Hanford Site

ENVIRONMENTAL REPORT

for Calendar Year 2010

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The cover photo shows an expanse of phlox, a spring-blooming perennial wildflower that is abundant at the Hanford Site. Photo is courtesy of B Bjornstad, Pacific Northwest National Laboratory, Richland, Washington. The cover design is by JE Gority, Pacific Northwest National Laboratory, Richland, Washington.

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U.S. Department of Energy
Hanford Site

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Addressees:

THE HANFORD SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR (CY) 2010 (PNNL-20548), RICHLAND, WASHINGTON, SEPTEMBER 2011

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 2010 but also includes some early 2011 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.

This report was prepared for DOE by Pacific Northwest National Laboratory (PNNL) under contract from Mission Support Alliance, LLC (MSA), with the support of Hanford Site contractors. It describes programs conducted by PNNL; MSA; CH2M HILL Plateau Remediation Company; Washington Closure Hanford LLC; Washington River Protection Solutions LLC; and Bechtel National Incorporated.

If you have any questions or comments about this report, please contact us, or you may contact Ray J. Corey, Assistant Manager for Safety and Environment, at (509) 376-0108. Technical questions may be directed to Dana C. Ward, Environmental Management Division, at (509) 372-1261.

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HANFORD SITE
ENVIRONMENTAL REPORT

for Calendar Year 2010
(Including Some Early 2011 Information)

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September 2011

Prepared for the U.S. Department of Energy by personnel from the Pacific Northwest National Laboratory under Contract DE-AC05-76RL01830, and Mission Support Alliance, LLC under Contract 36403, with contributions from Advanced Technologies and Laboratories International, Inc.; Bechtel National, Inc.; CH2M HILL Plateau Remediation Company; Mission Support Alliance, LLC; Washington Closure Hanford, LLC; and Washington River Protection Solutions LLC

Pacific Northwest National Laboratory
Richland, Washington

Preface

The Hanford Site environmental report is prepared annually for the U.S. Department of Energy (DOE) in accordance with the requirements in DOE Manual 231.1-1A, "Environment, Safety, and Health Reporting Manual," and DOE Order 231.1A, "Environment, Safety, and Health Reporting." The report provides an overview of activities at the Hanford Site; demonstrates the status of the site's compliance with applicable federal, state, and local environmental laws and regulations, permits, executive orders, and DOE policies and directives; and summarizes environmental data that characterize site environmental management performance. The report also highlights significant environmental and public protection programs and efforts. Some historical and early 2011 information is included where appropriate. More detailed environmental compliance, monitoring, and surveillance information is provided in reports referenced in the text.

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

Pacific Northwest National Laboratory produced this report for Mission Support Alliance, LLC. Battelle Memorial Institute operates the Pacific Northwest National Laboratory for DOE. Staff from the Pacific Northwest National Laboratory and Mission Support Alliance, LLC wrote major portions of the report. Washington Closure Hanford, LLC; Bechtel National, Inc.; CH2M HILL Plateau Remediation Company; Washington River Protection Solutions LLC; and Advanced Technologies and Laboratories International, Inc. also provided input.

Appendices 1 and 2, which were companion documents to the Hanford Site environmental report in previous years, were not produced for calendar year 2010. These appendices provided supplemental monitoring and surveillance data. Inquiries regarding this environmental report, including monitoring and surveillance data noted as available upon request in this report, should be directed to Dana Ward, DOE Richland Operations Office, P.O. Box 550, MS A5-15, Richland, Washington, 99352 (dana.ward@rl.doe.gov); Darci Teel, Mission Support Alliance, LLC, P.O. Box 650, MS H7-28, Richland, Washington, 99352 (Darci_D_Teel@rl.gov); or April Johnson, Mission Support Alliance, LLC, P.O. Box 650, MS H7-28, Richland, Washington, 99352 (April_L_Johnson@rl.gov).

Report Availability

This environmental report was produced in both paper and electronic formats. The paper formats include this technical report and a less-detailed summary report. The report is available in portable document format (PDF) on compact disk and electronically at the following website: http://msa.hanford.gov/msa/index.cfm/Env._Reports_2001_-_Latest. Report copies are also available at libraries in communities near the Hanford Site, at several university libraries in Washington and Oregon, and at the DOE's Public Reading Room located at the Washington State University Tri-Cities Consolidated Information Center in Richland, Washington. All versions of the report can be obtained from April Johnson, Mission Support Alliance, LLC, P.O. Box 650, MS H7-28, Richland, Washington, 99352 (April_L_Johnson@rl.gov), while supplies last.

Summary

JP Duncan

Each year, the U.S. Department of Energy (DOE) prepares this integrated Hanford Site Environmental Report in accordance with DOE Order 231.1A, "Environment, Safety and Health Reporting." This report is designed to inform the public, regulators, stakeholders, and other interested parties about Hanford Site environmental performance for the 2010 calendar year. Individual sections provide detail on the following:

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

DOE's current mission at the Hanford Site includes site cleanup and remediation and reduction in the amount of land directly controlled by DOE. 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 2010

A key feature in the Hanford Site compliance program is the *Hanford Federal Facility Agreement and Consent Order*, also known as the Tri-Party Agreement. The Tri-Party Agreement is an agreement among the Washington State Department of Ecology, the U.S. Environmental Protection Agency (EPA), and DOE to achieve compliance with the remedial action provisions in the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and with treatment, storage, and disposal unit regulations and corrective action provisions in the *Resource Conservation and Recovery Act of 1976* (RCRA). The Tri-Party Agreement has evolved to meet changing conditions as Hanford Site cleanup requirements have progressed. During 2010, there were 43 specific Tri-Party cleanup milestones scheduled for completion: 41 were completed on or before their required due dates and 2 were completed beyond their respective established due date. Forty negotiated change requests to the Tri-Party Agreement were approved in 2010 (Section 3.0).

RCRA Compliance. One RCRA non-compliance document was received at the Hanford Site in 2010; resolution was reached with no impact to the environment (Section 5.1.3).

CERCLA Compliance. Field inspections of institutional controls were conducted in 2010 at waste sites on the Hanford Site. No public trespass events occurred and all approved excavation permits were current (Section 5.1.1).

***Clean Air Act* Compliance**. 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 2010, the regulatory agencies conducted over 30 *Clean Air Act* inspections on the Hanford Site, resulting in two notices of violation and one notice of correction (Section 5.3).

Environmental Performance Measures. Mission Support Alliance, LLC in consultation with other Hanford Site prime contractors developed environmental performance measures for the Hanford Site in 2010. Performance measures address the goals of DOE Order 450.1A, DOE Order 430.2B, Executive Order 13423, and Executive Order 13514. Measures include regulated waste reduction; toxic and hazardous material reduction; sustainable acquisition; compliance with Electronic Product Environmental Assessment Tool standards; sanitary waste diversion; construction waste diversion; electricity use; facility fuel use; water use; vehicle fuel use; numbers of alternative fuel vehicles; on-time environmental deliverables; environmental inspections; and environmental non-compliances. Objectives for 2010 were achieved for the majority of performance measures; target objectives for petroleum-based fuel use, herbicide reduction, and regulated waste reduction were not met (Section 4.0).

Pollution Prevention Program. The Pollution Prevention Program (Section 5.6.2) 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 fiscal year 2010 (October 2009 through September 2010), over 3,100 metric tons (3,400 tons) of sanitary and hazardous wastes were recycled through Hanford Site-wide programs administered through the Mission Support Contract.

The Hanford Site won 4 of 5 "Environmental Management - Best in Class" awards and 6 of 12 "Honorable Mention" awards for pollution prevention and waste minimization accomplishments in 2010.

Environmental Occurrences. Environmental releases of radioactive and regulated materials from the Hanford Site are reported to DOE and other federal and state agencies as legally required. Six significance categories have been established: operational emergency; recurring; Category 1 (significant impact); Category 2 (moderate impact); Category 3 (minor impact); and Category 4 (some impact). In 2010, one Category 2, two Category 3, and three Category 4 events occurred at the Hanford Site (Section 5.7).

Compliance with Cultural Resources Statutes. *National Historic Preservation Act of 1979* Section 106 reviews are performed prior to federal undertakings at the Hanford Site.

Waste Discharge Permit Violations. In compliance with *Clean Water Act of 1977* provisions, the Hanford Site conforms to effluent and waste discharge permits. There were three state and one local waste discharge permit violations in 2010 (Section 5.4.1).

Table S.1 summarizes Hanford Site work activity compliance with federal statutes in 2010. Chapters 3 and 5 of this report describe compliance topics in greater detail.

Hanford Site Cleanup Operations

In 1996, when Hanford Site cleanup activities began, the primary focus was on former liquid effluent sites. 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 2010, remediation activities continued in the 100, 200, and 300 Areas, and for Hanford Site groundwater and vadose zone sediments.

Remediation of 100 Areas Waste Sites. Remediation in the 100 Areas during 2010 focused on waste burial grounds and miscellaneous waste sites throughout the 100 Areas. Washington Closure Hanford, LLC personnel remediated waste sites in the 100-B/C, 100-D, 100-F, 100-K, 100-H, and 100-N Areas (Section 6.1.2.1). CH2M HILL Plateau Remediation Company staff remediated sites in the 100-K Area (Section 6.1.2.2). A total of 640,200 metric tons (706,000 tons) of contaminated soil from all 100 Areas remediation activities were disposed of at the Environmental Restoration Disposal Facility (near the 200-West Area) during 2010.

Table S.1. Status of Compliance with Federal Acts on the Hanford Site in 2010

Regulation	What It Covers	2010 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 Act of 1935*; *National Historic Preservation Act of 1966*; and *Native American Graves Protection and Repatriation Act of 1990*	Cultural resources.	During 2010, 273 Section 106 reviews were completed on the Hanford Site. DOE determined that 239 undertakings would not affect cultural resources and were exempt from further review; the remaining 34 were those with the potential to affect historic properties. Ten cultural resources sites were visited in 2010 to assess the effects of erosion, weathering, and unauthorized excavation and collection. Thirty-six new archaeological sites and new isolated finds were recorded on the Hanford Site in 2010.
Atomic Energy Act of 1954	Proper management of radioactive materials.	In 2010, eight 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, two technical standards or handbooks underwent revision.
Bald and Golden Eagle Protection Act	Protects bald and golden eagles.	In 2010, a supplement was added to the *Bald Eagle Site Management Plan for the Hanford Site*.
Clean Air Act	Air quality, including emissions from facilities and unmonitored sources.	Revision F of the Hanford Site air operating permit was issued on December 23, 2010, incorporating new Washington State Department of Health and Washington State Department of Ecology air emission licenses, approval orders, and regulatory requirement updates. The Washington State Department of Health, the Washington State Department of Ecology, and the Benton Clean Air Agency conducted over 30 inspections in 2010, resulting in 2 notices of violation and 1 notice of correction.
Clean Water Act of 1977	Point-source discharges to U.S. surface waters.	The Hanford Site has one National Pollutant Discharge Elimination System permit and several state and local sanitary wastewater discharge permits. A construction general permit specifying storm water discharges associated with construction activities was effective until March 18, 2010. Four permit violations related to the *Clean Water Act of 1977* occurred in 2010.
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 2010, field inspections of institutional controls at waste sites were performed. Warning sign information was updated at the 100-IU-6 waste sites in response to these inspections. No public trespass events occurred in 2010, and approved excavation permits were in use at all active remediation sites.
Emergency Planning and 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 March 2011, Hanford Site officials issued the *2010 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory* report to the Washington State Department of Ecology's Community Right-To-Know Unit; local emergency planning committees for Benton, Franklin, and Grant Counties; and both the city of Richland and Hanford Site fire departments. The *2010 Hanford Site Toxic Chemical Release Inventory* was released June 21, 2011. Six toxic chemicals exceeded Hanford Site reporting thresholds during 2010.

Table S.1. (contd)

Regulation	What It Covers	2010 Status
Endangered Species Act of 1973	Rare plant and animal species.	Numerous plants and animals on the Hanford Site are federal- or state-listed as endangered, threatened, sensitive, or candidate species. Ecological compliance reviews are conducted prior to project initiation on the Hanford Site to prevent adverse impacts to biological resources, including listed species. In 2010, 389 reviews were performed, including 236 ecological compliance reviews for general site activities and 153 reviews for environmental restoration activities.
Federal Facility Compliance Act of 1992	Amends RCRA and requires new mixed waste reporting requirements.	In March 2010, the *Calendar Year 2009 Hanford Site Mixed Waste Land Disposal Restrictions Full Report* was issued, satisfying reporting requirements.
Federal Insecticide, Fungicide, and Rodenticide Act	Storage and use of pesticides.	On 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 complied with the requirements of this Act by using the ecological compliance review process to minimize adverse impacts to migratory birds.
National Environmental Policy Act of 1969 (NEPA)	Environmental impact statements and assessments for federal projects that have the potential to affect the quality of the human environment.	In October 2009, DOE released the *Draft Tank Farm Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* for review and comment. The public comment period was extended to May 3, 2010. The final report is in development. In 2010, DOE began considering whether an environmental impact statement should be prepared for a natural gas pipeline to the Hanford Site Waste Treatment and Immobilization Plant and 242-A Evaporator. Four environmental assessments were also prepared or in production.
Pollution Prevention Act of 1990	Reduction or prevention of wastes by treatment, control, reuse, and/or recycling.	In 2010, over 3,100 metric tons (3,400 tons) of sanitary and hazardous wastes were recycled through side-wide programs administered through the Mission Support Contract on the Hanford Site.
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 2010, one revision to the Hanford Facility RCRA Permit Part A Form was submitted to the state for review and approval. Washington State Department of Ecology performed 13 RCRA inspections on the Hanford Site during 2010 to assess compliance with applicable requirements. One RCRA notice of violation document was received at the Hanford Site in 2010: a notice of violation resulting from the 242-A Evaporator Dangerous Waste Permit Inspection.
Safe Drinking Water Act of 1974	Drinking water systems.	There were nine drinking water systems on the Hanford Site in 2010. The systems were monitored for radiological and chemical contaminants and disinfection residuals and byproducts. There were no microbiological detections during 2010, 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.

Table S.1. (contd)

Regulation	What It Covers	2010 Status
Superfund Amendments and Reauthorization Act of 1986	Amends and reauthorizes CERCLA.	Beginning in 2010, EPA initiated the Integrated Cleanup Initiative to identify and implement accelerated cleanup of contaminated sites.
Toxic Substances Control Act	Hazardous chemical regulation and tracking; primarily polychlorinated biphenyls (PCBs).	During 2010, the 2009 PCB annual document log report for the Hanford Site and a 2009 PCB annual report were submitted to the EPA as required. EPA-approved risk-based disposal approvals continued to be used in 2010 for retrieving waste from selected single-shell underground waste storage tanks and for the management of sludge from the K Basins.

DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.

Pump-and-treat systems continued to help remove contaminants from the groundwater beneath the 100 Areas in 2010 (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 by 2004, but fuel corrosion over the years left behind sludge and debris. In 2009, the K-East Basin was demolished and the structure and basins removed. During 2010, K Basins cleanup continued with the demolition of multiple buildings, basins, and storage facilities, as well as debris removal from the K-West Basin. The K-West Basin is undergoing cleanout that involves the removal of radioactive contaminated sludge and debris as a precursor to facility deactivation and demolition. Floor and pit sludge was containerized and stored in underwater containers in the basin. Sludge characterization and removal alternatives for K-West Basin were also evaluated in 2010. Further information on K Basins remediation and closure activities is in Section 6.1.2.3.

Remediation of Waste Sites on the Central Plateau. Remedial investigation and feasibility study activities continued at waste sites on the Hanford Site Central Plateau in 2010. Central Plateau operable units were restructured during 2010, aligning the units to geographic based operable units. 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. Descriptions of these activities are in Section 6.1.1.

Pump-and-treat systems and a soil-vapor extraction system continued to remove contaminants from the groundwater and vadose zone beneath the 200 Areas in 2010 (Table S.2).

Remediation of 300 Area Waste Sites. Remediation efforts in 2010 focused on the 300-FF-2 Operable Unit waste sites; activities at these waste sites began in 2002. In 2010, 138,000 metric tons (152,000 tons) of contaminated soil from the 300-FF-2 Operable Unit was removed and disposed of at the Environmental Restoration Disposal Facility. Remediation of the 618-1 Burial Ground, located in the northern 300 Area, was completed in 2010. Non-intrusive characterization field activities were completed at the 618-10 Burial Ground, located west of the 300 Area, in 2010. Descriptions of these activities are in Section 6.1.3.

Facility Decommissioning and Deactivation Activities

Decommissioning of 100 Areas Facilities. During 2010, 100 Areas deactivation, decontamination, decommissioning, and demolition activities focused on the 100-N Area, where several buildings, structures, tunnels, a tower, and above and below grade rooms of the 105-N/109-N Reactor Building Complex were demolished. In addition, safe storage enclosure preparations for the 105-N/109-N Reactor Building Complex continued through 2010 (Section 6.2.4).

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

Location	Startup Date	Contaminant	Mass Removed 2010	Mass Removed Since Startup
100-D Area (100-DR-5 Pump-and-Treat System)	2004	Chromium	74.9 kilograms (165.1 pounds)	326.2 kilograms (719.2 pounds)
100-D and 100-H Areas (100-HR-3 Pump-and-Treat System)	1997	Chromium	31 kilograms (68.3 pounds)	392.9 kilograms (866.2 pounds)
100-K Area (100-KR-4 Pump-and-Treat System)	1997	Chromium	7.2 kilograms (15.9 pounds)	354.7 kilograms (782 pounds)
100-K Area (KX Pump-and-Treat System)	2008	Chromium	39.8 kilograms (87.7 pounds)	83.7 kilograms (184.5 pounds)
100-K Area (Pump-and-Treat System near K-West Reactor)	2007	Chromium	54.1 kilograms (119.3 pounds)	137.4 kilograms (302.9 pounds)
200-West Area (200-ZP-1 Pump-and-Treat System)	1994	Carbon tetrachloride	685.8 kilograms (1,511.9 pounds)	12,646.8 kilograms (27,881.4 pounds)
200-West Area (241-T Pump-and-Treat System)	2007	Technetium-99	16.3 grams (0.57 ounce)	72.7 grams (2.56 ounces)
200-West Area (200-UP-1 Pump-and-Treat System)	1994	Carbon tetrachloride	0.9 kilograms (2 pounds)	41.2 kilograms (90.8 pounds)
		Nitrate	2,092 kilograms (4,612 pounds)	49,667 kilograms (109,497 pounds)
		Technetium-99	1.47 grams (0.05 ounce)	127.6 grams (0.28 pound)
		Uranium	0.9 kilograms (2 pounds)	220.3 kilograms (485.7 pounds)
Waste Management Area S-SX Extended Purging	2003	Technetium-99	0.071 gram (0.004 ounce)	0.735 gram (0.02 ounce)
200-West Area (Soil-Vapor Extraction System)	1991	Carbon tetrachloride	194 kilograms (427.7 pounds)	79,751 kilograms (175,821.9 pounds)

Decommissioning of Facilities on the Central Plateau. The transition and decommissioning of facilities on the Central Plateau continued in 2010. Activities at the Plutonium Finishing Plant included continued cleanout of contaminated equipment; disposition chemicals, glove boxes, pipes, and hoods from the buildings; and demolition of 22 structures (Section 6.2.1.1). Disposition of U Plant and the 209-E Criticality Mass Laboratory began in 2010, including demolition of support facilities and debris removal. Additional activities conducted on the Central Plateau included surveillance, maintenance, and decontamination or stabilization of over 1,000 waste sites, including former waste disposal cribs, ponds, ditches, trenches, unplanned release sites, and waste burial grounds in the 200-East, 200-West, and 200-North Areas and the Fitzner/Eberhardt Arid Lands Ecology Reserve Unit. Periodic surveillances, radiation surveys, and herbicide and pesticide applications were also conducted (Section 6.2.1.2).

Decommissioning of 300 Area Facilities. During 2010, 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. In addition, deactivation, decontamination, decommissioning, and demolition activities were authorized for a portion of the 337 Complex. Sixteen facilities and buildings were demolished in the 300 Area in 2010 (Section 6.2.2).

Deactivation of 400 Area Facilities – Fast Flux Test Facility. After multiple studies, a final decision was made by DOE to complete facility deactivation, including removing all nuclear fuel, draining the sodium systems, and deactivating systems and equipment to place the facility in a low-cost, long-term surveillance and maintenance condition, which was completed in June 2009. The Fast Flux Test Facility remains in a long-term surveillance and maintenance condition; routine surveillances are performed on an annual basis (Section 6.2.3).

Waste Management

Hanford Site cleanup activities generate non-regulated, radioactive, non-radioactive, mixed, and hazardous waste (Chapter 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 onsite or shipped to offsite facilities for treatment and disposal. Table S.3 provides a summary of waste stored, generated, and treated at the Hanford Site or received from offsite sources in 2010.

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 pending treatment 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 2010 included the treatment, storage, and disposal of solid waste at many site locations (Section 6.3.3). Onsite solid waste facilities include the Central Waste Complex, Waste Receiving and Processing Facility, T Plant Complex, Environmental Restoration Disposal Facility, low-level burial grounds, and the Waste Encapsulation and Storage Facility.

The Central Waste Complex, located in the 200-West Area, receives waste from Hanford Site sources and any offsite sources authorized by DOE to ship waste to the site for treatment, storage, and disposal. Ongoing cleanup and research and development activities at the Hanford Site generate most of the waste received at the Central Waste Complex. Waste received includes low-level, transuranic, or mixed waste, and radioactive waste contaminated with polychlorinated biphenyls.

The Central Waste Complex can store as much as 20,800 cubic meters (735,000 cubic feet) of low-level mixed waste and transuranic waste (Section 6.3.3.1). This capacity is adequate to store generated waste volumes, assuming on-schedule treatment of the stored waste. Treatment reduces the amount of waste in storage and makes room for newly generated mixed waste. The dangerous waste designation for each waste container is established at the point-of-origin based on process knowledge or sample analysis. The volume of waste stored at this complex in 2010 totaled approximately 8,500 cubic meters (300,000 cubic feet).

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. This facility, which began operating in 1997, dispositioned and shipped 50 cubic meters (1,770 cubic feet) of mixed low-level waste and 10 cubic meters (350 cubic feet) of low-level waste offsite for treatment in 2010 (Section 6.3.3.2).

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 2010, one thousand, three hundred and seventy-six 208-liter (55-gallon) drum equivalents of transuranic waste were repackaged to meet offsite waste acceptance criteria.

The Environmental Restoration Disposal Facility serves as the central disposal site for contaminated waste removed during Hanford Site cleanup operations conducted under CERCLA regulations. During 2010, approximately 1.6 million metric tons (1.8 million tons) of remediation waste were disposed of at the Environmental Restoration Disposal Facility. Approximately 9.7 million metric tons (10.7 million tons) of remediation waste have been disposed of from initial operations startup through 2010 (Section 6.3.3.4).

Table S.3. Hanford Site Waste Summary for 2010

Activity	Waste Type	Amount
Solid waste generated during onsite cleanup activities	Solid mixed waste	260,000 kilograms (286 tons)
	Radioactive waste	658,000 kilograms (725 tons)
Solid waste received at the Hanford Site from offsite (includes Hanford Site generated waste treated by an offsite contractor and returned to the site as newly generated waste)	Solid mixed waste	138,000 kilograms (152 tons)
	Radioactive waste	352,000 kilograms (388 tons)
Dangerous waste shipped off the Hanford Site	Containerized waste (dangerous waste only)	49,700 kilograms (55 tons)
	Bulk solids	208,600 kilograms (230 tons)
	Bulk liquids	0 kilograms (0 tons)
Waste volume pumped from underground single-shell waste storage tanks to double-shell waste storage tanks (includes flush/dilution water)	Liquid waste	909,000 liters (240,000 gallons)
Waste volume in underground single-shell waste storage tanks at the end of 2010	Liquid waste	112 million liters (29.5 million gallons)
Waste added to underground double-shell waste storage tanks	Liquid waste	1,560,000 liters (412,000 gallons)
Waste volume in underground double-shell waste storage tanks at the end of 2010	Liquid waste	97.8 million liters (25.8 million gallons)
Waste dispositioned and shipped offsite from the Waste Receiving and Processing Facility	Solid waste	50 cubic meters (1,770 cubic feet)
Waste treated or directly disposed of in Trenches 31 and 34	Mixed low-level solid waste	1,008 cubic meters (35,600 cubic feet)
Waste disposed of at the Environmental Restoration Disposal Facility	Solid waste	1.6 million metric tons (1.8 million tons)
Volume of aqueous waste received at the Liquid Effluent Retention Facility	Wastewater containing low levels of organic compounds and tritium	71.9 million liters (19 million gallons)
Volume of liquid effluent treated at the Effluent Treatment Facility	Wastewater containing toxic metals, radionuclides, ammonia, and organic compounds	69.7 million liters (18.4 million gallons)
Volume of wastewater treated (evaporated) at the 242-A Evaporator	Liquid waste from single-shell tanks	2.07 million liters (548,000 gallons)
Volume of effluent disposed of at the 200 Area Treated Effluent Disposal Facility	Uncontaminated, treated liquid waste	1,170 million liters (310 million gallons)

The low-level burial grounds consist of eight burial grounds located in the 200-East and 200-West Areas that are used for disposal of low-level waste and mixed waste (i.e., low-level radioactive waste with a dangerous waste component). The low-level burial grounds have been 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. In 2010, a total of 1,008 cubic meters (35,600 cubic feet) of waste was disposed of in Trenches 31 and 34, and 336 cubic meters (11,900 cubic feet) of retrievably stored waste were retrieved from the low-level burial grounds (Section 6.3.3.5).

The Waste Encapsulation and Storage Facility stores strontium and cesium encapsulated salts in double containment stainless-steel capsules in underwater pool cells, providing safe storage. The water provides cooling and shielding for the capsules that are considered sealed sources. As a storage-only unit, the Waste Encapsulation and Storage Facility did not generate regulated wastes in 2010 (Section 6.3.3.6).

Two defueled reactor compartments from the U.S. Navy were shipped to Trench 94 in the 200-East Area in 2010, bringing the total number of U.S. Navy reactor compartments received to 122 (Section 6.3.3.7).

The Integrated Disposal Facility (currently not operational), located in the south-central 200-East Area, is an expandable RCRA hazardous waste-compliant landfill. The facility will receive immobilized low-activity tank waste and other low-level radioactive waste from the Hanford Tank Waste Treatment and Immobilization Plant. The process design disposal capacity listed in the RCRA permit is 82,000 cubic meters (2.89 million cubic feet) (Section 6.3.3.8).

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

The Effluent Treatment Facility 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 2010 was approximately 69.7 million liters (18.4 million gallons) (Section 6.3.4.1).

Approximately 64.4 million liters (17 million gallons) of liquid waste were stored at the Liquid Effluent Retention Facility at the end of 2010 (Section 6.3.4.2). The volume of wastewater received for interim storage in 2010 was approximately 71.9 million liters (19 million gallons). The volume of wastewater transferred from this facility to the Effluent Treatment Facility for treatment in 2010 was approximately 70.4 million liters (18.6 million gallons).

In 2010, the 200 Area Treated Effluent Disposal Facility disposed of 1,170 million liters (310 million gallons) of unregulated effluent. The major source of this effluent was uncontaminated cooling water from various Hanford Site facilities and steam condensate from the 242-A Evaporator (Section 6.3.4.3).

The 242-A Evaporator 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 (Section 6.3.4.5). In 2010, the 242-A Evaporator completed two successful operating campaigns that reduced the volume of waste in two double-shell storage tanks by more than 1.7 million liters (454,000 gallons).

Underground Waste Storage Tanks. In 2010, approximately 909,000 liters (240,000 gallons) of liquid waste were pumped from the single-shell tanks to the double-shell tanks, leaving 112 million liters (30 million gallons) of waste remaining in the single-shell tanks. At the end of 2010, there were 97.8 million liters (25.8 million gallons) of waste in the double-shell tanks (Section 6.4).

Hanford Tank Waste Treatment and Immobilization Plant. The Hanford Tank Waste Treatment and Immobilization Plant is being built on 26 hectares (65 acres) adjacent to the 200-East Area to treat radioactive and hazardous waste currently stored in 177 underground tanks. Four major facilities are being constructed: a pretreatment facility, a high-level waste vitrification facility, a low-activity waste vitrification facility, and an analytical laboratory, as well as supporting facilities. Construction of these facilities continued in 2010 (Section 6.5).

Radiological Release of Property from the Hanford Site

No property with detectable residual radioactivity above authorized levels was released from the Hanford Site in 2010 (Section 7.0.1).

Radiological Clearance for Ion-Exchange Resin for Offsite Shipment and Regeneration. Ion-exchange resin is currently in use to remove hexavalent chromium from groundwater. Once saturated, the spent resin—which may contain radioactive elements—is removed and readied for shipment to an offsite facility for regeneration and reuse. In 2010, approximately 175,000 kilograms (386,000 pounds) of resin was shipped offsite for regeneration under authorized limits (Section 7.0.1.2).

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 shipped to an offsite facility for regeneration and reuse. In 2010, a total of 56,200 kilograms (124,000 pounds) of granular activated carbon was shipped offsite for regeneration under authorized limits (Section 7.0.1.3).

Columbia River Corridor Assessment and Integration

Environmental and biological samples to support development of the River Corridor Baseline Risk Assessment have been collected since 2005. The human health risk assessment portion of the River Corridor Baseline Risk Assessment was released for regulatory and stakeholder review in late December 2010 (Section 7.0.2.1). This report, along with the ecological risk assessment portion of the report, will present a comprehensive assessment of the River Corridor, considering all relevant sources of contamination, exposure pathways, and contaminants.

Columbia River Corridor Long-Term Stewardship

Columbia River Corridor long-term stewardship focuses on achieving end-state closure and transition of the River Corridor. Elements include risk assessment activities, orphan site evaluations, remedial action reports, and long-term stewardship plans that will provide a basis for independent closure reviews of the 100 and 300 Areas by independent experts. In 2010, orphan site evaluations were completed and reports issued for the 300 Area, 400 Area, Segment 1 of the 100-F/IU-2/IU-6 Area; and Segment 2 of the 100-F/IU-2/IU-6 Area. Evaluations were also initiated for Segments 3, 4, and 5 of the 100-F/IU-2/IU-6 Area.

Environmental and Resource Protection Programs

DOE Orders require that environmental monitoring programs be conducted at the Hanford Site to verify protection of the public and site workers, comply with government regulations, and protect environmental and cultural resources at the site. Programs and projects include Effluent and Near-Facility Environmental Monitoring Programs, Public Safety and Resource Protection Projects, the Soil and Groundwater Remediation Project, the Drinking Water Monitoring Project, the Biological Control Program, and the Washington State Department of Health Oversight Monitoring Program (Section 8.0). Table S.4 summarizes contaminant monitoring efforts at the Hanford Site in 2010.

Air Emissions

Hanford Site contractors monitor airborne emissions from site facilities to assess the effectiveness of emission treatment and control systems, pollution management practices, and determine compliance with state and federal regulatory requirements. Small quantities of tritium, strontium-90, iodine-129, cesium-137, plutonium-238, plutonium-239/240, plutonium-241, americium-241, and a few other isotopes are released at state and federally permitted discharge points (usually stacks or vents) in the 100, 200, 300, 400, and 600 Areas of the Hanford Site (Section 8.1.1).

Table S.4. Summary of Contaminant Monitoring On and Around the Hanford Site, 2010

	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. Ambient-air samples were collected at 91 locations near Hanford Site facilities, 21 locations around the site away from facilities, 11 site perimeter locations, 7 nearby community locations, and 1 distant community location.	Radionuclide levels near facilities in 2010 were generally similar to measurements from previous years. Plutonium-239/240, uranium-234, and uranium-238 results from the 200-West Area, as well as strontium-90 and cesium-137 results from the 100-K Area were greater than 10% of EPA's concentration values and were reported to federal and/or state officials. All measurements of radioactive materials in air around the Hanford Site away from facilities were below DOE-derived concentration guides.
Columbia River Water and Sediment	Columbia River water and sediment samples were collected from multiple Hanford Reach sampling points and from locations upstream and downstream of the Hanford Site. The samples were analyzed for radioactive and chemical contaminants.	As in past years, small amounts of radioactive materials were detected downriver from the Hanford Site. However, the amounts were far below federal and state limits. The concentrations of metals and anions observed in river water during 2010 were similar to those observed in the past and remain below regulatory limits. Radionuclide concentrations reported in river sediment during 2010 were similar to those reported for previous years. During 2010, 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	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 were collected at locations along the Hanford Reach.	Measurements of radiological contaminants in samples collected at the shoreline springs were less than applicable DOE-derived concentration guides, but exceeded the Washington State ambient water quality criteria for gross alpha at some 300 Area locations and for tritium at the Hanford town site. Most of the 2010 chemical sample results were similar to those previously reported. Concentrations of volatile organic compounds were near or below their detection limits in all samples. Trace amounts of chlorinated organic compounds were observed from 100-K Area samples. Concentrations of most metals were below Washington State ambient surface-water chronic toxicity levels. Dissolved chromium was at or above the Washington State ambient surface water level for chronic and acute toxicity levels at the 100-B, 100-K, 100-H, and 100-F Areas. Arsenic concentrations in shoreline spring water were below the Washington State ambient surface water chronic toxicity level, but concentrations in all samples exceeded the EPA limit for the protection of human health for the consumption of water and organisms, which is 10,500 times lower than the Washington State chronic toxicity standard.
Columbia River Shoreline Spring Sediment	Groundwater beneath the Hanford Site discharges to the Columbia River along the Hanford Site shoreline as shoreline springs. Samples of sediment from these springs were collected at locations along the Hanford Reach.	Radionuclide concentrations measured in shoreline sediment samples were similar to concentrations measured in Columbia River sediment, with the exception of the 300 Area where uranium concentrations were above the background concentration measured in the sediments from the reservoir behind Priest Rapids Dam. Metals concentrations in all samples were similar to concentrations measured in Hanford Reach Columbia River sediment samples.

Table S.4. (contd)

	What Was Monitored?	The Bottom Line
Food and Farm Products	Samples of grapes, leafy vegetables, milk, potatoes, and tomatoes 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.	Samples of carp, deer, elk, rabbit, and quail were collected and analyzed. Radionuclide levels in wildlife samples were well below levels that are estimated to cause adverse health effects to animals or to the people who may consume them. Most trace metal concentrations in liver samples were similar to or less than concentrations measured in background samples. Onsite wildlife samples had elevated maximum values for some trace metals.
Groundwater	Groundwater from 908 wells and 145 aquifer tubes to assess and characterize contamination.	Contaminant plumes with concentrations above drinking water standards encompass approximately 186 square kilometers (72 square miles), or 12.2% of the Hanford Site. Contaminants above drinking water standards in 2010 included tritium, strontium-90, technetium-99, iodine-129, total uranium, chromium (dissolved), carbon tetrachloride, nitrate, and trichloroethene.
Soil	Eighty-five routine soil samples were collected onsite near facilities and operations in 2010 to verify known radiological conditions.	In general, radionuclide concentrations in routine samples collected from or adjacent to waste disposal facilities in 2010 were higher than concentrations measured in distant communities in previous years. There were 22 instances of radiological contamination in soil samples investigated in 2010. Of the 22, 17 were cleaned up and 5 were controlled in a posted area.
Vegetation	Samples of perennial vegetation were collected near Hanford Site facilities and operations in 2010 and analyzed for radiological contaminants.	Concentrations of radionuclides were comparable to those from previous years and elevated in vegetation samples collected near facilities and operations when compared to concentrations in samples from distant communities collected in previous years.

DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.

Non-radioactive air pollutants are emitted from power-generating and chemical-processing facilities. These facilities are monitored when activities are known to generate potential pollutants of concern, which include carbon monoxide, gaseous ammonia, lead, nitrogen oxides, particulate matter, sulfur oxides, and volatile organic compounds (Section 8.1.2).

Air emissions data collected in 2010 were comparable to those collected in 2009.

