WAC 173-303-645	Planned facility; seven of eight wells in place
Liquid Effluent Retention Facility	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Insufficient wells; no statistical comparisons
Low-Level Waste Management Area 1	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
Low-Level Waste Management Area 2	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection;[a] north wells dry; no unconfined aquifer
Low-Level Waste Management Area 3	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	No statistical comparisons until background re-established
Low-Level Waste Management Area 4	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
Nonradioactive Dangerous Waste Landfill	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
PUREX Cribs	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment: iodine-129, nitrate, tritium
SST Waste Management Area A-AX	Interim status detection	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment: nitrate, technetium-99
SST Waste Management Area B-BX-BY	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment: nitrate, nitrite, technetium-99, uranium
SST Waste Management Area C	Interim status detection	WAC 173-303-400; 40 CFR 265.93(b)	Continued detection[a]
SST Waste Management Area S-SX	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment: chromium, technetium-99

Table 10.7.4 (contd)

Site or Waste Management Area	Type of Monitoring Program	Regulated Under	2007 Highlights
SST Waste Management Area T	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment: technetium-99, nitrate, chromium
SST Waste Management Area TX-TY	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment: chromium, nitrate, technetium-99
SST Waste Management Area U	Interim status assessment	WAC 173-303-400; 40 CFR 265.93(d)	Continued assessment: nitrate, technetium-99
		Other Regulated Units	
200 Area Treated Effluent Disposal Facility	Compliance with permit	WAC 173-216	No influence on upper aquifer
Environmental Restoration Disposal Facility	Similar to RCRA detection	EPA/ROD/R10-95/100	No impact on groundwater
State Approved Land Disposal Site	Compliance with permit	WAC 173-216	No permit limits exceeded
Solid Waste Landfill	Compliance with permit	WAC 173-304	Six constituents exceeded background or standards; low levels of organics

(a) Analysis of RCRA CIP provided no evidence of groundwater contamination with hazardous constituents from the unit.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
CFR = *Code of Federal Regulations.*
CIP = Contamination indicator parameters.
EPA = U.S. Environmental Protection Agency.
PUREX = Plutonium-Uranium Extraction Plant.
RCRA = *Resource Conservation and Recovery Act of 1976.*
ROD = Record of decision.
SST = Single-shell tank.
WAC = *Washington Administrative Code.*

100-µg/L drinking water standard underlies portions of the 100-K and 100-D Areas and the 600 Area west of 100-H Area. Chromium exceeds the state's aquatic standard (10 µg/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, particularly the north part of the 200-West Area.

The following section discusses groundwater contamination, monitoring, and remediation for each of the 11 groundwater operable units and in the confined aquifers.

10.7.3.2 Groundwater Monitoring Results for the 100-BC-5 Operable Unit

The 100-BC-5 Operable Unit includes the groundwater beneath the 100-B/C Area, located in the northwestern Hanford Site. Most of the groundwater contamination is found in the northern portion of the operable unit, beneath former waste trenches and retention basins. Tritium and strontium-90 exceeded drinking water standards (20,000 and 8 pCi/L [740 and 0.3 Bq/L], respectively) in several wells. Tritium concentrations in two new wells in the south 100-B/C Area were unexpectedly high, exceeding the drinking water standard in one well. Nitrate and chromium continued to be below drinking water standards (45 mg/L and 100 µg/L, respectively) in recent years in the 100-B/C Area, but chromium exceeds 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 under way. Groundwater monitoring has continued since the initial remedial investigation and while waste site remedial actions are being conducted.

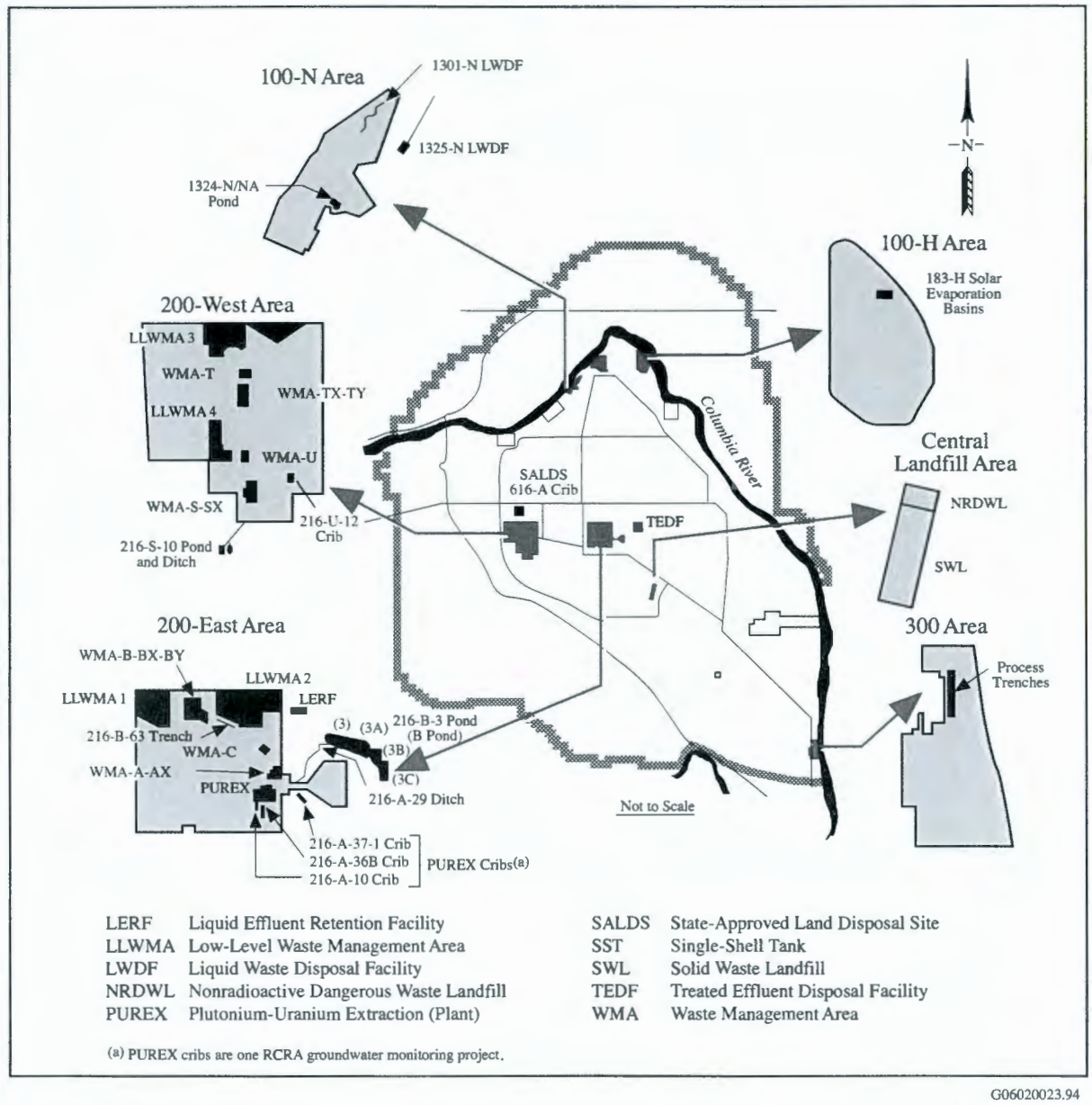


Figure 10.7.3. Locations of the Regulated Waste Management Units on the Hanford Site

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 1) cleaning up chromium in groundwater, 2) tracking plumes from past-practices sites, and 3) 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 being used to remove hexavalent chromium from the aquifer beneath the 116-K-2 Infiltration Trench (Figure 10.7.6). Approximately 312 kilograms (688 pounds) of chromium have been removed since startup in 1997. Although the

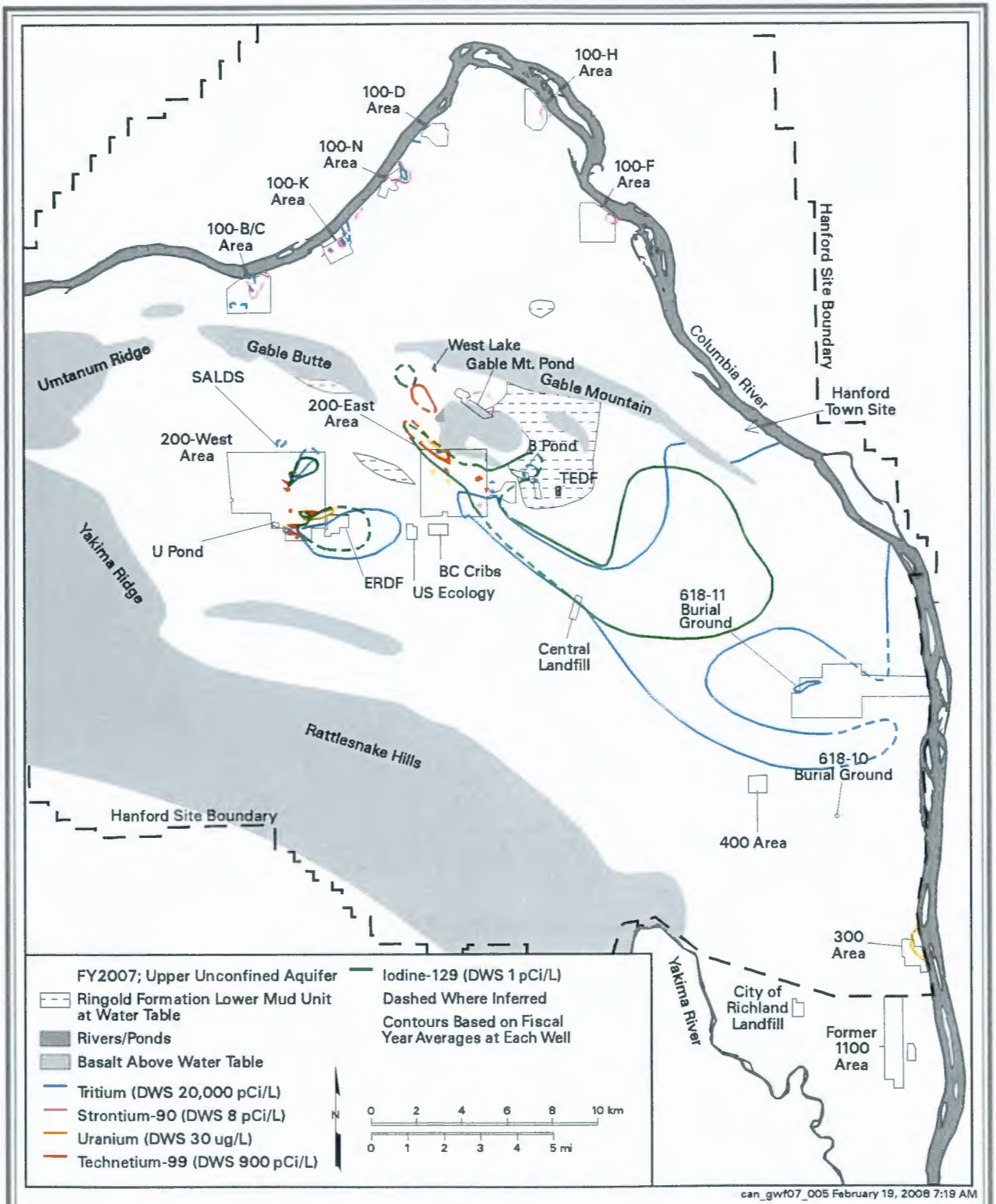


Figure 10.7.4. Distribution of Major Radionuclides in Hanford Site Groundwater at Concentrations Above Drinking Water Standards During 2007 (DOE/RL-2008-01)

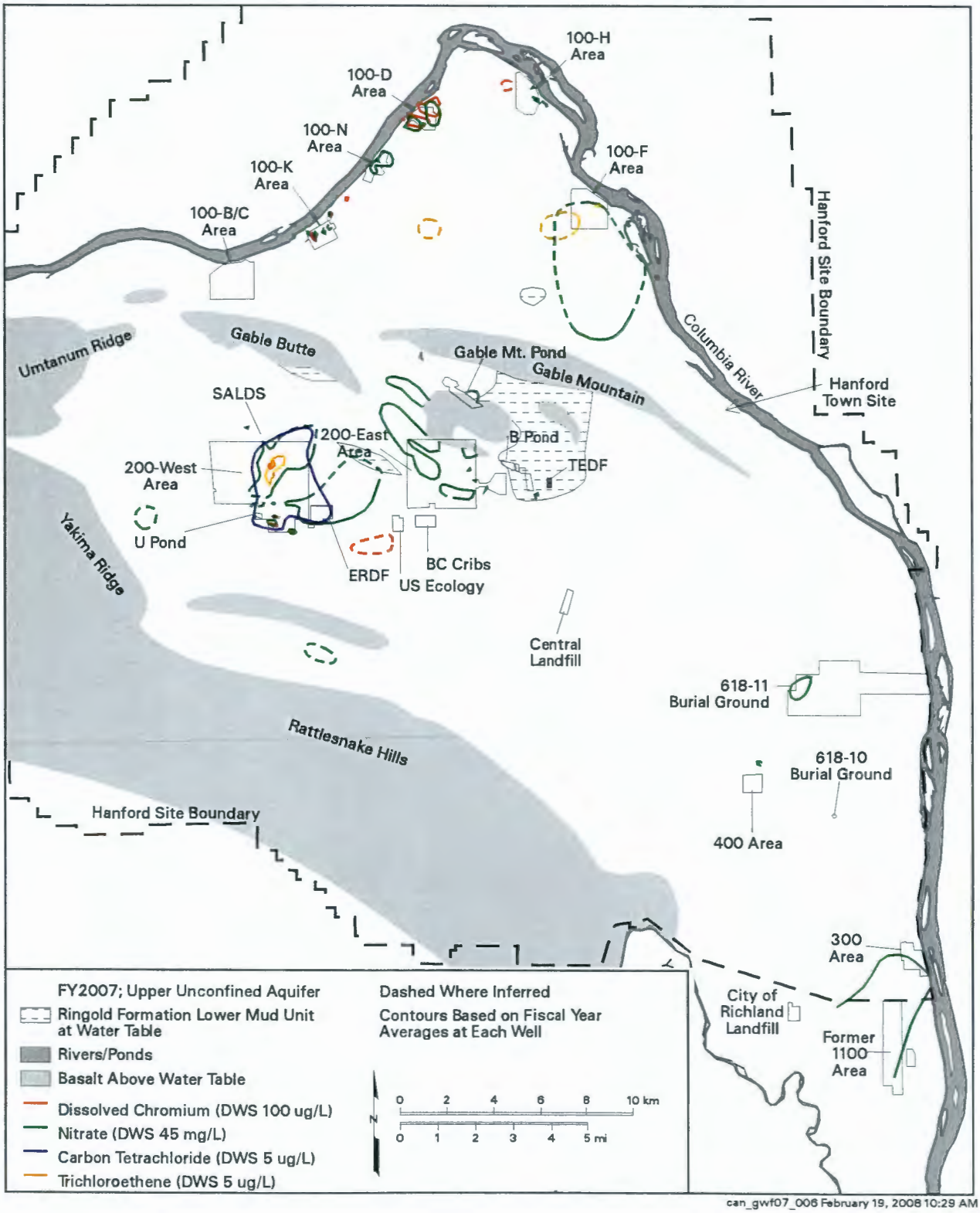


Figure 10.7.5. Distribution of Major Hazardous Chemicals in Hanford Site Groundwater at Concentrations Above Drinking Water Standards During 2007 (DOE/RL-2008-01)

Table 10.7.5. Areas of Contaminant Plumes on the Hanford Site at Levels Above Drinking Water Standards, FY 2007 (DOE/RL-2008-01)

Constituent	Drinking Water Standard	Area, km² (mi²)		Constituent	Drinking Water Standard	Area, km² (mi²)	
Tritium	20,000 pCi/L	127	(49.0)	Dissolved chromium	100 µg/L	2.2	(0.8)
Iodine-129	1 pCi/L	64.0	(24.7)	Strontium-90	8 pCi/L	2.3	(0.9)
Nitrate	45 mg/L	37.3[a]	(14.4)	Technetium-99	900 pCi/L	2.3	(0.9)
Carbon tetrachloride	5 µg/L	10.1	(3.9)	Total uranium	30 µg/L	1.4	(0.5)
Trichloroethene	5 µg/L	2.6	(1.0)	Combined plumes		183[a,b]	(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.

Table 10.7.6. Summary of Maximum Contaminant Concentrations in Hanford Site Groundwater by Groundwater Interest Area, FY 2007 (DOE/RL-2008-01)

	Hanford Site	100-BC-5	100-FR-3	100-HR-3-D	100-HR-3-H	100-KR-4	100-NR-2
Tritium (pCi/L)	1,760,000	59,000	9,930	28,500	5,150	370,000	23,000
Iodine-129 (pCi/L)	45.4	NA	NA	NA	NA	NA	NA
Nitrate (mg/L)	8,630	39.3	100	89	66.4	137	294
Carbon tetrachloride (µg/L)	3,400	NA	ND	NA	NA	ND	NA
Trichloroethene (µg/L)	21	NA	3.3	NA	NA	6.4	NA
Dissolved chromium (µg/L)	7,290	64	60.3	7,290	113	2,170	172
Strontium-90 (pCi/L)	12,800	38.2	3.5	7.84	30.7	757	12,800
Technetium-99 (pCi/L)	113,000	NA	NA	NA	99	34.6	NA
Total uranium (µg/L)	935	NA	13.3	4.48	22.1	6.78	NA

	1100-EM-1	200-BP-5	200-PO-1	200-UP-1	200-ZP-1	300-FF-5
Tritium (pCi/L)	262	173,000	580,000	310,000	1,760,000	1,060,000
Iodine-129 (pCi/L)	ND	5.01	8.18	38.7	45.4	NA
Nitrate (mg/L)	536[a]	8,630	154	1,540	3,810	82.8
Carbon tetrachloride (µg/L)	ND	ND	0.82	1,600	3,400	0.22
Trichloroethene (µg/L)	2	ND	0.79	13	21	290
Dissolved chromium (µg/L)	5.3	77.4	42.1	798	715	10.1
Strontium-90 (pCi/L)	NA	4,130	19.2	0.4	1.8	2.6
Technetium-99 (pCi/L)	58.3	73,400	7,930	46,300	113,000	227
Total uranium (µg/L)	23	935	75.3	613	56	218

(a) Nitrate from offsite sources.
NA = Not analyzed.
ND = Not detected.

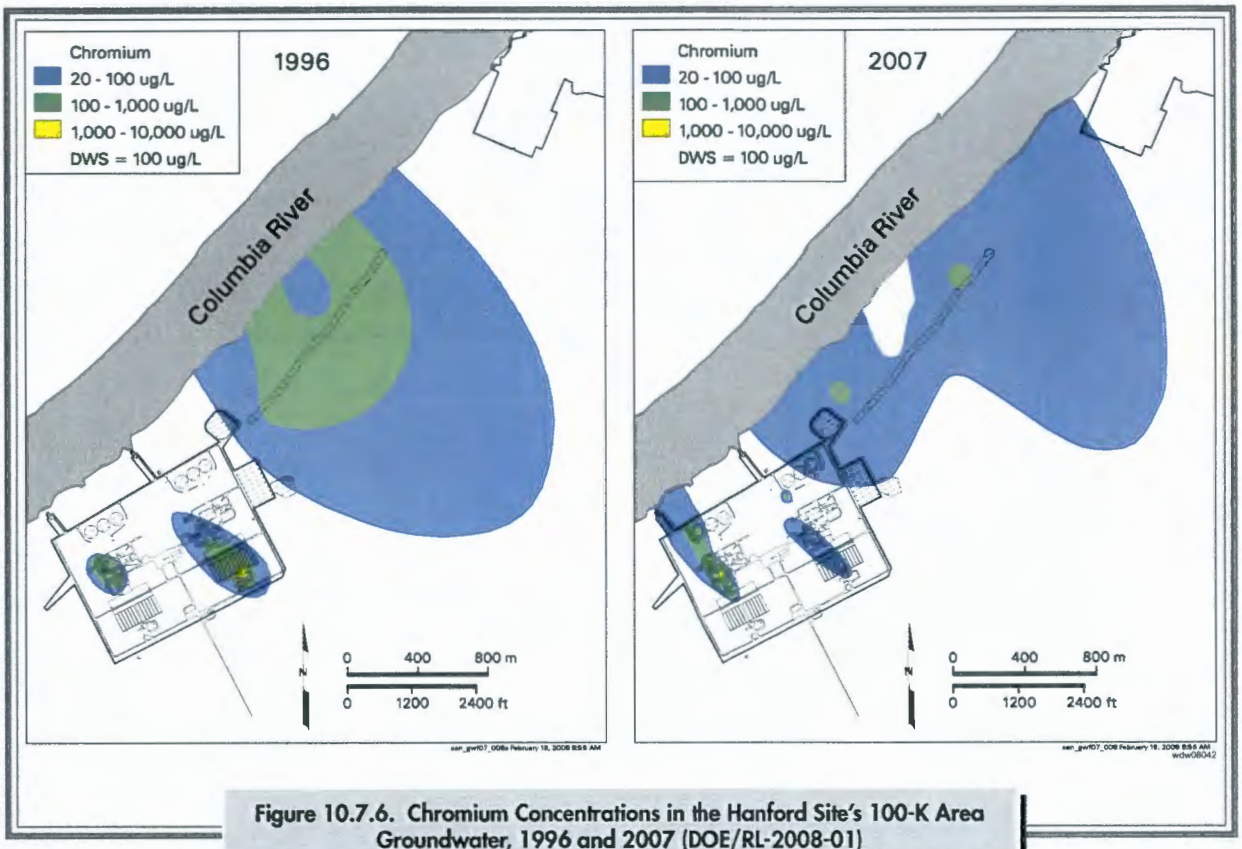


Figure 10.7.6. Chromium Concentrations in the Hanford Site's 100-K Area Groundwater, 1996 and 2007 (DOE/RL-2008-01)

mapped extent of contamination has remained fairly constant during the past 10 years, the area of highest concentrations (>100 µg/L) has decreased markedly. The concentration goal for the interim remedial action is 22 µg/L in groundwater near the Columbia River.

In 1998, chromium concentrations in groundwater near the K-West Reactor began to rise. One new monitoring well had chromium concentrations greater than 2,000 µg/L, higher than other wells in the area. In 2007, DOE began operating a new pump-and-treat system to clean up the K-West Reactor plume. The system removed 15.8 kilograms (34.8 pounds) of chromium during the year.

Monitoring Past-Practice Waste Sites. Other contaminants of potential concern in this operable unit are carbon-14, nitrate, strontium-90, trichloroethene, and tritium. Levels remain above drinking water standards, and decisions regarding groundwater remedial actions have been deferred until remedial actions of source areas are complete.

K Basins. The K-East and K-West Basins are integral parts of each reactor building. From the late 1970s to 2004, they were used to store irradiated fuel from N Reactor as well as miscellaneous fuel fragments recovered from cleanup at other reactor areas. The K-East Basin was drained of water in early 2008; the K-West Basin still contains contaminated water, which DOE will remove in coming years. In 2007, monitoring of water levels in the basins and groundwater in downgradient wells indicated no new leaks.

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, sulfate, and petroleum hydrocarbons also are present in 100-N Area groundwater.

Interim Remedial Action. DOE is applying an in situ technology to immobilize strontium-90 in the aquifer to

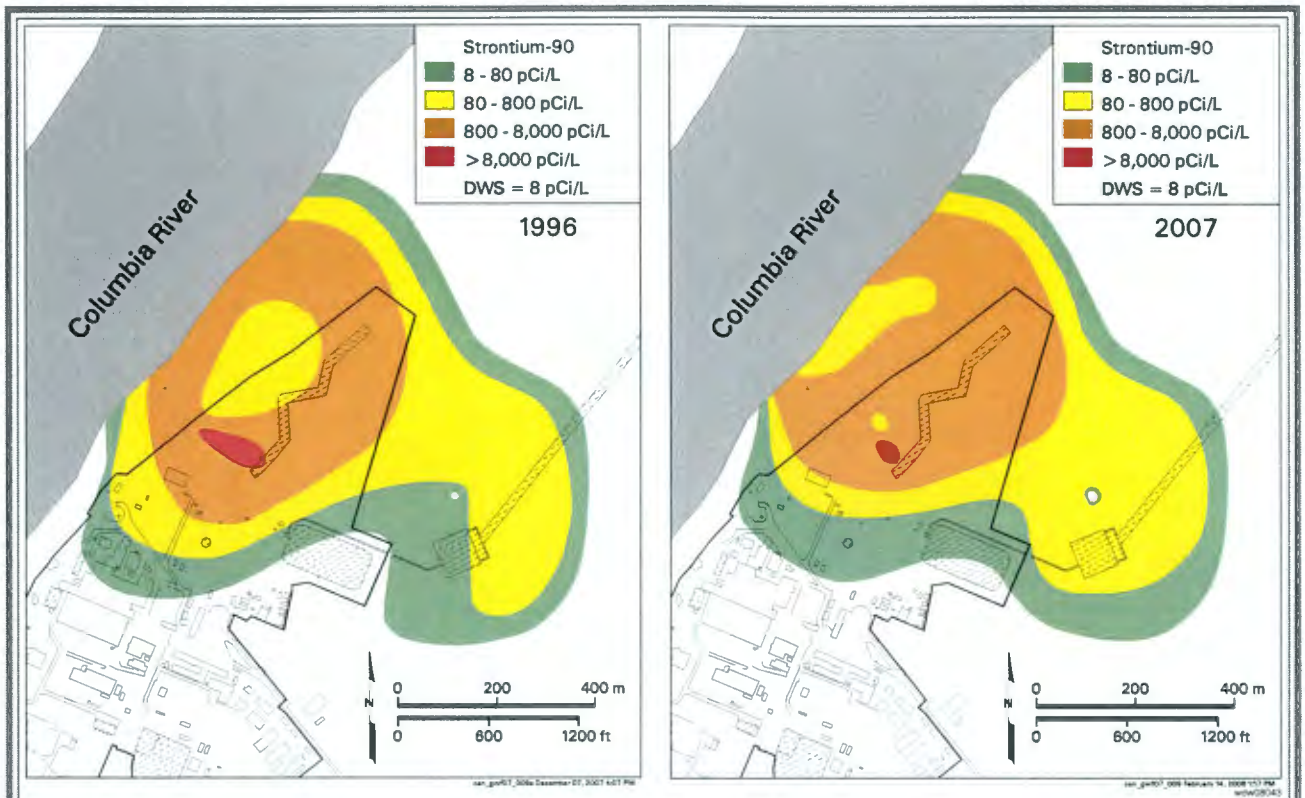


Figure 10.7.7. Strontium-90 Concentrations in the Hanford Site's 100-N Area Groundwater, 1996 and 2007 (DOE/RL-2008-01)

prevent it from entering the Columbia River. Workers injected a calcium citrate phosphate solution into a line of wells along the 100-N Area shoreline in spring and summer 2007. The goal is to create a permeable, reactive barrier that will capture strontium-90 as groundwater flows through it to the river. Monitoring shows strontium-90 concentrations declined below baseline levels within the barrier and in downgradient monitoring wells (e.g., well 199-N-123 in Figure 10.7.8). However, strontium-90 concentrations increased to new maxima in aquifer tubes downgradient of the barrier (e.g., NVP2-116.0 in Figure 10.7.8) in August 2007, then subsequently declined to previous levels.

116-N-1, 116-N-3, 120-N-1, and 120-N-2 (1301-N, 1325-N, 1324-N/NA) Facilities. Four RCRA units are located in the 100-N Area. During 2007, the sites remained in detection monitoring programs. The *Atomic Energy Act of 1954* and CERCLA monitoring continued to track strontium-90 and tritium plumes from the 116-N-1 and 116-N-3 Facilities and sulfate from the 120-N-1 Pond.

10.7.3.5 Groundwater Monitoring Results for the 100-HR-3-D Operable Unit

The 100-HR-3 Operable Unit underlies the 100-D and 100-H Areas and the region between. Hexavalent chromium is the primary contaminant of concern in groundwater beneath the 100-D Area, which comprises the west part of the operable unit (100-HR-3-D groundwater interest area). A principal cause for this contamination was the routine disposal of reactor coolant, which contained sodium dichromate as a corrosion inhibitor. A second cause was periodic spillage and leakage of sodium dichromate stock solution to the ground. Chromium is distributed in north and southwest plumes (Figure 10.7.9). Other contaminant plumes include tritium and nitrate.

Interim Remedial Actions. The north chromium plume is the target of a pump-and-treat system, which is designed

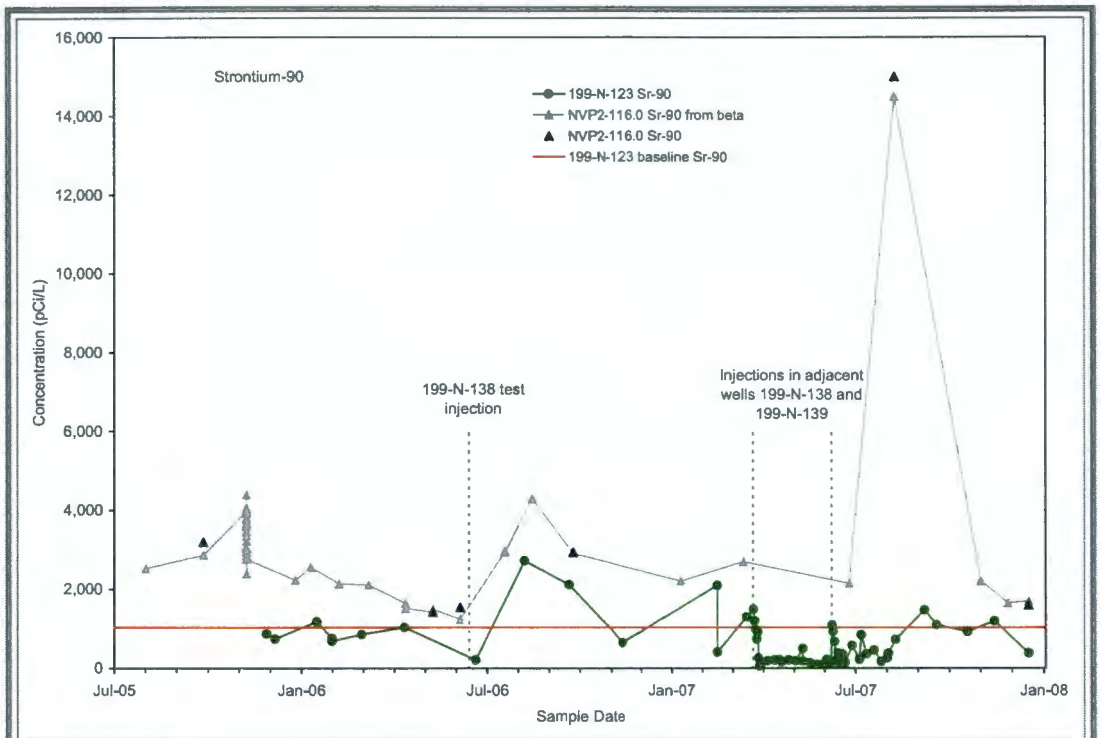


Figure 10.7.8. Strontium-90 Trends for Well and Aquifer Tube Monitoring of the 100-N Apatite Barrier

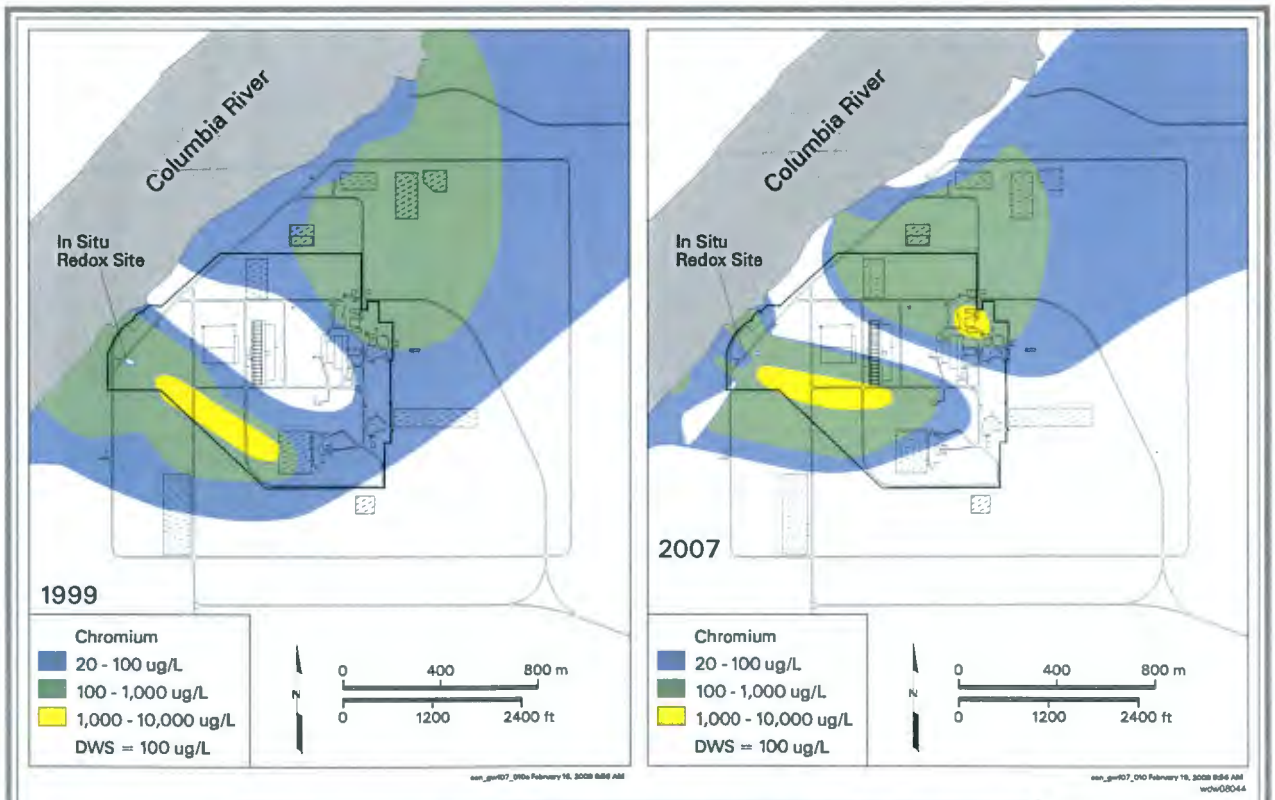


Figure 10.7.9. Chromium Concentrations in the Hanford Site's 100-D Area Groundwater, 1999 and 2007 (DOE/RL-2008-01)

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. In 2007, chromium concentrations remained above the remediation goal (22 µg/L) in compliance wells. The two extraction systems have removed 424 kilograms (935 pounds) of chromium from the aquifer since 1997. The southwest chromium plume is being remediated with a permeable barrier that immobilizes chromium in the aquifer. Data from recent years indicate that chromium is breaking through the barrier. In September 2007, concentrations in barrier wells ranged from below detection limits to 880 µg/L; concentrations in approximately 69% of the wells were below the remedial action goal of 20 µg/L. Most of the elevated concentrations are in the northeastern half of the barrier. Downgradient of the barrier, the 20-µg/L goal was met at two of the seven compliance wells.

Five-Year Review Actions. DOE has initiated several investigations in the 100-HR-3 Operable Unit that address items identified in a November 2006 CERCLA review:

- Chromium Source Investigation – DOE recently installed wells to obtain samples from the vadose zone and to monitor groundwater near suspected sources in the south 100-D Area. Chromium levels in some of the wells were the highest ever observed in Hanford Site groundwater (Figure 10.7.10). Information from ongoing studies will help DOE determine how to clean up the chromium.
- Chromium Plume in the Horn – DOE installed wells and aquifer tubes to define the plume between 100-D and 100-H Areas, the region known as the "horn" of the Hanford Site. Data show that concentrations greater than 20 µg/L extend across the horn.
- Micron-Size Iron Injection – Scientists think that injecting tiny particles of iron into redox barrier wells will help "repair" the barrier where chromium has been breaking through. A contractor conducted laboratory tests in 2007 to support this effort.

10.7.3.6 Groundwater Monitoring Results for the 100-HR-3-H Operable Unit

The eastern portion of the 100-HR-3 Operable Unit is informally known as the 100-HR-3-H interest area.

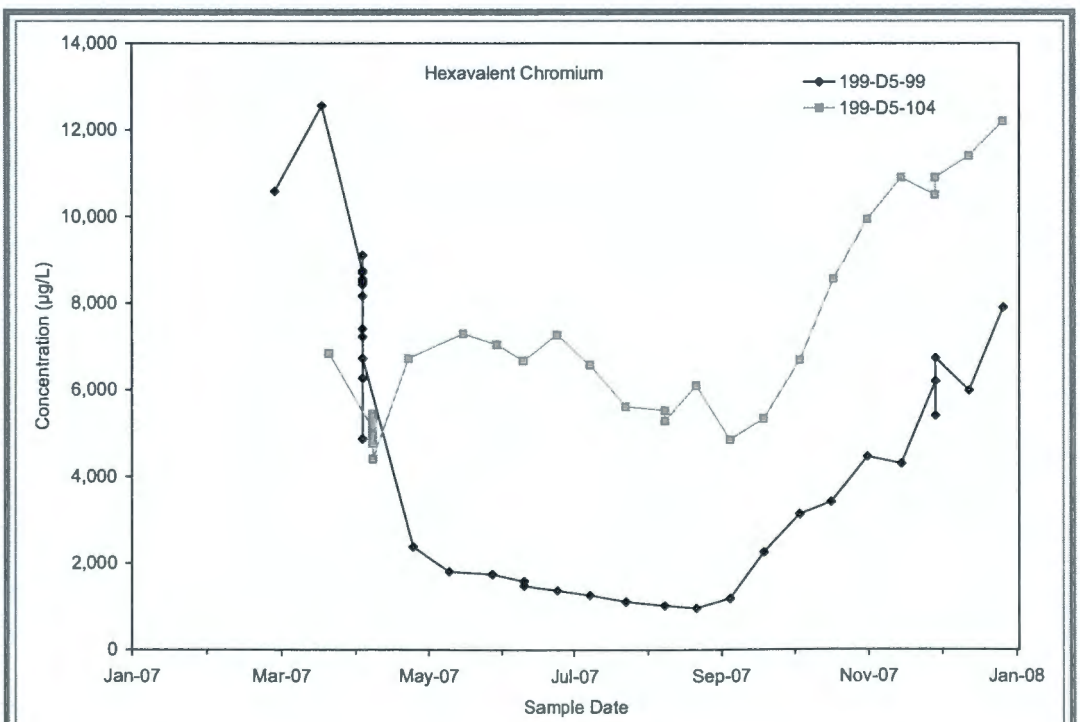


Figure 10.7.10. Chromium Trend Plots for Wells in Central 100-D Area

Hexavalent chromium is the primary contaminant of concern in this area, but the plume is smaller and concentrations are lower than in the 100-D Area (Figure 10.7.11). 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 did not exceed drinking water standards in 2007.

Interim Remedial Action. The chromium plume in the 100-H Area is the target of a pump-and-treat system. The remediation of the plume has removed 49 kilograms (108 pounds) of hexavalent chromium from the aquifer since 1997. Hexavalent chromium concentrations in compliance wells were mostly below the 22-µg/L remedial action goal in 2007.

Five-Year Review Action. DOE installed three wells as part of additional characterization of a deeper aquifer within the Ringold Formation upper mud unit.

116-H-6 (183-H) Evaporation Basins. These former basins comprise the only RCRA site in the 100-H Area. Leakage from the basins contaminated groundwater with chromium, nitrate, technetium-99, and uranium. 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. Other groundwater contaminants include strontium-90 and trichloroethene. Chromium exceeds the 10-µg/L aquatic standard in some wells.

A record of decision has not yet been developed for the 100-FR-3 Operable Unit, and no active remediation of groundwater is under way. Monitoring contaminant conditions has continued since the initial remedial investigation and while waste site remedial actions are conducted.

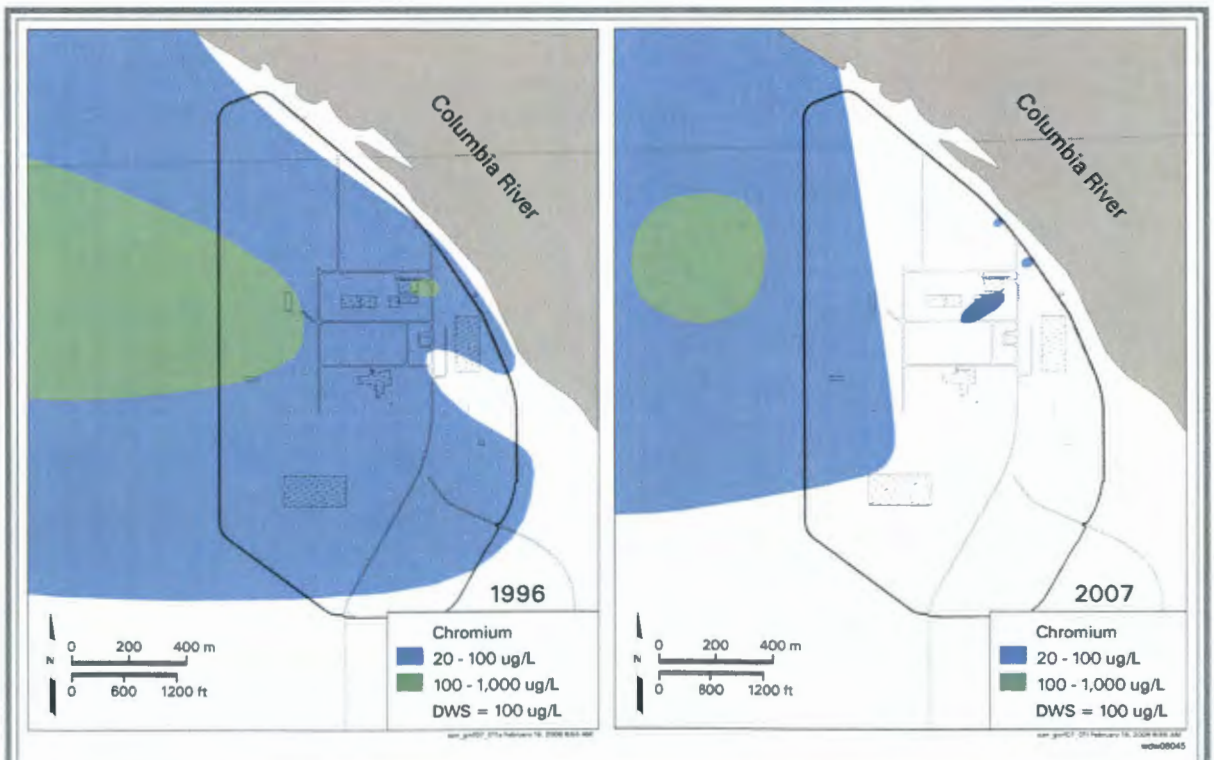


Figure 10.7.11. Chromium Concentrations in the Hanford Site's 100-H Area Groundwater, 1996 and 2007 (DOE/RL-2008-01)

10.7.3.8 Groundwater Monitoring Results for the 200-ZP-1 Operable Unit

The 200-ZP-1 Operable Unit encompasses the north portion of the 200-West Area. The primary contaminant of concern is carbon tetrachloride (Figure 10.7.12). Other contaminants include tritium, nitrate, chloroform, chromium, fluoride, technetium-99, iodine-129, trichloroethene, and uranium.

Work on the feasibility study for the 200-ZP-1 Operable Unit is ongoing. DOE published the remedial investigation report in October 2006 (DOE/RL-2006-24, Rev. 0) and drafts of the feasibility study and proposed plan (DOE/RL-2007-28, Draft A; DOE/RL-2007-33, Draft A) in September 2007. DOE installed four new monitoring wells in this operable unit in 2007.

The distribution of carbon tetrachloride is complex because it can migrate as a dense, non-aqueous phase liquid, as a gas, and dissolve in water. Contamination occurs at increasing depth to the east (downgradient) of the known source areas. In the 200-ZP-1 Operable Unit, natural and artificial recharge may have led to reduced carbon tetrachloride concentrations in the upper portion of the aquifer. Contamination in wells screened deeper in the aquifer indicates that a greater mass is present in the unconfined aquifer than previously calculated (Figure 10.7.13).

The 200-ZP-1 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. The system has removed approximately 11,000 kilograms (24,000 pounds) of carbon tetrachloride from groundwater.

Soil-Vapor Extraction. Soil vapor is extracted from the vadose zone and treated to remove carbon tetrachloride.

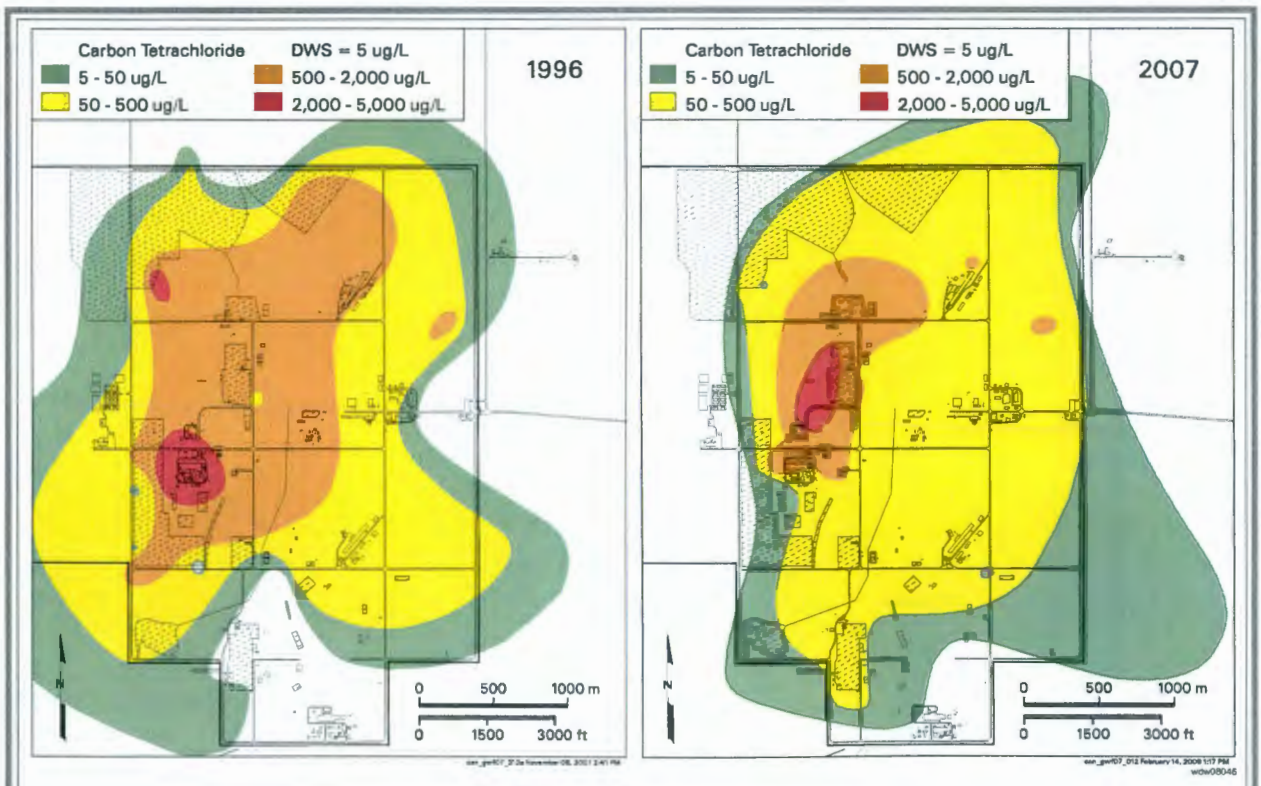


Figure 10.7.12. Carbon Tetrachloride Concentrations in the Hanford Site's 200-West Area Groundwater, 1996 and 2007 (DOE/RL-2008-01)

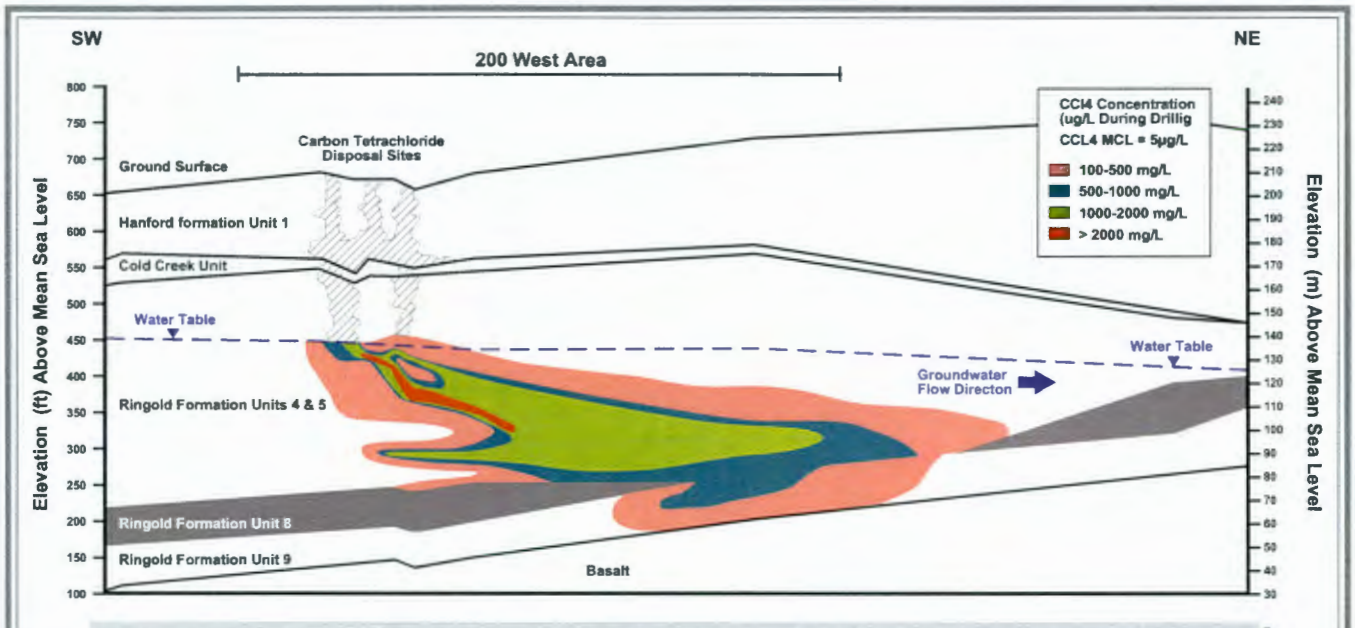


Figure 10.7.13. Cross Section of Carbon Tetrachloride Beneath Hanford Site's 200-West Area (DOE/RL-2007-20)

The soil-vapor extraction system has removed approximately 79,200 kilograms (175,000 pounds) of carbon tetrachloride from the vadose zone since operations started in 1991.

Low-Level Burial Grounds Waste Management Areas 3 and 4. RCRA groundwater monitoring continued under interim status requirements in 2007. The groundwater flow direction changed after liquid effluent discharges in 200-West Area ceased. The change 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.

Waste Management Area T. RCRA assessment monitoring continued in 2007. The waste management area has introduced technetium-99 and other tank waste contaminants to the uppermost aquifer in the area. Concentrations in downgradient well 299-W11-46, screened 6 to 12 meters (19.7 to 39.4 feet) below the water table, increased sharply in 2006 and 2007 (Figure 10.7.14). Concentrations in that well are much higher than in adjacent well 299-W11-39, screened at the water table. In September 2007, well 299-W11-46 and another downgradient well were converted to extraction wells to remove technetium-99 from the aquifer. Concentrations dropped sharply in response (Figure 10.7.14).

Waste Management Area TX-TY. RCRA assessment monitoring continued in 2007. Sources in this waste management area have contaminated groundwater with chromium, technetium-99, and other tank waste constituents. Groundwater flow beneath Waste Management Area TX-TY is changing due to the operation of the 200-ZP-1 pump-and-treat remediation system. Extraction wells operate south and west of Waste Management Area TX-TY.

State-Approved Land Disposal Site. This active disposal facility is regulated under a Washington 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 2007.

10.7.3.9 Groundwater Monitoring Results for the 200-UP-1 Operable Unit

The 200-UP-1 Operable Unit underlies the south portion of 200-West Area. The primary contaminants of concern are technetium-99 and uranium. Tritium, chromium, iodine-129, 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. One new monitoring well was drilled in this operable unit in 2007.

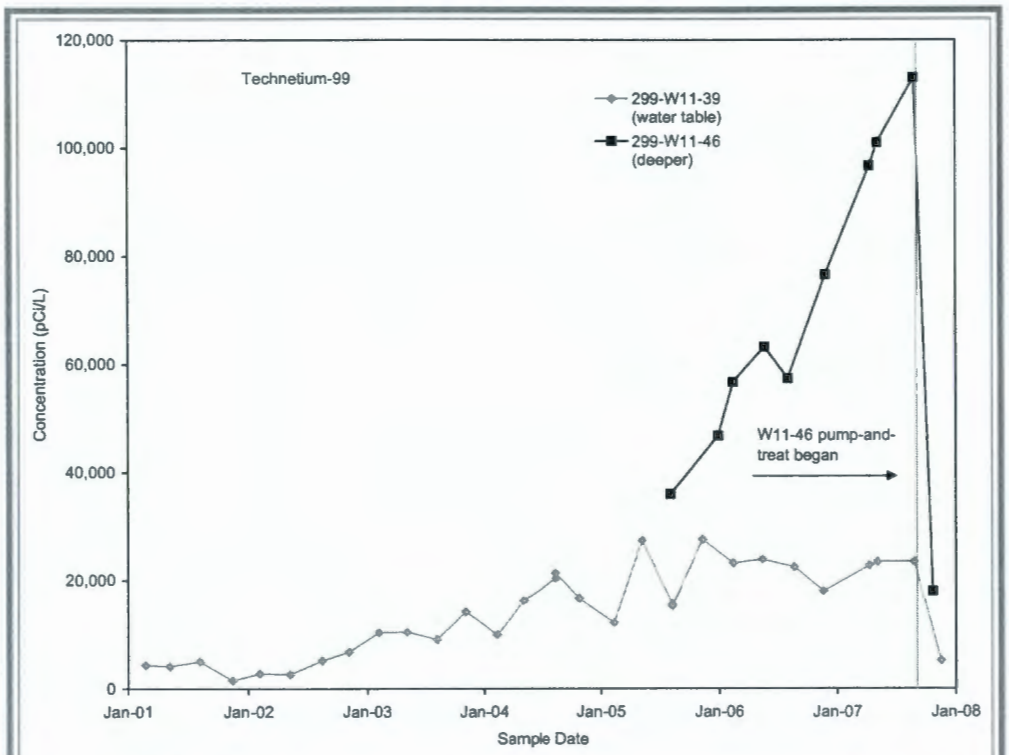


Figure 10.7.14. Technetium-99 Trend Plots for Wells Monitoring Waste Management Area T

The 200-UP-1 Operable Unit contains four facilities monitored under RCRA (in conjunction with CERCLA and the *Atomic Energy Act of 1954*), one CERCLA interim action, 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 10 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 that time, 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. Restarting the pump-and-treat system was a response to an action identified in the November 2006 CERCLA 5-year review. Figures 10.7.15 and 10.7.16 show concentrations of technetium-99 and uranium in wells monitoring the pump-and-treat system.