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 2010, ambient air was monitored at 91 locations on the Hanford Site near facilities and operations (Section 8.2.1). 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 2010 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 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.

Several samples from the 100-K and 200-West Areas had results greater than 10% of EPA's concentration values. Elevated results from samples obtained at the 100-K Area included strontium-90 and cesium-137. Results for uranium-234, uranium-238, and plutonium-239/240 were elevated in samples from the 200-West Area.

Hanford Site-Wide and Offsite Ambient-Air Monitoring. During 2010, samples were collected at 40 continuously operating locations: 21 onsite (site-wide), 11 perimeter locations, 7 in nearby communities, and 1 in a distant community (Section 8.2.2). Airborne particle samples were collected at each station biweekly and monitored for gross alpha and gross beta concentrations. Biweekly samples were combined into quarterly composite samples and analyzed for gamma-emitting radionuclides. Samples of atmospheric water vapor were collected every 4 weeks and analyzed for tritium at 20 locations in 2010. All sample results showed very low radiological concentrations. All radionuclide concentrations in air samples collected in 2010 were below levels comparable to the EPA *Clean Air Act* dose standard of 10 millirem (100 microsievert) per year (Section 8.2.2.2).

Liquid Effluent Monitoring

Liquid effluents are discharged from some facilities at the Hanford Site. Effluent streams were sampled for gross alpha and gross beta concentrations, as well as for concentrations of selected radionuclides. In 2010, facilities in the 200 Areas discharged radioactive liquid effluent to the ground at a single location, the State-Approved Land Disposal Site. Liquid effluent from the 100 Areas, primarily secondary cooling water from the 100-K Area, was discharged to the Columbia River via a permitted outfall. Non-radioactive hazardous materials in liquid effluent were monitored in the 100, 200, and 400 Areas to determine compliance with permits before discharging to the State-Approved Land Disposal Site or the Columbia River. During 2010, discharges were in compliance with the National Pollutant Discharge Elimination System permit (Section 8.3). Three state and one local waste discharge permit violations were reported on the Hanford Site in 2010 (Section 5.4.1).

Surface Water and Sediment Monitoring

Samples of surface water and sediment at and near the Hanford Site were collected and analyzed to determine concentrations of radiological and chemical contaminants from the site. Surface water bodies included the Columbia River, onsite ponds, and offsite irrigation sources. Aquatic sediment monitoring was conducted for the Columbia River and one onsite pond (Section 8.4).

Columbia River Water. During 2010, Columbia River water samples were collected with automated samplers at fixed-location monitoring stations at Priest Rapids Dam and the city of Richland, Washington, and analyzed for radionuclides. Samples were also taken from cross-river transects and near-shore locations near the 100-N Area, Vernita Bridge, Hanford town site, the 300 Area, and the city of Richland and analyzed for both radionuclides and chemicals. Transect samples were collected at multiple locations on a line across the Columbia River and at several near-shore locations. Radiological constituents of interest included gamma-emitting radionuclides, tritium, strontium-90, technetium-99, uranium-234, uranium-235, plutonium-238, uranium-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 2010 were less than 1/25th of the concentrations comparable to the DOE-derived concentration guide (effective dose equivalent of less than 100 millirem [1 microsievert] per year). Tritium, uranium-234, uranium-238, and naturally occurring beryllium-7 and potassium-40 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 2010 were below regulatory limits (Section 8.4.1).

Columbia River Sediment. During 2010, 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 shoreline. Radionuclides consistently detected in Columbia River sediment in 2010 included naturally occurring beryllium-7 and potassium-40, cesium-137, uranium-234, uranium-235, uranium-238, plutonium-239/240, and daughter products from naturally occurring radionuclides. Detectable amounts of most metals were in all river sediment samples; however, there are no Washington State freshwater sediment quality criteria for comparison to the measured values (Section 8.4.2).

Pond Water and Sediment. Two onsite ponds, West Lake and the Fast Flux Test Facility Pond, were sampled in 2010. Water samples were obtained quarterly from both ponds and sediment samples were obtained semiannually from West Lake. All samples were analyzed for tritium, and samples from the Fast Flux Test Facility Pond were also analyzed for gross alpha, gross beta, and gamma-emitting radionuclides. All radionuclide concentrations in onsite pond water samples were less than applicable DOE-derived concentration guides and Washington State ambient surface-water quality criteria. Concentrations in sediment samples were similar to concentrations measured in prior years (Section 8.4.3).

Offsite Irrigation Water. In 2010, samples were collected from an irrigation canal in the Riverview area of Pasco (east of the Columbia River and downstream from the Hanford Site) and from an irrigation water supply in Benton County near the southern boundary of the Hanford Site. All radionuclide concentrations were below applicable DOE-derived concentration guides and Washington State ambient surface-water quality criteria. With the exception of tritium results obtained from the Horn Rapids irrigation pumping station, all radionuclide concentrations were detected at the same levels detected in Columbia River water obtained upstream of the Hanford Site (Section 8.4.4).

Columbia River Shoreline Springs Monitoring

Samples of Columbia River shoreline spring water and sediment were collected along the Hanford Reach and analyzed for Hanford Site-associated radiological and chemical contaminants present in groundwater beneath the site (Section 8.5).

Columbia River Shoreline Springs Water. Samples were obtained from numerous locations in 2010 when Columbia River flows were low, typically in early fall. 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 2010 were less than applicable DOE concentration guidelines, but exceeded the Washington State ambient water quality criteria for gross alpha at some 300 Area locations and for tritium at the Hanford town site. In addition, uranium concentrations at some 300 Area locations exceeded the drinking water standard (Section 8.5.1.2). For most locations, the 2010 chemical sample results were similar to those reported previously. Concentrations of volatile organic compounds were near or below the analytical laboratory's required detection limits in all samples. Trace amounts of chlorinated organic compounds were observed at the 100-K and 300 Areas. The concentrations of most metals measured in spring water samples in 2010 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 8.5.1).

Columbia River Shoreline Springs Sediment. During 2010, shoreline springs sediment samples were collected in the 100-B, 100-H, and 100-F Areas, the 300 Area, and at the Hanford town site. Radionuclide concentrations were similar to concentrations measured in Columbia River sediment, with the exception of the 300 Area where uranium concentrations were above the background concentration measured in the sediment from the reservoir behind Priest Rapids Dam. Metals concentrations in all samples were similar to concentrations measured in Columbia River sediment samples (Section 8.5.2).

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 treated from the 100-K, 100-N, and 200-West Areas is obtained from the Columbia River; water used in the 400 Area is pumped from wells. Water samples were analyzed for gross alpha, gross beta, tritium, and strontium-90. During 2010, annual average concentrations of all monitored radionuclides in Hanford Site drinking water were below federal and state maximum allowable contaminant levels (Section 8.6).

Groundwater Monitoring

At the Hanford Site, liquid waste released to the ground over many years has reached the groundwater. Hazardous chemicals in the groundwater include carbon tetrachloride, chromium, and cyanide. Radioactive contaminants include tritium, strontium-90, technetium-99, iodine-129, and uranium. Currently, groundwater contaminant levels are greater than drinking water standards beneath 12.2% of the Hanford Site. The increase in plume area compared to 2009, reported as 11.3%, is due to advancements in map contour measurement precision. 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 possible near-shore effects where Hanford Site groundwater flows into the Columbia River (Section 8.7).

Food and Farm Products Monitoring

During 2010, food and farm products including grapes, leafy vegetables, milk, potatoes, and tomatoes, were collected at locations near the Hanford Site and analyzed for radiological contaminants. The concentrations of most radionuclides in food and farm product samples in 2010 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 8.8).

Soil Monitoring

In 2010, soil samples were collected near facilities and operations at the Hanford Site to detect potential contaminant migration, to monitor the deposition of onsite facility emissions, and to evaluate long-term trends in the environmental accumulation of radioactive materials. 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 2010 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 2010 were higher within different operational areas when compared to concentrations measured in distant communities in previous years. Generally, the predominant radionuclides detected were activation and fission products in the 100 Areas, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas (Section 8.9).

Contaminant Monitoring of Plant and Animal Communities

Section 8.10 presents contaminant monitoring of plant, fish, and wildlife populations on and around the Hanford Site in 2010. The section also includes the control of contaminated or unwanted vegetation and pests and contaminated biota on the site.

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 2010 were higher than concentrations in samples collected farther away, including concentrations measured offsite. Generally, the predominant radionuclides detected were activation and fission products in the 100-N Area, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas (Section 8.10.1).

Investigations of Radioactivity in Vegetation Near Hanford Site Facilities and Operations. During 2010, radiological contamination was detected in 36 vegetation samples. One sample was rabbitbrush, 1 was sagebrush, and 34 were tumbleweeds (Russian thistle) or tumbleweed fragments; all were disposed of at a licensed facility (Section 8.10.1.3).

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 8.10.3).

Monitoring Fish and Wildlife for Hanford-Produced Contaminants. In 2010, carp, deer, elk, quail, and rabbits were collected at locations on and around the Hanford Site (Section 8.10.4). Tissue samples were monitored for strontium-90 contamination and gamma emitters, including cesium-137. Cesium-137 was below detection limits in all samples in 2010. Strontium-90 was not found above the analytical detection limit in the carp or quail samples collected during 2010. Concentrations were above the analytical detection limit in the rabbit, deer, and elk samples. 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 (Section 8.10.4).

Control of Pests and Contaminated Biota. Animal species must be controlled when they become a nuisance, present health problems, or are radioactivity contaminated. Biological control personnel responded to approximately 29,000 animal control requests from Hanford Site employees in 2010, ranging from requests to remove animals within radioactive waste facilities to insect invasions of work areas. There were 24 contaminated animals or animal-related materials discovered during 2010 (Section 8.10.5).

External Radiation Monitoring

In 2010, external radiation at the Hanford Site was monitored onsite in relative close proximity to known or potential radiation sources (Section 8.11). 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 2010, external radiation fields were monitored at 119 locations near onsite facilities and operations. Measured radiation levels in the 100-K Area, 100-N Area, 100-N shoreline area (N Springs), the 200-West Area, and 400 Area were similar to or lower than levels measured in 2009. Increased dose rate levels were observed in the 200-East Area and 300 Area in 2010 (Section 8.11.1).

Radiological Surveys at Active and Inactive Waste Disposal Sites. During 2010, 632 environmental radiological surveys were conducted at active and inactive waste disposal sites and the terrain surrounding them to detect and characterize radioactive surface contamination. Vehicles equipped with radiation detection devices and global positioning systems were used to accurately measure the extent of contamination. Routine radiological survey locations included former waste disposal cribs and trenches, retention basin perimeters, ditch banks, solid waste disposal sites (e.g., burial grounds), unplanned release sites, tank farm perimeters, stabilized waste disposal sites, roads, and firebreaks in and around Hanford Site operational areas. During 2010, the Hanford Site had approximately 3,580 hectares (8,850 acres) of outdoor contaminated areas of all types and approximately 560 hectares (1,390 acres) that contained underground radioactive materials, not including active facilities. No new areas of significant size were discovered during 2010.

Approximately 18 hectares (43 acres) of previously posted contamination and/or underground radioactive materials areas underwent remediation and were closed for the interim in 2010 (Section 8.11.1.2).

Potential Radiological Doses from 2010 Hanford Site Operations

During 2010, 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 8.12). Doses were assessed in terms of 1) total dose (multiple pathways) to the hypothetical, maximally exposed individual at an offsite location (0.18 millirem [1.8 microsievert] per year at Sagemoor in Franklin County, approximately 1.4 kilometers [0.8 mile] east of the Hanford Site across the Columbia River); 2) average dose to the collective population living within 80 kilometers (50 miles) of Hanford Site operating areas (1.1 person-rem [0.011 person-sievert] per year); 3) dose to a maximally exposed individual for air pathways using EPA methods (excluding radon equals 0.053 millirem [0.53 microsievert] per year at Sagemoor, including radon equals 0.067 millirem [0.67 microsievert] per year at Sagemoor); 4) annual dose to site workers consuming drinking water (0.2 millirem [2 microsievert] per year); 5) dose from non-DOE industrial sources on and near the Hanford Site (0.004 millirem [0.04 microsievert] per year); and 6) absorbed dose received by aquatic organisms exposed to contaminants released to the Columbia River and in onsite surface water bodies (less than dose limits and guidelines). Estimated dose to a member of the public for radionuclides released from potential diffuse and fugitive sources of airborne radionuclides was 0.0081 millirem (0.081 microsievert) at Sagemoor.

Endangered and Threatened Species

Two fish species (spring-run Chinook salmon and steelhead) listed under the *Endangered Species Act of 1973* as endangered or threatened occur at the Hanford Site; two plant species (Umtanum desert buckwheat and White Bluffs bladderpod), one mammal (Washington ground squirrel), and one bird species (greater sage grouse) are candidates for listing. In addition, 13 plant species and 4 bird species are listed as either endangered or threatened by Washington State (Section 8.13).

Ecological Monitoring on the Hanford Site

Plant and animal species on the Hanford Site are monitored to assess abundance, condition, and population distributions. Data collection and analysis are integrated with environmental monitoring of biotic and abiotic media and analytical results are used to characterize potential risks or impacts.

Plant Communities and Population Surveys. More than 100 plant populations of 53 different taxa listed by Washington State as endangered, threatened, or sensitive, and species listed as review group 1 are found on the Hanford Site. Plant monitoring data are used to develop baseline information and to monitor for changes resulting from Hanford Site operations. Several species were monitored during 2010 including Umtanum buckwheat (a candidate for federal listing); and gray cryptantha and Columbia yellowcress, two federal species of concern (Section 8.14.1).

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 8.14.1). The number of fall Chinook salmon redds in the Hanford Reach is estimated by aerial surveys. The peak redd count in the fall of 2010 was estimated at 8,817 redds, higher than the 2009 count of 4,996, and 2,178 redds higher than the previous 10-year average of 6,639 redds. Two aerial observation flights were flown over the Hanford Reach to document the occurrence of any steelhead spawning along the shoreline regions; one possible redd was identified. Forty-nine driving surveys were conducted to investigate nesting activities and to document bald eagle numbers and age class in 2010. In addition, 104 surveys were conducted at the 100-K Area to document eagle behavior in preparation for demolition work. Roadside surveys were conducted for mule deer on the Hanford Site to assess age and sex ratios and the frequency of testicular atrophy in males. A combined total of 381 deer observations

were made over 3 repeated surveys during December 2010 to January 2011, which included multiple observations of the same animals in some cases.

Cultural and Historic Resources

DOE is responsible for managing and protecting the Hanford Site's cultural and historic resources. The Hanford Cultural and Historic Resources Program, which is managed by DOE, assures cultural and historic resources entrusted to DOE are managed responsibly and in accordance with applicable regulatory requirements (Section 8.15).

Pursuant to 36 CFR 800, Section 106 reviews must be completed before a federally funded, federally assisted, or federally licensed ground disturbance or building alteration/demolition project can occur. During 2010, Hanford Site archaeologists completed Section 106 reviews for 273 projects on the Hanford Site; 239 were determined to be of the type with no potential to cause effects; 33 were those with the potential to affect historic properties, and 1 was a multiple site inspection.

In 1987, a monitoring program to assess the effects of weathering and erosion or unauthorized excavation and artifact collection of Hanford Site's cultural resources was established. In 2010, 10 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, site operations, and atmospheric dispersion calculations. Activities include weather forecasting and maintaining and distributing climatological data (Section 8.16).

During 2010, average temperature and precipitation totals were above normal. The average temperature for 2010 was 12.1°C (53.9°F), which was 0.1°C (0.3°F) above normal (12.0°C [53.6°F]). Six months during 2010 were warmer than normal, and 6 months were cooler than normal. Precipitation during 2010 totaled 25.9 centimeters (10.19 inches), which is 146% of normal (17.7 centimeters [6.98 inches]). Snowfall for 2010 totaled 40.4 centimeters (15.9 inches), compared to average snowfall of 39.1 centimeters (15.4 inches).

The average wind speed during 2010 was 3.6 meters per second (8.1 miles per hour), which was 0.2 meter per second (0.5 mile per hour) above normal. The peak gust for the year was 28.6 meters per second (64 miles per hour) on May 3. One dust storm was recorded at the Hanford Meteorology Station during 2010, less than the five per year average for the entire period on record (1945-2010).

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 8.17). The programs are implemented through quality assurance plans designed to meet requirements of the American National Standards Institute, the American Society of Mechanical Engineers, and DOE Orders. Quality assurance plans are maintained for all activities, and certified 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 interlaboratory crosschecks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories.

Acknowledgments

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Management and coordination of report production activities were provided by Joanne P. Duncan. Hope E. Matthews was the lead text editor, with support from Andrea J. Currie and Susan K. Ennor, and Kathy R. Neiderhiser was the document production specialist. The authors appreciate the technical review provided by Kathleen Rhoads. Bruce Bjornstad provided the cover photograph and Jamie E. Gority designed the report cover. This report was produced using Adobe® InDesign and formatted for the Internet by Susan J. Widener.

Contents

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1.0 Introduction

This environmental report provides information and analytical data related to the Hanford Site for the 2010 calendar year, including a brief history of the site and its mission; compliance with applicable federal, state, and local environmental laws, regulations, permits, Executive Orders, and U.S. Department of Energy (DOE) policies and directives; and descriptions and summary data from environmental-related programs. Reports from 1959 through 2000 may be accessed at http://msa.hanford.gov/msa/index.cfm/Env._Reports_1959_-_2000; newer reports, indcluding this report, are available at http://msa.hanford.gov/msa/index.cfm/Env._Reports_2001_-_Latest.

Included are sections that describe the following:

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

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

1.0.1 Current Hanford Site Mission

Prior to 1988, the primary Hanford Site mission was the production of plutonium for national defense purposes. With the signing of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989), the primary site objective shifted to cleanup of the extensive contamination remaining due to the legacy of production. The Hanford Site's mission now focuses on environmental restoration, including remediation of contaminated areas and the decontamination and decommissioning of Hanford Site facilities; waste management; and related scientific and environmental research and development of waste management technologies.

1.0.2 Hanford Site Overview

The Hanford Site is located 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) north of the city of Richland (DOE/EIS-0222-F). This area has restricted public access and provides a buffer for areas on the site that were used for nuclear materials production, waste storage, and waste disposal. The Columbia River flows eastward through the northern part of the site and then turns south, forming part of the eastern site boundary.

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

- **100 Areas** – The 100 Areas, consisting of six distinct sites, are situated along the shore of the Columbia

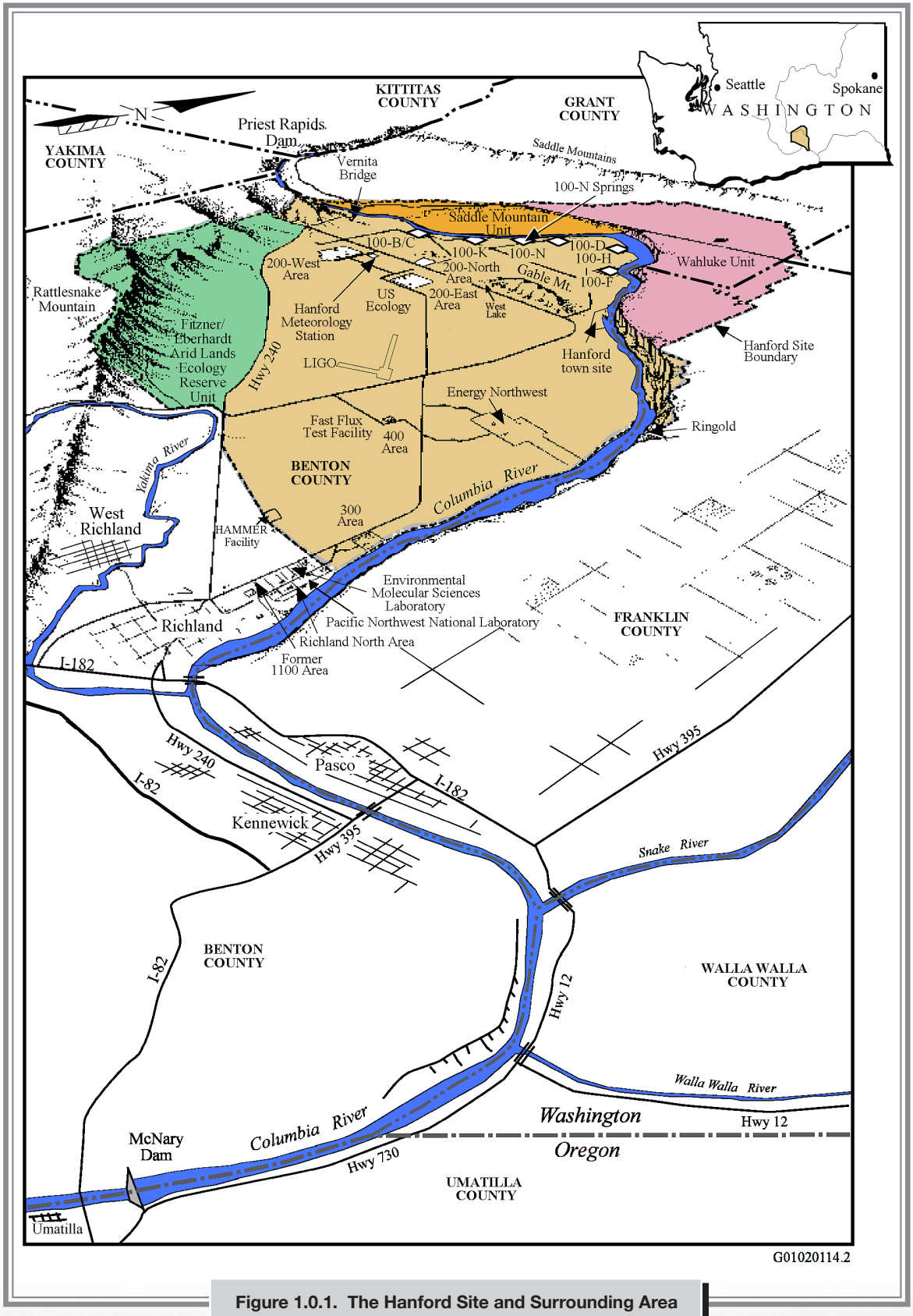

Figure 1.0.1. The Hanford Site and Surrounding Area

River in the northern portion of the site. These areas were the location of nine nuclear reactors that have since been retired. Collectively, the 100 Areas occupy approximately 11 square kilometers (4 square miles). The B Reactor, a National Historic Landmark, is located in the 100-B Area. As the world's first industrial-scale nuclear reactor, it is where plutonium was produced for the first atomic explosion (the Trinity Test) and the atomic bomb that was detonated over Nagasaki, Japan. DOE offers scheduled tours of the facility.

- **200 Areas** – The 200-East and 200-West Areas, covering approximately 16 square kilometers (6 square miles), are located on the Central Plateau, approximately 8 and 11 kilometers (5 and 7 miles) south and west, respectively, of the Columbia River. The plateau surface is approximately 100 meters (328 feet) above the level of the Columbia River and about 85 meters (280 feet) above the underlying water table. These areas contain underground waste storage tanks and housed facilities (known as "separations plants") that extracted plutonium from dissolved irradiated fuel. The 200-North Area, now considered part of the 600 Area, is located near Gable Mountain, north of the 200 Areas and approximately 7 to 12 kilometers (4 to 7.5 miles) south of the 100 Areas. The 200-North Area covered approximately 23.7 hectares (58.6 acres) and operations were mainly related to irradiated nuclear fuel interim storage. Thermal cooling of the spent fuel required water, which was disposed of at several sites within the 200-North Area. Remediation of these sites is ongoing.
- **300 Area** – The 300 Area is located just north of the city of Richland and covers approximately 1.5 square kilometers (0.6 square mile). From the early 1940s until the advent of the environmental contamination cleanup mission in 1989, nuclear fuel fabrication and research and development activities at the Hanford Site were performed at the 300 Area. Remediation of waste sites and decommissioning of 300 Area facilities continued in 2010.
- **400 Area** – The 400 Area is located northwest of the 300 Area, and covers approximately 0.61 square kilometer (0.23 square mile). This area includes the Fast Flux Test Facility, a nuclear reactor designed and used to test various types of nuclear fuel, produce medical and industrial isotopes, and conduct cooperative international research. The facility has not operated since 1992 and was in a low-cost, long-term surveillance and maintenance condition during 2010.
- **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, the Pacific Northwest National Laboratory Site, 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, used by site contractors, federal and state agencies, tribal governments, and private industry, is located on the Hanford Site near the city of Richland. It consists of a 0.31-square-kilometer (0.12-square-mile) main site and a 40.4-square-kilometer (15.6-square-mile) law enforcement and security training site. The DOE-owned facility was managed by Mission Support Alliance, LLC, in 2010.

Non-DOE Operations and Activities on Hanford Site Leased Land – These include commercial power production by Energy Northwest at the Columbia Generating Station (440 hectares [1,090 acres]), located north of the 300 Area and operation of a commercial low-level radioactive waste burial site by US Ecology Washington, Inc. (40 hectares [99 acres]), located west of the 200-East Area. The Laser Interferometer Gravitational-Wave Observatory (60 hectares [148 acres]), located west of the 400 Area, is sponsored by the National Science Foundation and operated jointly by the California Institute of Technology and the Massachusetts Institute of Technology.

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 Hanford Reach National Monument (Figure 1.0.2), which covers 789-square-kilometers (305-square-miles), was established on the Hanford Site by a Presidential Proclamation in June 2000 (65 FR 37253). 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. The U.S. Fish and Wildlife Service manages regions of the Hanford Reach National Monument, to include Rattlesnake Mountain, under an agreement with DOE. In 2009, communications operations were consolidated and excess facilities, infrastructure, and debris were removed from the Fitzner/Eberhardt Arid Lands Ecology Reserve on Rattlesnake Mountain, reducing the physical footprint, improving the landscape, and minimizing impacts to cultural and biological resources. A Combined Community Communications Facility was constructed and communication antenna towers were erected. Demolition of surplus infrastructure and debris was completed in 2010.

1.0.3 Hanford Site Management

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

DOE Richland Operations Office. The DOE Richland Operations Office serves as landlord of the Hanford Site and manages cleanup of legacy waste, related research, and other programs. During 2010, the principal contractors for the DOE Richland Operations Office and their respective responsibilities included the following:

- Mission Support Alliance, LLC – This contractor was awarded the Mission Support Contract for the Hanford Site in 2009. Work scope includes Hanford Site infrastructure and support services including safety, security, and environment; site infrastructure and utilities; site business management; information resources and content management; and portfolio management. Mission Support Alliance, LLC, is a limited liability company operated by Lockheed Martin, LLC; Jacobs Engineering Group, Inc.; and Wackenhut Services, Inc., with subcontractors Abadan; Akima Facilities Management; Computer Science Corporation; Dade Moeller & Associates; HPM Corporation; Lampson International; Lockheed Martin Services, Inc.; Longenecker and Associates; Protection Strategies; RJ Lee Group, Inc.; Vivid Learning Systems; and Westech International.
- Washington Closure Hanford, LLC – This contractor was awarded the River Corridor Closure Contract in March 2005. This contractor is a limited liability company owned by Washington Division of URS Corporation; Bechtel National, Inc.; and CH2M HILL Hanford Group, Inc. Work scope includes cleanup of waste sites and 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. Work includes emplacing the remaining deactivated plutonium-production reactors in interim safe storage (also known as "cocooning"), continuing cleanup of the remaining waste sites located near the Columbia River, demolishing contaminated facilities, and operating the Environmental Restoration Disposal Facility. The principle subcontractor to Washington Closure Hanford, LLC, is Eberline Services Hanford, Inc.

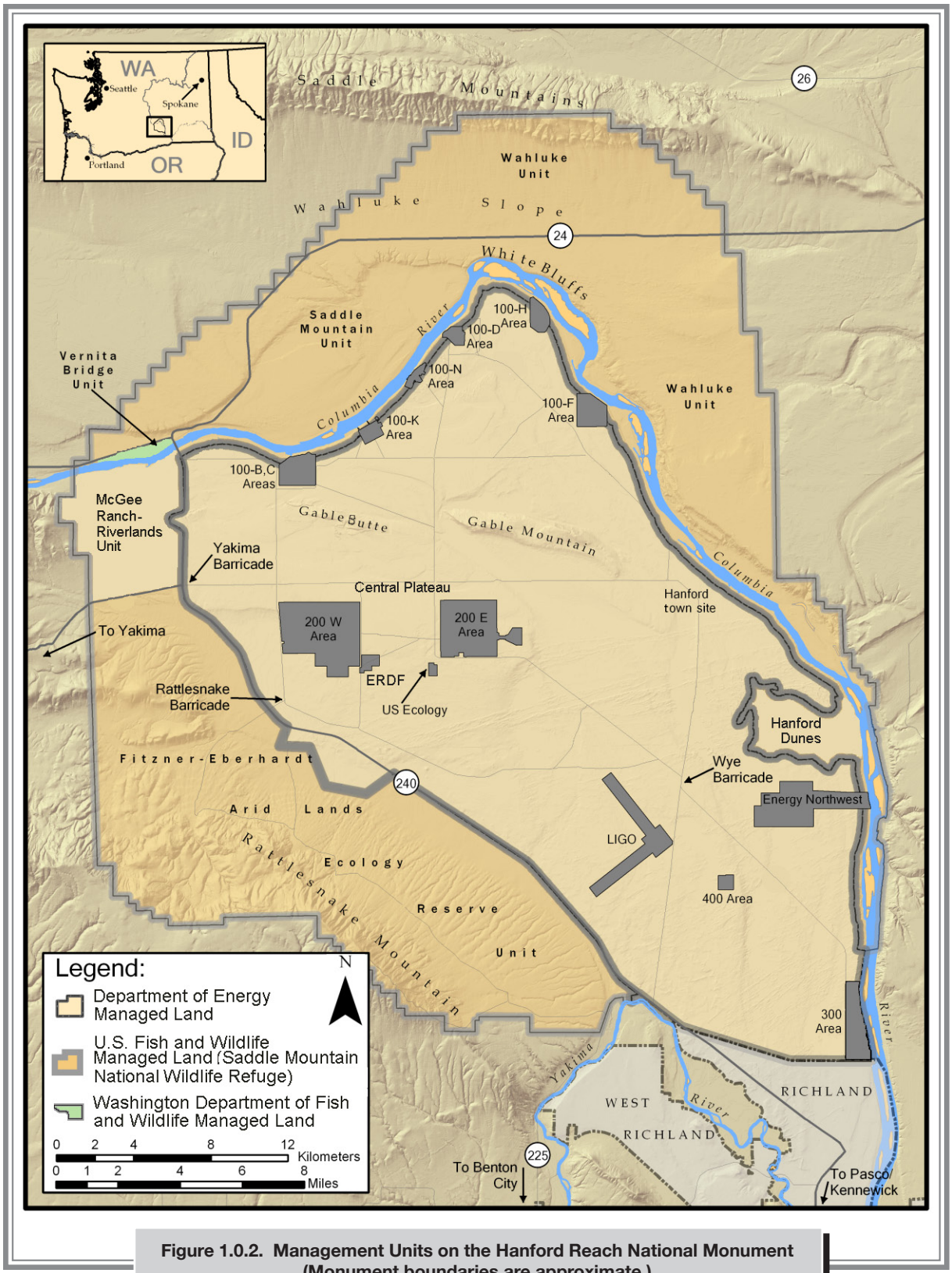

Figure 1.0.2. Management Units on the Hanford Reach National Monument (Monument boundaries are approximate.)

- CH2M HILL Plateau Remediation Company – This contractor became the plateau remediation contractor for the Hanford Site in 2008 and is responsible for safe environmental cleanup of the Central Plateau. The work scope includes environmental remediation, groundwater monitoring and remediation, waste site characterization, non-tank farm waste disposal, Fast Flux Test Facility maintenance and shutdown, environmental monitoring and maintenance, and completion of the Plutonium Finishing Plant closure project. The CH2M HILL Plateau Remediation Company team includes AREVA Federal Services, LLC; East Tennessee Materials and Energy Corporation, Inc.; Fluor Federal Services, Inc.; ARES Corporation; Babcock Services; GEM Technology International; INTERA, Inc.; ENREP, Inc.; Ascendent Engineering and Safety Solutions; Cavanagh Services Group; and Project Services Group.
- AdvanceMed Hanford – This contractor was the occupational health contractor for the Hanford Site in 2010. 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. In April 2011, AdvanceMed Hanford was renamed to CSC Hanford Occupational Health Services.

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

DOE Office of River Protection. The DOE Office of River Protection was established by Congress in 1998 as a field office to manage Hanford Site tank-waste storage, retrieval, treatment, and disposal. During 2010, the principal contractors for the DOE Office of River Protection and their respective responsibilities included the following:

- Bechtel National, Inc. – This contractor's mission is to design, build, and initiate the operation of the Hanford Tank Waste Treatment and Immobilization Plant, located on a 0.26-square-kilometer (0.1-square-mile) site on the Central Plateau of the Hanford Site. This facility is designed to convert liquid radioactive waste into a stable glass form (vitrification). The 10-year contract for this work was awarded in December 2000. In 2009, the Hanford Tank Waste Treatment and Immobilization Plant contract was modified and extended to August 15, 2019. The principle subcontractor to Bechtel National, Inc. is the URS Corporation.
- Washington River Protection Solutions LLC – This contractor was awarded the Tank Operations Contract for the Hanford Site in 2008. The work scope includes base operation of the tanks, analytical laboratory support, single-shell tank retrieval and closure, Hanford Tank Waste Treatment and Immobilization Plant support, and supplemental treatment. Hanford Site tank farms contain 210 million liters (56 million gallons) of radioactive and chemically hazardous waste stored in 177 underground tanks generated from more than three decades of plutonium production. Washington River Protection Solutions LLC was formed by the Washington Division of URS Corporation and Energy*Solutions*, with AREVA Federal Services, LLC serving as a subcontractor.
- 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 is equipped and staffed to receive, analyze, and store samples and report 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. The Pacific Northwest National Laboratory Site, a DOE facility in

Richland, Washington, is operated by Battelle Memorial Institute for DOE's national security and energy missions. Pacific Northwest National Laboratory delivers scientific solutions by using interdisciplinary teams from multiple scientific disciplines to solve energy, environmental, and national security challenges.

U.S. Fish and Wildlife Service. The U.S. Fish and Wildlife Service, through permits and a memorandum of understanding with DOE, manages regions of the Hanford Reach National Monument. During 2010, the U.S. Fish and Wildlife Service administered three major management units (Figure 1.0.2) totaling about 668 square kilometers (258 square miles). These included the following:

- 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
- 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
- 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. This unit occupies approximately 3.2-square-kilometers (1.25-square-miles) along the north side of the Columbia River, west of the Vernita Bridge, and south of State Highway 243 in Grant County. This unit is open to the public year round.

1.0.4 Hanford Site Websites

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

- AdvanceMed Hanford (CSC Hanford Occupational Health Services): http://www.hanford.gov/amh/
- Advanced Technologies and Laboratories International, Inc.: http://www.atlintl.com/
- Bechtel National, Inc.: http://www.hanfordvitplant.com/
- CH2M HILL Plateau Remediation Company: http://www.plateauremediation.hanford.gov/
- DOE Office of River Protection: http://www.hanford.gov/orp/
- DOE Office of Science: http://science.energy.gov/
- DOE Richland Operations Office: http://www.hanford.gov/rl/
- DOE Science and Technology: http://www.energy.gov/sciencetech/
- Eberline Services Hanford, Inc.: http://www.eberlineservices.com/page_field.htm
- Energy*Solutions*: http://www.energysolutions.com/?id=OTUy
- Environmental Restoration Disposal Facility: http://www.hanford.gov/page.cfm/ERDF
- Hanford Reach National Monument: http://www.fws.gov/hanfordreach/
- Hanford Site Tours: http://www.hanford.gov/page.cfm/HanfordSiteTours
- Jacobs Engineering Group Inc.: http://www.jacobs.com/
- Laser Interferometer Gravitational-Wave Observatory: http://www.ligo.caltech.edu/
- Lockheed Martin Corporation: http://www.lockheedmartin.com/
- Mission Support Alliance, LLC: http://msa.hanford.gov/msa/
- URS Corporation: http://www.urscorp.com/

- Volpentest Hazardous Materials Management and Emergency Response Training & Education Center (HAMMER): http://www.hammertraining.com/
- Wackenhut Services, Inc.: http://www.wsihq.com/
- Washington Closure Hanford, LLC: http://www.washingtonclosure.com/
- Washington River Protection Solutions LLC: http://www.wrpstoc.com/

Information about the Pacific Northwest National Laboratory Site can be accessed at the following websites:

- Battelle Memorial Institute: http://www.battelle.org/
- Environmental Molecular Sciences Laboratory: http://www.emsl.pnl.gov/emslweb/
- Pacific Northwest National Laboratory: http://www.pnl.gov/
- Pacific Northwest Site Office of the DOE Office of Science: http://pnso.oro.doe.gov/

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

- City of Kennewick: http://www.go2kennewick.com/
- City of Pasco: http://www.pasco-wa.gov/
- City of Richland: http://www.ci.richland.wa.us/
- City of West Richland: http://www.westrichland.org/
- Columbia River Basin: http://yosemite.epa.gov/r10/ecocomm.nsf/Columbia/Columbia
- Geology of Washington – Columbia Basin: http://www.dnr.wa.gov/ResearchScience/Topics/GeologyofWashington/Pages/columbia.aspx
- Port of Benton: http://www.portofbenton.com/
- Tri-Cities Visitor & Convention Bureau: 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:

- AREVA NP Inc.: http://www.us.areva-np.com/careers/locations/richland.htm
- Energy Northwest, Columbia Generating Station: http://www.energy-northwest.com/generation/cgs/index.php
- Perma-Fix Northwest, Inc.: http://www.perma-fix.com/facilities/pf_nuclear_richland/
- US Ecology, Inc.: http://www.americanecology.com/richland.htm
- Westinghouse Electric Company's Richland Service Center: http://www.westinghousenuclear.com/Products_&_Services/Nuclear_Services/richland_service_center.shtm

1.0.5 References

65 FR 37253. June 13, 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*, Office of the President.

DOE/EIS-0222-F. 1999. *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*. U.S. Department of Energy, Washington, D.C. Accessed on April 8, 2011, at http://nepa.energy.gov/nepa_documents/EIS/eis0222/eis0222.html.

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.

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, 2 vols., as amended, Olympia, Washington. Accessed March 28, 2011, at http://www.hanford.gov/?page=81.

2.0 Stakeholder Involvement on the Hanford Site

JP Duncan

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

2.0.1 Role of Native American Tribes

JA Conrad

The role of Native American tribes at the Hanford Site is guided by DOE Order 144.1, "Department of Energy American Indian Tribal Government Interactions and Policy," which communicates departmental, programmatic, and field responsibilities for interacting with American Indian governments. This Order incorporates both policy and consultation guidance in working with Native American tribes. *U.S. Department of Energy American Indian & Alaska Native Tribal Government Policy* (DOE 2006) states that, "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." The policy outlines the trust relationship that DOE has with Native American tribes and commits the agency to institute government-to-government relations with the tribes. DOE Order 144.1, Attachment 3 titled, "Framework to Provide Guidance for Implementation of U.S. Department of Energy's American Indian and Alaska Native Tribal Government Policy" provides additional detailed guidance on how tribal consultation is to be conducted.

The U.S. government has a unique political and legal relationship with tribal governments as defined by treaties, the U.S. Constitution, court decisions defining the federal trust responsibility, and Executive Orders. Additional federal laws and regulations requiring DOE to consult with Native American tribes on certain issues include the *American Indian Religious Freedom Act*, the *National Environmental Policy Act of 1969*, the *Archaeological Resources Protection Act of 1979*, the *National Historic Preservation Act of 1966*, and the *Native American Graves Protection and Repatriation Act of 1990*. As Hanford Site cleanup progresses, Native American tribes review various aspects of cleanup activities, including how these activities will affect cultural, natural, and biological resources, and the tribes' future ability to use and consume the resources that once existed at the site.

At the Hanford Site, DOE works primarily with four Native American tribes due to their prior occupation and/or use of Hanford Site lands. The Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe negotiated treaties with the U.S. government in 1855 (*Treaty with the Nez Perce, 1855*; *Treaty with the Walla Walla, Cayuse, etc., 1855*; *Treaty with the Yakama, 1855*). The Yakama and the Umatilla tribes ceded land to the U.S. government and the Nez Perce ceded rights on the Columbia River. Each of the treaties established in 1855 includes provisions that the Native American tribes reserve the right to fish at all usual and accustomed places; to hunt; gather roots and berries; and to pasture horses and cattle on open and unclaimed land. The Wanapum, now located in Priest Rapids, once resided on the lands that are now the Hanford Site and have historic ties to the site.

DOE provides financial assistance through cooperative agreements with the Confederated Tribes and Bands of

the Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe to support tribal involvement in environmental management, restoration, and remediation activities. Funding enables Native American tribes to retain staff to facilitate reviews and comment on site-related draft documents and plans, as well as participate in meetings and activities. Tribal experts in tribal culture, history, and resources often contribute their insight and expertise to Hanford Site decision-making processes and activities.

In 2010, the following activities were accomplished:

- Tribal representatives provided numerous document reviews under the *National Environmental Policy Act of 1969*, the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), and the *Resource Conservation and Recovery Act of 1976* (RCRA) concerning Hanford Site plans and policies.
- Technical issues were discussed at regular tribal working sessions involving tribal representatives, DOE Richland Operations Office managers, and Hanford Site project leads.
- The DOE Richland Operations Office, Central Plateau Division held monthly groundwater meetings to discuss groundwater-related issues.
- Various issues of tribal importance were discussed at bi-annual meetings of the State and Tribal Government Working Group, including DOE and tribal representatives throughout the Hanford Site environmental management complex.
- DOE and contractor project managers received tribal training that included information and guidance concerning the *U.S. Department of Energy American Indian & Alaska Native Tribal Government Policy* (DOE 2006) and Attachment 3 of DOE Order 144.1 titled, "Framework to Provide Guidance for Implementation of U.S. Department of Energy's American Indian and Alaska Native Tribal Government Policy"; tribal consultation; cultural resource reviews; and tribal perspectives.
- In November 2010, tribal representatives conducted activities with the DOE-Richland Tribal Affairs and Cultural Resources Program that educated employees and the community about tribal issues.
- Tribal representatives participated in a variety of meetings including State of the Hanford Site briefings, annual program reviews, budget discussions, and other meetings involving site-specific issues.

Further information regarding the Tribal Affairs and Cultural Resources Program is available on the following website: www.hanford.gov/page.cfm/INP.

2.0.2 Cultural and Historic Resource Consultations

JA Conrad

The *National Historic Preservation Act of 1966* requires DOE to consult with the Washington State Historic Preservation Officer, Native American tribes, local government representatives, the public, and other interested parties on cultural and historic resource matters. Regulations require that DOE solicit and gather input from Native American tribes and interested parties, obtain concurrence from the Washington State Historic Preservation Officer on the identification of cultural resources, evaluate the significance of these resources, and assess impacts of DOE activities on cultural resources. The *Hanford Cultural Resources Management Plan* (DOE/RL-98-10) provides guidance to DOE on cultural and historic resources issues. The plan is available at the following website: http://www.hanford.gov/page.cfm/INPDocuments.

DOE's Cultural and Historic Resources Program consults with the Washington State Historic Preservation Officer, the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Wanapum through individual meetings and discussions, field walk-downs, and project comment resolution. Tribal cultural experts discuss project scope and design monthly with DOE, tribal representatives, and other interested parties.

DOE also consults with the Washington State Historic Preservation Officer and other parties that express an interest in historic resources located on the Hanford Site, including 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.

2.0.3 Hanford Natural Resource Trustee Council

DC Ward

CERCLA and implementing regulations in 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan" establish DOE as both the CERCLA lead response agency on departmental facilities and a trustee for natural resources under its jurisdiction. As the lead response agency, DOE is mandated to conduct response actions to correct or mitigate threats to human health and the environment that result from the release of hazardous substances during the execution of its assigned missions. CERCLA also provides authority for assessment and restoration of natural resources that have been damaged by a hazardous substance release or response.

Under CERCLA (as amended), the United States is liable for damages or injury to, destruction of, or loss of natural resources resulting from release of hazardous substances or from removal or remedial activities made necessary because of such releases, including the cost of assessing such damage. 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.

Designated federal trustees for Hanford Site natural resources include the U.S. Department of the Interior represented by the U.S. Fish and Wildlife Service, and the U.S. Department of Commerce represented by the National Oceanic and Atmospheric Administration. CERCLA § 107(f)(2)(B) authorizes state governors to designate a state trustee to coordinate all state trustee responsibilities. State organizations include the Washington State Department of Ecology and the Oregon Department of Energy. Native American tribes also participate as members of the Hanford Natural Resource Trustee Council. Tribes include the Confederated Tribes and Bands of the Yakama 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 (DOE/RL 1996) and is a voluntary association of trust organizations. Members collaborate and coordinate on many issues, documents, and actions concerning natural resources. The primary purpose of the council is to facilitate the coordination and cooperation of the trustees in their efforts to mitigate effects to natural resources that result from either hazardous substance releases on the Hanford Site or remediation of those releases. The council has adopted bylaws to direct the process of arriving at consensus on all substantive decisions.

During 2010, the trustees met as a formal council six times and held numerous conference calls to conduct council business and discuss CERCLA natural resource issues for the Hanford Site. The senior trustees (upper-management level representatives from each trust organization) met twice in person and conducted one conference call in 2010 to discuss policy, management, and budget issues.

The Hanford Natural Resource Trustee Council performed the following actions in 2010:

- Selected Industrial Economics Incorporated to perform Phase II of the injury assessment process. The key deliverable of this phase is a Hanford Site Injury Assessment Plan. Supporting products and tasks under Phase II in 2010 included the following:
  - Completion of the draft injury assessment plan outline
  - Selected initial species and developed eco-toxicological profiles
  - Completed the service flow report task
  - Conducted a data management workshop
  - Completed the Phase II document review process.
- Organized and held routine (typically monthly) meetings for each of six technical work groups (Restoration, Aquatic Resources, Groundwater, Terrestrial Resources, Source/Pathway, and Human Uses)
- Formed a new data management and quality assurance/quality control technical work group
- Drafted early restoration sections for a restoration plan
- Identified initial high priority Hanford Natural Resource Damage Assessment studies including contaminant

transport/upwelling in the Columbia River, environmental baseline, and data mining

- Conducted Natural Resource Damage Assessment training for trustees, DOE managers, and support staff
- Provided input to DOE on a re-vegetation manual in development
- Provided updates to a book under development describing the history of the Hanford Natural Resource Trustee Council
- Authorized the U.S. Fish and Wildlife Service to hire a project coordinator to assist the Council in planning and managing the Hanford Natural Resource Damage Assessment effort
- Developed council budgets for natural resource injury assessment activities
- Supported funding for injury assessment in the President's budget request to Congress
- Obtained facilitator services for fiscal year 2011 to assist trustees in planning and conducting Hanford Natural Resource Trustee Council administrative business
- Received periodic briefings on ongoing and planned cleanup activities, including remedial investigation/feasibility study plans and results
- Provided comments to DOE, as representatives of the individual Hanford Natural Resource Trustee organizations, on cleanup activities including draft plans.

Information about the Hanford Natural Resource Trustee Council, including its objectives, history, and projects, is available on the following website: http://www.hanford.gov/page.cfm/HNRTC.

2.0.4 Public Participation in Hanford Site Decisions

PK Call

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

The *Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan* (DOE/RL 2002) outlines the public participation processes used by the Tri-Party Agreement agencies (Washington State Department of Ecology, 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 first plan was developed and approved with public input in 1990 and has since been revised four times; January 2002 is the most current revision. The plan is available on the following website: http://www.hanford.gov/?page=89. Presently, the plan is being revised by the Tri-Party agencies and is planned for release during 2011 for a 45-day public comment period. A final document should be available by the end of 2011 or early 2012.

A key goal of public involvement is to facilitate broad-based participation and obtain stakeholder and public perspectives on Hanford Site cleanup 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:

- Hanford Cleanup Line – Staff administrating the Hanford Cleanup Line (800) 321-2008 respond to information requests about the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement [Ecology et al. 1989]) cleanup activities. The Tri-Party Agreement agencies strive to provide a timely response to all requests. The line is advertised frequently in a variety of ways, including all Tri-Party Agreement announcements; media information such as newspaper articles, brochures, and meeting notices; and Hanford Site fact sheets.
- Mailing List – The Tri-Party Agreement agencies maintain a mailing list of about 2,500 individuals who have expressed interest in Hanford Site cleanup issues. The mailing list is used to provide information on upcoming public comment periods, cleanup decisions, and public forums. Information can be received by mail or electronically. To be placed on the mailing list to obtain Tri-Party Agreement information, call the Hanford Cleanup Line at (800) 321-2008 or send an e-mail to hanford-info@listserv.wa.gov.

- Hanford Site Public Involvement Activities – The Hanford Site Events Calendar is available at the following website: http://www.hanford.gov/. The calendar provides an overview of public involvement opportunities for the coming months and identifies current forums and emerging opportunities to inform and involve stakeholders and the public.
- A Tri-Party Agreement Public Involvement Calendar for the Hanford Site is available at the following website: http://www.ecy.wa.gov/programs/nwp/public.htm. This calendar provides a 12-month overview of upcoming key public involvement activities, including Hanford Advisory Board meeting dates and locations.
- Hanford Site Informational Links – Information concerning Hanford Site events, issues, cleanup activities, and public involvement opportunities is available at the following website: http://www.hanford.gov/.
- Comment and Response Documents – Following a DOE or Tri-Party Agreement public comment period, a comment and response document is developed to record public comments received on an issue. Comment and response documents are distributed to members of the public who provide comments or request a copy. These documents are available at the DOE Public Reading Room (Washington State University Tri-Cities Consolidated Information Center, 2710 University Drive, Richland, Washington); on the Tri-Party Agreement Administrative Record website: http://www5.hanford.gov/arpir/; and for proposed changes to the Tri-Party Agreement that underwent public comment, on the Tri-Party Agreement website: www.hanford.gov/?page=86.
- Informational Public Meetings – All Tri-Party Agreement quarterly public involvement planning meetings, semiannual meetings, special meetings, and workshops are open to the public. In addition, the Tri-Party Agreement agencies welcome opportunities for co-sponsoring meetings organized by local, state, and tribal governments and citizen groups.

Hanford Site cleanup documents are also available to the general public through the Tri-Party Agreement's Administrative Record and Public Information Repository available on the following website: http://www5.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, RCRA, and the *National Environmental Policy Act of 1969*; Hanford Advisory Board meetings; State of the Hanford Site meetings; and other Hanford Site-related public involvement/information meetings, workshops, or activities.

State of Oregon

DOE recognizes the State of Oregon's unique role and interests at the Hanford Site, and its concerns to protect Columbia River resources. DOE is interested in sharing, facilitating, and accommodating the exchange of information with the State of Oregon. DOE's Richland Operations Office and Office of River Protection entered into a Memorandum of Understanding (DOE/RL 2004) with the State of Oregon to consult, and whenever possible, cooperate on Hanford Site environmental issues. DOE will consult with and include the Oregon Department of Energy in planning and conducting Hanford Site-related public involvement activities in the State of Oregon.

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

- DOE Richland Operations Office (509) 376-7501
- DOE Office of River Protection (509) 372-8656
- Hanford Site Cleanup Line/Washington State Department of Ecology (800) 321-2008
- EPA (509) 376-8631

For more information about Hanford Site public involvement, visit the Hanford Site website: http://www.hanford.gov.

2.0.5 Hanford Advisory Board

PK Call

The Hanford Advisory Board is a broadly representative body consisting of a balanced mix of members that represent diverse interests affected by Hanford Site cleanup

decisions. The board was created in 1994 by the Tri-Party Agreement agencies and ultimately chartered as one of nine environmental management site-specific advisory boards across the country. The board is composed of 31 members and their alternates, including representatives from the Nez Perce Tribe and the Confederated Tribes and Bands of the Yakama Nation. A representative of the Confederated Tribes of the Umatilla Indian Reservation participates on the board in an ex-officio status. Current members with their affiliations are listed on the following website: http://www.hanford.gov/page.cfm/hab.

The Hanford Advisory Board assists the broader public in becoming more informed and meaningfully involved in Hanford Site cleanup decisions through its open public meetings. Board members' formal advice on cleanup issues reflects the values of its constituents. Copies of their advice and DOE's responses are on the following website: http://www.hanford.gov/?page=453.

Information about the Hanford Advisory Board, including its charter (operating ground rules) is available on the following website: http://www.hanford.gov/?page=449.

2.0.6 References

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Treaty with the Walla Walla, Cayuse, etc., 1855. June 9, 1855. 12 Stat. 945-951, Vol. 2, 694; 194 U.S. 401.

Treaty with the Yakama, 1855. June 9, 1855. 12 Stat. 951, Vol. 2, 698; 198 U.S. 371; 215 U.S. 291; 227 U.S. 355; 241 U.S. 556; and 249 U.S. 194.

3.0 Regulatory Oversight on the Hanford Site

TG Beam

Several federal, state, and local regulatory agencies are responsible for monitoring and enforcing compliance with applicable environmental regulations 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 requirements. In other activities, the state program is assigned direct environmental oversight of the U.S. Department of Energy (DOE) program, as provided by federal law. Where federal regulatory authority is not delegated or only partially authorized to the state, the EPA Pacific Northwest Regional Office (Region 10) is responsible for reviewing and enforcing compliance with EPA regulations as they pertain to the Hanford Site. EPA periodically reviews state environmental programs and may directly enforce federal environmental regulations.

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

TW Noland

The *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement [Ecology et al. 1989]) is an agreement among the Washington State Department of Ecology, EPA, and DOE (Tri-Party Agreement agencies) to achieve environmental regulation compliance on the Hanford Site with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), and the *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and disposal unit regulations and corrective action provisions. The Tri-Party Agreement is an interagency agreement (also known as a federal facility agreement) under Section 120 of CERCLA, a corrective action order under RCRA, and a consent order under the Washington State *Hazardous Waste Management Act of 1976* that 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* (DOE/RL 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-Party Agreement agencies have negotiated changes to the agreement since its publication in 1989 to meet the changing conditions and needs of cleanup activities on the Hanford Site. All significant changes undergo a process of public involvement that enhances communication and addresses public concerns prior to final approvals. As changes are approved through the Tri-Party Agreement change control process, they are incorporated into the Tri-Party Agreement and available on the Internet at the following website: http://www.hanford.gov/?page=81. Printed copies of Revision 7 of the Tri-Party Agreement, which is current as of July 23, 2007, are publicly available at DOE's Public Reading Room located in the Washington State University Tri-Cities Consolidated Information Center, 2770 University Drive,

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, call the Hanford Cleanup Line at (800) 321-2008 or send an e-mail to hanford-info@listserv.wa.gov.

3.0.2 Status of Tri-Party Agreement Milestones

TW Noland

The Tri-Party Agreement (Ecology et al. 1989) commits DOE to comply with the remedial-action provisions of CERCLA as well as with RCRA treatment, storage, and disposal unit regulations and corrective-action provisions, including Washington State's implementing regulations (WAC 173-303, "Dangerous Waste Regulations"). From 1989 through 2010, a total of 1,100 Tri-Party Agreement milestones were completed and 307 target dates were met. During 2010, 43 specific cleanup milestones were scheduled for completion; 40 were completed early, 1 was completed on time, and 2 were completed late.

3.0.3 Approved Modifications to the Tri-Party Agreement

TW Noland

During 2010, 40 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/c.cfm/tpa/.

3.0.4 Washington State Department of Health

TG Beam

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

3.0.5 References

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4.0 Environmental Management Systems

AS Nagel

The U.S. Department of Energy (DOE) requires that all Hanford Site contractors develop and operate under an Integrated Safety Management System that includes an Environmental Management System consistent with the International Organization for Standardization standard—*Environmental management systems – Requirements with guidance for use* (ISO 14001:2004[E]).

Hanford Site contractors have established Integrated Safety Management Systems as mandated by their contracts with DOE. These systems are intended to protect workers, the public, and the environment by integrating environmental, safety, and health considerations into the way work is planned, performed, and improved. DOE verified that all Hanford Site entities under the authority of DOE Policy 450.4, "Safety Management System Policy," had incorporated the requirement within DOE Order 450.1, "Environmental Protection Program," to establish an Environmental Management System within their Integrated Safety Management System prior to December 31, 2005. Washington Closure Hanford, LLC began implementation of the River Corridor Closure Project Contract on August 27, 2005, and in November 2007, completed full implementation of its Integrated Safety Management System.

More recent contract awards required that DOE verify its new contractors have an Integrated Safety Management System in place. Washington River Protection Solutions LLC began implementation of the Tank Operations Contract at the Hanford Site on October 1, 2008, and in September 2009, completed full implementation of its Integrated Safety Management System. CH2M HILL Plateau Remediation Company began implementation of the Plateau Remediation Contract at the Hanford Site on October 1, 2008, and in November 2009, completed full implementation of its Integrated Safety Management System. Mission Support Alliance, LLC began implementation of the Mission Support Contract at the Hanford Site on August 24, 2009, and in January 2011, completed full implementation of its Integrated Safety Management System.

DOE Order 450.1A, "Environmental Protection Program," was issued June 4, 2008, and superseded DOE Order 450.1. DOE Order 450.1A requires implementation of an Environmental Management System that is integrated into each DOE site's Integrated Safety Management System and reflects the elements and framework in the ISO 14001:2004(E) standard (ISO 14001). Elements of ISO 14001 include a defined environmental policy; planning, including environmental aspects, legal and other environmental requirements, and environmental objectives, targets, and programs; implementation and operations, including resources, roles, responsibility and authority, competence, training and awareness, communication, documentation, document control, operational control, and emergency preparedness and response; checking, including monitoring and measuring, evaluation of compliance, nonconformity, corrective and preventative action, records control, and internal audit; and management review.

DOE Order 450.1A further states that each Environmental Management System must include policies, procedures, and training to identify operations and activities with significant environmental impacts; to manage, control, and mitigate impacts; and to assess performance, implement corrective actions where needed, and to assure continual environmental improvement. In addition, the Environmental Management System must address sustainable practices for enhancing environmental, energy, and transportation performance required by Executive Order 13423, "Strengthening Federal

Environmental, Energy and Transportation Management" (72 FR 3919) and DOE Order 430.2B, "Departmental Energy, Renewable Energy and Transportation Management"; protection of public health and the environment; wildland fire protection; natural and cultural resource protection and stewardship; effluent and environmental monitoring; quality of analytical data; assessment of engineered nanomaterials hazards; and identification of opportunities to implement additional sustainable practices (see Section 5.6.3).

Implementing an Environmental Management System provides further assurance that contractors are employing sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources potentially impacted by their operations. Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance" (74 FR 52117), builds upon the requirements of Executive Order 13423 (72 FR 3919), including the requirement to implement an Environmental Management System and includes additional obligations for federal agencies to increase efficiency energy, conserve and protect water resources, reduce greenhouse gas emissions, and implement and maintain other sustainable practices (see Section 5.6.3).

In 2009, DOE offices at the Hanford Site required several contractors to implement the requirements of DOE Order 450.1A. With the exception of Pacific Northwest National Laboratory, which established an ISO 14001-based Environmental Management System in 1996 and has maintained registration of that system since 2002, four of seven Hanford Site prime contractors implemented ISO 14001-based Environmental Management Systems in 2009. In 2010, one prime contractor awaited DOE verification that it successfully implemented its Environmental Management System, one contractor provided a proposal for implementation of an Environmental Management System, and one contractor has taken no action.

Pacific Northwest National Laboratory, operated by Battelle Memorial Institute for the DOE Office of Science's Pacific Northwest Site Office, currently has a mature, robust Environmental Management System that was established in 1996. Pacific Northwest National Laboratory has maintained ISO 14001 certification since 2002. In 2008, Pacific Northwest National Laboratory received direction from the DOE Office of Science's Pacific Northwest Site Office to implement the requirements of DOE Order 450.1A, DOE Order 430.2B, and Executive Order 13423 (72 FR 3919). Auditing has verified the Pacific Northwest National Laboratory Environmental Management System is fully integrated into its Integrated Safety Management System and meets the requirements of DOE Order 450.1A. Therefore, the DOE Office of Science's Pacific Northwest Site Office was able to declare Pacific Northwest National Laboratory in conformance with DOE Order 450.1A in June 2009. While formal contract direction was not received in 2010, Pacific Northwest National Laboratory has integrated the requirements of Executive Order 13514 (74 FR 52117) into its Environmental Management System. The 2010 Environmental Management System Scorecard developed by the DOE Office of Science's Pacific Northwest Site Office rates Pacific Northwest National Laboratory's performance as "Green" for all performance metrics, which is the highest ranking.

In June 2009, Fluor Hanford, Inc.; CH2M HILL Plateau Remediation Company; and Washington Closure Hanford, LLC received direction from the DOE Richland Operations Office to implement the requirements of DOE Order 450.1A, DOE Order 430.2B, and Executive Order 13423 (72 FR 3919). On August 24, 2009, Mission Support Alliance, LLC assumed the role of integration contractor from Fluor Hanford, Inc. and was also directed to implement the requirements of these Orders. The three contractors—Mission Support Alliance, LLC; CH2M HILL Plateau Remediation Company; and Washington Closure Hanford, LLC—were each successful in developing an ISO 14001-based Environmental Management System that was integrated into their respective Integrated Safety Management System in 2009. Auditing, along with approved corrective action plans, verified that each Environmental Management System met the requirements of DOE Order 450.1A. Each contractor notified the DOE Richland Operations Office that they were able to declare their Environmental Management System "fully implemented" and in conformance with DOE Order 450.1A. Washington Closure Hanford, LLC declared conformance in September 2009; CH2M HILL Plateau Remediation Company in November 2009; and Mission Support Alliance, LLC in December

2009. Following review and approval of these declarations, the DOE Richland Operations Office was able to declare that each Environmental Management System was in conformance with DOE Order 450.1A, ahead of their renegotiated due date of December 31, 2009. DOE Order 450.1A required Environmental Management Systems to be "fully implemented" by June 30, 2009; however, issues in awarding the Mission Support Alliance, LLC contract necessitated a renegotiated implementation date. AdvanceMed Hanford, at the direction of the DOE Richland Operations Office, also implemented an Environmental Management System in December 2009. However, in 2010, the DOE Richland Operations Office did not declare the AdvanceMed Hanford Environmental Management System to be in conformance with DOE Order 450.1A. The DOE Richland Operations Office prepared the 2010 Environmental Management System Scorecard and rated its performance as "Green" for all performance metrics, which is the highest ranking.

Washington River Protection Solutions LLC; Bechtel National, Inc.; and Advanced Technologies and Laboratories International, Inc. perform work at the Hanford Site under the direction of the DOE Office of River Protection. In October 2008, Washington River Protection Solutions LLC was directed to implement the requirements of DOE Order 450.1A, DOE Order 430.2B, and Executive Order 13423 (72 FR 3919). Washington River Protection Solutions LLC was successful in developing an ISO 14001-based Environmental Management System that was integrated into its Integrated Safety Management System. Auditing, along with an approved corrective action plan, verified the Washington River Protection Solutions LLC Environmental Management System met the requirements of DOE Order 450.1A. In August 2009, Washington River Protection Solutions LLC notified the DOE Office of River Protection that it was able to declare its Environmental Management System in conformance with DOE Order 450.1A. Following review and approval of these declarations, the DOE Office of River Protection was able to declare Washington River Protection Solutions LLC's Environmental Management System in conformance with DOE Order 450.1A in September 2009. In November 2009, Advanced Technologies and Laboratories International, Inc. was directed by the DOE Office of River Protection to implement DOE Order 450.1A; however, no action was implemented in 2010. In response to a December 2009 request, Bechtel National, Inc., submitted a detailed proposal to the DOE Office of River Protection in February 2010 for implementation of DOE Order 450.1A, DOE Order 430.2B, Executive Order 13423 (72 FR 3919), and Executive Order 13514 (74 FR 52117), including development of an Environmental Management System within 2 years of contract direction. In 2010, Bechtel National awaited direction to implement these Orders. The DOE Office of River Protection prepared the 2010 Environmental Management System Scorecard and rated its performance as "Yellow," which is the second highest ranking.

In February 2010, the DOE Richland Operations Office directed Mission Support Alliance, LLC; Washington Closure Hanford, LLC; and CH2M HILL Plateau Remediation Company to develop a proposal for implementation of Executive Order 13514 (74 FR 52117). Mission Support Alliance, LLC received limited authorization to implement Executive Order 13514 (74 FR 52117) in October 2010. Washington Closure Hanford, LLC received limited authorization to implement Executive Order 13514 (74 FR 52117) in April 2010 and received final authorization in February 2011. CH2M HILL Plateau Remediation Company did not receive authorization to implement Executive Order 13514 (74 FR 52117) in 2010. The DOE Office of River Protection directed Washington River Protection Solutions LLC in February 2010 to develop a proposal for implementation of Executive Order 13514 (74 FR 52117). Advanced Technologies and Laboratories International, Inc. did not receive direction to develop a proposal to implement Executive Order 13514 (74 FR 52117) in 2010. Washington River Protection Solutions LLC; Bechtel National, Inc.; and Advanced Technologies and Laboratories International, Inc., did not receive authorization to implement Executive Order 13514 (74 FR 52117) from the DOE Office of River Protection in 2010.

Mission Support Alliance, LLC—as the services and infrastructure contractor for the Hanford Site—developed a sustainability plan for the Hanford Site in 2010 with input from site contractors. The plan describes the energy management program; identifies planned energy efficiency, water conservation, transportation fleet management, and sustainable buildings activities; and includes an Emergency Conservation Plan, as required by DOE Order 430.2B and Executive Order 13423 (72 FR 3919). Environmental

objectives were developed in 2010, as well as updated plans for recycling and ozone-depleting substance management, and new plans for environmentally preferred procurement management and electronic asset stewardship.

Several contractors have made their environmental policy and environmental aspects available to the public through company Internet websites (Table 4.0.1). Benefits of implementing the systematic approach of an Environmental Management System as reported by Hanford Site contractors include enhanced public perception as a "good neighbor"; reduced operational costs; use of upfront planning to identify waste-disposal pathways and reduce volume; early requirements identification to avoid project delays; high level of integration with existing programs to reduce administrative burden; more efficient systems; cooperation with key stakeholders; fewer environmental violations; improvements in business practices and staff awareness; reduced water use; improvement in groundwater quality; reduction in energy needs through building removal; efficient environmental sampling; increased recycling; and more efficient waste disposal.

In 2010, the *Hanford Site Ozone-Depleting-Substance Control and Phase-Out Plan* (DOE/RL-94-86) was replaced with the *Hanford Site Ozone-Depleting Substance Program Plan* (DOE/RL-2010-86). The plan describes ozone-depleting substance management and disposal requirements at the Hanford Site as well as requirements for evaluating and considering the use of non-ozone-depleting alternatives before procuring any refrigerant material. Hanford Site officials coordinate with the U.S. Department of Defense (as required by DOE Order 450.1A) when disposing of ozone-depleting substances that are removed from refrigerant systems being decommissioned or taken out of service.

4.0.1 Environmental Performance Measures

Mission Support Alliance, LLC, in consultation with other Hanford Site prime contractors, developed environmental performance measures for the Hanford Site in 2010. Performance measures address the goals of DOE Order 450.1A, DOE Order 430.2B, Executive Order 13423 (72 FR 3919), and Executive Order 13514 (74 FR 52117). The measures developed in response to these Executive Orders and DOE Orders include regulated waste reduction; toxic and hazardous material reduction; sustainable acquisition; compliance with Electronic Product Environmental Assessment Tool standards; sanitary waste diversion; construction waste diversion; electricity use; facility fuel use; water use; vehicle fuel use; numbers of alternative fuel vehicles; on-time environmental deliverables; environmental inspections; and environmental non-compliances. Baseline data were obtained in accordance with guidance in the Orders. Where no guidance was available, data from 2009 or 2010 were used to establish performance baselines. Performance measurement data are used as a tool to assure environmental goals within the DOE Orders are appropriately managed.

Through fiscal year 2010, the number and percentage of alternative fuel vehicles in inventory at the Hanford Site has increased annually (Figure 4.0.1). Requirements specified in Executive Order 13514 (74 FR 52117) include the acquisition of such vehicles, optimizing their numbers within the onsite fleet. Low greenhouse gas-emitting vehicles, including alternative fuel vehicles, are associated with alternative fuel usage.

Table 4.0.1. Hanford Site Contractor Environmental Management System Internet Links

Contractor	Website	Category
CH2M HILL Plateau Remediation Company	https://www.plateauremediation.hanford.gov/index.php/page/154/	Policy
Mission Support Alliance, LLC	http://msa.hanford.gov/msa/filedisplay.cfm?fileid=1158	Policy, Aspects
Pacific Northwest National Laboratory	http://www.pnl.gov/about/environmental.asp	Policy
	http://www.pnl.gov/ems/env_impacts.asp	Aspects
Washington Closure Hanford, LLC	http://www.washingtonclosure.com/about_us/environmental_stewardship	Policy, Aspects
Washington River Protection Solutions LLC	http://www.wrpstoc.com/what_we_do/environmental_management	Policy, Aspects

The alternative fuel use target was surpassed for fiscal year 2010; however, petroleum-based fuel use did not meet its target (Figure 4.0.2). The requirement specifies the Hanford Site contractors' entire fleet operate alternative fuel vehicles exclusively on alternative fuels to the maximum extent possible to reduce the amount of petroleum-based fuels by 2% annually through to fiscal year 2020, relative to a fiscal year 2005 baseline (Executive Order 13514 [74 FR 52117]).