Waste Management Area S-SX. RCRA assessment monitoring continued in 2007. Groundwater beneath Waste Management Area S-SX is contaminated with tank waste constituents, which include nitrate, chromium, and technetium-99, and attributed to two general source areas. In the north plume, concentrations of the mobile tank waste constituents increased in 2007. Both plumes continued to expand in a downgradient direction.

Waste Management Area U. RCRA assessment monitoring continued in 2007. Waste Management Area U 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 nitrate and technetium-99. One monitoring well went dry during 2007.

216-U-12 Crib. The 216-U-12 Crib is one of several sources that have contributed to a nitrate plume in the area.

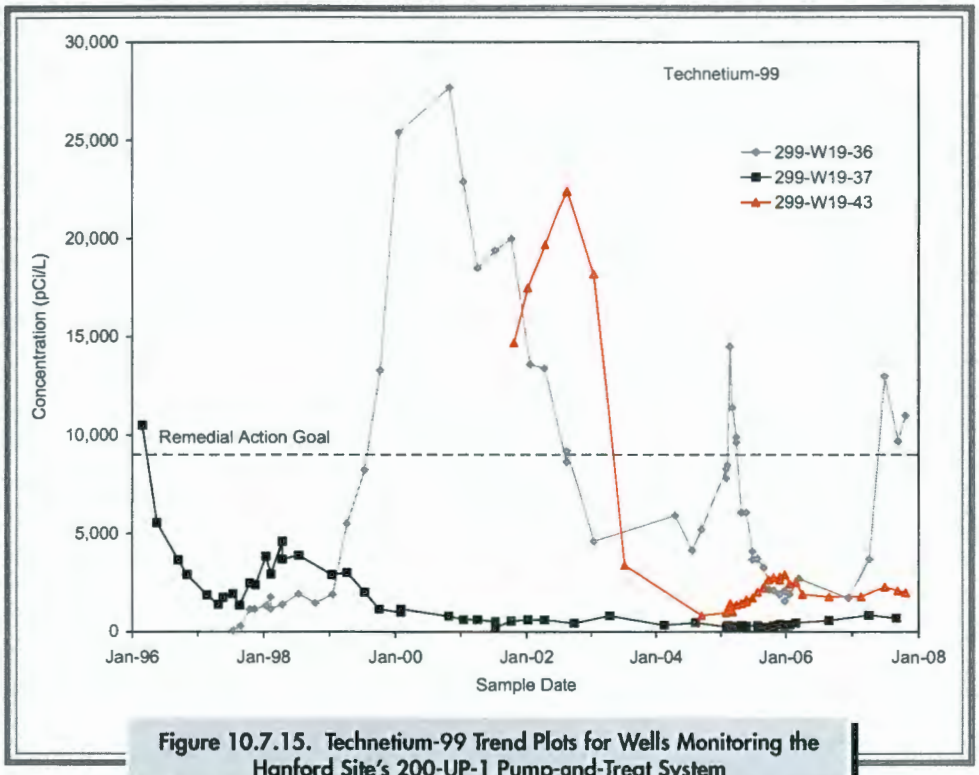


Figure 10.7.15. Technetium-99 Trend Plots for Wells Monitoring the Hanford Site's 200-UP-1 Pump-and-Treat System

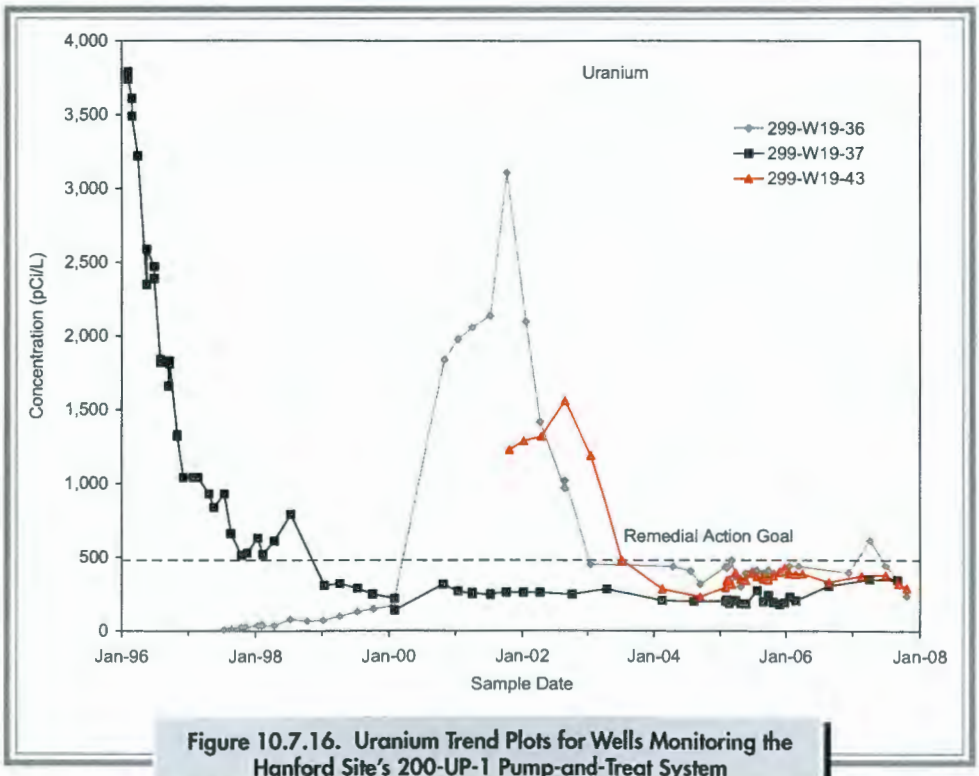


Figure 10.7.16. Uranium Trend Plots for Wells Monitoring the Hanford Site's 200-UP-1 Pump-and-Treat System

In June 2007, the Tri-Parties (DOE, EPA, and Washington State Department of Ecology) approved two change requests to the *Hanford Federal Facility Agreement and Consent Order* (Ecology 1989) reclassifying the crib from a RCRA treatment, storage, or disposal unit to a RCRA past-practice unit. Based on this approval, RCRA groundwater monitoring was discontinued in October 2007. DOE will continue to monitor groundwater near the crib under CERCLA.

216-S-10 Pond and Ditch. The 216-S-10 Facility continued to be monitored under a RCRA interim status detection program in 2007. The current RCRA monitoring network consists of only two shallow downgradient wells and one deeper downgradient well because other wells have gone dry. Three new wells are planned for installation in 2008.

Environmental Restoration Disposal Facility. The Environmental Restoration Disposal Facility is a low-level mixed-waste facility where waste from surface remedial actions and other activities on the Hanford Site is disposed. The site was built under CERCLA and is designed to meet standards for hazardous waste landfills. Results of groundwater monitoring continued to indicate that the facility has not adversely impacted groundwater quality.

10.7.3.10 Groundwater Monitoring Results for the 200-BP-5 Operable Unit

The 200-BP-5 Operable Unit includes groundwater beneath the north 200-East Area and adjacent 600 Area. The water table is flat in this portion of the Hanford Site, so it is not possible to determine groundwater flow directions from water-table data alone. One of the primary objectives of the remedial investigation in the 200-BP-5 Operable Unit is to define the direction and rate of contaminant migration.

Technetium-99 and tritium plumes extend northward between Gable Mountain and Gable Butte. Uranium forms a narrow plume that extends northwest of the 200-East Area (Figure 10.7.17). 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,

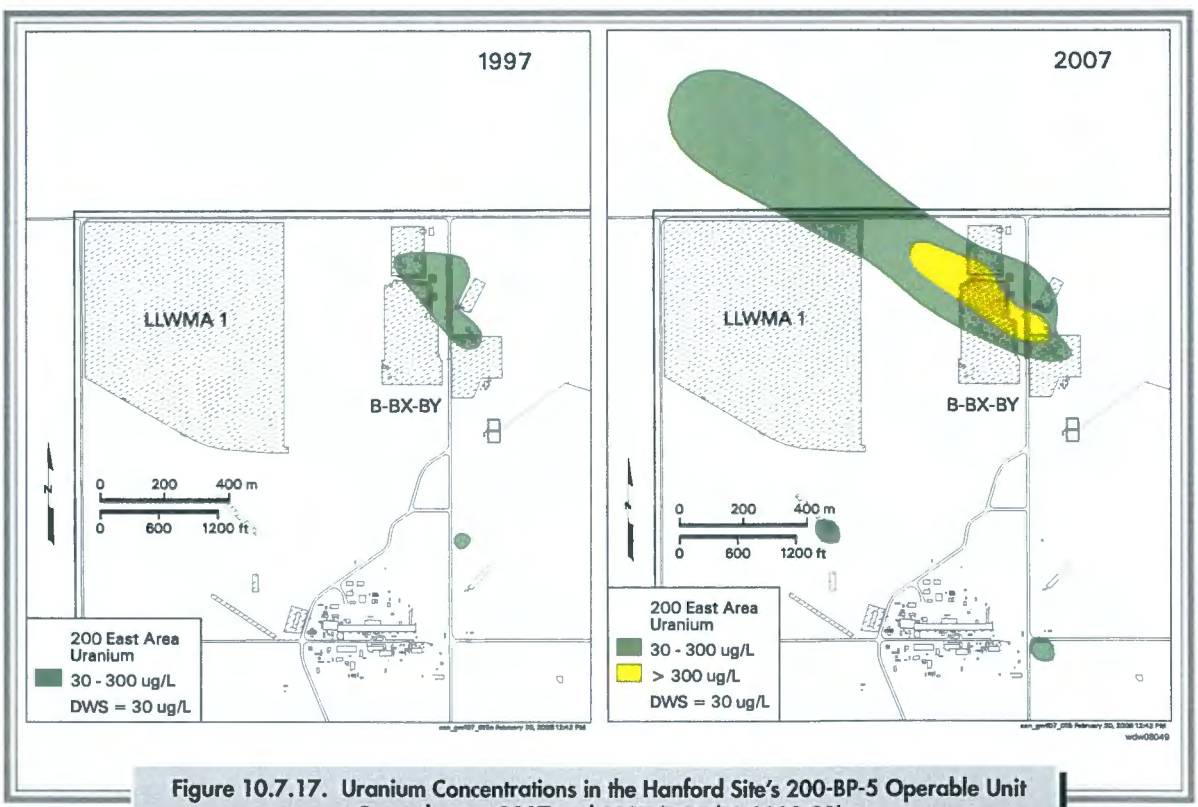


Figure 10.7.17. Uranium Concentrations in the Hanford Site's 200-BP-5 Operable Unit Groundwater, 1997 and 2007 (DOE/RL-2008-01)

strontium-90, iodine-129, cesium-137, cyanide, nitrate, plutonium, sulfate, and uranium.

In 2007, DOE continued to work on the 200-BP-5 Operable Unit remedial investigation/feasibility study. An aggressive characterization program will support decisions during this process. DOE released a data quality objectives summary report (WMP-28945) and a draft work plan (DOE/RL-2007-18). Drillers installed 3 new wells in 2007 and will add 10 more in 2008. Scientists continued to characterize the vadose zone and groundwater in the operable unit through sampling, geophysics, and aquifer tests.

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 Waste Management Area B-BX-BY in 2007. Contaminants include uranium, technetium-99, and nitrate. Concentrations of these contaminants continued to increase, as illustrated for uranium in Figure 10.7.18.

Waste Management Area C. This waste management area continued to be monitored under an interim status RCRA detection program in 2007 but is sampled quarterly at the request of the Washington State Department of Ecology. RCRA indicator parameters did not exceed critical mean values. However, nitrate, technetium-99, and sulfate are elevated in wells monitoring the waste management area.

216-B-63 Trench. The 216-B-63 Trench, a RCRA site, continued to be monitored under an interim status detection monitoring program.

Low-Level Waste Management Area 1. Low-Level Waste Management Area 1 continued to be monitored under RCRA interim status requirements. Specific conductance continued to exceed its critical mean value, but exceedances were reported previously and do not appear to indicate contamination from the waste management area.

Low-Level Waste Management Area 2. Low-Level Waste Management Area 2 continued to be monitored under RCRA interim status requirements.

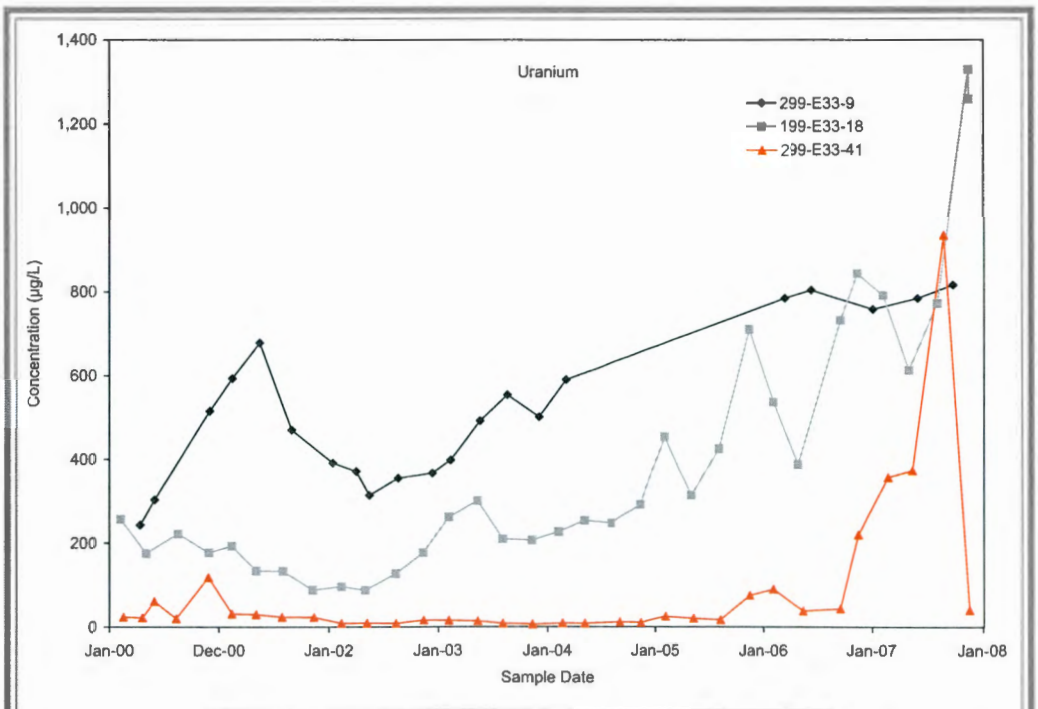


Figure 10.7.18. Uranium Trend Plots for Wells Monitoring Waste Management Area B-BX-BY

Liquid Effluent Retention Facility. The water table has dropped below the top of basalt in all but two monitoring wells at the Liquid Effluent Retention Facility. DOE and the Washington State Department of Ecology are pursuing an agreement for environmental monitoring. Two new wells are planned that will explore the possibility of monitoring the basalt flow-top and weathered zone.

10.7.3.11 Groundwater Monitoring Results for the 200-PO-1 Operable Unit

The 200-PO-1 Operable Unit encompasses the south portion of the 200-East Area and a large region to the east and southeast that is contaminated with plumes of tritium (Figure 10.7.19) and iodine-129. Concentrations of tritium continued to decline as the plume attenuates naturally due to radioactive decay and dispersion. Nitrate forms a large plume but mostly 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.

During 2007, DOE published a data quality objectives report (SGW-34011) for groundwater remediation and started to develop a work plan for a 2-year groundwater site characterization study.

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. The Integrated Disposal Facility will be an expandable, lined, RCRA-compliant landfill. The facility is scheduled to receive its first waste in 2010. Until the facility begins to operate, results from semi-annual monitoring will be added to the background data set.

PUREX Cribs. Three Plutonium-Uranium Extraction (PUREX) Cribs (216-A-10, 216-A-36B, and 216-A-37-1) are monitored jointly under a RCRA interim status assessment program, CERCLA, and the *Atomic Energy Act of 1954*. The cribs have contributed to widespread contaminant plumes in the area, including nitrate, tritium, and iodine-129. The nitrate and tritium plumes are generally attenuating throughout most of their area.

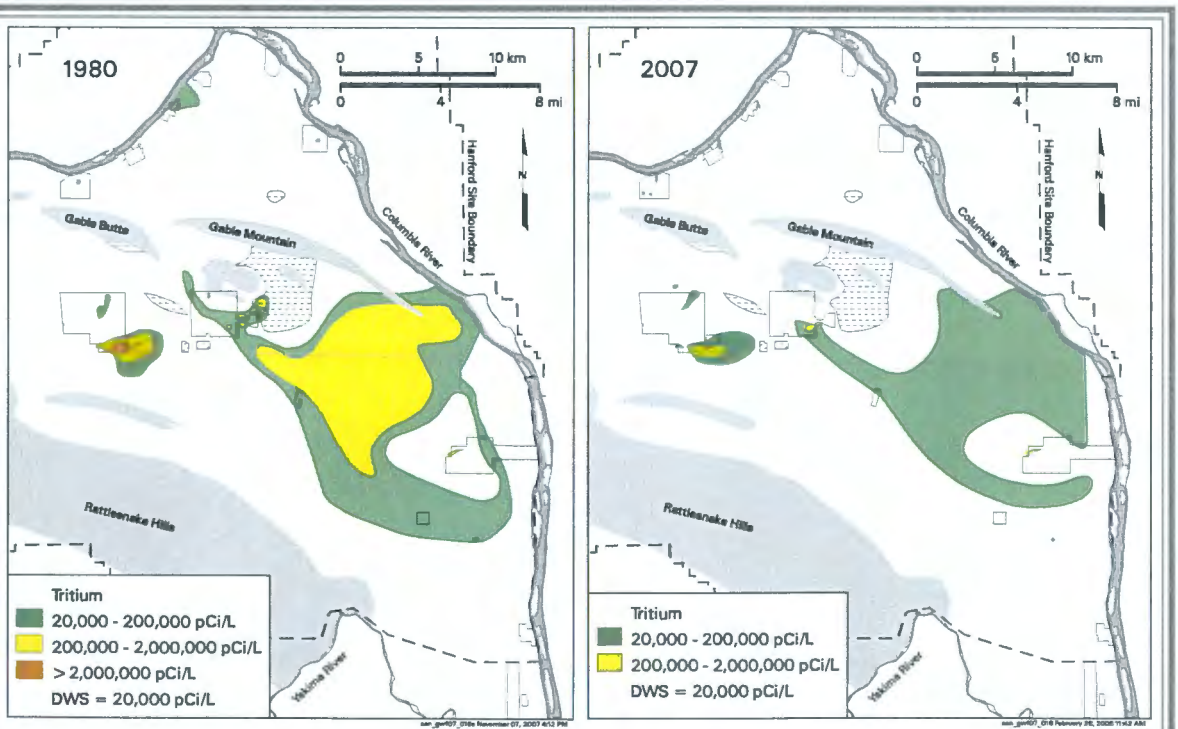


Figure 10.7.19. Tritium Concentrations in Hanford Site Groundwater, 1980 and 2007 (DOE/RL-2008-01)

Waste Management Area A-AX. RCRA assessment monitoring continued in 2007. Technetium-99 concentrations exceeded the drinking water standard (900 pCi/L [33.3 Bq/L]) in two wells, but levels decreased in 2007.

216-A-29 Ditch. The groundwater beneath the 216-A-29 Ditch continued to be monitored as required by RCRA interim status detection regulations. Groundwater quality beneath the ditch closely resembles regional patterns.

216-B-3 Pond. The groundwater beneath the 216-B Pond continued to be monitored as required by RCRA interim status detection regulations.

200 Area Treated Effluent Disposal Facility. A state waste discharge permit governs groundwater sampling and analysis in the three monitoring wells at the 200 Area Treated Effluent Disposal Facility. No permit criteria for constituents in groundwater were exceeded in 2007. 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. Thus, groundwater beneath the facility is isolated from the effects of the effluent.

Nonradioactive Dangerous Waste Landfill. A RCRA site, the Nonradioactive Dangerous Waste Landfill is located in the 600 Area, within the footprint of the 200-PO-1 regional plume. Interim status detection monitoring continued 2007.

600 Area Central Landfill (formerly Solid Waste Landfill). The 600 Area Central Landfill is adjacent to the Nonradioactive Dangerous Waste Landfill and is regulated under Washington State solid waste regulations. As in previous years, some downgradient wells showed higher chemical oxygen demand, chloride, coliform bacteria, specific conductance, and sulfate, and lower pH than upgradient wells. Some of these constituents may be related to past disposal of sewage materials to the 600 Area Central 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 lies in the path of the site-wide tritium plume, the wells are routinely monitored for tritium. Tritium concentrations in all samples were below the drinking water standard in 2007.

10.7.3.12 Groundwater Monitoring Results for the 300-FF-5 Operable Unit

The 300-FF-5 Operable Unit includes three geographic regions: the 300 Area, the 618-11 Burial Ground region, and the 316-4 Cribs/618-10 Burial Ground region. The operable unit is currently regulated under a record of decision for interim action (ROD 1996) that calls for groundwater monitoring and institutional controls on the use of groundwater. In 2007, DOE installed 16 new wells that support a uranium treatability test and aquifer characterization.

Contaminants of concern in 300 Area groundwater are uranium, trichloroethene, and cis-1,2-dichloroethene. Monitoring and plume characterization activities indicate relatively constant or gradually decreasing levels for these contaminants. Uranium is the primary contaminant of concern and remains above the drinking water standard (30 µg/L) beneath part of the 300 Area (Figure 10.7.20). Nitrate exceeds the drinking water standard (45 mg/L) in the southern 300 Area. This plume originates from sources off the Hanford Site.

Trichloroethene continued to be below the 5-µg/L drinking water standard in wells monitoring the top of the unconfined aquifer. However, characterization samples collected in 2006 detected higher concentrations from a fine-grained unit within the upper portion of the Ringold Formation. Wells subsequently completed to monitor this unit showed only low levels of trichloroethene (<1 µg/L). This suggests contamination in a relatively small area.

Groundwater downgradient of the 618-11 Burial Ground is contaminated by a high-concentration tritium plume whose origin is believed to be 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 850,000 pCi/L (31,450 Bq/L) in September 2007.

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 remedial investigations, DOE continued a detailed investigation of the natural processes that cause the plume to persist and the residual sources that may supply uranium

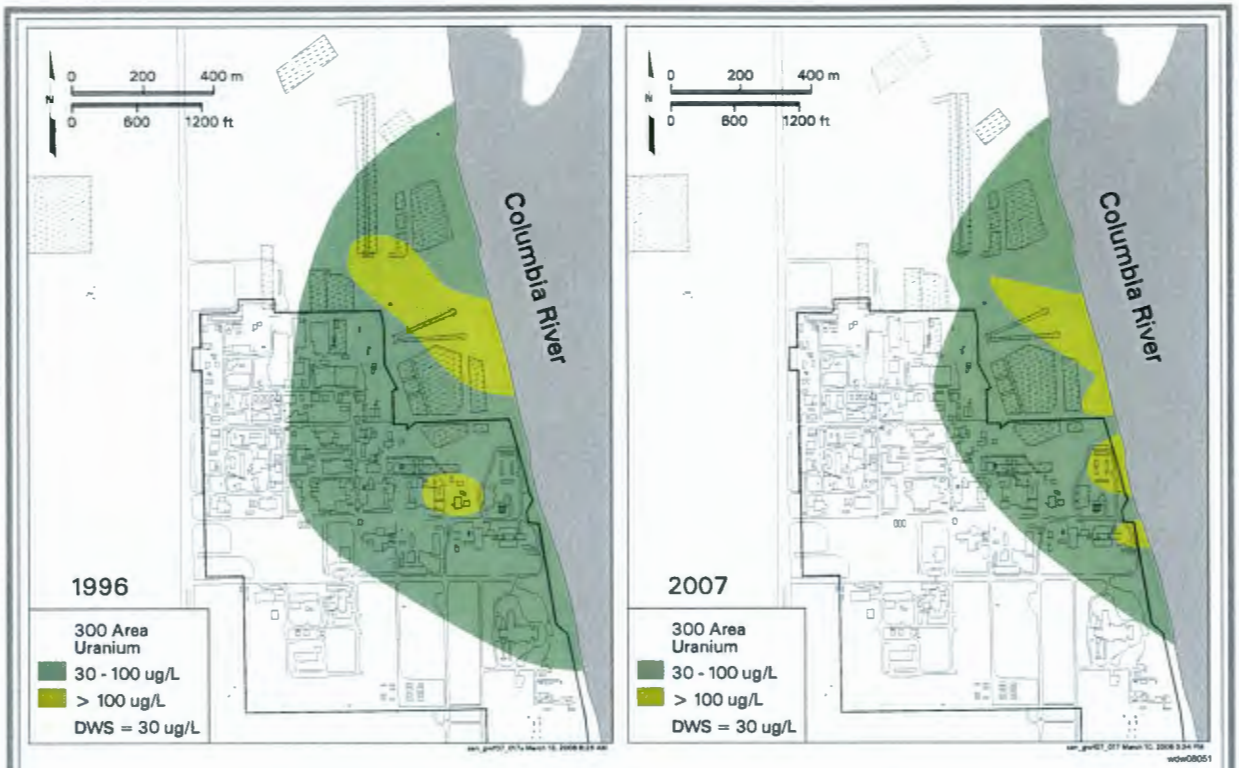


Figure 10.7.20. Uranium Concentrations in the Hanford Site's 300 Area Groundwater, 1996 and 2007 (DOE/RL-2008-01)

to the plume. During 2007, a report describing the screening of potential remedial action technologies was prepared (PNNL-16761). The most promising technologies are those that use in situ methods to reduce the mobility of uranium in the environment.

In 2007, scientists continued a comprehensive program of simulation, laboratory, and field research tasks to support the 300-FF-5 feasibility study, designed to improve conceptual and transport-simulation models for uranium movement.

A treatability test to immobilize uranium in the aquifer continued during 2007. The test involved injecting polyphosphate into the aquifer. Preliminary information indicates that the timing of injections relative to seasonal conditions is very important in the implementation of this technology.

316-5 Process Trenches. This former liquid waste disposal site was the last in the 300 Area to receive uranium-bearing effluent. DOE ceased discharging hazardous waste to the trenches in 1985 and ceased all discharges in 1994. 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 that is completed near the bottom of the unconfined aquifer.

10.7.3.13 Groundwater Monitoring Results for the 1100-EM-1 Operable Unit

The 1100-EM-1 Operable Unit is located in the southern part of the Hanford Site adjacent to the northern part of the city of Richland. Trichloroethene was the primary contaminant of concern. Contaminants also flow into the area from offsite sources (e.g., nitrate from agriculture and industry).

The final remedy selected for 1100-EM-1 Operable Unit groundwater is monitored natural attenuation of volatile organic compounds. Concentrations of trichloroethene have remained below the drinking water standard since 2001. DOE reduced groundwater monitoring for the 1100-EM-1 Operable Unit in response to an action item identified by the CERCLA 5-year review published in November 2006 (DOE/RL-2006-20). A Tri-Party Agreement change notice, approved in June 2007, specifies annual monitoring of three wells.

Wells in the city of 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.

Uranium concentrations in wells downgradient of DOE's inactive Horn Rapids Landfill have been increasing since 1996 but remained below the 30-µg/L drinking water standard in 2007.

10.7.3.14 Groundwater Monitoring Results for the Confined Aquifers

Although most of the Hanford Site groundwater contamination is in the unconfined aquifer, DOE monitors wells in deeper aquifers because of the potential for downward migration of contamination in some areas 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 lower mud unit. Groundwater in this aquifer flows generally west to east in the vicinity of the 200-West Area. In the central portion of the aquifer, flow appears to converge into the 200-East Area from the west, south, and east. Groundwater likely discharges from the confined aquifer to the overlying unconfined aquifer where the confining mud unit has been removed by erosion.

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 2007, tritium in a single well near the former B Pond was the only contaminant present at concentrations above the drinking water standard.

Within the upper basalt-confined aquifer system, groundwater occurs within basalt fractures and joints, interflow contacts, and sedimentary interbeds. Groundwater in the upper basalt-confined aquifer generally flows from west to east across the Hanford Site, up through fractures or other pathways in the confining layers, into the unconfined aquifer, and into the Columbia River. Vertical gradients between the basalt-confined aquifer and the unconfined aquifer are upward on most of the Hanford Site. Downward gradients are measured in the western portion of the Hanford Site, near B Pond, and north and east of the Columbia River.

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. Cyanide, nitrate, and technetium-99 were elevated in an upper basalt-confined aquifer well in the northwestern part of the 200-East Area. Migration of high-salt waste from the vadose zone or unconfined aquifer via the well bore during well construction is responsible for this contamination.

10.7.4 Shoreline Groundwater Monitoring

DOE monitors groundwater near the Columbia River via aquifer tubes, which are small-diameter, flexible tubes implanted in the shallow aquifer and natural seepage points or springs. Results are discussed in the following paragraphs, and details are available in *Aquifer Sampling Tube Results for Fiscal Year 2007* (SGW-35028).

Concentrations of strontium-90 continued to exceed the 8-pCi/L (0.3-Bq/L) drinking water standard in aquifer tubes in the 100-BC-5 and 100-NR-2 interest 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 15,000 pCi/L (555 Bq/L) in one tube in August 2007 (Figure 10.7.8).

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 concentrations also exceeded the standard in springs at the Hanford town site but were below the standard in aquifer tube samples.

Uranium concentrations exceeded the 30-µg/L drinking water standard in aquifer tubes and springs in the 300 Area.

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.

All nitrate concentrations were below the 45-mg/L drinking water standard in aquifer tubes in samples collected through September 2007. Levels have exceeded the standard in the 100-F, 100-H, and 300 Areas in the past.

Trichloroethene was detected in several aquifer tubes in the 300 Area. Concentrations are highest in two deep tubes. The maximum in 2007 was 450 µg/L in tube AT-3-3-D, which monitors a fine-grained portion of the aquifer.

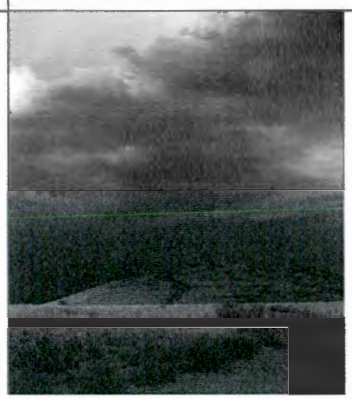
10.7.5 Well Installation, Maintenance, and Decommissioning

DOE installs new wells when needed for monitoring or characterization, maintains wells to repair problems, and decommissions wells that are no longer needed. DOE, EPA, and the Washington State Department of Ecology worked together to develop a prioritized list of new wells needed to meet requirements of various groundwater monitoring regulations. Fifty-seven new wells were installed during October 2006 through September 2007.

Temporary characterization boreholes are installed around the Hanford Site to characterize subsurface contamination or determine hydrogeologic properties (e.g., moisture, grain-size distribution). From October 2006 through September 2007, 100 temporary boreholes were installed. Four borings were drilled to groundwater; the remainder extended no farther than the vadose zone.

Approximately 8,836 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, 3,948 of these, or approximately 45% 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. All candidate wells must be reviewed and approved by potential well users prior to decommissioning. Through September 2007, a total of 3,085 unique well identification numbers were documented as "in use." This number includes 2,310 wells, 129 piezometers within host wells, 354 aquifer tubes, and 292 soil-gas boreholes. A total of 91 wells were physically decommissioned from October 2006 through September 2007, and 623 temporary boreholes and subsurface installations were administratively decommissioned by records management.

Staff performed maintenance on 186 wells from October 2006 through September 2007. Surface tasks include labeling wells, fixing or replacing locking well caps, repairing casing, repairing or replacing sampling pumps, and performing camera surveys.



10.8 Food and Farm Products Monitoring

B. G. Fritz

During 2007, food and farm products, including alfalfa, grapes, milk, potatoes, tomatoes, and wines, were collected at locations near the Hanford Site (Figure 10.8.1). Samples were analyzed to determine concentrations of radiological contaminants. Samples 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
- Other 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 like 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.

Concentrations of most radionuclides in food and farm product samples in 2007 were below levels that could be detected by analytical laboratories. However, some contaminants that potentially could have originated from the Hanford Site (e.g., uranium-234 and tritium) 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 Hanford Site-produced contaminants that were detected 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

Some 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 (PNNL-16369). 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 the Pacific Northwest National Laboratory in the event 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 2007. Most samples were obtained from commercial

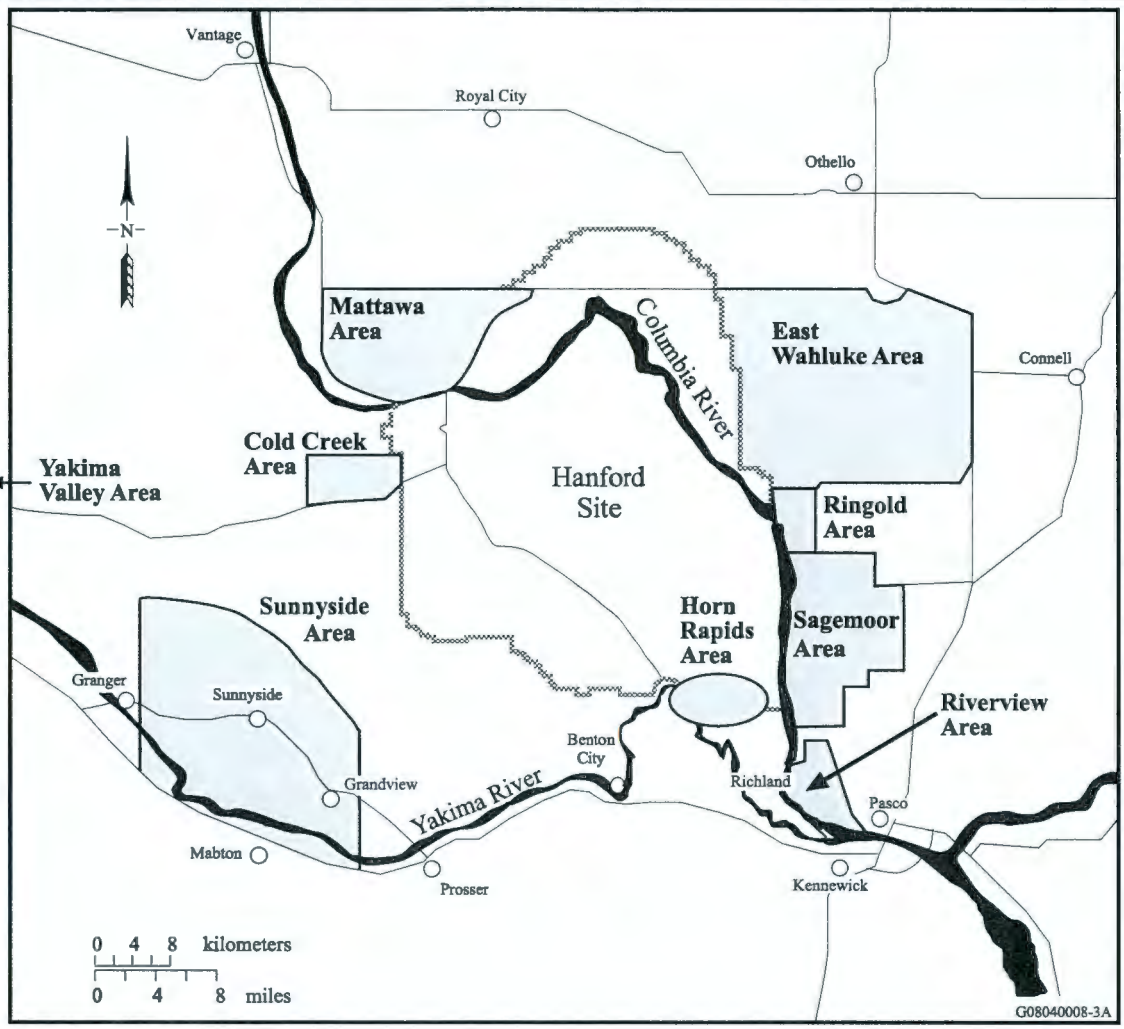


Figure 10.8.1. Food and Farm Product Sampling Locations, 2007

Table 10.8.1. Sampling Locations and Analytes for Food and Farm Products Sampled Around the Hanford Site in 2007

Product	Sampling Locations	Analytes
Alfalfa	Horn Rapids, Riverview, Sagemoor, Sunnyside	Gamma, ^{90}Sr
Grapes	Cold Creek, Riverview, Sagemoor, Sunnyside	Gamma, ^{90}Sr
Milk	Sagemoor, Sunnyside, Wahluke	^{3}H, Gamma, ^{90}Sr
Potatoes	Horn Rapids, Sunnyside, Wahluke	Gamma, ^{90}Sr
Tomatoes	Riverview, Sunnyside	^{3}H, Gamma, ^{90}Sr
Wine	Columbia Basin,[a] Mattawa, Yakima	^{3}H, Gamma

(a) Columbia Basin includes all of Benton and Franklin Counties.

producers; however, some were obtained from residential gardens because commercial growers could not be located.

10.8.2 Milk

During 2007, 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, strontium-90, and tritium. 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.

Strontium-90 – Strontium-90 was measured at a detectable level in one milk sample collected in 2007. The sample was collected from the Sunnyside sampling area in July 2007. The concentration of strontium-90 measured in this sample was 0.64 pCi/L (0.024 Bq/L), or 26 times below the unusual concentration reporting level for strontium-90 in milk (27 pCi/L [1.0 Bq/L]).

Tritium – Tritium was detected in all milk samples collected in 2007. Concentrations ranged from a maximum of 162 pCi/L (6.0 Bq/L) in a Sagemoor area sample to 48 pCi/L (1.8 Bq/L) in a Sunnyside area sample. Annual average concentrations for the three sampling areas were 125 pCi/L (4.6 Bq/L) for Sagemoor (n = 4); 84 pCi/L (3.1 Bq/L) for East Wahluke (n = 4); and 76 pCi/L (2.8 Bq/L) for Sunnyside (n = 4). These concentrations are within the range of 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).

Cesium-137 – No manmade gamma emitters were detected in milk samples collected and analyzed in 2007 (PNNL-17603, APP. 1).

Potassium-40 – Potassium-40 was detected in all milk samples collected in 2007. 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 870 pCi/L (32 Bq/L) and 1,300 pCi/L (49 Bq/L). The annual average concentration in all milk samples collected was 1,160 pCi/L (43 Bq/L), with a standard deviation of 330 pCi/L (12 Bq/L).

10.8.3 Alfalfa

Alfalfa samples were collected in the spring from commercial fields in the Riverview, Sagemoor, Horn Rapids, and Sunnyside sampling areas (Figure 10.8.1). Samples were analyzed for gamma-producing radionuclides and strontium-90 (Table 10.8.1). Strontium-90 was the only radionuclide detected in the samples with a possible Hanford Site origin. Strontium-90 was detected in all four alfalfa samples collected in 2007. The strontium-90 concentrations measured in the samples collected from the Horn Rapids and Riverview locations had higher concentrations than were measured in the other two samples. The difference was more than could be attributed to analytical error alone (Figure 10.8.2). The measured concentrations were consistent with previously reported concentrations of strontium-90 in alfalfa (Poston et al. 1998). However, with only one sample collected from each location, no meaningful statistical analysis could be performed. The maximum measured strontium-90 concentration measured in alfalfa (0.086 pCi/g [0.0032 Bq/g]) was less than the 1.5-pCi/g (0.56-Bq/L) unusual concentration reporting level for strontium-90 in alfalfa.

10.8.4 Grapes

Concord grape samples were collected in fall 2007 from the Riverview, Sagemoor, Cold Creek, and Sunnyside sampling areas (Figure 10.8.1). Samples were analyzed for gamma-producing radionuclides and strontium-90 (Table 10.8.1). The only radionuclide found in detectable quantities was naturally occurring potassium-40.

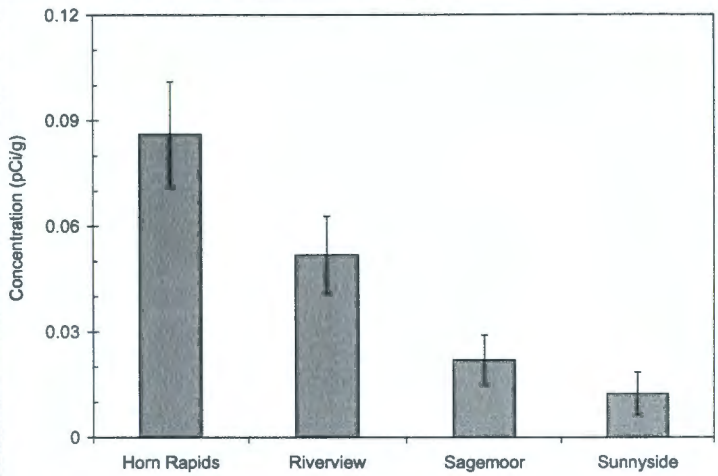


Figure 10.8.2. Strontium-90 Concentrations Measured in Alfalfa Samples Collected in 2007 (Error bars represent the analytical error associated with each result.)

10.8.5 Potatoes and Tomatoes

Potato and tomato samples were collected from both upwind and downwind sampling areas (Figure 10.8.1) during the growing season. 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 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.

10.8.6 2007 Wines

Red and white wine samples were obtained in December 2007 from two wineries near the Hanford Site and at an upwind location. The wines were produced from 2007 vintage grapes that were harvested in fall 2007 from vineyards in the Columbia Basin area just north of Pasco (downwind of the site), near Mattawa (near the site perimeter), and just east of Yakima (generally upwind of the site) (Figure 10.8.1). Each wine was divided (split) into two samples and all samples were analyzed for gamma-emitting radionuclides. Tritium was analyzed for the samples collected from the Columbia Basin and Yakima areas (Table 10.8.1).

Cesium-137 – No manmade gamma emitters (including cesium-137) were detected in wine samples collected and analyzed in 2007 (PNNL-17603, APP. 1).

Potassium-40 – Naturally occurring potassium-40 was measured in all wine samples collected in 2007. Concentrations in all samples ranged from 264 to 1,480 pCi/L (9.8 to 55 Bq/L). Potassium-40 concentrations were higher in the red wines than in the white, probably a result of the grape skin being included in the processing of red wines.

Tritium – Tritium was measured in both red and white wine samples collected from the Columbia Basin and Yakima sampling areas in 2007. Low levels of tritium were measured in all wine samples analyzed in 2007. Concentrations in all samples ranged from 5.3 to 18 pCi/L (0.20 to 0.67 Bq/L). The average concentration for all samples was 12 pCi/L (0.44 Bq/L). Concentrations measured in samples collected in the Yakima area were slightly lower than concentrations measured in samples collected from the Columbia Basin area, but the difference was less than the analytical error associated with each result. Similarly, slightly higher tritium concentrations were measured in the red wine samples than in the white wine samples, but the differences were less than the analytical error. This is consistent with the potassium-40 results. While there is no health-based standard for tritium in wine, the standard for tritium in drinking water is 20,000 pCi/L (740 Bq/L).

10.9 Soil Monitoring

The following sections summarize soil monitoring efforts conducted in 2007 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 exists documenting 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 soil monitoring efforts, the programs that support them, and their purposes, see Section 10.0 and DOE/RL-91-50, Rev. 4.

10.9.1 Soil Monitoring Near Hanford Site Facilities and Operations

J. W. 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 facilities and remedial action sites. The number and locations of soil samples collected during 2007 are summarized in Table 10.9.1. Only radionuclides

Table 10.9.1. Number and Locations of Soil Samples Collected Near Hanford Site Facilities and Operations, 2007

Number of Samples	Operational Area									
	100-D	100-F	100-K	100-N	200-West[a]	200-East	600[a]	300[a]	400	ERDF[b]
76	0	0	0	0	27	14	17	16	1	1

(a) Number of samples includes one or more replicate samples.
(b) Environmental Restoration Disposal Facility in the 200-West Area.

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-17603, 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, then dried in the laboratory prior to analysis 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 Grant, Yakima, Walla Walla, Adams, Benton, and Franklin Counties (Figure 10.9.1). 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 at the Hanford Site. These concentration values for radionuclides were established to ensure that 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. A partial listing of these values is provided in Table 10.9.2 (see PNNL-17603, 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 the collection and analysis of 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 2007 were higher than the concentrations in samples collected farther away and were significantly higher than concentrations measured offsite. The data also show, as expected, that concentrations of certain radionuclides in 2007 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.

Cesium-134, cesium-137, plutonium-239/240, and uranium were detected consistently in the samples taken in 2007. 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 2007 and the preceding 4 years. Some individual levels demonstrate a high degree of variability, although overall trends are stable.

Table 10.9.3 provides a summary of selected analytical results for near-facility soil samples collected and analyzed in 2007. The average and maximum results are reported for five operational areas, along with comparative data for the preceding 5 years. Complete listings of radionuclide concentrations for all soil samples collected during 2007, as well as sampling location maps, are provided in PNNL-17603, APP. 2.

Soil samples collected in 2007 at locations in the 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

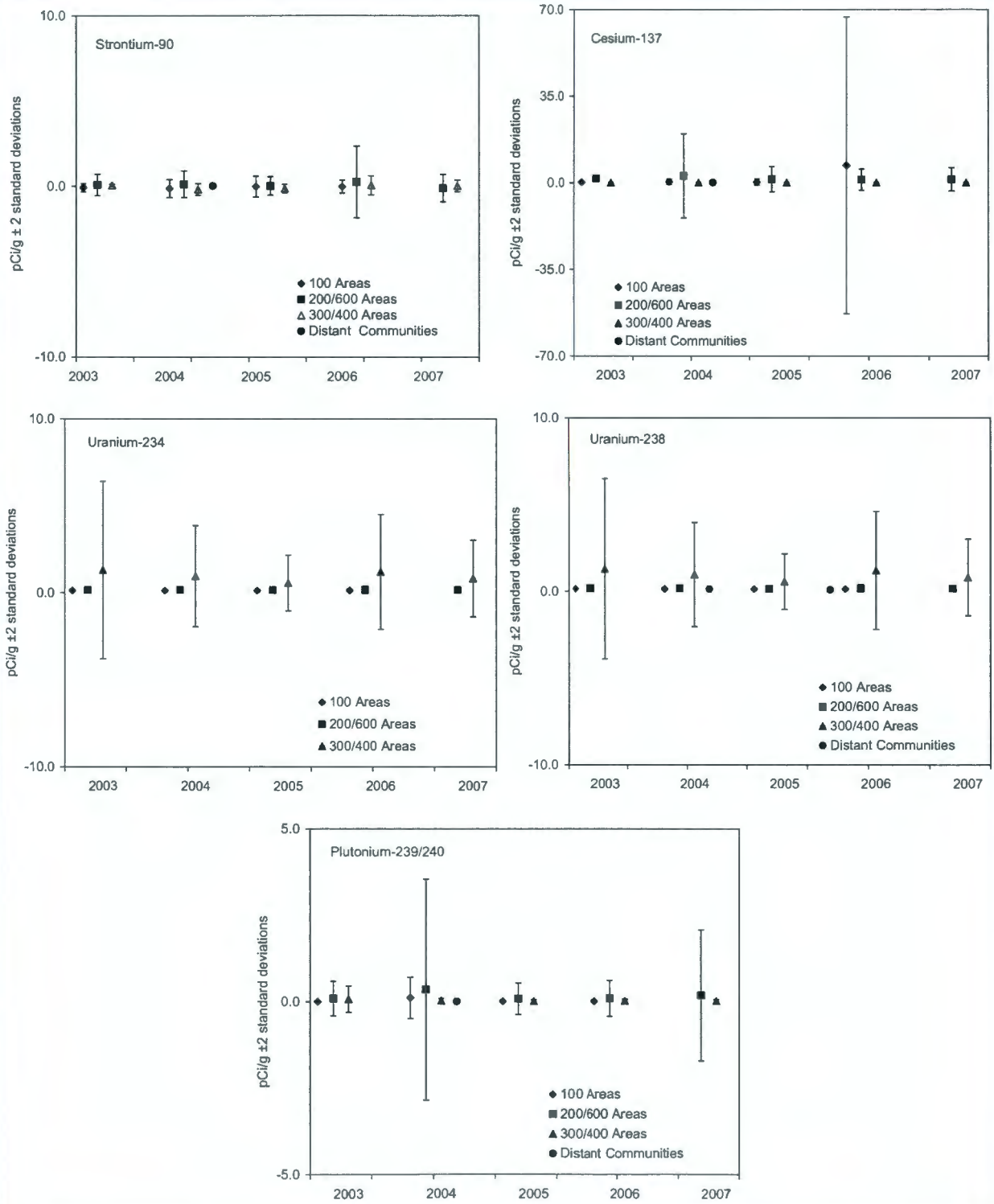


Figure 10.9.1. Average Concentrations of Selected Radionuclides in Soil Samples Collected on the Hanford Site Near Facilities and Operations Compared to Those Collected in Distant Communities, 2003 Through 2007. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

Table 10.9.2. Accessible Soil Concentration Limits (pCi/g[a] dry wt.) for Selected Radionuclides

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	$^{239/240}Pu$
Accessible soil[b] 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.

in the 300 Area. There was no soil sampling in support of the environmental restoration contractor projects in the 100 Areas in 2007.

10.9.1.3 Investigations of Radioactive Contamination in Soil Near Hanford Site Facilities and Operations

S. M. McKinney and R. C. 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.

During 2007, there were 17 instances of radiological contamination in soil samples collected during investigations. Of the 17, 13 were identified as speck contamination and 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 2007 were generally within historical values (WHC-MR-0418).

The number and general locations of soil contamination incidents investigated during 2007 are summarized in Table 10.9.5. The number of contamination incidents investigated in 2007 and during the previous 10 years is provided in Table 10.9.6.

10.9.2 Soil Monitoring at Hanford Site-Wide and Offsite Locations

B. G. 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 have been collected on and around the Hanford Site for more than 50 years. Consequently, a large database exists that documents 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. Routine radiological monitoring of soil at site-wide (onsite away from facilities and operations) and offsite locations was last conducted in 2004 (Section 8.9 in PNNL-15222) and is scheduled to be conducted again in 2008.

Table 10.9.3. Concentrations of Selected Radionuclides (pCi/g dry wt.)[a] in Near-Facility Soil Samples, 2007 Compared to Previous Years

		2007				2002-2006			
		Number of				Number of			
Radionuclide	Hanford Area	Samples	Detections[b]	Average[c]	Maximum[d]	Samples	Detections[b]	Average[c]	Maximum[d]
Cobalt-60	200-E	14	0	0.00064 ± 0.0086	0.010 ± 0.0078[e]	74	0	0.00075 ± 0.0065	0.0099 ± 0.0076[e]
	200-W[f]	28	0	-0.00035 ± 0.0080	0.0069 ± 0.0067[e]	137	3	0.0017 ± 0.031	0.18 ± 0.020
	300	16	0	0.00072 ± 0.0089	0.0083 ± 0.0075[e]	69	0	-0.00059 ± 0.0061	0.0083 ± 0.0063[e]
	400[f]	1	0	0.00065	0.00065 ± 0.0065[e]	5	0	0.00080 ± 0.0055	0.0052 ± 0.0069[e]
	600	17	0	0.00022 ± 0.0065	0.0059 ± 0.0099[e]	81	1	0.00018 ± 0.0084	0.013 ± 0.013
Cesium-137	200-E	14	14	1.5 ± 5.2	9.1 ± 1.5	74	73	2.2 ± 7.4	17.0 ± 3.0
	200-W[f]	28	27	1.9 ± 5.4	14.0 ± 2.3	137	135	1.7 ± 4.3	13.0 ± 2.4
	300	16	14	0.095 ± 0.22	0.36 ± 0.064	69	63	0.082 ± 0.14	0.23 ± 0.040
	400[g]	1	1	0.025 ± 0.0000034	0.025 ± 0.010	5	5	0.038 ± 0.083	0.12 ± 0.022
	600	17	15	0.41 ± 0.70	1.1 ± 0.20	81	79	1.2 ± 13.0	61.0 ± 9.7
Plutonium-238	200-E	14	0	0.00068 ± 0.033	0.046 ± 0.045[e]	74	1	0.0053 ± 0.033	0.047 ± 0.039[e]
	200-W[f]	28	0	0.0089 ± 0.052	0.12 ± 0.094[e]	137	7	0.0076 ± 0.051	0.22 ± 0.066
	300	16	0	0.0012 ± 0.010	0.011 ± 0.011[e]	69	2	0.0037 ± 0.048	0.16 ± 0.061
	400[g]	1	0	-0.00180	-0.0018 ± 0.018[e]	5	0	0.0043 ± 0.018	0.011 ± 0.021[e]
	600	17	0	0.0026 ± 0.0094	0.0094 ± 0.014[e]	81	3	0.020 ± 0.18	0.77 ± 0.22
Plutonium-239/240	200-E	14	3	0.0074 ± 0.022	0.032 ± 0.016	74	25	0.013 ± 0.028	0.062 ± 0.029
	200-W[f]	28	24	0.33 ± 2.7	7.3 ± 1.9	137	111	0.17 ± 0.74	2.4 ± 0.48
	300	16	6	0.018 ± 0.047	0.075 ± 0.028	69	21	0.033 ± 0.19	0.73 ± 0.15
	400[g]	1	0	0.00180	0.0018 ± 0.018[e]	5	0	0.0037 ± 0.0040	0.0075 ± 0.010[e]
	600	17	11	0.067 ± 0.23	0.43 ± 0.11	81	42	0.22 ± 2.7	12.0 ± 3.1
Strontium-90	200-E	14	1	0.82 ± 6.2	12.0 ± 1.7	74	23	0.21 ± 0.75	1.9 ± 0.38
	200-W[f]	28	3	-0.085 ± 0.94	0.98 ± 0.43	137	33	0.18 ± 1.5	8.1 ± 1.6
	300	16	0	0.010 ± 0.32	0.29 ± 0.23[e]	69	3	-0.020 ± 0.39	1.0 ± 0.35
	400[g]	1	0	0.28 ± 0.000032	0.28 ± 0.26[e]	5	0	-0.029 ± 0.34	0.18 ± 0.13[e]
	600	17	0	-0.17 ± 0.84	0.48 ± 0.48[e]	81	12	0.054 ± 0.49	1.1 ± 0.25

Table 10.9.3. (contd)

Radionuclide	Hanford Area	2007 Number of Samples	2007 Number of Detections[b]	2007 Average[c]	2007 Maximum[d]	2002-2006 Number of Samples	2002-2006 Number of Detections[b]	2002-2006 Average[c]	2002-2006 Maximum[d]
Uranium-234	200-E	14	14	0.15 ± 0.086	0.25 ± 0.082	74	74	0.17 ± 0.19	0.84 ± 0.28
	200-W[f]	28	28	0.17 ± 0.13	0.39 ± 0.12	137	137	0.16 ± 0.11	0.51 ± 0.14
	300	16	16	0.86 ± 2.3	3.9 ± 1.0	69	69	1.2 ± 4.5	12.0 ± 2.3
	400[g]	1	1	0.099 ± 0.000043	0.099 ± 0.040	5	5	0.13 ± 0.047	0.16 ± 0.056
	600	17	17	0.15 ± 0.083	0.24 ± 0.074	81	81	0.17 ± 0.18	0.84 ± 0.23
Uranium-235	200-E	14	5	0.013 ± 0.016	0.033 ± 0.019	74	44	0.013 ± 0.014	0.037 ± 0.020
	200-W[f]	28	11	0.013 ± 0.022	0.052 ± 0.028	137	80	0.014 ± 0.015	0.054 ± 0.024
	300	16	12	0.056 ± 0.13	0.21 ± 0.067	69	53	0.072 ± 0.23	0.65 ± 0.16
	400[g]	1	0	0.00650	0.0065 ± 0.013[e]	5	2	0.011 ± 0.011	0.021 ± 0.014
	600	17	3	0.0087 ± 0.020	0.024 ± 0.017	81	52	0.015 ± 0.019	0.056 ± 0.027
Uranium-238	200-E	14	14	0.15 ± 0.093	0.25 ± 0.080	74	74	0.17 ± 0.18	0.77 ± 0.26
	200-W[f]	28	28	0.17 ± 0.16	0.42 ± 0.12	137	137	0.16 ± 0.12	0.53 ± 0.15
	300	16	16	0.85 ± 2.3	3.8 ± 0.99	69	69	1.2 ± 4.5	12.0 ± 2.3
	400[g]	1	1	0.13 ± 0.000043	0.13 ± 0.048	5	5	0.14 ± 0.055	0.18 ± 0.050
	600	17	17	0.15 ± 0.089	0.25 ± 0.078	81	81	0.16 ± 0.15	0.68 ± 0.19

(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[a] dry wt.)[b] in Environmental Restoration Contractor Field Remediation Projects' Soil Samples, 2007

Site	Sample Location[c]	Sample Date	Cobalt-60	Strontium-90	Cesium-137
ERDF	D146	05/14/2007	-0.00021	-0.240 ± 0.00008	0.0099 ± 0.0000017
Accessible Soil Concentration [d]			7.1	2,800	30
			Uranium-234	**Uranium-238**	**Plutonium-239/240**
			0.15 ± 0.049	0.12 ± 0.00004	0.0056 ± 0.0000026
Accessible Soil Concentration [d]			630	370	190

(a) 1 pCi = 0.037 Bq.
(b) ± total analytical uncertainty.
(c) Sampling location code. See PNNL-17603, 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, 2007

Locations	Number of Incidents
200-East Area	
tank farms	6
burial grounds	0
cribs, ponds, and ditches	1
fence lines	0
roads and railroads	1
unplanned release sites	1
underground pipelines	1
miscellaneous	0
200-West Area	
tank farms	4
burial grounds	0
cribs, ponds, and ditches	1
fence lines	0
roads and railroads	0
unplanned release sites	1
underground pipelines	0
miscellaneous	0
Cross-site transfer line	0
200-BC cribs and trenches	0
200-North Area	0
100 Areas	1
300 Area	0
400 Area	0
600 Area	0
Former 1100 Area	0
Total	**17**

Table 10.9.6. Annual Number of Soil Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 1997 Through 2007

Year	Number of Incidents	Year	Number of Incidents
1997	51	2003	30
1998	41	2004	19
1999	42	2005	20
2000	25	2006	25
2001	20	2007	17
2002	22		

10.10 Vegetation Monitoring

Vegetation monitoring and control activities conducted at and around the Hanford Site in 2007 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 at the site, and control of contaminated or unwanted vegetation at the site.