The target objective for potable water was met in 2010 (Figure 4.0.3). Water use requirements, as specified by Executive Order 13514 (74 FR 52117), stipulate the reduction

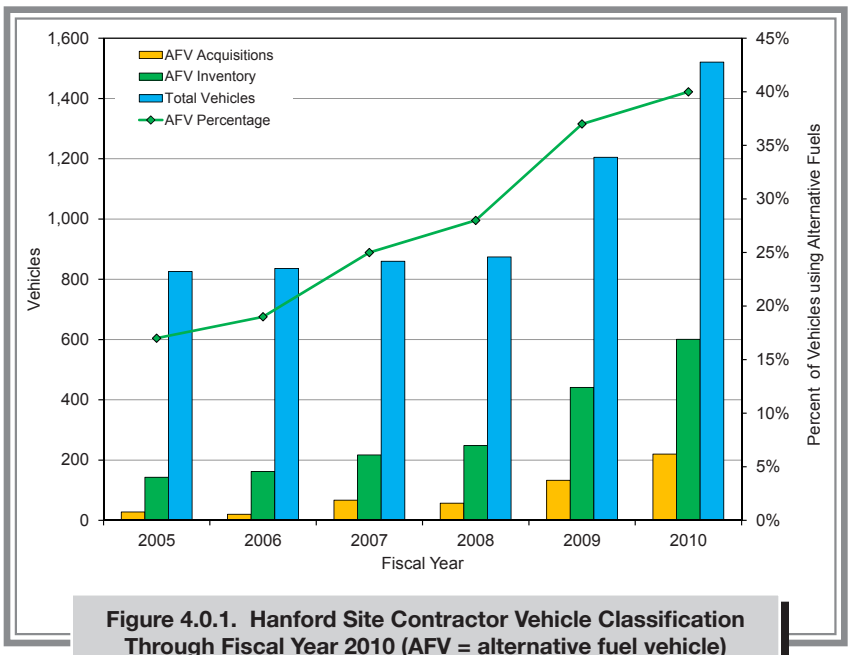

Figure 4.0.1. Hanford Site Contractor Vehicle Classification Through Fiscal Year 2010 (AFV = alternative fuel vehicle)

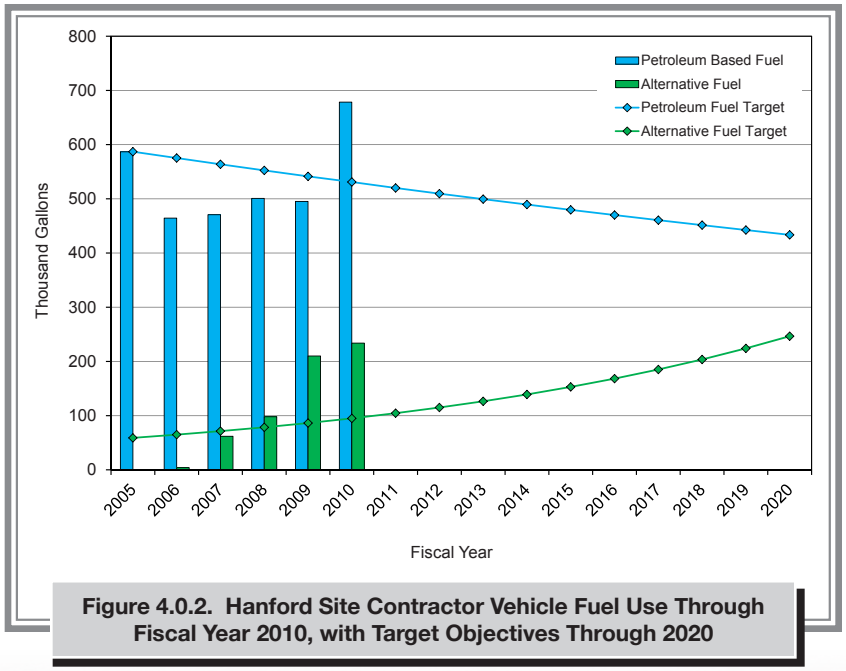

Figure 4.0.2. Hanford Site Contractor Vehicle Fuel Use Through Fiscal Year 2010, with Target Objectives Through 2020

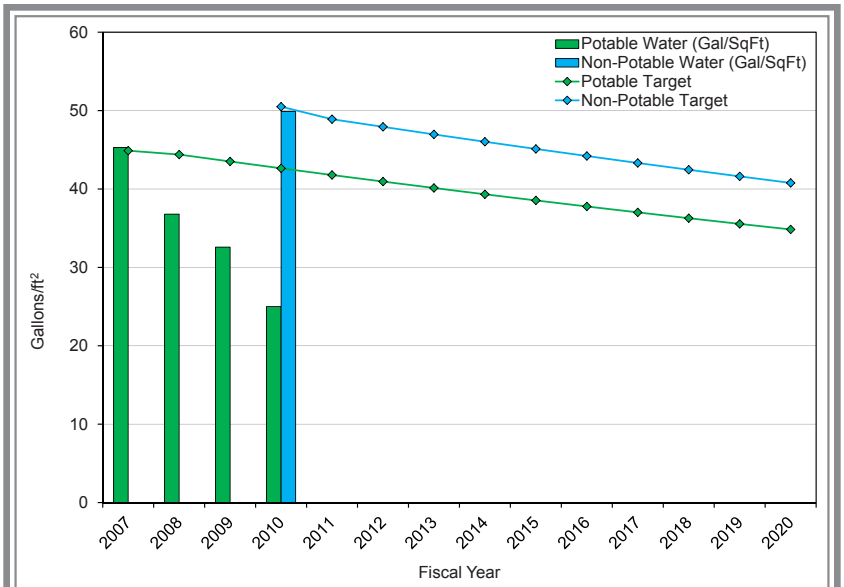

Figure 4.0.3. Hanford Site Contractor Water Use Through Fiscal Year 2010, with Target Objectives Through 2020

of potable water consumption intensity by 2% annually through fiscal year 2020, or 26% by the end of fiscal year 2020, relative to a baseline of water consumption in fiscal year 2007. Correspondingly, there is a requirement to reduce non-potable water use by 2% annually through the end of fiscal year 2020, or 20% by the end of fiscal year 2020, relative to a fiscal year 2010 baseline.

The target objectives for both electricity and green electricity were met in fiscal year 2010 (Figure 4.0.4). Targets and objectives for electricity use designate improvements to increase energy efficiency and energy management. Requirements call for the reduction of standard electricity use by 3% annually, or 45% through the end of fiscal year 2020, relative to the fiscal year 2003 baseline, and an increase in renewable energy consumption (green electricity) equivalent to 7.5% of the annual electricity and thermal consumption total by fiscal year 2010.

The target objectives for Hanford Site facility fuel use were met in 2010 (Figure 4.0.5). Objectives were established to demonstrate improvements in energy efficiency and effective management of energy use while increasing the use of clean energy sources. The target requirements include reducing energy use by 3% annually (or 45% through the end of fiscal year 2020) relative to the fiscal year 2003 baseline.

In fiscal year 2010, the Hanford Site exceeded the Electronic Product Environmental Assessment Tool target, with 99% of the purchases meeting the requirements (Figure 4.0.6). Executive Order 13514 (74 FR 52117) specifies 95% of procured electronic assets (notebooks, computers and monitors) must comply with the Electronic Product Environmental Assessment Tool standard in an effort to reduce or eliminate the environmental impacts of electronic assets by incorporating electronic stewardship practices.

In 2010, Hanford Site target objectives were met for chlorine reduction; however, the herbicide target was exceeded by over 18% (Figure 4.0.7). A 5% annual reduction target was established for herbicides and chlorine, using fiscal year 2007 values as baselines. Executive Order 13514 (74 FR 52117) stipulates the elimination or minimization of the acquisition, use, and associated release of toxic and hazardous chemicals and materials, including hazardous substances, ozone-depleting substances, and other pollutants.

Reduction of regulated sanitary wastes requires the diversion of post-consumer materials suitable for reuse and recycling from landfills by 10% per year, based on a fiscal year 2010 baseline (Figure 4.0.8).

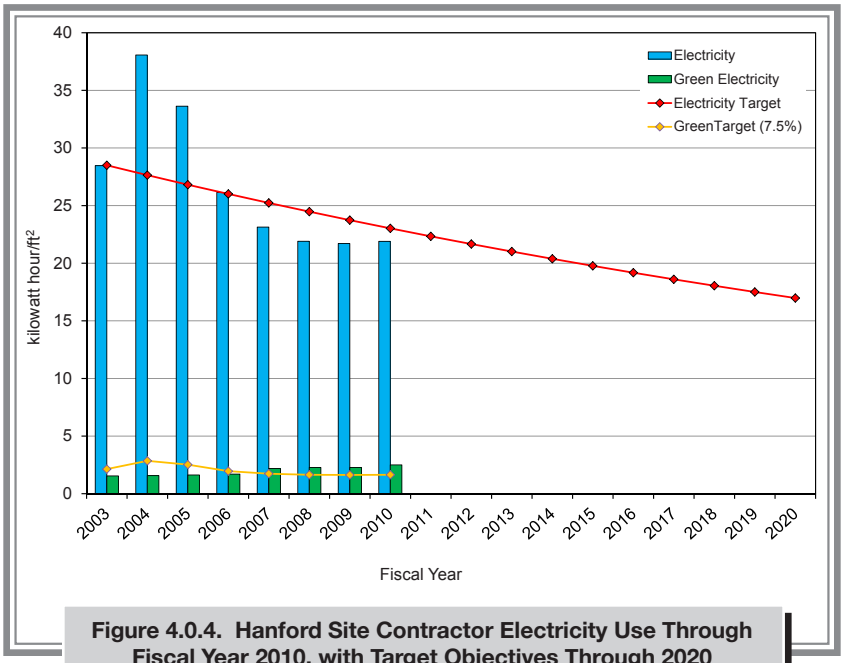

Figure 4.0.4. Hanford Site Contractor Electricity Use Through Fiscal Year 2010, with Target Objectives Through 2020

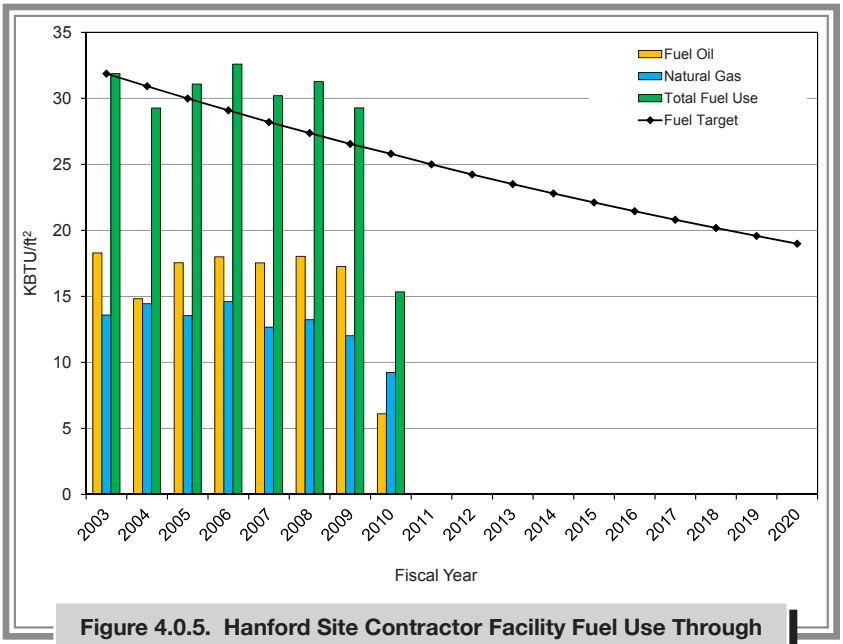

Figure 4.0.5. Hanford Site Contractor Facility Fuel Use Through Fiscal Year 2010, with Target Objectives Through 2020 (KBTU = one thousand British thermal units)

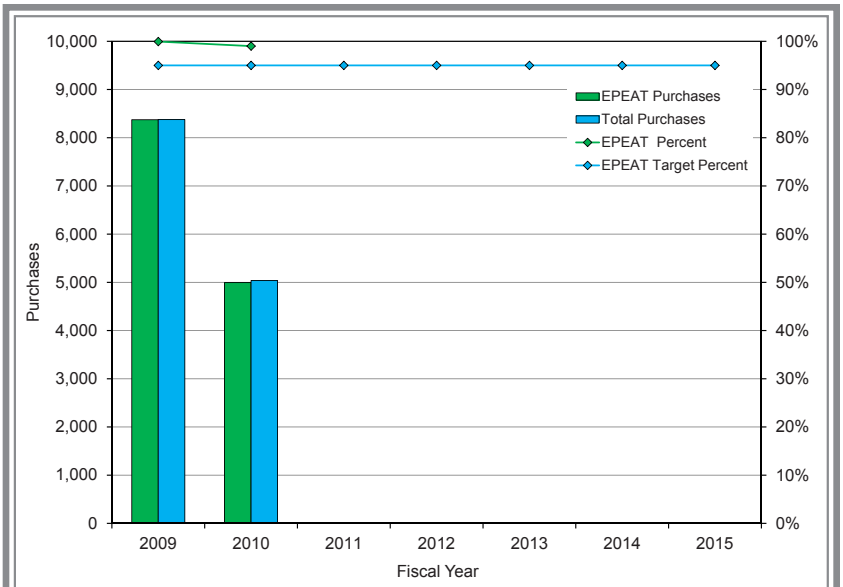

Figure 4.0.6. Hanford Site Contractor Compliance with Electronic Product Environmental Assessment Tool Standards Through Fiscal Year 2010, with Target Objectives Through 2015

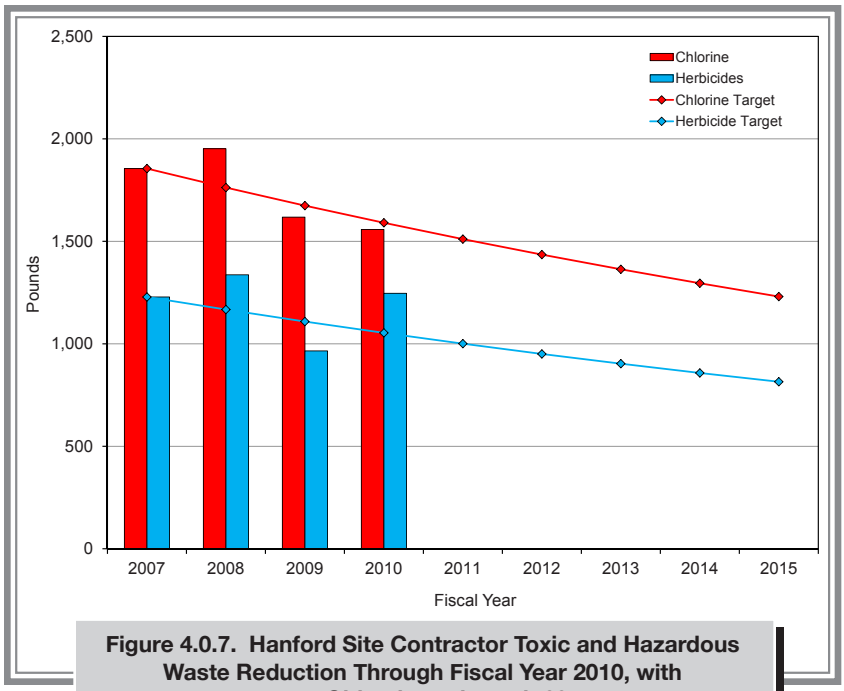

Figure 4.0.7. Hanford Site Contractor Toxic and Hazardous Waste Reduction Through Fiscal Year 2010, with Target Objectives Through 2015

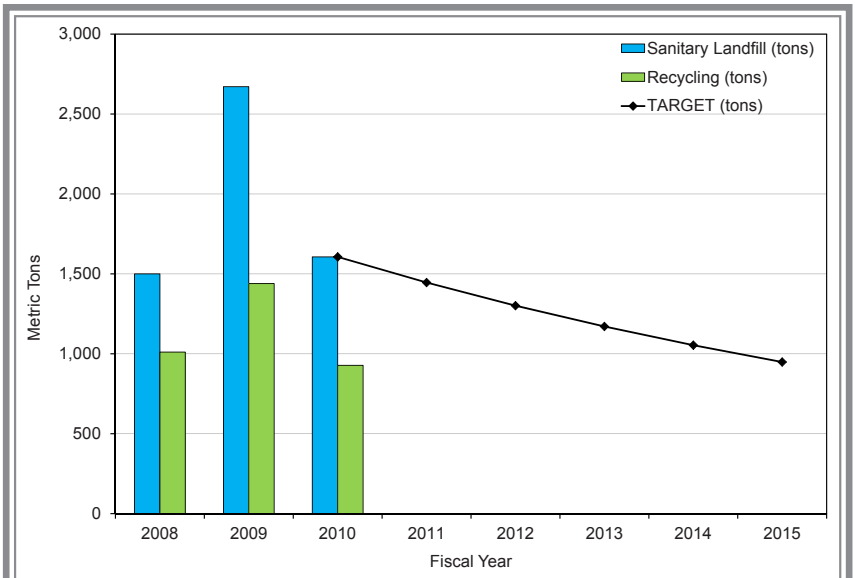

Figure 4.0.8. Sanitary Waste Reduction at the Hanford Site, 2008 to 2010, and Target Objectives Through 2015

The regulated waste reduction target was not met in 2010, as non-cleanup waste (waste produced from environmental restoration activities including wastes associated with retrieval and remediation operations, legacy wastes, and wastes from decontamination and decommissioning operations, as well as *Toxic Substances Control Act* regulated wastes), were nearly 200% greater than the target value (Figure 4.0.9). Objectives for regulated waste reduction on the Hanford Site include the elimination or minimization of waste generation 5% annually (based on fiscal year 2009 generation) through source reduction including segregation, substitution, and reuse that would otherwise require storage, treatment, and long-term monitoring and surveillance. Regulated wastes include wastes—such as hazardous, universal, special, state-regulated industrial, and radioactive wastes—not suitable for disposal in sanitary or construction and demolition landfills. Regulated wastes from the Environmental Restoration Disposal Facility are not included in Figure 4.0.9. Wastes to this facility increased considerably in 2010 as a result of Hanford Site remediation activities (Figure 4.0.10).

In addition to these metrics, individual contractors have established company-specific performance measures within their Environmental Management Systems.

4.0.2 Awards and Recognition

The Hanford Site received a U.S. Environmental Protection Agency Federal Electronic Challenge Bronze Award in 2010 for its efforts in achieving compliance with Electronic Product Environmental Assessment Tool requirements. Greater than 97% of the computers, laptops, and computer monitors purchased demonstrated Electronic Product Environmental Assessment Tool requirements.

In addition, Pacific Northwest National Laboratory received recognition and several awards for environmental stewardship in 2010, including the City of Richland's Green Project of the Year for its zero-waste picnic where 87% of the 153 kilograms (337 pounds) of waste generated was recycled, and waste generated was equivalent to less than 14.2 grams (0.5 ounce) per participant. Pacific Northwest National Laboratory also received two DOE Headquarters Star of Excellence awards for "PNNL's First Zero Waste Picnic" and "Managing Information Technology to Reduce Energy Consumption." For the latter, Pacific Northwest National Laboratory acquired Leadership in Energy and Environmental Design Gold certification for its new Biological

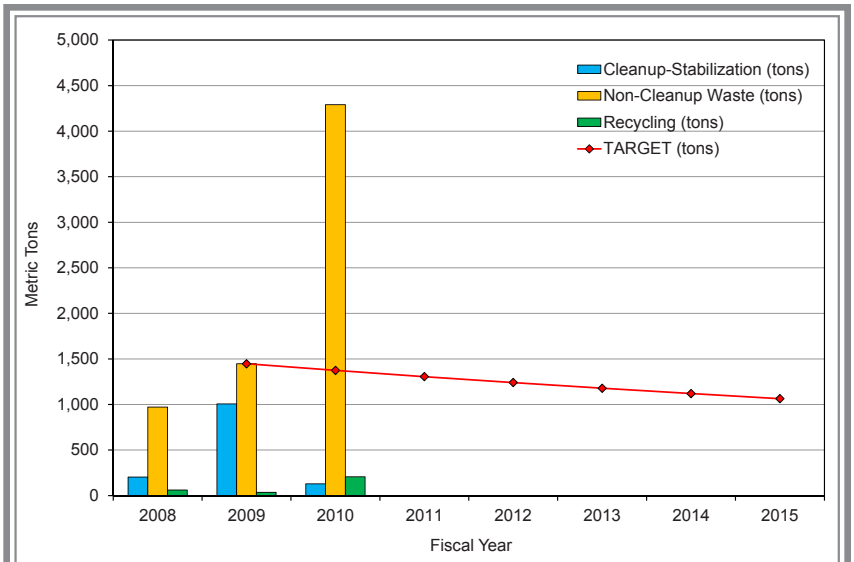

Figure 4.0.9. Hanford Site Contractor Waste Reduction Through Fiscal Year 2010, with Target Objectives Through 2015

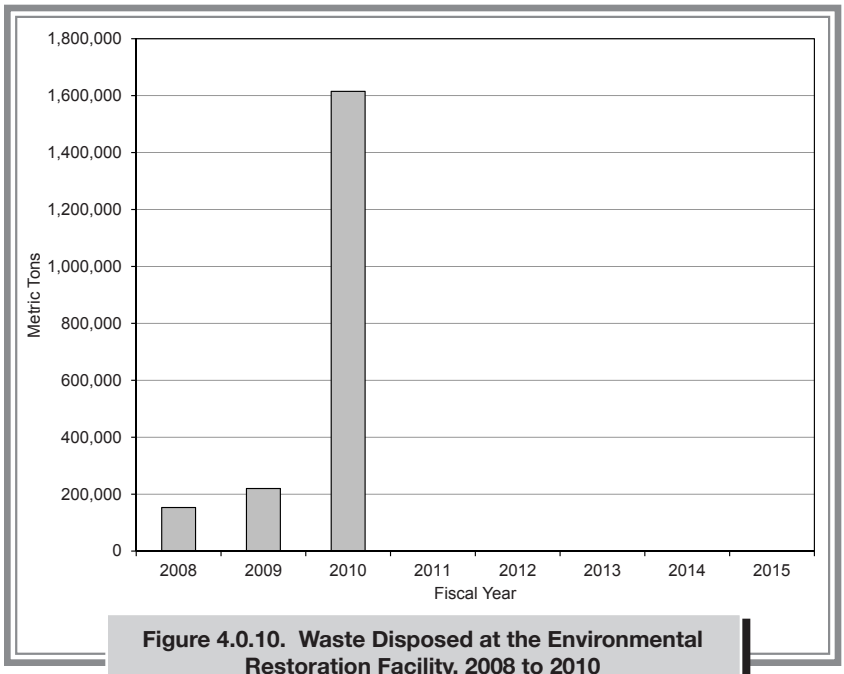

Figure 4.0.10. Waste Disposed at the Environmental Restoration Facility, 2008 to 2010

Sciences Facility and Computational Sciences Facility, reducing projected energy usage by 35%. Energy saving features within the new facility include a ground-source heat pump and reuse of heat from computer cooling. Pacific Northwest National Laboratory also received a DOE Headquarters Star of Excellence Honorable Mention for "ChemAgain, PNNL's Blue Light Special." The ChemAgain program saved an estimated $1.8 million in fiscal year 2009 by onsite chemical redistribution, reducing the need for additional purchases and/or disposal. These three projects were also submitted for DOE Office of Science awards where the ChemAgain program achieved a Best-in-Class Award. "PNNL's First Zero Waste Picnic" and "Managing Information Technology to Reduce Energy Consumption" won Best-in-Class Honorable Mentions.

In September 2010, the Hanford Tank Waste Treatment and Immobilization Plant construction site was awarded DOE Voluntary Protection Program Star status, the highest achievement level, for outstanding safety and health programs.

The Hanford Site did not receive any additional DOE or other federal agency, state agency, or industry-sponsored environmental awards or recognition in 2010. As part of their Environmental Management System, several Hanford Site contractors have developed internal environmental awards programs to recognize leadership in environmental, energy, and transportation stewardship.

4.0.3 References

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74 FR 52117. October 5, 2009. Executive Order 13514. "Federal Leadership in Environmental, Energy, and Economic Performance." *Federal Register*, Office of the President.

DOE Order 430.2B. 2008. "Departmental Energy, Renewable Energy and Transportation Management." U.S. Department of Energy, Washington, D.C.

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

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

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

DOE/RL-94-86. 1994. *Ozone-Depleting-Substance Control and Phase-Out Plan*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2010-86. 2010. *Hanford Site Ozone-Depleting Substance Program Plan*. U.S. Department of Energy, Richland Operations Office, Richland, Washington.

ISO 14001:2004(E). 2004. *Environmental management systems – Requirements with guidance for use*. International Organization for Standardization, Geneva, Switzerland.

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

5.0 Compliance Summary

JP 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 and Executive 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. Additionally, DOE Order 231.1A, Chg. 1, "Environment, Safety and Health Reporting" includes the requirement for reporting annual compliance status with environmental standards and requirements, which this site environmental report describes.

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

5.1 Statutes Related to Environmental Restoration and Waste Management

This section provides compliance information regarding federal environmental statutes and regulations related to hazardous materials and waste management at the Hanford Site.

5.1.1 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

JW Cammann

The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) was promulgated to address response, compensation, and liability for past releases or potential releases of hazardous substances, pollutants, and contaminants to the environment. CERCLA was amended by the *Superfund Amendments and Reauthorization Act of 1986* (Section 5.1.2), which made several important changes and additions, including clarification that federal facilities are subject to the same provisions of CERCLA as any non-governmental entity. The EPA maintains the "National Priorities List for Uncontrolled Hazardous Waste Sites" (59 FR 43314) of the uncontrolled hazardous substance releases in the United States that are priorities for long-term evaluation and response actions. Federal facilities identified on the EPA's National Priorities List (59 FR 43314) must enter into an interagency agreement with EPA to remediate the sites. At the Hanford Site, this interagency agreement is better known as the *Hanford Federal Facilities Agreement and Consent Order* (i.e., Tri-Party Agreement [Ecology et al. 1989]). Under CERCLA, two kinds of response actions are authorized: 1) short-term removal actions to address releases or threatened releases requiring prompt response; and 2) long-term remedial actions that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening.

EPA is responsible for oversight of DOE's implementation of CERCLA regulations. The Hanford Site was divided into four aggregate areas when it was placed on EPA's National Priorities List (59 FR 43314) on November 3, 1989, pursuant to CERCLA. The four aggregate areas include the 100 Areas, 200 Areas (i.e., Central Plateau), 300 Area, and 1100 Area of the Hanford Site. DOE and its contractors have made considerable progress in cleaning up the Hanford Site. This cleanup progress has led to the removal of portions of the 100 Areas from the EPA's National Priorities List (59 FR 43314) including the Wahluke Slope north of the Columbia River and the entire 1100 Area.

There can be significant overlap between the CERCLA response action program and the *Resource Conservation and Recovery Act of 1976* (RCRA) corrective action program (Section 5.1.3). Many waste management units on the Hanford Site could potentially be subject to cleanup under both programs. The CERCLA response action program is implemented through 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," which establishes procedures for characterization, evaluation, and remediation of waste sites. The Tri-Party Agreement (Ecology et al. 1989) addresses implementation of both CERCLA response actions and RCRA corrective actions on the Hanford Site through administrative application of either program while meeting the technical requirements of both.

Executive Order 12580, "Superfund Implementation" (52 FR 2923) directs that DOE, as the lead agency, must conduct CERCLA response actions (i.e., removal and

remedial actions) on the Hanford Site. The CERCLA regulatory framework for both removal and remedial actions consists of five general activities that include the following: 1) investigation, 2) evaluation, 3) decision, 4) implementation, and 5) closeout.

For remedial actions during the investigation phase, the lead agency conducts a preliminary assessment and site inspection following the discovery of a release or the threat of release to the environment. Upon determination that the site of the release meets the criteria for inclusion on the EPA's National Priorities List (59 FR 43314), the lead agency conducts more detailed site characterization in accordance with the data quality objectives process; a remedial investigation/feasibility study work plan; sampling and analysis plan; field work plan; and quality assurance plan. The evaluation phase includes development of alternatives to eliminate the release or threat of release. The lead agency then considers the results of site characterization as documented in remedial investigation reports used to support feasibility studies of candidate remedial technologies. During the decision phase, the lead agency documents implementation of the preferred alternative, obtains regulatory approval, and seeks public involvement through issuance of a proposed plan that is made available for public review and a record of decision that defines the action(s) that will be taken to mitigate the threat to human health and the environment caused by the release of hazardous substances. During the implementation phase, the lead agency executes the preferred alternative including the preparation of a remedial design and remedial-action work plan, remedial design report, air monitoring plan, waste management plan, mitigation action plan, and operations and maintenance plan. Finally, during the closeout phase, the lead agency issues a remedial site verification package that documents remedial-action goals, objectives, and applicable or relevant and appropriate requirements are achieved in accordance with the record of decision.

There are three types of removal actions under CERCLA: 1) emergency, 2) time-critical, and 3) non-time-critical. Emergency removals must be initiated within hours or days in response to acute problems and may involve fires, explosions, imminent contamination of water supplies, or the release or imminent release of hazardous substances. Time-critical removals are conducted in response to releases requiring onsite action within 6 months (e.g., removal of drums or small volumes of contaminated soil). Non-time-critical removals are conducted in response to releases where a planning period of at least 6 months is available before onsite activities must begin and the need is less immediate. The majority of removal actions on the Hanford Site are conducted as non-time-critical.

Non-time-critical removal actions usually remove or reduce the threat caused by a release of a hazardous substance such that no further action is necessary to be protective of human health and the environment. When a removal action is unsuccessful in reaching a protective situation, it may be followed by a remedial action to complete the site response. Non-time-critical removal actions can provide substantial risk reduction by addressing specific problems without requiring the more time consuming remedial investigation/feasibility study process associated with CERCLA remedial actions.

As with remedial actions, non-time-critical removal actions include activities involving investigation, evaluation, decision, implementation, and closeout. Upon completion of an initial evaluation to develop an understanding of the threat posed by a release, the lead agency initiates an engineering evaluation and cost analysis process. This process involves preparation of an engineering evaluation and cost analysis of removal action alternatives, conducting community relations activities, and documentation of the removal action decision in an action memorandum. The engineering evaluation and cost analysis process is comparable to the remedial investigation/feasibility study process; however, it is less comprehensive. The action memorandum is comparable to a record of decision; however, it is less elaborate. A removal action work plan is prepared to implement the decisions in the action memorandum. Closeout of the non-time-critical removal process ensures that all removal action objectives have been met and that threats to human health and the environment have been mitigated. If the removal action location is within the boundaries of a CERCLA operable unit on the National Priorities List (59 FR 43314), then the remedy selected for the removal action must be consistent with the final remedy for the entire operable unit.

CERCLA requires a status review of response actions (i.e., removal and remedial actions) for contaminated waste sites no less frequently than once every 5 years to determine whether selected actions remain protective of human health

and the environment. EPA initiated the first CERCLA 5-year review of the Hanford Site in fiscal year 2000. This 5-year review addressed all portions of the Hanford Site for which a decision document (i.e., record of decision or action memorandum) had been issued and covered areas that contain hazardous substances, pollutants, or contaminants that will be remediated under CERCLA (EPA 2001). DOE considered the first CERCLA 5-year review, issued by EPA in April 2001, as the starting point for subsequent 5-year reviews. It evaluated the performance of the response actions selected in records of decision and action memoranda, including existing institutional controls implemented to protect the public and the environment from exposure to contaminants. EPA concluded the selected response actions were protective, or would be protective upon completion of the remedial or removal actions. In conducting the second CERCLA 5-year review of the Hanford Site in 2006, DOE applied the same approach EPA used and followed EPA and DOE guidance on how to conduct 5-year reviews (DOE/RL-2006-20, Rev. 1).

DOE began planning the third CERCLA 5-year review of the Hanford Site in 2009, including initial coordination with EPA (Region 10) and the Washington State Department of Ecology. DOE will conduct the third review in cooperation with EPA and the Washington State Department of Ecology; EPA is ultimately responsible for certifying the review.

On January 6, 2010, DOE provided the Oregon Department of Energy a briefing on plans for the third CERCLA 5-year review of the Hanford Site and received comments. On March 8, 2010, DOE announced its intent to conduct the third CERCLA 5-year review starting on April 12, 2010. A CERCLA Five-Year Review Assessment and Communications Plan was completed and submitted to DOE for future incorporation into the third CERCLA 5-year review document (DOE/RL-2011-56, Draft A). A federal integrated project team that includes DOE, Hanford Site contractors, and regulatory agency participants was formed and convened several times during calendar year 2010 to facilitate the planning process.

Hanford Site contractor efforts during calendar year 2010 focused on drafting the 100 Areas source and groundwater operable unit sections for the third CERCLA 5-year review document. Future efforts will concentrate on obtaining input from Hanford Site contractors engaged in CERCLA response actions in remaining areas of the site and determining the adequacy of those actions with respect to protecting human health and the environment in accordance with response action goals, objectives, and applicable or relevant and appropriate requirements.

The scope of the third 5-year review will cover all CERCLA actions at the Hanford Site, but will not include all activities covered by the Tri-Party Agreement (Ecology et al. 1989). For example, the CERCLA 5-year review will not address RCRA treatment, storage, and disposal units (i.e., single-shell and double-shell tank farms).

The third CERCLA 5-year review will address the following:

- Evaluate the performance of the selected removal and remedial cleanup actions for source and groundwater operable units in the 100, 200, 300, and 1100 Areas, and other areas on the Hanford Site where CERCLA response actions are being performed to determine whether they are or will be protective of human health and the environment.
- Confirm that immediate threats have been addressed; or where a CERCLA response action is in progress, that the selected remedy, when complete, will be protective of human health and the environment and compliant with state and federal laws.
- Confirm for sites that are in the surveillance and maintenance phases that the selected remedy is protective and will remain protective for as long as the waste remains hazardous.
- Recommend actions to improve performance when the CERCLA 5-year review indicates that a remedy is not performing as designed.

Interactions with Native American tribes, the Hanford Natural Resource Trustees Council, Hanford Advisory Board, Oregon Hanford Cleanup Board, and other stakeholders and interested parties are being conducted to keep them informed of the status of the third CERCLA 5-year review process. The third CERCLA 5-year review report is scheduled for completion and issuance by November 6, 2011.

5.1.1.1 Hanford Site Institutional Controls Plan

R Ranade

The *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* (DOE/RL-2001-41, Rev. 4) 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 implemented under 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 these 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 Hanford Site or activities that may affect remedial action, are generally employed during remediation. After remediation is completed, the lead agency employs passive institutional controls such as permanent markers, retaining public records and archives, or sustaining regulations regarding land or resource use. Some active institutional controls, such as monitoring and controlling access to the Hanford Site, may also be employed after remediation is completed.

Several CERCLA decision documents require annual reviews of institutional controls for specific areas. Annual reviews of these institutional controls are reported by contractors in a unit manager's meeting each September. Section 4.2 of DOE/RL-2001-41, Rev. 4, requires DOE to conduct a Hanford Site-wide assessment every 5 years coinciding with the CERCLA 5-year review. This DOE assessment will be a "roll up" of annual reviews conducted by the contractors. The next site-wide institutional control review is scheduled in 2011. Minutes from the unit manager's meeting are available in the Tri-Party Agreement Administrative Record and can be accessed at the following website: http://www5.hanford.gov/arpir.

The River Corridor Project has a number of institutional controls in both interim action and final record of decision documents. Washington Closure Hanford, LLC, which manages the River Corridor Project, reported no public trespass events on Washington Closure Hanford, LLC-managed projects during 2010. Approved excavation permits were in place for all active remediation activities. Field inspection of required signage on entrances to active 100 Areas waste sites within 100-B/C, 100-D, 100-K, 100-H, 100-N, 100-IU-2, 100-IU-6, 300 North Areas, and on the entrance to the 618-10 waste site in the 300 Area were conducted. Inspections indicated that all required signage was in place except at northern and southern entrances to 100-IU-6 waste sites. The signs at northern and southern entrances to 100-IU-6 waste sites were subsequently installed. The Central Plateau Project, managed by CH2M HILL Plateau Remediation Company, also has a number of institutional controls in both interim and final record of decision documents. In September 2010, DOE, EPA, and the Washington State Department of Ecology (Tri-Party Agreement agencies) published the *Explanation of Significant Differences USDOE Hanford 1100 Area* (Ecology et al. 2010), identifying required institutional controls for the Horn Rapids Landfill.

5.1.1.2 CERCLA and Washington State Dangerous Waste/Hazardous Substance Reportable Releases to the Environment

TH Pysto

Federal regulations establish reporting requirements for certain environmental releases. As required, releases are reported to the National Response Center, the federal central point of contact for reporting hazardous substances and oil spills. Reportable releases include spills or discharges of hazardous substances 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. Washington 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. The requirement applies to spills or discharges onto the ground, into groundwater or surface water (e.g., the Columbia River), or in the air such that human health or the environment are threatened, regardless of the quantity of dangerous waste or hazardous substance.

During calendar year 2010, hazardous substance releases were conservatively assessed under WAC 173-303-145, and notifications were provided to the Washington State Department of Ecology for various minor spills. These spills were cleaned up, and materials were disposed of in accordance with applicable requirements. Washington Closure Hanford, LLC notified the Washington State Department of Ecology of a spill of approximately 1,140 liters (300 gallons) of diesel fuel from a portable generator at the 100-N Area in January 2010.

5.1.2 *Superfund Amendments and Reauthorization Act of 1986*

JW Cammann

The Superfund hazardous substance cleanup program was created by CERCLA (Section 5.1.1). It was expanded and reauthorized by the *Superfund Amendments and Reauthorization Act of 1986*.

Congress passed RCRA in 1976 to govern how hazardous wastes were to be treated, stored, and disposed of to minimize the present and future threat to human health and the environment. Although RCRA provided a "cradle to grave" approach to management of present and future hazardous waste, it did not address prior activities or abandoned waste sites. Therefore, federal, state, and local authorities did not have guidelines for addressing or cleaning up properties contaminated by hazardous substances from past practices.