Surveys and monitoring of plant populations and habitats found onsite are conducted 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. Radiological monitoring of vegetation near onsite facilities and operations is done to determine the effectiveness of effluent monitoring and controls within facilities, to assess the adequacy of containment at waste-disposal sites, and to detect and monitor unusual conditions. Site-wide and offsite vegetation samples (not collected in 2007 but scheduled for collection in 2009) 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

J. L. Downs, M. R. Sackschewsky, and M. A. 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 at 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 at the 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) (Washington Natural Heritage Program 1997). Data are collected for plant populations and plant communities on the Hanford Site to develop baseline information and to monitor any changes resulting from 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 focus 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. 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. Significant changes to the vegetation cover and habitats on the Hanford Site occurred during the past year as a result of several wildfires that burned on the Hanford Reach National Monument and across the central part of the Hanford Site. Lightening-caused fires burned on the Hanford Site during July 2007, and two fires were caused by human activities in August 2007.

On July 13, 2007, three lightning-caused wildfires merged and became known as the Overlook Fire that covered 8,527 hectares (21,071 acres) on the east side of the Columbia River on Hanford Reach National Monument lands. The Overlook Fire burned native shrubland and grasslands in areas on the Wahluke Slope. Lightening also started several small (less than 40.5 hectares [100 acres]) fires on the west side of the Columbia River that were quickly contained. On August 13, 2007, the Milepost 17 fire started along Highway 240 and burned about 1,905 hectares (4,708 acres) in a crescent-shaped area on the Fitzner/Eberhardt Arid Lands Ecology Reserve. The Wautoma Fire started on August 16, 2007, on private lands and burned across the Fitzner/Eberhardt Arid Lands Ecology Reserve onto the central Hanford Site. These two fires burned approximately 31,161 hectares (77,000 acres) of private and federal lands. About 26,709 hectares (66,000 acres) burned on the Fitzner/Eberhardt Arid Lands Ecology Reserve and approximately 3,116 hectares (7,700 acres) burned on the central Hanford Site (Figure 10.10.1).

The extent and effects of these large wildfires on vegetation and habitats are monitored and mapped using several types of tools. In addition to ground-based surveys, satellite imagery was used to map the burned area extent on the Hanford Site in 2007. Work will continue during 2008 to map changes in habitats and vegetation associations as a result of past wildfires.

Numerous activities associated with cleanup, including excavation, remediation, and restoration, have influenced the vegetation inside the areas and at their 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). Periodic surveys of the frequency, cover, and number of species found on permanent monitoring plots provide information on trends or changes in species diversity, presence of invasive and key species, and the overall condition of the plant community and available habitat (PNNL-16623). Additional 2006 aerial imagery was obtained in 2007 and will be used in 2008 to update and complete a data layer describing shrub canopy cover across the Hanford Site.

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 at 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 persistent sepal yellowcress (*Rorippa columbiae*). Two species, Umtanum buckwheat (*Eriogonum codium*) and White Bluffs bladderpod (*Lesquerella tuplashensis*) are proposed as candidates for federal listing as endangered and threatened, respectively (http://www1.dnr.wa.gov/nhp/refdesk/lists/plantrnk.html). In addition to the rare-plant populations, several areas on the Hanford Site are designated as special habitat types with regard to potential occurrence of plant species of concern listed by Washington State. These are areas that potentially support populations of rare annual forbs that have been documented in adjacent habitats.

During May 2007, surveys for rare annual species were conducted as part of annual compliance review activities for firebreak construction and maintenance. Several populations of the Washington State-sensitive taxa Suksdorf monkeyflower (*Mimulus suksdorfii*) were relocated in the habitat north of Gable Mountain. Repeated surveys for some of the previously known locations of loeflingia (*Loeflingia squarrosa var. squarrosa*) and rosy pussypaws (*Calyptridium roseum*) in the same vicinity did not relocate these annual species. During baseline and project compliance surveys, individuals and/or populations of the following

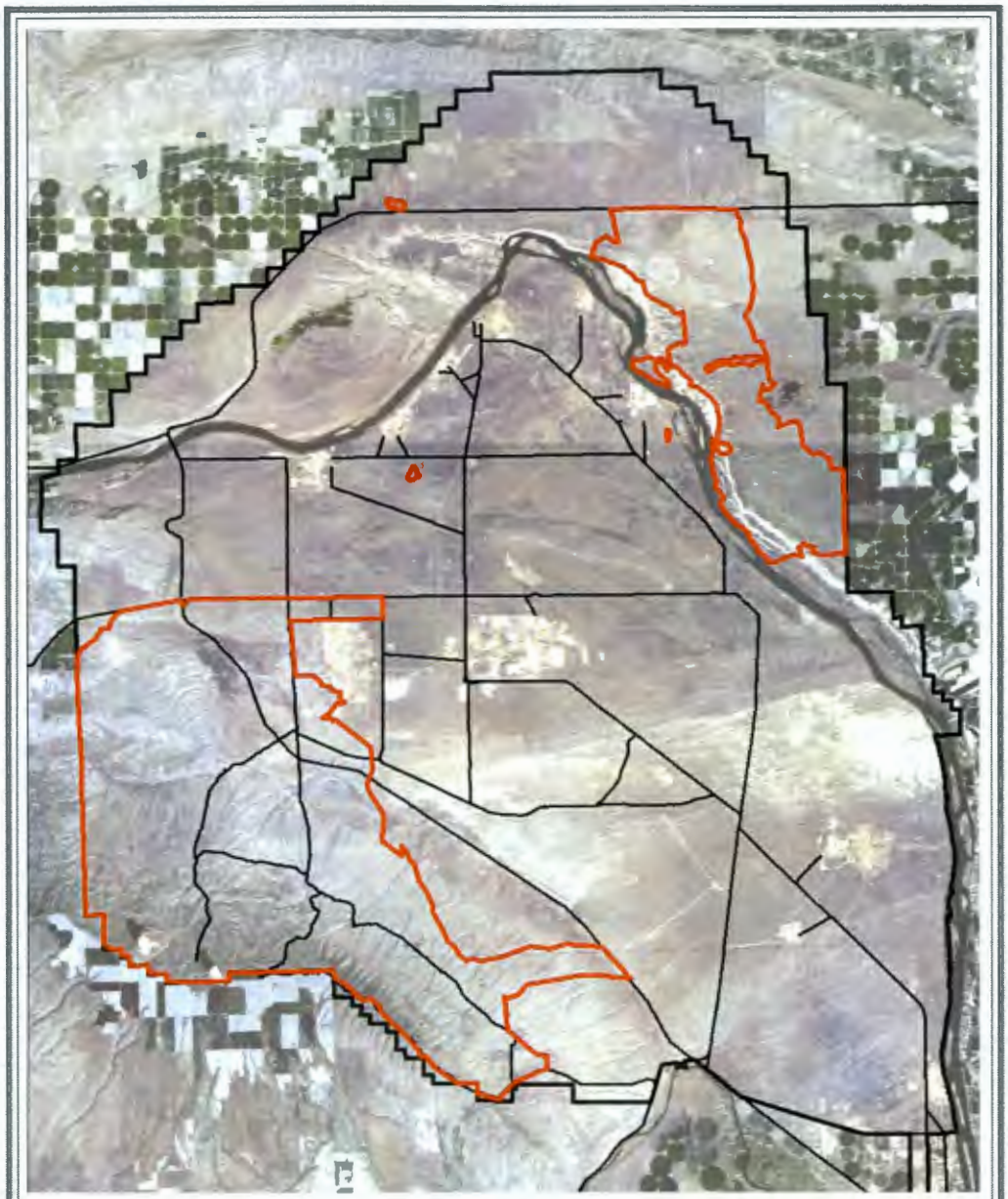


Figure 10.10.1. Boundaries of Wildfires on the Hanford Site in 2007

species were also located: Piper's daisy (*Erigeron piperianus*), Columbia milkvetch, gray cryptantha, and tufted evening primrose (*Oenothera caespitosa*).

Surveys for persistent sepal yellowcress were not conducted during 2007 along the Columbia River shoreline and the islands in the downstream stretch of the Hanford Reach. Data collected during previous years indicate that on the islands at the downstream stretch of the Hanford Reach (such as Island 18 near the 300 Area), the cobble habitats that supported persistent sepal yellowcress in the previous decade now may be inundated with silts. Cobbles are embedded in silt matrix on much of the island shoreline. This change in the substrate may affect persistent sepal yellowcress occurrence or survival on the lower islands. Data that describe 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

J. W. 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.

The number and location of vegetation samples collected near facilities and operations during 2007 are summarized in Table 10.10.1. 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-17603, 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 rabbitbrush) at a sampling location. Often, the sample consisted of a composite of several like members of the sampling-site plant community to avoid decimation of any individual plant through overharvesting. Vegetation samples were dried prior to analyses, 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, 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 the collection and analysis of 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 2007 were higher than concentrations in samples collected farther away and were significantly higher than concentrations measured offsite. Generally, the predominant radionuclides were 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, plutonium-239/240 were detected occasionally in samples taken in 2007. Concentrations of these radionuclides were elevated near and within facility boundaries compared to historic concentrations measured at distant communities. Figure 10.10.2 shows the average concentrations of selected radionuclides in vegetation samples collected near Hanford Site

Table 10.10.1. Number and Locations of Vegetation Samples Collected Near Hanford Site Facilities and Operations in 2007

Number of Samples	Operational Area					
	100-N	200-East	200-West[a]	300[a]	400	600[a]
64	3	8	21	16	1	15

(a) Number of samples includes one or more replicate samples.

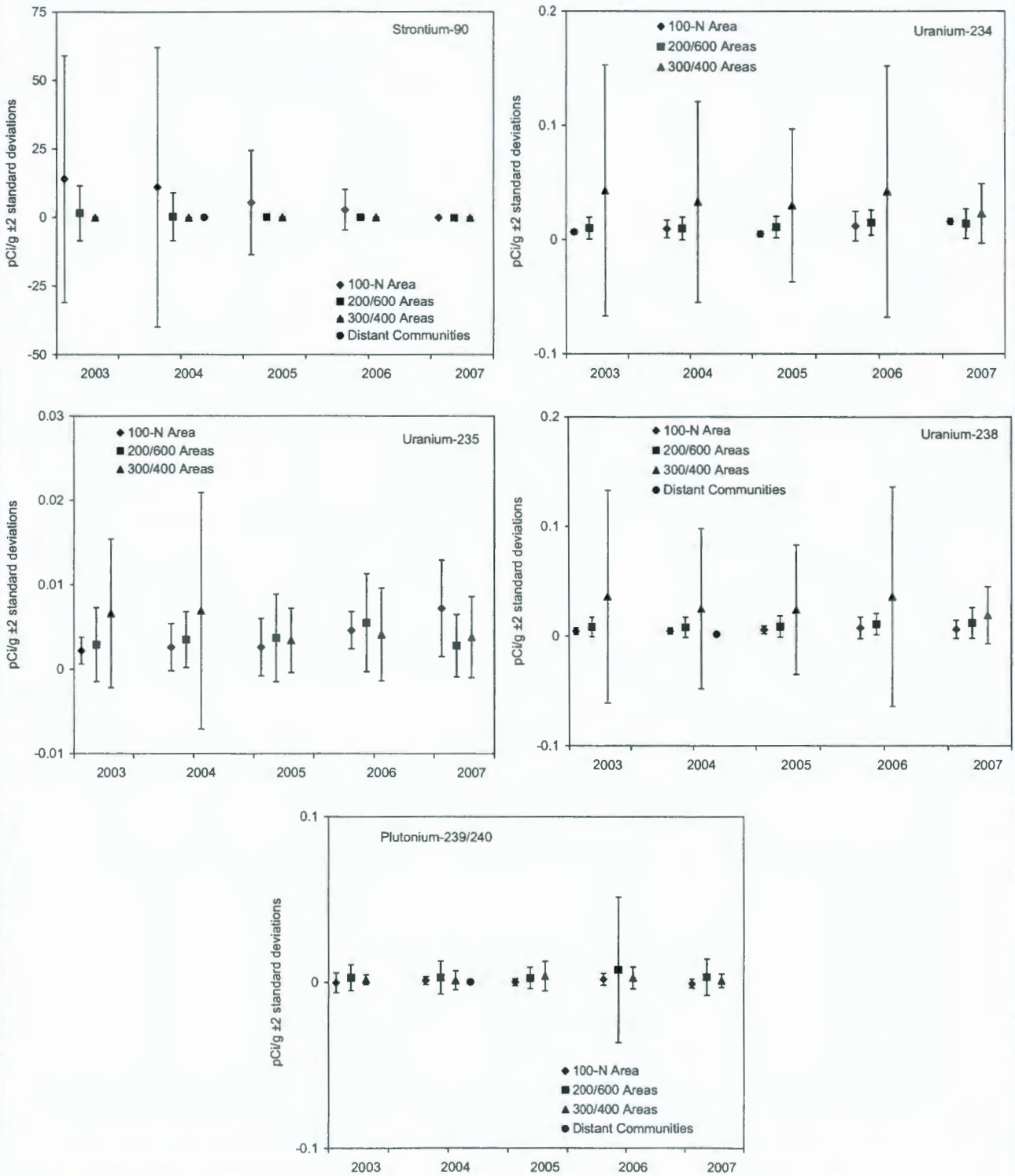


Figure 10.10.2. Average Concentrations of Selected Radionuclides in Vegetation Samples Collected Near Hanford Site Facilities and Operations Compared to Those Collected in Distant Communities, 2003 Through 2007. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

facilities and operations during 2007 and the preceding 4 years, as well as results for 2004 at distant communities. The results demonstrate a high degree of variability in concentrations.

Table 10.10.2 provides a summary of selected radionuclides detected in vegetation samples collected and analyzed in 2007 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 2007 radionuclide concentrations, as well as sampling location maps, are provided in PNNL-17603, APP. 2.

Vegetation samples collected in 2007 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 due to uranium releases to the environment during past fuel-fabrication operations in the 300 Area.

10.10.2.3 Investigations of Radioactive Contamination in Vegetation Near Hanford Site Facilities and Operations

S. M. McKinney and R. C. 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 2007, radiological contamination was found in 62 vegetation samples. All of the samples were tumbleweeds (Russian thistle) or tumbleweed fragments. None of the samples was analyzed for specific radionuclides, and all were disposed at a licensed facility.

The number and general locations of vegetation contamination incidents investigated during 2007 are summarized in Table 10.10.3. The numbers of contamination incidents investigated in 2007 and during the previous 10 years are provided in Table 10.10.4. A discussion of vegetation control efforts at the Hanford Site during 2007 is provided in Section 10.10.4.

10.10.3 Vegetation Monitoring at Hanford Site-Wide and Offsite Locations

B. G. Fritz

Monitoring of rabbitbrush and sagebrush leaves and stems provides information on atmospheric deposition of radioactive materials in uncultivated areas and at site-wide locations that could potentially be affected by contaminants from Hanford Site operations. Vegetation samples have been collected from 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 man-made 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. Collection of vegetation samples at site-wide and offsite locations was last conducted in 2004 (Section 8.10 in PNNL-15222) and is scheduled to be conducted again in 2008.

10.10.4 Vegetation Control Activities

A. R. Johnson, R. C. Roos, J. G. Caudill, J. M. Rodriguez, and G. S. Hauger

Vegetation control at 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 re-growth of plants in contaminated or potentially contaminated areas on the site, and monitoring and removing unwanted (noxious) plant species.

Approximately 2,000 hectares (5,000 acres) were treated with herbicides in 2007 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.

Table 10.10.2. Concentrations of Selected Radionuclides (pCi/g dry wt.)[a] in Near-Facility Vegetation Samples, 2007 Compared to Previous Years

		2007				2002-2006			
Radionuclide	Hanford Area	Number of Samples	Number of Detections[b]	Average[c]	Maximum[d]	Number of Samples	Number of Detections[b]	Average[c]	Maximum[d]
Cobalt-60	100-N	3	0	-0.0050 ± 0.017	0.0043 ± 0.043	22	3	0.021 ± 0.11	0.18 ± 0.046
	200-East	8	0	-0.0073 ± 0.046	0.023 ± 0.050	46	0	-0.0034 ± 0.060	0.039 ± 0.083
	200-West	21	0	-0.017 ± 0.078	0.031 ± 0.062	116	1	0.011 ± 0.14	0.72 ± 3.1
	300	16	0	-0.012 ± 0.057	0.037 ± 0.049	66	0	-0.011 ± 0.15	0.041 ± 0.044
	400	1	0	0.021 ± 0.0000067	0.021 ± 0.036	4	0	-0.00050 ± 0.015	0.0083 ± 0.045
	600	15	0	-0.00019 ± 0.057	0.043 ± 0.058	79	0	-0.0023 ± 0.10	0.095 ± 0.077
Cesium-137	100-N	3	0	-0.040 ± 0.060	0.0021 ± 0.021	22	3	0.043 ± 0.21	0.51 ± 0.13
	200-East	8	1	0.030 ± 0.22	0.30 ± 0.097	46	15	0.051 ± 0.17	0.33 ± 0.096
	200-West	21	3	0.069 ± 0.51	1.2 ± 2.1	116	29	0.14 ± 1.3	6.0 ± 4.3
	300	16	0	-0.010 ± 0.042	0.021 ± 0.043	66	1	-0.022 ± 0.29	0.072 ± 0.085
	400	1	0	-0.054 ± 0.000015	-0.054 ± 0.054	4	0	-0.0091 ± 0.023	0.0082 ± 0.019
	600	15	0	-0.012 ± 0.072	0.043 ± 0.057	79	12	0.053 ± 0.41	1.7 ± 2.2
Plutonium-238	100-N	3	0	0.0079 ± 0.017	0.019 ± 0.018	22	0	0.0012 ± 0.012	0.012 ± 0.024
	200-East	8	0	-0.00081 ± 0.0089	0.0055 ± 0.018	46	1	-0.0011 ± 0.017	0.016 ± 0.010
	200-West	21	1	-0.00098 ± 0.019	0.027 ± 0.018	116	3	0.0011 ± 0.018	0.064 ± 0.029
	300	16	1	0.0023 ± 0.0098	0.012 ± 0.0089	66	3	0.0032 ± 0.018	0.050 ± 0.017
	400	1	0	-0.0056 ± 0.0000026	-0.0056 ± 0.023	4	0	0.0037 ± 0.0025	0.0051 ± 0.015
	600	15	0	-0.0011 ± 0.018	0.014 ± 0.016	79	1	0.0022 ± 0.018	0.026 ± 0.016
Plutonium-239/240	100-N	3	0	-0.00069 ± 0.0027	0.0011 ± 0.0038	22	1	0.00098 ± 0.0040	0.0044 ± 0.0040
	200-East	8	1	0.0018 ± 0.0064	0.0088 ± 0.0070	46	2	0.0011 ± 0.0052	0.0058 ± 0.0056
	200-West	21	3	0.0045 ± 0.014	0.032 ± 0.015	116	36	0.0078 ± 0.031	0.15 ± 0.045
	300	16	0	0.00066 ± 0.0029	0.0032 ± 0.0065	66	5	0.0016 ± 0.0073	0.016 ± 0.010
	400	1	0	0.00700	0.0070 ± 0.0076	4	1	0.0027 ± 0.0083	0.0098 ± 0.0063
	600	15	1	0.0022 ± 0.0050	0.0066 ± 0.0072	79	10	0.0029 ± 0.015	0.052 ± 0.017
Strontium-90	100-N	3	0	-0.0063 ± 0.080	0.025 ± 0.21	22	11	8.1 ± 36.0	68.0 ± 8.2
	200-East	8	1	-0.039 ± 0.34	0.30 ± 0.24	46	18	0.55 ± 3.7	12.0 ± 1.8
	200-West	21	0	-0.14 ± 0.29	0.095 ± 0.22	116	37	0.57 ± 8.6	25.0 ± 3.8
	300	16	0	-0.16 ± 0.28	0.039 ± 0.20	66	7	0.0062 ± 0.36	0.88 ± 0.18
	400	1	0	0.16 ± 0.000045	0.16 ± 0.18	4	0	0.045 ± 0.21	0.17 ± 0.14
	600	15	1	-0.081 ± 0.38	0.31 ± 0.23	79	17	0.21 ± 1.3	4.8 ± 0.72

Table 10.10.2. (contd)

Radionuclide	Hanford Area	2007 Number of Samples	2007 Number of Detections[b]	2007 Average[c]	2007 Maximum[d]	2002-2006 Number of Samples	2002-2006 Number of Detections[b]	2002-2006 Average[c]	2002-2006 Maximum[d]
Uranium-234	100-N	3	3	0.016 ± 0.0025	0.017 ± 0.010	22	11	0.0086 ± 0.0086	0.021 ± 0.011
	200-East	8	8	0.015 ± 0.010	0.022 ± 0.011	46	38	0.012 ± 0.012	0.026 ± 0.012
	200-West	21	18	0.016 ± 0.015	0.035 ± 0.014	116	94	0.013 ± 0.012	0.038 ± 0.014
	300	16	14	0.024 ± 0.026	0.051 ± 0.019	66	63	0.038 ± 0.092	0.24 ± 0.067
	400	1	1	0.0077 ± 0.0000010	0.0077 ± 0.0058	4	2	0.010 ± 0.0076	0.016 ± 0.0083
	600	15	11	0.011 ± 0.0080	0.022 ± 0.011	79	61	0.012 ± 0.013	0.036 ± 0.013
Uranium-235	100-N	3	2	0.0072 ± 0.0057	0.0099 ± 0.0079	22	2	0.0032 ± 0.0030	0.0061 ± 0.0052
	200-East	8	1	0.0029 ± 0.0032	0.0063 ± 0.0054	46	11	0.0038 ± 0.0060	0.016 ± 0.0093
	200-West	21	0	0.0024 ± 0.0035	0.0052 ± 0.0054	116	31	0.0038 ± 0.0044	0.015 ± 0.0078
	300	16	4	0.0038 ± 0.0049	0.0091 ± 0.0068	66	24	0.0051 ± 0.0092	0.030 ± 0.023
	400	1	0	0.00320	0.0032 ± 0.0038	4	0	0.0021 ± 0.0019	0.0036 ± 0.0043
	600	15	3	0.0032 ± 0.0042	0.0065 ± 0.0052	79	19	0.0041 ± 0.0065	0.013 ± 0.0084
Uranium-238	100-N	3	1	0.0062 ± 0.0083	0.012 ± 0.0094	22	12	0.0055 ± 0.0055	0.014 ± 0.0081
	200-East	8	7	0.0089 ± 0.0082	0.016 ± 0.0090	46	34	0.0097 ± 0.0091	0.023 ± 0.011
	200-West	21	18	0.015 ± 0.016	0.039 ± 0.016	116	99	0.011 ± 0.012	0.039 ± 0.014
	300	16	16	0.020 ± 0.026	0.045 ± 0.017	66	58	0.032 ± 0.083	0.21 ± 0.059
	400	1	1	0.0097 ± 0.0000017	0.0097 ± 0.0072	4	4	0.0076 ± 0.0044	0.0098 ± 0.0067
	600	15	13	0.0088 ± 0.0057	0.013 ± 0.0082	79	57	0.0090 ± 0.011	0.025 ± 0.012

(a) 1 pCi = 0.037 Bq.
(b) Number of samples with measurable concentrations of contaminants.
(c) Average ± two standard deviations.
(d) Maximum ± analytical uncertainty.

Table 10.10.3. Number of Vegetation Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 2007

Location	Number of Incidents
200-East Area	
tank farms	13
burial grounds	10
cribs, ponds, and ditches	2
fence lines	0
roads and railroads	0
unplanned release sites	3
underground pipelines	1
miscellaneous	4
200-West Area	
tank farms	5
burial grounds	7
cribs, ponds, and ditches	8
fence lines	0
roads and railroads	0
unplanned release sites	4
underground pipelines	0
miscellaneous	4
Cross-site transfer line	0
200-BC cribs and trenches	0
200-North Area	1
100 Areas	0
300 Area	0
400 Area	0
600 Area	0
Former 1100 Area	0
Total	**62**

Table 10.10.4. Annual Number of Vegetation Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 1997 Through 2007

Year	Number of Incidents	Year	Number of Incidents
1997	46	2003	32
1998	51	2004	60
1999	85	2005	66
2000	66	2006	75
2001	31	2007	62
2002	16		

10.10.4.1 Waste Site Remediation and Revegetation During 2007

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.[a] 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 two sites in 2007 that totaled approximately 40 square meters (approximately 430 square feet). Tests at the Hanford Site confirm this barrier is effective in preventing the spread of contamination. The total number of areas at the Hanford Site covered with Biobarrier since 1999 is up to 38, with 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 3,000 hectares (7,500 acres) were overseeded with bunchgrass seed in 2007, including the 200-BC Cribs Area; 216-U-10 Stabilized Pond; and 216-B-3 Pond. The great increase in acreage revegetated in 2007 compared to 2006 was because of the large acreage burned in the 2007 Wautoma Fire. The majority of that revegetation was to control dust erosion.

10.10.4.2 Noxious Weed Control

Noxious weeds are controlled on the Hanford Site (between State Highway 240 and the Columbia River and along the paved road to the top of Rattlesnake Mountain) 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 3,000 hectares (7,400 acres) on the Hanford Site were treated in 2007.

Ten plant species are on a high-priority list for control at the Hanford Site. These species are described in the following paragraphs, along with a summary of 2007 control activities.

(a) Biobarrier is a registered trademark of Fiberweb plc, Old Hickory, Tennessee.

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 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 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. In 2007, approximately 500 hectares (1,200 acres) were treated for yellow starthistle infestation south of the Hanford town site, both on the east and west side of Route 2 South.

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 that 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. They 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 on some areas burned in the 24 Command Wildland Fire in June 2000 and can be expected to increase in the areas burned by the Wautoma Fire in 2007.

In 2007, control of rush skeletonweed focused on individual areas scattered from the Volpentest Hazardous Materials Management and Emergency Response (HAMMER) Training and Education Center, north to the 400 Area, and between State Highway 240 near Vernita Bridge and the 100-B/C Reactors. Approximately 1,900 hectares (4,700 acres) were treated to remove an infestation that was becoming dense in many areas.

The deep and extensive root system of rush skeletonweed makes it extremely difficult to eliminate. The area north of the 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 2007. The Hanford Site will continue to be monitored for several years to ensure the seed bank has been eradicated.

Babysbreath (*Gypsophila paniculata*). There were no efforts to control babysbreath in 2007 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*). No dalmatian toadflax plants were found on the Hanford Site in 2007. Sprouts and seedlings of the long-lived perennial plant will be eliminated as they are identified. No biological controls have been released at the Hanford Site for dalmatian toadflax.

Spotted Knapweed (*Centaurea maculosa*). Spotted knapweed at the Hanford Site has been controlled so that sprouts or seedlings are rare. No sprouts or seedlings were found in 2007. The site will continue to be monitored for several years to be sure that 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 2007, approximately 600 hectares (1,500 acres) 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 actively been controlled by herbicides due to 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. Herbicide applications using backpack sprayers are planned for the 2008 season if changing herbicide regulations allow such applications.

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.

10.11 Endangered and Threatened Species at the Hanford Site

M. R. Sackschewsky

This section discusses 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 2008) and the Washington Department of Fish and Wildlife (WDFW 2008).

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 that 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 steelhead and spring-run Chinook salmon 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) has been recorded on the Hanford Site but is believed to be transient. The bald eagle was removed from the list of threatened species in July 2007. 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, 12 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 maintains additional lower-level lists of species, including a monitor list for animals (WDFW 2008) and a Review and Watch lists for plants (WNHP 2008). 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

Table 10.11.1. Federal and Washington State Listed Endangered, Threatened, Sensitive, and Candidate Species Occurring or Potentially Occurring on the Hanford Site

Common Name	Scientific Name	Federal Status[a]	State Status[a]
Plants			
awned halfchaff sedge	*Lipocarpha (= Hemicarpha) aristulata*		Threatened
beaked spike-rush	*Eleocharis rostellata*		Sensitive
Canadian St. John's wort	*Hypericum majus*		Sensitive
Columbia milkvetch	*Astragalus columbianus*	Species of concern	Sensitive
coyote tobacco	*Nicotiana attenuata*		Sensitive
desert dodder	*Cuscuta denticulata*		Threatened
desert evening-primrose	*Oenothera caespitosa*		Sensitive
dwarf evening primrose	*Camissonia (= Oenothera) pygmaea*		Sensitive
fuzzytongue penstemon	*Penstemon eriantherus whitedii*		Sensitive
Geyer's milkvetch	*Astragalus geyeri*		Threatened
grand redstem	*Ammannia robusta*		Threatened
gray cryptantha	*Cryptantha leucophaea*	Species of concern	Sensitive
Great Basin gilia	*Gilia leptomeria*		Threatened
Hoover's desert parsley	*Lomatium tuberosum*	Species of concern	Sensitive
loeflingia	*Loeflingia squarrosa var. squarrosa*		Threatened
lowland toothcup	*Rotala ramosior*		Threatened
candle	*Cryptantha scoparia*		Sensitive
persistent sepal yellowcress	*Rorippa columbiae*	Species of concern	Endangered
Piper's daisy	*Erigeron piperianus*		Sensitive
rosy pussypaws	*Calyptridium roseum*		Threatened
small-flowered evening-primrose	*Camissonia (= Oenothera) minor*		Sensitive
Snake River cryptantha	*Cryptantha spiculifera (= C. interrupta)*		Sensitive
Suksdorf's monkey flower	*Mimulus suksdorfii*		Sensitive
Umtanum desert buckwheat	*Eriogonum codium*	Candidate	Endangered
White Bluffs bladderpod	*Physaria (= Lesquerella) tuplashensis*	Candidate	Threatened
white eatonella	*Eatonella nivea*		Threatened
Mollusks			
California floater	*Anodonta californiensis*	Species of concern	Candidate
great Columbia River spire snail	*Fluminicola columbiana*	Species of concern	Candidate
shortfaced lanx	*Fisherola nuttalli*		Candidate
Insects			
Columbia River tiger beetle[b]	*Cicindela columbica*		Candidate
silver-bordered fritillary	*Boloria selene atrocostalis*		Candidate
Fish			
bull trout[c]	*Salvelinus confluentus*	Threatened	Candidate
leopard dace[c]	*Rhinichthys flacatus*		Candidate
mountain sucker[c]	*Catastomus platyrhynchus*		Candidate
Pacific lamprey	*Lampetra tridentata*	Species of concern	
river lamprey[c]	*Lampetra ayresi*	Species of concern	Candidate
spring-run Chinook salmon	*Oncorhynchus tshawytscha*	Endangered	Candidate
steelhead	*Oncorhynchus mykiss*	Threatened	Candidate
Amphibians and Reptiles			
sagebrush lizard	*Sceloporus graciosus*	Species of concern	Candidate
striped whipsnake	*Masticophis taeniatus*		Candidate
western toad	*Bufo boreas*		Candidate

Table 10.11.1. (contd)

Common Name	Scientific Name	Federal Status[a]	State Status[a]
Birds			
American white pelican	*Pelecanus erythrorhynchos*		Endangered
bald eagle	*Haliaeetus leucocephalus*	Species of concern	Sensitive[d]
burrowing owl	*Athene cunicularia*	Species of concern	Candidate
common loon	*Gavia immer*		Sensitive
ferruginous hawk	*Buteo regalis*	Species of concern	Threatened
flamulated owl[c]	*Otus flammeolus*		Candidate
golden eagle	*Aquila chrysaetos*		Candidate
greater sage grouse	*Centrocercus urophasianus*	Candidate	Threatened
Lewis's woodpecker[c]	*Melanerpes lewisi*		Candidate
loggerhead shrike	*Lanius ludovicianus*	Species of concern	Candidate
merlin	*Falco columbarius*		Candidate
northern goshawk[c]	*Accipter gentilis*	Species of concern	Candidate
olive-sided flycatcher	*Contopus cooperi*	Species of concern	
peregrine falcon	*Falco peregrinus*	Species of concern	Sensitive
sage sparrow	*Amphispiza belli*		Candidate
sage thrasher	*Oreoscoptes montanus*		Candidate
sandhill crane	*Grus canadensis*		Endangered
western grebe	*Aechmorus occidentalis*		Candidate
Mammals			
black-tailed jackrabbit	*Lepus californicus*		Candidate
Merriam's shrew	*Sorex merriami*		Candidate
Townsend's ground squirrel	*Spermophilus townsendii*	Species of concern	Candidate
Washington ground squirrel[c]	*Spermophilus washingtoni*	Candidate	Candidate
white-tailed jackrabbit	*Lepus townsendii*		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.

high native diversity. Approximately 50 Washington State Monitor 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

Common Name	Scientific Name
Mollusks	
Oregon floater	*Anodonta oregonensis*
western floater	*Anodonta kennerlyi*
western pearlshell	*Margaritifera falcata*
Insects	
Bonneville skipper	*Ochlodes sylvanoides bonnevilla*
canyon green hairstreak	*Callophrys sheridanii neoperplexa*
coral hairstreak	*Harkenclenus titus immaculosus*
juba skipper	*Hesperia juba*
Nevada skipper	*Hesperia nevada*
northern checkerspot	*Chlosyne palla palla*
Pasco pearl	*Phyciodes tharos pascoensis*
Persius' duskywing	*Erynnis persius*
purplish copper	*Lycaena helloides*
ruddy copper	*Lycaena rubida perkinsorum*
silver-spotted skipper	*Epargyreus clarus californicus*
viceroy	*Limenitis archippus lahontani*
Fish	
piute sculpin	*Cottus beldingi*
reticulate sculpin	*Cottus perplexus*
sand roller	*Percopsis transmontana*
Amphibians and Reptiles	
night snake	*Hypsiglena torquata*
short-horned lizard	*Phrynosoma douglassii*
tiger salamander	*Ambystoma tigrinum*
Woodhouse's toad	*Bufo woodhousii*
Birds	
Arctic tern[a]	*Sterna paradisaea*
ash-throated flycatcher[a]	*Myiarchus cinerascens*
black tern	*Chlidonias niger*
black-crowned night-heron	*Nycticorax nycticorax*
black-necked stilt	*Himantopus mexicanus*
bobolink[a]	*Dolichonyx oryzivorus*
Caspian tern	*Sterna caspia*
Clark's grebe	*Aechmophorus clarkii*
Forster's tern	*Sterna forsteri*
grasshopper sparrow	*Ammodramus savannarum*
gray flycatcher	*Empidonax wrightii*
great blue heron	*Ardea herodias*
great egret	*Ardea alba*
gyrfalcon[a]	*Falco rusticolus*
horned grebe	*Podiceps auritus*
lesser goldfinch	*Carduelis psaltria*
long-billed curlew	*Numenius americanus*
osprey	*Pandion haliaetus*
prairie falcon	*Falco mexicanus*
red-necked grebe[a]	*Podiceps grisegena*
snowy owl	*Nyctea scandiaca*
Swainson's hawk	*Buteo swainsoni*
turkey vulture[a]	*Cathartes aura*
western bluebird	*Sialia mexicana*
Mammals	
long-legged myotis	*Myotis volans*
northern grasshopper mouse	*Onychomys leucogaster*
pallid bat	*Antrozous pallidus*
sagebrush vole	*Lagurus curtatus*
small-footed myotis	*Myotis leibii*
western pipistrelle	*Pipistrellus hesperus*

(a) Reported, but seldom observed on the Hanford Site.

Table 10.11.3. Washington State Review and Watch List Plant Species Potentially Found on the Hanford Site

Common Name	Scientific Name	State Listing[a]
annual paintbrush	*Castilleja exilis*	Watch List
annual sandwort	*Minuartia pusilla var. pusilla*	Review Group 1
basalt milk-vetch	*Astragalus conjunctus var. rickardii*	Watch List
bristly combseed	*Pectocarya setosa*	Watch List
chaffweed	*Centunculus minimus*	Review Group 1
Columbia River mugwort	*Artemisia lindleyana*	Watch List
crouching milkvetch	*Astragalus succumbens*	Watch List
false pimpernel	*Lindernia dubia anagallidea*	Watch List
giant helleborine	*Epipactis gigantea*	Watch List
hedgehog cactus	*Pediocactus simpsonii var. robustior =(P. nigrispinus)*	Review Group 1
Kittitas larkspur	*Delphinium multiplex*	Watch List
medic milkvetch	*Astragalus speirocarpus*	Watch List
pigmy-weed	*Crassula aquatica*	Watch List
porcupine sedge	*Carex hystericina*	Watch List
Robinson's onion	*Allium robinsonii*	Watch List
rosy balsamroot	*Balsamorhiza rosea*	Watch List
scilla onion	*Allium scilloides*	Watch List
shining flatsedge	*Cyperus bipartitus (rivularis)*	Watch List
small-flowered nama	*Nama densum var. parviflorum*	Watch List
smooth cliffbrake	*Pellaea glabella simplex*	Watch List
southern mudwort	*Limosella acaulis*	Watch List
stalked-pod milkvetch	*Astragalus sclerocarpus*	Watch List
vanilla grass	*Hierchloe odorata*	Review Group 1
winged combseed	*Pectocarya penicillata*	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 2007. 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.

Wildlife populations at the Hanford Site 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 may be used to help characterize potential risks or impact to biota. Results may also be used to support objectives for completing the 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 (Section 10.12.3) spread across the Hanford Site. 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).

For further information about these monitoring and pest control activities and the programs that support them, see Section 10.0 of this report or DOE/RL-91-50, Rev. 4.

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

R. P. 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 the 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 starting to rise 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 2007 was estimated at 4,018 (Figure 10.12.1). This count was lower than the 2006 count of 6,190 and well below the previous 5-year average of 8,011. The counts during the past 4 years have shown a general downward trend. However, these fluctuations are not unusual, as a similar trend was noted from 1987 to 1993 when counts decreased from 8,834 to 2,873. The main spawning areas observed from the 2007 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.

Figure 10.12.1. Number of Fall Chinook Salmon Redds in the Hanford Reach of the Columbia River

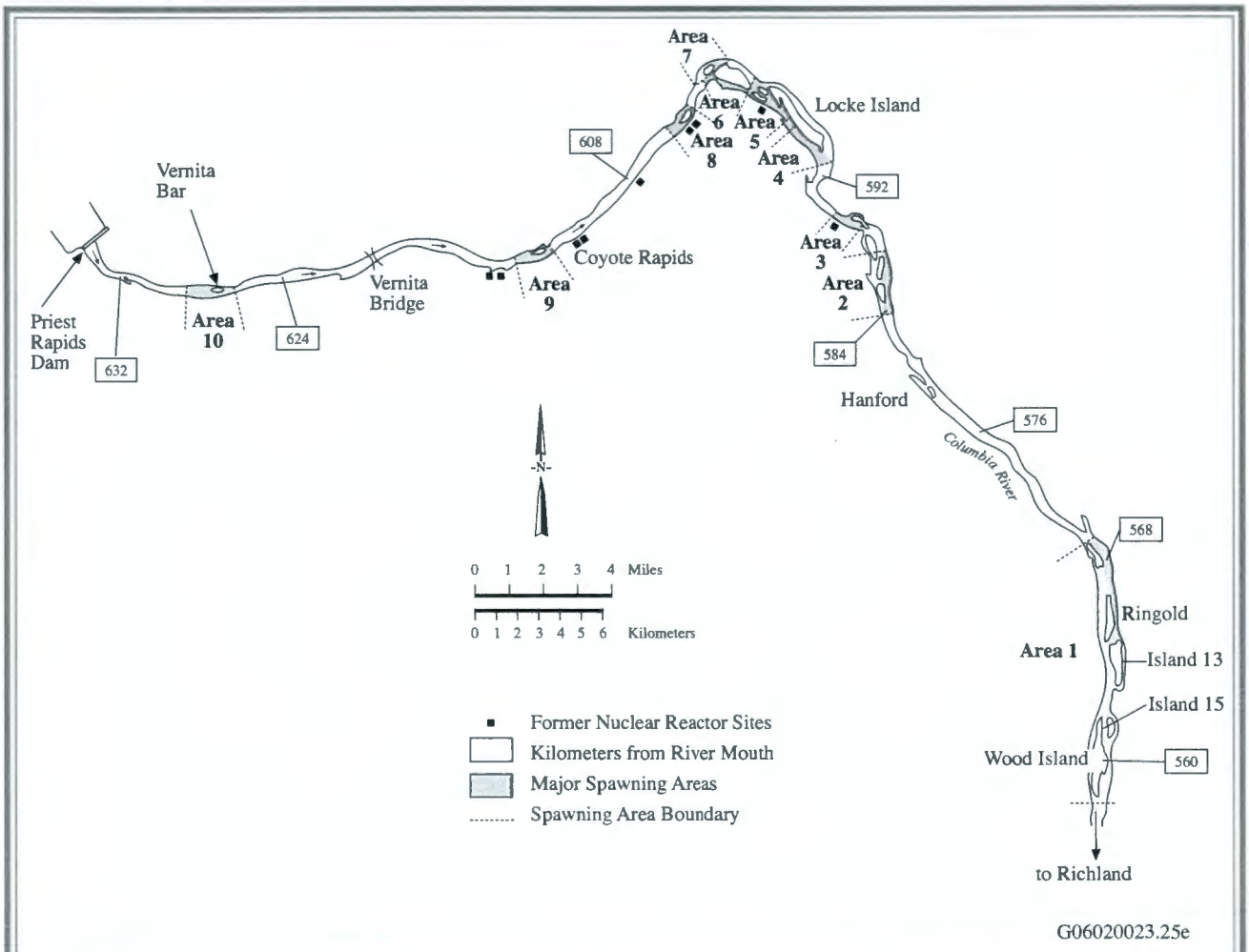


Figure 10.12.2. Major Fall Chinook Salmon Spawning Areas in the Hanford Reach of the Columbia River

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 (that 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, see the website at http://www.streamnet.org/).

10.12.1.2 Steelhead

R. P. 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 2007, two aerial observation flights were flown on the Hanford Reach from north Richland (river kilometer [RK] 547) to near Vernita Bridge (RK 624) to document the occurrence of any steelhead spawning along the shoreline regions. Flight environmental conditions were favorable, characterized by relatively low river flow (~3,500 cubic meters [125,000 cubic feet] per second), clear water, light wind, and clear skies. No evidence of any steelhead spawning was observed during either flight.

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 Protection

R. E. Durham, C. A. Duberstein, and M. R. Sackschewsky

On July 9, 2007, the U.S. Fish and Wildlife Service removed the bald eagle from the threatened and endangered species list. Following the federal delisting, the Washington Department of Fish and Wildlife reclassified the bald eagle from threatened to sensitive in January 2008. Bald eagles on the Hanford Site are still federally protected under the *Bald and Golden Eagle Protection Act*, and the *Migratory Bird Treaty Act*. 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 on the Hanford Site follow these guidelines. Buffer zones were resized around four traditional communal roosts and the active nest area near the White Bluffs boat launch. In addition, two new 400-meter (437-yard) buffer zones were established in the Hanford town site around active communal roosts identified during the previous two winters (Figure 10.12.3).

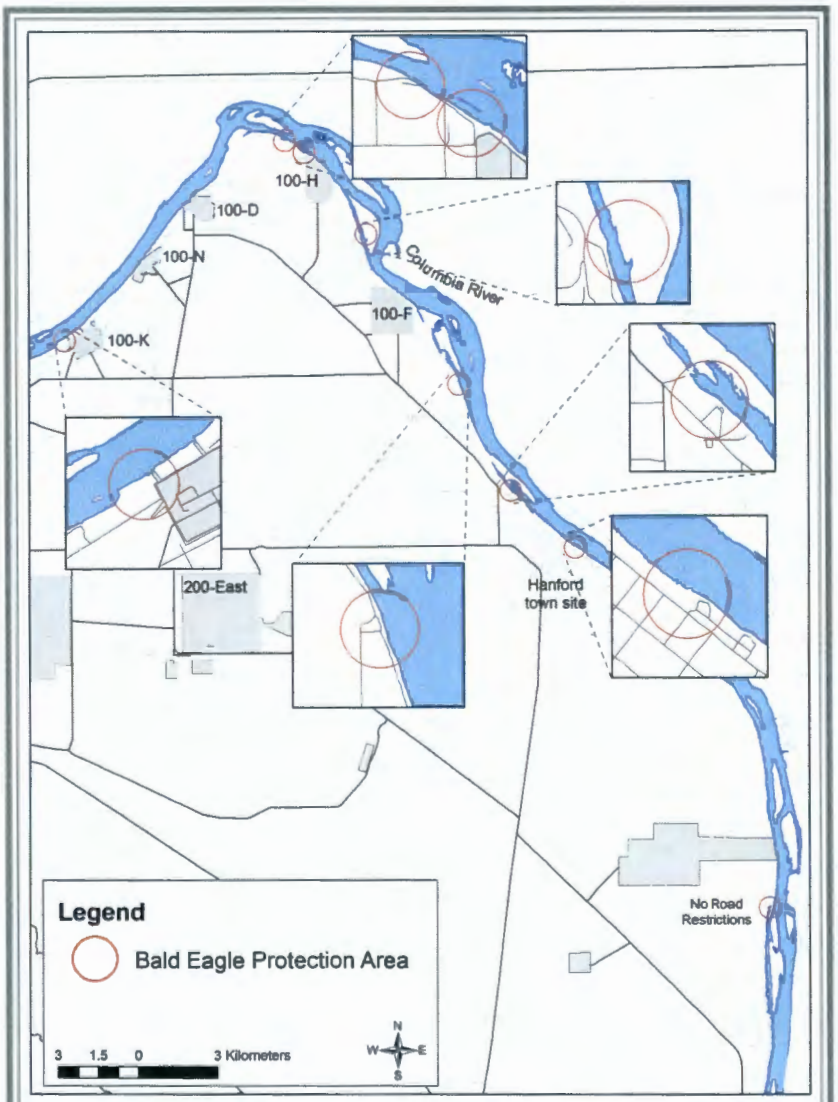


Figure 10.12.3. Location of Bald Eagle Protection Areas on the Hanford Site

A pair of adult bald eagles returned during 2007 to occupy the historical nest site in the vicinity of the former White Bluffs town site. As of March 15, 2008, bald eagles were still being observed at the town site. However, researchers determined the historical nest site was no longer occupied by the bald eagle pair. Primary causes of eagle nest abandonment 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 magpies and ravens). The causes of eagle nest abandonment along the Hanford Reach have not been determined.

10.12.1.4 Mule Deer

K. D. 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 late November 2007 and late December 2007. A combined total of 376 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. After an increase in 2006, the 2007 fawn-to-doe ratios decreased to rates similar to those observed in 2004 and 2005. In 2007, the northern region fawn-to-doe mean estimate was 25 fawns per 100 does, while the southern region mean estimate was 19 fawns per 100 does (Figure 10.12.4). For the northern region in 2004 and 2005, the mean estimates were 20 and 27 fawns per 100 does, respectively. For the southern region in 2004 and 2005, the mean estimates were 24 and 22 fawns per 100 does, respectively. Fawn-to-doe estimates were not statistically different between regions ($P > 0.05$). Hanford fawn-to-doe ratios for all survey years (1994 through 2006) 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; PNNL-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 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 1998 to a low of 0% in 2003 (Figure 10.12.5). 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, survey data again show a decrease in observations of affected bucks. In 2007, no affected male deer were observed in the northern region, and a single affected male deer was observed in the southern region (2.4% of male deer observations). However, because small sample sizes may not fully reflect population conditions, these frequency estimates need to be interpreted with caution.

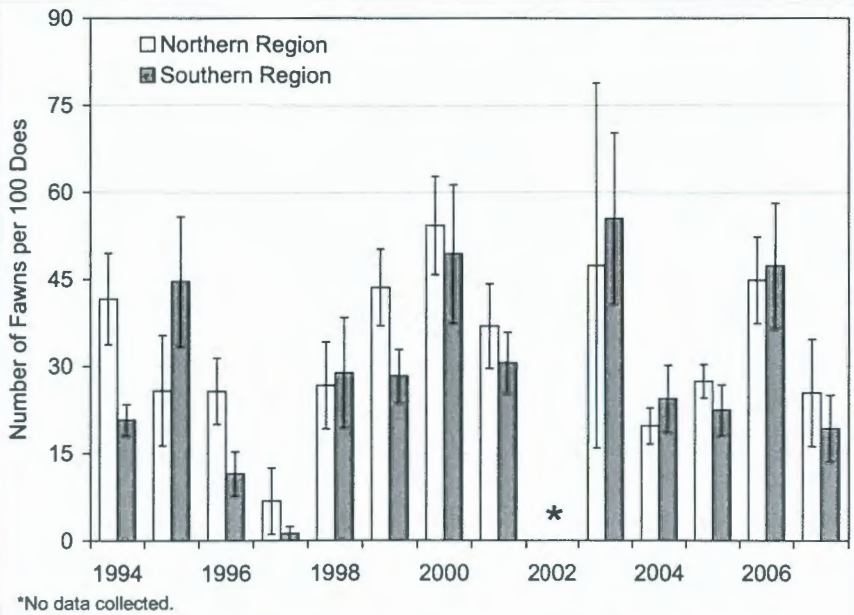


Figure 10.12.4. Estimates of the Number of Fawns per 100 Mule Deer Does in the Post-Hunting Period (Winter) on the Hanford Site from 1994 Through 2007 (mean ±1 standard error)

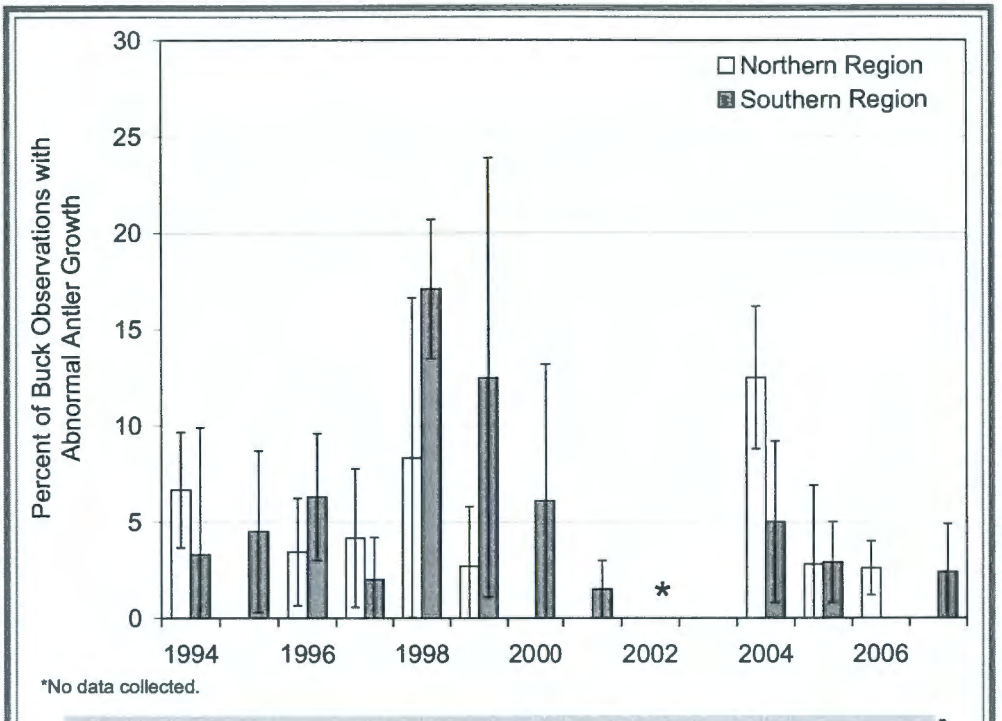


Figure 10.12.5. Percent of Male Mule Deer on the Hanford Site from 1994 Through 2007 Showing Signs of Abnormal Antler Growth (mean ±1 standard error)

10.12.2 Habitat and Species Characterizations

As part of work done to characterize Hanford Site biological resources, efforts in 2007 focused on assessing key wildlife: amphibians using the Columbia River corridor and the burrowing owl—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 2007 focused on an inventory of amphibian breeding habitats to better understand habitat use on the Hanford Site. Burrowing owls were once common in shrub-steppe areas and typically occupy eastern Washington shrub-steppe habitats during the breeding season (Larsen et al. 2004). However, burrowing owls are believed to be declining throughout their historic range. Surveys were conducted during 2007 to identify the current distribution of burrowing owls and their nesting habitats on the Hanford Site. The information will be used to characterize important habitat for this species, providing location data that can be used to minimize impacts of Hanford Site operations on this priority species.

10.12.2.1 Amphibians

J. M. Becker and B. F. 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 2007, Pacific Northwest National Laboratory staff monitored the post-breeding movements of Woodhouse's toads along the Benton County side of the Columbia River on the Hanford Site using radio telemetry.

Thirty-one adult male Woodhouse's toads were captured near the 100-F Area slough and Hanford Site slough in June and July 2007 and were equipped with external radio transmitters. Toads were tracked one to two times per week from July 13 through August 20, 2007, during daytime and nighttime hours (Figure 10.12.6). Toads completed the breeding season using ephemeral pools and sloughs. Subsequent to breeding, toads used wetted areas around pool margins and dry upland areas.

Twenty-one toads retained transmitters for 2 weeks or more, with only six retaining transmitters throughout the winter until spring. Most of those that shed transmitters did so by traversing substantial accumulations of tumbleweeds located around the margins of breeding pools. The mean distance traveled by individual toads was 479 meters (524 yards). The greatest movement documented during a day was more than 400 meters (437 yards), and the longest distance traveled by an individual toad during the study was 1.5 kilometers (0.9 mile).

Radio transmitters did not appear to affect the burrowing ability of the toads. Toads either excavated their own burrows for aestivation (dormancy during the hottest part of the summer) or used abandoned small mammal burrows. The six toads that retained transmitters were found to enter their aestivation burrow in mid-August 2007. These individuals were confirmed present at the same location throughout the winter until mid-March 2008. During 2008, additional telemetry information will be gathered to document the dispersal of toads from burrows and travel to breeding grounds.

10.12.2.2 Burrowing Owls

K. B. Larson

Populations of burrowing owls (*Athene cunicularia*) are thought 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).

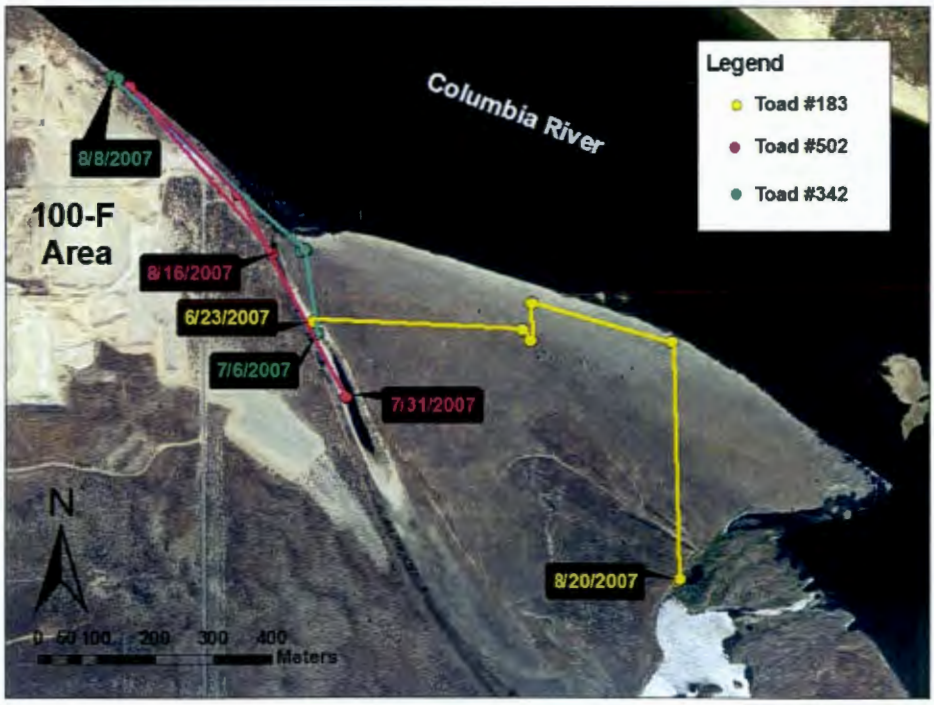


Figure 10.12.6. Locations of Three Radio-Tagged Woodhouse's Toads in the 100-F Slough Area of the Hanford Site (Dates are when the transmitter was affixed and the last relocation prior to aestivation.)

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). In Washington State, burrowing owls are being considered for listing as 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 on the site designed specifically to locate burrowing owls 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). Additional surveys were conducted by U.S. Fish and Wildlife Service in 2004 and 2005 on the Saddle Mountain and Wahluke Units of the Hanford Reach National Monument.[a]

In 2007, Pacific Northwest National Laboratory conducted driving surveys on the Hanford Site to estimate burrowing owl nest density. This survey technique is designed to collect data that can be used to assess burrowing owl population change over time. "Nests" were defined as burrows in which one or more burrowing owls were observed on two or more occasions. A total of 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). Only seven nests were detected during the driving surveys, resulting in an estimated density of 0.22 burrowing owl nest per square kilometer (0.4 square mile).

In addition to the seven nests detected during the driving surveys, nine other active burrowing owl nests on the Hanford Site were monitored in 2007 that had either been previously occupied in 2006 or were located incidentally in 2007 (Figure 10.12.7). Additional surveys and continued observations of previously identified burrowing owl nest locations will be used in 2008 to monitor the population and habitat use.

10.12.3 Ecological Monitoring on Long-Term Plots

J. L. 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 2007 because of a funding reduction.

10.12.4 Monitoring of Fish and Wildlife for Hanford Site-Produced Contaminants

J. A. Stegen and R. E. Durham

In 2007, several types of wildlife and fish were collected at locations on and around the Hanford Site as part of routine monitoring for site-produced contaminants (Figure 10.12.8). 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). Samples were also collected at locations distant from the site to obtain reference (background) contaminant measurements.

(a) Newsome, H. 2008. Telephone call to Heidi Newsome (Biologist, U.S. Fish and Wildlife Service) from Kyle Larson (Pacific Northwest National Laboratory), March 18, 2008.

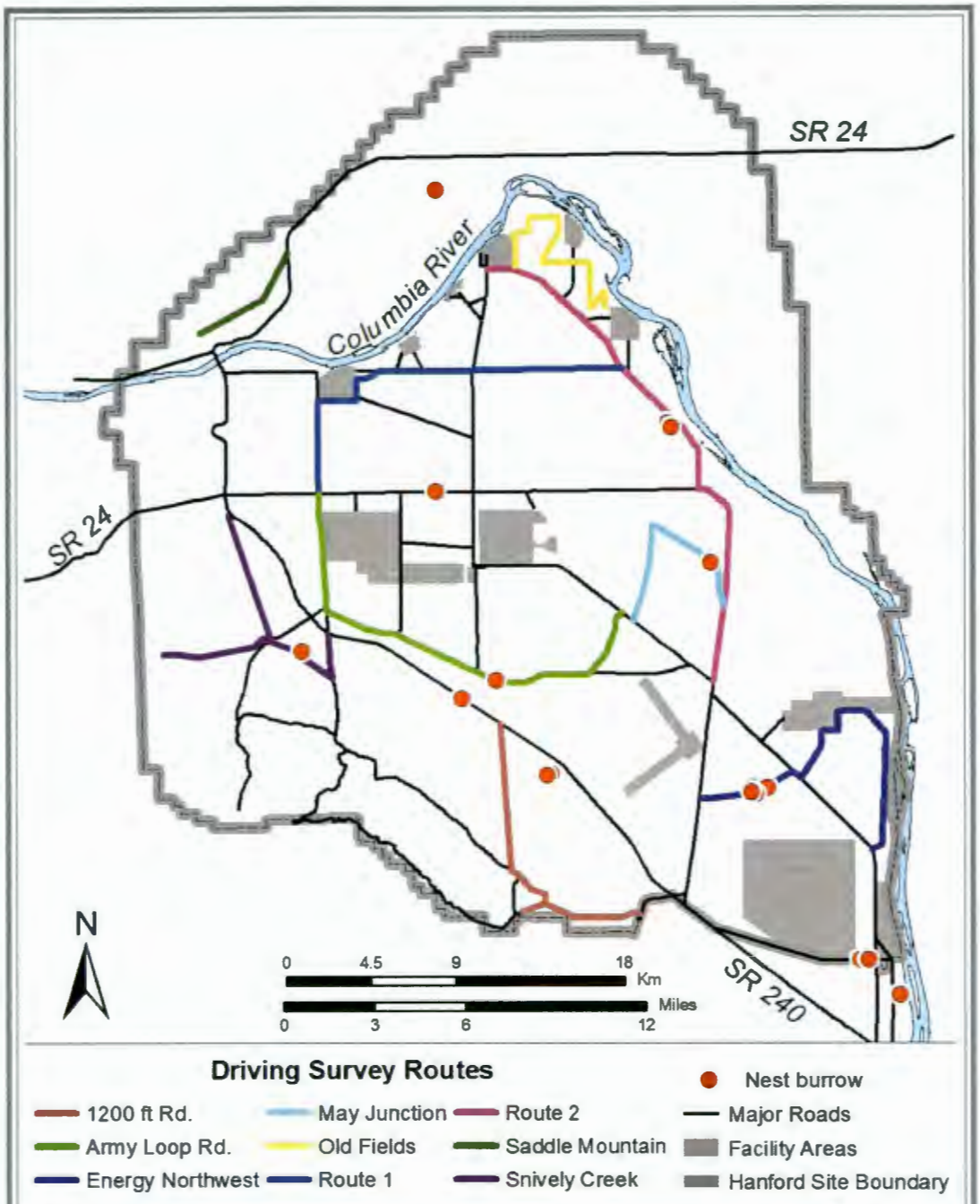


Figure 10.12.7. Burrowing Owl Driving Survey Routes and Active Nest Locations on the Hanford Site, 2007

Most fish and wildlife samples collected on or near the Hanford Site for routine human-exposure pathway assessments are obtained annually, but specific species are sampled only every 2 or 3 years. Samples obtained at locations believed to be unaffected by Hanford Site effluents and emissions are collected approximately every 5 years.

Monitoring various biota for uptake and exposure to radionuclides both near and distant from Hanford Site operations continues to ensure that consumption of fish and wildlife obtained from the Hanford Site environs does not pose a threat to humans. Monitoring also provides long-term contamination trends in selected components of the

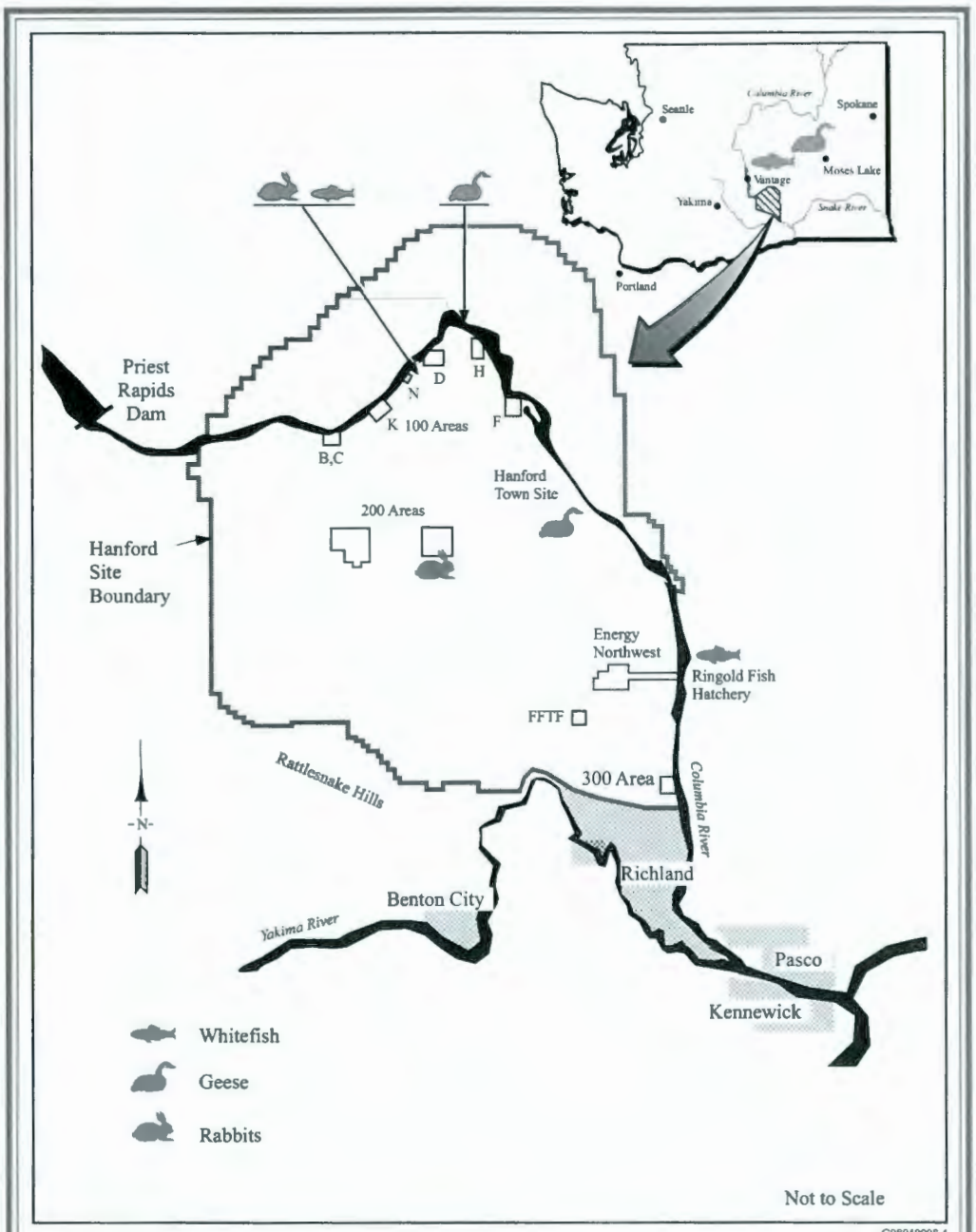


Figure 10.12.8. Fish and Wildlife Sampling Locations On and Around the Hanford Site, 2007

ecosystem. Wildlife and fish sampled and analyzed during 2007 for radioactive constituents included Canada geese (*Branta canadensis*), cottontail rabbits (*Sylvilagus nuttallii*), and whitefish (*Prosopium williamsonii*). The species that are monitored provide a potential pathway for offsite human consumption.

In 2007, all fish and wildlife samples collected were monitored for strontium-90 contamination and were analyzed by gamma spectrometry to detect a number of gamma emitters, including cesium-137 (Appendix F). Since the 1990s, strontium-90 and cesium-137 have been the most frequently measured radionuclides in fish and wildlife

Table 10.12.1. Number of Sampling Locations and Number and Kind of Analyses Performed on Fish and Wildlife Samples Collected On and Around the Hanford Site, 2007

Biota	No. of Offsite Locations	No. of Onsite Locations	No. of Analyses			
			Gamma	Strontium-90	Trace Metals	Plutonium-238, Plutonium-239/240
Whitefish	2[a,b]	1	11	11	11	0
Canada geese	1[c]	2	15	15	15	0
Rabbits	0	2	2	2	2	1

(a) Samples collected near the Wanapum Dam, Washington.
(b) Samples collected near the Ringold Fish Hatchery, Washington.
(c) Samples collected near Moses Lake, Washington.

samples. In addition, plutonium-238 and plutonium-239/240 were measured in the rabbit liver collected in the 200-East Area.

Strontium-90 is chemically similar to calcium; consequently, it accumulates in hard tissues rich in calcium such as bones, antlers, and eggshells. 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 lifetime exposure to strontium-90. However, strontium-90 generally does not contribute much to human dose because it does not accumulate in edible portions of fish and wildlife (National Council on Radiation Protection and Measurements 1991). Strontium-90 is present in the Hanford Site environs as a result of past operating 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 result of past Hanford Site operating and waste-disposal practices as well as from historical worldwide fallout resulting from nuclear weapons testing.

Gamma spectrometry results for most radionuclides were too low to measure, or measured concentrations were considered artifacts of low background counts. Low background counts occur at random intervals during sample counting and can produce occasional spurious false-positive results. For many radionuclides, concentrations were below levels that could be detected by the analytical laboratory. Results, propagated analytical uncertainties, and minimum detection amounts for all 2007 wildlife samples may be found in PNNL-17603, APP. 1.

A number of 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., chromium, copper, lead, and mercury), particularly along Hanford's Columbia River shoreline where contaminated groundwater flows into the river (PNNL-14295). Historical operations at the Hanford Site resulted in the production of both radiological and non-radiological wastes, including metals, in various forms. Liquid and solid wastes were placed in various disposal sites at the site, including trenches, cribs, ditches, ponds, and underground storage tanks (PNNL-13487). Fly ash (ash produced from burning coal) from coal-fired steam/power plants, associated with some reactors, was released to the atmosphere. Fly ash contains trace metals and natural radionuclides that may have deposited on the soil around the reactor areas. In addition to trace metals associated with past Hanford Site operations, other sources of contamination have impacted the site. Trace metals generated from upriver mining and smelting activities have been transported down the Columbia River and into the Hanford

Reach (Johnson et al. 2005). Also, contaminants associated with past and present agricultural practices have contributed to the metals inventory at 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 the contributions of both natural sources and industrial contaminants, and organisms may range widely over areas influenced to varying degrees by both. Thus, concentrations of metals and organism exposures can vary between locations. This variability can produce some uncertainty in the source of the metals within the sampled organism. To determine the Hanford Site contribution to levels of metals in biota collected onsite or in the Hanford Reach, samples were also collected from the Columbia River upstream of the site and from background areas distant from the site. A comparison of concentrations of metals in upstream and background samples with concentrations in Hanford Reach or Hanford Site samples could ultimately indicate increases in concentrations of metals potentially due to activities on the site. However, currently there is only a relatively small set of metals data for wildlife and fish from the Hanford Reach, the Hanford Site, and from background locations, and the data show some degree of variability. Sample sizes are relatively small for targeted organisms in these areas, and samples have been taken only during 3 years within a 5-year period. The combination of small sample sizes taken over a relatively short period of time and the spatial variability inherent in an organism's exposure underlie to some degree the inconsistency in the metals data evidenced in the discussion that follows. The addition of future monitoring data may reduce this variability and enhance the utility of the data in determining Hanford Site contribution to levels of metals in biota.

Trace metal concentrations were monitored in Canada geese, cottontail rabbits, and whitefish in 2007, and data results are summarized in the following discussions. Individual results and their associated uncertainties may be found in PNNL-17603, 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, including whitefish, are harvested for food and could potentially contribute to human exposure. Whitefish are known to migrate seasonally and may be exposed to metals and persistent radionuclides in the river environment. Monitoring fish for uptake and exposure to radionuclides and metals at locations both near to and distant from the Hanford Site continues to be important to track the extent and long-term trends of contamination in the Hanford Reach environment. During 2007, four whitefish were collected between the 100-N and 100-D Areas, two were collected near the Ringold Fish Hatchery on the Franklin County side of the Columbia River in the Hanford Reach, and five were collected near Wanapum Dam, upstream of the Hanford Site. Fillets and the eviscerated remains (carcasses) of whitefish were analyzed for a variety of radiological contaminants, and liver samples were analyzed for 16 metals.

Cesium-137. Cesium-137 results were below the analytical detection limit (0.03 pCi/g [0.001 Bq/g] wet weight) in the 11 whitefish fillet samples collected during 2007. These results are consistent with results reported throughout the past 10 years that indicate a gradual decline in cesium-137 levels in fish found both at background locations and near the Hanford Site.

Strontium-90. Strontium-90 was detected in all whitefish samples collected during 2007. The maximum concentration of strontium-90 was 0.0118 pCi/g (0.00044 Bq/g) wet weight in samples collected between the 100-N and 100-D Areas, 0.0122 pCi/g (0.00045 Bq/g) wet weight in samples collected from the background location, and 0.00821 pCi/g (0.00030 Bq/g) wet weight from the samples collected near the Ringold Fish Hatchery on the Franklin County side of the Columbia River in the Hanford Reach. These results are similar to results reported in preceding years (Figure 10.12.9).

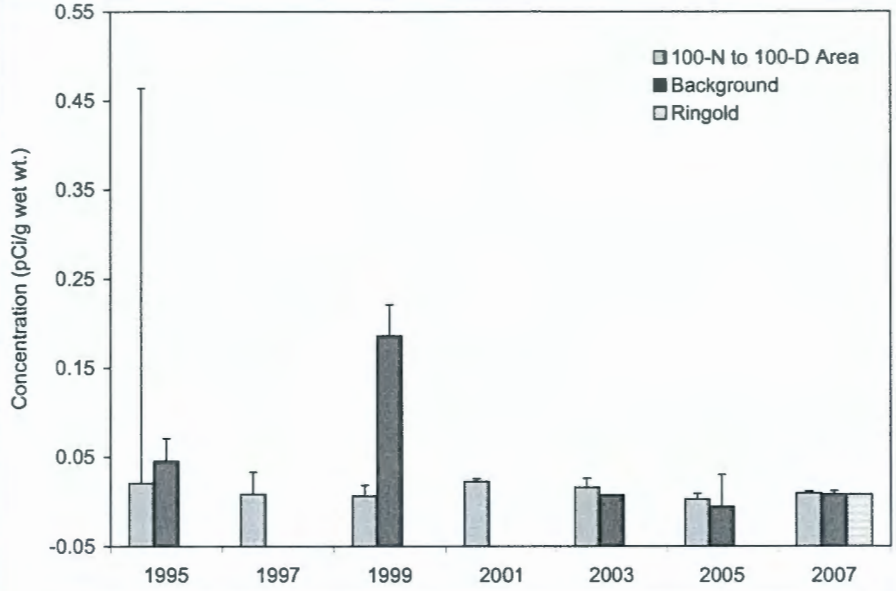


Figure 10.12.9. Median and Maximum Strontium-90 Concentrations (pCi/g wet wt.) in Hanford Reach Whitefish Carcass Samples, 2007 Compared to Previous Years (Background Areas: 1995 – Wenatchee River; 1999 – Clearwater River, Idaho; 2003–2007 – Columbia River in the Wanapum Dam Reservoir. Maximum concentrations are represented by the upper bar.)

Trace Metals. Liver samples from four whitefish collected between the 100-N and 100-D Areas were analyzed for 16 trace metals during 2007. Concentrations in the samples were compared to concentrations in five whitefish samples collected upstream of the Hanford Site near Wanapum Dam, and samples collected near the Ringold Fish Hatchery on the Franklin County side of the Columbia River in 2007. Samples were also compared to previous whitefish samples collected between the 100-N and 100-D Areas and upstream of the site near Wanapum Dam in 2003 and 2005.

Beryllium was not detected above method detection limits (0.008 µg/g dry weight) in any samples in 2007 (Appendix C, Table C.12). Maximum concentrations of manganese, thorium, lead, and chromium were higher in whitefish samples collected near Wanapum Dam than samples collected between the 100-N and 100-D Areas during 2007 (Appendix C, Table C.12). Mercury was not measured in fish collected between the 100-N and 100-D Areas during 2007. However, the maximum concentration of mercury was higher in fish samples collected near Wanapum Dam (2.1 µg/g dry weight) than in samples collected near Ringold (0.18 µg/g dry weight). The median concentration of lead was higher in samples collected between the 100-N and 100-D Areas in 2007 (0.09115 µg/g dry weight) than the medians of samples collected from the background location in 2003, 2005, and 2007 (0.03 µg/g dry weight, 0.03 µg/g dry weight, 0.0475 µg/g dry weight, respectively). The maximum concentrations of arsenic and silver were elevated slightly in samples collected between the 100-N and 100-D Areas compared to the background samples from 2007 (Appendix C, Table C.12). However, the maximum concentrations of arsenic and silver in samples collected between the 100-N and 100-D Areas in 2007 (arsenic, 0.686 µg/g dry weight; silver, 0.291 µg/g dry weight) were similar to or less than the maximum background sample concentrations in 2003 (arsenic, 1.11 µg/g dry weight; silver, 0.335 µg/g dry weight) and 2005 (arsenic, 0.83 dry weight; silver, 2.8 µg/g dry weight). The maximum and median concentrations of zinc, uranium, thallium, aluminum, selenium, nickel, copper, and cadmium were elevated in the whitefish samples collected between the 100-N and 100-D Areas compared to concentrations in samples collected at the background location near the Wanapum Dam in 2007 (Appendix C, Table C.12). However, with

the exception of selenium, uranium, aluminum, and nickel, median and maximum concentrations of metals sampled in whitefish between the 100-N and 100-D Areas were similar to (within a factor of 4) concentrations in liver samples collected from whitefish at the background location in 2003 and/or 2005 (Appendix C, Table C.12; PNNL-14687, APP. 1; PNNL-15892, APP. 1). Maximum and median concentrations of nickel and selenium in whitefish collected in 2007 between the 100-N and 100-D Areas were similar to or less than concentrations in liver samples collected from whitefish between the 100-N and 100-D Areas in 2003 and 2005 (Appendix C, Table C.12; PNNL-14687, APP. 1; PNNL-15892, APP. 1). The maximum concentration of uranium was higher in whitefish collected between the 100-N and 100-D Areas in 2007 (0.125 µg/g dry weight) than maximum concentration in samples collected from the same area in 2003 (0.037 µg/g dry weight) and in 2005 (0.025 µg/g dry weight). The maximum concentration of aluminum in samples collected between the 100-N and 100-D Areas in 2007 (6.36 µg/g dry weight) was similar to the maximum concentration in fish collected in the same location in 2003 (6.56 µg/g dry weight) and to the maximum concentration in whitefish collected at the background location in 2005 (6.2 µg/g dry weight). However, the median concentration of aluminum in samples collected between the 100-N and 100-D Areas in 2007 (3.735 µg/g dry weight) was higher than in samples collected from the same location in 2003 (2.69 µg/g dry weight) and in 2005 (2.0 µg/g dry weight) and samples collected at the background location in 2003 (2.55 µg/g dry weight) and 2005 (3.0 µg/g dry weight).

Maximum concentrations of nickel, arsenic, selenium, manganese, zinc, and thorium were elevated in samples collected near the Ringold Fish Hatchery in 2007 compared to samples collected at the background location near Wanapum Dam and samples collected between the 100-N and 100-D Areas in 2007 (Appendix C, Table C.12), 2005, and 2003. All of these metals are known to occur in fertilizer (Takeda et al. 2006; WSDA 2007). The area surrounding the Ringold Fish Hatchery is largely agricultural and historic run-off may be contributing to the elevated levels of these metals in these samples.

10.12.4.2 Analytical Results for Goose Samples

During spring 2007, 10 Canada geese were collected along the Hanford Reach of the Columbia River; 5 between the Hanford town site and the 300 Area and 5 near the 100 Areas. Five other geese were collected at a background location near Moses Lake, Washington, in the fall (Figure 10.12.8). These background geese were hunter donated. All organisms were analyzed for gamma-emitting radionuclides (including cesium-137) in muscle tissue, strontium-90 in bones, and 16 trace metals in the liver.

Cesium-137. Manmade gamma-emitting radionuclides, including cesium-137, were not found above the detection limit in any of the onsite muscle samples analyzed in 2007. These results were similar to results reported for goose samples collected along the Hanford Reach from 1995 through 2005. Cesium-137 was identified in one goose sample collected from the background location near Moses Lake, Washington (0.0249 pCi/g [0.00009 Bq/g]). The analytical results suggest that Canada geese are not accumulating measurable amounts of cesium-137 along the Hanford Reach of the Columbia River.

Strontium-90. Strontium-90 was detected in all goose bone samples collected near the 100 Areas, samples collected between the Hanford town site and the 300 Area, and background samples collected near Moses Lake during 2007. The maximum concentration in goose bone samples collected near the 100 Areas (0.147 pCi/g [0.0055 Bq/g wet weight]) and the maximum concentration in bone samples collected between the Hanford town site and the 300 Area (0.0574 pCi/g [0.0021 Bq/g wet weight]) were less than the maximum concentration in goose bone samples from the geese collected from the background location near Moses Lake, Washington (0.362 pCi/g [0.013 Bq/g wet weight]) in 2007. The background geese were likely fall migrants. The geese along the Hanford Reach, collected in July 2007, are assumed to be residents. If the background geese migrated from regions that receive more rainfall (and more atmospheric fallout) than the Hanford Site, it would be expected that they may have increased levels of fallout radionuclides, including strontium-90 (Palsson et al. 2006). Maximum and median concentrations in Hanford Reach goose samples in 2007 were similar to or less than results

reported since 1999 (Figure 10.12.10). Strontium-90 concentrations in Hanford Reach goose samples would need to exceed approximately 60 pCi/g (2.2 Bq/g) wet weight to be near the current DOE dose limit of 0.1 rad (0.001 Gy) per day for terrestrial organisms (Section 10.14).

Trace Metals. Liver samples from five geese collected near the 100 Areas, five collected between the Hanford town site and the 300 Area, and five collected near Moses Lake, Washington, were analyzed for 17 trace metals during 2007. Beryllium was not detected above method detection limits in samples collected from the Hanford Reach or the background location (Appendix C, Table C.13; PNNL-14687, APP. 1; PNNL-15892, APP. 1). The maximum and median concentrations of thallium, cadmium, arsenic, chromium, mercury, and selenium were elevated in geese collected in the Hanford Reach compared to the maximum and median concentrations of these metals found in geese collected near Moses Lake, Washington, in 2007 (Appendix C, Table C.13; PNNL-14687, APP. 1; PNNL-15892, APP. 1). Maximum and median concentrations of thallium, cadmium, and mercury in samples collected in the Hanford Reach in 2007 were similar to samples collected in the same locations in 2003 and 2005 (Appendix C, Table C.13; PNNL-14687, APP. 1; PNNL-15892, APP. 1). Maximum and median concentrations of selenium in samples from the Hanford Reach in 2007 were elevated compared to background samples in 2003 and 2005 (Appendix C, Table C.13; PNNL-14687, APP. 1; PNNL-15892, APP. 1). Maximum concentrations of chromium and arsenic in Hanford Reach geese in 2007 were similar to maximum concentrations of these metals in background geese sampled in 2003 (PNNL-14687, APP. 1). The median concentration of chromium and arsenic is slightly elevated in Hanford Reach samples collected in 2007 compared to samples collected in the same locations and at the background location in 2005 (PNNL-15892, APP. 1). The maximum concentration of lead in samples collected near the 100 Areas in 2007 ranged from 2 to 18 times those of samples collected between the Hanford town site and the 300 Area and at the background location in 2007, and samples collected in the Hanford Reach in 2003 and 2005 (Appendix C, Table C.13; PNNL-14687, APP. 1; PNNL-15892, APP. 1). However, the median concentration of

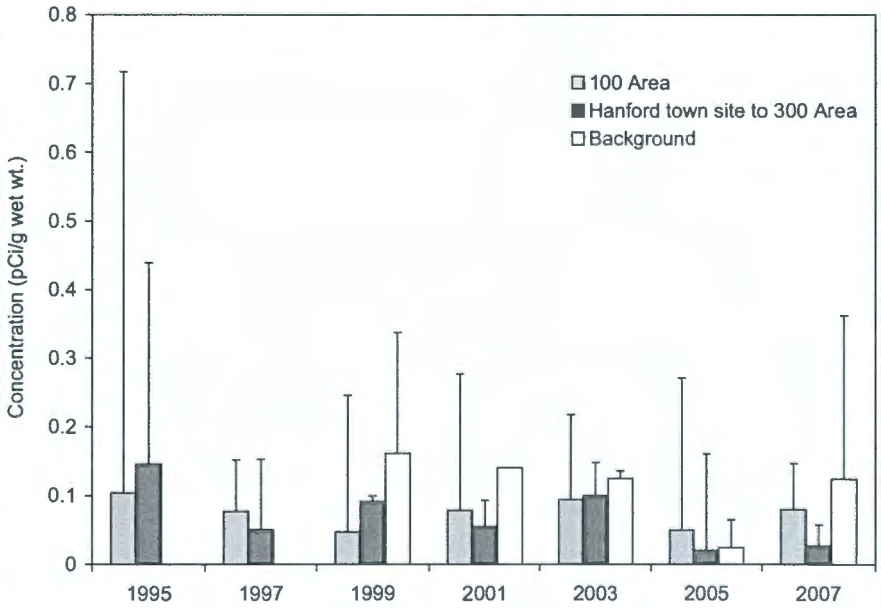


Figure 10.12.10. Median and Maximum Strontium-90 Concentrations (pCi/g wet wt.) in Hanford Site and Background Canada Goose Bone Samples, 2007 Compared to Previous Years (Background areas: 1999-2003 – Vantage, Washington; 2005 – Desert Aire, Washington; 2007 – Moses Lake, Washington. Maximum concentrations are represented by the upper bar.)

lead in samples collected near the 100 Areas in 2007 was less than the median concentration of lead in samples collected from the same area in 2003 and 2005 and only slightly elevated (less than a factor of 2) above median background concentrations and median concentrations from the Hanford Reach in 2003 and 2005 (Appendix C, Table C.13; PNNL-14687, APP. 1; PNNL-15892, APP. 1). Maximum and median concentrations of uranium, aluminum, and antimony in samples collected near the 100 Areas and between the Hanford town site and the 300 Area were similar to the maximum and median concentrations in geese collected near Moses Lake, Washington, in 2007 (Appendix C, Table 13). The maximum and median concentrations of manganese and silver were higher in geese sampled at the background site in 2007 compared to geese sampled in the Hanford Reach in 2007. The maximum concentrations of thorium, copper, and zinc were elevated in goose samples collected at the background location in 2007 compared to samples collected from Hanford Reach geese in 2007. However, median values for thorium, copper, and zinc were similar at all sites in 2007.

10.12.4.3 Analytical Results for Rabbit Samples

Rabbits are useful for detecting localized radioactive contamination because they have relatively small home ranges, occupy burrows in potentially contaminated soil, and can enter fenced restricted areas that contain radioactive waste materials. They may also be useful as sentinel organisms both on and off the site. During 2007, one cottontail rabbit was collected near the 100-N Area, and one was collected near the 200-East Area (Figure 10.12.8). Rabbits were monitored for cesium-137 in muscle tissue, strontium-90 in bones, and 16 trace metals in the liver. Plutonium-238 and plutonium-239/240 were monitored in the rabbit liver obtained from animals collected near the 200 Areas.

Cesium-137. Cesium-137 concentration in the muscle sample from the cottontail rabbit collected near the 200-East Area was below the analytical detection limit (0.03 pCi/g [0.001 Bq/g] wet weight). Cesium-137 was detected in the muscle sample from the cottontail rabbit collected near the 100-N Area (0.4 pCi/g [0.015 Bq/g] wet weight). The effective dose equivalent to a hunter from consuming 1 kilogram (2.2 pounds) of muscle from the 100-N Area cottontail rabbit, containing 0.4 pCi/g (0.015 Bq/g) cesium-137, would be about 0.02 millirem (0.2 microsievert).

Strontium-90. Strontium-90 concentrations in bone tissues from the two rabbits collected onsite during 2007 were above the analytical detection limit (Figure 10.12.11). The maximum concentration measured in rabbits near the 100-N Area during 2007 (5.03 pCi/g [0.186 Bq/g] wet weight) was similar to the maximum concentration measured in cottontail rabbits collected near the 100-N Area in 2003 (5.89 pCi/g [0.218 Bq/g] wet weight). The strontium-90 concentration in the bone sample collected near the 200-East Area in 2007 (0.338 pCi/g [0.013 Bq/g] wet weight) was similar to the maximum concentration in samples collected near the 200-East Area in 2003 and 2005. Results from rabbits collected near the 100-N Area have been higher historically and more variable than results obtained from background areas. Although small sample sizes limit the ability to interpret long-term trends, major changes in strontium-90 levels within rabbit bone tissues have not been apparent over the past decade (Figure 10.12.11).

Plutonium. Plutonium-238 and plutonium-239/240 results were below their respective analytical detection limits (0.003 pCi/g [0.0001 Bq/g] and 0.005 pCi/g [0.00019 Bq/g] wet weight) in the rabbit liver sample obtained during 2007 near the 200-East Area.

Trace Metals. Liver samples from one rabbit collected in the 100-N Area and one collected near the 200-East Area were analyzed for 16 trace metals during 2007. Beryllium, thorium, thallium, uranium, antimony, arsenic, nickel, and silver were not detected above method detection limits in the rabbit samples collected in 2007 (Appendix C, Table C.14). The concentrations of aluminum, chromium, lead, copper, manganese, and zinc in samples collected from the 100-N Area and near the 200-East Area in 2007 were less than or similar to maximum concentrations in rabbits collected near the same locations and at background locations in 2003 and 2005 (Appendix C, Table C.14; PNNL-14687, APP. 1; PNNL-15892, APP. 1). Cadmium concentrations in samples collected from the 100-N Area and near the 200-East Area in 2007 were less than the maximum cadmium concentration at the background location in 2005 (Appendix C, Table C.14; PNNL-15892, APP. 1).

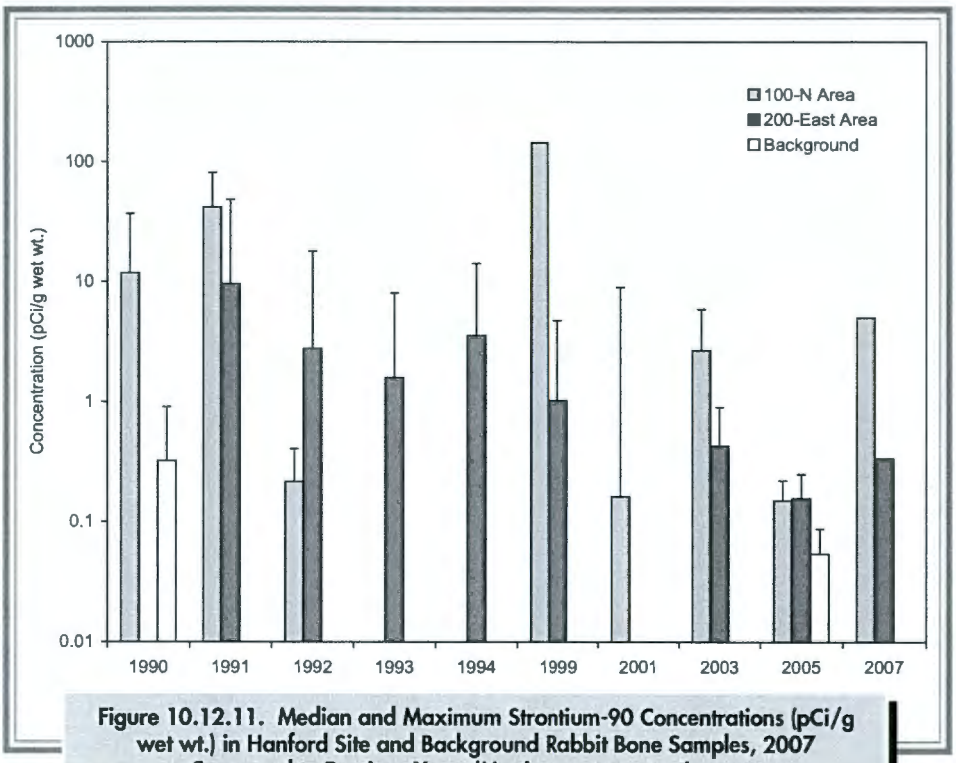


Figure 10.12.11. Median and Maximum Strontium-90 Concentrations (pCi/g wet wt.) in Hanford Site and Background Rabbit Bone Samples, 2007 Compared to Previous Years (Maximum concentrations are represented by the upper bar.)

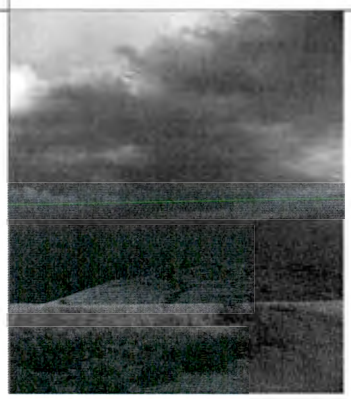
Selenium was elevated in rabbit samples collected from the 100-N and 200-East Areas during 2007 compared to samples collected at the background location in 2005. However, the concentration in rabbit samples collected from the 100-N and 200-East Areas during 2007 was less than the maximum concentration in samples collected from the same locations in 2003 and 2005 and samples collected at the background location in 2003 (Appendix C, Table C.14; PNNL-14687, APP. 1; PNNL-15892, APP. 1).

10.12.5 Control of Pests and Contaminated Biota

A. R. Johnson, R. C. Roos, J. G. Caudill, J. M. Rodriguez, and G. S. Hauger

Animal species such as the domestic pigeon (*Columbia livia*), Northern pocket gopher (*Thomomus talpoides*), house mouse (*Mus musculus*), and deer mouse (*Peromyscus maniculatus*) must be controlled when they become a nuisance, health problem, or contaminated with radioactivity. Biological control personnel responded to approximately 28,000 animal control requests (ranging from requests to remove animals within radioactive waste facilities to insect invasions of work areas) from Hanford Site employees in 2007. Approximately 3,000 trap or bait stations were used to control populations of animals in and near facilities and offices.

During 2007, 35 contaminated animals or animal-related materials were discovered. This is approximately 25% less than the peak number of 46 in 1999, and 14 more than the total for 2006. 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. Only six of the contaminated animal samples collected in 2007 related to insects, and four of those were approximately 4-year-old inactive wasp nests found on equipment that had been relocated from the 100-H Area near where the wasps were building nests from contaminated mud exposed during the demolition of the 105-H Building in 2003 (PNNL-14687). A fifth incident was from an old piece of an insect carapace found near a waste treatment facility. The remaining contaminated insect incident was from a harvester ant mound (*Pogonomyrmex* species) found on a low-level solid waste burial ground.



10.13 External Radiation Monitoring

External radiation is defined as radiation originating from a source external to the body. In 2007, external radiation at the Hanford Site was monitored onsite in relative proximity to known, suspected, or potential radiation sources. Sources of external radiation at 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™ thermoluminescent dosimeter (TLD) system is used to measure external radiation at 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. The two TLD-700 chips were used to determine the average total environmental dose at each location. 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 two TLD-200 chips were included only to determine doses in the event of a radiological emergency and were not used during 2007. 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 2007 included underground radioactive materials 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

C. J. Perkins

During 2007, 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. A comparison of 2007 and 2006 results for TLDs located near waste-handling facilities at the Hanford Site can be found in Table 10.13.1. Individual TLD results and detailed maps of monitoring locations are provided in PNNL-17603, APP. 2.

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 2007 were comparable to those measured in previous years.

(a) Harshaw is a trademark of Thermo Fisher Scientific, Waltham, Massachusetts.

100-K Area. Cleanup activities at the 100-K Area fuel storage basins and adjacent retired reactor buildings continued in 2007, and overall average dose rates measured during the year decreased by approximately 60% relative to 2006 values (Figure 10.13.1). The decrease became noticeable during the last half of 2006 and was apparent at nearly all monitoring locations near the K-East and K-West spent nuclear fuel storage basins and load-out stations.

A similar decrease in dose rate levels was also observed at dosimeter monitoring sites around the 100-K Area Cold Vacuum Drying Facility where overall annual dose rates decreased approximately 53% in 2007 compared to 2006.

In March 2006, three additional dosimeters were deployed at the 100-K Area to monitor the total dose during the transfer of radioactively contaminated basin sludge from the 105-K East fuel storage basin to the 105-K West fuel storage basin and then to the Cold Vacuum Drying Facility (known as the Hose-in-Hose project). Two of the new dosimeters, situated near the Columbia River shoreline, were at typical site baseline levels throughout 2006 and 2007. The third new dosimeter, located east of the 105-K East facility, began showing somewhat higher than baseline dose rates levels during the fourth quarter of 2006, and these levels continued to gradually increase until mid-year 2007 when they leveled off. Similarly, another TLD location near (south of) the 105-K West facility continued to exhibit consistently higher-than-baseline dose rate levels again during 2007. In both cases, these slightly elevated levels appeared to be in conjunction with sludge transferral activities.

100-N Area. Average dose rates observed in the 100-N Area were comparable to those of 2006.

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 using the river. Continued cleanup activities at the retired 116-N-1 and 116-N-3 Trenches (located near the Columbia River) have reduced the skyshine effect (i.e., radiation reflected by the atmosphere back to the Earth's surface) at the shoreline. The dose rates have decreased notably over the past few years (Figure 10.13.1). The 2007 dose rates were approximately 7% lower than the 2006 dose rates and averaged less than 100 millirem (1 millisievert) per year.

200-East and 200-West Areas. Dose rates measured during 2007 in the 200-East Area were very similar to those measured in 2006 and remained much lower than levels measured during peak waste-retrieval activities at the A Tank Farm (200-East Area) and at the S Tank Farm (200-West Area) during the second quarter of 2004 (Figure 10.13.1).

Dose rates measured in the 200-West Area were slightly higher (6%) than 2006 levels.

Average dose rates measured in 2007 at the Environmental Restoration Disposal Facility (located near the 200-West Area) were comparable to 2006 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 a decrease of 18% in the annual average dose rate in 2007 compared to 2006. This TLD location was established in 2000 to monitor expected high radiation levels emitted from contaminated railroad cars staged in the immediate vicinity.

300 and 400 Areas. The average dose rates in the 300 Area, at the 300 Area Treated Effluent Disposal Facility, at the 300-FF-2 field remediation project site, and in the 400 Area in 2007 were comparable to 2006 levels (Figure 10.13.1).

10.13.1.2 Radiological Surveys at Active and Inactive Waste-Disposal Sites

S. M. McKinney

During 2007, 464 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. 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

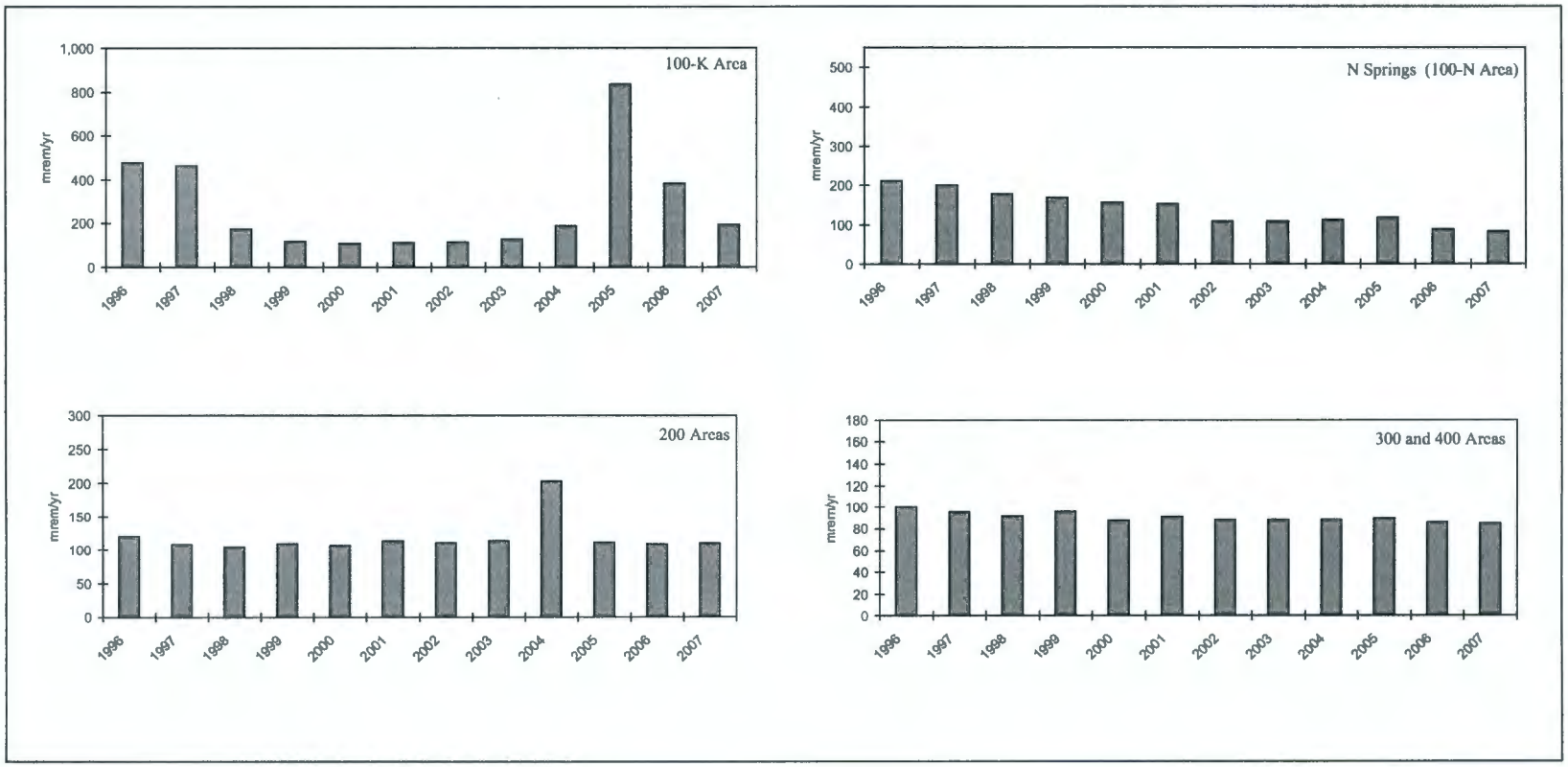


Figure 10.13.1. Annual Average Dose Rates Determined with Thermoluminescent Dosimeters in Selected Operations Areas at the Hanford Site

Table 10.13.1. Thermoluminescent Dosimeter Results (mrem/yr)[a] Near Hanford Site Operations in 2006 and 2007

Hanford Site Locations	No. of Dosimeters	2006 Maximum[b]	2006 Average[c,d]	2007 Maximum[b]	2007 Average[c,d]	% Change[e]
100-B/C Area	4	90 ± 9	84 ± 8	89 ± 12	85 ± 7	1
100-K Area	14	2,300 ± 5,800	483 ± 1,300	590 ± 15	206 ± 273	-56
100-N Area	6	176 ± 124	119 ± 59	142 ± 153	102 ± 48	-2
200-East Area	42	338 ± 275	113 ± 106	305 ± 148	110 ± 95	-1
200-West Area	24	174 ± 120	104 ± 54	241 ± 287	110 ± 77	6
200-North Area (212-R)[f]	1	2,200 ± 329	2,100 ± 207	1,700 ± 268	1,700 ± 81	-18
300 Area	8	113 ± 158	91 ± 24	109 ± 6	87 ± 20	-4
300 Area TEDF	6	87 ± 15	84 ± 4	87 ± 12	84 ± 4	<1
300-FF-2	4	93 ± 14	88 ± 10	88 ± 11	85 ± 5	-2
400 Area	7	85 ± 9	81 ± 5	98 ± 8	85 ± 12	4
CVDF	4	666 ± 939	337 ± 475	306 ± 13	154 ± 205	-53
ERDF	3	88 ± 16	86 ± 4	93 ± 6	88 ± 8	2
IDF[f]	1	93 ± 14	90 ± 5	99 ± 15	91 ± 13	1

(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 (-) or increase from the 2006 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.

materials areas, contamination areas, and soil contamination areas. It was estimated that 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 materials 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-17603, 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 2007, the Hanford Site had approximately 3,583 hectares (8,853 acres) of outdoor contaminated areas of all types and approximately 593 hectares (1,464 acres)

that contained underground radioactive materials, not including active facilities. A list of contamination areas, underground radioactive materials areas, interim-closed waste sites, their status, and their general locations is provided in Table 10.13.2. No new areas of significant size were discovered during 2007. 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 2007, approximately 7 hectares (18 acres) of previously posted contamination and/or underground radioactive materials areas underwent remediation action and were interim-closed. Table 10.13.3 summarizes the change in status of outdoor contamination areas during 2007.

Table 10.13.2. Status of Outdoor Contamination Areas at the Hanford Site, 2007

Area	Contamination Areas,[a] ha	(acres)	Underground Radioactive Materials Areas,[b] ha	(acres)	Interim Closed, ha	(acres)
100-B/C	0	(0)	33	(81)	13	(32)
100-D/DR	0	(0)	22	(54)	6	(15)
100-F	0	(0)	8	(19)	14	(35)
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[c]	71	(175)	141	(348)	0	(0)
200-West[c]	27	(67)	224	(554)	0	(0)
300	0	(0)	42	(104)	22	(54)
400	0	(0)	0	(0)	0	(0)
600[d]	3,478	(8,594)	55	(136)	0	(0)
Totals	**3,583**	**(8,853)**	**593**	**(1,464)**	**107**	**(264)**

(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.

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 the 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 years should refer to previous Hanford Site environmental reports and their data appendices (see http://hanford-site.pnl.gov/envreport).

Table 10.13.3. Change in Status of Outdoor Contamination Areas at the Hanford Site, 2007

Areas	Changes	Area, ha	(acres)
100	CA/URM to interim closed[a]	7	(18)
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	None to report	0	(0)

(a) Changes due to remediation activities.
CA = Contamination/soil contamination area.
URM = Underground radioactive material area.

10.14 Potential Radiological Doses from 2007 Hanford Site Operations

E. J. Antonio and K. Rhoads

During 2007, potential radiological doses to the public and biota from Hanford Site operations were evaluated in detail 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 2007 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)
- Inhalation dose associated with measured radionuclide concentrations in air (Section 10.14.4.3)
- 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 2007 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 in PNNL-17603, APP. 1.

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). During 2007, tritium and three uranium isotopes were found in the Columbia River downstream of the Hanford Site at greater levels than predicted, based on direct discharges from the 100-K Area (Section 10.4 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 2007.

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 2007. 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 released to the air and liquid effluents released to the Columbia River from Hanford Site facilities (Figure 10.14.1). During 2007, the dose assessment determined that the maximally exposed individual was located across the Columbia River (east of the Hanford Site) at Sagemoor (Figure 10.14.1). For the calculation, it was assumed this individual

- 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 shoreline 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

Historically at Hanford, 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 (CAP-88) 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 Hanford'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 based on exposure to Hanford Site radiological contaminants through food, water, and air pathways and 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.