On December 11, 1980, Congress enacted CERCLA to provide the means to identify responsible parties, fund the cleanup of impacted sites under the "polluter pays principle," and address the dangers of past-practice hazardous waste sites that create significant risk to human health and the environment. On October 17, 1986, the *Superfund Amendments and Reauthorization Act of 1986* was enacted, which amended and reauthorized CERCLA. The *Superfund Amendments and Reauthorization Act of 1986* reflected EPA's experience in administering the complex Superfund program during its first 6 years and made several important changes and additions to the program. Changes and additions under the *Superfund Amendments and Reauthorization Act of 1986* included the following:

- Stressed the importance of permanent remedies and innovative treatment technologies in cleaning up hazardous waste sites.
- Required Superfund actions to consider and generally comply with the standards and requirements found in other state and federal environmental laws and regulations.
- Provided new enforcement authorities and settlement tools.
- Increased state involvement in every phase of the Superfund program.
- Increased the focus on human health problems posed by hazardous waste sites.
- Encouraged greater citizen participation in decisions on how sites should be cleaned up.
- Increased the size of the cleanup trust fund to $8.5 billion.

The *Superfund Amendments and Reauthorization Act of 1986* also required EPA to revise its hazard ranking system to assure it accurately assessed the relative degree of risk to human health and the environment posed by uncontrolled hazardous waste sites that may be placed on the EPA's National Priorities List (59 FR 43314).

The *Superfund Amendments and Reauthorization Act of 1986* attempted to accelerate the cleanup of hazardous waste sites and resolve questions of jurisdiction. Section 120 of the *Superfund Amendments and Reauthorization Act of 1986* establishes a timetable and requires participation in the planning and cleanup selection process by state and local officials and the public. In cases where a federal government agency and EPA disagree on the proposed remedy at a site, EPA is to make the selection. Although subsection (g) of Section 120 prohibits the transfer of EPA's authorities to any other agency or person, Executive Order 12580, "Superfund Implementation," signed by President Reagan on January 23,

1987 (52 FR 2923), gives the Office of Management and Budget the final authority in cases where the EPA and another federal government agency disagree on the remedy selection.

In May and June 1988, EPA concurred with the U.S. Department of Defense and DOE on model language to be inserted in all federal facility cleanup agreements at Superfund sites owned by the two Departments. The model language provides for and recognizes the following: 1) EPA's authority to assess penalties in the case of non-compliance with the agreement; 2) the Departments' commitment to study and perform EPA-approved cleanup activities at the facilities; 3) EPA's commitment to review and comment on the Departments' studies and plans; 4) a mechanism for resolving disputes, with final authority resting with the EPA Administrator when staff of the Agency and the Departments cannot reach agreement on selection of the final remedy; and 5) enforceability of the agreements by states and citizens. The *Superfund Amendments and Reauthorization Act of 1986* also places restrictions on federal government property to assure that any hazardous waste sites will be cleaned up prior to sale of the property. A number of new statutory authorities, such as the *Emergency Planning and Community Right-To-Know Act of 1986* were also established by the *Superfund Amendments and Reauthorization Act of 1986* (Section 5.6.1). The *Emergency Planning and Community Right-To-Know Act of 1986*, also known as *Superfund Amendments and Reauthorization Act Title III*, establishes emergency planning and reporting requirements for industry and government; and gives communities the necessary tools for planning and responding to the potential release of hazardous waste.

In 1994, President Clinton's administration proposed a new Superfund reform bill that was seen as an improvement to existing legislation by some environmentalists and industry lobbyists. However, the effort was unable to gain bipartisan support. Until the mid-1990s, most of the Superfund program funding came from a tax on the petroleum and chemical industries, reflecting the "polluter pays principle."

Approximately 70% of Superfund program cleanup activities historically have been funded by potentially responsible parties who may eventually be held liable under CERCLA for the contamination or misuse of a particular property or resource. The only time cleanup costs are not borne by a potentially responsible party is when that party either cannot be found or is unable to pay for cleanup activities, creating an "orphan" site. For orphan sites, the Superfund program originally paid for hazardous waste cleanups through the tax on petroleum and chemical industries. The tax went to a trust fund for cleaning up abandoned or uncontrolled hazardous waste sites. However, the last full fiscal year in which the U.S. Department of the Treasury collected the tax was fiscal year 1995. This fund was exhausted by the end of fiscal year 2003. Since then, funding for the cleanup of orphan sites has been appropriated by Congress out of general revenues.

Beginning in fiscal year 2010, EPA initiated a 3-year strategy called the Integrated Cleanup Initiative. The Integrated Cleanup Initiative will identify and implement opportunities to integrate and leverage the EPA's land cleanup authorities to accelerate cleanup activities, address a greater number of contaminated sites, and put these sites back into productive use while protecting human health and the environment. The Integrated Cleanup Initiative is examining opportunities for improvements across all of EPA's land cleanup programs, including Superfund, the Brownfields Program, Federal Facilities Restoration and Reuse Office programs, RCRA programs, and the Underground Storage Tanks Program. In addition, the Integrated Cleanup Initiative will include a focus on enforcement activities that are critical to assuring that potentially responsible parties are compelled to clean up contaminated sites, thereby preserving Superfund program funds to be used to clean up other sites where potentially responsible parties do not exist.

During fiscal year 2010 and continuing through fiscal year 2012, EPA is examining a number of opportunities for improvements to land cleanup programs that support the goals of the Integrated Cleanup Initiative. By examining and identifying opportunities for improvements at all stages of the cleanup process, from assessment through cleanup completion, EPA expects to focus and in some cases accelerate the cleanup process as a whole.

5.1.3 *Resource Conservation and Recovery Act of 1976*

JF Ollero

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

5.1.3.1 Hanford Facility RCRA Permit

JF Ollero

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

5.1.3.2 RCRA/Dangerous Waste Permit and Closure Plan

JF Ollero

The Hanford Site is considered a single facility for RCRA and WAC 173-303 regulatory purposes and is comprised of 43 treatment, storage, and disposal units. The Tri-Party Agreement (Ecology et al. 1989) agencies recognized that not all of the units could be issued dangerous waste permits simultaneously, and a schedule (Tri-Party Agreement M-20 Milestones) was established to submit unit-specific permit applications and closure plans to the Washington State Department of Ecology. The last Tri-Party Agreement M-20 Milestone for the 242-CX Tank System was completed on December 22, 2008, and the Washington State Department of Ecology is in the process of preparing the draft Hanford Facility RCRA Permit, WA7890008967, Revision 9, to incorporate the 35 treatment, storage, and disposal units.

During 2010, one revision to the Hanford Facility RCRA Permit, WA7890008967 Part A Form (Ecology 1994), was submitted to the Washington State Department of Ecology. The Washington State Department of Ecology approved the revision pertaining to the 200 Areas—the 216-A-10 Crib Part A Form, which documents the clean closure of the unit. The 216-A-10 Crib Part A Form was marked closed on March 30, 2010.

5.1.3.3 RCRA Groundwater Monitoring

SP Luttrell

RCRA groundwater monitoring is conducted under the Soil and Groundwater Remediation Project (Section 10.7). In 2010, 14 RCRA treatment, storage, and disposal units were monitored to determine whether they may have contaminated groundwater with dangerous constituents. Eight sites were monitored to assess the extent of known contaminants. One site, Single-Shell Tank Farm Waste Management Area C, was included in this monitoring program during the year because contamination from the unit was confirmed in the groundwater and two sites were monitored to determine the progress of groundwater contamination cleanup activities.

Mixed Waste Trenches 31 and 34 (currently within Waste Management Area 3), and Trench 94 (currently within Waste Management Area 2) are expected to receive permits as operating RCRA treatment, storage, and disposal units in the near future. The Liquid Effluent Retention Facility is currently in the RCRA Permit, but revisions are pending permit modification or renewal. The Integrated Disposal Facility received a RCRA operating permit in June 2006 and is under a unit-specific groundwater monitoring plan, although the site has not yet received wastes and is being monitored under a Pre-Active Life Program (standby mode).

The other sites monitored under RCRA are scheduled for closure under the Hanford Facility RCRA Permit (Ecology 1994).

A summary of groundwater monitoring activities for these sites during 2010 is provided in Section 10.7. Detailed information for calendar year 2010 will be available in September 2011 with the release of *Hanford Site Groundwater Monitoring Report for 2010* (DOE/RL-2011-01).

5.1.3.4 RCRA Inspections

DL Hagel

The Washington State Department of Ecology performed 13 RCRA inspections on the Hanford Site during 2010 to assess compliance with applicable requirements. Hanford Site contractors and DOE worked to resolve all notices of violation and warning letters of non-compliance that were received from the Washington State Department of Ecology based on those inspections. These documents identified conditions that were alleged to be non-compliant with RCRA requirements. The following item summarizes the RCRA notice of violation received in 2010.

Notice of Violation Resulting from the Dangerous Waste Permit Inspection of the 242-A Evaporator. A notice of violation was received from the Washington State Department of Ecology on March 15, 2010 (Szendre 2010) based on observations made during a Dangerous Waste Permit inspection of the 242-A Evaporator facility that began operations on July 21, 2009. The evaporator facility is operated by Washington River Protection Solutions LLC.

The inspection identified three violations of the Hanford Facility RCRA Permit regarding personnel training and facility inspection recordkeeping. Two concerns were also identified that related to training documentation and excessive response time for providing requested information. Three action items were assigned to correct the violations.

The DOE Office of River Protection submitted a formal response to the Washington State Department of Ecology on April 14, 2010 (10-ESQ-125), which provided written verification that requested training and permit modifications had been completed. The March 2010 Washington State Department of Ecology notice of violation was closed out with the submittal of the Class I Permit Modifications for the quarter ending June 2010 (10-EMD-0080, Enclosure 1). The Washington State Department of Ecology provided a notice dated August 23, 2010 (Davis 2010), concurring with the revisions made to the 242-A Evaporator RCRA permit. Training deficiencies had been completed before receipt of the notice of violation.

Modifications to the 242-A Evaporator RCRA permit requires that annual fire inspections be available in the 242-A Evaporator operating record, as well as historical inspection records documenting the previous 5 years. The Hanford Site Fire Marshall coordinated record management responsibilities.

5.1.3.5 *Washington Administrative Code* Groundwater Monitoring

SP Luttrell

Groundwater monitoring was required for three regulated, non-RCRA waste facilities in 2010. The 200 Area Treated Effluent Disposal Facility and the State-Approved Land Disposal Site are monitored under state waste discharge permits (WAC 173-216). The Solid Waste Landfill is monitored for compliance with requirements in WAC 173-350, "Solid Waste Handling Standards." Wells near these facilities were monitored in 2010 for waste constituents specified in the facility permits.

Section 10.7 summarizes groundwater monitoring activities for these sites during 2010; detailed information for 2009 is available in the *Hanford Site Groundwater Monitoring and Performance Report for 2009* (DOE/RL-2010-11, Rev. 1). Information for 2010 is available in *Hanford Site Groundwater Monitoring Report for 2010* (DOE/RL-2011-01).

5.1.4 *Federal Facility Compliance Act of 1992*

JF Ollero

The *Federal Facility Compliance Act of 1992*, enacted by Congress on October 6, 1992, amends Section 6001 of RCRA to specify that the United States waives sovereign immunity from civil and administrative fines and penalties

for RCRA violations. In addition, RCRA requires EPA to conduct annual inspections of all federal facilities. Authorized states are also given authority to conduct inspections of federal facilities to enforce compliance with state hazardous waste programs.

The *Federal Facility Compliance Act of 1992* was effective upon enactment on October 6, 1992, with the exception that "departments, agencies, and instrumentalities of the executive branch of the Federal Government" would not be subject to the sovereign immunity waiver "with respect to civil, criminal, and administrative penalties and fines (as added by the amendments made by subsection (a))" until 3 years after enactment for violations of RCRA section 3004(j) "involving storage of mixed waste that is not subject to an existing agreement, permit, or administrative or judicial order, so long as such waste is managed in compliance with all other applicable requirements." This section forbids the storage of hazardous waste prohibited from land disposal unless the storage is for accumulating such quantities as necessary to facilitate proper recovery, treatment, or disposal.

After October 6, 1995, the provisions added to RCRA's existing waiver of sovereign immunity by the *Federal Facility Compliance Act of 1992* with respect "to civil, criminal, and administrative penalties and fines" shall still not apply to DOE as long as DOE is in compliance with both a plan that has been submitted and approved and an order requiring compliance with such a plan. The required plan calls for the development of treatment capacities and technologies to treat all mixed wastes at each DOE facility.

The *Federal Facility Compliance Act of 1992* further amends RCRA by imposing several new reporting requirements on DOE related to mixed waste. The Secretary of Energy must submit reports containing a national inventory of mixed wastes on a state-by-state basis, and a national inventory of mixed waste treatment capacities and technologies to the EPA administrator and the governors of states in which DOE stores or generates mixed wastes. The mixed waste inventory must describe each mixed waste type, list the amount currently stored, and estimate the amount of each type of mixed waste expected to be generated in the next 5 years at each DOE facility. Wastes not characterized by sampling and analysis also had to be described. The inventory of treatment capacities and technologies is required to contain an estimate of available treatment capacity for each waste category described in the waste inventory. DOE submitted its initial draft "Interim Mixed Waste Inventory Report: Waste Streams, Treatment Capacities and Technologies" in April 1993 (58 FR 25822). Also, the Secretary of Energy was directed to prepare and submit plans for developing treatment capacities and technologies for all facilities generating or storing mixed waste that are not subject to any permit, agreement, or order. These plans would include schedules for developing treatment capacity where treatment technologies exist and schedules for identifying and developing treatment technologies where none are currently available. These plans would be reviewed and approved either by EPA or the states, depending on whether the state is authorized to regulate mixed waste.

In 2010, these reporting requirements were met by the *Calendar Year 2009 Hanford Site Mixed Waste Land Disposal Restrictions Full Report* (DOE/RL-2010-27, Rev. 0).

5.1.5 *National Environmental Policy Act of 1969*

JW Cammann

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

An environmental assessment is prepared when it is uncertain if a proposed action would require the preparation of an environmental impact statement. A "finding of no significant impact" may be issued to present the reasons why an action will not have a significant effect on human health or the environment, and therefore will not require preparation of an environmental impact statement. Mitigated findings of no significant impact can result when a federal agency concludes its NEPA review with an environmental assessment that is based on a commitment to mitigate significant environmental impacts, so that a more detailed environmental impact statement is not required. However, federal agencies must ensure that appropriate levels of funding are

available to mitigate significant environmental impacts and monitor the effectiveness of the mitigation measures.

A mitigation action plan is prepared in accordance with NEPA regulations (10 CFR 1021.331). A mitigation action plan describes the approach for implementing commitments made in an environmental impact statement and its associated record of decision, or an environmental assessment and its mitigated finding of no significant impact, to mitigate adverse environmental impacts associated with a proposed action.

A supplement analysis is prepared in accordance with NEPA regulations (10 CFR 1021.314(c)), when it is unclear whether a supplement to an existing environmental impact statement or a new environmental impact statement is needed (40 CFR 1502.9(c)). A supplement analysis is prepared to consider new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts if significant.

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

Certain proposed actions may be categorized into classes that have already been analyzed and determined to either individually or cumulatively have no significant environmental impact (10 CFR 1021, Subpart D, Appendices A and B). Known as categorical exclusions, these actions are exempt from NEPA environmental assessment or environmental impact statement requirements if eligibility criteria such as "no extraordinary circumstances" and "not connected" are met. Some categorical exclusions are applicable to general DOE actions and do not require written documentation for application. These categorical exclusions are administrative in nature and are listed in 10 CFR 1021, Subpart D, Appendix A. Other categorical exclusions are applicable to specific DOE actions and must be documented in writing when applied. These categorical exclusions are listed in 10 CFR 1021, Subpart D, Appendix B.

Action-specific categorical exclusions listed in 10 CFR 1021, Subpart D, Appendix B must be reviewed and approved by the DOE NEPA Compliance Officer prior to their citation in meeting NEPA requirements. Some action-specific categorical exclusions at the Hanford Site have been pre-approved by the DOE NEPA Compliance Officer as site-wide categorical exclusions because they not only satisfy the criteria in 10 CFR 1021.410, but also meet conditions that are "integral elements" such as not impacting traditional cultural properties, or properties of historic, archaeological, or cultural nature and apply to routine activities (see Section 5.1.5.3). Site-wide categorical exclusions may be applied to proposed actions by individuals properly trained in NEPA determinations without further approval by the DOE NEPA Compliance Officer.

Hanford Site NEPA documents are prepared and approved in accordance with NEPA policies, regulations, and implementing procedures (i.e., 40 CFR 1500-1508; 10 CFR 1021). DOE activities conducted under CERCLA authority rely on the CERCLA process for review of proposed actions. Under the CERCLA process, DOE incorporates NEPA values including analysis of cumulative, offsite, ecological, cultural, and socioeconomic impacts to the extent practicable in work planning documents in lieu of preparing separate NEPA documentation.

To further transparency and openness in DOE's implementation of the NEPA process, a new policy was established in November 2009 with regard to the online posting of categorical exclusion determinations made by DOE NEPA Compliance Officers. Under the new policy, each program and field office is required to document and post online all categorical exclusion determinations involving classes of actions listed in 10 CFR 1021, Subpart D, Appendix B of DOE's NEPA implementing procedures that do not disclose classified, confidential, or other information that DOE would not disclose pursuant to the *Freedom of Information Act*. DOE Order 451.1B, "National Environmental Policy Act Compliance Program," has been revised to be consistent with this new policy. NEPA documentation for the Hanford Site is available at the following website: http://www.hanford.gov/page.cfm/OfficialDocuments.

5.1.5.1 Hanford Site Environmental Impact Statements

Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington **(DOE/EIS-0391)**. In February 2006, DOE announced its intent to prepare a new environmental impact statement for the Hanford Site pursuant to NEPA requirements titled, "Notice of Intent to Prepare the Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington" (71 FR 5655).

The Tank Closure and Waste Management Environmental Impact Statement (DOE/EIS-0391) analyzes the following three key areas:

- Retrieval, treatment, and disposal of waste from 149 single-shell tanks and 28 double-shell tanks and closure of the single-shell tank system
- Final decontamination and decommissioning of the Fast Flux Test Facility
- Disposal of Hanford Site waste and other DOE site low-level waste and mixed low-level waste.

A Notice of Availability for the Tank Closure and Waste Management Environmental Impact Statement (DOE/EIS-0391) was issued in the *Federal Register* on October 30, 2009 (74 FR 56194), initiating a 140-day public comment period. DOE extended the public comment period in March 2010 (75 FR 13268) for an additional 45 days for a total comment period of 185 days (longer than the required minimum of 45 days) from October 30, 2009 to May 3, 2010. Eight public hearings on the draft Tank Closure and Waste Management Environmental Impact Statement (DOE/EIS-0391) were held between January 26 and March 8, 2010, in Washington, Oregon, and Idaho. Since the draft was published, the Washington State Department of Ecology and EPA Region 10 are cooperating agencies for the Tank Closure and Waste Management Environmental Impact Statement.

Environmental Impact Statement for a Natural Gas Pipeline to the Waste Treatment Plant and 242-A Evaporator, Richland, Washington. In 2010, DOE determined that an environmental impact statement may be needed to evaluate a proposed action to construct a natural gas pipeline to the Hanford Tank Waste Treatment and Immobilization Plant and 242-A Evaporator located on the Central Plateau of the Hanford Site. DOE proposes to extend an existing natural gas pipeline that runs parallel to State Highway 395 on the east side of the Columbia River. The extension would run under the Columbia River, crossing near the 300 Area of the Hanford Site. The pipeline would run north along Route 4 South to the Central Plateau of the Hanford Site. Two lift stations (i.e., compressor stations), measuring approximately 930 square meters (10,000 square feet) each, may be required to condition the natural gas. One lift station would be located near the 300 Area and the other along Route 4 South either on or near the Central Plateau of the Hanford Site. The environmental impact statement will be prepared during 2011 and 2012 with the record of decision expected during September 2012.

5.1.5.2 Hanford Site Environmental Assessments

Environmental Assessment for Upgrades and Life Extension of the 242-A Evaporator Conducted Under the American Recovery and Reinvestment Act of 2009, Hanford Site, Richland, Washington **(DOE/EA-1682)**. On February 5, 2009, DOE determined that an environmental assessment was needed to evaluate proposed upgrades and a life extension of the 242-A Evaporator in the 200-East Area of the Hanford Site. This interim action environmental assessment was prepared to determine if the proposed upgrades to extend the life of the 242-A Evaporator would potentially cause significant adverse impacts to the environment or limit the choice of actions among the reasonable alternatives being considered in the ongoing *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (DOE/EIS-0391). The current and future mission of the 242-A Evaporator is to support environmental restoration and remediation of the Hanford Site by optimizing the 200 Areas double-shell tank waste volumes in support of the tank operations contractor and the Hanford Tank Waste Treatment and Immobilization Plant contractor.

DOE/EA-1682 provided an analysis of a no action alternative and the proposed action. The proposed action included upgrades in the leak detection system for the discharge

pipeline from the 242-A Evaporator to the Liquid Effluent Retention Facility; upgrades to flow, pressure, weight factor, and density measuring and transmitting instrumentation in the 242-A Evaporator; and upgrades to the heating, ventilation, and air conditioning system. Proposed actions and associated upgrades will support continued operation of the 242-A Evaporator through the year 2032. DOE/EA-1682 was issued with a "finding of no significant impact" on February 3, 2010.

Supplement Analysis to the *Environmental Assessment for Use of Existing Borrow Areas, Hanford Site, Richland, Washington* (DOE/EA-1403). DOE/EA-1403 included a proposal to obtain sand, gravel, and cobble materials from existing borrow pits on the Hanford Site with the potential of expanding the disturbed surface area by an additional 10%. The supplement analysis to DOE/EA-1403 will clarify ambiguity regarding the expansion of a single pit, 100-N, analyzed in the environmental assessment. Efforts during 2010 focused on the preparation of the supplement analysis, which is scheduled for issuance during 2011.

***Environmental Assessment for Closure of the Solid Waste Landfill and the Non-Radioactive Dangerous Waste Landfill* (DOE/EA-1707).** DOE proposes to close the Solid Waste Landfill and the Nonradioactive Dangerous Waste Landfill located southeast of the Central Plateau off Army Loop Road. The two facilities are adjacent to one another and ceased operations in 1996 and 1988, respectively. On May 13, 2010, DOE issued DOE/EA-1707 for a 30-day public comment period. The comment period was extended an additional 30 days to July 15, 2010. Based on public comments received, DOE decided to revise and reissue DOE/EA-1707. Additional efforts during 2010 focused on responding to public comments for the reissue draft. The Washington State Department of Ecology is a cooperating agency on the reissue draft. The schedule for issuing the revised DOE/EA-1707 is under review.

***Environmental Assessment for Integrated Vegetation Management on the Hanford Site, Richland, Washington* (DOE/EA-1728).** For decades, vegetation management on the Hanford Site has been implemented using NEPA categorical exclusions in an individual, project-specific approach. However, DOE now believes it is appropriate to evaluate the overall scope of vegetation management activities conducted on the Hanford Site assessing both individual and cumulative impacts. DOE is evaluating an integrated vegetation management approach on the Hanford Site using physical, chemical, biological, prescribed burning, and revegetation methods for the purposes of eradicating noxious weeds and invasive plants; minimizing biological uptake and transport of contaminants; promoting worker health and safety; eliminating wildfire hazards; preserving and restoring desirable plant species and wildlife habitat; and protecting natural, cultural, and ecological resources. Work during 2010 focused on preparing a draft of DOE/EA-1728 for review by the DOE integrated project team. A decision regarding a "finding of no significant impact" or the need to prepare an environmental impact statement is expected in 2011.

5.1.5.3 Hanford Site Categorical Exclusions

Categorical exclusions encompass classes of actions that do not individually or cumulatively have a significant effect on human health or the environment, and for which neither an environmental assessment nor an environmental impact statement is required. To find that a proposed action is categorically excluded, the DOE NEPA Compliance Officer must determine the following: 1) the proposed action fits within the class of actions listed in 10 CFR 1021, Subpart D, Appendix B; 2) there are no extraordinary circumstances related to the proposal that may affect the significance of the environmental effects of the proposal; 3) the proposal is not connected to other actions with potentially significant impacts, is not related to actions with cumulatively significant impacts, and is not precluded by 40 CFR 1506.1 or 10 CFR 1021.211; and 4) the proposed action meets the conditions that are integral elements of the classes of actions in 10 CFR 1021, Subpart D, Appendix B. To meet the conditions that are integral elements, a proposed action must be one that 1) does not threaten a violation of applicable statutory, regulatory, or permit requirements; 2) does not require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities; 3) does not disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that preexist such that an uncontrolled or unpermitted release would occur; and 4) does not adversely affect environmentally sensitive resources.

Copies of categorical exclusions approved in 2010 are posted on the DOE NEPA web page at: http://www.hanford.gov/page.cfm/CategoricalExclusions.

5.1.6 *Toxic Substances Control Act*

JF Ollero

Toxic Substances Control Act requirements that apply to the Hanford Site primarily involve regulation of polychlorinated biphenyls (PCBs). Federal regulations for PCB use, storage, and disposal are provided in 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." PCB wastes on the Hanford Site are stored and/or disposed of in accordance with 40 CFR 761. Some radioactive PCB waste remains in storage onsite pending the development of adequate treatment and disposal technologies and capacities. Electrical equipment that might contain PCBs is also maintained and serviced in accordance with 40 CFR 761.

During 2010, the DOE Richland Operations Office submitted both the *2009 Hanford Site Polychlorinated Biphenyl Annual Document Log* (DOE/RL-2010-61, Rev. 0) and the *2009 Hanford Site Polychlorinated Biphenyl Annual Report* (DOE/RL-2010-60, Rev. 0) to EPA as required by 40 CFR 761.180. These documents describe the PCB waste management and disposal activities occurring on the Hanford Site. The *Framework Agreement for Management of Polychlorinated Biphenyls (PBCs) in Hanford Tank Waste* (Ecology et al. 2000), signed on August 31, 2000, resulted in EPA, the Washington State Department of Ecology, and DOE and its Hanford Site contractors working together to resolve the regulatory issues associated with managing PCB waste at 1) the Hanford Tank Waste Treatment and Immobilization Plant (currently under construction); 2) the waste tank farms; and 3) affected waste management units adjacent to the waste tank farms. The 1998 PCB disposal amendments in 40 CFR 761 allow for necessary storage and the expedited disposal of PCB waste regulated under the *Toxic Substances Control Act*.

During 2010, single-shell tank waste retrieval activities continued in accordance with EPA Phase I and II risk-based disposal approvals for the use of double-shell tank PCB remediation waste in accordance with 40 CFR 761.61(c). Phase I identifies general conditions that apply to the overall strategy and retrieval process and Phase II identifies tank-specific conditions. Approvals have been received for the eight single-shell tanks classified as integrally sound.

During 2010, other risk-based disposal approvals were implemented on the Hanford Site, including continued management of K Basins sludge. The two K Basins water tower tanks previously covered under a risk-based disposal approval are now being managed under CERCLA.

5.1.7 *Federal Insecticide, Fungicide, and Rodenticide Act*

JM Rodriguez

The *Federal Insecticide, Fungicide, and Rodenticide Act* is administered by EPA. The standards administered by the Washington State Department of Agriculture to regulate implementation of the Act in the state include the *Washington Pesticide Control Act*, the *Washington Pesticide Application Act*, and rules relating to general pesticide use codified in WAC 16-228, "General Pesticide Rules." On the Hanford Site, commercial pesticides are applied by commercial pesticide operators that are listed on one of two commercial pesticide applicator licenses, and by a licensed private commercial applicator.

5.2 Radiation Protection Statutes

The Hanford Site is subject to radiation protection statutes and regulations designed to protect the health and safety of the public, workforce, and the environment.

5.2.1 *Atomic Energy Act of 1954*

WM Glines

The *Atomic Energy Act of 1954* was promulgated to assure the proper management of radioactive materials. The Act and its amendments include provisions to delegate the roles and responsibilities for the control of radioactive materials and nuclear energy primarily to DOE, the U.S. Nuclear Regulatory Commission, and EPA. Through 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 establish 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, Chg 1 [Section 5.2.3] and DOE Order 5400.5, Chg 2 [Section 5.2.2]) to protect public health and the environment from potential risks associated with radioactive materials. Hanford Site operations are subject to the requirements in these regulations and directives. In 2010, the following DOE regulations or directives that potentially impact the management and control of radioactive materials were issued or underwent significant revision:

- DOE Notice 251.86, "Extension of DOE N 234.1, Reporting of Radioactive Sealed Sources"
- DOE Notice 251.93, "Cancellation of DOE G 421.1-1, DOE Good Practices Guide: Criticality Safety Good Practices Program Guide for DOE Nonreactor Nuclear Facilities"
- DOE Order 422.1, "Conduct of Operations"
- DOE Guide 423.1-1A, "Implementation Guide for Use in Developing Technical Safety Requirements"
- DOE Guide 424.1-1B, "Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements"
- DOE Order 425.1D, "Verification of Readiness to Start Up or Restart Nuclear Facilities"
- DOE Order 426.2, "Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities"
- DOE Order 460.1C, "Packaging and Transportation Safety."

Directives issued in 2010 may be accessed via the Departmental Directives Program website at https://www.directives.doe.gov/.

In addition, in 2010 the following DOE technical standards pertaining to the management and control of radioactive materials were issued or underwent significant revision:

- *Facility Representative Functional Area Qualification Standard* (DOE-STD-1151-2010)
- *Planning and Conducting Readiness Reviews* (DOE-STD-3006-2010).

Standards issued in 2010 may be accessed via the DOE Office of Health, Safety, and Security website at http://www.hss.doe.gov/nuclearsafety/ns/techstds/.

5.2.2 DOE Order 5400.5, "Radiation Protection of the Public and the Environment"

WM Glines

DOE Order 5400.5, "Radiation Protection of the Public and the Environment" was initially issued in February 1990, and underwent minor revisions in June 1990 (Change 1) and January 1993 (Change 2). The purpose of this Order is to establish standards and requirements for conduct of DOE and DOE contractor operations with respect to radiological protection of the public and the environment. This Order integrated, consolidated, and updated portions of previous DOE directives that had addressed public and environmental radiation protection standards and control practices. This Order was developed and issued consistent with DOE's policy to implement legally applicable radiation protection requirements; to consider and adopt, as appropriate, recommendations by authoritative organizations (e.g., the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection); and to adopt and implement standards generally consistent with those of the U.S. Nuclear Regulatory Commission for DOE facilities and activities not subject to U.S. Nuclear Regulatory Commission authority. Specifically, relative to guidance, standards, and regulatory requirements existing at the time of its issuance, this Order adopted applicable standards issued by the International Commission on Radiological Protection and the National Council on Radiation Protection and Measurements, incorporated regulatory requirements applicable to DOE operations, and consolidated and upgraded DOE guidance for contaminated property.

DOE Order 5400.5, Chg 2, applies to all DOE elements and contractors performing work for DOE, as provided by law and/or contract, and as implemented by the appropriate contracting officer. This Order was developed and issued under the authority of the *Atomic Energy Act of 1954*, as amended, which authorizes DOE to provide for the radiological health and safety of the public for operations conducted under DOE direction.

Relative to the radiological health and safety of the public, the objectives of DOE Order 5400.5, Chg 2, are to assure that DOE operations achieve the following:

- Radiation exposures to the public are maintained within established limits.
- Radioactive contamination is controlled through the management of real and personal property.
- Potential exposures to the public are as far below established limits as is reasonably achievable.
- DOE facilities have the capabilities, consistent with the types of operations conducted, to monitor routine and non-routine releases and to assess doses to the public.

In addition to providing radiological protection to the public, the objective of DOE Order 5400.5 is to provide radiological protection of the environment to the extent practical.

DOE Order 5400.5, Chg 2 also provides derived concentration guide values as reference values for conducting radiological environmental protection programs at operational DOE facilities and sites. These DOE-derived concentration guide values are based on a committed dose standard of 100 millirem (1 millisievert) due to ingestion, inhalation, or direct exposure during a given year, and are provided for three exposure pathways: 1) ingestion of water; 2) inhalation of air; and 3) immersion in a gaseous cloud. This Order also provides radiological protection requirements and guidelines for cleanup of residual radioactive material, management of the resulting wastes and residues, and clearance of property. These requirements and guidelines are applicable at the time the property is released.

In 2008, DOE initiated a comprehensive revision and update to DOE Order 5400.5, Chg 2; this effort continued in 2009 and 2010. A draft revision to this Order (re-numbered DOE Order 458.1) was issued for comment in October 2009, and re-issued in September 2010 for comment resolution. Following resolution of all comments, a final revision of DOE Order 5400.5, Chg 2 was issued as DOE Order 458.1 in February 2011.

5.2.3 DOE Order 435.1, "Radioactive Waste Management"

MS Collins

The purpose of DOE Order 435.1, "Radioactive Waste Management," is to establish requirements to ensure DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment. The Order takes a "cradle-to-grave" approach to managing waste and includes requirements for waste generation, storage, treatment, disposal, and post-closure monitoring of facilities.

Radioactive waste shall be managed such that the requirements of other DOE Orders, standards, and regulations are met, including the following:

- 10 CFR 835, "Occupational Radiation Protection"
- DOE Order 440.1A, "Worker Protection Management for DOE Federal and Contractor Employees"
- DOE Order 450.1A, "Environmental Protection Program"
- DOE Order 5400.5, Chg 2, "Radiation Protection of the Public and the Environment."

DOE Order 435.1 establishes requirements for the management of high-level waste, transuranic waste, and low-level waste. It also covers mixed waste (i.e., high-level waste, transuranic waste, and low-level waste that also contain chemically hazardous constituents). DOE Order 435.1 (approved in 1999) superseded a previous set of requirements (DOE Order 5820.2A, dated September 26, 1988) for managing radioactive waste. DOE Order 435.1, Chg 1, approved in 2001, includes minor revisions to the original Order.

5.3 Air Quality Statutes

TG Beam

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

5.3.1 Air Quality Regulatory Authority

The federal *Clean Air Act* was enacted to protect and enhance air quality and is the legal basis for federal, state, and local air quality regulations. The law, originally passed in 1967, 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 current federal air quality regulations. The *Washington Clean Air Act*, which parallels and supplements federal law, 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 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, Subpart H—which is part of the Federal National Emission Standards for Hazardous Air Pollutants (NESHAP)—are collectively referred to at 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 at the Hanford Site by enforcing 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 at 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 at the Hanford Site in accordance with federal requirements in 40 CFR 61, Subpart M. The Benton Clean Air Agency also regulates outdoor burning activities at the Hanford Site in accordance with state requirements in WAC 173-425.

5.3.2 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 Hanford Site Radioactive Air Emissions License #FF-01 issued by the Washington State Department of Health (2007). The #FF-01 license is a compilation of all applicable radioactive air emission requirements and is renewed every 5 years.

For each emission unit, the #FF-01 license includes either 1) an approval to modify/construct, or 2) an operating license. 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-2011-12).

As a major source of air pollutants, the Hanford Site is subject to the air operating permit requirements in 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 for both radioactive and criteria/toxic air pollutant emissions, including the Hanford Site air emissions license #FF-01 issued by the Washington State Department of Health (2007) and notice of construction approval orders issued by the Washington State Department of Ecology. Provisions in the air operating permit require that semiannual reports documenting the status of required monitoring and any identified permit deviations be submitted to the regulatory agencies (DOE/RL-2010-03, Rev. 0; DOE/RL-2011-07, Rev. 0). An annual report that documents the compliance status of Hanford Site emission sources against applicable *Clean Air Act* requirements is also required (DOE/RL-2011-08), as well as an annual report that documents total emissions of criteria and toxic pollutants at the Hanford Site (DOE/RL-2011-24, Rev. 0). The air operating permit was revised once in 2010 to incorporate new Washington State Department of Health and Washington State Department of Ecology air emission licenses, approval orders, and updated regulatory requirements. Revision F of the air operating permit was issued on December 23, 2010.