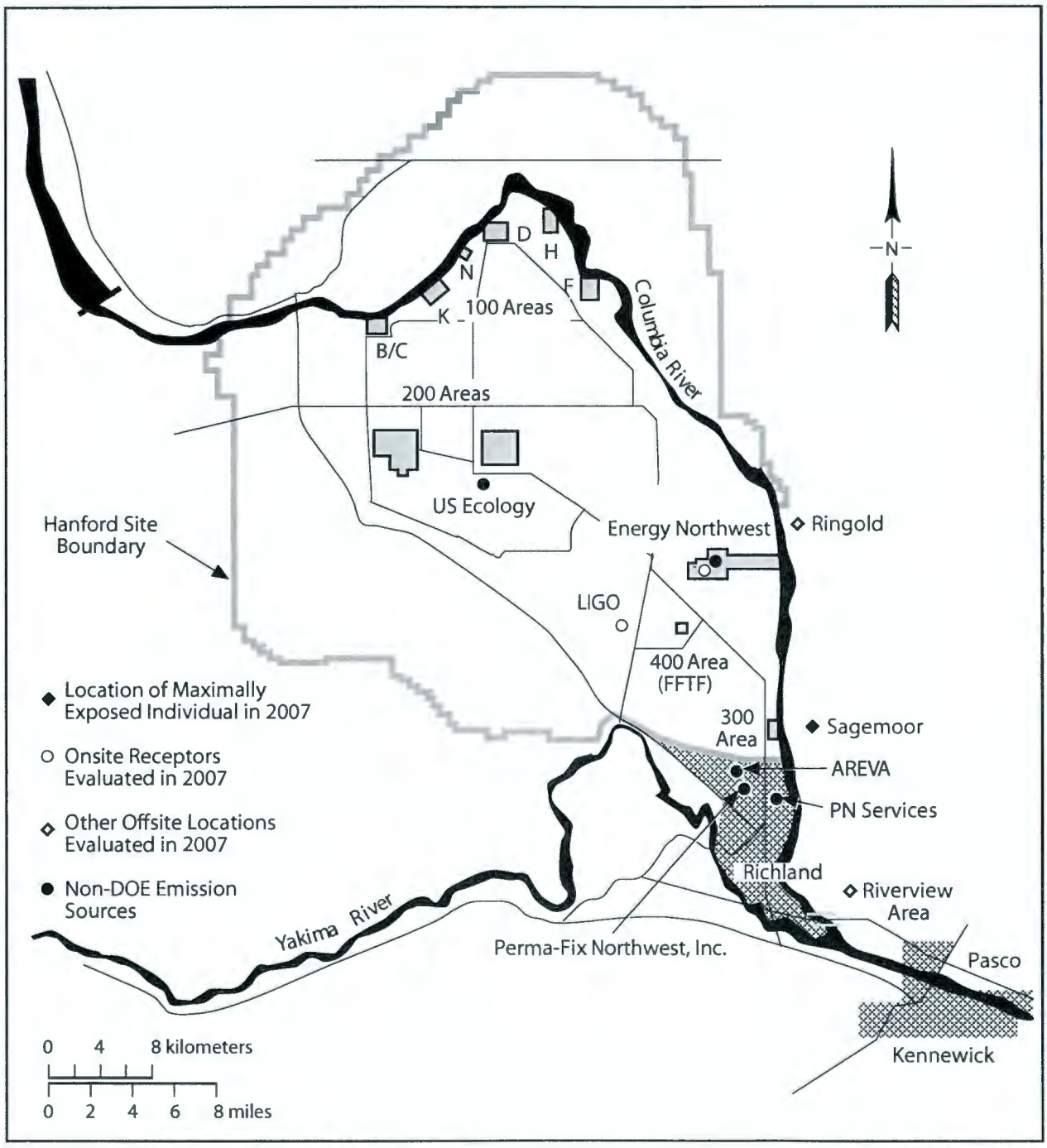


Figure 10.14.1. Locations Important to Dose Calculations at the Hanford Site, 2007

have entered the Columbia River through shoreline groundwater springs between the 100-B/C Area and the 300 Area.

During 2007, the total dose to the maximally exposed individual at Sagemoor (Figure 10.14.1) was calculated to be 0.12 millirem (1.2 microsievert) per year (Table 10.14.1; Figure 10.14.2). This dose was 0.12% 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 all pathways) were as follows:

- The inhalation of air downwind from the Hanford Site (10%) and the consumption of food products grown downwind from the Hanford Site (approximately 83%), resulting in exposure to airborne releases of tritium and radon from the 300 Area

Table 10.14.1. Dose to the Hypothetical, Maximally Exposed Individual Residing at Sagemoor from 2007 Hanford Site Operations

		Dose Contributions from Operating Areas, mrem				
Effluent	Pathway	100 Areas	200 Areas	300 Area	400 Area	Total
Air	External	8.0×10^{-10}	3.8×10^{-7}	1.6×10^{-5}	2.0×10^{-8}	1.6×10^{-5}
	Inhalation	7.5×10^{-5}	5.5×10^{-5}	1.2×10^{-2}	7.3×10^{-6}	1.2×10^{-2}
	Foods	1.9×10^{-6}	2.9×10^{-4}	1.0×10^{-1}	5.6×10^{-6}	1.0×10^{-1}
	Subtotal air	**7.7×10^{-5}**	**3.4×10^{-4}**	**1.1×10^{-1}**	**1.3×10^{-5}**	**1.1×10^{-1}**
Water	Recreation	1.8×10^{-8}	8.3×10^{-5}	0.0	0.0	8.3×10^{-5}
	Foods	1.2×10^{-6}	4.2×10^{-2}	0.0	0.0	4.2×10^{-3}
	Fish	3.5×10^{-6}	3.7×10^{-3}	0.0	0.0	3.7×10^{-3}
	Subtotal water	**4.7×10^{-6}**	**8.0×10^{-3}**	**0.0**	**0.0**	**8.0×10^{-3}**
Combined total		**8.2×10^{-5}**	**8.3×10^{-3}**	**1.1×10^{-1}**	**1.3×10^{-5}**	**1.2×10^{-1}**

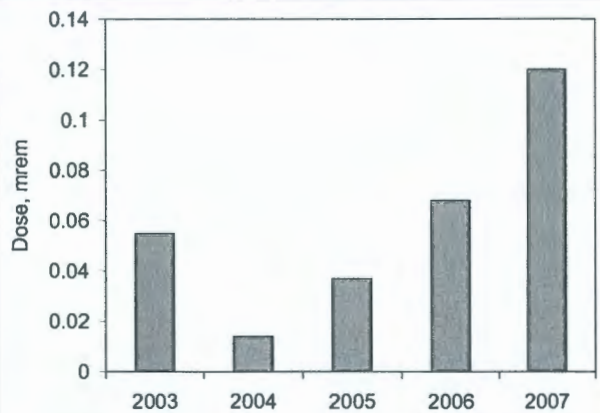


Figure 10.14.2. Calculated Dose to the Hypothetical, Maximally Exposed Individual Near the Hanford Site, 2003 Through 2007

- The consumption of food irrigated with Columbia River water withdrawn downstream from the Hanford Site (3.5%) and consumption of fish from the Columbia River (3.1%), 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 2007 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. During 2007, the collective dose calculated for the population was 0.9 person-rem (0.009 person-sievert) per year (Table 10.14.2; Figure 10.14.3), which is about 70% higher than the 2006 collective dose (0.65 person-rem [0.0065 person-sievert]) per year (Appendix E, Tables E.5 to E.10).

Table 10.14.2. Collective Dose to the Population from 2007 Hanford Site Operations

		Dose Contributions from Operating Areas, person-rem				
Effluent	Pathway	100 Areas	200 Areas	300 Area	400 Area	Pathway Total
Air	External	1.4×10^{-7}	3.3×10^{-5}	1.7×10^{-4}	8.9×10^{-7}	2.0×10^{-4}
	Inhalation	2.0×10^{-2}	6.9×10^{-3}	1.1×10^{-1}	4.9×10^{-4}	1.4×10^{-1}
	Foods	2.5×10^{-4}	2.7×10^{-2}	5.4×10^{-1}	2.2×10^{-4}	5.7×10^{-1}
	Subtotal air	**2.0×10^{-2}**	**3.4×10^{-2}**	**6.5×10^{-1}**	**7.1×10^{-4}**	**7.2×10^{-1}**
Water	Recreation	8.1×10^{-8}	4.2×10^{-4}	0.0	0.0	4.2×10^{-4}
	Foods	1.3×10^{-6}	4.6×10^{-3}	0.0	0.0	4.6×10^{-3}
	Fish	1.3×10^{-6}	1.4×10^{-3}	0.0	0.0	1.4×10^{-3}
	Drinking water	6.2×10^{-6}	1.9×10^{-1}	0.0	0.0	1.9×10^{-1}
	Subtotal water	**8.9×10^{-6}**	**2.0×10^{-1}**	**0.0**	**0.0**	**2.0×10^{-1}**
Combined total		**2.0×10^{-2}**	**2.3×10^{-1}**	**6.5×10^{-1}**	**7.1×10^{-4}**	**9.0×10^{-1}**

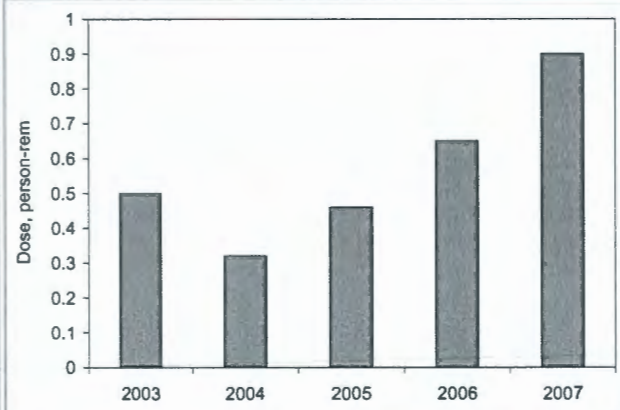


Figure 10.14.3. Collective Dose to the Population within 80 Kilometers (50 miles) of Hanford Site Operating Areas, 2003 Through 2007

Primary pathways contributing to the 2007 collective dose (and the percentage of all pathways) included the following:

- Consumption of food grown downwind of the Hanford Site (approximately 63%) and inhalation of radionuclides that were released to the air, principally tritium and radon from the 300 Area and iodine-129 from the 200 Areas (16%)
- 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 0.5%) containing principally tritium, uranium-234, uranium-235, and uranium-238.

Collective doses reported for 2007 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 24% to 29%.

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 0.002 millirem (0.02 microsievert) in 2007. 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). The estimated annual average individual dose to members of the public from Hanford Site sources in 2007 was approximately 0.0007% of the estimated annual individual dose received from natural background sources (300 millirem [3 millisievert]). The calculated radiological doses from Hanford Site operations in 2007 were a small percentage of the federal standards and of doses from natural background sources (Table 10.14.3).

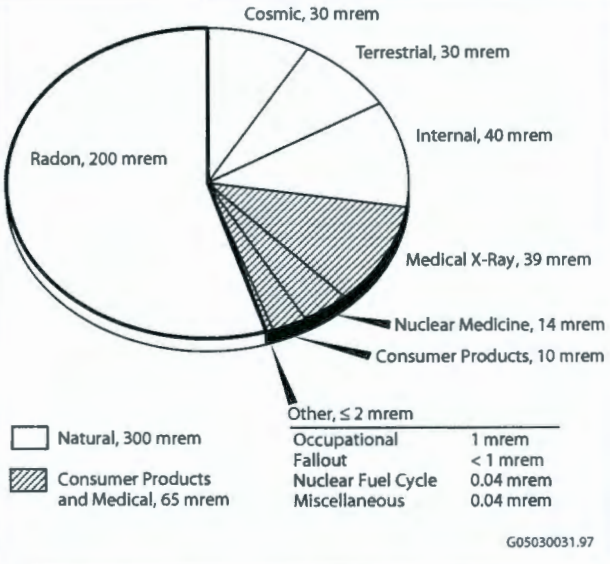


Figure 10.14.4. Annual National Average Radiological Doses from Various Sources (National Council on Radiation Protection and Measurements 1987)

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 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 the DOE uses the GENII computer code at the Hanford Site to determine dose to the all-pathways maximally exposed individual, the EPA requires the use of the CAP-88 computer code (EPA 402-R-00-004) or other EPA-approved computer models to demonstrate compliance with the requirements in 40 CFR 61, Subpart H. The assumptions embodied in the CAP-88 computer code

Table 10.14.3. Comparison of 2007 Doses to the Public from Hanford Site Effluent and Emissions to Federal Standards and Natural Background Levels

Federal Standard	Hanford Dose[a]	Percent of Standard or of Background Dose
DOE - 100 mrem/yr all pathways MEI[b]	0.12 mrem/yr	0.12
EPA - 10 mrem/yr air pathway MEI[c]	0.14 mrem/yr	1.4
Background Dose		
300 mrem/yr average U.S. individual[d]	0.002 mrem/yr	0.0007
145,800 person-rem/yr to population within 80 km (50 mi)	0.9 person-rem/yr	0.0006

(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 (1987).
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.
MEI = Maximally exposed individual.

differ slightly from standard assumptions used with the GENII computer code. Therefore, air-pathway doses calculated by the two codes may differ somewhat. 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).

The EPA regulation also requires that an annual report for each DOE facility be submitted to the EPA that supplies information about atmospheric emissions for the preceding year and their potential contributions to offsite dose. For more detailed information about 2007 air emissions at the Hanford Site, refer to the DOE's report to the EPA, *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2007* (DOE/RL-2008-03).

10.14.3.1 Dose to an Offsite Maximally Exposed Individual

Using EPA-specified methods, the maximally exposed offsite individual for air pathways in 2007 was in the Sagemoor area of Franklin County, 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 (including radon) to a maximally exposed individual at that location calculated using the CAP-88 computer code was determined to be 0.14 millirem (1.4 microsievert) per year, which represented less than 2% of the EPA standard. This is similar to the offsite individual doses calculated for the EPA in previous years and to the air pathway doses for stack emissions in Table 10.14.1.

The dose from radon-220 and radon-222 amounted to 0.0046 millirem (0.046 microsievert) in 2007. 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.

10.14.3.2 Maximum Dose to Non-U.S. Department of Energy Workers at 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 the Hanford Site but who are not under direct DOE control. 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 2007 EPA air emissions report (DOE/RL-2008-03). 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 CAP-88 computer code was 0.0042 millirem (0.042 microsievert) per year, assuming full-time occupancy.

EPA guidance does not currently allow for adjustment of doses calculated using the CAP-88 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 2007, 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. The 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). The 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-2008-03).

During 2007, the estimated dose from diffuse emissions to a maximally exposed individual at a location in the Sagemoor area was calculated using the CAP-88 computer code to be 0.0039 millirem (0.039 microsievert) per year. This is somewhat lower than results for recent years, where the dose from diffuse emissions has been similar to the dose from stack emissions. Doses for 2007 were calculated using CAP88-PC, Version 3 (Rosnick 2007), which has a different basis for the dosimetry system and other parameters compared to that in CAP88-PC, Version 1 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 2007 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 existed that could have resulted in somewhat higher doses. Three scenarios that could have potentially led to larger doses included 1) a person who consumed contaminated wildlife that migrated from the Hanford Site, 2) a person who drank water at the Fast Flux Test Facility in the 400 Area, and 3) individuals at various locations who breathed the measured radionuclide concentrations in air for an entire year. The potential doses resulting from these scenarios are examined in the following sections. A fourth scenario where an individual would spend time at the Hanford Site boundary location with the maximum external radiological dose rate was not evaluated for 2007 because external radiation surveillance by the Pacific Northwest National Laboratory, on and around the site, was discontinued in December 2005.

10.14.4.1 Outdoor Recreationalist Dose

Wildlife have access to Hanford Site areas that are contaminated with radioactive materials. Wildlife have 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 2007 included potassium-40, a primordial radioisotope not of Hanford Site origin. Strontium-90 was measured only in animal bone or carcass samples, which are not routinely consumed; therefore, it was not considered further. Cesium-137 was identified in one goose sample collected from a background location near Moses Lake, Washington (Section 10.11.4.2), and one cottontail rabbit sample collected onsite from the 100-N Area (Section 10.11.4.3). The effective dose equivalent from consuming 1 kilogram (2.2 pounds) of muscle from the background goose sample, containing 0.0249 pCi/g (0.0009 Bq/g) cesium-137 was calculated as 0.001 millirem (0.01 microsievert). The effective dose equivalent from consuming 1 kilogram (2.2 pounds) of muscle from the 100-N Area cottontail rabbit, containing 0.4 pCi/g (0.015 Bq/g) cesium-137, would be about 0.02 millirem (0.2 microsievert).

10.14.4.2 Onsite Drinking Water

During 2007, drinking water was sampled and analyzed throughout the year 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 2007 were below applicable drinking water standards. However, tritium in the 400 Area was detected at levels above the minimum detectable concentration and strontium-90 was identified in the 100-K, 100-N, and 200-West Areas drinking water (Section 10.6).

Based on the detected concentrations, the potential annual dose to a worker at the Fast Flux Test Facility (400 Area) in

2007 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.

10.14.4.3 Inhalation Doses for Entire Year

A nominal inhalation rate of 23 cubic meters (812 cubic feet) per day of air and an exposure period of 8,766 hours (365.25 days) were assumed for all offsite calculations. For onsite locations, the exposure period was reduced to 2,000 hours (250, 8-hour workdays) to simulate a typical work year, and the breathing rate was increased to 28.8 cubic meters (1,017 cubic feet) per day to account for light-duty work.

Table 10.14.4 presents radiological inhalation doses to hypothetical offsite individuals modeled to be in the same location for the entire year and to onsite individuals located near site-wide air monitoring stations during their workday. The average radionuclide concentrations measured at the site-wide air monitoring stations were used in the calculations (Table 10.2.3) and assumed to be constant for the year-long evaluation period. Inhalation doses calculated using this method ranged from 0.001 millirem (0.01 microsievert) in the 300 Area to 0.087 millirem (0.87 microsievert) at the site perimeter. These were comparable to doses calculated using the CAP-88 computer code and reported for various air pathways (Section 10.14.3). However, CAP-88 doses include all air pathways, not only inhalation.

Table 10.14.4. Inhalation Doses On and Around the Hanford Site Based on 2007 Average Air Surveillance Data[a]

Radionuclide	Group	Dose (mrem/yr)[b,c]
Tritium	Onsite	4.2×10^{-4}
	300 Area	1.0×10^{-3}
	Perimeter	3.4×10^{-3}
	Nearby communities	4.2×10^{-4}
	Distant community	2.1×10^{-3}
Uranium-234	Onsite	6.3×10^{-3}
	Perimeter	2.7×10^{-2}
	Nearby communities	2.8×10^{-2}
	Distant community	1.4×10^{-2}
Uranium-238	Onsite	4.7×10^{-3}
	Perimeter	2.3×10^{-2}
	Nearby communities	2.4×10^{-2}
	Distant community	1.7×10^{-2}
Plutonium-238	Onsite	7.7×10^{-4}
	Perimeter	3.3×10^{-2}
	Nearby communities	2.5×10^{-3}
Plutonium-239	Onsite	2.5×10^{-3}
Totals	Onsite	1.5×10^{-2}
	300 Area	1.0×10^{-3}
	Perimeter	8.7×10^{-2}
	Nearby communities	5.5×10^{-2}
	Distant community	3.3×10^{-2}

(a) Onsite inhalation dose calculations were based on a 2,000-hour exposure period and a 1.2-m^3/hr breathing rate; all offsite inhalation dose calculations were based on an 8,766-hour exposure period and a 0.958-m^3/hr breathing rate.
(b) Includes contributions from DOE activities as well as contributions from atmospheric fallout, naturally occurring radionuclides, and non-DOE facilities on and near the site.
(c) To convert to international metric system units (mSv/yr), divide reported values by 100.

10.14.4.4 Doses from June 2007 Contamination Event

In June 2007, an exit survey from a radiological buffer area identified alpha contamination on a Hanford Site employee. Follow-up surveys identified three additional employees with some level of contamination. The origin of the contamination was a leaking plutonium-238 source. Surveys were conducted in other Pacific Northwest National Laboratory facilities, employees' homes, vehicles, and their clothing. Contamination was found at two residences, in three personal vehicles, on computer keyboards, chairs, and tools. Members of the public (family and co-habitants of the employees involved in this incident) received doses of up to 33 millirem (330 microsievert) committed effective dose equivalent.

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 2007, various non-DOE industrial sources of public radiation exposure existed on or near the

Hanford Site. These included a commercial, low-level, radioactive waste burial ground at the Hanford Site operated by U.S. Ecology; a nuclear power-generating station at the Hanford Site operated by Energy Northwest; a nuclear-fuel production plant operated near the site by AREVA NP; a commercial, low-level, radioactive waste treatment facility operated near the site by Perma-Fix Northwest, Inc.; and a commercial decontamination facility operated near the site by PN Services (Figure 10.14.1).

The 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 2007 individual dose from their combined activities was less than 0.2 millirem (2 microsievert) per year. Therefore, the combined annual dose from non-DOE and DOE sources on and near the site to a member of the public for 2007 was well below any regulatory dose limit.

10.14.6 Dose Rates to Animals

Upper estimates of the radiological dose to aquatic organisms were made in accordance with the DOE Order 5400.5 interim requirement for management and control of 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 > 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 2007 from on and around the Hanford Site.

Maximum concentrations of radionuclides measured in sediment, onsite pond water, and Columbia River shoreline spring water 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 < 1.0) (Table 10.14.5).

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 performed 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.

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 due to 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

Table 10.14.5. Results of Using the RESRAD-BIOTA[a] Computer Code to Estimate Radiological Doses to Biota On and Around the Hanford Site, Using 2007 Onsite Pond Water, Columbia River Shoreline Spring Water, and River and Pond Sediment, as Available

Location	Tier 1 Screen, Sum of Fractions[b]	Pass or Fail
100-B Area	3.10×10^{-2}	Pass
100-D Area	1.48×10^{-3}	Pass
100-F Slough	4.01×10^{-2}	Pass
100-F Spring	3.10×10^{-2}	Pass
100-H Spring	5.07×10^{-2}	Pass
100-K Spring	4.86×10^{-2}	Pass
100-N Spring	2.99×10^{-5}	Pass
300 Area Spring	5.15×10^{-1}	Pass
Hanford town site Spring	2.42×10^{-2}	Pass
Hanford Slough	2.74×10^{-2}	Pass
McNary Dam sediment	6.11×10^{-4}	Pass
Priest Rapids Dam sediment	1.62×10^{-1}	Pass
Richland Beach sediment	1.48×10^{-2}	Pass
Richland Spring	1.07×10^{-2}	Pass
West Lake sediment	4.18×10^{-1}	Pass
White Bluffs Slough	1.00×10^{-1}	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.

greater than radiation from current Hanford Site releases, increases each individual's probability or chance of developing a detrimental health effect.

Scientists do not 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, the EPA used a probability value of approximately 4 per 10 million (4×10^{-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 (6×10^{-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 10.14.6 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 2007 are shown in Table 10.14.7.

Table 10.14.6. Estimated Risk from Various Activities and Exposure[a]

Activity or Exposure Per Year	Risk of Fatality
Smoking 1 pack of cigarettes per day (lung/heart/other diseases)	$3{,}600 \times 10^{-6}$
Home accidents	100×10^{-6}[b]
Taking contraceptive pills (side effects)	20×10^{-6}
Drinking 1 can of beer or 0.12 L (4 oz) of wine per day (liver cancer/cirrhosis)	10×10^{-6}
Firearms (sporting accidents)	10×10^{-6}[b]
Flying as an airline passenger (cross-country roundtrip – accidents)	8×10^{-6}[b]
Eating ~54 g (4 Tbsp) of peanut butter per day (liver cancer)	8×10^{-6}
Recreational boating (accidents)	6×10^{-6}
Drinking chlorinated tap water (trace chloroform – cancer)	3×10^{-6}
Riding or driving 483 km (300 mi) in a passenger vehicle	2×10^{-6}[b]
Eating 41 kg (90 lb) of charcoal-broiled steaks (gastrointestinal tract cancer)	1×10^{-6}
Natural background radiological dose (300 mrem [3 mSv])	0 to 120×10^{-6}
Flying as an airline passenger (cross-country roundtrip – radiation)	0 to 5×10^{-6}
Dose of 1 mrem (10 μSv) for 70 yr	0 to 6×10^{-7}
Dose to the hypothetical, maximally exposed individual living near the Hanford Site	7×10^{-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 10.14.7. Activities Comparable in Risk to the 0.12-mrem (0.0012-mSv) Dose Calculated for the Hanford Site Maximally Exposed Individual in 2007

Driving or riding 0.18 km (~570 ft) in a car	Eating one 475-g (16.8-oz) charcoal-broiled steak
Smoking less than 1/1,000 of a cigarette	Drinking 0.18 L (5.9 oz) of chlorinated tap water
Flying 0.45 km (1,462 ft) on a commercial airliner	Drinking 9 mL (0.32 oz) of beer or 3 mL (0.1 oz) of wine
Eating 0.1 Tbsp (1.5 mL) of peanut butter	Exposed to the U.S. national average background dose for 3.5 hours

10.15 Cultural and Historic Resources Monitoring

E. P. Kennedy

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 2007 included the following:

- Performing cultural resources reviews for all federal undertakings conducted at the Hanford Site in accordance with Section 106 of the *National Historic Preservation Act* and the *National Environmental Policy Act of 1969*
- Monitoring cultural resources conditions to ensure important resources were protected
- Maintaining a database of cultural resource 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 (CREHST) 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*, DOE conducts cultural resources reviews of all federal activities on 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 2007, 129 requests were received for Hanford Site cultural resources reviews. The Pacific Northwest National Laboratory received 74 review requests, and Washington Closure Hanford LLC received 55 review requests. Upon initial review, DOE determined that 115 of the 129 activities were not the type that had the potential to cause effects and therefore were exempt from full review. Examples of these activities included small excavations, such as routine maintenance activities in previously disturbed areas, especially those located within the fence lines of existing operable units. The largest number of activities determined to be not the type with potential to cause effects were located in the 200 Areas in 2007 (Figure 10.15.1).

The remaining 14 activities required full reviews because they involved undisturbed ground, areas that had not been surveyed in the past, or locations in proximity to known cultural resources. 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 of the full reviews required new areas (approximately 1,011 hectares [2,498 acres]) to be surveyed for cultural resources. Others

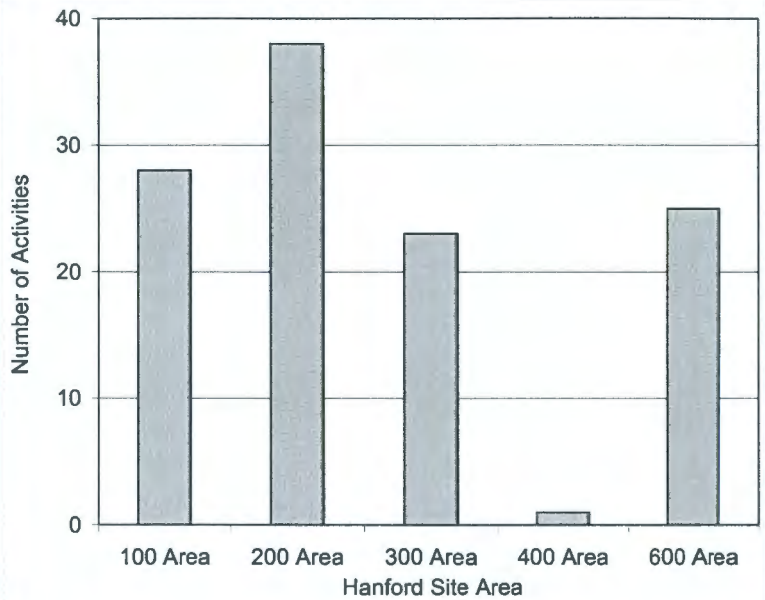


Figure 10.15.1. Number of Activities that were Reviewed in 2007 and were Determined to be Not the Type with Potential To Cause Effects to Hanford Site Cultural Resources

required the development of a Memorandum of Agreement to mitigate adverse effects 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*, the *Native American Graves Protection and Repatriation Act*, 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, assessment of impact, if any, and identification of protective measures when an impact is significant. In 2007, 34 cultural resource sites were inspected at the Hanford Site.

Cultural resource site visits were conducted with the participation of tribal cultural resources personnel. Although no major impacts were noted at the sites inspected, minor impacts as a result of recreation, natural erosion, and animal activity were recorded in 2007. A technical report summarizing the results of the cultural resources monitoring program since its implementation in 1987 was published.[a] DOE also continued to visit Locke Island in the Hanford Reach of the Columbia River to measure river-caused erosion so protective measures can be taken if erosion rates begin to increase. In 2007, the rate of erosion decreased on the island relative to that of 2006. Examination of eroded areas has revealed there may be two separate causal variables: high water levels and periods of water fluctuation.

Evidence of looting was observed at one significant site along the Columbia River. A formal *Archaeological Resources Protection Act of 1979* Damage Assessment was completed for this site.[b] As a result, DOE implemented protective measures, including installing a locked gate and no trespassing signage to minimize impacts to the area. Recent monitoring indicates that the area is recovering. The DOE Richland Operations Office also implemented another protective measure for the highly culturally sensitive Gable Mountain and Gable Butte area through the development of a management plan.[c] This plan was developed in consultation with area tribes and outlines management practices for the protection of these sensitive areas.

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*. In 2007, 16 new archaeological sites and 23 new isolated finds were recorded. A determination of eligibility for listing in the National Register of Historic Places was completed for Rattlesnake Mountain, a traditional

(a) Document not publicly available.
(b) Document not publicly available.
(c) Document not publicly available.

Table 10.15.1. Full Cultural Resources Reviews Conducted on the Hanford Site in 2007

Reviewing Organization	Proposed Activity	Field Survey?	Survey Size (hectares [acres])	Review Finding
PNNL	Phase 2 exterior building modifications to four repeater buildings (600 Area)	No	0	Adverse effect to Rattlesnake and Gable Mountains; Memorandum of Agreement developed; mitigation plan to be followed
PNNL	Install monitoring wells at two drilling sites (C5573 and C5574) in the 200-West Area	No	0	No adverse effect to atmospheric dispersion grid
PNNL	Roof replacements in the T Plant Complex in the 200-West Area	No	0	No adverse effect to T Plant
PNNL	300 Area characterization-geophysical Task 2 hyporheic corridor	No	0	No adverse effect to 45BN162
PNNL	Tank waste and solid waste environmental impact statement cultural resources review and inventory	Yes	400 [990]	Adverse effect to atmospheric dispersion grid, Gable and Rattlesnake Mountains; Memorandum of Agreement being developed
PNNL	Six new monitoring wells in the 100-D and 100-H Areas	No	0	No affect to historic properties; archaeological excavation mitigation plan followed
PNNL	Repair road on Rattlesnake Mountain in the 600 Area	No	0	Project discontinued; initial finding was conditional no adverse effect to Rattlesnake Mountain
PNNL	Wautoma fire emergency re-seed, 600 Area	Yes	566 [1,400]	To be determined; project still in review stage
PNNL	200-BC-U treatability test at the 216-B-26 Trench and the remediation of a portion of the BC control area, 600 Area	No	0	No affect to historic properties
PNNL	Navy storage area and load test site in the 600 Area	No	0	No affect to historic properties
WCH	Staging and storage areas for the 618-7 and 618-13 Burial Grounds in the 300 Area	Yes	44 [108]	No affect to historic properties
WCH	Demolition of the 337, 337-B, and 3718-M Buildings in the 300 Area	No	0	No affect to historic properties
WCH	100-NR-1: Remediation of seven waste sites near *Mooli Mooli* in Zone A in the 100-N Area	No	0	No affect to historic properties
WCH	Characterization sampling at waste site 100-F-45 in the 100-F Area	No	0	No affect to historic properties

PNNL = Pacific Northwest National Laboratory.
WCH = Washington Closure Hanford LLC.

cultural property sacred to area tribes in collaboration with the Confederated Tribes and Bands of the Yakama Indian Nation, the Environmental Restoration and Waste Management Program, and cultural resources personnel from Pacific Northwest National Laboratory. Additionally, *Mooli Mooli*, another traditional cultural property, was also determined eligible for listing in the National Register of Historic Places, along with an archaeological site complex (sites 45BN431, 45BN432, and 45BN433), and a Hanford Site Construction-era refuse dump site (45BN1437).

Pacific Northwest National Laboratory cultural resources personnel continue to pursue the use of magnetometry as a non-invasive way to characterize buried archaeological deposits. A small-scale survey was conducted in cooperation with Washington Closure Hanford LLC cultural resources personnel at an archaeological site to verify the magnetic signature of an eroding fire-cracked rock (oven) feature. State-of-the-art magnetic modeling software was acquired to assist in the interpretation of both previously acquired and future data.

A history and summary of past cultural resources investigations conducted at the Riverlands/Midway area was completed in 2007 and will be published in 2008.

10.15.2.2 Data Recovery Activities

Washington Closure Hanford LLC personnel conducted two data recovery excavations in 2007 in advance of projects conducted by Fluor Hanford, Inc. Six 1-meter by 1-meter (3-feet by 3-feet) units were excavated at the 100-KR-4 Pump-and-Treat Expansion Project area. These units allowed exploration of the Pleistocene-Holocene interface as well as lower Holocene terrace locations along the Columbia River. Only a few items were discovered; no living floors, features, or diagnostic artifacts were encountered. A report is being prepared to document this excavation. Similarly, four 1-meter by 1-meter (3-feet by 3-feet) units were excavated at the 100-HR-3 Pump-and-Treat Project area. The few items found were primarily historic debris (i.e., nails, glass) with little diagnostic value. A separate report is being written to document this excavation. In addition to excavation, construction of well pads and access roads was monitored at the 100-HR-3 area. No cultural materials were observed during monitoring.

10.15.2.3 Management of Artifact and Data Collections

The 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, geographical 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 2007, temperature and humidity levels within the archive room remained within limits for storage of numerous types of archived materials. During 2007, 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 (CREHST) 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 (DOE/RL-96-77, Rev. 0), which directs DOE to assess the contents of Hanford Site historic 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. Walk-throughs were conducted within seven buildings located in the 300 and 600 Areas in 2007. A total of five artifacts were evaluated, none of which had been previously evaluated. One was mitigated in place through photography. The remaining four were transferred to the CREHST Museum. Teams of cultural resource specialists, historians, archivists, curators, and facility experts accomplished the assessments.

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* and the *National Environmental Policy Act of 1969* (see Section 2.0.2). In 2007, DOE consulted with the Washington State Historic Preservation Office and Native American tribes on 14 full cultural reviews (Table 10.15.1).

Hanford Cultural and Historic Resources Program staff held 11 meetings in 2007 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 14 full cultural resources reviews initiated in 2007, tribal notification and consultation processes, development of two Memoranda of Agreement, development of a cultural resources management plan for Gable Mountain, and approaches to protecting threatened archaeological sites and places containing human remains. No cultural resources meetings were held with non-tribal interested parties in 2007.

10.16 Climate and Meteorology

K. W. 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 to help plan weather-dependent activities and are used 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 the presence of 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 that are 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 site. Figure 10.16.1 shows the 2007 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

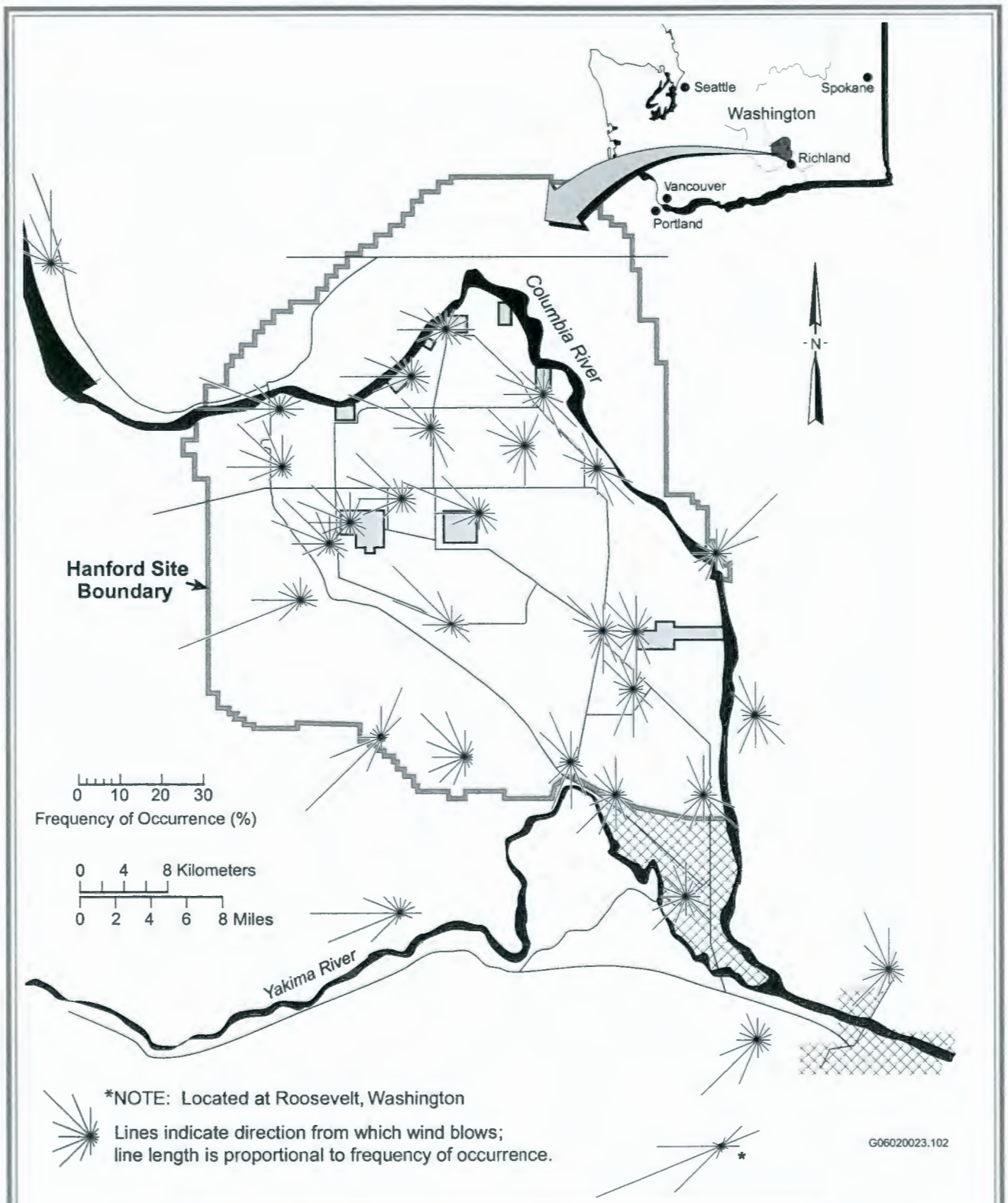


Figure 10.16.1. Hanford Meteorological Monitoring Network Wind Roses, 2007 (measured at a height of 9 meters [30 feet])

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 2007, the record maximum temperature was 45°C (113.0°F) recorded in July 2006, July 2002, and August 1961. 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 2007 Monitoring

The calendar year 2007 average temperature and precipitation totals were below normal.

The average temperature for 2007 was 11.9°C (53.5°F), which was 0.1°C (0.1°F) below normal (12.0°C [53.6°F]). Four months during 2007 were warmer than normal; seven months were cooler than normal. July had the greatest positive departure, 2.6°C (4.7°F); January, at 1.7°C (3.0°F) below normal, had the greatest negative departure.

Precipitation during 2007 totaled 13.9 centimeters (5.48 inches), which is 79% of normal (17.7 centimeters [6.98 inches]). Snowfall for 2007 totaled 25.4 centimeters (10.0 inches), compared to normal snowfall of 39.1 centimeters (15.4 inches).

The average wind speed during 2007 was 3.6 meters per second (8.0 miles per hour), which was 0.2 meter per second (0.4 mile per hour) above normal. The peak gust for the year was 26.8 meters per second (60 miles per hour) on November 12 and December 15.

Two dust storms were recorded at the Hanford Meteorology Station during 2007. There has been an average of five dust storms per year at the Hanford Meteorology Station during the entire period of record (1945–2007).

Table 10.16.1 provides monthly and annual climatological data collected at the Hanford Meteorology Station during 2007.

Table 10.16.1. Monthly and Annual Climatological Data for 2007 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[a]				
	Averages				Extremes						Snowfall						Peak Gusts		
	Daily Maximum	Daily Minimum	Monthly	Departure[b]	Highest	Date	Lowest	Date	Total	Departure[b]	Total	Departure[b]	Average	Departure[b]	Average Speed, m/sec	Departure[b]	Speed, m/sec	Direction	Date
J	2.9	−6.5	−1.8	−1.7	14.4	7[c]	−15.6	15[c]	0.4	−1.8	3.8	−6.9	76.0	−1.6	2.9	+0.1	28.2	WSW	6
F	7.9	−1.4	3.2	−0.1	17.8	17	−12.2	2	1.9	+0.2	5.6	−1.0	78.3	+7.6	3.1	0	20.6	SSW	20[c]
M	15.2	2.1	8.6	+0.8	23.9	11	-4.4	2	1.9	+0.4	1.3	+0.3	61.4	+4.8	3.7	+0.2	20.1	SW	11
A	18.7	3.9	11.3	-0.6	26.1	27	−2.8	3	0.7	−0.4	0	−T[d]	51.2	−3.7	3.8	−0.1	21.9	W	9
M	26.2	8.4	17.3	+0.7	35.6	31	2.8	4	0.8	−0.6	0	0	39.5	−3.5	4.0	0	19.7	NW	21
J	28.6	11.9	20.3	−0.4	40.0	3	7.2	25	1.1	+0.1	0	0	40.6	+1.0	4.1	0	19.2	WNW	3
J	36.1	18.4	27.2	+2.6	43.3	5	11.1	1	0.2	−0.5	0	0	31.9	−1.4	3.9	+0.1	18.8	WNW	7
A	32.0	14.6	23.3	−0.8	39.4	2	9.4	21[c]	0.8	+0.1	0	0	38.8	+3.1	3.7	+0.2	17.9	NW	2
S	26.6	10.9	18.8	0	33.9	3	3.3	29	1.4	+0.6	0	0	42.4	+0.3	3.8	+0.5	18.3	WNW	28
O	17.6	4.1	10.6	−1.1	22.8	24[c]	−5.6	31	0.5	−0.7	0	−0.1	60.4	+4.3	3.5	+0.6	22.4	SW	2
N	9.4	−1.3	4.0	−0.5	21.7	4	−7.2	23	2.9	+0.4	8.1	−2.3	72.3	−1.3	2.8	−0.1	26.8	SW	12
D	4.4	−3.6	0.4	+0.6	17.2	4[c]	−10.6	10[c]	1.3	−1.5	6.6	−8.1	78.6	−1.8	3.4	+0.7	26.8	NNW	29
Y[e]	18.8	5.1	11.9	−0.1	43.3	Jul 5	−15.6	Jan 15[c]	13.9	−3.8	25.4	−13.7	56.0	+1.4	3.6	+0.2	26.8	NNW	Dec 29[c]

NOTE: See Table A.2, Conversion Table in the section, Helpful Information, 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 2007 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 were collected.
- Avoid cross-contamination by using dedicated well sampling pumps.

10.17.1 Hanford Site-Wide and Offsite Environmental Surveillance and Environmental Monitoring

E. A. Lepel

During 2007, 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 and the DOE Soil and Groundwater Remediation Project (managed by Fluor Hanford, Inc., which assumed the program in fiscal year 2007). The samples collected by the Surface Environmental Surveillance Project staff were submitted to TestAmerica Laboratories, Inc., Richland, Washington, for radiochemical analyses. Samples for inorganic analyses were submitted to the Battelle Marine Sciences Laboratory, located at the Pacific Northwest National Laboratory Sequim Marine Research Operations in Washington State. A small number of water samples were also collected for inorganic and organic analyses by the Soil and Groundwater Remediation Project and were analyzed as part of the overall Surface Environmental Surveillance Program sample set.

In fiscal year 2007, the Soil and Groundwater Remediation Project transitioned the radiochemical and chemical analyses from TestAmerica Laboratories in St. Louis, Missouri, and Richland, Washington, to the Waste Sampling and Characterization Facility, an onsite laboratory managed by Fluor Hanford, Inc. Quality assurance plans were maintained for all project activities and defined the appropriate controls and documentation required by the EPA and DOE.

10.17.1.1 Project Management Quality Assurance

Site environmental monitoring, groundwater 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 each monitoring project; these plans describe the specific quality assurance elements that apply to each project. These plans were approved by the Pacific

Northwest National Laboratory and Fluor Hanford, Inc. 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 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, water, and biota (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. There were 13 duplicate air samples collected for tritium analyses, but results for only 12 are currently available. A field duplicate is used to assess sampling and measurement precision. The 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, 61% of the total 2007 field duplicates were acceptable, but 75% of the air-tritium results did not meet the acceptance criterion.

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:

$$RPD = \left(\frac{|S-D|}{\frac{(S+D)}{2}} \right) \times 100$$

Samples for the Soil and Groundwater Remediation Project were collected by trained personnel according to approved and documented procedures. Chain-of-custody procedures in *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, Third Edition* (EPA 1986) were followed. Samples representing field blanks and field duplicates were obtained during field operations. Summaries of the 2007 groundwater field quality control sample results are provided in Appendix C of DOE/RL-2008-01. In fiscal year 2007, the percentage of acceptable field blank results was 97%, and the percentage of acceptable field duplicate results was 98%. For field blanks, a result was acceptable if it was less than two times the method detection limit for non-radiological data or less than two times the total propagated analytical uncertainty for radiological data. An acceptable result indicates that a contamination problem was not found with the sample. For a field duplicate, the result was acceptable if the measured precision was within 20%, as measured by the relative percentage difference, and the result was greater than five times the minimum detectable activity or method detection limit.

Table 10.17.1. Summary of Field Duplicate Sample Results for Samples Submitted to TestAmerica Laboratories, Inc., Richland, Washington, for the Surface Environmental Surveillance Project, 2007

Media (Number of Samples)	Radionuclides	Number of Results Reported for Each Radionuclide[a]	Number Within Control Limits for Each Radionuclide[b]
Air (13)	^{3}H	13	6
Water (4)	^{3}H	4	4
	^{234}U, ^{238}U	3	3
	Gross beta	1	1
	^{90}Sr	2	1
Biota[c] (2)	^{3}H	2	2
	^{40}K	2	2

(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's milk.

10.17.1.3 Analytical Results Quality Assurance and Quality Control

Routine chemical analyses of water samples were performed at the onsite Waste Sampling and Characterization Facility for the environmental surveillance and

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.

groundwater monitoring projects. Chemical analysis of split samples and blind standards for the CERCLA groundwater program were performed under contract by Lionville Laboratory, Inc. in Lionville, Pennsylvania, which served as a secondary laboratory. Each laboratory participated in the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation Studies conducted by Environmental Resource Associates in Arvada, Colorado. Each laboratory maintained an internal quality control program that met the requirements in EPA (1986); each program was audited and reviewed internally by Pacific Northwest National Laboratory personnel, who submitted additional quality control double-blind spiked samples to these laboratories for analysis.

Routine metals analyses were performed by the Battelle Marine Sciences Laboratory, located at the Pacific Northwest National Laboratory Sequim Marine Research Operations in Washington State. The 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 two (four for mercury) studies in 2007 were reported. The acceptance criteria were met by 96% of the results from the water samples. Results also reported from two soil studies in 2007; 100% of these results were acceptable. The results are summarized in Table 10.17.2.

Routine radiochemical analyses of samples for the environmental surveillance monitoring project were performed by TestAmerica Laboratories, Inc., Richland, Washington. TestAmerica Richland participated in the DOE Mixed Analyte Performance Evaluation Program and the InterLab RadChem Proficiency Testing Program conducted by Environmental Resource Associates. Environmental Resource Associates prepared and distributed proficiency standard samples according to EPA requirements. A quality control blind-spiked sample program also was conducted for each project by the Pacific Northwest National Laboratory. TestAmerica Laboratory maintains an internal quality control program, which was audited and internally reviewed. Additional information on these quality control efforts is provided in the following sections.

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

Table 10.17.2. Summary of Battelle's Marine Sciences Laboratory Performance on NSI Solutions, Inc. Proficiency Testing Program Samples (five studies), 2007

Media	Analytes	Number of Results Reported for Each Analyte	Number Within Control Limits for Each Analyte
Soil	Al, Sb, As, Ba, Be, B, Ca, Cd, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Na, Ni, K, Se, Ag, Sr, Sn, Tl, Ti, V, Zn	2	2
Water	Hg	2	2
	Mo, Se	2	2
	Al, Sb, As, Ba, Be, Cd, Cr, Cu, Pb, Mg, Mn, Ni, K, Ag, Na, Tl, V	2	2
	Ca, Fe	2	2
	Co, Sr	2	2

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. Summaries of the results for 2007 groundwater samples are provided in DOE/RL-2008-01, Appendix C, for the primary laboratory, Waste Sampling and Characterization Facility, and the secondary laboratory, Lionville Laboratory, Inc.

The DOE Mixed Analyte Performance Evaluation Program conducted by the Radiological and Environmental Sciences Laboratory in Idaho Falls, Idaho, and the Environmental Resource Associates Proficiency Testing Program provided standard samples of environmental media (e.g., water, air filters, soil, and vegetation) that contained specific amounts of one or more radionuclides that were unknown by the participating laboratory. After analysis, the results were forwarded to the Radiological and Environmental Sciences Laboratory (one study) or Environmental Resource Associates (three studies) for comparison with known values and results from other laboratories. Both the Radiological and Environmental Sciences Laboratory and Environmental Resource Associates had established criteria for evaluating the accuracy of results (NERL-Ci-0045). The Radiological and Environmental Sciences Laboratory evaluates the DOE Mixed Analyte Performance Evaluation Program radiological and inorganic samples results for accuracy by determining if each result falls within ±30% of a reference value. Summaries of the 2007 results are provided in Tables 10.17.3 and 10.17.4. The DOE Mixed Analyte Performance Evaluation Program provided one set of performance evaluation samples consisting of soil, water, vegetation, and air filters that were analyzed by TestAmerica Richland. 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 as defined by the *National Standards for Water Proficiency Testing Studies, Criteria Document* (NERL-Ci-0045) was met by 90% of the Environmental Resource Associates samples.

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.

Table 10.17.3. Summary of TestAmerica Laboratories, Inc., Richland, Washington, Performance on Six Performance Evaluation Program Samples Provided by the DOE Mixed Analyte Performance Evaluation Program, 2007

Media	Radionuclides	Number of Results Reported for Each Radionuclide	Number of Results Within Control Limits for Each Radionuclide[a]
Air filters	Gross alpha, gross beta, ^{54}Mn, ^{57}Co, ^{60}Co ^{65}Zn, ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{234}U, ^{238}Pu, ^{238}U,	1	1
	$^{239/240}$Pu, ^{241}Am	1	0
Soil	^{40}K, ^{54}Mn, ^{55}Fe, ^{57}Co, ^{60}Co, ^{63}Ni, ^{65}Zn, ^{90}Sr, ^{99}Tc, ^{134}Cs, ^{137}Cs, ^{234}U, ^{238}Pu, ^{238}U, $^{239/240}$Pu, ^{241}Am	1	1
Vegetation	^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{234}U, ^{238}Pu, $^{239/240}$Pu, ^{241}Am	1	1
	^{238}U	1	0
Water	Gross alpha, gross beta, ^{3}H, ^{54}Mn, ^{55}Fe, ^{57}Co, ^{60}Co, ^{63}Ni, ^{65}Zn, ^{90}Sr, ^{99}Tc, ^{134}Cs, ^{137}Cs, ^{234}U, ^{238}Pu, ^{238}U, $^{239/240}$Pu, ^{241}Am	1	1

(a) Control limits are from EML-621.

Table 10.17.4. Summary of TestAmerica Laboratories, Inc., Richland, Washington, Performance on Three Performance Evaluation Program Water Samples Provided by the Environmental Resource Associates Proficiency Testing Program, 2007

Media	Radionuclides	Number of Results Reported for Each Radionuclide	Number of Results Within Control Limits for Each Radionuclide[a]
Water	Gross alpha	6	4
	^{226}Ra	4	4
	Gross beta, ^{65}Zn, ^{89}Sr, ^{90}Sr, ^{133}Ba, ^{134}Cs	3	3
	^{60}Co, ^{137}Cs	3	2
	^{228}Ra	2	2
	^{3}H, ^{131}I, U(natural)	1	1

(a) Control limits are from NERL-Ci-0045.

10.17.1.5 Pacific Northwest National Laboratory Evaluations

In addition to the DOE and EPA interlaboratory quality control programs, the Pacific Northwest National Laboratory maintained a quality control program to evaluate analytical contractor precision and accuracy, and to conduct special intercomparisons. This program included the use of both radiological and non-radiological blind-spiked samples. Blind-spiked quality control samples and blanks were prepared and submitted to check the accuracy and precision of analyses at TestAmerica Richland. In fiscal year 2007, 82% of blind-spiked groundwater samples were acceptable (DOE/RL-2008-01, Appendix C).

Eight blind-spiked samples were submitted for analyses for the Surface Environmental Surveillance Project. The samples included air filters, soil, water, and vegetation (Table 10.17.5). For all media, 82% of TestAmerica Richland radiochemistry blind-spiked determinations were within the control limit (±30% of the known value). In 2006, 73% of the results were acceptable. In 2007, 5 of 14 air filter blind-spiked analysis results were outside the control limit. Three of the air filter results were determined by gamma-ray (cobalt-60 and cesium-137) analysis and the

Table 10.17.5. Summary of TestAmerica Laboratories, Inc., Richland, Washington, Performance on Blind-Spiked Samples Submitted by Pacific Northwest National Laboratory for the Surface Environmental Surveillance Project, 2007

Media	Radionuclides	Number of Results Reported for Each Radionuclide	Number of Results Within the Control Limit for Each Radionuclide[a]
Air Filters	^{90}Sr, ^{238}Pu, $^{239/240}Pu$	2	2
	^{60}Co, ^{234}U, ^{238}U	2	1
	^{137}Cs	2	0
Soil	^{40}K, ^{137}Cs, $^{239/240}Pu$	2	2
	^{90}Sr, ^{234}U, ^{238}U	2	1
Vegetation	^{40}K, ^{90}Sr, ^{137}Cs, $^{239/240}Pu$	2	2
	^{60}Co	2	1
Surface Water	^{3}H, ^{60}Co, ^{134}Cs ^{137}Cs, ^{234}U, ^{238}Pu, ^{238}U, $^{239/240}Pu$	2	2

(a) Control limit of ±30%.

other two by uranium isotopic (uranium-234 and uranium-238) analysis in one sample. One analysis of vegetation for cobalt-60 was outside the control limits. Analyses of strontium-90 and uranium isotopic (uranium-234 and uranium-238) in the same soil sample had results outside the control limits.

10.17.1.6 Laboratory Internal Quality Assurance Programs

Analytical laboratories were required to maintain an internal quality assurance and control program. The laboratories are audited at least annually for compliance to the quality assurance and control programs. At the Waste Sampling and Characterization Facility, 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 TestAmerica Richland 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 Marine Sciences Laboratory involved routine daily calibrations of analytical instruments, analysis of certified reference 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 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 2007, five audits of the commercial laboratories supporting the Soil and Groundwater Remediation Project were performed by the DOE Consolidated Assessment Program. The DOE Consolidated Assessment Program audit evaluated 1) TestAmerica St. Louis in St. Louis, Missouri, in April 2007; 2) Eberline Services in Richmond, California, in February and March 2007; 3) Lionville Laboratory, Inc. in Lionville, Pennsylvania, in July 2007; and 4) TestAmerica Richland in Richland, Washington, in June 2007. The audits at the TestAmerica Laboratories were initiated prior to the laboratory name change and therefore were issued to Severn Trent Laboratories, Incorporated. However, the name change to TestAmerica Laboratories, Inc. does not affect the review of the laboratory audits because the laboratories are still part of the same legal corporate entity.

The scope of the DOE Consolidated Assessment 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) hazardous and radioactive materials management, and 6) verification of corrective-action implementation from previous audit findings.

A total of 48 findings (requiring some corrective action by the laboratory) and 34 observations were noted for the 5 DOE Consolidated Assessment Program audits. Results

of these audits are summarized in Appendix C, Table C.29 of DOE/RL-2008-01. Corrective actions for all the audit findings were accepted, and verification of the corrective actions will be performed in future audits. All laboratories have been qualified by the DOE Consolidated Assessment Program to continue to provide analytical services for samples generated at DOE sites.

An integrated contractor assessment team assessment is performed by Hanford Site contractor personnel on Hanford Site analytical laboratories and is used to verify the implementation of the requirements stated in *Hanford Analytical Services Quality Assurance Requirements Documents*, Volumes 1 and 4 (DOE/RL-96-68, Rev. 2). An integrated contractor assessment team evaluation of the Waste Sampling and Characterization Facility laboratory was performed in February 2007. The overall results of the assessment indicated that programs and processes reviewed were in place and implemented in accordance with the laboratory quality assurance program plan and DOE/RL-96-68, Rev. 2. No issues were noted to indicate concern over the technical adequacy of the Waste Sampling and Characterization Facility to meet the needs of the groundwater project.

A total of 6 findings and 15 observations were noted during the assessment. Results of this assessment are summarized in Table C.29 of Appendix C of DOE/RL-2008-01. Corrective actions have been accepted for all findings, and observations, and verification of the corrective actions will be performed in a future assessment.

Internal laboratory quality control program data were reported with the analytical results. Pacific Northwest National Laboratory scientists summarized the results quarterly. The Surface Environmental Surveillance Project and the Soil and Groundwater Remediation Project indicated that each laboratory met the contract-specified requirements for each quarter of calendar year 2007 (for the Surface Environmental Surveillance Project) and fiscal year 2007 (for the Soil and Groundwater Remediation 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 2007 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 16 locations along and across the Columbia River, water from 5 Columbia River shoreline springs, water from 1 onsite drinking water location, sediment from 6 Columbia River sites extending from Priest Rapids Dam (upriver from the Hanford Site) to McNary Dam (downriver from the Hanford Site), and sediment adjacent to 4 springs. Also analyzed for radionuclides were 6 samples of whitefish (carcass and muscle), 13 cottontail rabbits (muscle and bone), as well as samples of potato tubers, leafy vegetables, concord grapes, alfalfa, and red and white wine.

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 collected air samples on a weekly basis, while Pacific Northwest National Laboratory collected samples on a biweekly basis. Data were compared for sites at the Battelle Complex, Prosser Barricade, Wye Barricade, and Yakima Barricade (Figure 10.2.2). Comparison of gross beta concentrations at the Battelle Complex is shown in Figure 10.17.1. The Pacific Northwest National Laboratory data are presented with two sigma error bars, and the values are generally lower than those for the data reported by the Washington State Department of Health. Within these measured uncertainties, there was fair agreement between the Washington State Department of Health and Pacific Northwest National Laboratory data at the four sites.

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 potato tubers, alfalfa, and concord grapes for radionuclides (Table 10.17.6). Potassium-40 concentrations measured by the U.S. Food and Drug Administration and TestAmerica Richland in concord grapes and potato tubers were in agreement. However, the potassium-40 values determined by the U.S. Food and Drug Administration in alfalfa were significantly lower than that determined by TestAmerica Richland. Potassium-40 is taken up by plants from the soil. The abundance of potassium-40 in the Earth's crust is about 14 pCi/g (0.52 Bq/g) soil (Mason

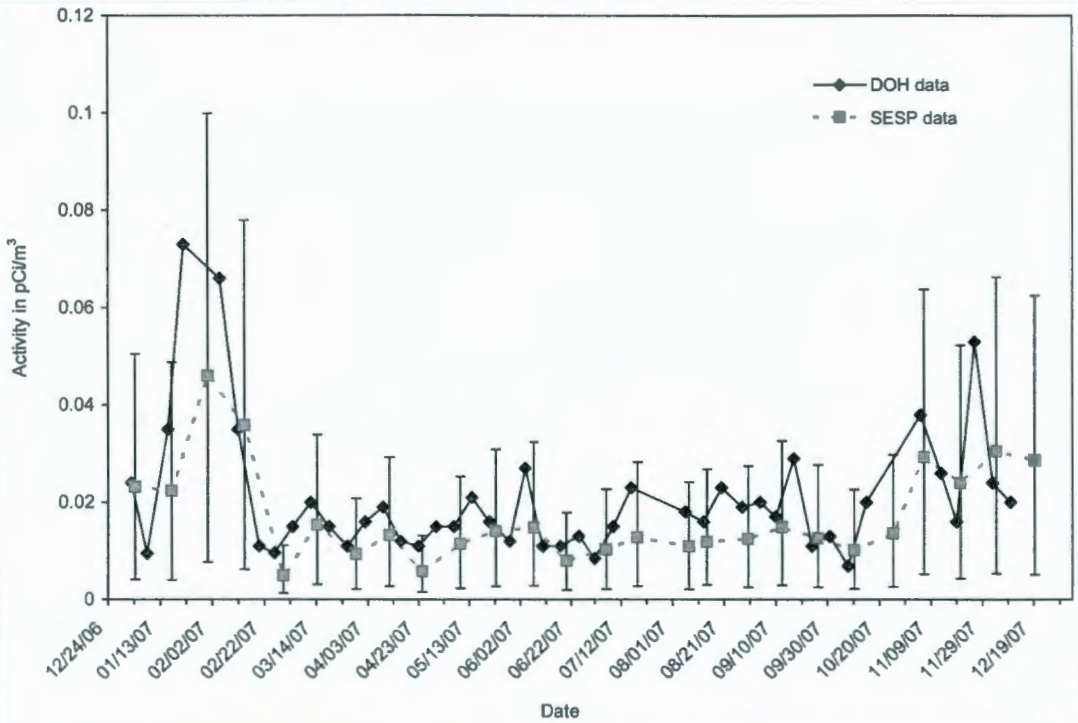


Figure 10.17.1. Comparison of Gross Beta Concentrations from Samples Collected at the Battelle Complex as Reported by the Washington State Department of Health and Pacific Northwest National Laboratory's Surface Environmental Surveillance Project

Table 10.17.6. Comparison of U.S. Food and Drug Administration and Pacific Northwest National Laboratory[a] Results for Food and Farm Product Samples Collected Near the Hanford Site, 2007[b]

Media	Sampling Area[c]	Organization	Potassium-40 pCi/g[d,e]	Strontium-90, pCi/g[d,e]	Ruthenium-106, pCi/g[d,e]	Cesium-137 pCi/g[d,e]
Alfalfa	Riverview	FDA	3.3 ± 1.0	0.0031 ± 0.0011	<0.24	<0.028
		FDA	1.43 ± 0.63	<0.0012	<0.20	<0.030
		STL	0.98 ± 0.22	0.00082 ± 0.0017	0.022 ± 0.039	0.00022 ± 0.0048
Apples	Sagemoor	FDA	0.77 ± 0.62	<0.0012	<0.22	<0.026
		FDA	0.97 ± 0.62	<0.0014	<0.23	<0.028
		STL	0.57 ± 0.22	-0.0027 ± 0.0041	0.0031 ± 0.056	0.0028 ± 0.0064
Potato tuber	Sunnyside	FDA	3.4 ± 0.7	<0.0037	<0.27	<0.029
		FDA	3.3 ± 0.8	<0.0018	<0.28	<0.031
		STL	4.4 ± 0.7	0.0011 ± 0.0051	0.024 ± 0.038	-0.0043 ± 0.0048
Potato tuber	Sagemoor	FDA	3.8 ± 0.8	<0.0012	<0.24	<0.030
		FDA	4.0 ± 0.8	<0.0012	<0.25	<0.029
		STL	3.9 ± 0.5	-0.0015 ± 0.0049	-0.018 ± 0.038	0.00030 ± 0.0045

(a) Samples analyzed by Severn Trent Laboratories, Inc., Richland, Washington.
(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 are 2 standard deviations. Less than (<) values are minimum detectable activities at 3 standard deviations.
FDA = U.S. Food and Drug Administration.
STL = Severn Trent Laboratories, Inc., Richland.

and Berry 1968, p. 126). Strontium-90 was observed in two alfalfa samples and one concord grapes sample. Within the analytical error associated with each analysis, the results between the U.S. Food and Drug Administration and TestAmerica Richland are in agreement. Strontium-90 was detected in one of two potato tubers analyzed by the U.S. Food and Drug Administration from the Horn Rapids area; however, the error associated with the analysis was quite high. Strontium-90 was not detected by TestAmerica Richland in the sample from the Horn Rapids area. Strontium-90 was not detected in the two samples analyzed by the U.S. Food and Drug Administration from the Sunnyside area, and also was not detected in the sample analyzed by TestAmerica Richland (the sample error was 700%).

10.17.2 Effluent Monitoring and Environmental Monitoring Near Facilities and Operations Quality Assurance Programs

J. J. Dorian

The Effluent Monitoring and Near-Facility Environmental Monitoring Programs were subject to the quality assurance 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-1-1997 Edition) 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 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 the requirements of these plans. 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-17603, APP. 2.

10.17.2.2 Analytical Results Quality Assurance

H. K. Meznarich and E. J. 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 10.17.7 provides a summary of the analytical laboratories used for analyzing Hanford Site effluent monitoring and near-facility monitoring samples in 2007.

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, 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 2007: the EPA studies (i.e., water pollution, soil study, and

Table 10.17.7. A Summary of Hanford Site Laboratories Used by Site Contractors and Types of Effluent Monitoring and Near-Facility Monitoring Samples Analyzed, 2007

	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.		
Analytical Laboratory	Air	Water	Air	Water	Air	Water	Air	Water	Other
Waste Sampling and Characterization Facility[a]	X	X			X	X	X	X	X
222-S Analytical Laboratory[b]				X					X
TestAmerica Laboratories, Inc., Richland	X	X	X		X	X			
Radiochemical Processing Laboratory[c]	X	X	X						

(a) Operated by Fluor Hanford, Inc.
(b) Operated by Advanced Technologies and Laboratories International, Inc.
(c) Operated by Pacific Northwest National Laboratory.

MRAD study), 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. 144 and 150 and EPA Soil Studies Nos. 57 and 59. Of the 414 reported analytes, 407 results were acceptable while 7 were unacceptable, for a total acceptable rate of 98%. In the MRAD soil study, only strontium-90 was analyzed and was acceptable. In the DOE Mixed Analyte Performance Evaluation Program study (MAPEP-07-Study 17), samples containing 229 different radionuclides and analytes were submitted to the Waste Sampling and Characterization Facility for analysis. Of the 229 reported radionuclide analytes, 218 results were acceptable while 11 were unacceptable, for a total acceptable rate of 95%. (Note: MAPEP-07-Study 18 was not available until January 2008.) In the National Institute of Standards and Technology Radiochemistry Intercomparison Program study, samples containing strontium-90, isotopic plutonium, isotopic uranium, and americium-241 in filters and soils were submitted to the Waste Sampling and Characterization Facility for 50 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 10.17.8.

The 222-S Analytical Laboratory (located at the Hanford Site) received accreditation from the American Industrial Hygiene Association and the Washington State Department of Ecology in 2007. Analytical performance was evaluated by its participation in five different laboratory intercomparison studies in 2007. The laboratory added the Environmental Resource Associates soil study for obtaining Washington State Department of Ecology accreditation for non-radiological constituents, and added the Environmental Resource Associates' MRAD study, a radiological performance evaluation study, when the DOE Mixed Analyte Performance Evaluation Program suspended its Round 18 study in late 2007. The laboratory's 2007 studies included Environmental Resource Associates water pollution studies 147 and 153, Environmental Resource

Table 10.17.8. The Hanford Site's Waste Sampling and Characterization Facility[a] Performance on DOE Mixed Analyte Performance Evaluation Program Samples, MRAD, and National Institute of Standards and Technology Radiochemistry Intercomparison Program Samples, 2007

Media	Program	Radionuclide	Number of Results Reported	Number of Results Within Control Limits
Air filters	MAPEP	^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{134}Cs, ^{137}Cs, $^{233/234}$U, ^{238}Pu, ^{238}U, $^{239/240}$Pu, ^{241}Am, gross alpha, gross beta	14	13 (Failed ^{134}Cs)
	NRIP	^{90}Sr, $^{233/234}$U, ^{238}Pu, ^{238}U, ^{241}Am	5	5
Soil	MAPEP	^{40}K, ^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{99}Tc, ^{134}Cs, ^{137}Cs, $^{233/234}$U, ^{238}Pu, ^{238}U, $^{239/240}$Pu, ^{241}Am	14	13 (Failed ^{90}Sr)
	NRIP	$^{233/234}$U, ^{238}Pu, ^{238}U, $^{239/240}$Pu, ^{241}Am	6	6
	ERA (MRAD study)	^{90}Sr	1	1
Vegetation	MAPEP	^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{134}Cs, ^{137}Cs, $^{233/234}$U, ^{238}Pu, ^{238}U, $^{239/240}$Pu, ^{241}Am	12	6 (Failed GEA for ^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{134}Cs, and ^{137}Cs due to reporting wrong units. Acceptable after correction.)
Water	MAPEP	^{3}H, ^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{99}Tc, ^{134}Cs, ^{137}Cs, $^{233/234}$U, ^{238}Pu, ^{238}U, $^{239/240}$Pu, ^{241}Am, gross alpha, gross beta	16	16

(a) Onsite laboratory operated by Fluor Hanford, Inc.
ERA = Environmental Resource Associates.
GEA = Gamma energy analysis.
MAPEP = Mixed Analyte Performance Evaluation Program.
NRIP = National Institute of Standards and Technology Radiochemistry Intercomparison Program.

Associates soil studies 58 and 60, Mixed Analyte Performance Evaluation Program study 17, Environmental Resource Associates MRAD study 008, and the International Atomic Energy Agency annual worldwide open proficiency test (IAEA-CU-2007-03 and IAEA-CU-2007-04). In addition, the 222-S Analytical Laboratory 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.

The 222-S Analytical Laboratory received and analyzed samples containing 342 different analytes and compounds during participation in the Environmental Resource Associates water pollution studies. Of the 342 reported analytes, 338 results were acceptable while 4 were unacceptable, for a total acceptable rate of 98.8%. For the 2 soil studies, a total of 160 analytes were reported, of which 158 were acceptable, for an overall score of 98.8%. For the Mixed Analyte Performance Evaluation Program-17 study, 49 of 52 radiological results were acceptable, for an acceptable rate of 94.2%; 79 of 80 non-radiological (i.e., inorganic and organic) results reported on the same study were acceptable, for a score of 98.8%. For the MRAD study, 26 of 26 results were acceptable, for an acceptable rate of 100%. The International Atomic Energy Agency worldwide open proficiency test on the determination of alpha- and gamma-emitting radionuclides resulted in 18 of 20 acceptable accuracy results, for a score of 90.0%. Performance evaluation results for the 222-S Analytical Laboratory are presented in Tables 10.17.9 through 10.17.11.

Table 10.17.9. The Hanford Site's 222-S Laboratory[a] Performance on DOE Mixed Analyte Performance Evaluation Program[b] Samples and MRAD, 2007

Media	Radionuclide	Number of Results Reported	Number of Results Within Control Limits
MAPEP			
Air filters	^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{235}U, ^{238}Pu, ^{238}U, $^{239/240}$Pu, ^{241}Am, gross alpha, gross beta	14	12 (Incorrect value for ^{90}Sr and ^{241}Am)
Soil	^{40}K, ^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{241}Am, total U	10	10
Vegetation	^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{134}Cs, ^{137}Cs, ^{235}U, ^{238}Pu, ^{238}U, $^{239/240}$Pu, ^{241}Am	11	10 (Incorrect value for ^{137}Cs)
Water	^{3}H, ^{54}Mn, ^{57}Co, ^{60}Co, ^{63}Ni, ^{65}Zn, ^{90}Sr, ^{99}Tc, ^{134}Cs, ^{137}Cs, ^{235}U, ^{238}Pu, ^{238}U, $^{239/240}$Pu, ^{241}Am, gross alpha, gross beta	17	17
MRAD			
Air filters	^{60}Co, ^{65}Zn, ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{241}Am, gross alpha, gross beta	8	8
Soil	^{60}Co, ^{65}Zn, ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{241}Am	6	6
Water	^{3}H, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{238}Pu, $^{239/240}$Pu, ^{241}Am, total U, gross alpha, gross beta	12	12

(a) Onsite laboratory operated by Advanced Technologies and Laboratories International, Inc.
(b) The data represent values from the MAPEP-17 study.
MAPEP = Mixed Analyte Performance Evaluation Program.
MRAD = Environmental Resource Associates Multi-Media Radiochemistry Study.

Table 10.17.10. The Hanford Site's 222-S Laboratory[a] Performance on EPA Laboratory Water Pollution Inorganic and Organic Studies, 2007

Laboratory	Water Pollution Study (WP-147) June 2007 % Acceptable	Water Pollution Study (WP-153) December 2007 % Acceptable
222-S Laboratory	98.8[b]	98.8[c]

(a) Onsite laboratory operated by Advanced Technologies and Laboratories International, Inc.
(b) 171 of 173 analytes were evaluated as acceptable.
(c) 167 of 169 analytes were evaluated as acceptable.

Table 10.17.11. The Hanford Site's 222-S Laboratory[a] Performance on International Atomic Energy Agency Worldwide Open Proficiency Test on the Determination of Gamma-Emitting Radionuclides

Media	Radionuclide	Number of Results Reported	Number of Results Within Control Limits
Soil	^{54}Mn, ^{60}Co, ^{65}Zn, ^{134}Cs, ^{137}Cs, ^{241}Am	6	6
Water	^{54}Mn, ^{60}Co, ^{65}Zn, ^{134}Cs, ^{137}Cs, ^{241}Am	6	6
Spinach	^{40}K, ^{90}Sr, ^{137}Cs, ^{234}U, ^{238}Pu, ^{238}U, $^{239/240}Pu$, ^{241}Am	8	6 (False positives reported for $^{239/240}Pu$ and ^{241}Am.)

(a) Onsite laboratory operated by Advanced Technologies and Laboratories International, Inc.

10.18 References

10 CFR 835. 2007. "Occupational Radiation Protection." *Code of Federal Regulations*, U.S. Department of Energy.

40 CFR 50. 2008. "National Primary and Secondary Ambient Air Quality Standards." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

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

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

40 CFR 122. 2008. "EPA Administered Permit Programs: The National Pollutant Discharge Elimination System." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 136, Appendix B. 2007. "Definition and Procedure for the Determination of the Method Detection Limit-Revision 1.11." *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 265. 2006. "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 265.93(b) and (d). "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; Preparation, Evaluation, and Response." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

50 CFR 17. 2008. "Endangered and Threatened Wildlife and Plants." *Code of Federal Regulations*, U.S. Department of Interior.

50 CFR 17.11. 2008. "Endangered and Threatened Wildlife." *Code of Federal Regulations*, U.S. Department of Interior.

50 CFR 17.12. 2008. "Endangered and Threatened Plants." *Code of Federal Regulations*, U.S. Department of Interior.

Ames BN, R Magaw, and LS Gold. 1987. "Ranking Possible Carcinogenic Hazards." *Science* 236:271-280.

AP-42. 1995. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*, Fifth Edition. Office of Air Quality Planning and Standards, Office of Air and Radiation, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.

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

ARH-CD-775. 1976. *Geohydrologic Study of the West Lake Basin*. RE Gephart, PA Eddy, RC Arnett, and GA Robinson, Atlantic Richfield Hanford Company, Richland, Washington.

ASME NQA-1-1997 Edition. 1997. *Quality Assurance Requirements for Nuclear Facility Applications*. American Society of Mechanical Engineers, New York.

Atallah S. 1980. "Assessing and Managing Industrial Risk." *Chemical Engineering* 9/8/80:94-103.

Atomic Energy Act of 1954. 1954. Chapter 1073, 42 USC 2011 et seq.

Bald and Golden Eagle Protection Act. 1992. Public Law 87-884, as amended, 16 USC 688 et seq.

Beasley TM, LA Ball, and JE Andrews III. 1981. "Hanford-Derived Plutonium in Columbia River Sediments." *Science* 214(20):913-915.

BHI-01153, Rev. 0. 1998. *Aquifer Sampling Tube Completion Report: 100 Area and Hanford Townsite Shorelines*. RE Peterson, JV Borghese, and DB Erb, Bechtel Hanford, Inc., Richland, Washington.

BNWL-1790. 1973. *Raptorial Birds of the U.S.A.E.C. Hanford Reservation, South-Central Washington*. RR Olendorff, Pacific Northwest Laboratories, Richland, Washington.

BNWL-1979. 1976. *Environmental Surveillance at Hanford for CY-1975*. DR Speer, JJ Fix, and PJ Blumer, Pacific Northwest Laboratory, Richland, Washington.

BNWL-2305. 1977. *Association of Hanford Origin Radionuclides with Columbia River Sediment*. DE Robertson and JJ Fix, Pacific Northwest Laboratory, Richland, Washington.

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, 33 USC 1251 et seq.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980. 1980. Public Law 96-510, as amended, 42 USC 9601 et seq. Accessed April 22, 2008, at http://www.epa.gov/region5/defs/html/cercla.htm.

Conway CJ and KL Pardieck. 2006. "Population Trajectory of Burrowing Owls (*Athene cunicularia*) in Eastern Washington." *Northwest Science* 80:292-297.

Conway CJ, MD Smith, and V Garcia. 2002. *Population Ecology and Habitat Use of Burrowing Owls in Eastern Washington, Annual Report for 2001*. U.S. Geological Survey Biological Resources Division, Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson, Arizona.

Conway CJ, V Garcia, MD Smith, and LA Ellis. 2003. *Population Ecology and Habitat Use of Burrowing Owls in Eastern Washington, Annual Report for 2002*. U.S. Geological Survey Biological Resources Division, Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson, Arizona.

Conway CJ, V Garcia, and LA Ellis. 2004. *Population Ecology and Habitat Use of Burrowing Owls in Eastern Washington, Annual Report for 2003*. Wildlife Research Report 04-06, U.S. Geological Survey Biological Resources Division, Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson, Arizona.

Conway CJ, LA Ellis, V Garcia, and MD Smith. 2005. *Population Ecology and Habitat Use of Burrowing Owls in Eastern Washington, 2004 Annual Report*. Wildlife Research Report 2005-02, U.S. Geological Survey Biological Resources Division, Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson, Arizona.

Cox SE, PR Bell, JS Lowther, and PC VanMetre. 2004. *Vertical Distribution of Trace Element Concentrations and Occurrence of Metallurgical Slag Particles in Accumulated Bed Sediments of Lake Roosevelt, Washington, September 2002*. Scientific Investigations Report 2004-2005, U.S. Geological Survey.

Cushing CE, DG Watson, AJ Scott, and JM Gurtisen. 1981. "Decrease of Radionuclides in Columbia River Biota Following Closure of the Hanford Reactors." *Health Physics* 41:59-67.

Dauble DD and DG Watson. 1997. "Status of Fall Chinook Salmon Populations in the Mid-Columbia River: 1948-1992." *North American Journal of Fisheries Management* 17:283-300.

Dechant JA, ML Sondreal, DH Johnson, LD Igl, CM Goldade, PA Rabie, and BR Euliss. 2002. *Effects of Management Practices on Grassland Birds: Burrowing Owl.* U.S. Geological Survey Northern Prairie Wildlife Research Center, Jamestown, North Dakota.

Dinman BD. 1980. "The Reality and Acceptance of Risk." *Journal of the American Medical Association (JAMA)* (11):1226-1228.

DOE/EH-0173T. 1991. *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance.* U.S. Department of Energy, Washington, D.C.

DOE/EH-0676. 2004. *User's Guide, Version 1. RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation.* Interagency Steering Committee on Radiation Standards Technical Report 2004-02, U.S. Department of Energy, Washington, D.C.

DOE M 231.1-1A. "Environment, Safety, and Health Reporting Manual."

DOE Order 414.1C. 2005. "Quality Assurance." U.S. Department of Energy, Washington, D.C.

DOE Order 435.1. 1999. "Radioactive Waste Management." U.S. Department of Energy, Washington, D.C.

DOE Order 450.1. 2003. "Environmental Protection Program." U.S. Department of Energy, Washington, D.C.

DOE Order 5400.5. 1990. "Radiation Protection of the Public and the Environment." U.S. Department of Energy, Washington, D.C.

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

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-92-12, Rev. 1. 1992. *Sampling and Analysis of 100 Area Springs.* U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-92-67, Draft B. 1992. *Final Remedial Investigation/Feasibility Study - Environmental Assessment Report for the 1100-EM-1 Operable Unit, Hanford.* U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-94-150, Rev. 0. 1994. *Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington.* RE Fitzner and SG Weiss, Pacific Northwest Laboratory and CH2M HILL Hanford, Inc. for U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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.

DOE/RL-96-68, Rev 2. 1996. *Hanford Analytical Services Quality Assurance Requirements Document.* U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-96-77, Rev 0. 1996. *Programmatic Agreement Among the U.S. Department of Energy, Richland Operations Office, the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office for the Maintenance, Deactivation, Alteration, and Demolition of the Built Environment on the Hanford Site, Washington.* U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2006-20. 2007. *The Second CERCLA Five-Year Review Report for the Hanford Site.* U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2006-24, Rev. 0. 2006. *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit.* U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-18. 2007. *Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit and the Appended Sampling and Analysis Plan.* U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-20. 2007. *Hanford Integrated Groundwater and Vadose Zone Management Plan.* U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-21, Draft A. 2007. *River Corridor Baseline Risk Assessment Report*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-28, Draft A. 2007. *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2007-33, Draft A. 2007. *Proposed Plan for Remediation of the 200-ZP-1 Groundwater Operable Unit*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-01. 2008. *Hanford Site Groundwater Monitoring for Fiscal Year 2007*. Prepared by MJ Hartman and WD Webber (eds.) for the U.S. Department of Energy, Richland, Washington.

DOE/RL-2008-03. 2008. *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2007*. Prepared by DJ Rokkan (Fluor Hanford, Inc.), K Rhoads (Pacific Northwest National Laboratory), RH Anderson (Fluor Federal Services), and CJ Perkins (Energy*Solutions*) for the U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-STD-1153-2002. 2002. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. U.S. Department of Energy, Washington, D.C.

DOH 320-047. 2008. *Hanford Environmental Oversight Program 2006 Data Summary Report*. Washington State Department of Health, Olympia, 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 through February 12, 2008, Olympia, Washington. Accessed April 22, 2008, at http://www.hanford.gov/?page=91&parent=0.

Eisenbud M. 1987. *Environmental Radioactivity from Natural, Industrial, and Military Sources*. Third Edition, Chapter 5, Academic Press, Inc., New York.

EML-621. June 2003. *Semi-Annual Report of the Department of Energy, Office of Environmental Management, Quality Assessment Program*. PD Greenlaw and A Berne, Environmental Measurements Laboratory, U.S. Department of Energy, New York.

Endangered Species Act of 1973. 1973. Public Law 93-205, as amended, 16 USC 1531 et seq.

EPA. 1986. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, Third Edition*. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA 402-B-92-001. 1992. *User's Guide for CAP88-PC, Version 1.0*. Office of Radiation Programs, U.S. Environmental Protection Agency, Las Vegas, Nevada.

EPA 402-R-00-004. 2000. *Updated User's Guide for CAP88-PC, Version 2.0*. Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C.

EPA 520/1-80-012. 1980. *Upgrading Environmental Radiation Data: Health Physics Society Committee Report HPSR-1 (1980)*. U.S. Environmental Protection Agency, Washington, D.C.

EPA 520/1-89-005. 1989. *Risk Assessment Methodology: Draft Environmental Impact Statement for Proposed NESHAPS for Radionuclides, Vol. 1, Background Information Document*. U.S. Environmental Protection Agency, Washington, D.C.

EPA-570/9-76-003. 1976. *National Interim Primary Drinking Water Regulations*. U.S. Environmental Protection Agency, Office of Water Supply, Washington, D.C.

EPA 822-R-96-001. 1996. *Drinking Water Regulations and Health Advisories*. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

EPA QA/R-5. 1994. *Requirements for Quality Assurance Project Plans for Environmental Data Operations*. U.S. Environmental Protection Agency, Washington, D.C.

EPA/ROD/R10-95/100. 1995. *Record of Decision for the US DOE Hanford Environmental Restoration Disposal Facility Remedial Action*. U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

FSWO-OEM-001. 2008. *Operational Environmental Monitoring*. SM McKinney, Energy*Solutions*, Richland, Washington.

Gibbons GJ. 2000. *An Investigation of the Origin of ^{152}Eu in Columbia River Sediments*. Masters Thesis, Idaho State University, Department of Physics, Pocatello, Idaho.

HNF-EP-0527-17. 2008. *Environmental Releases for Calendar Year 2007*. DJ Rokkan, Fluor Hanford, Inc., Richland, Washington.

HW-73672. 1962. *Dispersion of 300 Area Liquid Effluent in the Columbia River*. GE Backman, Hanford Atomic Products Operation, General Electric Company, Richland, Washington.

IAEA-CU-2007-03. 2007. *World-Wide Open Proficiency Test on the Determination of Radionuclides in Water, Soil and Vegetation*. Accessed May 13, 2008, at http:///www.iaea.or.at/programmes/aqcs/interlab_studies.shtml.

IAEA-CU-2007-04. 2007. *ALMERA Proficiency Test on the Determination of Radionuclides in Water, Soil and Vegetation*. Accessed May 13, 2008, at http:///www.iaea.or.at/programmes/aqcs/interlab_studies.shtml.

ISCORS. 2002. *A Method for Estimating Radiation Risk from TEDE*. ISCORS Technical Report No. 1, Interagency Steering Committee on Radiation Standards, Washington, D.C. Accessed June 11, 2008, at http://homer.ornl.gov/oepa/guidance/risk/iscors.pdf.

Jenkins OP. 1922. *Underground Water Supply of the Region About White Bluffs and Hanford*. State of Washington Department of Conservation and Development, Olympia, Washington.

Johnson VG, RE Peterson, and KB Olsen. 2005. "Heavy Metal Transport and Behavior in the Lower Columbia River, USA." *Environmental Monitoring and Assessment* 100:271-289.

Klute DS, LW Ayers, MT Green, WH Howe, SL Jones, JA Shaffer, SR Sheffield, and TS Zimmerman. 2003. *Status Assessment and Conservation Plan for the Western Burrowing Owl in the United States*. U.S. Department of Interior, Fish and Wildlife Service, Biological Technical Publication FWS/BTP-R6001-2003, Washington, D.C.

Larsen EM, JM Azerrad, and N Nordstrom (eds.). 2004. Priority Habitat and Species Management Recommendations, Volume IV: Birds. Washington Department of Fish and Wildlife, Olympia, Washington.

MAPEP-07 Study 17. 2007. *Study 17 Participating Laboratory Reports*. U.S. Department of Energy, Mixed Analyte Performance Evaluation Program, Radiological and Environmental Sciences Laboratory, Idaho Falls, Idaho. Accessed May 13, 2008, at http://www/inl.gov/resl/mapep/reports.htm.

Mason B and LG Berry. 1968. *Elements of Mineralogy*. W. H. Freemen and Company, San Francisco, California.

Migratory Bird Treaty Act. 1918. Chapter 128, as amended, 16 USC 703-712.

Morgan G, S Corbett, and J Wlodarczyk. 1998. "Air Pollution and Hospital Admissions in Sydney, Australia, 1990 to 1994." *American Journal of Public Health* 88:1761-1766.

National Council on Radiation Protection and Measurements. 1975. *Natural Background Radiation in the United States*. NCRP Report No. 45, Washington, D.C.

National Council on Radiation Protection and Measurements. 1991. *Some Aspects of Strontium Radiobiology*. NCRP Report No. 110, Washington, D.C.

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

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

National Oceanic and Atmospheric Administration (NOAA) Fisheries. 2008. *Species Under the Endangered Species Act (ESA)*. Office of Protected Resources, Seattle, Washington. Accessed on May 13, 2008, at http://www.nmfs.noaa.gov/pr/species/esa.

National Research Council. 1980. *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980*. Committee on the Biological Effects of Ionizing Radiations, National Academy Press, Washington, D.C.

National Research Council. 1990. *Health Effects of Exposure to Low Levels of Ionizing Radiation*. Committee on the Biological Effects of Ionizing Radiations, National Academy Press, Washington, D.C.

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

NERL-Ci-0045. December 30, 1998. *National Standards for Water Proficiency Testing Studies, Criteria Document*. U.S. Environmental Protection Agency, Washington, D.C.

Ostro BD, S Hurley, and MJ Lipsett. 1999. "Air Pollution and Daily Mortality in the Coachella Valley, California: A Study of PM10 Dominated by Coarse Particles." *Environmental Research* 81:231-238.

Palsson SE, BJ Howard, and SM Wright. 2006. "Prediction of Spatial Variation in Global Fallout of ^{137}Cs Using Precipitation." *Science of the Total Environment* 367:745-756.

Patton GW, AT Cooper, and MR Tinker. 1997. "Ambient Air Sampling for Tritium - Determination of Breakthrough Volumes and Collection Efficiencies for Silica-Gel Absorbent." *Health Physics* 72:397-407.

PNL-3127. 1980. *Radiological Survey of Exposed Shorelines and Islands of the Columbia River Between Vernita and the Snake River Confluence*. MJ Sula, Pacific Northwest Laboratory, Richland, Washington.

PNL-3212. 1981. *Raptors of the Hanford Site and Nearby Areas of Southcentral Washington*. RE Fitzner, WH Rickard, LL Cadwell, and LE Rogers, Pacific Northwest Laboratory, Richland, Washington.

PNL-5289. 1984. *Investigation of Ground-Water Seepage from the Hanford Shoreline of the Columbia River*. WD McCormack and JMV Carlile, Pacific Northwest Laboratory, Richland, Washington.

PNL-6584 (3 vols). 1988. *GENII - The Hanford Environmental Radiation Dosimetry Software System*. BA Napier, RA Peloquin, DL Strenge, and JV Ramsdell, Pacific Northwest Laboratory, Richland, Washington.

PNL-7500. 1990. *1988 Hanford Riverbank Springs Characterization Report*. RL Dirkes, Pacific Northwest Laboratory, Richland, Washington.

PNL-7662. 1991. *An Evaluation of the Chemical, Radiological, and Ecological Conditions of West Lake on the Hanford Site*. TM Poston, KR Price, and DR Newcomer, Pacific Northwest Laboratory, Richland, Washington.

PNL-8073. 1992. *Hanford Site Ground-Water Monitoring for 1990*. JC Evans, RW Bryce, and DJ Bates, Pacific Northwest Laboratory, Richland, Washington.

PNL-8148. 1992. *Hanford Site Environmental Report for Calendar Year 1991*. RK Woodruff, RW Hanf, and RE Lundgren (eds.), Pacific Northwest Laboratory, Richland, Washington.

PNL-8531. 1993. *Columbia River Monitoring: Distribution of Tritium in Columbia River Water at the Richland Pumphouse*. RL Dirkes, Pacific Northwest Laboratory, Richland, Washington.

PNL-8580. 1993. *Water Level Measurements for Modeling Hydraulic Properties in the 300-FF-5 and 100 Aggregate Area Operable Units*. MD Campbell, WJ McMahon, and KR Simpson, Pacific Northwest Laboratory, Richland, Washington.

PNL-8654. 1993. *Columbia River Monitoring: Summary of Chemical Monitoring Along Cross Sections at Vernita Bridge and Richland*. RL Dirkes, GW Patton, and BL Tiller, Pacific Northwest Laboratory, Richland, Washington.

PNL-8789. 1993. *Investigation of Exposure Rates and Radionuclide and Trace Metal Distributions Along the Hanford Reach of the Columbia River*. AT Cooper and RK Woodruff, Pacific Northwest Laboratory, Richland, Washington.

PNL-8817. 1993. *Contribution of Hanford Liquid Effluents to Strontium-90 Levels in Offsite Soils*. RE Jaquish, Pacific Northwest Laboratory, Richland, Washington.

PNL-8942. 1993. *Habitat Types on the Hanford Site: Wildlife and Plant Species of Concern*. JL Downs, WH Rickard, CA Brandt, LL Cadwell, CE Cushing, DR Geist, RM Mazaika, DA Neitzel, LE Rogers, MR Sackschewsky, and JJ Nugent, Pacific Northwest Laboratory, Richland, Washington.

PNL-9394. 1994. *Ecotoxicity Literature Review of Selected Hanford Site Contaminants*. CJ Driver, Pacific Northwest Laboratory, Richland, Washington.

PNL-10174. 1994. *A Qualitative Evaluation of Radionuclide Concentrations in Hanford Site Wildlife, 1983 through 1992.* TM Poston and AT Cooper, Pacific Northwest Laboratory, Richland, Washington.

PNL-10400. 1995. *Identification of Contaminants of Concern, Columbia River Comprehensive Impact Assessment—Draft.* BA Napier, NC Batishko, DA Heise-Craff, MF Jarvis, and SF Snyder, Pacific Northwest Laboratory, Richland, Washington.

PNL-10535. 1995. *Environmental Monitoring of Columbia River Sediments: Grain-Size Distribution and Containment Association.* ML Blanton, WW Gardiner, and RL Dirkes, Pacific Northwest Laboratory, Richland, Washington.

PNL-10698. 1995. *Hanford Site Ground-Water Monitoring for 1994.* PE Dresel, PD Thorne, SP Luttrell, BM Gillespie, WD Webber, JK Merz, JT Rieger, MA Chamness, SK Wurstner, and BE Optiz, Pacific Northwest Laboratory, Richland, Washington.

PNL-10817. 1995. *Hydrochemistry and Hydrogeologic Conditions Within the Hanford Upper Baslat Confined Aquifer System.* FA Spane, Jr. and WD Webber, Pacific Northwest Laboratory, Richland, Washington.

PNNL-11518. 1997. *Investigation of Anatomical Anomalies in the Hanford Site Mule Deer.* BL Tiller, GE Dagle, LL Cadwell, TM Poston, and A Oganesian, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-11933. 1998. *Survey of Radiological Contaminants in the Near Shore Environment at the Hanford Site 100-N Reactor Area.* SP Van Verst, CL Albin, GW Patton, ML Blanton, TM Poston, AT Cooper, and EJ Antonio, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13417. 2001. *Simultaneously-Extracted Metals/Acid-Volatile-Sulfide and Total Metals in Surface Sediment from the Hanford Reach of the Columbia River and the Lower Snake River.* GW Patton and EA Crecelius, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13487. 2001. *Hanford Site Environmental Report for Calendar Year 2000.* TM Poston, RW Hanf, RL Dirkes, and LF Morasch (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13688. 2001. *Vascular Plants of the Hanford Site.* MR Sackschewsky and JL Downs, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13692. 2002. *Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area.* GW Patton, SP Van Verst, BL Tiller, EJ Antonio, and TM Poston, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13910. 2002. *Hanford Site Environmental Report for Calendar Year 2001.* TM Poston, RW Hanf, RL Dirkes, and LF Morasch (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14295. 2003. *Hanford Site Environmental Report for Calendar Year 2002.* TM Poston, RW Hanf, RL Dirkes, and LF Morasch (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14444. 2003. *Aquifer Sampling Tube Results for Fiscal Year 2003.* MJ Hartman and RE Peterson, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14548. 2004. *Hanford Site Groundwater Monitoring for Fiscal Year 2003.* MJ Hartman, LF Morasch, and WD Webber, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14687. 2004. *Hanford Site Environmental Report for Calendar Year 2003.* TM Poston, RW Hanf, RL Dirkes, and LF Morasch (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14687, APP. 1. 2004. *Hanford Site Environmental Surveillance Data Report for Calendar Year 2003.* LE Bisping, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-15160. 2005. *Hanford Site Climatological Data Summary 2004 with Historical Data.* DJ Hoitink, JV Ramsdell Jr., KW Burk, and WJ Shaw, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-15222. 2005. *Hanford Site Environmental Report for Calendar Year 2004.* TM Poston, RW Hanf, and RL Dirkes (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-15892. 2006. *Hanford Site Environmental Report for Calendar Year 2005*. TM Poston, RW Hanf, RL Dirkes, and LF Morasch (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-15892, APP. 1. 2006. *Hanford Site Environmental Surveillance Data Report for Calendar Year 2005*. LE Bisping, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-16369. 2007. *Hanford Site Environmental Surveillance Master Sampling Schedule for Calendar Year 2007*. LE Bisping, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-16435. 2007. *Limited Field Investigation Report for Uranium Contamination in the 300-FF-5 Operable Unit at the 300 Area, Hanford Site, Washington*. BA Williams, CF Brown, W Um, MJ Nimmons, RE Peterson, BN Bjornstad, DC Lanigan, RJ Serne, FA Spane, and ML Rockhold, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-16623. 2007. *Hanford Site Environmental Report for Calendar Year 2006*. TM Poston, RW Hanf, JP Duncan, and RL Dirkes (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-16744. 2007. *Surface Environmental Surveillance Procedures Manual, PNL-MA-580, Rev. 5*. RW Hanf, TM Poston, and LE Bisping (eds.), Pacific Northwest National Laboratory, Richland, Washington.

PNNL-16761. 2007. *Evaluation and Screening of Remedial Technologies for Uranium at the 300-FF-5 Operable Unit, Hanford Site, Washington*. MJ Nimmons, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-16805. 2007. *Investigation of the Hyporheic Zone at the 300 Area, Hanford Site*. BG Fritz, NP Kohn, TJ Gilmore, D McFarland, EV Arntzen, RD Mackley, GW Patton, DP Mendoza, and AL Bunn, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-16894. 2007. *Investigation of the Strontium-90 Contaminant Plume along the Shoreline of the Columbia River at the 100-N Area of the Hanford Site*. DP Mendoza, BG Fritz, GW Patton, TJ Gilmore, MJ Hartman, R Mackley, FA Spane, BN Bjornstad, MD Sweeney, and RE Clayton, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-16990. 2007. *Summary of Radiological Monitoring of Columbia and Snake River Sediment, 1988 Through 2004*. GW Patton and RL Dirkes, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-17603, APP. 1. 2008. *Hanford Site Environmental Surveillance Data Report for Calendar Year 2007*. LE Bisping, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-17603, APP. 2. 2008. *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 2007*. CJ Perkins, MC Dorsey, SM McKinney, and RC Roos, Energy*Solutions*, LLC for Pacific Northwest National Laboratory, Richland, Washington.

PNWD-2223, HEDR. 1994. *Radionuclide Releases to the Columbia River from Hanford Operations, 1944-1971*. CM Heeb and DJ Bates, Battelle Pacific Northwest Division, Richland, Washington.

Poston TM, RE Jaquish, EJ Antonio, and GW Patton. 1998. "Strontium-90 in Alfalfa (*Medicago sativa*) Around the Hanford Site in Southeastern Washington State: An Evaluation of Surveillance Data." *Journal of Environmental Radioactivity* 39(1):87-105.

RCW 77.12.655. "Habitat Buffer Zones for Bald Eagles – Rules." *Revised Code of Washington*, Olympia, Washington.

Resource Conservation and Recovery Act of 1976. 1976. Public Law 94-580, as amended, 42 USC 6901 et seq. Accessed April 22, 2008, at http://www.epa.gov/region5/defs/html/rcra.htm.

RHO-RE-ST-12P. 1984. *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*. MJ Graham, GV Last, and KR Fecht, Rockwell Hanford Operations, Richland, Washington.

Rhoads K, BG Fritz, LH Staven, LP Diediker, and DL Dyekman. 2005. "Comparison of Measured and Model Radionuclide Air Concentrations in the Environment Following Emissions from the Hanford Site." *Health Physics* 89(1):S40-S40 Suppl. S JUL 2005.

ROD. 1996. *Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units*. Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

ROD. 1997. *Declaration of the Record of Decision for the 200-UP-1 Operable Unit*. Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Rosnick R. 2007. *CAP88-PC Version 3.0 User Guide*. Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C.

Sagan LA. 1987. *Health Physics Society Official Journal: Special Issue on Radiation Hormesis* 52(5).

Schwartz J. 1994. "PM_{10}, Ozone, and Hospital Admissions for the Elderly in Minneapolis-St. Paul, Minnesota." *Archives of Environmental Health* 49(5):366-373.

SGW-34011, Rev. 0. 2007. *Data Quality Objectives Summary Report Supporting the 200-PO-1 Groundwater Operable Unit*. GD Cummins, Fluor Hanford, Inc., Richland, Washington.

SGW-35028. 2007. *Aquifer Sampling Tube Results for Fiscal Year 2007*. MJ Hartman and RO Mahood, Fluor Hanford, Inc., Richland, Washington.

Smith MR, PW Mattocks, Jr., and KM Cassidy. 1997. "Breeding Birds of Washington State, Vol. 4." In *Washington State Gap Analysis, Final Report*, KM Cassidy, CE Grue, MR Smith, and KM Dvornich (eds.), Seattle Audubon Society Publications in Zoology No. 1, Seattle, Washington.

Soll J, JA Hall, R Pabst, and C Soper (eds.). 1999. *Biodiversity Inventory and Analysis of the Hanford Site – Final Report 1994-1999*. The Nature Conservancy of Washington, Seattle, Washington.

Takeda A, T Hirofumi, Y Takaku, S Hisamatsu, and N Masami. 2006. "Accumulation of Uranium Derived from Long-Term Fertilizer Applications in a Cultivated Andisol." *Total Science of the Environment* 365:924-931.

Tiller BL and TM Poston. 2000. "Mule Deer Antlers as Biomonitors of Sr-90 on the Hanford Site." *Journal of Environmental Radioactivity* 47:29-44.

Tiller BL, GE Dagle, and LL Cadwell. 1997. "Testicular Atrophy in a Mule Deer Population." *Journal of Wildlife Management* 33:420-429.

Travis CC and ST Hester. 1990. "Background Exposure to Chemicals: What Is the Risk?" *Risk Analysis* 10(4).

United Nations Science Committee on the Effects of Atomic Radiation. 1988. *Sources, Effects and Risks of Ionizing Radiation*. Report E.88.1X.7, United Nations, New York.

U.S. Fish and Wildlife Service (USFWS). 2008. *Endangered Species Program*. Accessed on May 13, 2008, at http://www.fws.gov/easternwashington/ESA.html.

U.S. Geological Survey. 1995. *Nitrate Concentrations in Ground Water of the Central Columbia Plateau*. Open File Report 95-445, U.S. Geological Survey, Tacoma, Washington.

U.S. Geological Survey Circular 1144. 1998. "Water Quality in the Central Columbia Plateau, Washington and Idaho, 1992-95." AK Williamson, MD Munn, SJ Ryker, RJ Wagner, JC Ebbert, and AM Vanderpool, U.S. Geological Survey, Tacoma, Washington. Accessed on May 13, 2008, at http://pubs.usgs.gov/circ/circ1144/.

WA-94-1. 1995. *Water Resources Data, Washington, Water Year 1994*. WD Wiggins, GP Ruppert, RR Smith, LL Reed, LE Hubbard, and ML Courts, U.S. Geological Survey, Tacoma, Washington.

WAC 173-201A. 2006. "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 173-216. 2006. "State Waste Discharge Program." *Washington Administrative Code*, Olympia, Washington.

WAC 173-303-400. 2007. "Dangerous Waste Regulations; Interim Status Facility Standards." *Washington Administrative Code*, Olympia, Washington.

WAC 173-303-645. 2007. "Dangerous Waste Regulations; Releases from Regulated Units." *Washington Administrative Code*, Olympia, Washington.

WAC 173-303-645(11)(g). "Dangerous Waste Regulations; Releases from Regulated Units." *Washington Administrative Code*, Olympia, Washington.

WAC 173-304. 1988. "Minimum Functional Standards for Solid Waste Handling." *Washington Administrative Code*, Olympia, Washington.

WAC 173-340. 2007. "Washington State Model Toxic Control Act - Cleanup." *Washington Administrative Code*, Olympia, Washington.

RCW 70.105D, as amended. 1989. "Hazardous Waste Cleanup – Model Toxics Control Act." *Revised Code of Washington*, Olympia, Washington.

WAC 173-400. 2007. "General Regulations for Air Pollution Sources." *Washington Administrative Code*, Olympia, Washington.

WAC 232-12-292. 2008. "Bald Eagle Protection Rules." *Washington Administrative Code*, Olympia, Washington.

WAC 246-247. 2008. "Radiation Protection–Air Emissions." *Washington Administrative Code*, Olympia, Washington.

WAC 246-290. 2008. "Public Water Supplies." *Washington Administrative Code*, Olympia, Washington.

Washington Department of Fish and Wildlife (WDFW). 2008. *Species of Concern*. Olympia, Washington. Accessed on May 13, 2008, at http://www.wdfw.wa.gov/wlm/diversity/soc/concern.htm.

Washington Natural Heritage Program (WNHP). 2008. *Rare Plant Lists by County*. Washington State Department of Natural Resources, Olympia, Washington. Accessed on April 15, 2008, at http://www1.dnr.wa.gov/nhp/refdesk/plants.htm.

Washington Natural Heritage Program (WNHP). As amended. *Rare Plants Information Available from the Washington Natural Heritage Program*. Washington State Department of Natural Resources, Olympia, Washington. Accessed on July 29, 2008, at http://www1.dnr.wa.gov/nhp/refdesk/plants.htm.

WCH-71. 2007. *Integrated Strategy for Achieving Final Cleanup Decisions in the River Corridor*. LC Hulstrom and JA Lerch, Washington Closure Hanford LLC, Richland, Washington.

WDR-US-2007. 2007. *Water Data Report*. U.S. Geological Survey, Tacoma, Washington. Accessed on June 9, 2008, at http://wdr.water.usgs.gov/wy2007/search.jsp. Site Number 12472900 (the Vernita Bridge) and Site Number 12473520 (Columbia River near Richland).

Wellicome TI and GL Holroyd. 2001. "The Second International Burrowing Owl Symposium: Background and Context." *Journal of Raptor Research* 35:269-273.

WHC-EP-0609. 1992. *Riverbank Seepage and Groundwater Along the 100 Areas Shoreline, Hanford Site*. RE Peterson and VG Johnson, Westinghouse Hanford Company, Richland, Washington.

WHC-MR-0418. 1994. *Historical Records of Radio-active Contamination in Biota at the 200 Areas of the Hanford Site*. AR Johnson, BM Markes, JW Schmidt, AN Shah, SG Weiss, and KJ Wilson, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-EN-TI-006. 1992. *Hydrologic and Geologic Data Available for the Region North of Gable Mountain, Hanford Site, Washington*. RE Peterson, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-EN-TI-070. 1992. *Soil Concentration Limits for Accessible and Inaccessible Areas*. PD Rittman, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-EN-TI-125, Rev. 0. 1993. *Sampling and Analysis of the 300-FF-5 Operable Unit Springs, Near Shore Sediments and River Water*. SL Friant and LC Hulstrom, prepared by Pacific Northwest Laboratory for Westinghouse Hanford Company, Richland, Washington.

WHC-SD-EN-TI-198. 1993. *100 Area Columbia River Sediment Sampling.* SG Weiss, Westinghouse Hanford Company, Richland, Washington.

Wilson R and ESC Crouch. 1987. "Risk Assessment and Comparisons: An Introduction." *Science* 236(4799):267-270.

WMP-28945. 2006. *Data Quality Objectives Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process.* GS Thomas, Fluor Hanford, Inc., Richland, Washington.

WSDA. 2007. *Levels of Nonnutritutive Substances in Fertilizers.* Washington State Department of Agriculture, Report to the Legislature, Olympia, Washington, 249 pp.

Yokel J and DA Delistraty. 2003. "Arsenic, Lead, and Other Trace Elements in Soils Contaminated with Pesticide Residues at the Hanford Site (USA)." *Environmental Toxicology* 18(2):104-114.

Appendix A
Helpful Information

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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 1×10^9 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 2.0×10^3 (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 2.0×10^{-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

Symbol	Name
Temperature	
°C	degree Celsius
°F	degree Fahrenheit
Time	
d	day
hr	hour
min	minute
sec	second
yr	year
Rate	
cfs (or ft^3/sec)	cubic feet per second
cpm	counts per minute
gpm	gallon per minute
mph	mile per hour
mR/hr	milliroentgen per hour
mrem/yr	millirem per year
Volume	
cm^3	cubic centimeter
ft^3	cubic foot
gal	gallon
L	liter
m^3	cubic meter
mL	milliliter (1×10^{-3} L)
yd^3	cubic yard
Concentration	
ppb	parts per billion
ppm	parts per million
ppmv	parts per million by volume
Length	
cm	centimeter (1×10^{-2} m)
ft	foot
in.	inch
km	kilometer (1×10^3 m)
m	meter
mi	mile
mm	millimeter (1×10^{-3} m)
µm	micrometer (1×10^{-6} m)
Area	
ha	hectare (1×10^4 m^2)
km^2	square kilometer
mi^2	square mile
ft^2	square foot
Mass	
g	gram
kg	kilogram (1×10^3 g)
mg	milligram (1×10^{-3} g)
µg	microgram (1×10^{-6} g)
lb	pound

Table A.2. Conversion Table

Multiply	By	To Obtain	Multiply	By	To Obtain
cm	2.54	in.	in.	0.394	cm
m	0.305	ft	ft	3.28	m
km	1.61	mi	mi	0.621	km
kg	0.454	lb	lb	2.205	kg
L	3.785	gal	gal	0.2642	L
m^2	0.093	ft^2	ft^2	10.76	m^2
ha	0.405	acres	acre	2.47	ha
km^2	2.59	mi^2	mi^2	0.386	km^2
m^3	0.0283	ft^3	ft^3	35.31	m^3
m^3	0.7646	yd^3	yd^3	1.308	m^3
pCi	0.001	nCi	nCi	1,000	pCi
µCi/mL	10^9	pCi/L	pCi/L	10^{-9}	µCi/mL
Ci/m^3	10^{12}	pCi/m^3	pCi/m^3	10^{-12}	Ci/m^3
mCi/cm^3	10^{15}	pCi/m^3	pCi/m^3	10^{-15}	mCi/cm^3
nCi/m^2	1.0	mCi/km^2	mCi/km^2	1.0	nCi/m^2
Ci	3.7×10^{10}	Bq	Bq	2.7×10^{-11}	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	0.9072	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 radionuclide 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

Symbol	Name	Symbol	Name
Ci	curie	Bq	becquerel (2.7×10^{-11} Ci)
mCi	millicurie (1×10^{-3} Ci)	kBq	kilobecquerel (1×10^{3} Bq)
µCi	microcurie (1×10^{-6} Ci)	MBq	megabecquerel (1×10^{6} Bq)
nCi	nanocurie (1×10^{-9} Ci)	mBq	millibecquerel (1×10^{-3} Bq)
pCi	picocurie (1×10^{-12} Ci)	GBq	gigabecquerel (1×10^{9} Bq)
fCi	femtocurie (1×10^{-15} Ci)	TBq	terabecquerel (1×10^{12} Bq)
aCi	attocurie (1×10^{-18} 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 µBq	37 µBq	1 mBq	37 mBq	1 Bq	37 Bq	1 kBq	37 kBq	1 MBq	37 MBq	1 GBq	37 GBq	1 TBq	37 TBq

New unit of quantity = Becquerel (Bq) (formerly curie [Ci]) (1 Ci = 3.7×10^{10} 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.