5.3.3 Inspections

The Washington State Department of Health, the Washington State Department of Ecology, and the Benton Clean Air Agency conduct regular inspections of Hanford Site emission sources to verify compliance with applicable *Clean Air Act* requirements. Hanford Site contractors and DOE actively work to resolve any potential compliance issues identified during these inspections. During 2010, the regulatory agencies conducted over 30 *Clean Air Act* inspections at the Hanford Site. Those inspections resulted in a total of two notices of violation and one notice of correction issued to the Hanford Site by regulatory agencies, as summarized below:

- Based on findings from a January 2010 inspection, the Washington State Department of Health issued a notice of violation on July 7, 2010 (AIR 10-703/RAEL FF-01), alleging a failure to comply with certain applicable radioactive air emissions sampling requirements at three tank farm emission units (296-A-43, 241-S-302, and 296-A-44) operated by Washington River Protection Solutions LLC. The DOE Office of River Protection submitted responses documenting completed corrective actions addressing issues identified in the notice of violation on August 3, 2010 (10-ESQ-240), and August 18, 2010 (10-ESQ-254). Revisions to the Washington River Protection Solutions LLC's radioactive air emissions quality assurance plan were provided to the Washington State Department of Health on March 1, 2011, which completed the corrective actions in the notice of violation.
- Based on findings from a February 2010 inspection, the Washington State Department of Health issued a notice of violation on May 24, 2010 (AIR 10-504),[(a)] alleging a failure to perform required quality assurance inspections of the monitoring system at the Canister Storage Building emission unit (296-H-212) operated by CH2M HILL Plateau Remediation Company. The DOE Richland

(a) AIR 10-504. 2010. Letter to D Brockman (U.S. DOE Office of River Protection) from J Martell (Washington State Department of Health), dated May 24, 2010, Richland, Washington.

Operations Office issued a response on August 23, 2010 (10-EMD-0089),[b] which documented completion of all necessary corrective actions in the notice of violation. The Washington State Department of Health formally closed out the inspection and associated notice of violation on January 10, 2011 (AIR 11-105).[c]

- Based on findings from a May 2010 inspection, the Washington State Department of Ecology issued a notice of correction on August 18, 2010, alleging a failure to perform required maintenance and alleging the inaccurate reporting of compliance status in annual air operating permit compliance certification reports for a permitted tank farms diesel-fueled boiler operated by Washington River Protection Solutions LLC. The DOE Office of River Protection issued responses and transmitted closure information for corrective actions in a letter dated September 29, 2010 (10-ESQ-305).

(b) 10-EMD-0089. 2010. Letter to J Martell (Washington State Department of Health) from RJ Corey (DOE Richland Operations Office), dated August 23, 2010, Richland, Washington.
(c) AIR 11-105. 2011. Letter to RJ Corey (DOE Richland Operations Office) from J Martell (Washington State Department of Health), dated January 10, 2011, Richland, Washington.

5.4 Water Quality Protection Statutes

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

5.4.1 *Clean Water Act of 1977*

CJ Clement

The *Clean Water Act of 1977*, as amended, applies to 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 NPDES permit covers two outfalls in the 100-K Area. CH2M HILL Plateau Remediation Company is the holder of this permit.

CH2M HILL Plateau Remediation Company held a NPDES Construction General Permit in early 2010 that began on June 3, 2009. This permit established the terms and conditions under which stormwater discharges associated with construction activity were authorized. CH2M HILL Plateau Remediation Company filed a notice of termination for its coverage under this permit on March 18, 2010.

State Waste Discharge Permits

The Washington State Department of Ecology has a State Wastewater Discharge Permit Program that regulates discharges to waters of the state, including groundwater. Five Washington State Department of Ecology state waste discharge permits were in effect during 2010 (ST-4500, ST-4501, ST-4502, ST-4507, and ST-4511). DOE is the holder of all the state waste discharge permits. DOE received a letter from the Washington State Department of Ecology in February 2010 stating that ST-4507 and ST-4511 will remain in effect until new permits are issued.

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

Four permit violations on the Hanford Site were reported in 2010:

- On September 2, 2010, approximately 380 to 760 liters (100 to 200 gallons) of raw water was inadvertently released to the soil within SY Tank Farm. The event was reported to the Washington State Department of Ecology under ST-4511, Permit Condition G.11.B.

- On November 3, 2010, the pH level of the 300 Area combined sewer discharge temporarily went below the pH 5 limit established in the City of Richland Industrial Wastewater Discharge Permit #CR-IU010.
- On November 10, 2010, discharge sampling for 100-N Lagoon indicated total dissolved solids was 513 mg/L, which exceeded the permit requirement of 500 mg/L. This event was reported to the Washington State Department of Ecology under ST-4507.
- On December 16 and 17, 2010, approximately 1.7 million liters (458,325 gallons) of raw water was inadvertently released to the soil in the 200-East Area. The event was reported to the Washington State Department of Ecology under ST-4511, Permit Condition G.11.B.

5.4.2 *Safe Drinking Water Act of 1974*

LM Kelly

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

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

The *Safe Drinking Water Act of 1974* was amended in 1986 and 1996 (*Safe Drinking Water Act Amendments*). While the 1986 amendments included provisions that emphasized treatment to ensure safe drinking water, the 1996 amendments focused on source water protection, funding for water system improvements, operator training, providing public information, and strengthening EPA's scientific work, including the use of risk and cost benefit analysis in establishing drinking water standards. Between 1975 and 2006, these amendments have resulted in the development of 18 new drinking water regulations. Post-1996 regulations have included more complex compliance determinations and more advanced treatment technologies. Based on site-specific conditions, many public water systems are either employing or investigating the use of new treatment technologies to comply with the increasingly complex requirements.

The Microbial and Disinfection Byproduct Rules that include nine drinking water regulations, address acute threats from microbial contamination and chronic threats from disinfectant residuals and disinfection byproducts. These rules limit disinfectant residuals and disinfection byproducts in the distribution systems while improving particle removal in the drinking water treatment plants. In 2010, affected Hanford Site water systems demonstrated compliance with the filtration and disinfection treatment technique requirements and limits for disinfectant residuals and disinfection byproducts.

On November 18, 2010, the Washington State Department of Health conducted sanitary surveys for the Group A Hanford Site water systems supplied from the Columbia River. A Group A water system in Washington State is a public water system with 15 or more connections, or serves an average of 25 people per day for 60 or more days within a calendar year (WAC 246-290-020). A sanitary survey evaluates the ability of a water system to reliably produce and distribute safe drinking water. During the survey, the Washington State Department of Health presented the 283-W Water Treatment Plant with the "Bronze Certificate of Achievement" for three continuous years of outstanding performance and drinking water treatment optimization for calendar years 2007 through 2009. No major issues or deficiencies were noted in the final sanitary survey reports.

To protect the health of workers using public water supplies on the Hanford Site, water systems were monitored during 2010 for microbiological, chemical, physical, and radiological constituents. There were no microbiological detections during the 2010 monitoring cycle, and all chemical concentrations in Hanford Site drinking water were well below the maximum contaminant levels established by EPA. System-specific information and analytical results for 2010 radiological monitoring are summarized in Section 8.6.

5.5 Statutes Related to Natural and Cultural Resources

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

5.5.1 Ecological Compliance

MR Sackschewsky

DOE policies require that all Hanford Site projects with the potential to adversely affect biological resources have an ecological compliance review conducted before the project starts. Regulators use the review to determine if the project will comply with the *Endangered Species Act of 1973*, the *Migratory Bird Treaty Act*, and the *Bald and Golden Eagle Protection Act*, as well as Executive Orders 11988 (42 FR 26951) and 11990 (42 FR 26961). The review also addresses whether other significant resources such as Washington State-listed species of concern, wetlands, and native shrub-steppe habitats are adequately considered during the project planning process. Where adverse effects are identified, mitigation actions are prescribed. Mitigation actions may include avoidance of significant resources, minimization of effects, and rectification or compensation if resources are affected.

Because many projects occur during periods of the year when plants are not growing and are difficult to identify or evaluate, each of the operational areas (200-East, 200-West, 100-K, and 300 Areas) are surveyed each spring. All habitat areas within these areas are surveyed, and each building is inspected for nests of migratory birds. These baseline visual surveys provide information about habitat types and species inventories and abundances, which can be used throughout the year to assess potential impacts to resources. These data are also used to support ecological inventory and data requirements for ecological risk evaluations. There were 389 reviews performed during 2010, including 236 ecological compliance reviews to support general Hanford Site activities, and 153 reviews for River Corridor environmental restoration activities.

5.5.1.1 *Endangered Species Act of 1973*

Several protected species of plants and animals exist on the Hanford Site and along the Hanford Reach of the Columbia River. Steelhead trout (*Oncorhynchus mykiss*) and spring-run Chinook salmon (*Oncorhynchus tshawytscha*) are listed under the *Endangered Species Act of 1973* as either threatened or endangered (50 CFR 17, Subpart B) and occur onsite. DOE has a management plan in place for these species (DOE/RL-2000-27, Rev. 0). The bull trout (*Salvelinus confluentus*) is also listed under the *Endangered Species Act of 1973* and may occasionally occur in the Hanford Reach of the Columbia River; critical habitat for bull trout was designated in the Hanford Reach in 2010 (USFWS 2010). Consultation under Section 7 of the Act was initiated in 2010 with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service regarding potential impacts of the demolition of the 100-K Area and 100-N Area intake structures to Upper Columbia River spring Chinook, steelhead, and bull trout and their critical habitat. Other species on the Hanford Site are listed by the Washington Department of Fish and Wildlife as endangered, threatened, or sensitive (see Section 8.13).

5.5.1.2 *Migratory Bird Treaty Act*

The *Migratory Bird Treaty Act* prohibits taking or disturbing specified migratory birds or their feathers, eggs, or nests. Over 100 species of birds that regularly occur on the Hanford Site are protected by the *Migratory Bird Treaty Act*. All Hanford

Site projects with a potential to affect federal or state-listed species of concern complied with the requirements of this Act by using the ecological compliance review process as described in the *Hanford Site Biological Resources Management Plan* (DOE/RL 96-32, Rev. 0). When applicable, ecological reviews produce recommendations to minimize adverse impacts to migratory birds, such as performing work outside of the nesting season and minimizing the loss of habitat.

5.5.1.3 *Bald and Golden Eagle Protection Act*

The *Bald and Golden Eagle Protection Act* provides for the protection of the bald eagle and the golden eagle by prohibiting, except under certain specified conditions, the taking, possession, or commerce of such birds. A revised *Bald Eagle Site Management Plan for the Hanford Site, South Central Washington* was published in 2009 to direct Hanford Site activities in accordance with current federal and state regulations and guidelines (DOE/RL-94-150, Rev. 1). This management plan outlines seasonal access restrictions around documented nesting and communal roosting sites at the Hanford Site between November 15 and March 15, and establishes guidelines for the protection of perches, roosts, and alternative nest sites. When applicable, ecological reviews have produced recommendations to minimize adverse impacts to bald eagles including performing work outside of the winter season; staying out of established buffer areas; or entering buffer areas at mid-day, minimizing impacts by avoiding eagle roosting periods.

In 2010, a supplement was added to the *Bald Eagle Site Management Plan for the Hanford Site* (DOE/RL-94-150, Rev. 1) to clarify allowable activities at the 100-K Area. Work supporting demolition of the 181-KW River Pump House required the acquisition of a bald eagle take permit from the U.S. Fish and Wildlife Service to cover potential disturbance to eagles using the 100-K Area night roost.

5.5.1.4 Executive Orders 11988 and 11990

Executive Order 11990, "Protection of Wetlands" (42 FR 26961), and Executive Order 11988, "Floodplain Management" (42 FR 26951), require federal agencies to minimize the loss or degradation of wetlands on federal lands, and account for floodplain management when developing water- and land-use plans, respectively. DOE implements the requirements of these two Executive Orders through 10 CFR 1022, "Compliance with Floodplain and Wetlands Environmental Review Requirements." It is DOE policy to 1) restore and preserve natural and beneficial values served by floodplains; 2) minimize the destruction, loss, or degradation of wetlands; and 3) preserve and enhance the natural and beneficial value of wetlands. At the Hanford Site, compliance with these Executive Orders, as well as the wetland provisions of the *Clean Water Act of 1977*, are implemented through the ecological compliance review process in conjunction with the appropriate site Environmental Compliance Officers. The compliance process includes the identification, protection, and when necessary, mitigation of wetlands and floodplains on the Hanford Site.

5.5.2 Cultural Resource Compliance

EP Kennedy

DOE's policy is to comply with all cultural resource-related laws and regulations (DOE Policy 141.1). On the Hanford Site, cultural resources are subject to the provisions of laws, regulations, Executive Orders, and proclamations. Laws include the *American Indian Religious Freedom Act*; *Antiquities Act of 1906*; *Archaeological and Historic Preservation Act of 1974*; *Archaeological Resources Protection Act of 1979*; *Historic Sites Act of 1935*; *National Environmental Policy Act of 1969*; *National Historic Preservation Act of 1966*; and *Native American Graves Protection and Repatriation Act of 1990*. Regulations applicable to cultural resources include the following: 36 CFR 79, "Curation of Federally-Owned and Administered Archaeological Collections"; 36 CFR 65, "National Historic Landmarks Program"; 36 CFR 60, "National Register of Historic Places"; 36 CFR 63, "Determinations of Eligibility for Inclusion in the National Register of Historic Places"; 43 CFR 10, "Native American Graves Protection and Repatriation and Regulations"; 43 CFR 7, "Protection of Archaeological Resources"; and 36 CFR 800, "Protection of Historic Properties." 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); Executive Order 13287, "Preserve America" (68 FR 10635); and Presidential Proclamation 7319, "Establishment of the Hanford Reach National Monument" (65 FR 37253).

See Section 8.15 for details regarding Hanford Site cultural resource programs.

5.6 Other Environmental Statutes

JP Duncan

The *Emergency Planning and Community Right-to-Know Act of 1986* requires federal, state, and local emergency planning authorities are informed regarding the presence and storage of hazardous substances, as well as planned or unplanned releases to the environment.

The *Pollution Prevention Act of 1990* requires that pollution be prevented or reduced at the source whenever possible, and pollution that cannot be prevented be recycled or treated in an environmentally safe manner. The Hanford Site Pollution Prevention Program was created to address these requirements.

Recent legislation has imposed additional environmental protection orders intended to promote increased environmental protection and management at federal facilities. The establishment of responsibilities, requirements, and goals with respect to improved energy efficiency, pollution prevention, and sustainable practices for energy, the environment, and transportation at DOE facilities and other federal agencies are addressed in recent DOE and Presidential Executive Orders.

Information regarding these additional statutes is presented in the following sections.

5.6.1 *Emergency Planning and Community Right-to-Know Act of 1986*

MC Ramos

The *Emergency Planning and Community Right-to-Know Act of 1986* requires each state to establish an emergency response commission and local emergency planning committees, and develop a process to distribute information on hazardous chemicals present in local facilities. These committees gather information and develop emergency plans for local planning districts. Facilities that produce, use, release, or store toxic or hazardous substances in quantities above threshold quantities must submit information regarding the chemicals to emergency planning committees to support emergency planning.

The *Emergency Planning and Community Right-to-Know Act of 1986* has four major provisions: emergency planning, emergency release notification, hazardous chemical inventory reporting, and toxic chemical release inventory reporting. Table 5.6.1 summarizes sections of the Act and their requirements.

Two annual reports are required under the *Emergency Planning and Community Right-to-Know Act of 1986*: 1) a 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) a Toxic Chemical Release Inventory, which contains information about total annual releases of certain toxic chemicals and associated waste management activities.

The *2010 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory* report (DOE/RL-2011-22, Rev. 0), was submitted 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 on March 1, 2011. Sixty-one hazardous chemicals exceeded the reporting thresholds for the Hanford Site. One chemical category (lead acid batteries, which contain sulfuric acid, an extremely hazardous substance) exceeded the reporting threshold for offsite locations (700 Area, 1100 Area, and the

Table 5.6.1. *Emergency Planning and Community Right-to-Know Act of 1986* Sections and Requirements Summary

Section	Code of Federal Regulations Section	Reporting Criteria	Due Date	Agencies Receiving Report
302	40 CFR 355: Emergency Planning Notifications	The presence of an extremely hazardous substance in quantity equal to or greater than threshold planning quantity at any one time.	Within 60 days of threshold planning quantity exceedance.	Local Emergency Planning Committee; State Emergency Response Commission
302	40 CFR 355: Emergency Planning Notifications	Change occurring at a facility that is relevant to emergency planning.	Within 30 days after the change has occurred.	Local Emergency Planning Committee
304	40 CFR 355: Emergency Release Notifications	Release of an extremely hazardous substance or a CERCLA hazardous substance in quantity equal to or greater than reportable quantity.	Initial notification: immediate (within 15 minutes of knowledge of reportable release). Written follow-up: within 14 days of the release.	Local Emergency Planning Committee; State Emergency Response Commission
311	40 CFR 370: Material Safety Data Sheet Reporting	The presence at any one time at a facility an OSHA hazardous chemical in quantity equal to or greater than 4,500 kilograms (10,000 pounds), or an extremely hazardous substance in quantity equal to or greater than threshold planning quantity or 230 kilograms (500 pounds), whichever is less.	Revised list of chemicals due within 3 months of a chemical exceeding a threshold.	Local Emergency Planning Committee; State Emergency Response Commission; Local Fire Departments
312	40 CFR 370: Tier Two Report	The presence at any one time at a facility an OSHA hazardous chemical in quantity equal to or greater than 4,500 kilograms (10,000 pounds), or an extremely hazardous substance in quantity equal to or greater than threshold planning quantity or 230 kilograms (500 pounds), whichever is less.	Annually by March 1.	Local Emergency Planning Committee; State Emergency Response Commission; Local Fire Departments
313	40 CFR 372: Toxic Release Inventory Report	Manufacture, process, or use at a facility, any listed Toxic Release Inventory chemical in excess of its threshold amount during the course of a calendar year. Thresholds are 11,300 kilograms (25,000 pounds) for manufactured or processed or 4,500 kilograms (10,000 pounds) for otherwise used except for persistent, bio-accumulative, toxic chemicals, which have thresholds of 45 kilograms (100 pounds) or less.	Annually by July 1.	EPA; State Emergency Response Commission

OSHA = Occupational Safety and Health Administration.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.

Federal Building). Table 5.6.2 lists the average quantities of the 10 hazardous chemicals stored in greatest quantity on the Hanford Site in 2010.

The *2010 Hanford Site Toxic Chemical Release Inventory* report (DOE/RL-2011-23, Rev. 0), was submitted to EPA and the Washington State Department of Ecology on June 21, 2011. Information concerning six toxic chemicals that exceeded Hanford Site reporting thresholds during calendar year 2010 is described in Table 5.6.3.

Table 5.6.4 provides an overview of reporting under the *Emergency Planning and Community Right-to-Know Act of 1986* during 2010 and early 2011.

Table 5.6.2. Average Quantity of the Ten Hazardous Chemicals[a] Stored in Greatest Quantities on the Hanford Site, 2010

Hazardous Chemical	Average Quantity, kg (lb)
Mineral oil	1,100,000 (2,420,000)
Sodium	1,070,000 (2,360,000)
Diesel fuel (Grades 1 and 2)	540,000 (1,190,000)
Petroleum distillates (unspecified)	316,000 (696,000)
Portland cement	270,000 (569,000)
Propane	211,000 (466,000)
Lead acid batteries	196,000 (432,000)
Sodium chloride	145,000 (320,000)
Gasoline	93,400 (206,000)
Fly ash (class F)	82,600 (182,000)

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

Chemical Management Systems

Hanford Site contractors have developed and documented formal systems to manage chemicals. Chemical Management Systems apply to the acquisition, use, storage, transportation, and final disposition of chemicals, including hazardous chemicals as defined in 29 CFR 1910, Subpart Z, "Occupational Safety and Health Standards." Chemical Management Systems are reviewed periodically and improvements are made as needed. In summer 2010, a site-wide *Emergency Planning and Community Right-to-Know Act of 1986* requirements implementation process was developed and approved by affected contractors. The new site-wide process will improve the efficiency and accuracy of the data submitted for *Emergency Planning and Community Right-to-Know Act of 1986* reports and notifications.

5.6.2 Pollution Prevention Program

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

Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management" (72 FR 3919), Executive Order 13514, "Federal Leadership

Table 5.6.3. Toxic Chemicals Exceeding Hanford Site Reporting Thresholds, 2010

Chemical Name	CAS No.	Main Source	Use Description
Diuron	330-54-1	Herbicides and pesticides	Control of brush and noxious weeds; radioactive contamination control (non-exempt); non-radioactive contamination control (exempt)
Lead	7439-92-1	Ammunition	Discharged during firearms range practice by Hanford Site safeguards and security programs
Naphthalene	91-20-3	Diesel	Vehicle use (exempt); non-vehicle use (non-exempt)
Propylene	115-07-1	Propane gas	Used for construction-related heating purposes
Toluene	108-88-3	Gasoline	Vehicle use (exempt); non-vehicle use (non-exempt)
Xylene	1330-20-7	Gasoline	Vehicle use (exempt); non-vehicle use (non-exempt)

Table 5.6.4. *Emergency Planning and Community Right-to-Know Act of 1986* Compliance Reporting for the Hanford Site

Section	Description of Reporting	Status	Notes
302	Emergency planning notifications	Yes	A notification regarding changes relevant to emergency planning (new Extremely Hazardous Substances present on site) was submitted on March 3, 2011.
304	Extremely hazardous substance release notification	Not required	No releases occurred.
311	Material safety data sheet	Yes	A revised listing of hazardous chemicals on site was submitted on March 3, 2011.
312	Chemical inventory	Yes	The 2009 and 2010 Tier Two Emergency and Chemical Inventory reports were submitted on February 24, 2010, and March 1, 2011, respectively.
313	Toxic release inventory	Yes	The 2009 Toxic Release Inventory report was submitted on June 24, 2010.

in Environmental, Energy, and Economic Performance" (74 FR 52117), and DOE Order 450.1A, "Environmental Protection Program" establish pollution prevention and environmental stewardship requirements. In accordance with these requirements, pollution prevention and waste minimization activities are documented, tracked, and reported. Table 5.6.5 summarizes Hanford Site pollution prevention and waste minimization activities.

5.6.2.1 Pollution Prevention and Waste Minimization Accomplishments and Awards

The Hanford Site submitted 16 Star of Excellence (E-Stars) award applications to DOE Headquarters for pollution prevention and waste minimization accomplishments. The Hanford Site won 4 of 5 "Environmental Management - Best in Class" awards and 6 of 12 honorable mention awards.

5.6.2.2 Contractor-Specific Accomplishments

Mission Support Alliance, LLC recycle/reuse and waste minimization activities included the following:

- reuse of approximately 9 metric tons (10 tons) of electronic server equipment
- reduction of Hanford Site-wide data centers' energy use by 50%
- consolidation of buildings on Rattlesnake Mountain from nine to one
- removal of 0.86 metric ton (0.95 ton) of hazardous waste from Rattlesnake Mountain
- savings of $1,000,000 with the setup and use of WiMax (Worldwide Interoperability for Microwave Access), a wireless network to provide high-speed wireless coverage for over 57% of the Hanford Site
- savings of nearly $300,000 for phone and computer connections in *American Recovery and Reinvestment Act of 2009* trailers.

CH2M HILL Plateau Remediation Company recycle/reuse and waste minimization activities included the following:

- streamlining operations, saving manpower, and reducing operational and waste-disposal costs by upgrading radiological equipment used to identify isotopes
- conserving approximately 11 million liters (3 million gallons) of water annually as a result of modifying Maintenance and Storage Facility valves and reducing compressor discharge flow
- reducing waste-disposal costs by nearly 40% by increasing dump truck load capacity, and enabling the transport of larger quantities of demolition debris per load.

Table 5.6.5. Fiscal Year 2010 Recycle Quantities

Recycled Material	Quantity, metric tons (tons)
Non-Hazardous Material	
Appliances and furniture	77 (84.9)
Ballasts	1 (1.1)
Computers and electronics	9 (9.9)
Used oil (engine, machinery)	22 (24.3)
Ferrous (iron, steel, and stainless steel)	265 (292.1)
Office and mixed paper	490 (540)
Corrugated cardboard	42 (46.3)
Non-ferrous metal (copper only)	13 (14.3)
Non-ferrous metal	26 (28.7)
Software	1 (1.1)
Plastic bottles	4.18 (4.6)
Tires	17 (18.7)
Toner cartridges	31 (34.2)
Used automobile oil	56 (61.8)
Asphalt material (held at Pit 9 for reuse)	1,814 (2,000)
Soil (uncontaminated held at Pit 9 for reuse)	179 (197)
Cured concrete (held at Pit 9 for reuse)	9 (9.9)
Hazardous Material	
Antifreeze	18 (19.8)
Batteries	6 (6.6)
Lead acid batteries	23 (25.4)
Lamps	2 (2.2)
PCB oil[(a)]	37 (40.8)
Shop towels	<1 (<1.1)

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

Washington River Protection Solutions LLC recycle/reuse and waste minimization activities included the following:

- upgrades to the 222-S Laboratory using initiatives identified in the federal *Guiding Principles for Sustainable Design* (NPS 1993)
  - installed auxiliary heating, ventilation, and air conditioning units that use R-410A, a non-ozone depleting refrigerant
  - installed energy-efficient light fixtures resulting in 23% energy reduction.
- roof upgrades to meet or exceed federal guiding principles for sustainable design, which complies with "cool roof" initiatives
- water conservation by the incorporation of xeriscape landscaping consisting of drought tolerant native plants.

Washington Closure Hanford, LLC recycle/reuse and waste minimization activities included the following:

- explosive demolition of the 337 and 337-B Buildings
  - imploded the buildings, providing safer cleanup
  - recycled and reused concrete rubble from building demolition as 300 Area groundcover
  - recycled 405 metric tons (446 tons) of salvaged metal
  - saved over $250,000 in disposal costs.

5.6.3 Latest Environmental Orders

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The Hanford Site must comply with environmental protection orders including two recent DOE Orders and two Presidential Executive Orders.

Executive Order 13423 (72 FR 3919) established a policy for federal agencies to conduct legally, environmentally, economically, and fiscally sound environmental, transportation, and energy-related activities in an integrated, efficient, continuously improving, and sustainable manner. The Order established goals for the following areas: improved energy efficiency; reduced greenhouse gas emissions; use of renewable energy sources; renewable energy generation; reduced water consumption; acquisition of goods and services; reduced use of toxic and hazardous chemicals and materials; increased waste minimization, prevention and recycling; use of sustainable building practices; reduced use of petroleum products for vehicles; and electronics stewardship. In addition, Executive Order 13423 requires that an Environmental Management System be established as the mechanism for managing environmental goals, as well as other impacts to the environment from Hanford Site operations, and establishing environmental objectives and targets. The Order also requires establishment of environmental management training, environmental compliance review and auditing, and leadership awards to recognize outstanding environmental, energy, or transportation management performance.

Executive Order 13514, "Federal Leadership in Environmental, Energy and Economic Performance" (74 FR 52117), states that federal agencies "shall increase energy efficiency; measure, report, and reduce their greenhouse gas emissions from direct and indirect activities; conserve and protect water resources through efficiency, reuse, and stormwater management; eliminate waste, recycle, and prevent pollution; leverage agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services; design, construct, maintain, and operate high performance sustainable buildings in sustainable locations; strengthen the vitality and livability of the communities in which Federal facilities are located; and inform Federal employees about and involve them in the achievement of these goals."

Executive Order 13514 requires that targets for baseline Scope 1 (generated from site operations and activities) and Scope 2 (associated with the purchase of energy [electricity, heat, or steam] used by site contractors) greenhouse gas emissions, along with 2020 reduction targets, be established. Similar numbers for Scope 3 (emissions associated with ancillary activities related to Hanford Site operations, including business travel, employee commuting, vendor activities, delivery services, etc.) emissions must also be established. Executive Order 13514 also sets goals for the following areas: improved water use efficiency and management; promotion of pollution prevention and waste elimination; advancement of regional and local integrated planning; implementation of sustainable building lifecycle management practices; advancement of sustainable acquisition; and promotion of electronics stewardship. Executive Order 13514 also requires continued implementation of a formal sustainable Environmental Management System.

DOE Order 430.2B, "Departmental Energy, Renewable Energy and Transportation Management" provides requirements and responsibilities for managing energy, buildings, and vehicle fleets at all DOE facilities, laboratories, and sites. The Order implements the requirements of Executive Orders 13423 (72 FR 3919) and 13514 (74 FR 52117) including the establishment of an Environmental Management System that includes environmental, energy, and transportation objectives and targets.

DOE Order 450.1A, "Environmental Protection Program," requires implementation of an Environmental Management System that is integrated into the Integrated Safety Management System and reflects the elements and framework found in the International Organization for Standardization's 14001:2004(E) standard, *Environmental management systems – Requirements with guidance for use*. DOE Order 450.1A states that each Environmental Management System include policies, procedures, and training to identify operations and activities with significant environmental impacts; to manage, control, and mitigate impacts; and to assess performance, implement corrective actions where needed, and to ensure continual environmental improvement. In addition, the Environmental Management System must address sustainable practices for enhancing environmental, energy, and transportation performance required by Executive Order 13423 (72 FR 3919) and DOE Order 430.2B; protecting public health and the environment; wildland fire protection; natural and cultural resource protection and stewardship; monitoring effluent and environmental data; providing quality analytical data; assessing engineered nanomaterials hazards; and identifying opportunities to implement sustainable practices.

Implementation of DOE and Executive Orders by Hanford Site contractors is addressed in Section 4.0.

Mission Support Alliance, LLC—as the services and infrastructure contractor for the Hanford Site—developed a sustainability plan for the Hanford Site in 2010 with input from site contractors. The plan describes the energy management program; identifies planned energy efficiency, water conservation, transportation fleet management, and sustainable buildings activities; and includes an Emergency Conservation Plan, as required by DOE Order 430.2B and Executive Order 13423 (72 FR 3919). Environmental objectives were developed in 2010, as were updated plans for recycling and ozone-depleting substance management, and new plans for environmentally preferred procurement management and electronic asset stewardship (Section 4.0).

5.7 Environmental Occurrences

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Releases of radioactive and regulated materials to the environment 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 each release event. This section addresses releases or potential releases to the environment that may not be documented by other reporting mechanisms. All Hanford Site occurrences are reported to the Occurrence Notification Center and subsequently recorded in the Occurrence Reporting and Processing System. This system is a DOE electronic database that tracks occurrence reports across the DOE complex (DOE Manual 231.1-2). The following sections summarize occurrences that occurred in 2010 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 2010, there were no Hanford Site environmental occurrences ranked as Operational Emergency, Recurring, or Category 1.

5.7.1 Category 2 – Moderate Impact

One Category 2 occurrence with potential moderate environmental impacts occurred in 2010. On January 10, 2010, several hundred gallons of diesel fuel spilled from a temporary generator and auxiliary fuel tank. The generator and tank were providing power to the Bio-Venting remediation operation in the 100-N Area. The auxiliary fuel tank was incorrectly connected to the generator, resulting in an estimated 1,140 liters (330 gallons) of diesel fuel being spilled on the ground. The spill was identified quickly and soil remediation (excavation) began almost immediately. Soil was placed in large waste containers and taken to an onsite landfill for proper disposal. No environmental impact is likely from this occurrence.

5.7.2 Category 3 – Minor Impact

In 2010, two Category 3 occurrences with potential environmental implications were documented: legacy contamination spread by a release of underground vapor and contaminated animal incursion.

Underground Vapor Release. In February 2010, during waste retrieval operations in the 200-West Area, a backhoe was used to groom overburden dirt from a trench to access uncovered containers. The excavator operator felt upward pressure on the bucket and when the bucket was lifted, an upward spray of dirt and organic vapor occurred. Personnel evacuated the trench and industrial hygiene samples were collected using a volatile organic meter extension probe, which measured organic vapors at 5 parts per million near the source. No radiological contamination was identified.

Animal Incursion. In October 2010, a radiation control technician identified contaminated rabbit feces on the boot of an employee during a survey near the 327 Building in the 300 Area. Subsequently, radiation control surveys were conducted to determine the extent of the contamination. Animal fences were installed and live trapping was authorized as an abatement method, as rabbits were suspected to be the cause of contamination spread. Continued radiation control surveys and decontamination methods were implemented to identify and remove the contamination.

5.7.3 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. Three Category 4 occurrences with potential environmental implications occurred on the Hanford Site in 2010 and are summarized below. Discoveries of legacy contamination are also briefly summarized.

Water Spill. On February 10, 2010, excavation activities in the 100-K Area resulted in three water lines that originated from the 1706-KE Facility being cut. The project followed an excavation design process, which had not identified any active water lines; however, these lines were part of a modification from the late 1950s that was not included in the documentation. On February 11, 2010, back flushing of water lines in the 100-K Area resulted in water flowing out of one of the severed pipes for approximately 1 hour. Surveys determined the water was not contaminated, but the spill had potential environmental impacts, as leaks from the K-East Basin are known to have contaminated vadose zone soil; any additional water flushing through the vadose zone has the potential to mobilize contamination from the soil and move it into the water column. However, the relatively short duration of water flow makes it unlikely that any contamination was mobilized as a result of this spill.

Brush Fires. Several small brush fires were reported in 2010 and occurred in July and August at various locations across the Hanford Site. Causes included lightning strikes, birds contacting an electrical transformer, and an electrical arc from a high-voltage power line. The largest of these brush fires burned 526 hectares (1,300 acres) of unoccupied range land.

Soil Contamination Discovery. In preparation for removal of B-Cell (located within Building 324 in the 300 Area), an onsite investigation identified a potentially breached stainless steel liner in the sump floor. Anticipating that a leak may have occurred, a cone penetrometer was used to collect a soil sample under the B-Cell sump. Sample results indicated the presence of radioactive material in the soil near the sump, indicating radioactive material may be migrated through the breach in the sump liner and concrete floor into the surrounding soils.

Discovery of Legacy Contamination. Each year on the Hanford Site, legacy contamination is spread as a result of environmental conditions. Some contamination is discovered during routine survey work. Biological vectors also spread contamination; tumbleweeds, rabbits, and mud daubers (wasps) are all common biological vectors. Tumbleweeds have a deep taproot that can sequester contamination from below the soil surface into the plant body on the surface. Rabbits could eat vegetation located in contaminated areas, and then deposit contaminated feces outside of the contaminated area. Mud daubers build nests from mud and occasionally use mud from contaminated areas, resulting in the transfer of contamination to uncontaminated areas. Of these three biological vectors, contaminated tumbleweeds occur most frequently and have the potential to transfer contamination the farthest distance from their original locations. High winds may contribute to the spread of legacy contamination beyond posted areas. Reports of legacy contamination discovered throughout the year are consolidated into quarterly reports. In 2010, 52 occurrences of legacy contamination were documented.

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6.0 Environmental Restoration and Waste Management

JP Duncan

Environmental cleanup and decommissioning activities continued on the Hanford Site during 2010. The following sections describe ongoing environmental restoration and mitigation, facility decommissioning activities, and waste management on the Hanford Site. Underground waste storage tank status, the construction of the Hanford Tank Waste Treatment and Immobilization Plant and its associated facilities, and research activities related to waste cleanup also are described.

6.1 Cleanup Operations

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

6.1.1 Waste Site Investigations and Remediation Activities on the Central Plateau

PA Burke

The Central Plateau is a 194-square-kilometer (75-square-mile) region near the center of the Hanford Site that includes the area designated in the *Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE/EIS-0222) and record of decision (64 FR 61615) as the Industrial-Exclusive Area, a rectangular area of about 52 square kilometers (20 square miles) in the center of the Central Plateau. The Industrial-Exclusive Area contains the 200-East and 200-West Areas, used primarily for Hanford Site's nuclear fuel processing and waste management and disposal activities. The Central Plateau also encompasses the 200 Area *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) National Priorities List site. The Central Plateau has a large physical inventory of chemical processing and support facilities, tank systems, liquid- and solid-waste disposal and storage facilities, utility systems, administrative facilities, and groundwater monitoring wells.