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 µrem	10 µrem	100 µrem	1 mrem	10 mrem	100 mrem	1 rem	10 rem	100 rem

Unit of absorbed dose – Gray (Gy) (formerly rad).
Unit of dose equivalent – Sievert (Sv) (formerly rem).
Table also converts Gy to rad.

Also used in this report is the **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.

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

Symbol	Name
mrad	millirad (1×10^{-3} rad)
mrem	millirem (1×10^{-3} rem)
µrem	microrem (1×10^{-6} rem)
Sv	sievert (100 rem)
mSv	millisievert (1×10^{-3} Sv)
µSv	microsievert (1×10^{-6} Sv)
R	roentgen
mR	milliroentgen (1×10^{-3} R)
µR	microroentgen (1×10^{-6} R)
Gy	gray (100 rad)
mGy	milligray (1×10^{-3} rad)

Table A.7. Radionuclides and Their Half-Lives[a]

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
^{3}H	tritium	12.35 yr	^{137m}Ba	barium-137m	2.552 min
^{7}Be	beryllium-7	53.3 d	^{152}Eu	europium-152	13.33 yr
^{14}C	carbon-14	5,730 yr	^{154}Eu	europium-154	8.8 yr
^{40}K	potassium-40	1.28×10^{9} yr	^{155}Eu	europium-155	4.96 yr
^{51}Cr	chromium-51	27.704 d	^{212}Pb	lead-212	10.64 h
^{54}Mn	manganese-54	312.5 d	^{220}Rn	radon-220	55.6 sec
^{55}Fe	iron-55	2.7 yr	^{222}Rn	radon-222	3.8235 d
^{59}Fe	iron-59	44.529 d	^{232}Th	thorium-232	1.405×10^{10} yr
^{59}Ni	nickel-59	7.5×10^{4} yr	U or uranium	natural uranium	~4.5×10^{9}[b]
^{60}Co	cobalt-60	5.271 yr	^{233}U	uranium-233	1.585×10^{5} yr
^{63}Ni	nickel-63	96 yr	^{234}U	uranium-234	2.445×10^{5} yr
^{65}Zn	zinc-65	243.9 d	^{235}U	uranium-235	7.038×10^{8} yr
^{85}Kr	krypton-85	10.72 yr	^{237}Np	neptunium-237	2.14×10^{6} yr
^{90}Sr	strontium-90	29.12 yr	^{238}U	uranium-238	4.468×10^{9} yr
^{90}Y	yttrium-90	64.0 h	^{238}Pu	plutonium-238	87.74 yr
^{95}Zr	zirconium-95	63.98 d	^{239}Pu	plutonium-239	2.4065×10^{4} yr
^{99}Tc	technetium-99	2.13×10^{5} yr	^{240}Pu	plutonium-240	6.537×10^{3} yr
^{103}Ru	ruthenium-103	39.28 d	^{241}Pu	plutonium-241	14.4 yr
^{106}Ru	ruthenium-106	368.2 d	^{242}Pu	plutonium-242	3.763×10^{5} yr
^{113}Sn	tin-113	115.1 d	^{241}Am	americium-241	432.2 yr
^{125}Sb	antimony-125	2.77 yr	^{243}Am	americium-243	7,380 yr
^{129}I	iodine-129	1.57×10^{7} yr	^{243}Cm	curium-243	28.5 yr
^{131}I	iodine-131	8.04 d	^{244}Cm	curium-244	18.11 yr
^{134}Cs	cesium-134	2.062 yr	^{245}Cm	curium-245	8,500 yr
^{137}Cs	cesium-137	30.0 yr			

(a) From EPA 402-R-99-01.
(b) Natural uranium is a mixture dominated by ^{238}U, thus the half-life is ~4.5×10^{9} 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 ±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

Symbol	Constituent	Symbol	Constituent
Ag	silver	K	potassium
Al	aluminum	LiF	lithium fluoride
As	arsenic	Mg	magnesium
B	boron	Mn	manganese
Ba	barium	Mo	molybdenum
Be	beryllium	NH_3	ammonia
Br	bromine	NH_4^+	ammonium
C	carbon	N	nitrogen
Ca	calcium	Na	sodium
CaF_2	calcium fluoride	Ni	nickel
CCl_4	carbon tetrachloride	NO_2^-	nitrite
Cd	cadmium	NO_3^-	nitrate
$CHCl_3$	trichloromethane	Pb	lead
Cl^-	chloride	PO_4^{-3}	phosphate
CN^-	cyanide	P	phosphorus
Cr^{+6}	chromium (hexavalent)	Sb	antimony
Cr	chromium (total)	Se	selenium
CO_3^{-2}	carbonate	Si	silicon
Co	cobalt	Sr	strontium
Cu	copper	SO_4^{-2}	sulfate
F^-	fluoride	Ti	titanium
Fe	iron	Tl	thallium
HCO_3^-	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 ±2 times the standard error of the calculated mean (or ±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 ± 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.

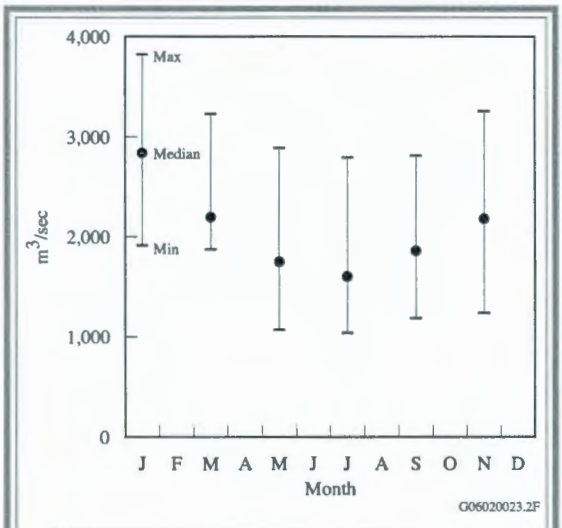

Figure A.1. A Graphical Representation of Maximum, Median (or sometimes average), and Minimum Values

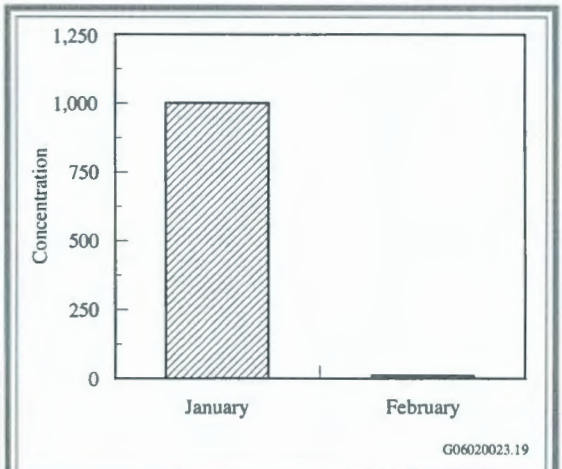

Figure A.2. Data Plotted Using a Linear Scale

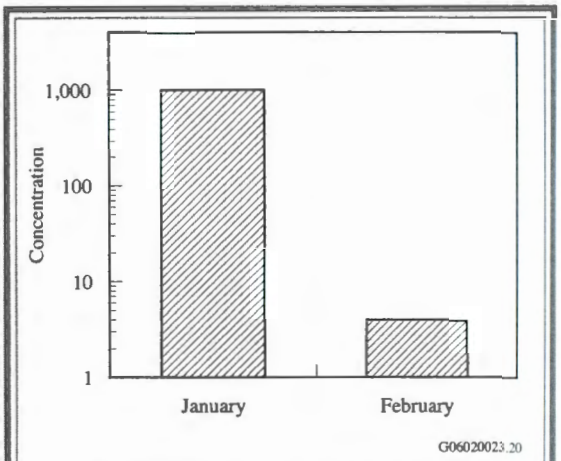

Figure A.3. Data Plotted Using a Logarithmic Scale

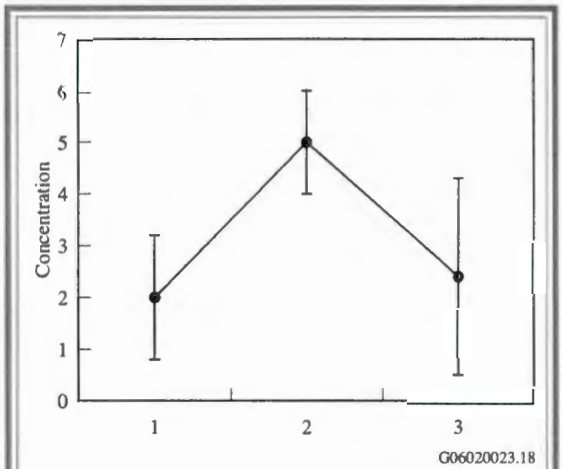

Figure A.4. Data with Error Bars Plotted Using a Linear Scale

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.[a] For example, in Figure A.4, the first plotted value is 2.0 ± 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 (≤ or ≥) 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 ability 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 our 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 = 3.7×10^{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.

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 Hanford.

curie (Ci) - A unit of *radioactivity* equal to 37 billion (3.7×10^{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). 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.

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.

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.

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 prior to termination of Hanford's nuclear materials production mission.

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.

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 Hanford.

mean (or average) - Average value of a series of measurements. The mean is computed as:

$$\text{mean} = \frac{\Sigma x}{n}$$

where n is the number of measurements and Σx 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 ^{239}Pu, which is produced by the *irradiation* of ^{238}U. Routine analysis cannot distinguish between the ^{239}Pu and ^{240}Pu *isotopes*; hence, the term $^{239/240}Pu$ 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 for the management and disposal of Toxic Substances Control Act-regulated polychlorinated biphenyl waste not addressed suitably within the regulations. The risk-based disposal approval process is applicable 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 Hanford, 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). "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 22, 2008, at http://www.epa.gov/region5/defs/html/rcra.htm.

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 2007

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This appendix contains additional information on 2007 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 2007* (PNNL-17603, APP. 1) and *Hanford Site Near-Facility Monitoring Data Report for Calendar Year 2007* (PNNL-17603, APP. 2).

Table C.1. Concentrations of Selected Radionuclides (pCi/m³)[a] in Near-Facility Air Samples, 2007 Compared to Previous Years

		2007					2002-2006				
Radionuclide	Site	Number of Samples	Number of Detections[b]	Average[c]	Maximum[d]	Sampler Number	Number of Samples	Number of Detections[b]	Average[c]	Maximum[d]	EPA Table 2[e,f]
Gross alpha	100-B/C FR	108	100	1.1E-03 ± 1.3E-03	3.4E-03 ± 9.1E-04	N466	587	525	1.2E-03 ± 1.3E-03	4.1E-03 ± 1.0E-03	2.0E-02
	100-D FR	92	84	1.0E-03 ± 9.4E-04	2.4E-03 ± 7.5E-04	N467	217	166	1.6E-03 ± 4.5E-03	2.3E-02 ± 1.2E-01	
	100-F FR	130	123	1.2E-03 ± 1.2E-03	3.6E-03 ± 9.4E-04	N521	453	399	1.3E-03 ± 1.6E-03	4.7E-03 ± 1.1E-03	
	100-K SNF	204	182	1.2E-03 ± 1.4E-03	5.1E-03 ± 1.8E-03	N478	1,044	912	1.2E-03 ± 1.8E-03	1.4E-02 ± 1.6E-02	
	118-K-1 FR	78	69	1.2E-03 ± 1.2E-03	2.9E-03 ± 1.2E-03	N403	196	171	1.2E-03 ± 1.8E-03	7.5E-03 ± 1.6E-03	
	100-N	78	76	1.3E-03 ± 1.2E-03	3.3E-03 ± 9.5E-04	N102	394	362	1.3E-03 ± 1.4E-03	5.7E-03 ± 1.5E-03	
	200-East	545	501	1.2E-03 ± 1.3E-03	5.0E-03 ± 1.1E-03	N019	2,560	2,334	1.2E-03 ± 1.5E-03	6.7E-03 ± 1.6E-03	
	200-West	657	608	1.2E-03 ± 1.4E-03	6.5E-03 ± 2.9E-03	N200	3,000	2,722	1.3E-03 ± 1.5E-03	1.1E-02 ± 1.6E-02	
	200-North	34	28	1.1E-03 ± 1.5E-03	3.7E-03 ± 1.2E-03	N564			Not applicable		
	200-UW-1	106	97	1.2E-03 ± 1.5E-03	5.0E-03 ± 2.1E-03	N168	453	408	1.3E-03 ± 1.5E-03	6.5E-03 ± 1.6E-03	
	300 Area D&D	26	23	1.1E-03 ± 1.3E-03	3.3E-03 ± 9.0E-04	N557	49	46	1.3E-03 ± 2.1E-03	7.3E-03 ± 1.7E-03	
	300-FF-2 FR	129	121	1.2E-03 ± 1.3E-03	4.0E-03 ± 1.1E-03	N540	242	223	1.3E-03 ± 1.5E-03	6.3E-03 ± 7.8E-03	
	ERDF	108	99	1.2E-03 ± 1.4E-03	4.7E-03 ± 2.9E-03	N482	527	447	1.1E-03 ± 1.3E-03	5.4E-03 ± 1.5E-03	
Gross beta	100-B/C FR	108	108	1.6E-02 ± 2.2E-02	4.8E-02 ± 4.4E-03	N497	587	587	1.7E-02 ± 2.2E-02	6.7E-02 ± 5.8E-03	9.0E+00
	100-D FR	92	92	1.4E-02 ± 1.3E-02	3.1E-02 ± 3.2E-03	N467	217	213	2.1E-02 ± 5.4E-02	3.6E-01 ± 1.7E-01	
	100-F FR	130	130	1.6E-02 ± 2.0E-02	5.6E-02 ± 5.0E-03	N521	453	453	1.8E-02 ± 2.5E-02	7.6E-02 ± 6.4E-03	
	100-K SNF	204	204	1.7E-02 ± 2.1E-02	7.9E-02 ± 8.1E-03	N478	1,044	1,044	1.8E-02 ± 2.5E-02	1.2E-01 ± 1.1E-02	
	118-K-1 FR	78	78	1.6E-02 ± 1.8E-02	4.1E-02 ± 4.5E-03	N534	196	196	1.8E-02 ± 2.4E-02	7.8E-02 ± 7.9E-03	
	100-N	78	78	1.6E-02 ± 1.6E-02	4.3E-02 ± 4.1E-03	N103	394	394	1.8E-02 ± 2.4E-02	8.2E-02 ± 7.0E-03	
	200-East	545	545	1.6E-02 ± 2.0E-02	5.8E-02 ± 5.2E-03	N972	2,560	2,560	1.7E-02 ± 2.2E-02	9.6E-02 ± 7.8E-03	
	200-West	657	657	1.6E-02 ± 1.9E-02	7.4E-02 ± 6.9E-03	N168	3,000	2,999	1.7E-02 ± 2.1E-02	7.1E-02 ± 6.8E-03	
	200-North	34	34	1.1E-02 ± 7.5E-03	2.0E-02 ± 3.5E-03	N564			Not applicable		
	200-UW-1	106	106	1.6E-02 ± 2.2E-02	7.4E-02 ± 6.9E-03	N168	453	453	1.7E-02 ± 2.2E-02	7.1E-02 ± 6.8E-03	
	300 Area D&D	26	26	1.8E-02 ± 2.2E-02	4.7E-02 ± 5.0E-03	N557	49	49	1.7E-02 ± 2.3E-02	6.4E-02 ± 6.8E-03	
	300-FF-2 FR	129	129	1.7E-02 ± 2.1E-02	5.0E-02 ± 5.3E-03	N540	242	241	1.7E-02 ± 2.2E-02	8.1E-02 ± 7.2E-03	
	ERDF	108	108	1.5E-02 ± 1.8E-02	4.7E-02 ± 4.4E-03	N518	527	526	1.6E-02 ± 2.2E-02	7.1E-02 ± 6.8E-03	
Cobalt-60	100-B/C FR	10	0	3.7E-05 ± 8.7E-05	1.2E-04 ± 4.8E-04	N464	47	0	9.7E-07 ± 7.3E-05	8.1E-05 ± 9.0E-05	1.7E-02
	100-D FR	8	0	1.3E-05 ± 7.4E-05	8.4E-05 ± 9.0E-05	N468	36	0	-3.1E-06 ± 5.5E-04	5.6E-04 ± 1.3E-03	
	100-F FR	10	0	2.8E-06 ± 1.1E-04	1.3E-04 ± 9.0E-05	N521	47	1	2.1E-05 ± 2.7E-04	7.5E-04 ± 5.4E-04	
	100-K SNF	16	0	2.3E-06 ± 7.2E-05	7.7E-05 ± 9.2E-05	N477	80	0	9.0E-06 ± 9.1E-05	1.2E-04 ± 8.5E-05	
	118-K-1 FR	6	0	2.3E-05 ± 9.6E-05	1.0E-04 ± 1.2E-04	N535	18	0	4.9E-05 ± 3.0E-04	5.5E-04 ± 5.7E-04	
	100-N	6	0	-1.8E-05 ± 6.7E-05	2.1E-05 ± 7.0E-05	N102	30	8	8.9E-05 ± 1.9E-04	2.8E-04 ± 1.5E-04	
	200-East	42	0	7.4E-06 ± 6.9E-05	1.0E-04 ± 1.2E-04	N978	196	2	7.4E-06 ± 9.3E-05	1.7E-04 ± 2.7E-04	
	200-West	50	0	9.7E-09 ± 7.1E-05	1.1E-04 ± 9.9E-05	N965	232	1	4.8E-06 ± 9.0E-05	1.6E-04 ± 9.0E-05	
	200-North	4	1	1.1E-04 ± 1.9E-04	2.5E-04 ± 1.2E-04	N564			Not applicable		
	200-UW-1	8	0	1.4E-05 ± 7.3E-05	5.7E-05 ± 7.1E-05	N168	35	0	9.9E-06 ± 8.1E-05	9.6E-05 ± 8.4E-05	
	300 Area D&D	4	0	-1.4E-04 ± 9.7E-05	-6.4E-05 ± 2.4E-04	N557	8	0	-3.0E-05 ± 2.7E-04	8.2E-05 ± 1.6E-04	
	300-FF-2 FR	11	0	-1.9E-06 ± 9.0E-05	8.0E-05 ± 9.2E-05	N527	22	0	-5.6E-05 ± 3.0E-04	1.0E-04 ± 1.7E-04	
	ERDF	8	0	1.7E-05 ± 9.4E-05	9.3E-05 ± 1.1E-04	N482	40	1	1.4E-05 ± 1.2E-04	2.0E-04 ± 1.0E-04	

Table C.1. (contd)

Radionuclide	Site	2007 Number of Samples	2007 Number of Detections[b]	2007 Average[c]	2007 Maximum[d]	Sampler Number	2002-2006 Number of Samples	2002-2006 Number of Detections[b]	2002-2006 Average[c]	2002-2006 Maximum[d]	EPA Table 2[e,f]
Strontium-90	100-B/C FR	10	0	-5.3E-05 ± 4.9E-04	5.8E-04 ± 7.5E-04	N464	47	7	1.2E-06 ± 2.4E-04	2.7E-04 ± 1.1E-04	1.9E-02
	100-D FR	8	1	9.1E-06 ± 2.7E-04	2.9E-04 ± 2.4E-04	N515	36	10	7.7E-04 ± 8.1E-03	2.4E-02 ± 4.7E-03	
	100-F FR	10	0	-1.1E-04 ± 2.0E-04	1.2E-05 ± 1.2E-04	N552	47	14	1.6E-04 ± 1.4E-03	4.4E-03 ± 1.4E-03	
	100-K SNF	16	0	-9.7E-05 ± 3.2E-04	1.0E-04 ± 1.8E-04	N477	80	13	1.6E-05 ± 2.1E-04	2.7E-04 ± 1.2E-04	
	118-K-1 FR	6	0	-1.6E-04 ± 2.5E-04	5.5E-06 ± 5.5E-05	N403	18	5	7.3E-05 ± 6.9E-04	9.5E-04 ± 4.3E-04	
	100-N	6	0	-9.7E-05 ± 1.6E-04	1.5E-05 ± 1.3E-04	N103	30	6	2.8E-05 ± 2.7E-04	4.5E-04 ± 1.8E-04	
	200-East	42	1	-5.7E-05 ± 2.4E-04	4.7E-04 ± 2.3E-04	N967	196	43	4.0E-05 ± 3.0E-04	1.0E-03 ± 3.3E-04	
	200-West	50	0	-5.7E-05 ± 2.0E-04	1.7E-04 ± 1.8E-04	N550	232	33	5.6E-06 ± 2.2E-04	6.2E-04 ± 2.2E-04	
	200-North	4	0	-3.1E-04 ± 1.1E-04	-2.7E-04 ± 2.8E-04	N563			Not applicable		
	200-UW-1	8	0	-5.6E-05 ± 2.5E-04	1.7E-04 ± 1.8E-04	N550	35	4	-9.1E-06 ± 1.9E-04	1.8E-04 ± 9.7E-05	
	300 Area D&D	4	0	-3.2E-04 ± 2.7E-04	-2.0E-04 ± 2.1E-04	N557	8	0	-1.1E-05 ± 3.6E-04	3.8E-04 ± 4.7E-04	
	300-FF-2 FR	2	0	-4.7E-05 ± 1.8E-04	4.1E-05 ± 1.4E-04	N130	10	2	-2.4E-06 ± 2.1E-04	1.4E-04 ± 8.7E-05	
	ERDF	8	1	3.4E-05 ± 5.0E-04	6.7E-04 ± 2.7E-04	N482	40	3	9.7E-06 ± 1.8E-04	2.3E-04 ± 1.1E-04	
Cesium-137	100-B/C FR	10	0	-1.0E-05 ± 7.8E-05	4.7E-05 ± 2.7E-04	N465	47	0	1.8E-05 ± 8.6E-05	1.5E-04 ± 2.0E-04	1.9E-02
	100-D FR	8	0	8.7E-06 ± 5.7E-05	3.9E-05 ± 5.9E-05	N515	36	0	1.1E-04 ± 7.3E-04	1.5E-03 ± 9.0E-04	
	100-F FR	10	0	7.9E-07 ± 1.1E-04	1.1E-04 ± 8.2E-05	N553	47	5	1.4E-04 ± 1.3E-03	4.3E-03 ± 1.3E-03	
	100-K SNF	16	2	5.0E-05 ± 1.2E-04	1.7E-04 ± 1.2E-04	N403	80	3	3.0E-05 ± 9.8E-05	1.4E-04 ± 1.3E-04	
	118-K-1 FR	6	2	1.4E-04 ± 4.8E-04	6.6E-04 ± 2.6E-04	N535	18	3	4.4E-05 ± 1.5E-04	1.4E-04 ± 1.3E-04	
	100-N	6	0	1.7E-05 ± 5.5E-05	5.5E-05 ± 8.1E-05	N103	30	4	5.2E-05 ± 1.2E-04	1.9E-04 ± 1.1E-04	
	200-East	42	5	3.6E-05 ± 1.7E-04	4.9E-04 ± 2.2E-04	N984	196	28	8.0E-05 ± 4.3E-04	2.3E-03 ± 7.6E-04	
	200-West	50	4	3.9E-05 ± 1.1E-04	3.0E-04 ± 1.4E-04	N433	232	24	6.3E-05 ± 2.6E-04	1.3E-03 ± 5.1E-04	
	200-North	4	0	4.6E-05 ± 1.2E-04	1.5E-04 ± 1.6E-04	N563			Not applicable		
	200-UW-1	8	1	5.9E-05 ± 8.2E-05	1.2E-04 ± 7.2E-05	N550	35	10	1.3E-04 ± 2.6E-04	4.8E-04 ± 1.9E-04	
	300 Area D&D	4	0	5.0E-05 ± 1.0E-04	1.0E-04 ± 1.1E-04	N557	8	0	6.2E-06 ± 1.3E-04	1.2E-04 ± 3.1E-04	
	300-FF-2 FR	11	0	-3.9E-06 ± 7.8E-05	6.4E-05 ± 6.5E-05	N539	22	0	3.9E-05 ± 2.2E-04	4.6E-04 ± 7.8E-04	
	ERDF	8	0	3.7E-05 ± 4.7E-05	7.5E-05 ± 8.4E-05	N963	40	4	6.6E-05 ± 1.3E-04	2.8E-04 ± 1.7E-04	
Uranium-234	100-B/C FR	10	9	2.0E-05 ± 4.0E-05	6.7E-05 ± 3.6E-05	N465	47	42	1.2E-05 ± 1.6E-05	5.1E-05 ± 2.1E-05	7.7E-03
	100-D FR	8	6	1.2E-05 ± 8.8E-06	1.8E-05 ± 1.0E-05	N515	36	26	3.0E-05 ± 5.4E-05	1.6E-04 ± 8.0E-05	
	100-F FR	10	10	1.3E-05 ± 7.5E-06	1.8E-05 ± 1.1E-05	N553	47	41	1.8E-05 ± 2.0E-05	5.0E-05 ± 3.0E-05	
	100-K SNF	16	12	1.1E-05 ± 1.0E-05	2.2E-05 ± 1.2E-05	N404	80	70	1.1E-05 ± 8.3E-06	2.2E-05 ± 1.2E-05	
	118-K-1 FR	6	5	1.3E-05 ± 8.5E-06	1.8E-05 ± 9.8E-06	N403	18	15	1.9E-05 ± 3.7E-05	8.4E-05 ± 4.3E-05	
	100-N	6	6	1.2E-05 ± 1.2E-05	2.0E-05 ± 1.1E-05	N103	30	29	1.3E-05 ± 7.4E-06	2.2E-05 ± 1.1E-05	
	200-East	42	41	1.2E-05 ± 8.3E-06	2.3E-05 ± 1.2E-05	N984	196	178	1.3E-05 ± 1.2E-05	3.9E-05 ± 1.8E-05	
	200-West	50	43	1.4E-05 ± 1.7E-05	6.0E-05 ± 2.6E-05	N550	232	205	1.3E-05 ± 1.2E-05	5.0E-05 ± 2.1E-05	
	200-North	4	4	1.5E-05 ± 6.7E-06	1.8E-05 ± 1.2E-05	N563			Not applicable		
	200-UW-1	8	8	2.0E-05 ± 3.2E-05	6.0E-05 ± 2.6E-05	N550	35	31	1.5E-05 ± 1.4E-05	3.0E-05 ± 1.4E-05	
	300 Area D&D	4	4	2.5E-05 ± 1.8E-05	4.0E-05 ± 2.1E-05	N557	8	8	3.9E-05 ± 5.6E-05	1.1E-04 ± 5.3E-05	
	300-FF-2 FR	11	11	1.5E-05 ± 9.7E-06	2.6E-05 ± 1.3E-05	N538	22	21	5.0E-05 ± 1.2E-04	1.9E-04 ± 9.7E-05	
	ERDF	8	8	1.8E-05 ± 1.5E-05	3.2E-05 ± 1.6E-05	N518	40	38	1.6E-05 ± 1.6E-05	4.8E-05 ± 2.2E-05	

Table C.1. (contd)

Radionuclide	Site	2007 Number of Samples	2007 Number of Detections[b]	2007 Average[c]	2007 Maximum[d]	Sampler Number	2002-2006 Number of Samples	2002-2006 Number of Detections[b]	2002-2006 Average[c]	2002-2006 Maximum[d]	EPA Table 2[e,f]
Uranium-235	100-B/C FR	10	2	4.5E-06 ± 9.0E-06	1.7E-05 ± 1.6E-05	N464	47	12	3.8E-06 ± 6.8E-06	2.1E-05 ± 1.6E-05	7.1E-03
	100-D FR	8	1	3.3E-06 ± 3.5E-06	6.2E-06 ± 5.3E-06	N515	36	7	1.1E-05 ± 2.5E-05	6.7E-05 ± 6.8E-05	
	100-F FR	10	2	2.6E-06 ± 2.7E-06	5.0E-06 ± 4.5E-06	N521	47	9	4.0E-06 ± 7.1E-06	1.5E-05 ± 1.0E-05	
	100-K SNF	16	0	1.6E-06 ± 2.5E-06	3.2E-06 ± 3.4E-06	N403	80	15	2.6E-06 ± 3.8E-06	1.2E-05 ± 7.9E-06	
	118-K-1 FR	6	0	2.4E-06 ± 1.9E-06	3.4E-06 ± 3.6E-06	N534	18	4	5.5E-06 ± 1.1E-05	2.3E-05 ± 2.3E-05	
	100-N	6	1	1.9E-06 ± 2.6E-06	4.6E-06 ± 4.5E-06	N102	30	8	2.4E-06 ± 4.0E-06	8.2E-06 ± 6.9E-06	
	200-East	42	11	2.4E-06 ± 3.7E-06	5.7E-06 ± 4.8E-06	N559	196	44	2.9E-06 ± 4.2E-06	1.4E-05 ± 1.7E-05	
	200-West	50	10	2.6E-06 ± 3.4E-06	7.9E-06 ± 6.2E-06	N550	232	61	3.0E-06 ± 5.2E-06	1.9E-05 ± 1.2E-05	
	200-North	4	2	6.4E-06 ± 3.0E-06	8.3E-06 ± 7.9E-06	N563			Not applicable		
	200-UW-1	8	2	3.2E-06 ± 4.3E-06	7.9E-06 ± 6.2E-06	N550	35	11	3.1E-06 ± 3.9E-06	7.8E-06 ± 5.7E-06	
	300 Area D&D	4	1	5.5E-06 ± 5.9E-06	8.8E-06 ± 9.8E-06	N557	8	0	4.1E-06 ± 4.7E-06	6.0E-06 ± 7.2E-06	
	300-FF-2 FR	11	2	2.5E-06 ± 4.9E-06	8.2E-06 ± 6.0E-06	N540	22	6	8.6E-06 ± 2.5E-05	4.7E-05 ± 4.6E-05	
	ERDF	8	2	2.7E-06 ± 3.3E-06	5.2E-06 ± 4.7E-06	N482	40	7	2.5E-06 ± 3.6E-06	7.8E-06 ± 5.7E-06	
Plutonium-238	100-B/C FR	10	0	3.7E-06 ± 1.7E-05	1.6E-05 ± 2.0E-05	N464	47	2	2.2E-06 ± 1.8E-05	2.9E-05 ± 2.1E-05	2.1E-03
	100-D FR	8	0	7.6E-07 ± 3.5E-06	3.4E-06 ± 3.5E-06	N467	36	0	-1.1E-06 ± 1.1E-04	1.1E-04 ± 1.9E-04	
	100-F FR	10	0	1.1E-06 ± 3.9E-06	5.2E-06 ± 6.1E-06	N520	47	0	1.2E-06 ± 2.4E-05	2.4E-05 ± 2.7E-05	
	100-K SNF	16	0	-8.5E-07 ± 1.4E-05	7.5E-06 ± 1.6E-05	N479	80	0	1.2E-06 ± 2.2E-05	3.0E-05 ± 3.7E-05	
	118-K-1 FR	6	1	2.4E-08 ± 1.3E-05	5.7E-06 ± 4.8E-06	N534	18	0	3.3E-06 ± 2.9E-05	3.3E-05 ± 6.0E-05	
	100-N	6	0	2.2E-06 ± 4.6E-06	7.3E-06 ± 1.2E-05	N103	30	0	-2.9E-07 ± 1.6E-05	2.2E-05 ± 1.5E-05	
	200-East	42	0	4.2E-07 ± 1.2E-05	1.9E-05 ± 1.8E-05	N480	196	1	2.8E-07 ± 1.4E-05	3.7E-05 ± 2.8E-05	
	200-West	50	0	3.2E-06 ± 1.5E-05	2.5E-05 ± 2.3E-05	N441	232	2	1.7E-06 ± 1.4E-05	4.0E-05 ± 2.5E-05	
	200-North	4	1	1.2E-06 ± 8.1E-06	7.7E-06 ± 6.8E-06	N563			Not applicable		
	200-UW-1	8	0	4.2E-06 ± 1.2E-05	1.4E-05 ± 1.6E-05	N168	35	1	1.2E-06 ± 9.2E-06	1.4E-05 ± 1.4E-05	
	300 Area D&D	4	0	2.5E-09 ± 4.7E-06	1.5E-06 ± 1.5E-05	N557	8	1	8.2E-06 ± 4.6E-05	5.5E-05 ± 4.4E-05	
	300-FF-2 FR	11	0	8.7E-07 ± 7.3E-06	5.3E-06 ± 5.9E-06	N527	15	2	2.6E-06 ± 9.4E-06	1.1E-05 ± 1.5E-05	
	ERDF	8	0	4.9E-06 ± 1.2E-05	1.6E-05 ± 1.5E-05	N482	40	1	1.6E-06 ± 1.1E-05	1.4E-05 ± 1.4E-05	
Uranium-238	100-B/C FR	10	8	1.1E-05 ± 1.3E-05	2.4E-05 ± 2.2E-05	N465	47	40	9.2E-06 ± 8.3E-06	2.8E-05 ± 1.3E-05	8.3E-03
	100-D FR	8	6	9.0E-06 ± 7.3E-06	1.5E-05 ± 9.0E-06	N514	36	20	2.0E-05 ± 3.5E-05	7.8E-05 ± 7.3E-05	
	100-F FR	10	8	9.1E-06 ± 7.2E-06	1.8E-05 ± 1.0E-05	N552	47	35	1.3E-05 ± 1.4E-05	4.0E-05 ± 2.0E-05	
	100-K SNF	16	14	7.7E-06 ± 5.4E-06	1.5E-05 ± 8.2E-06	N401	80	73	8.9E-06 ± 7.1E-06	2.2E-05 ± 1.1E-05	
	118-K-1 FR	6	5	9.6E-06 ± 6.1E-06	1.5E-05 ± 9.3E-06	N535	18	16	1.6E-05 ± 1.7E-05	3.9E-05 ± 2.6E-05	
	100-N	6	5	9.6E-06 ± 8.7E-06	1.7E-05 ± 9.3E-06	N103	30	25	8.5E-06 ± 6.8E-06	1.5E-05 ± 9.5E-06	
	200-East	42	35	7.6E-06 ± 6.5E-06	1.5E-05 ± 8.6E-06	N999	196	171	1.0E-05 ± 1.1E-05	4.0E-05 ± 1.9E-05	
	200-West	50	42	9.6E-06 ± 1.3E-05	4.7E-05 ± 2.1E-05	N550	232	207	1.1E-05 ± 1.1E-05	3.5E-05 ± 1.6E-05	
	200-North	4	3	1.3E-05 ± 5.0E-06	1.7E-05 ± 1.0E-05	N564			Not applicable		
	200-UW-1	8	8	1.5E-05 ± 2.7E-05	4.7E-05 ± 2.1E-05	N550	35	33	1.3E-05 ± 1.5E-05	3.3E-05 ± 1.6E-05	
	300 Area D&D	4	3	1.4E-05 ± 1.3E-05	2.1E-05 ± 1.3E-05	N557	8	5	1.9E-05 ± 2.4E-05	3.6E-05 ± 2.0E-05	
	300-FF-2 FR	11	9	1.1E-05 ± 8.7E-06	1.7E-05 ± 9.5E-06	N537	22	21	3.6E-05 ± 8.6E-05	1.3E-04 ± 7.9E-05	
	ERDF	8	8	1.6E-05 ± 1.4E-05	2.7E-05 ± 1.4E-05	N518	40	37	1.4E-05 ± 1.7E-05	4.9E-05 ± 2.2E-05	

Table C.1. (contd)

Radionuclide	Site	2007 Number of Samples	2007 Number of Detections[b]	2007 Average[c]	2007 Maximum[d]	Sampler Number	2002-2006 Number of Samples	2002-2006 Number of Detections[b]	2002-2006 Average[c]	2002-2006 Maximum[d]	EPA Table 2[e,f]
Plutonium-239/240	100-B/C FR	10	3	2.4E-06 ± 4.7E-06	4.9E-06 ± 4.2E-06	N466	47	6	2.9E-06 ± 9.8E-06	2.6E-05 ± 1.2E-05	2.0E-03
	100-D FR	8	0	1.1E-06 ± 3.4E-06	3.9E-06 ± 6.0E-06	N467	36	7	2.1E-05 ± 1.1E-04	3.0E-04 ± 2.4E-04	
	100-F FR	10	0	1.1E-06 ± 2.1E-06	2.8E-06 ± 3.1E-06	N553	47	9	1.4E-05 ± 9.7E-05	3.3E-04 ± 1.1E-04	
	100-K SNF	16	3	8.3E-06 ± 9.3E-06	1.8E-05 ± 1.4E-05	N477	80	18	6.5E-06 ± 1.4E-05	4.1E-05 ± 2.4E-05	
	118-K-1 FR	6	1	1.2E-05 ± 3.1E-05	4.5E-05 ± 1.8E-05	N535	18	6	8.4E-06 ± 2.8E-05	5.4E-05 ± 3.3E-05	
	100-N	6	2	3.3E-06 ± 4.2E-06	6.8E-06 ± 5.6E-06	N106	30	12	5.0E-06 ± 6.2E-06	1.2E-05 ± 8.0E-06	
	200-East	42	4	2.1E-06 ± 3.7E-06	9.3E-06 ± 6.3E-06	N984	196	25	3.4E-06 ± 1.7E-05	7.2E-05 ± 3.2E-05	
	200-West	50	19	3.0E-05 ± 2.4E-04	7.1E-04 ± 2.7E-04	N165	232	101	2.6E-05 ± 1.7E-04	5.4E-04 ± 2.1E-04	
	200-North	4	0	2.5E-06 ± 2.5E-06	3.9E-06 ± 4.6E-06	N563			Not applicable		
	200-UW-1	8	5	6.1E-06 ± 1.2E-05	1.9E-05 ± 1.0E-05	N168	35	17	1.1E-05 ± 4.5E-05	1.3E-04 ± 5.2E-05	
	300 Area D&D	4	0	1.2E-06 ± 4.3E-06	4.0E-06 ± 4.8E-06	N557	8	1	7.4E-06 ± 2.4E-05	3.9E-05 ± 2.8E-05	
	300-FF-2 FR	11	0	1.8E-06 ± 2.5E-06	4.5E-06 ± 4.8E-06	N538	15	2	4.3E-06 ± 1.6E-05	2.9E-05 ± 1.5E-05	
	ERDF	8	2	2.8E-06 ± 3.7E-06	6.4E-06 ± 6.2E-06	N963	40	17	1.1E-05 ± 4.3E-05	1.3E-04 ± 5.2E-05	
Americium-241	100-K SNF	16	15	1.2E-05 ± 8.7E-06	2.0E-05 ± 1.1E-05	N477	80	18	1.3E-05 ± 9.7E-05	4.4E-04 ± 1.7E-04	1.9E-03
	118-K-1 FR	2	2	9.9E-06 ± 4.0E-06	1.2E-05 ± 7.4E-06	N403	10	4	5.7E-05 ± 2.6E-04	4.4E-04 ± 1.7E-04	
	100-N	6	0	7.1E-06 ± 7.3E-06	1.2E-05 ± 1.3E-05	N103	6	1	3.2E-06 ± 1.2E-05	1.4E-05 ± 1.0E-05	
	200-East	4	3	7.3E-06 ± 2.6E-06	9.0E-06 ± 5.5E-06	N481	20	1	4.5E-06 ± 8.0E-06	1.3E-05 ± 1.6E-05	
Plutonium-241	100-K SNF	16	0	-4.1E-04 ± 1.1E-03	5.3E-04 ± 6.7E-04	N404	80	12	3.1E-04 ± 1.3E-03	1.8E-03 ± 8.8E-04	1.0E-01
	118-K-1 FR	2	0	-3.8E-04 ± 1.4E-03	2.9E-04 ± 4.5E-04	N403	10	0	3.6E-04 ± 1.0E-03	1.1E-03 ± 1.0E-03	
	200-East	4	0	-6.1E-04 ± 6.2E-04	-2.4E-04 ± 2.4E-03	N481	20	3	1.7E-04 ± 1.5E-03	1.7E-03 ± 8.7E-04	

(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).
D&D = Decontamination and decommissioning.
DOE = U.S. Department of Energy.
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, 2007

		Vernita Bridge (upstream)				Richland (downstream)				Washington Ambient Surface Water Quality Standard[a]
Analysis	Units	No. of Samples	Maximum	Median	Minimum	No. of Samples	Maximum	Median	Minimum	
Temperature	°C	3	20	11	7.1	3	20	10	7.0	20 (maximum)
Dissolved oxygen	mg/L	3	13	11	10	3	13	12	8.9	8 (minimum)
Turbidity	NTU	3	<2	<2	1.2[b]	3	2	<2	1.4[b]	5 + background
pH	pH units	3	7.9	7.8	7.7	3	8.0	7.7	7.7	6.5 - 8.5
Sulfate, dissolved	mg/L	3	9.1	9.1	8.5	3	9.3	9.2	9.0	--[c]
Dissolved solids, 180°C (356°F)	mg/L	3	86	83	78	3	82	79	78	--
Specific conductance	µS/cm	3	137	136	133	3	140	136	134	--
Total hardness, as $CaCO_3$	mg/L	3	67	66	65	3	67	66	65	--
Alkalinity	mg/L	3	58	56	52	3	58	58	52	
Phosphorus, total	mg/L	3	<0.04	<0.04	0.02[b]	3	<0.04	<0.04	<0.04	--
Chromium, dissolved	µg/L	3	0.09[b]	0.08[b]	0.06[b]	3	0.09[b]	0.09[b]	0.08[b]	10
Dissolved organic carbon	mg/L	3	2.3	1.5	1.3	3	1.8	1.3	1.3	--
Iron, dissolved	µg/L	3	<8	7	<6	3	8	<8	<6	--
Ammonia, dissolved, as nitrogen	mg/L	3	<0.02	<0.02	<0.02	3	<0.02	<0.02	<0.02	--
Nitrite + nitrate, dissolved, as nitrogen	mg/L	3	0.14	0.10	0.06[b]	3	0.15	0.12	0.07	--

(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, 2007 Compared to Previous 5 Years

Radionuclide[a]		2007 No. of Samples	2007 Concentration,[b] pCi/L Maximum	2007 Concentration,[b] pCi/L Average	2002-2006 No. of Samples	2002-2006 Concentration,[b] pCi/L Maximum	2002-2006 Concentration,[b] pCi/L Average	Ambient Surface Water Quality Standard, pCi/L
Composite System								
Tritium[c]		12	55 ± 26	31 ± 21	60	80 ± 9.0	30 ± 27	20,000[d]
Alpha (gross)		12	1.4 ± 0.99	0.68 ± 0.98	60	1.4 ± 1.2	0.45 ± 0.75	15[e,f]
Beta (gross)		12	4.2 ± 1.7	1.2 ± 2.3	60	3.2 ± 1.8	0.80 ± 1.7	50[e,f]
Strontium-90		12	0.10 ± 0.041	0.059 ± 0.043	60	0.24 ± 0.085	0.066 ± 0.068	8[e,f]
Technetium-99		12	1.1 ± 0.043	0.35 ± 0.63	60	0.53 ± 0.55[g]	0.086 ± 0.44[g]	900[d]
Iodine-129		0			16	2.1E-05 ± 2.8E-06	7.3E-06 ± 1.1E-05	1[d]
Uranium-234		12	0.28 ± 0.057	0.21 ± 0.083	60	0.28 ± 0.064	0.22 ± 0.057	--[h]
Uranium-235		12	0.012 ± 0.0082	-0.0041 ± 0.014	60	0.014 ± 0.014[g]	5.5E-03 ± 9.9E-03	--
Uranium-238		12	0.22 ± 0.084	0.18 ± 0.052	60	0.25 ± 0.058	0.18 ± 0.056	--
Uranium (total)		12	0.49 ± 0.072	0.38 ± 0.13	60	0.54 ± 0.087	0.40 ± 0.10	--
Continuous System								
Cesium-137	P	12	8.9E-03 ± 6.0E-03[g]	2.1E-03 ± 4.6E-03	60	1.9E-03 ± 1.2E-03[g]	3.8E-04 ± 1.1E-03[g]	200[d]
	D	12	2.2E-03 ± 2.5E-03[g]	5.7E-04 ± 2.3E-03[g]	60	4.7E-03 ± 3.1E-03	9.7E-04 ± 2.2E-03[g]	
Plutonium-238	P	4	3.5E-06 ± 5.3E-06[g]	1.9E-06 ± 3.3E-06[g]	19	8.2E-05 ± 4.2E-05	8.5E-06 ± 5.1E-05	600[d]
	D	4	-2.2E-09 ± 3.6E-05[g]	-2.1E-04 ± 4.7E-04[g]	20	4.9E-05 ± 5.7E-05[g]	-1.7E-04 ± 4.6E-04[g]	
Plutonium-239/240	P	4	4.6E-05 ± 1.6E-05	3.6E-05 ± 2.3E-05	19	1.2E-04 ± 4.9E-05	2.4E-05 ± 5.5E-05	--
	D	4	1.9E-05 ± 8.4E-05[g]	4.5E-06 ± 3.6E-05[g]	20	5.5E-05 ± 5.7E-05[g]	2.5E-05 ± 2.6E-05[g]	

(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) January through October samples were processed using electrolytic enrichment, November through December samples were not.
(d) WAC 173-201A-250 and EPA-570/9-76-003.
(e) WAC 246-290.
(f) 40 CFR 141.
(g) Less than the laboratory-reported detection limit.
(h) Dashes indicate no concentration guides available.

Table C.4. Radionuclide Concentrations in Columbia River Water Samples Collected at Richland, Washington, 2007 Compared to Previous 5 Years

Radionuclide[a]		2007 No. of Samples	2007 Concentration,[b] pCi/L Maximum	2007 Concentration,[b] pCi/L Average	2002-2006 No. of Samples	2002-2006 Concentration,[b] pCi/L Maximum	2002-2006 Concentration,[b] pCi/L Average	Ambient Surface Water Quality Standard, pCi/L
Composite System								
Tritium[c]		12	140 ± 32	64 ± 72	60	140 ± 14	55 ± 47	20,000[d]
Alpha (gross)		12	1.5 ± 0.95	0.50 ± 0.75	60	1.6 ± 1.1	0.45 ± 0.73	15[e,f]
Beta (gross)		12	3.3 ± 1.5	1.1 ± 1.9	60	2.8 ± 2.1[g]	0.90 ± 1.4	50[e,f]
Strontium-90		12	0.075 ± 0.037	0.049 ± 0.024	60	0.26 ± 0.059	0.065 ± 0.074	8[e,f]
Technetium-99		12	0.81 ± 0.39	0.39 ± 0.61	60	1.2 ± 0.57	0.15 ± 0.53	900[d]
Iodine-129		0			16	1.2E-04 ± 9.6E-06	6.6E-05 ± 4.9E-05	1[d]
Uranium-234		12	0.28 ± 0.097	0.25 ± 0.065	60	0.32 ± 0.11	0.26 ± 0.065	--[h]
Uranium-235		12	0.020 ± 0.011	-0.0024 ± 0.017	60	0.018 ± 0.018[g]	6.8E-03 ± 9.4E-03	--
Uranium-238		12	0.25 ± 0.089	0.20 ± 0.062	60	0.30 ± 0.066	0.20 ± 0.064	--
Uranium (total)		12	0.54 ± 0.076	0.44 ± 0.13	60	0.62 ± 0.10	0.47 ± 0.12	--
Continuous System								
Cesium-137	P	12	9.1E-03 ± 4.8E-03[g]	1.2E-03 ± 5.3E-03[g]	59	1.6E-03 ± 1.0E-03[g]	3.7E-04 ± 1.1E-03[g]	200[f]
	D	12	3.7E-03 ± 2.4E-03[g]	7.2E-04 ± 3.0E-03[g]	59	2.6E-03 ± 2.9E-03[g]	6.3E-04 ± 2.0E-03[g]	
Plutonium-238	P	4	1.4E-06 ± 8.3E-06[g]	-9.2E-07 ± 5.7E-06[g]	19	6.0E-05 ± 6.8E-05[g]	5.1E-06 ± 4.5E-05	600[f]
	D	4	-7.3E-06 ± 2.5E-05[g]	-3.0E-04 ± 4.0E-04[g]	20	4.1E-05 ± 8.7E-05[g]	-2.0E-04 ± 4.6E-04[g]	
Plutonium-239/240	P	4	2.4E-05 ± 1.8E-05	1.2E-05 ± 1.6E-05	19	8.9E-05 ± 4.6E-05	2.4E-05 ± 4.5E-05	--
	D	4	5.1E-05 ± 7.6E-05[g]	1.0E-05 ± 6.1E-05[g]	20	7.3E-05 ± 8.6E-05[g]	1.4E-05 ± 6.2E-05[g]	

(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) January through October samples were processed using electrolytic enrichment, November through December samples were not.
(d) WAC 173-201A-250 and EPA-570/9-76-003.
(e) WAC 246-290.
(f) 40 CFR 141.
(g) Less than the laboratory-reported detection limit.
(h) Dashes indicate no concentration guides available.

Table C.5. Radionuclide Concentrations Measured in Columbia River Water Samples Collected Along Transects of the Hanford Reach, 2007

Transect/Radionuclide	No. of Samples	Concentration,[a] pCi/L Maximum	Concentration,[a] pCi/L Minimum
Vernita Bridge (HRM 0.3)			
Tritium	16	72 ± 16	13 ± 6.5
Strontium-90	16	0.079 ± 0.041	0.036 ± 0.041[b]
Uranium (total)	16	0.58 ± 0.14	0.32 ± 0.12
100-N Area (HRM 9.5)			
Tritium	7	32 ± 9.0	19 ± 7.0
Strontium-90	7	0.083 ± 0.037	0.043 ± 0.035
Uranium (total)	7	0.44 ± 0.13	0.32 ± 0.12
Hanford town site (HRM 28.7)			
Tritium	6	860 ± 150	22 ± 8.7
Strontium-90	6	0.083 ± 0.041	0.025 ± 0.034[b]
Uranium (total)	6	0.38 ± 0.13	0.31 ± 0.12
300 Area (HRM 43.1)			
Tritium	6	81 ± 18	31 ± 10
Strontium-90	6	0.051 ± 0.033	0.023 ± 0.033[b]
Uranium (total)	6	1.7 ± 0.22	0.36 ± 0.13
Richland (HRM 46.4)			
Tritium	26	160 ± 31	15 ± 6.7
Strontium-90	24	0.066 ± 0.034	0.016 ± 0.036[b]
Uranium (total)	26	1.1 ± 0.18	0.31 ± 0.12

(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.

ble C.6. Radionuclide Concentrations Measured in Columbia River Water Samples Collected at Near-Shore Locations in the Hanford Reach, 2007

Near-Shore/Radionuclide	No. of Samples	Concentration,[a] pCi/L Maximum	Minimum
Vernita Bridge (HRM 0.3)			
Tritium	4	50 ± 13	17 ± 7.1
Strontium-90	4	0.056 ± 0.039	0.047 ± 0.035
Uranium (total)	4	0.58 ± 0.14	0.33 ± 0.13
100-N Area (HRM 8.4 to 9.8)			
Tritium	6	37 ± 9.8	24 ± 7.8
Strontium-90	6	0.30 ± 0.073	0.013 ± 0.031[b]
Uranium (total)	6	0.38 ± 0.13	0.32 ± 0.12
Hanford town site (HRM 26 to 30)			
Tritium	5	1,200 ± 210	29 ± 9.8
Strontium-90	3	0.059 ± 0.040	0.058 ± 0.037
Uranium (total)	5	0.59 ± 0.15	0.37 ± 0.13
300 Area (HRM 41.5 to 43.1)			
Tritium	5	1,200 ± 210	81 ± 18
Strontium-90	5	0.054 ± 0.034	0.041 ± 0.035
Uranium (total)	5	1.2 ± 0.18	0.35 ± 0.13
Richland (HRM 43.5 to 46.4)			
Tritium	22	350 ± 63[c]	19 ± 7.3
Strontium-90	22	0.079 ± 0.046	0.018 ± 0.030[b]
Uranium (total)	22	0.94 ± 0.17	0.31 ± 0.12

(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.
(c) This sample was reported with a high blank value; the sample was reanalyzed and reported as undetected at 120 ± 130 pCi/L.
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, August 2007

Location	Metal	No. of Samples	Maximum	Minimum	Average	±2SD
Vernita Bridge	Antimony	4	0.29	0.15	0.20	0.12
	Arsenic	4	0.60	0.50	0.55	0.086
	Beryllium[a]	4	0.008[a]	0.008[a]	0.008[a]	0.0
	Cadmium	4	0.015	0.0052	0.0093	0.0083
	Chromium[a]	4	0.083[a]	0.083[a]	0.083[a]	0.0
	Copper	4	0.89	0.70	0.79	0.18
	Lead	4	0.079	0.046	0.066	0.031
	Nickel	4	0.71	0.51	0.63	0.17
	Selenium	4	0.21	0.12	0.16	0.098
	Silver	4	0.0026	0.002[a]	0.0022	0.00063
	Thallium	4	0.016	0.013	0.014	0.0025
	Zinc	4	3.0	1.4	2.0	1.3
100-N Area	Antimony	10	0.36	0.18	0.23	0.11
	Arsenic	10	0.61	0.54	0.57	0.039
	Beryllium	10	0.0084	0.008[a]	0.0080	0.00028
	Cadmium	10	0.012	0.0040	0.0089	0.0048
	Chromium	10	0.20	0.094	0.14	0.064
	Copper[b]	10	2.1	0.63	0.86	0.90
	Lead	10	0.075	0.039	0.055	0.023
	Nickel	10	1.0	0.68	0.87	0.23
	Selenium	10	0.45	0.064	0.19	0.24
	Silver[a]	10	0.002[a]	0.002[a]	0.002[a]	0.0
	Thallium	10	0.016	0.014	0.015	0.0012
	Zinc	10	2.6	1.0	1.7	1.0
Hanford town site	Antimony	10	0.23	0.16	0.18	0.044
	Arsenic	10	0.68	0.52	0.58	0.097
	Beryllium[a]	10	0.008[a]	0.008[a]	0.008[a]	0.0
	Cadmium	10	0.012	0.0058	0.0088	0.0033
	Chromium	10	0.16	0.083[a]	0.096	0.055
	Copper	10	0.73	0.56	0.63	0.11
	Lead	10	0.058	0.027	0.039	0.017
	Nickel	10	0.83	0.57	0.67	0.19
	Selenium	10	0.26	0.063	0.15	0.11
	Silver	10	0.0026	0.002[a]	0.0021	0.00046
	Thallium	10	0.015	0.013	0.014	0.00090
	Zinc	10	1.4	0.74	1.1	0.43
300 Area	Antimony[a]	10	0.23	0.15	0.17	0.022
	Arsenic	10	1.2	0.52	0.69	0.22
	Beryllium[a]	10	0.008[a]	0.008[a]	0.008[a]	0.0
	Cadmium	10	0.024	0.0071	0.013	0.0045
	Chromium	10	0.47	0.090	0.23	0.13
	Copper	10	0.90	0.54	0.63	0.011
	Lead	10	0.051	0.020	0.028	0.0091
	Nickel	10	0.86	0.62	0.69	0.076
	Selenium	10	0.76	0.020[a]	0.28	0.22
	Silver[a]	10	0.0022	0.002[a]	0.0020	0.000072
	Thallium	10	0.017	0.012	0.015	0.0013
	Zinc	10	1.4	0.79	0.95	0.18

Table C.7. (contd)

Location	Metal	No. of Samples	Maximum	Minimum	Average	±2SD
Richland	Antimony	10	0.21	0.13	0.18	0.048
	Arsenic	10	0.71	0.42	0.55	0.15
	Beryllium[a]	10	0.008[a]	0.008[a]	0.008[a]	0.0
	Cadmium	10	0.013	0.0060	0.0092	0.0045
	Chromium[a]	10	0.083[a]	0.083[a]	0.083[a]	0.0
	Copper	10	0.92	0.43	0.66	0.25
	Lead	10	0.061	0.025	0.039	0.021
	Nickel	10	0.89	0.46	0.71	0.26
	Selenium	10	0.20	0.020[a]	0.11	0.10
	Silver	10	0.0035	0.002[a]	0.0023	0.00096
	Thallium	10	0.016	0.012	0.014	0.0032
	Zinc	10	1.9	0.82	1.4	0.70

(a) Values shown were below the limit of detection.
(b) The filtered result for copper was elevated compared to the unfiltered sample and blank contamination of the filtered sample is suspected.
SD = Standard deviation.

Table C.8. Radionuclide and Total Organic Carbon Concentrations in Sediment from the Columbia River Near the Hanford Site, 2007 Compared to Previous 5 Years

Location and Total Organic Carbon Concentrations (2007 TOC Value)	Radionuclide	2007 No. of Samples	2007 Concentration, pCi/g[a] Average[b]	2007 Concentration, pCi/g[a] Maximum[c]	2002-2006 No. of Samples	2002-2006 Concentration, pCi/g[a] Average[b]	2002-2006 Concentration, pCi/g[a] Maximum[c]
Priest Rapids Dam (9,620-12,500 mg/kg)	Cobalt-60	2	6.3E-03 ± 0.011[d]	0.010 ± 0.015[d]	11	3.4E-04 ± 0.010[d]	6.8E-03 ± 0.015[d]
	Strontium-90	2	5.7E-03 ± 1.3E-03	6.1E-03 ± 4.9E-03	11	2.0E-03 ± 0.029[d]	0.031 ± 0.029[d]
	Cesium-137	2	0.26 ± 0.056	0.28 ± 0.052	11	0.35 ± 0.22	0.65 ± 0.086
	Europium-152	2	5.3E-03 ± 0.024[d]	0.014 ± 0.029[d]	9	-7.2E-03 ± 0.063[d]	0.026 ± 0.032[d]
	Europium-155	2	0.059 ± 2.5E-03[d]	0.060 ± 0.035[d]	11	0.056 ± 4.6E-03[d]	0.093 ± 0.045[d]
	Uranium-234	2	0.82 ± 0.021	0.83 ± 0.15	11	0.74 ± 0.28	0.95 ± 0.16
	Uranium-235	2	0.032 ± 2.8E-03	0.033 ± 0.012	11	0.024 ± 0.014	0.038 ± 0.017
	Uranium-238	2	0.67 ± 0.10	0.71 ± 0.14	11	0.63 ± 0.21	0.78 ± 0.15
	Plutonium-239/240	2	7.5E-03 ± 2.4E-03	8.3E-03 ± 1.8E-03	13	9.8E-03 ± 3.7E-03	0.015 ± 2.4E-03
White Bluffs Slough (7,180 mg/kg)	Cobalt-60	1		0.018 ± 0.011[d]	5	0.029 ± 0.042	0.060 ± 0.025[d]
	Strontium-90	1		-9.4E-04 ± 4.2E-03[d]	5	-1.7E-03 ± 0.032[d]	0.016 ± 0.015[d]
	Cesium-137	1		0.64 ± 0.085	5	1.2 ± 1.9	2.8 ± 0.33
	Europium-152	1		0.20 ± 0.053[d]	4	0.26 ± 0.35	0.51 ± 0.099
	Europium-155	1		0.086 ± 0.032[d]	5	0.050 ± 0.034[d]	0.072 ± 0.037[d]
	Uranium-234	1		0.41 ± 0.089	5	0.65 ± 1.1	1.6 ± 0.30
	Uranium-235	1		0.012 ± 8.2E-03	5	0.025 ± 0.033	0.053 ± 0.016
	Uranium-238	1		0.31 ± 0.093	5	0.58 ± 0.84	1.3 ± 0.24
	Plutonium-239/240	1		5.2E-03 ± 9.9E-04	5	7.2E-03 ± 3.7E-03	0.010 ± 1.9E-03
100-F Slough (1,340 mg/kg)	Cobalt-60	1		6.5E-03 ± 9.3E-03[d]	5	6.9E-03 ± 6.9E-03[d]	0.012 ± 0.010[d]
	Strontium-90	1		1.6E-03 ± 4.0E-03[d]	5	-2.2E-03 ± 0.022[d]	7.9E-03 ± 0.017[d]
	Cesium-137	1		0.30 ± 0.043	5	0.28 ± 0.14	0.39 ± 0.055
	Europium-152	1		0.025 ± 0.023[d]	4	0.034 ± 0.054[d]	0.072 ± 0.044[d]
	Europium-155	1		0.054 ± 0.026[d]	5	0.038 ± 0.035[d]	0.064 ± 0.028[d]
	Uranium-234	1		0.14 ± 0.060	5	0.25 ± 0.40	0.60 ± 0.11
	Uranium-235	1		4.1E-03 ± 6.4E-03[d]	5	6.9E-03 ± 0.014	0.015 ± 9.0E-03
	Uranium-238	1		0.16 ± 0.081	5	0.25 ± 0.39	0.60 ± 0.13
	Plutonium-239/240	1		1.6E-03 ± 6.2E-04	4	1.3E-03 ± 1.2E-03	2.0E-03 ± 1.2E-03
Hanford Slough (3,940 mg/kg)	Cobalt-60	1		0.040 ± 0.026[d]	5	0.013 ± 0.048	0.055 ± 0.020
	Strontium-90	1		-1.6E-03 ± 4.1E-03	5	-3.2E-03 ± 0.025[d]	5.9E-03 ± 0.019[d]
	Cesium-137	1		0.28 ± 0.041	5	0.078 ± 0.27	0.32 ± 0.046
	Europium-152	1		0.069 ± 0.028[d]	4	0.037 ± 0.19[d]	0.18 ± 0.049[d]
	Europium-155	1		0.070 ± 0.034[d]	5	0.043 ± 0.038[d]	0.058 ± 0.038[d]
	Uranium-234	1		0.22 ± 0.068	5	0.40 ± 0.28	0.56 ± 0.11
	Uranium-235	1		8.7E-03 ± 7.3E-03	5	0.015 ± 0.012	0.021 ± 0.016
	Uranium-238	1		0.22 ± 0.086	5	0.38 ± 0.23	0.53 ± 0.13
	Plutonium-239/240	1		2.6E-03 ± 6.8E-04	5	2.3E-03 ± 4.8E-03	5.3E-03 ± 2.6E-03

Table C.8. (contd)

Location and Total Organic Carbon Concentrations	Radionuclide	2007 No. of Samples	2007 Concentration, pCi/g[a] Average[b]	2007 Concentration, pCi/g[a] Maximum[c]	2002-2006 No. of Samples	2002-2006 Concentration, pCi/g[a] Average[b]	2002-2006 Concentration, pCi/g[a] Maximum[c]
(2007 TOC Value)							
Richland (623 mg/kg)	Cobalt-60	1		-5.0E-04 ± 0.011[d]	5	3.2E-03 ± 9.9E-03[d]	9.2E-03 ± 0.011[d]
	Strontium-90	1		-01.4E-03 ± 4.0E-03[d]	5	-7.9E-03 ± 0.030[d]	0.015 ± 0.020[d]
	Cesium-137	1		0.14 ± 0.025	5	0.15 ± 0.067	0.19 ± 0.033
	Europium-152	1		0.032 ± 0.024[d]	4	0.043 ± 0.030[d]	0.057 ± 0.033[d]
	Europium-155	1		0.065 ± 0.031[d]	5	0.074 ± 0.056[d]	0.10 ± 0.053[d]
	Uranium-234	1		0.17 ± 0.062	5	0.24 ± 0.18	0.36 ± 0.089
	Uranium-235	1		3.2E-03 ± 5.6E-03[d]	5	7.7E-03 ± 8.6E-03	0.014 ± 9.1E-03
	Uranium-238	1		0.16 ± 0.080	5	0.24 ± 0.18	0.38 ± 0.11
	Plutonium-239/240	1		7.7E-04 ± 3.2E-04	4	1.5E-03 ± 2.2E-04	1.6E-03 ± 4.9E-04
McNary Dam (14,000 - 18,900 mg/kg)	Cobalt-60	2	4.1E-03 ± 0.041[d]	0.018 ± 0.016[d]	13	0.023 ± 0.038[d]	0.062 ± 0.028[d]
	Strontium-90	2	6.0E-03 ± 2.7E-03	7.0E-03 ± 4.4E-03	16	0.010 ± 0.031[d]	0.034 ± 0.047[d]
	Cesium-137	2	0.26 ± 0.18	0.32 ± 0.050	13	0.28 ± 0.13	0.42 ± 0.083
	Europium-152	2	0.090 ± 0.23[d]	0.17 ± 0.050[d]	11	0.11 ± 0.19[d]	0.29 ± 0.11[d]
	Europium-155	2	0.069 ± 1.4E-04[d]	0.069 ± 0.038[d]	13	0.064 ± 0.052[d]	0.11 ± 0.074[d]
	Uranium-234	2	0.94 ± 0.21	1.0 ± 0.17	13	0.94 ± 0.38	1.4 ± 0.24
	Uranium-235	2	0.030 ± 0.015	0.036 ± 0.012	13	0.031 ± 0.021	0.052 ± 0.015
	Uranium-238	2	0.70 ± 0.20	0.78 ± 0.15	13	0.74 ± 0.24	1.0 ± 0.19
	Plutonium-239/240	2	8.2E-03 ± 2.7E-03	9.2E-03 ± 1.7E-03	16	8.2E-03 ± 2.7E-03	0.011 ± 2.2E-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, 2007

Metal	(n=2) Priest Rapids Dam	(n=4) Hanford Reach[a]	(n=2) McNary Dam	(n=8) Shoreline Springs[b]
Antimony	0.82 - 1.1	0.39 - 0.73	0.69 - 0.80	0.49 - 1.1
Arsenic	8.8 - 12	4.3 - 6.1	7.7 - 8.8	3.1 - 11
Beryllium	1.3 - 1.5	1.2 - 1.4	1.4 - 1.6	1.3 - 1.8
Cadmium	6.9 - 8.1	0.41 - 2.3	1.3 - 1.4	0.39 - 1.1
Chromium	72 - 88	38 - 50	54 - 56	35 - 100
Copper	50 - 58	17 - 28	29 - 37	14 - 30
Lead	50 - 64	18 - 48	25 - 26	18 - 80
Mercury	0.16 - 0.18	0.010 - 0.051	0.081 - 0.11	0.0079 - 0.023
Nickel	39 - 51	14 - 20	27 - 29	14 - 20
Selenium	0.27 - 0.32	0.24 - 0.24	0.24 - 0.36	0.095 - 0.39
Silver	0.18 - 0.28	0.033 - 0.065	0.18 - 0.19	--
Thallium	1.0 - 1.3	0.53 - 1.9	0.58 - 0.61	0.41 - 0.62
Zinc	580 - 590	160 - 380	230 - 250	110 - 290

(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, 2007 Compared to Previous 5 Years

Location/Radionuclide	2007 No. of Samples	2007 Concentration,[a] pCi/L Maximum	2007 Concentration,[a] pCi/L Average	2002-2006 No. of Samples	2002-2006 Concentration,[a] pCi/L Maximum	2002-2006 Concentration,[a] pCi/L Average	Washington State Ambient Surface Water Quality Standard,[b] pCi/L
100-B Area							
Alpha (gross)	2	14 ± 5.6	8.5 ± 17	7	2.5 ± 1.8	1.3 ± 1.4	15
Beta (gross)	2	23 ± 5.1	15 ± 23	7	13 ± 3.3	8.3 ± 7.6	50
Strontium-90	2	2.0 ± 0.30	0.98 ± 2.8	7	4.0 ± 0.59	1.4 ± 3.6	8
Technetium-99	2	4.6 ± 0.61	3.2 ± 4.0	7	12 ± 0.95	6.0 ± 8.1	900[c]
Tritium	2	2,300 ± 250	2,200 ± 280	7	5,800 ± 500	4,500 ± 2,400	20,000
100-K Area							
Alpha (gross)	2	13 ± 4.8	6.5 ± 18	7	2.7 ± 1.1	1.0 ± 2.2	15
Beta (gross)	2	19 ± 5.2	12 ± 20	7	7.2 ± 2.3	5.2 ± 2.1	50
Strontium-90	2	1.9 ± 0.29	0.96 ± 2.7	7	3.2 ± 0.72	1.8 ± 2.6	8
Technetium-99	0			2	1.1 ± 0.60	0.43 ± 2.0	900[c]
Tritium	2	4,200 ± 370	2,100 ± 5,800	7	1,400 ± 130	410 ± 1,300	20,000
100-N Area							
Alpha (gross)	1	1.7 ± 1.5[d]		5	4.9 ± 2.7	2.0 ± 3.6	15
Beta (gross)	1	5.2 ± 2.1		5	9.3 ± 2.4	4.4 ± 6.0	50
Strontium-90	1	0.017 ± 0.033[d]		7	0.043 ± 0.020	0.020 ± 0.041	8
Technetium-99	0			2	0.64 ± 0.40	0.61 ± 0.089	900[c]
Tritium	1	7,900 ± 600		7	11,000 ± 430	9,200 ± 4,300	20,000
100-D Area							
Alpha (gross)	2	0.64 ± 0.79[d]	0.58 ± 0.16[d]	9	14 ± 4.9	4.4 ± 9.0	15
Beta (gross)	2	5.8 ± 2.2	4.5 ± 3.8	9	41 ± 7.9	8.2 ± 25	50
Strontium-90	2	0.40 ± 0.074	0.25 ± 0.43	8	0.38 ± 0.079	0.15 ± 0.27	8
Tritium	2	480 ± 140	260 ± 610	9	4,800 ± 250	870 ± 3,200	20,000
Uranium (total)	0			8	3.2 ± 0.43	1.1 ± 1.9	--[e]
100-H Area							
Alpha (gross)	2	3.0 ± 1.6	1.8 ± 3.4	8	3.9 ± 2.2	2.0 ± 3.1	15
Beta (gross)	2	21 ± 3.9	13 ± 24	8	25 ± 4.2	9.6 ± 14	50
Strontium-90	2	6.2 ± 0.89	3.1 ± 8.8	7	14 ± 2.0	3.9 ± 9.9	8
Technetium-99	2	0.16 ± 0.35[d]	0.14 ± 0.085[d]	8	8.0 ± 0.97	1.2 ± 5.4	900[c]
Tritium	2	2,400 ± 270	1,300 ± 3,000	8	4,100 ± 250	1,400 ± 2,900	20,000
Uranium (total)	2	5.0 ± 0.56	3.2 ± 5.0	8	4.1 ± 0.60	1.5 ± 2.6	--[e]

Table C.10. (contd)

Location/Radionuclide	2007 No. of Samples	2007 Concentration,[a] pCi/L Maximum	2007 Concentration,[a] pCi/L Average	2002-2006 No. of Samples	2002-2006 Concentration,[a] pCi/L Maximum	2002-2006 Concentration,[a] pCi/L Average	Washington State Ambient Surface Water Quality Standard,[b] pCi/L
100-F Area							
Alpha (gross)	1	3.6 ± 2.2		5	28 ± 8.8	12 ± 20	15
Beta (gross)	1	6.0 ± 3.0		5	43 ± 9.6	17 ± 30	50
Strontium-90	1	0.12 ± 0.050		5	0.058 ± 0.023	0.022 ± 0.055	8
Tritium	1	1,400 ± 190		5	1,300 ± 130	820 ± 880	20,000
Uranium (total)	1	5.3 ± 0.60		5	20 ± 2.1	6.6 ± 15	--[e]
Hanford town site							
Alpha (gross)	3	3.8 ± 2.0	2.3 ± 2.5	13	14 ± 5.6	2.5 ± 7.1	15
Beta (gross)	3	27 ± 4.5	21 ± 10	13	47 ± 12	17 ± 23	50
Iodine-129	3	0.65 ± 0.27[d]	0.31 ± 0.59[d]	7	0.20 ± 0.014	0.15 ± 0.093	1
Technetium-99	3	68 ± 3.9	47 ± 37	13	78 ± 4.5	33 ± 53	900[c]
Tritium	3	53,000 ± 3,300	38,000 ± 25,000	13	67,000 ± 4,800	29,000 ± 41,000	20,000
Uranium (total)	3	2.8 ± 0.34	2.3 ± 0.88	12	5.6 ± 0.69	1.9 ± 2.7	--[e]
300 Area							
Alpha (gross)	4	120 ± 28	55 ± 92	14	140 ± 36	58 ± 81	15
Beta (gross)	4	24 ± 4.2	17 ± 9.4	14	55 ± 10	23 ± 26	50
Iodine-129[f]	2	0.045 ± 0.10[d]	0.014 ± 0.089[d]	6	0.0068 ± 0.00084	0.0044 ± 0.0026	1
Tritium	4	10,000 ± 760	6,800 ± 5,200	15	12,000 ± 920	7,500 ± 6,700	20,000
Uranium (total)	4	110 ± 11	54 ± 84	15	140 ± 15	63 ± 87	--[e]

(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) WAC 173-201A-250 and EPA-570/9-76-003.
(d) Value below the laboratory-reported detection limit.
(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 2007 Compared to Previous 5 Years

		2007			2002-2006		
		No. of	Concentration, pCi/g[a]		No. of	Concentration, pCi/g[a]	
Location	Radionuclide	Samples	Average[b]	Maximum[c]	Samples	Average[b]	Maximum[c]
100-B Spring	Cobalt-60	1		0.0051 ± 0.010[d]	4	0.0017 ± 0.014[d]	0.0076 ± 0.012[d]
	Strontium-90	1		-0.00067 ± 0.0048[d]	4	-0.0050 ± 0.030[d]	0.0068 ± 0.016[d]
	Cesium-137	1		0.044 ± 0.018	4	0.052 ± 0.033	0.068 ± 0.023
	Europium-152	1		-0.019 ± 0.027[d]	3	-0.0083 ± 0.046[d]	0.0097 ± 0.045[d]
	Europium-155	1		0.082 ± 0.033[d]	4	0.074 ± 0.036[d]	0.095 ± 0.037[d]
	Uranium-234	1		0.22 ± 0.068	4	0.24 ± 0.23	0.41 ± 0.077
	Uranium-235	1		0.0035 ± 0.0060[d]	4	0.0089 ± 0.0079	0.014 ± 0.0080
	Uranium-238	1		0.23 ± 0.086	4	0.21 ± 0.19	0.35 ± 0.067
100-K Spring	Cobalt-60	1		0.013 ± 0.0085[d]	2	0.0049 ± 0.0012[d]	0.0053 ± 0.013[d]
	Strontium-90	1		0.0027 ± 0.0045[d]	2	0.016 ± 0.0031[d]	0.017 ± 0.019[d]
	Cesium-137	1		0.094 ± 0.020	2	0.11 ± 0.019	0.11 ± 0.024
	Europium-152	1		-0.018 ± 0.022[d]	1		-0.0059 ± 0.023[d]
	Europium-155	1		0.046 ± 0.025[d]	2	0.038 ± 0.052[d]	0.057 ± 0.041[d]
	Uranium-234	1		0.24 ± 0.068	2	0.28 ± 0.059	0.30 ± 0.065
	Uranium-235	1		0.0089 ± 0.0067	2	0.088 ± 0.00079	0.0091 ± 0.0064
	Uranium-238	1		0.19 ± 0.082	2	0.26 ± 0.057	0.28 ± 0.060
100-H Spring	Cobalt-60	1		0.0052 ± 0.0092[d]	4	0.0091 ± 0.0057[d]	0.012 ± 0.012[d]
	Strontium-90	1		0.0043 ± 0.0047[d]	4	0.024 ± 0.10	0.10 ± 0.017
	Cesium-137	1		0.091 ± 0.020	4	0.16 ± 0.055	0.20 ± 0.029
	Europium-152	1		0.043 ± 0.026[d]	4	0.037 ± 0.036[d]	0.061 ± 0.047[d]
	Europium-155	1		0.048 ± 0.025[d]	4	0.061 ± 0.032[d]	0.074 ± 0.034[d]
	Uranium-234	1		0.27 ± 0.072	4	0.36 ± 0.10	0.43 ± 0.10
	Uranium-235	1		0.0066 ± 0.0064	4	0.011 ± 0.0044	0.013 ± 0.012
	Uranium-238	1		0.26 ± 0.088	4	0.32 ± 0.11	0.39 ± 0.12
100-F Spring	Cobalt-60	1		0.0054 ± 0.011[d]	5	0.0039 ± 0.0090[d]	0.0085 ± 0.014[d]
	Strontium-90	1		0.0050 ± 0.0048[d]	5	-0.0064 ± 0.016[d]	-0.0010 ± 0.0046[d]
	Cesium-137	1		0.11 ± 0.025	5	0.12 ± 0.16	0.26 ± 0.051
	Europium-152	1		-0.0013 ± 0.026	4	0.048 ± 0.10[d]	0.13 ± 0.060[d]
	Europium-155	1		0.070 ± 0.034[d]	5	0.051 ± 0.031[d]	0.073 ± 0.033[d]
	Uranium-234	1		0.45 ± 0.093	5	0.50 ± 0.28	0.60 ± 0.13
	Uranium-235	1		0.021 ± 0.0091	5	0.020 ± 0.0093	0.026 ± 0.011
	Uranium-238	1		0.40 ± 0.10	5	0.42 ± 0.22	0.50 ± 0.13

Table C.11. (contd)

Location	Radionuclide	2007 No. of Samples	2007 Concentration, pCi/g[a] Average[b]	2007 Concentration, pCi/g[a] Maximum[c]	2002-2006 No. of Samples	2002-2006 Concentration, pCi/g[a] Average[b]	2002-2006 Concentration, pCi/g[a] Maximum[c]
Hanford Spring	Cobalt-60	2	0.0056 ± 0.0070[d]	0.0081 ± 0.012[d]	6	0.018 ± 0.022[d]	0.032 ± 0.012[d]
	Strontium-90	2	0.0016 ± 0.0030[d]	0.0027 ± 0.0049[d]	6	0.011 ± 0.068	0.074 ± 0.013
	Cesium-137	2	0.14 ± 0.13	0.18 ± 0.031	6	0.15 ± 0.14	0.26 ± 0.041
	Europium-152	2	0.075 ± 0.12[d]	0.12 ± 0.041[d]	5	0.080 ± 0.095[d]	0.15 ± 0.058[d]
	Europium-155	2	0.069 ± 0.046[d]	0.085 ± 0.034[d]	6	0.077 ± 0.045[d]	0.10 ± 0.035[d]
	Uranium-234	2	0.53 ± 0.37	0.66 ± 0.12	6	0.53 ± 0.11	0.61 ± 0.13
	Uranium-235	2	0.015 ± 0.011	0.019 ± 0.0088	6	0.014 ± 0.0042	0.016 ± 0.011
	Uranium-238	2	0.44 ± 0.19	0.51 ± 0.11	6	0.40 ± 0.11	0.45 ± 0.089
300 Area Spring	Cobalt-60	4	-0.0011 ± 0.0083[d]	0.0044 ± 0.012[d]	14	0.0048 ± 0.011[d]	0.014 ± 0.011[d]
	Strontium-90	2	0.0019 ± 0.0018[d]	0.0025 ± 0.0041[d]	10	0.0051 ± 0.031	0.027 ± 0.021[d]
	Cesium-137	4	0.12 ± 0.18	0.23 ± 0.035	14	0.10 ± 0.15	0.25 ± 0.038
	Europium-152	4	0.026 ± 0.056[d]	0.064 ± 0.028[d]	12	0.022 ± 0.064[d]	0.082 ± 0.049[d]
	Europium-155	4	0.053 ± 0.030[d]	0.065 ± 0.029[d]	14	0.060 ± 0.032[d]	0.085 ± 0.037[d]
	Uranium-234	4	1.3 ± 1.1	1.8 ± 0.28	14	2.3 ± 5.7	11 ± 2.0
	Uranium-235	4	0.054 ± 0.046	0.070 ± 0.018	14	0.095 ± 0.20	0.38 ± 0.075
	Uranium-238	4	1.3 ± 1.1	1.7 ± 0.27	14	2.1 ± 5.0	10 ± 1.8

(a) To convert to the International System of Units, multiply pCi/g by 0.037 to obtain Bq/g.
(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 Whitefish Collected from the Hanford Reach of the Columbia River and at a Reference Location Above Wanapum Dam in 2007[a]

	100-N to 100-D Areas (n=4)			Ringold (n=2)		Upriver, Wanapum Dam (n=5)		
Metal	Maximum	Minimum	Median	Maximum	Minimum	Maximum	Minimum	Median
Aluminum	6.4	2.0[b]	3.7	2.9	2.8	4.3[b]	1[c]	1.4
Antimony	0.3[c]	0.3[c]	0.3	0.033[d]	0.024	0.3[c]	0.3[c]	0.3
Arsenic	0.69	0.3[c]	0.3	1.5	1.5	0.3[c]	0.3[c]	0.3
Beryllium	0.01[c]	0.01[c]	0.01	0.02[c]	0.02[c]	0.01[c]	0.01[c]	0.01
Cadmium	1.8	1.1	1.5	2.8	1.5	1.3	0.25	0.62
Chromium	0.26	0.16	0.22	0.40	0.30	0.29	0.16	0.19
Copper	25	6.8	8.6	8.5	8.0	8.7	5.2	7.2
Lead	0.18	0.024[b,d]	0.091	0.088	0.060	0.76	0.01[c]	0.048
Manganese	8.3	4.5	5.2	14	7.5	12	4.6	5.6
Mercury	NA	NA	NA	0.18	0.14	2.1	0.15	0.46
Nickel	0.13	0.045[b]	0.080	0.25	0.22	0.071	0.04[c]	0.04
Selenium	16	6.8	11	21	17	15	4.1	8.7
Silver	0.29[d]	0.01[c]	0.01	0.035	0.035	0.01[c]	0.01[c]	0.01
Thallium	1.4	0.45	0.84	0.66	0.59	0.90	0.25	0.60
Thorium	0.01[c]	0.01[c]	0.01	0.11[d]	0.026[d]	0.024[b]	0.01[c]	0.01
Uranium	0.13	0.020	0.037	0.077	0.028	0.076	0.0058[b]	0.016
Zinc	120	84	110	240	150	100	87	88

(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 five times the blank concentration.
n = Number of samples.
NA = Not analyzed.

Table C.13. Concentrations (µg/g dry wt.) of Metals in Livers from Canada Geese Collected from the Hanford Reach of the Columbia River and at a Reference Location Near Desert Aire, Washington, in 2007[a]

	100 Areas (n=5)			Hanford Town Site to 300 Area (n=5)			Desert Aire, Washington (n=5)		
Metal	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
Aluminum	2.8	0.68	1.2	1.4	0.84	1.2	2.9[b]	1.2[b]	1.8
Antimony	0.02[c]	0.02[c]	0.02	0.02[c]	0.02[c]	0.02	0.02[c]	0.02[c]	0.02
Arsenic	0.45	0.27	0.38	0.45	0.37	0.40	0.1[c]	0.1[c]	0.1
Beryllium	0.02[c]	0.02[c]	0.02	0.02[c]	0.02[c]	0.02	0.01[c]	0.01[c]	0.01
Cadmium	5.5	0.20	2.8	6.4	0.31	0.4	0.99	0.12	0.42
Chromium	0.40	0.22	0.27	0.65	0.23	0.28	0.17	0.13	0.14
Copper	44	18	36	47	38	44	59	9.7	28
Lead	1.1	0.049	0.095	0.23	0.038	0.066	0.12	0.022[b,d]	0.078
Manganese	10	6.2	6.6	13	9.1	9.6	14	8.9	12
Mercury	0.056	0.036[d]	0.042	0.057	0.034[b,d]	0.041	0.044[b,d]	0.024[b,d]	0.041
Nickel	0.061	0.04[c]	0.04	0.043[b]	0.04[c]	0.04	0.04[c]	0.04[c]	0.04
Selenium	6.4	4.0	4.9	7.0	6.3	6.8	2.1	0.89	1.1
Silver	0.014	0.01[c]	0.01	0.020	0.01[c]	0.01	0.039	0.01[c]	0.021
Thallium	0.080	0.024	0.044	0.063	0.036	0.048	0.039	0.01[c]	0.012
Thorium	0.019[d]	0.0070[b,d]	0.013	0.013[d]	0.003[c]	0.0040	0.033	0.01[c]	0.01
Uranium	0.0030[b]	0.002[c]	0.002	0.0024[b]	0.002[c]	0.002	0.002[c]	0.002[c]	0.002
Zinc	170	140	150	190	150	170	500	130	140

(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 five times the blank concentration.
n = Number of samples.

Table C.14. Concentrations (µg/g dry wt.) of Metals in Livers from Cottontail Rabbits Collected from the Hanford Reach of the Columbia River and the Hanford Site Central Plateau in 2007[a]

	100-N Area (n=1)	200-East Area (n=1)
Metal	Maximum	Maximum
Aluminum	3.6[b]	4.9[b]
Antimony	0.02[c]	0.02[c]
Arsenic	0.1[c]	0.1[c]
Beryllium	0.01[c]	0.01[c]
Cadmium	1.4	0.61
Chromium	0.17	0.15
Copper	8.7	7.9
Lead	0.38	0.63
Manganese	7.3	7.1
Nickel	0.04[c]	0.04[c]
Selenium	2.1	2.0
Silver	0.01[c]	0.01[c]
Thallium	0.01[c]	0.01[c]
Thorium	0.01[c]	0.01[c]
Uranium	0.002[c]	0.002[c]
Zinc	130	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.

References

40 CFR 61, Appendix E, Table 2. "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. "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-17603, APP. 1. 2008. *Hanford Site Environmental Surveillance Data Report for Calendar Year 2007*. LE Bisping, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-17603, APP. 2. 2008. *Hanford Site Near-Facility Monitoring Data Report for Calendar Year 2007*. CJ Perkins, MC Dorsey, SM McKinney, and RC Roos, Energy*Solutions*, 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. "Public Water Supplies." *Washington Administrative Code*, Olympia, Washington.

Appendix D
Standards and Permits

G. W. Patton and J. P. 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 2007 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 (40 CFR 141), "National Primary Drinking Water Regulations" and WAC 246-290, "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 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-1U005 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 is scheduled to be reissued in 2008. 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.

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 is scheduled to be reissued in 2008. 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. Still operating on an extension of the old permit, which will be 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 06-468, issued by the Washington Department of Fish and Wildlife to Pacific Northwest National Laboratory for 2007; 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, 2009.

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[a,b,c]

Radionuclide	Consumed Water, pCi/L	(Bq/L)	Inhaled Air, pCi/m³	(Bq/m³)
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[a]

Parameter	Permissible Levels
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[a]
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)[b]	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_3^-	45 mg/L	(45 ppm)	EPA, DOH
Nitrite, as NO_2^-	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 pi/L[c]	(11.1 Bq/L)	EPA
Beta particle and photon activity	4 mrem/yr[d]	(40 µSv/yr)	EPA, DOH
Carbon-14	2,000 pCi/L[c]	(74.1 Bq/L)	EPA
Cesium-137	200 pCi/L[c]	(7.4 Bq/L)	EPA
Cobalt-60	100 pCi/L[c]	(3.7 Bq/L)	EPA
Iodine-129	1 pCi/L[c]	(0.037 Bq/L)	EPA
Ruthenium-106	30 pCi/L[c]	(1.11 Bq/L)	EPA
Strontium-90	8 pCi/L[c]	(0.296 Bq/L)	EPA, DOH
Technetium-99	900 pCi/L[c]	(33.3 Bq/L)	EPA
Total alpha (excluding uranium)	15 pCi/L[c]	(0.56 Bq/L)	EPA, DOH
Tritium	20,000 pCi/L[c]	(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, µg/L (ppm)[a]	Level that Yields Chronic Toxicity, µg/L (ppm)[a]	Level to Protect Human Health for the Consumption of Water and Organisms, µg/L (ppm)[b]
Dissolved Metals			
Antimony	--	--	14 (0.014)
Arsenic	360.0 (0.360)	190.0 (0.19)	0.018 (0.000018)
Cadmium	1.6 (0.0016)[c]	0.59 (0.00059)[d]	--
Chromium(VI)	15 (0.015)	10 (0.01)	--
Copper	8.4 (0.0084)[e]	6.0 (0.006)[f]	--
Lead	28 (0.028)[g]	1.1 (0.0011)[h]	--
Mercury	2.1 (0.0021)	--	0.14 (0.00014)
Nickel	750 (0.75)[i]	83 (0.083)[j]	610 (0.61)
Silver	0.94 (0.00094)[k]	--	--
Thallium	--	--	1.7 (0.0017)
Zinc	60 (0.060)[l]	55 (0.055)[m]	--
Total Recoverable Metals			
Chromium(III)[n]	300 (0.30)[o]	96 (0.096)[p]	--
Mercury	--	0.012 (0.000012)	
Selenium	20 (0.02)	5.0 (0.005)	--
Anions			
Cyanide[q]	22.0 (0.022)	5.2 (0.0052)	700 (0.70)
Chloride[r]	860,000 (860)	230,000 (230)	--
Organic Compounds			
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 $CaCO_3$/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(hardness)] 0.04184) exp(1.128[ln(hardness)]-3.828). Hardness expressed as mg $CaCO_3$/L.
(d) (1.1017 - [ln(hardness)] 0.04184) exp(0.7852[ln(hardness)]-3.490).
(e) (0.960) exp(0.9422[ln(hardness)]-1.464).
(f) (0.960) exp(0.8545[ln(hardness)]-1.465).
(g) (1.4620 - [ln(hardness)] 0.1457) exp(1.273[ln(hardness)]-1.460).
(h) (1.4620 - [ln(hardness)] 0.1457) exp(1.273[ln(hardness)]-4.705).
(i) (0.998) exp(0.8460[ln(hardness)]+3.3612).
(j) (0.997) exp(0.8460[ln(hardness)]+1.1645).
(k) (0.85) exp(1.72[ln(hardness)]-6.52).
(l) (0.978) exp(0.8473[ln(hardness)]+0.8604).
(m) (0.986) exp(0.8473[ln(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(hardness)]+3.688).
(p) (0.860) exp(0.8190[ln(hardness)]+1.561).
(q) Criteria based on weak and dissociable method.
(r) Dissolved in association with sodium.

Table D.6. Radiation Standards (Dose Limits[a]) 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[b] shall not exceed the values given below.

	Effective Dose Equivalent[c]	
	mrem/yr	mSv/yr
Routine public dose	100	1
Potential authorized temporary public dose[d]	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[e] 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)	Effective Dose Equivalent[c]	
	mrem/yr	mSv/yr
Public dose limit at location of maximum annual air concentration as a consequence of routine DOE operations[b]	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. "National Emission Standards for Hazardous Air Pollutants." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 131.36. "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. "National Primary Drinking Water Regulations." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 143. "National Secondary Drinking Water Regulations." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR Parts 9, 141, and 142. "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. "Public Water Systems." *Washington Administrative Code*, Olympia, Washington.

Appendix E
Dose Calculations

E. J. Antonio

The radiological dose that the public could have received in 2007 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)[(a)] 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 site operations areas. This appendix describes how the doses in this report were calculated.

The calculation of 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.

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 2007 radionuclide concentrations in water, soil,

(a) 1 rem (0.01 sievert) = 1,000 millirem (10 millisievert).

and sediment to see if they exceeded established biota concentration guides (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. In the initial screening assessment, one compares maximum measured concentrations to the biota concentration guides. 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 2007 air emissions report (DOE/RL-2008-03).

Types of Dose Calculations Performed

Calculations of radiological doses to the public from radionuclides released into the environment are performed 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 (millirem [microsievert]). 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 N Reactor.
- Exposure to ground contaminated by both airborne deposition and irrigation water.
- Ingestion 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 from year to year, 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 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 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 Richland. Although the Ringold area is closer than the Riverview area to Hanford 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 2007 and previous years 2003 through 2006, the hypothetical, maximally exposed individual was located across the Columbia River from the 300 Area in the Sagemoor area (Figure 10.13.1).

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 also is considered for this individual, resulting in direct exposure from water, and radionuclides deposited on the shoreline, and doses from ingestion 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 facilities. For the calculation, it was assumed that the Riverview area maximally exposed individual obtained domestic water from a local water treatment system that 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 taken from the Columbia 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 was also considered, resulting in direct exposure from water, and 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. Because of the shift in site operations from nuclear weapons production to the current mission of managing waste products, cleaning up the site, and researching new ideas and technologies for waste disposal and cleanup, the significance of air emissions from production facilities in the 200 Areas has decreased compared to emissions from research facilities in the 300 Area.

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 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, evaluation of the collective population doses to all residents within an 80-kilometer (50-mile) radius of Hanford Site operations is required by DOE Order 5400.5. 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 the 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, an estimate was made of the fraction of the offsite population expected to be affected by each pathway. 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 230,000 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 for irrigation of 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 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-17603, 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 give the parameters describing the diet, residency, and river recreation parameters assumed for maximally exposed and average individuals.

Dose Calculation Documentation

The DOE established the Hanford Dose Overview Panel to promote consistency and defensibility of environmental dose calculations at Hanford. The panel was responsible for defining standard, documented computer codes and input parameters used for radiological dose calculations for the public in the vicinity of the Hanford 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). The calculations were then reviewed by a former panel

Table E.1. Food Pathway Parameters Used in Hanford Site Dose Calculations, 2007

Medium	Holdup (days)[a] Maximally Exposed Individual	Holdup (days)[a] Average Individual	Growing Period (days)	Yield kg/m² (lb/yd²)		Irrigation Rate L/m²/mo (gal/yd²/mo)	
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][b]	[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[c]	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.

Table E.2. Dietary Parameters Used in Hanford Site Dose Calculations, 2007

Medium	Consumption: Maximally Exposed Individual		Consumption: Average Individual	
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)	--[a]	
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).

member. Summaries of dose calculation technical details for this report are shown in Tables E.5 through E.10 and in PNNL-17603, 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 2007 are given in Table E.11.

Ambient-Air Inhalation Doses

Radionuclide concentrations measured in ambient air at locations on or near the Hanford Site were used to calculate radiological doses from breathing contaminated air. Inhalation rates were taken from International Commission on Radiological Protection (1994). Occupancy times ranged from 100% at offsite locations to 33% for onsite locations.

Table E.3. Residency Parameters Used in Hanford Site Dose Calculations, 2007

Parameter	Exposure (hr/yr) Maximally Exposed Individual	Exposure (hr/yr) Average Individual
Ground contamination	4,383	2,920
Air submersion	8,766	8,766
Inhalation[a]	8,766	8,766

(a) Inhalation rates: adult 270 cm^3/sec (16.5 $in.^3$/sec).

Table E.4. Columbia River Recreational Parameters Used in Hanford Site Dose Calculations, 2007

Parameter	Exposure (hr/yr)[a] Maximally Exposed Individual	Exposure (hr/yr)[a] Average Individual
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, 2007

Facility name	100-K Area
Releases (Ci [Bq])	^{90}Sr (3.2×10^{-5} [1.2×10^{6}]), ^{238}Pu (3.6×10^{-6} [1.3×10^{5}]), ^{239}Pu (2.6×10^{-5} [9.6×10^{5}]), ^{241}Pu (8.7×10^{-5} [3.2×10^{-6}], ^{241}Am (2.0×10^{-5} [7.4×10^{5}])
Meteorological conditions	2007 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 2007
$\overline{X}/Q'$ dispersion factors	Maximally exposed individual, 1.5×10^{-8} sec/m^3 at 41 km (25 mi) SE; 80-km (50-mi) population, 4.0×10^{-3} person-sec/m^3
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, 2007

Facility name	100-K Area
Releases (Ci [Bq])	^{90}Sr (3.2×10^{-4} [1.2×10^{7}]), ^{137}Cs (7.5×10^{-5} [2.8×10^{-6}]), ^{239}Pu (3.3×10^{-6} [1.2×10^{5}])
Mean river flow	3,299 m^3/sec (116,489 ft^3/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, 2007

Facility name	200 Areas
Releases (Ci [Bq])	200-East Area ^{90}Sr (6.9 x 10^{-5} [2.6 x 10^{6}]), ^{129}I (1.6 x 10^{-3} [5.9 x 10^{7}]), ^{137}Cs (1.9 x 10^{-5} [7.0 x 10^{5}]), ^{238}Pu (1.2 x 10^{-7} [4.4 x 10^{3}]), ^{239}Pu (1.5 x 10^{-6} [5.6 x 10^{4}]), ^{241}Am (2.9 x 10^{-7} [1.1 x 10^{4}]) 200-West Area ^{90}Sr (2.2 x 10^{-5} [8.1 x 10^{5}]), ^{137}Cs (2.4 x 10^{-7} [8.9 x 10^{3}]), ^{238}Pu (5.1 x 10^{-7} [1.9 x 10^{4}]), ^{239}Pu (2.6 x 10^{-5} [9.6 x 10^{5}]), ^{241}Pu (1.9 x 10^{-5} [7.0 x 10^{5}]), ^{241}Am (5.3 x 10^{-6} [2.0 x 10^{5}])
Meteorological conditions	2007 annual average, calculated using the GENII Joint Frequency Data (GENJFD) computer code from data collected at the Hanford Meteorology Station from January through December 2007
$\overline{X}$/Q' dispersion factors	Maximally exposed individual, 1.7 x 10^{-8} sec/m^3 at 28 km (17 mi) SE; 80-km (50-mi) population, 2.2 x 10^{-3} 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	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.8. Technical Details of Liquid Release Dose Calculations for the 200 Areas of the Hanford Site Calculated as Difference in Upstream and Downstream Concentrations, 2007

Facility name	200 Areas
Releases (Ci [Bq])	^{3}H (3.4×10^{3} [1.3×10^{14}]), ^{234}U (4.1×10^{0} [1.5×10^{-11}]), ^{235}U (8.3×10^{-1} [3.1×10^{10}], ^{238}U (2.5×10^{0} [9.3×10^{10}])
Mean river flow	3,299 m^3/sec (116,489 ft^3/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, 2007

Facility name	300 Area
Releases (Ci [Bq])	^{3}H (as HT)[a] (1.8×10^{2} [6.5×10^{12}]), ^{3}H (as HTO)[a] (4.0×10^{2} [1.5×10^{13}]), ^{90}Sr (6.7×10^{-6} [2.5×10^{5}]), ^{133}Xe (3.0×10^{-9} [1.1×10^{2}]), ^{131m}Xe (2.0×10^{-10} [7.4×10^{0}]), ^{137}Cs (1.4×10^{-7} [5.2×10^{3}]), ^{220}Rn (1.8×10^{1} [6.8×10^{11}]), ^{222}Rn (2.2×10^{-2} [8.1×10^{8}]), ^{239}Pu (5.6×10^{-7} [2.1×10^{4}]), ^{241}Am (3.8×10^{-9} [1.4×10^{2}])
Meteorological conditions	2007 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 2007
$\bar{X}/Q'$ dispersion factors	Maximally exposed individual at residence, 1.1×10^{-6} sec/m^3 at 1.4 km (0.87 mi) E; 80-km (50-mi) population, 1.0×10^{-2} person-sec/m^3
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, 2007

Facility name	400 Area
Releases (Ci [Bq])	^{3}H (as HTO)[a] (2.5×10^{-1} [9.3×10^{9}]), ^{137}Cs (5.9×10^{-6} [2.2×10^{5}]), ^{239}Pu (8.9×10^{-7} [3.3×10^{4}])
Meteorological conditions	2007 annual average, calculated using the GENJFD computer code from data collected at the 400 Area and the Hanford Meteorology Station from January through December 2007
$\bar{X}/Q'$ dispersion factors	Maximally exposed individual at residence, 9.4×10^{-8} sec/m^3 at 11 km (7 mi) SE; 80-km (50-mi) population, 6.2×10^{-3} person-sec/m^3
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, 2007

Area	Radionuclide	Average Drinking Water Activity (pCi/L)	Intake (pCi/yr)	Ingestion Dose Factor (rem/pCi)	Ingestion Dose (rem/yr)
100-K	^{90}Sr	0.049	12.15	1.30×10^{-7}	1.6×10^{-6}
	Total				**1.6×10^{-6}**
100-N	^{90}Sr	0.067	16.8	1.30×10^{-7}	2.2×10^{-6}
	Total				**2.2×10^{-6}**
200-West	^{90}Sr	0.0918	22.95	1.30×10^{-7}	3.0×10^{-6}
	Total				**3.0×10^{-6}**
400	Gross beta	6.560	1,640	5.00×10^{-8}	8.2×10^{-5}
	Tritium	2,500	625,000	6.30×10^{-11}	3.9×10^{-5}
	Total				**1.2×10^{-4}**

References

40 CFR 61, Subpart H. "National Emission Standards for Hazardous Air Pollutants." *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.

DOE/RL-2008-03. 2008. *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2007.* Prepared by DJ Rokkan (Fluor Hanford, Inc.), K Rhoads (Pacific Northwest National Laboratory), RH Anderson (Fluor Federal Services) and CJ Perkins (Energy*Solutions*) for the U.S. Department of Energy, Richland, Washington.

DOE-STD-1153-2002. 2002. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.* Final Technical Standard, Office of Environmental Policy and Guidance, Washington, D.C.

EPS-87-367A. 1988. *Environmental Radiation Program, 26th Annual Report, January Through December 1987.* Washington State Department of Health, Olympia, Washington.

International Commission on Radiological Protection. 1979a. "ICRP Publication 30, Part 1, Limits for Intakes of Radionuclides by Workers." *Annals of the ICRP* 2:3/4, Pergamon Press, Elmsford, New York.

International Commission on Radiological Protection. 1979b. "ICRP Publication 30, Supplement to Part 1, Limits for Intakes of Radionuclides by Workers." *Annals of the ICRP* 3:1 4, Pergamon Press, Elmsford, New York.

International Commission on Radiological Protection. 1980. "ICRP Publication 30, Part 2, Limits for Intakes of Radionuclides by Workers." *Annals of the ICRP* 4:3/4, Pergamon Press, Elmsford, New York.

International Commission on Radiological Protection. 1981a. "ICRP Publication 30, Supplement to Part 2, Limits for Intakes of Radionuclides by Workers." *Annals of the ICRP* 5:1-6, Pergamon Press, Elmsford, New York.

International Commission on Radiological Protection. 1981b. "ICRP Publication 30, Part 3 Including Addendum to Parts 1 and 2, Limits for Intakes of Radionuclides by Workers." *Annals of the ICRP* 6:2/3, Pergamon Press, Elmsford, New York.

International Commission on Radiological Protection. 1982a. "ICRP Publication 30, Supplement A to Part 3, Limits for Intakes of Radionuclides by Workers." *Annals of the ICRP* 7:1-3, Pergamon Press, Elmsford, New York.

International Commission on Radiological Protection. 1982b. "ICRP Publication 30, Supplement B to Part 3 Including Addendum to Supplements to Parts 1 and 2, Limits for Intakes of Radionuclides by Workers." *Annals of the ICRP* 8:1-3, Pergamon Press, Elmsford, New York.

International Commission on Radiological Protection. 1988. "ICRP Publication 30, Part 4, Limits for Intakes of Radionuclides by Workers: an Addendum." *Annals of the ICRP* 19:4, Pergamon Press, Elmsford, New York.

International Commission on Radiological Protection. 1994. "ICRP Publication 66, Human Respiratory Tract Model for Radiological Protection." *Annals of the ICRP* 24:1-3. Pergamon Press, Elmsford, New York.

PNL-3777, Rev. 2. 1993. *Recommended Environmental Dose Calculation Methods and Hanford-Specific Parameters.* RG Schreckhise, K Rhoads, JS Davis, BA Napier, and JV Ramsdell, Pacific Northwest Laboratory, Richland, Washington.

PNL-6584. 1988. *GENII - The Hanford Environmental Radiation Dosimetry Software System*, 3 vols. BA Napier, RA Peloquin, DL Strenge, and JV Ramsdell, Pacific Northwest Laboratory, Richland, Washington.

PNNL-14428. 2004. *Hanford Area 2000 Population.* DB Elliott, MJ Scott, EJ Antonio, and K Rhoads, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-17603, APP. 1. 2008. *Hanford Site Environmental Surveillance Data for Calendar Year 2007.* LE Bisping, Pacific Northwest National Laboratory, Richland, Washington.

Appendix F Radionuclides Measured by Gamma Spectroscopy (Gamma Scan)

E. J. 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

Radionuclide	Symbol	Principal Source
Beryllium-7[a]	^{7}Be	Natural - cosmogenic
Sodium-22	^{22}Na	Fission product
Sodium-24	^{24}Na	Fission product
Potassium-40[a]	^{40}K	Natural - primordial
Manganese-54	^{54}Mn	Fission product
Cobalt-58	^{58}Co	Fission product
Cobalt-60[a]	^{60}Co	Fission product
Iron-59	^{59}Fe	Fission product
Zinc-65	^{65}Zn	Fission product
Zirconium/niobium-95	$^{95}Zr/Nb$	Activation product and fission product
Molybdenum-99	^{99}Mo	Activation product and fission product
Ruthenium-103	^{103}Ru	Activation product and fission product
Ruthenium-106[a]	^{106}Ru	Fission product
Antimony-125[a]	^{125}Sb	Activation product
Iodine-131	^{131}I	Fission product
Cesium-134[a]	^{134}Cs	Activation product
Cesium-137[a]	^{137}Cs	Fission product
Barium/lanthanum-140	$^{140}Ba/La$	Fission product
Cerium-141	^{141}Ce	Activation product and fission product
Cerium/praseodymium-144	$^{144}Ce/Pr$	Fission product
Europium-152[a]	^{152}Eu	Activation product
Europium-154[a]	^{154}Eu	Activation product
Europium-155[a]	^{155}Eu	Activation product

(a) Routinely reported by contracting laboratory for Pacific Northwest National Laboratory environmental monitoring samples.

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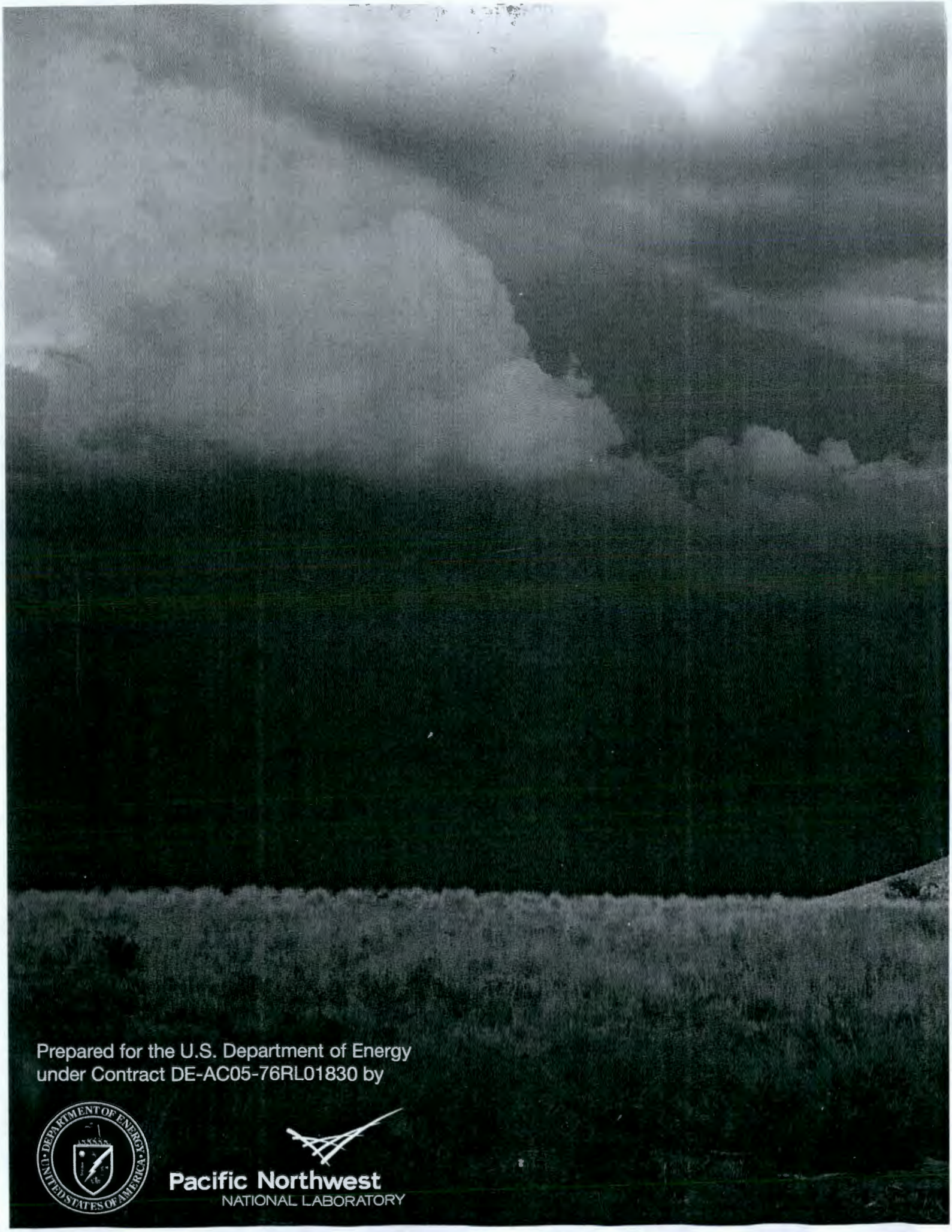

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