In July 2010, DOE issued the *Hanford Site Cleanup Completion Framework* (DOE/RL-2009-10, Rev. 0) to define the path forward for cleanup at the Hanford Site. The draft framework document defines the main components of cleanup and two main geographic areas—the River Corridor and the Central Plateau. As a result of the goals established in DOE/RL-2009-10, Rev. 0, the Washington State Department of Ecology, U.S. Department of Energy (DOE), and U.S. Environmental Protection Agency (EPA) (Tri-Party Agreement agencies) developed changes to *the Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement; Ecology et al. 1989) that reflect a path forward for Central Plateau cleanup. Tri-Party Agreement change requests were approved in October 2010 and can be viewed at the Tri-Party Agreement website: http://www.hanford.gov/c.cfm/tpa/.

The Central Plateau component of cleanup includes two principal areas:

- **Inner Area**. This area contains major nuclear fuel processing, waste management, and disposal facilities, and is defined as the final footprint area of the Hanford Site that will be dedicated to permanent waste management and containment of residual contamination. The Inner Area is anticipated to be approximately 26 square kilometers (10 square miles) or less in size and will remain under federal ownership and control for as long as potential hazards exist.
- **Outer Area**. This area is defined as areas of the Central Plateau beyond the boundary of the Inner Area. Completion of cleanup for the approximately 168-square-kilometer (65-square-mile) Outer Area will reduce the active footprint of cleanup for the Central Plateau to the Inner Area.

One of the changes proposed in the Central Plateau strategy (CHPRC-01187-FP, Rev. 0) and refined during the Tri-Party Agreement negotiation process involved restructuring the Central Plateau operable units to geographic-based operable units. Tri-Party Agreement change request C-09-07, approved in October 2010, aligned the operable unit assignments for Central Plateau waste sites to be consistent with decisions agreed to as part of the negotiations. Some existing operable units were retained, while others were absorbed into new

geographic-based operable units. The resulting operable units and the designated lead regulatory agency for each are listed in Table 6.1.1 and are discussed in subsequent sections.

6.1.1.1 Inner Area

The Inner Area (anticipated to encompass approximately 26 square kilometers [10 square miles]) is the projected final footprint region of the Hanford Site. Dedicated to waste management and residual contamination containment, it will remain under federal ownership and control as long as potential hazards exist. Operable units within the Inner Area include those described in the following paragraphs.

200-PW-1/3/6 and 200-CW-5 Operable Units. This operable unit group includes 22 soil waste sites located in the 200-East and 200-West Areas that are contaminated with plutonium from processing activities at the Plutonium Finishing Plant and the Plutonium Uranium Extraction Plant (PUREX). Specific sites are listed in Appendix C of the Tri-Party Agreement Action Plan (Ecology et al. 2010). At EPA's request, the Tri-Party Agreement agencies agreed to retain the 200-PW-1/3/6 Operable Unit group and the 200-CW-5 Operable Unit and consolidate them into a single decision.

Draft C of the feasibility study (DOE/RL-2007-27, Draft C) along with a combined proposed plan for the 200-CW-5 Operable Unit and the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units (DOE/RL-2009-117, Draft A) was submitted to DOE, EPA, and Washington State Department of Ecology in January 2011.

200-WA-1/200-BC-1 Operable Unit (200-West Inner Area). This operable unit group includes soil waste sites located in the BC Cribs and Trenches and soil waste sites in the Inner Area portion of the 200-West Area not included in the 200-SW-2, 200-CR-1, 200-PW-1/6, 200-CW-5, and 200-IS-1 Operable Units. Specific sites are listed in Appendix C of the Tri-Party Agreement Action Plan (Ecology et al. 2010). Additional sites may be added to the 200-WA-1/200-BC-1 Operable Unit as new waste sites in the geographic area are discovered or created (e.g., soil that is determined to require additional evaluation or remediation following demolition of a structure).

The 200-WA-1/200-BC-1 Operable Unit group incorporates soil waste sites from several previous operable units. A remedial investigation/feasibility study report for the 200-BC-1 Operable Unit was initiated in 2010 but deferred to a remedial investigation/feasibility study report that will combine the 200-WA-1 and 200-BC-1 Operable Units as part of the October 2010 Tri-Party Agreement change package. The 200-WA-1/200-BC-1 Operable Unit Remedial Investigation/Feasibility Study work plan was initiated in 2010 and will incorporate information from remedial investigation reports that were developed for predecessor operable units. In addition, DOE obtained approval of the *216-U-8 Crib and 216-U-12 Vadose Zone Characterization Sampling and Analysis Plan* (DOE/RL-2009-94), which supports the 200-WA-1 Operable Unit remedial investigation.

200-EA-1 Operable Unit (200-East Inner Area). The 200-EA-1 Operable Unit consolidates the remaining Inner Area sites in the 200-East Area except for the environmental media underlying tank farm waste management areas, landfills within the 200-SW-2 Operable Unit, the Plutonium Uranium Extraction Plant (PUREX), B Plant Canyon, and several waste sites with deep vadose zone contamination that are adjacent to waste management area environmental media sites. Specific sites are listed in Appendix C of the *Tri-Party Agreement Action Plan* (Ecology et al. 2010). Additional sites may be added to the 200-EA-1 Operable Unit as new waste sites in the geographic area are discovered or created (e.g., soil that is determined to require additional evaluation or remediation following demolition of a structure). The 200-EA-1 Operable Unit will also make use of a comprehensive application of the technical cleanup principles for the Inner Area developed for the 200-WA-1 Operable Unit.

The analysis for the 200-EA-1 Operable Unit will follow the same pattern as the 200-WA-1 Operable Unit and will utilize the same technical basis documents and comprehensive alternatives evaluation to clearly demonstrate how selected remedies for each fit within the framework of impacts from the entire Inner Area. *Resource Conservation and Recovery Act of 1976* (RCRA) closure plans will be developed as needed for closure of treatment, storage, and disposal units within the 200-EA-1 Operable Unit to coordinate with the decision unit activities.

Table 6.1.1. Central Plateau Operable Unit Structure

New Operable Unit Group	Description	Predecessor Operable Units		Lead Regulatory Agency
Inner Area				
200-PW-1/3/6 and 200-CW-5	Plutonium-contaminated soil sites located near the Plutonium Finishing Plant and cesium-contaminated sites near the Plutonium Uranium Extraction Plant (PUREX)	No change		EPA
200-WA-1 and 200-BC-1	Soil waste sites located in the 200-West Inner Area that are not included in the 200-SW-2, 200-CR-1, 200-PW-1/6, 200-CW-5, and 200-IS-1 Operable Units; Soil waste sites in the BC Cribs and Trenches	200-BC-1 200-LW-1/2 200-MG-1/2 200-MW-1 200-PW-2/4	200-SC-1 200-TW-1/2 200-UR-1 200-UW-1	EPA
200-EA-1	200-East Inner Area that are not included in the 200-SW-2, 200-CB-1, 200-CP-1, and 200-PW-3 Operable Units	200-CS-1 200-IS-1 200-LW-1/2 200-MG-1/2	200-MW-1 200-PW-2/4 200-SC-1 200-TW-1/2 200-UR-1	Washington State Department of Ecology
200-IS-1[(a)]	Pipelines, diversion boxes, etc., in the 200-IS-1 Operable Unit			Washington State Department of Ecology
200-SW-2	Solid waste burial grounds and waste sites in the footprint of the burial grounds	200-CW-1 200-MG-1/2	200-SW-2	Washington State Department of Ecology
200-DV-1	Selected soil waste sites in the Inner Area with deep vadose zone contamination	200-TW-1/2	200-PW-5	Washington State Department of Ecology
200-CB-1	B Plant Canyon; Associated waste sites	200-IS-1 200-MG-1/2 200-MW-1	200-PW-2/4 200-UR-1	Washington State Department of Ecology
200-CP-1	Plutonium Uranium Extraction Plant (PUREX) Canyon; Associated waste sites	200-IS-1 200-MG-1/2	200-MW-1 200-UR-1	Washington State Department of Ecology
200-CR-1	Reduction-Oxidation Plant (REDOX) Canyon; Associated waste sites	200-IS-1 200-MG-1/2	200-UR-1	EPA
Outer Area				
200-OA-1, 200-CW-1, and 200-CW-3	Sites located in the Outer Area	200-CS-1 200-CW-1 200-CW-3 200-IS-1 200-MG-1/2	200-MW-1 200-SW-2 200-UR-1 200-UW-1	EPA

(a) Some sites currently assigned to the 200-IS-1 Operable Unit may be reassigned to operable units based on their geographic location, pending the outcome of discussions among the three parties taking place in fiscal year 2011.

EPA = U.S. Environmental Protection Agency.

200-IS-1 Operable Unit. This operable unit includes inactive waste transfer pipelines and pipeline components in the 200-IS-1 Operable Unit and soil waste sites in the Inner Area portion of the 200-East area that are not included in the canyon area operable units or within tank farm waste management areas. Specific sites are listed in Appendix C of the *Tri-Party Agreement Action Plan* (Ecology et al. 2010).

In 2010, field characterization of the Gable Mountain pipeline (200-E-127 PL) was completed, and the *Hexone Storage and Treatment Facility Closure Plan* (DOE/RL-2009-112, Rev. 0) and *Sampling and Analysis Plan for the Hexone Storage and Treatment Facility Closure Plan* (DOE/RL-2009-116, Rev. 0) were submitted to the Washington State Department of Ecology.

The Tri-Party Agreement agencies agreed to utilize a coordinated CERCLA remedial action and RCRA corrective action process for cleanup decisions in the pipelines operable unit group. The *200-IS-1 Operable Unit Pipeline System Waste Sites RFI/CMS and RI/FS Work Plan* (DOE/RL-2010-114) was initiated in 2010 and will be submitted for agency review in December 2011. The 200-EA-1 Work Plan has not been initiated.

200-SW-2 Operable Unit (Burial Grounds). This operable unit group includes 24 landfills located in the 200-East and 200-West Areas. Three soil waste sites located within the boundary of one of the burial grounds were also added to the 200-SW-2 Operable Unit during restructuring. Specific sites are listed in Appendix C of the Tri-Party Agreement Action Plan (Ecology et al. 2010). Portions of the burial grounds include treatment, storage, and disposal facilities in the Hanford Site Dangerous Waste Permit. DOE is working with the Washington State Department of Ecology to remove unused areas from the permit scope.

The Tri-Party Agreement agencies agreed to utilize a coordinated CERCLA remedial action and RCRA corrective action process for cleanup decisions in the 200-SW-2 Operable Unit. Geophysical investigations of four potentially unused areas (totaling about 65 hectares [160 acres]) were investigated in 2010. A revised remedial investigation/feasibility study work plan is under development and will be transmitted to the Washington State Department of Ecology for review by December 30, 2011.

200-DV-1 Operable Unit (Deep Vadose Zone). This operable unit group includes 44 soil waste sites located in the 200-East and 200-West Areas. The sites currently in the 200-DV-1 Operable Unit were previously in the 200-TW-1/2 and 200-PW-5 Operable Units. Specific sites are listed in Appendix C of the Tri-Party Agreement Action Plan (Ecology et al. 2010). Additional sites may be transferred from other operable units if deep vadose zone contamination is present and the selected remedy is not protective of groundwater. Criteria and methods for identifying and transferring those sites will be defined in the forthcoming work plan for the 200-DV-1 Operable Unit.

Work on the 200-DV-1 Operable Unit is being closely coordinated with the ongoing RCRA Facility Investigation/Corrective Measures Study process for tank farm Waste Management Area C. Initial decisions are planned for 2015, although resolution for the more difficult issues, including tank farm closure, may span several decades. Near-term decisions will balance the need to take action based upon best available scientific and technical knowledge or deferring decisions, pending research and technology development for targeted problems. The *Long-Range Deep Vadose Zone Program Plan* (DOE/RL-2010-89, Rev. 0), issued in October 2010, summarizes the state of knowledge about contaminant cleanup challenges faced by the deep vadose zone beneath the Central Plateau and the approach to solving those challenges.

200-CB-1 Operable Unit (B Plant Canyon). This operable unit group includes the B Plant Canyon Building (221-B) and the Waste Encapsulation and Storage Facility, along with exterior ventilation system components for each of the structures (e.g., high-efficiency particulate air filters, sand filter), and 17 soil waste sites within the vicinity. Specific sites are listed in Appendix C of the Tri-Party Agreement Action Plan (Ecology et al. 2010). Additional sites may be added to the 200-CB-1 Operable Unit as new waste sites in the geographic area are discovered or created (e.g., soil that is determined to require additional evaluation or remediation following demolition of a structure). Sites near the B Plant Canyon currently assigned to the 200-IS-1 Operable Unit may be reassigned to the 200-CB-1 Operable Unit, pending the outcome of discussions among the Tri-Party Agreement agencies. Cesium and strontium capsules located in the

Waste Encapsulation and Storage Facility are not included in the scope of the 200-CB-1 Operable Unit. The work plan for B Plant Canyon was initiated in 2010.

U Plant Canyon (200-CU-1 Operable Unit). This operable unit group includes the U Plant Canyon Building (221-U) and other structures included in the 2005 record of decision for the U Plant Canyon (DOE et al. 2005). The U Plant Canyon Disposition Initiative is a pilot project for disposition of the five canyon buildings in the 200-East and 200-West Areas. Implementation of the selected remedial action (close in place – partially demolished structure) continued in 2010.

200-CP-1 Operable Unit (Plutonium Uranium Extraction Plant [PUREX] Canyon). This operable unit group includes the PUREX Canyon Building (202-A), PUREX Storage Tunnels (218-E-15 and 218-E-16), the exterior components of the ventilation system for each of the structures (e.g., deep bed filters), and 20 soil waste sites in the vicinity. Specific sites are listed in Appendix C of the Tri-Party Agreement Action Plan (Ecology et al. 2010). Additional sites may be added to the 200-CP-1 Operable Unit as new waste sites in the geographic area are discovered or created (e.g., soil that is determined to require additional evaluation or remediation following demolition of a structure). Sites near the PUREX Canyon currently assigned to the 200-IS-1 Operable Unit may be reassigned to the 200-CP-1 Operable Unit, pending the outcome of discussions among the Tri-Party Agreement agencies. Planning activities for the PUREX Canyon were initiated in 2010.

200-CR-1 Operable Unit (Reduction-Oxidation Plant [REDOX] Canyon). This operable unit group includes the REDOX Canyon Building (202-S), the exterior components of the ventilation system (e.g., filters), and 12 soil waste sites located in the vicinity. Specific sites are listed in Appendix C of the Tri-Party Agreement Action Plan (Ecology et al. 2010). Additional sites may be added to the 200-CR-1 Operable Unit as new waste sites in the geographic area are discovered or created (e.g., soil that is determined to require additional evaluation or remediation following demolition of a structure). Sites near the REDOX Canyon currently assigned to the 200-IS-1 Operable Unit may be reassigned to the 200-CR-1 Operable Unit, pending the outcome of discussions among the Tri-Party Agreement agencies. Planning activities for the REDOX Canyon were initiated in 2010.

6.1.1.2 Outer Area

The Outer Area is defined as all areas of the Central Plateau beyond the boundary of the Inner Area. The Outer Area covers approximately 168 square kilometers (65 square miles) and contains more than 90 waste sites and structures scattered throughout largely undisturbed sagebrush-steppe habitat. Most of the waste sites in the Outer Area are small near-surface sites that will be removed for treatment as needed for onsite disposal or sampled to confirm that no additional action is required, apart from implementation of appropriate institutional controls. The largest components of Outer Area remediation are ponds where cooling water and chemical sewer effluents were discharged and the BC Control Area where surface contamination was spread through animal intrusion.

In 2010, a variety of interim actions were in progress or completed, contributing to the reduction of the active cleanup footprint and supporting final cleanup decisions planned in a future Outer Area record of decision, including:

- demolition of the 212-N, 212-P, and 212-R facilities
- remediation of 212-N, 212-P, and 212-R facility-associated waste sites
- removal actions to clean up the BC Control area
- removal actions associated with the 200-MG-1 Operable Unit.

200-OA-1/200-CW-1/3 Operable Units (Outer Area). Soil waste sites in the Outer Area requiring cleanup are assigned to one of three operable units:

- 200-CW-1 Operable Unit – contains the ponds that were used for discharge of large volumes of cooling water and other effluents with low levels of contamination or that were only potentially contaminated. There are 14 sites in the 200-CW-1 Operable Unit, including 8 ponds and associated sewer lines, control structures, and unplanned releases.
- 200-CW-3 Operable Unit – contains 16 sites that were associated with operation of the 200-North Area, a small complex used initially for temporary spent nuclear fuel storage and later for storage of miscellaneous materials and rail cars. The soil waste sites (trenches, small ponds,

septic tanks, and sewer lines) were cleaned up as part of interim actions conducted from 2005 through 2010.

- 200-OA-1 Operable Unit – contains the remaining soil waste sites in the Outer Area that require cleanup under CERCLA, currently totaling 63 sites (debris and solid waste dumping areas, small liquid discharge sites, septic and sewer system components, and unplanned releases). Additional sites may be added as cleanup progresses and sites are discovered, or as existing non-CERCLA sites are reclassified.

The 200-OA-1/200-CW-1 and 200-CW-3 Operable Unit group incorporates soil waste sites from several previous operable units. Work was initiated in 2010 on the 200-OA-1/200-CW-1 and 200-CW-3 Operable Unit remedial investigation/feasibility study work plan. In addition, DOE obtained approval of the West Lake sampling and analysis plan in 2010 (DOE/RL-2009-121).

Nonradioactive Disposal Waste Landfill and Solid Waste Landfill. The Nonradioactive Disposal Waste Landfill and Solid Waste Landfill are located in the Outer Area and are not included in the operable units described above. The Nonradioactive Disposal Waste Landfill is a RCRA-permitted disposal facility for dangerous wastes generated at the Hanford Site that were not contaminated with radioactive materials. It received dangerous waste from 1975 through 1985, as well as asbestos waste through 1988 and sanitary solid waste during 1976. The Solid Waste Landfill is a non-RCRA solid waste landfill north of the Nonradioactive Disposal Waste Landfill. It received non-dangerous and non-radioactive solid waste, including paper, construction debris, asbestos, and lunchroom waste from 1973 through March 1996. It also received up to 5 million liters (1.3 million gallons) of sewage and 380,000 liters (100,000 gallons) of garage wash water.

Because the Nonradioactive Disposal Waste Landfill is a RCRA-permitted treatment storage and disposal site, closure is being managed in accordance with WAC-173-303, "Dangerous Waste Regulations." The Solid Waste Landfill is regulated under WAC 173-350, "Solid Waste Handling Standards." Evaluation of the closure actions are also being conducted in accordance with the *National Environmental Policy Act of 1969*.

6.1.2 Cleanup and Remediation Activities in the 100 Areas

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

6.1.2.1 Remediation of Waste Sites in the 100 Areas – Washington Closure Hanford, LLC

DG Saueressig

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 2010 were performed in multiple locations in the 100 Areas, including the 100-B/C, 100-D, 100-F, 100-K, 100-H, and 100-N 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; and waste disposal, backfill, and revegetation.

Waste sites vary in complexity and waste type. Typical waste sites include waste burial grounds, liquid effluent waste sites, burn pits, retired septic systems, piping systems, and miscellaneous waste sites. The primary focus early in the cleanup process was to address waste sites receiving liquid waste because those sites generally contained significant quantities of contaminants and served as potential sources for groundwater contamination.

In 2010, remediation activities focused on waste burial grounds and miscellaneous waste sites. 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 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-size 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 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 at the 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 the material does not meet the waste acceptance criteria for the facility.

During 2010, a total of 406,200 metric tons (448,000 tons) of contaminated soil from 100 Areas remediation activities were disposed at the Environmental Restoration Disposal Facility. Quantities and respective locations are as follows:

- 2.7 metric tons (3 tons) from the 100-B/C Area
- 156,100 metric tons (172,100 tons) from the 100-D Area
- 45,900 metric tons (50,600 tons) from the 100-F Area
- 13,500 metric tons (14,900 tons) from 100-H Area
- 137,700 metric tons (151,800 tons) from the 100-K Area
- 53,000 metric tons (58,500 tons) from the 100-N Area.

6.1.2.2 Remediation of Waste Sites in the 100-K Area – CH2M HILL Plateau Remediation Company

JL Hammons and DL Klages

Remediation activities in 2010 were performed in multiple locations in the 100-K Area. Activities included sampling to determine if suspected waste sites exceeded cleanup objectives, sampling to confirm that cleanup objectives had been met, physical excavation operations, waste sorting and segregation, waste treatment, and waste disposal.

Waste sites vary in complexity, waste type, and nature and extent of contamination. Typical waste sites include liquid effluent waste sites, retired septic systems, piping systems, and miscellaneous waste sites. Sampling requirements for determining if a waste site requires cleanup or is in compliance with post-cleanup goals can vary significantly from one waste site to another.

The 100-K Area waste sites are authorized for remediation activities through 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 at the 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 the material does not meet the waste acceptance criteria for the facility.

During 2010, a total of 234,000 metric tons (258,000 tons) of contaminated soil from 100-K Area remediation activities were disposed at the Environmental Restoration Disposal Facility. Seven waste sites were closed following remediation: 100-K-4, 100-K-37, 100-K-38, 116-KE-6A, 116-KE-6B, 116-KE-6C, and 116-KE-6D. In addition, 49 waste sites were confirmed to require removal, 27 waste sites began remediation activities, 5 waste sites from 2009 continued to be remediated, and 14 new waste sites were discovered.

6.1.2.3 K Basins Closure Activities

BM Barnes

CH2M HILL Plateau Remediation Company managed 100-K Area remediation activities during 2010 that included facility demolition, waste site remediation, cleanout of the 105-K West Basin, and groundwater pump-and-treat operations.

American Recovery and Reinvestment Act of 2009 funding made possible increased decontamination and demolition of structures within the 100-K Area. The 105-K West Basin and the Cold Vacuum Drying Facility are the only remaining operating nuclear facilities. The 105-K West

Basin is undergoing cleanout that involves the removal of radioactive contaminated sludge and debris as a precursor to facility deactivation and demolition. For nearly 30 years, the basins stored 2,100 metric tons (2,300 tons) of Hanford Site N Reactor spent fuel and a small quantity of slightly irradiated single-pass reactor fuel (fuel from other Hanford Site reactors). The fuel was removed in a major cleanup effort that ended in October 2004.

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

Floor and pit sludge is a non-homogenous mixture of debris that includes windblown sand and environmental particulates; concrete fragments from the basin walls; corrosion products from fuel canisters and fuel racks; fuel cladding pieces; tiny pieces of corroded uranium (uranium oxides, hydrates, and hydrides); ion-exchange resin beads; polychlorinated biphenyls (PCBs); and fission products. Sludge has been defined as any material that is less than or equal to 0.64 centimeter (0.25 inch) in size. The means by which sludge will be treated and the national repository at which it will be disposed will be described in the project's CERCLA remedial design documentation. The K-West Basin fuel cleaning system transferred sludge generated from the cleaning of fuel to either knock-out pots or settler tanks. Knock-out pots collect particles greater than 500 microns (0.02 inch) in size by using either a downstream strainer or an internal screen. Settler tanks, a series of horizontal tubes downstream of the knock-out pots, allow particles less than 500 microns (0.02 inch) to settle out and not be recirculated.

During 2010, the following lists progress and accomplishments in remediation of the 100-K Area:

- Began preparation for interim safe storage configuration of the 105-KE Reactor Building.
- Demolished and disposed of the following:
  - 116-KE Stack
  - 1706-KE, 1706-KEL, and 1706-KER above-grade structures
  - 117-KE Exhaust Air Filter Building (above-grade portion)
  - 115-KE Gas Recirculation Building (above-grade portion)
  - 118-KW-2 Horizontal Control Rod Storage Cave
  - 183.1-KW Head House
  - 183.2-KW Sedimentation Basins
  - 183.3-KW Filter Basins
  - 183.5-KW Lime Feeder Building
  - 183.6-KW Lime Feeder Building
  - 182-K Emergency Water Pumphouse (above-grade portion)
  - 1614-KE Environmental Monitoring Station
  - 1724-KB Gas Bottle Storage Building
  - 1713-KER Warehouse
  - 110-KE Gas Storage.
- Demolished and/or removed the following mobile office structures for reuse:
  - MO-955
  - MO-236
  - MO-237
  - MO-293.
- Continued testing of systems and components at Hanford's Maintenance and Storage Facility in the 400 Area for deployment in the K-West Basin for the pretreatment and processing of knock-out-pot sludge that will undergo separation into a stream to be managed as fuel and one to be managed as waste, and the retrieval, transfer, and loading of sludge in underwater containers into sludge transfer and storage containers for removal from the basin as waste.

- Completed the sampling of sludge from underwater containers in the K-West Basin for laboratory analysis at Pacific Northwest National Laboratory to support design and waste management information needs. Analyses from four of the six containers have been completed; two are in progress.
- Completed the transfer of sludge from the settler tubes to an underwater container to facilitate sampling for characterization and removal from the basin.
- Initiated alternatives analysis of different technologies for the treatment and packaging of sludge involving testing using sludge simulants.
- Completed design of systems to be used underwater in the K-West Basin for the pretreatment of knock-out-pot sludge.
- Continued design associated with the modifications to the K-West Basin for the removal of sludge being stored in underwater containers.
- Completed the vacuuming of sludge on the floor and pits of the K-West Basin into underwater containers to facilitate sampling for characterization and removal from the basin.
- Increased groundwater pumping and treatment capacity.

6.1.2.4 DOE Richland Operations Office Progress on Defense Nuclear Facilities Safety Board Recommendations Regarding K Basins

CA Zaccone

Under a June 30, 2010, letter from the DOE Office of Environmental Management (DOE 2010 0000952), the DOE Richland Operations Office transmitted a project execution plan for the Sludge Treatment Project to the Defense Nuclear Facilities Safety Board, incorporating milestones for the removal of knock-out-pot sludge and engineered container sludge wastes from the K Basins. Project execution plan milestones will be used as a basis to update the K Basins Sludge Treatment Project commitment dates contained in the DOE Implementation Plan (DOE 2002) and its revision (DOE 2005) for stabilization of the nuclear materials identified in DNFSB Recommendation 2000-1 (DNFSB 2000). Revisions to the implementation plan commitment dates for completion of K Basins sludge treatment and packaging are in development.

Removal and treatment of engineered container sludge will be completed in two phases. The first phase involves removing the sludge from K-West Basin to T Plant (located on the Central Plateau) for interim storage and is scheduled for completion by December 2015. The second phase involves sludge treatment and packaging and its subsequent shipping to the appropriate facility for final disposal. An 18-month Phase II alternative analysis to identify and develop treatment and packaging technologies is anticipated for completion by July 2011.

Knock-out-pot sludge will be processed in the K-West Basin. The coarse sludge will be separated from the finer sludge material, packaged into multi-canister overpacks, and transferred to the Canister Storage Building for interim storage until its disposal with other spent nuclear fuel. Transfer to the coarse knock-out-pot sludge to the Canister Storage Building is expected to be completed by September 2012. The fine knock-out-pot sludge material will be processed in the same manner as the engineered container sludge, using the two-phase approach.

In a periodic report to Congress dated September 3, 2010, on the status of significant unresolved issues with DOE's design and construction projects, the Defense Nuclear Facilities Safety Board declared that previous problems with Sludge Treatment Project management and engineering were resolved (DNFSB 2010). The Defense Nuclear Facilities Safety Board noted project management improvements recently implemented by DOE as the basis for closing this issue.

6.1.3 Remediation of Waste Sites in the 300 Area

DE Faulk

Remediation efforts in 2010 focused on 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 used 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.

Waste generated from the cleanup of waste sites in the 300-F-2 Operable Unit is disposed of at the Environmental Restoration Disposal Facility (Section 6.3.3.4) located on the Central Plateau and other EPA-approved disposal facilities. Approximately 138,000 metric tons (152,000 tons) of contaminated soil from the 300-FF-2 Operable Unit were disposed at the Environmental Restoration Disposal Facility in 2010.

Remediation of the 618-1 Burial Ground was completed in 2010. The 618-1 Burial Ground was located in the northern 300 Area and operated from 1945 through 1951. Remediation of waste sites within the northern part of the 300 Area began in 2009 and is ongoing. In 2010, remediation focused on waste sites north of Apple Street within the 300 Area.

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 Columbia Generating Station in Richland, Washington, operated from 1962 through 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. Nonintrusive characterization field activities begun in 2009 concluded in 2010. Intrusive characterization of 618-10 disposal trenches involving the construction of a series of test pits designed to investigate waste forms and validate planned remediation was completed in summer 2010. Results of this activity are detailed in WCH-437, *Field Investigation Report for the 618-10 Burial Ground Intrusive Sampling.* Remediation of the 618-10 Burial Ground trenches began in April 2011.

6.2 Facility Decommissioning Activities

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

6.2.1 Central Plateau Facilities

The Central Plateau facilities include the buildings and waste sites in the 200-East, 200-West, and 200-North Areas, as well as those on the adjoining Fitzner/Eberhardt Arid Lands Ecology Reserve Unit. The transition toward decommissioning encompasses surveillance, maintenance, and deactivation activities.

6.2.1.1 Plutonium Finishing Plant Decommissioning Progress

WG Cox

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

In 2004, workers at the Plutonium Finishing Plant complex completed a large and multi-faceted effort to stabilize, immobilize, repackage, and/or properly dispose of nearly 18 metric tons (19.8 tons) of plutonium-bearing materials in the plant. Workers then focused on decontaminating and deactivating the processing facilities while still providing for the safe and secure storage of nuclear materials until final disposition.

By the end of 2009, all the special nuclear materials and remaining stored fuel elements were removed from the plant and, security was downgraded. In addition, the removal and disposal of process equipment, chemicals, gloveboxes, and hoods from the buildings began, continuing into 2010.

Significant accomplishments at the Plutonium Finishing Plant during 2010 include the following:

- Completed disposition/demolition of 22 structures with *American Recovery and Reinvestment Act of 2009* funding.
- Removed 126 gloveboxes and hoods from the facility and shipped 110 for disposal.
- Removed 106 meters (350 feet) of process transfer pipe and 161 meters (530 feet) of process vacuum pipe.
- Lifted the restriction on deactivation and decontamination work for the McCluskey room in the 242-Z Plant after more than 30 years. A 1976 explosion injured Harold McCluskey and contaminated both him and the room with americium-241.

6.2.1.2 Surveillance, Maintenance, and Deactivation of Other Central Plateau Facilities and Structures

GJ LeBaron

Other Central Plateau facilities include interim-status RCRA treatment, storage, and disposal units awaiting closure; the canyon buildings (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.

Disposition of U Plant and the 209-E Criticality Mass Laboratory began in 2010 using funding from the *American Recovery and Reinvestment Act of 2009*. Many of the support facilities around U Plant were demolished in 2010. The demolition of 209-E and its associated exhaust system to slab on grade is planned for completion by the end of September 2011, as is the grouting of the 221-U Building and shutdown of its associated exhaust system in preparation for demolition of the upper portion of the canyon building (see Section 6.2.1.3). Further progress in 2010 included the demolition of three fuel storage facilities in the 200-North Area and the removal of the majority of buildings and debris on the Fitzner/Eberhardt Arid Lands Ecology Reserve. Contaminated rail cars remaining in the 200-North Area are scheduled for removal during 2011.

Surveillance, maintenance, and decontamination or stabilization of approximately 1,000 waste sites continued in 2010, including former waste-disposal cribs, ponds, ditches, trenches, unplanned release sites, and waste burial grounds. Periodic surveillances, radiation surveys, and pesticide and herbicide applications were performed at these sites. Timely responses to identified problems were initiated. The overall objective is to maintain these sites in safe and stable condition and prevent contaminants at these sites from spreading in the environment. In addition, waste sites were remediated during 2010 by the Soil and Groundwater Remediation Project using *American Recovery and Reinvestment Act of 2009* funding.

6.2.1.3 Canyon Disposition Initiative

GJ LeBaron

The Canyon Disposition Initiative was created to investigate the potential for using the five former chemical separations facilities (B Plant, T Plant, U Plant, Plutonium Uranium Extraction Plant, and Reduction-Oxidation Plant) in the 200 Areas as disposal facilities for Hanford Site remediation waste rather than demolishing these canyon buildings. 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 implementing the Canyon Disposition Initiative at U Plant began in the mid-1990s. In fall 2005, EPA issued the 221-U Facility (Canyon Disposition Initiative) record of decision (DOE et al. 2005), selecting the "close in place—partially demolished structure" alternative for the remediation of the 221-U Facility. In accordance with the record of decision, process equipment already in the plant will be consolidated into the below-ground plant process cells. In addition, the cells, the two lower galleries, and other void spaces will be filled with grout; the exterior walls and roof will be collapsed in place; and the site will be covered with a barrier.

Implementation of the selected alternative for the 221-U Facility began in 2009. Beginning in 2009 and continuing during 2010, process equipment on the canyon deck was moved to specific below-ground cells within the canyon structure for final disposition, in accordance with the *Remedial Design/Remedial Action Work Plan for the 221-U Facility* (DOE/RL-2006-21).

Planning and preparation for grouting the canyon cells and lower galleries, tunnels, and piping in accordance with the remedial design work plan was accomplished in 2010. The grouting and preparations to collapse the walls and ceiling are scheduled for completion by October 2011.

6.2.2 300 Area Facilities

CP Strand

During 2010, deactivation, decontamination, decommissioning, and demolition activities in the 300 Area continued to focus on removing physical barriers to perform remedial actions in the 300-FF-2 Operable Unit. These activities were conducted as non-time-critical removal actions under CERCLA in accordance with *Action Memorandum #1 for the 300 Area Facilities* (DOE and EPA 2005), *Action Memorandum #2 for the 300 Area Facilities* (DOE and EPA 2006a), and *Action Memorandum #3 for the 300 Area Facilities* (DOE and EPA 2006b).

Additionally, the *Memorandum for General Hanford Site Decommissioning Activities* (DOE et al. 2010) authorized deactivation, decontamination, decommissioning, and demolition activities for a portion of the 337 Complex.

During decommissioning and decontamination activities at the 324 Building in late 2009, a breach in the Radiochemical Engineering B-Cell floor liner was noted in the bottom of a sump. Radiological dose measurements of approximately 14,000 rad/hr were observed at the failure location, indicating a possible release from the building had occurred during past operations. In November 2010, casings containing closed-end push probes were installed under B-Cell at the northern corner of Building 324. Dose measurements taken from these probes showed peak radiation readings of 8,900 rad/hr, confirming a significant source term from within B-Cell had been released to the soil column beneath the building. Additional probes to greater depths and reviews of downgradient monitoring wells confirmed the contamination had not come into contact with the groundwater. Characterization sampling of the contaminated soils and ongoing engineering evaluations will be used to develop a retrieval methodology that is protective of both workers and the environment.

The following 300 Area buildings and structures were demolished during 2010:

- 309 Building Stack
- 315, 315A, 315B Water Treatment Plant
- 324 High Bay
- 327 Post Irradiated Test Facility
- 335 Building
- 336 Building
- 337, 337B Buildings
- 338 Maintenance Building
- 3621D Diesel Generator Building
- 3718P Warehouse
- 3718M Sodium Storage Facility
- 3723 Acid Storage Building
- 384 Powerhouse (below grade).

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

6.2.3 400 Area Facilities

LE Harville

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

The Fast Flux Test Facility remains in a long-term surveillance and maintenance condition. Routine surveillances are performed on an annual basis.

Final decommissioning of the Fast Flux Test Facility is dependent on the outcome of the *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (DOE/EIS-0391). The resultant record of decision will determine the final end state for the Fast Flux Test Facility.

6.2.4 100 Area Facilities

CD McCurley

During 2010, deactivation, decontamination, decommissioning, and demolition activities in the 100 Areas focused on the 100-N Area. These activities were conducted as non-time-critical removal actions under CERCLA. The following 100-N Area buildings were demolished during 2010:

- Various rooms (above- and below-grade) along the north and west sides of the 105-N/109-N Reactor Building

Complex including but not limited to the Zone 1 Supply Plenum Room, W Elevator Room, Metal and Dummy Storage Rooms, Equipment and Miscellaneous Storage Rooms, Gas Facility Pipe Tunnel, Zones I through III Exhaust Tunnels, and the Zone II Exhaust Fan Room.

- 1310-N Radioactive Liquid and Waste Treatment Facility (Silo and Golf Ball below-grade)
- 1322-N Waste Treatment Pilot Plant (including 1322-NA, 1322-NB, and 1322-NC)
- 1605-NE East Observation Post (on top of 105-N)
- 1909-N Waste Disposal Valve Pit
- 1902-D Water Tower
- 183-H West Clearwell
- MO-417 at F Area.

Demolition and pre-demolition work began or continued on the following facilities during 2010:

- 105-NE Fission Products Trap
- 105-N Fuel Storage Basin, Transfer Bay, and Lift Station
- 117-N Exhaust Air Filter House
- 181-N River Pumphouse
- 116-N Exhaust Air Stack (below-grade)
- 181-NE HGP River Pumphouse
- 1143-N Carpenter/Paint Shop
- 186-N Alternative Potable Water Plant
- 1902-N Export Water Tie-In Building.

In addition, safe storage enclosure preparations for the 105-N/109-N Reactor Building Complex continued through 2010.

6.3 Waste Management Operations

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

6.3.1 Waste Classifications

WE Toebe and CD Wollam

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

Radioactive and/or mixed wastes are currently managed in several ways. High-level waste is stored in large underground single- and double-shell tanks or 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 above-ground storage pads in a manner to enable its retrieval. A DOE annual report lists the dangerous and mixed wastes that are generated, treated, and disposed of onsite or shipped offsite (DOE/RL-2011-16, Rev. 0). Dangerous and mixed wastes are treated, stored, and prepared for disposal at several Hanford Site facilities. Dangerous waste generated at the site is also shipped offsite for treatment and/or disposal. Some types of dangerous waste, such as used lead–acid batteries and aerosol products (e.g., spray paint), are shipped offsite for recycling.

Waste that does not contain hazardous or radioactive substances is non-regulated waste. Historically, non-regulated waste generated at the Hanford Site was disposed onsite. 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 include 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 (in place) or in designated disposal locations on the Hanford Site.

6.3.2 Solid Waste Inventories

N Weston

The Solid Waste Information and Tracking System is a computer database used to track a portion of mixed and radioactive waste at the Hanford Site, primarily non-CERCLA containerized waste managed by CH2M HILL Plateau Remediation Company; Mission Support Alliance, LLC; and Washington River Protection Solutions LLC. The database does not include all waste from Washington Closure Hanford, LLC; the Environmental Restoration Disposal Facility; or any Pacific Northwest National Laboratory wastes. The database also does not include high-level radioactive waste volumes managed at Hanford Site tank farms.

Quantities for both mixed and radioactive wastes generated onsite or received from offsite sources and disposed of at the Hanford Site from 2006 through 2010, as tracked by the Solid Waste Information and Tracking System database, are shown in Tables 6.3.1 and 6.3.2. Quantities of dangerous waste shipped offsite from 2006 through 2010, as tracked by the database, are shown in Table 6.3.3. 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 by DOE to ship waste to the site. These facilities are operated and maintained in accordance with state and federal regulations and facility permits. The following sections describe specific waste treatment, storage, or disposal locations at the Hanford Site.

6.3.3.1 Central Waste Complex

NW Ware

The Central Waste Complex, a solid waste storage facility located in the 200-West Area, receives waste from sources on the Hanford Site and offsite sources that are authorized by DOE to ship waste to the Hanford Site for treatment, storage, and disposal. The majority of wastes received at the Central Waste Complex are generated from ongoing cleanup, research, and development activities at the Hanford Site. Waste types stored include low-level, mixed low-level, transuranic, and polychlorinated biphenyl (PCB) radioactive. The current volume of waste stored totals approximately 8,500 cubic meters (300,000 cubic feet).

The Central Waste Complex can store as much as 20,800 cubic meters (735,000 cubic feet) of waste. This capacity is adequate to store the projected volumes of generated waste from the activities identified above, assuming on-schedule treatment and disposal of the stored waste.

Table 6.3.1. Quantities of Solid Waste[a] Generated on the Hanford Site, 2006 Through 2010

Waste Category		2006	2007	2008	2009	2010
Mixed	kilograms (tons)	315,000 (347)	235,000 (259)	314,000 (346)	255,000 (281)	260,000 (286)
Radioactive	kilograms (tons)	465,000 (513)	300,000 (330)	361,000 (398)	632,000 (696)	658,000 (725)

(a) Solid waste includes containerized liquid waste.

Table 6.3.2. Quantities of Solid Waste[a] Received on the Hanford Site from Offsite Sources, 2006 Through 2010

Waste Category		2006	2007	2008	2009	2010
Mixed[b]	kilograms (tons)	152,000 (168)	177,000 (195)	416,000 (459)	233,000 (257)	138,000 (152)
Radioactive[b]	kilograms (tons)	71,200 (79)	168,000 (185)	404,000 (445)	178,000 (196)	352,000 (388)

(a) Solid waste includes containerized liquid waste. Solid waste quantities do not include U.S. Navy reactor compartments.
(b) Total includes Hanford Site-generated waste treated by an offsite contractor and returned as newly generated waste. Includes both low-level radioactive and transuranic waste.

Table 6.3.3. Quantities of Dangerous Waste[a] Shipped Off the Hanford Site, 2006 Through 2010

Waste Category		2006	2007	2008	2009	2010
Containerized	kilograms	18,700[b]	48,000[b]	116,000[b]	42,800[b]	49,700[b]
	(tons)	(21)	(53)	(128)	(47)	(55)
	kilograms	33,300[c]	35,100[c]	50,900[c]	71,300[c]	33,900[c]
	(tons)	(37)	(39)	(56)	(79)	(37)
Bulk Solids – Total	kilograms	0	0	0	74,800	208,600
	(tons)	–	–	–	(83)	(230)
Dangerous	kilograms	–	–	–	3,430	18,000
	(tons)	–	–	–	(3.8)	(20)
Non-radioactive	kilograms	–	–	–	71,400	190,600
	(tons)	–	–	–	(79)	(210)
Bulk Liquids – Total	kilograms	917[d]	96,700[d]	201,000[d]	2,050[d]	0[d]
	(tons)	(1)	(107)	(221)	(2)	(0)
Dangerous	kilograms	–	14,300	51,900	2,050	0
	(tons)	–	(16)	(57)	(2)	(0)
Non-radioactive	kilograms	–	82,400	149,000	0	0
	(tons)	–	(91)	(164)	0	(0)
Total	kilograms	**52,900**	**180,000**	**367,000**	**191,000**	**292,000**
	(tons)	**(58)**	**(198)**	**(405)**	**(211)**	**(322)**

(a) Does not include *Toxic Substances Control Act* waste.
(b) Dangerous waste only.
(c) Mixed waste (radioactive and dangerous).
(d) Bulk liquid classifications are not readily available prior to 2007.

An outdoor storage area was constructed in 2007 to store large containers of suspect transuranic waste from waste retrieval operations. The volume of waste currently stored in the outdoor expansion area is 1,160 cubic meters (41,000 cubic feet).

The Central Waste Complex is currently operating under RCRA interim status while DOE and the Washington State Department of Ecology develop a final status permit.

6.3.3.2 Waste Receiving and Processing Facility

LC Tuott

The Waste Receiving and Processing Facility began operating in 1997 with the mission to analyze, characterize, and prepare drums and boxes of low-level, mixed, and transuranic wastes for disposal. The 4,800-square-meter (52,000-square-foot) facility, along with two 2,000-square-meter (21,500-square-foot) storage buildings, is located north of the Central Waste Complex on the Central Plateau.

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 (i.e., debris). Processed waste that qualifies as low-level radioactive waste and meets disposal requirements is buried at the Hanford Site. Low-level radioactive waste not meeting burial requirements is processed at the Waste Receiving and Processing 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.

In 2010, the Waste Receiving and Processing Facility dispositioned and shipped 50 cubic meters (1,770 cubic feet) of mixed low-level waste and 10 cubic meters (350 cubic feet) of low-level waste offsite for treatment. The treated waste was then returned to the Hanford Site for disposal. In addition to these shipments, 416 cubic meters (14,690 cubic feet) of transuranic waste were sent to the Waste Isolation Pilot Plant for disposal, and 132 cubic meters (4,660 cubic feet) were sent to the Advanced Mixed Waste Treatment Facility in Idaho for treatment, certification, and subsequent shipment to the Waste Isolation Pilot Plant in 2010.

6.3.3.3 T Plant Complex

PT Karschnia

The T Plant Complex, located in the 200-West Area, provides solid waste treatment, storage, and decontamination services for the Hanford Site as well as for offsite facilities. At the T Plant Complex during 2010, workers performed the following:

- Sampled, characterized, treated, and repackaged numerous containers and boxes of waste to meet waste acceptance criteria and land disposal restriction requirements.
- Repackaged 1,376 containers (208 liters, or 55-gallon drum equivalents) of transuranic waste to meet offsite waste acceptance criteria and eventual disposal at the Waste Isolation Pilot Plant in Carlsbad, New Mexico.
- Used a super-compactor in the 221-T Canyon to crush 1,224 empty waste containers, conserving landfill space in onsite disposal units.

The T Plant Complex is currently operating under RCRA interim status. Drafting of the T Plant RCRA Part B permit application for final status began in June 2008. Review, approval, and issuance by the Washington State Department of Ecology are expected in 2011.

6.3.3.4 Environmental Restoration Disposal Facility

MA Casbon

The Environmental Restoration Disposal Facility is located near the 200-West Area. The facility began operations in July 1996 and serves as the central disposal site for contaminated waste removed during Hanford Site cleanup operations conducted under CERCLA regulations. To provide a barrier to prevent contaminant migration from the in-ground facility, the Environmental Restoration Disposal Facility is 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 10 waste cells within the Environmental Restoration Disposal Facility. Construction of cells 1 and 2 was finished in 1996; waste placement in these cells is complete, and an interim cover has been placed over them. Cells 3 and 4 were subsequently constructed and have reached their operational capacity. Cells 5 and 6 are being filled and are nearing operational capacity. Cells 7 and 8, constructed in 2009, are approximately half full. Cells 1 through 8 are roughly equal in size, each holding approximately 1.27 million metric tons (1.4 million tons) or approximately 0.61 million cubic meters (0.8 million cubic yards). Construction of two additional cells ("super cells" 9 and 10) was completed in the first quarter of calendar year 2011; waste disposal in Cell 9 began upon operational acceptance of the cell in February 2011. The super cells are each the size of two conventional cells, making the two super cells the combined equivalent of four conventional cells. Addition of the two super cells will bring the total number of cells to 10 and increases the constructed trench capacity to 14.9 million metric tons (16.4 million tons).

In calendar year 2010, approximately 1,625,050 metric tons (1,791,320 tons) of remediation waste were disposed of at the facility. Approximately 9.7 million metric tons (10.7 million tons) of remediation waste have been placed in the Environmental Restoration Disposal Facility from initial

operations startup through calendar year 2010. 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).

6.3.3.5 Low-Level Burial Grounds

LC Petersen, NW Ware, and DE Nester

The low-level burial grounds consist of eight separate burial grounds—two in the 200-East Area and six in the 200-West Area. They are regulated under the *Atomic Energy Act of 1954*. Trenches that contain mixed low-level waste are also regulated under RCRA. Two of the burial grounds are currently being 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). The first is designated as low-level waste burial ground 218-W-5, which is located in the 200-West Area and contains Trenches 31 and 34. The second, located in the 200-East Area, is low-level burial ground 218-E-12B, which includes Trench 94. This trench is dedicated for the disposal of defueled U.S. Navy reactor compartments (Section 6.3.3.7). Five of the burial grounds in the 200-West Area were previously used for disposal of low-level waste and/or retrievable storage of transuranic waste, as were portions of the 218-E-12B Burial Ground. The 218-W-6 Burial Ground has never received waste.

The low-level burial grounds have been under a RCRA Part A interim status permit since 1985. A draft revision to the subsequent RCRA Part B final 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 Washington State Department of Ecology concerning the Part B permit application are ongoing. In addition, the low-level burial grounds are included in the *200-SW-1 Nonradioactive Landfills and Dumps Group Operable Unit and 200-SW-2 Radioactive Landfills and Dumps Group Operable Units Remedial Investigation/Feasibility Study Work Plan* (DOE/RL-2004-60, Rev. 0). The plan outlines proposed characterization and remediation activities for specified burial grounds in the 200-East and 200-West Areas.

On June 23, 2004, DOE issued a record of decision (69 FR 39449-39456) for the Solid Waste Program on the Hanford Site. Part of the record of decision stated that DOE will dispose of low-level waste in lined disposal facilities. Disposal of U.S. Navy reactor compartments in Trench 94 was not affected by this record of decision.

While some of the low-level burial grounds contain only low-level waste and mixed low-level waste, suspect transuranic waste had previously been placed in retrievable storage in four of these burial grounds. Since August 19, 1987, no transuranic waste has been placed in the low-level burial grounds without specific DOE approval.

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]), and removal of waste from trenches in this burial ground was completed in May 2008. 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 in the 218-W-4B and 218-W-3A Burial Grounds continues in accordance with Tri-Party Agreement Milestone M-91-40 (Ecology et al. 1989).

In 2010, 336 cubic meters (11,900 cubic feet) of retrievably stored waste were retrieved from the low-level burial grounds. Preparations began in 2009 for removal of retrievably stored suspect transuranic waste from the 218-E-12B Burial Ground, using the next-generation retrieval approach. This approach involves venting, assaying, non-destructive examination, and processing of containers closer to their retrieval location, reducing the number of waste transfers and waste handling necessary for processing in preparation for certification and transport to the Waste Isolation Pilot Plant. In 2010, next-generation retrieval preparations continued in the 218-E-12B Burial Ground and began in burial grounds 218-W-3A and 218-W-4B. Next-generation retrieval in the 218-E-12B Burial Ground began in February 2011.

Low-Level Waste Burial Ground 218-W-5, Trenches 31 and 34. Trenches 31 and 34 are rectangular landfills with

approximate base dimensions of 76 by 30 meters (250 by 100 feet). The floor of the excavation slopes slightly (nominally 1:3), giving a variable depth of 9 to 12 meters (30 to 40 feet). These trenches comply with *Washington Administrative Code* requirements for double liners and leachate removal/collection systems. The floor and sides of the trenches are covered with a layer of soil 1 meter (3.3 feet) deep to protect the liner system during landfill operations. A recessed section at the end of each excavation houses a sump for leachate collection. Ramps along the perimeter walls provide vehicle access to the bottom of each trench.

These lined disposal units were designated originally for disposal of mixed low-level waste only. On June 23, 2004, disposal of low-level waste in the unlined trenches on the Hanford Site ceased. Since that date, Trenches 31 and 34 have accepted low-level waste and mixed low-level wastes for disposal. Disposal in Trench 31 began in May 2005, and disposal in Trench 34 began in September 1999.

In 2010, a total of 1,008 cubic meters (35,600 cubic feet) of waste were disposed in Trenches 31 and 34.

- Trench 34 has approximately 5,150 cubic meters (182,000 cubic feet) of disposed waste in 5,278 waste packages. During summer 2004, the first operational layer of waste packages was covered with compacted gravel and soil, and the covering of the second waste layer was initiated. At the end of 2010, Trench 34 was filled to approximately 81% of waste capacity.
- Trench 31 has approximately 4,150 cubic meters (146,540 cubic feet) of waste disposed in 2,877 waste packages. During summer 2009, the first operational layer of waste packages was covered with compacted gravel and soil, and the covering of the second waste layer was initiated. Trench 31 is filled to approximately 30% of waste capacity.

Treatment of legacy mixed low-level waste continued at the Hanford Site during 2010. The majority of wastes was treated offsite and returned to the Hanford Site following treatment for disposal in Trenches 31 and 34. A small volume of treated wastes was disposed of at an offsite commercial disposal unit. On a pretreatment volume basis, 420 cubic meters (14,800 cubic feet) of waste was treated prior to disposal.

In 2010, treatment of mixed wastes at offsite commercial waste processors met the performance objectives of Tri-Party Agreement milestones M-091-42 (small package contact-handled mixed low-level waste) and M-091-43 (large package and/or remote-handled mixed low-level waste).

6.3.3.6 Waste Encapsulation and Storage Facility

FM Simmons

The Waste Encapsulation and Storage Facility, located in the 200-East Area, was constructed in 1970 and 1971 on the west end of B Plant and became operational in 1974. The mission of the Waste Encapsulation and Storage Facility was encapsulation and storage of cesium chloride and strontium fluoride salts that had been separated from the Hanford Site's high-level radioactive tank waste. The facility is a two-story, 1,860-square-meter (20,000-square-foot) building, 48 meters (157 feet) long and 12 meters (40 feet) high, constructed of steel-reinforced concrete and partitioned into seven hot cells, a hot cell service area, operating areas, building service areas, and a pool cell area. The hot cells are labeled A through G, and activities within the hot cells are performed remotely using manipulators. Waste and drum load-out can be performed in hot cell A. Hot cells B through E have been placed on cold standby status. Only hot cells F and G remain active for cesium and strontium capsule storage. The operating areas and other building service areas associated with the hot cells provide areas for instrumentation monitoring, utility support, or manipulator repair as required.

The Waste Encapsulation and Storage Facility currently stores strontium and cesium encapsulated salts in double-containment stainless-steel capsules in underwater pool cells, providing safe storage. The water provides cooling and shielding for the capsules that are considered sealed sources. As a storage-only unit, the facility does not currently generate regulated wastes.

DOE Richland Operations Office Progress on Defense Nuclear Facilities Safety Board Recommendations Regarding the Waste Encapsulation and Storage Facility

CA Zaccone

The DOE Richland Operations Office submitted a report on a re-evaluation of the ventilation system serving the Waste Encapsulation and Storage Facility in support of Defense Nuclear Facilities Safety Board Recommendation 2004-2, "Active Confinement Systems" in March 2010 (CHPRC 2010). The report included a gap analysis and cost-benefit analysis for portions of the ventilation system that did not fully meet the design criteria. As a result, a project has been initiated to upgrade the confinement ventilation system to address the gaps.

6.3.3.7 Disposal of U.S. Navy Reactor Compartments

SG Arnold

In 2010, two defueled U.S. Navy reactor compartments were received and placed in Trench 94 of the 218-E-12B Burial Ground, bringing the total number of reactor compartments received to 122. All U.S. Navy reactor compartments shipped to the Hanford Site for disposal originated from decommissioned nuclear-powered submarines or cruisers. Decommissioned submarine reactor compartments are approximately 10 meters (33 feet) in diameter, 14.3 meters (47 feet) long, and weigh between 900 and 1,400 metric tons (1,000 and 1,500 tons). Decommissioned cruiser reactor compartments are approximately 10 meters (33 feet) in diameter, 12.8 meters (42 feet) high, and weigh approximately 1,362 metric tons (1,500 tons).

6.3.3.8 Integrated Disposal Facility

NW Ware

The Integrated Disposal Facility is a newly constructed, unused landfill that is not yet actively operating. Located in the south-central part of the 200-East Area, the landfill is an expandable RCRA hazardous waste-compliant unit (i.e., a double high-density polyethylene-lined trench with leachate collection and a leak detection system). The landfill is divided lengthwise (north to south) into two distinct cells: the east cell is for disposal of low-level radioactive waste (non-RCRA permitted), and the west cell is for disposal of low-level mixed waste (radioactive and RCRA-regulated hazardous waste). The process design disposal capacity listed in the RCRA permit is 82,000 cubic meters (2.89 million cubic feet). The Integrated Disposal Facility is referenced in the *Draft Tank Closure and Waste Management Environmental Impact Statement* (DOE/EIS-0391) as a future disposal option for Hanford Site wastes.

6.3.4 Liquid Waste Management

Facilities are operated on the Hanford Site to store, treat, reduce, 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 Effluent Treatment Facility

HC Boynton

The Effluent Treatment Facility, located in the 200-East Area, treats liquid effluent to remove toxic metals, radionuclides, and ammonia, in addition to destroying organic compounds. The treatment process constitutes best available technology and includes pH adjustment; filtration; ultraviolet light and peroxide oxidation to destroy 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. Storage and treatment activities are managed in compliance with the facility RCRA permit, and effluent discharges comply with the limitations set forth in State Waste Discharge Permit ST-4500 (Ecology 2000a) and with the 200 Area Effluent Treatment Facility delisting requirements and modifications.

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 2010 was approximately 69.7 million liters (18.4 million gallons). This wastewater was primarily CERCLA-regulated wastewater (groundwater from the 200-UP-1 and 200-ZP-1 Operable Units in the 200-West Area).

6.3.4.2 Liquid Effluent Retention Facility

HC Boynton

The Liquid Effluent Retention Facility, located in the 200-East Area, consists of three RCRA-compliant surface basins used to temporarily store process condensate from the 242-A Evaporator and other aqueous waste. The Liquid Effluent Retention Facility provides a steady flow and consistent pH for 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 in the event of leakage. 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 resulting from cleanup activities regulated by both RCRA and CERCLA. Typically, RCRA and CERCLA wastewaters 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. Treatment and storage activities at the Liquid Effluent Retention Facility are managed in accordance with the facility RCRA permit.

The volume of wastewater received for interim storage in 2010 was approximately 71.9 million liters (19 million gallons). This included approximately 4 million liters (1 million gallons) of RCRA-regulated wastewater from 242-A Evaporator process condensate and approximately 5.4 million liters (1.4 million gallons) of CERCLA-regulated wastewater from Environmental Restoration Disposal Facility leachate. The majority of wastewater received at the Liquid Effluent Retention Facility was pipeline-transported contaminated groundwater from 200-UP-1 and 200-ZP-1 wells, totaling approximately 60.6 million liters (16 million gallons). Approximately 2.2 million liters (0.6 million gallons) of wastewater were received from various facilities by tanker trucks that included approximately 0.8 million liters (0.2 million gallons) of water purged from wells prior to sampling. The wastewater volume transferred to the Effluent Treatment Facility for treatment and disposal in 2010 was 70.4 million liters (18.6 million gallons).

The volume of wastewater being stored in the Liquid Effluent Retention Facility at the end of 2010 was 64.4 million liters (17.0 million gallons).

6.3.4.3 200 Area Treated Effluent Disposal Facility

HC Boynton

The 200 Area Treated Effluent Disposal Facility, located east of the 200-East Area, 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 methods in accordance with "Submission of Plans and Reports for Construction of Wastewater Facilities" (WAC 173-240), which is the responsibility of the generating facilities. Effluent discharges comply with the limitations established in State Waste Discharge Permit ST-4502 (Ecology 2002b).

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. 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 in 2010 was 1,170 million liters (310 million gallons). The major source of this effluent was uncontaminated cooling water and steam condensate from the 242-A Evaporator with various other uncontaminated waste streams received from Hanford Site facilities.

6.3.4.4 242-A Evaporator

AL Hummer

The 242-A Evaporator, located in the 200-East Area, concentrates dilute liquid tank waste by evaporation. The resultant water vapor is captured, condensed, filtered, sampled, and sent to the nearby Liquid Effluent Retention Facility for further treatment and disposal before being returned to the double-shell tanks. This reduces the volume of liquid waste sent to double-shell waste storage tanks for storage and reduces the potential need for additional double-shell tanks.

In 2010, design activities to upgrade and extend the 242-A Evaporator service life through 2032 occurred using *American Recovery and Reinvestment Act of 2009* funding. These upgrades are described in the following paragraphs.

Discharge Pipeline Leak Detection System Upgrades from the 242-A Evaporator to the Liquid Effluent Retention Facility. Several modifications were made to improve the efficiency of operations and to re-establish the design function of its leak detection system. Specifically, the six leak detectors within the secondary containment casing were replaced, and new secondary containment fittings with better sealing properties were installed on the leak detector risers. In addition, an integral catch tank to collect any leakage from the primary containment piping was installed at the end of the secondary containment casing at the Liquid Effluent Retention Facility, and a seventh leak detector was installed in the catch tank system.

Instrumentation Replacement (transmitters). Flow transmitters, pressure transmitters, pressure differential transmitters, pressure switches, weight factor transmitters, and density transmitters were modified or upgraded to correct deficiencies and support continued facility operations.

Additionally in 2010, the 242-A Evaporator successfully completed two operating campaigns, the feed from both of which originated from double-shell tank AW-106, resulting in a waste volume reduction of 1.7 million liters (454,000 gallons).

6.4 Underground Waste Storage Tanks

Most Hanford Site waste is stored in 149 large underground single-shell (single-walled) and 28 double-shell (double-walled) tanks located on the Central Plateau near the center of the site. A grouping of tanks is referred to as a farm. The 149 single-shell tanks were constructed in the late 1940s and early 1950s; 67 are assumed to have leaked in the past. Pumpable liquids in the single-shell tanks were transferred to the newer and safer double-shell tanks several years ago under the Interim Stabilization Program to help prevent additional environmental releases. This section provides information about the single-shell and double-shell tanks on the Hanford Site, and activities that occurred in 2010 related to their operation and closure.

6.4.1 Waste Tank Status

AL Hummer

Quantities of liquid waste generated in 2010 and stored in underground storage tanks are provided in the *Hanford Site Annual Dangerous Waste Report Calendar Year 2010* (DOE/RL-2011-16, Rev. 0). Table 6.4.1 summarizes the liquid waste generated and stored from 2005 through 2010 in underground storage tanks.

Table 6.4.1. Quantities of Liquid Waste[a] Generated and Stored Within the Tank Farm System on the Hanford Site During 2010 and the Previous 5 Years in Liters (gallons)[b]

Type of Waste	2005	2006	2007	2008	2009	2010
Volume of waste added to double-shell tanks	3,668 (969)	3,547 (937)	5,901 (1,559)	322 (85)	1,230 (325)	1,560 (412)
Total volume in double-shell tanks (year end)	98,943 (26,138)	101,411 (26,790)	101,052 (26,695)	101,366 (26,778)	98,311 (25,971)	97,796 (25,835)
Volume evaporated at 242-A Evaporator	707 (187)	1,052 (278)	4,500 (1,189)	0 (0)	3,634 (960)	2,074 (548)
Volume pumped from single-shell tanks	888[c] (235)[c]	2,953[d] (780)[d]	4,342[d] (1,147)[d]	262[d] (69)[d]	386[d] (102)[d]	909[c] (240)[c]

(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) Multiply volumes shown by 1,000.
(c) Volume does not include dilution or flush water.
(d) Volume does include dilution or flush water.

6.4.1.1 Single-Shell Tanks

AL Hummer

During 2010, approximately 909,000 liters (240,000 gallons) of radioactive and hazardous waste were removed from single-shell Tanks C-104 and C-111 and transferred to safer double-shell tank storage. At the end of 2010, approximately 112 million liters (29.5 million gallons) of waste remained in the single-shell tanks.

6.4.1.2 Vadose Zone Program

DA Myers and DL Parker

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

In 2010, Vadose Zone Program workers installed several direct-push boreholes for soil sampling and geophysical logging in the C and BY Tank Farms and completed surface geophysical surveys in Waste Management Areas C and BY. Monitoring was conducted at the interim surface barrier that covers a portion of the 241-T Tank Farm to reduce infiltration of precipitation through the remnants of the 1973 release from Tank T-106. Also in 2010, an interim barrier consisting of polymer-modified asphalt was constructed over 0.73 hectare (1.8 acres) of the TY Tank Farm, along with an evapotranspiration basin to dispose of the water redirected from the barrier. Single-shell tanks or associated infrastructure are suspected to have leaked radioactive waste to the ground in this region, and the barrier is designed to minimize contaminant transport in the vadose zone.

Direct-Push Boreholes and Sampling

Direct-push technology, using a hydraulic hammer unit to evaluate subsurface contamination in the vadose zone, was deployed in two tank farms during 2010. Several direct-push boreholes were made in the C Tank Farm as part of the Phase II RCRA investigation of that waste management area. The hydraulic hammer unit was also deployed in the western portions of BY Tank Farm to assess the extent of contamination in support of a proposed interim barrier in that farm.

Surface Geophysical Exploration

Surface geophysical exploration is a combination of surface-deployed geophysical techniques, including pole-to-pole electrical resistivity, electro-magnetic induction, magnetic gradiometry, and ground-penetrating radar, used to help define the presence and distribution of buried infrastructure so that those features may be considered during resistivity data analysis. The depth to which the resistivity measurements interrogate the subsurface is determined by the distance between electrode pairs (the farther apart, the deeper the interrogation). Because resistivity is an indirect measure of several subsurface phenomena (e.g., moisture distribution, saline contaminants, and soil texture), the greater the depth of interrogation, the lower the resolution of the analysis.

During 2010, surface geophysical exploration was performed at the S/SX Tank Farm (RPP-RPT-47851). In addition, the analysis of a fully three-dimensional surface geophysical exploration survey using buried electrodes (waste site UPR-200-E-86, near the 241-C Tank Farm) was completed during the period (RPP-RPT-47486). A survey to facilitate characterization efforts of Waste Management Area A-AX using existing drywells as long electrodes, was completed in 2010 (RPP-RPT-46613). A survey of a third unplanned release in C farm (waste site UPR-200-E-82) is planned for 2011.

Interim Surface Barriers

Effectiveness of the T Tank Farm interim surface barrier at reducing infiltration is assessed through a barrier monitoring program (PNNL-16538). Pre-barrier data were collected and a monitoring report for fiscal year 2007 was issued in January 2008 (PNNL-17306). The most recent post-barrier data were compiled into a fiscal year 2010 monitoring report issued in January 2011 (PNNL-20144). The barrier is resulting in slow drying of the vadose zone as water that would normally recharge the surface is diverted. Barrier monitoring continues.

A second interim barrier, at TY Tank Farm, was constructed during 2010. This barrier applied lessons learned through the T Farm barrier:

- Use an evapotranspiration facility that diverts intercepted water back to the atmosphere
- Coat the surface of the tank farm with approximately 10 centimeters (4 inches) of modified asphalt to test its ability to redirect water
- Monitor using techniques similar to T Farm barrier monitoring.

A third interim barrier is being designed to be placed over tanks in the SX Tank Farm. Modified asphalt was selected as the impermeable surface, and an evapotranspiration basin will be located south of the tank farm to redirect any runoff back to the atmosphere. Options for monitoring this barrier are being assessed.

Innovations in Characterization

Characterization activities in the tank farm environment are constrained due to the nature of the contaminants; by default, they are classified as mixed wastes. To reduce the cost and waste-disposal requirements associated with these materials, innovative approaches are being developed to focus characterization. The hydraulic hammer direct push and surface geophysical exploration approaches are examples that have been deployed. Two new technologies were under development during 2010; Time-Domain ElectroMagnetics and a technetium-99 discriminating beta detector.

- Time-Domain ElectroMagnetics is being developed as a tool to identify the locations of historical releases from waste transfer pipelines. A proof-of-principle deployment in 2010 showed that there is significant promise in this approach. The goal is to provide direct cleanup to areas where environmental insult has occurred and prevent unnecessary procedures at uncontaminated sites.
- In the tank farm environment, technetium-99 is the predominant risk driver; it is long-lived and exists in a mobile form. The measurement of technetium-99 decay is via a low-energy beta particle that requires laboratory analysis to quantify. Working with researchers at the Idaho National Laboratory, an innovative down-hole sensor passed a series of proof-of-principle tests, detecting and differentiating technetium-99 at activities as low as one picocurie per gram in the presence of background levels of potassium-40. Further development of this valuable tool was passed to the DOE Office of Science in 2010, as its potential extends beyond Hanford Site vadose zone applications.

6.4.1.3 Double-Shell Tanks

AL Hummer

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, and includes emergency pumping space available at all times for 3.8 million liters (1 million gallons).

At the end of 2010, there were 98 million liters (26.0 million gallons) of waste in the double-shell tanks.

6.4.2 DOE Office of River Protection Progress on Defense Nuclear Facilities Safety Board Recommendations Regarding the Underground Waste Storage Tanks and Associated Facilities

LM Gamache

Throughout 2010, the DOE Office of River Protection and its contractors met with and provided information to the Defense Nuclear Facilities Safety Board and its technical staff

to resolve concerns regarding Hanford Site underground storage tank farm projects. The following technical topics were addressed in 2010:

- Revisions to the *Tank Farms Documented Safety Analysis* (RPP-13033, Rev. 3) and the *222-S Laboratory Documented Safety Analysis* (HNF-12125, Rev. 4) to implement the following:
  - current guidance on Specific Administrative Controls
  - assessments of the adequacy of Specific Administrative Control implementation by the tank farms contractor and DOE Environmental Management staff
  - reviews of all tank farm signage and labels to ensure information is current
  - upgrades to software quality assurance documentation for support of the waste compatibility assessment
- Concerns related to work planning, the control program, and the overall Integrated Safety Management at Hanford Site tank farms.

6.5 Hanford Tank Waste Treatment and Immobilization Plant

JF Schneider

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. The plant comprises four major facilities now under construction (Pretreatment Facility, High-Level Waste Vitrification Facility, Low-Activity Waste Vitrification Facility, and Analytical Laboratory), along with 20 support buildings and the associated underground utilities.

During 2010, Hanford Site contractors made significant progress on the Hanford Tank Waste Treatment and Immobilization Plant Project. The initial fifth lift concrete walls were installed at the Pretreatment Facility, reaching nearly 30 meters (98 feet) in elevation. In addition, a 27-metric ton (30-ton)-capacity overhead crane was installed in the hot cell, along with a 77-metric ton (85-ton) shield door.

Engineers for the High-Level Waste Vitrification Facility completed the heating, ventilation, and air-conditioning system design, which will contain more than 544 metric tons (600 tons) of materials and nearly 150 major pieces of equipment. Construction crews for the facility completed precision installations for four protective shield doors in the facility's melter area; two of the doors are 12 metric tons (14 tons), and two are 45 metric tons (50 tons).

Two 113-metric ton (125-ton) melter assemblies to be installed in the Low-Activity Waste Vitrification Facility were delivered and offloaded at the construction site in 2010. They will be the world's largest waste-processing melters in operation.

During 2010, engineers completed the design for the Analytical Laboratory facility's mechanical systems. Additionally, autosampling system equipment for the Analytical Laboratory and Low-Activity Waste Facility was received. The autosampling equipment is an essential quality control system that will ensure accurate waste characterization. In addition, crews continued to install underground piping for the Anhydrous Ammonia Facility and air-receiving tanks and piping for the Glass Former Building at the Balance of Facilities.

In September 2010, the Hanford Tank Waste Treatment and Immobilization Plant construction site was awarded the U.S. Department of Energy Voluntary Protection Program Star status for outstanding safety and health programs. Star status is the highest level of recognition under the program.

As of December 2010, the overall project is approximately 57% complete, including the following:

- Approximately 81% design complete
- Approximately 60% construction complete on the Balance of Facilities
- Approximately 64% construction complete on the Low-Activity Waste Facility
- Approximately 69% construction complete on the Analytical Laboratory
- Approximately 33% construction complete on the Pretreatment Facility
- Approximately 33% construction complete on the High-Level Waste Vitrification Facility.

From project inception through 2010, the Hanford Tank Waste Treatment and Immobilization Plant placed 158,600 cubic meters (5.6 million cubic feet) of concrete; erected 15,600 metric tons (17,200 tons) of structural steel; installed 69,200 meters (227,000 linear feet) of pipe; and 85,600 meters (280,900 linear feet) of cable and wire.

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

LM Gamache

Throughout 2010, the DOE Office of River Protection and its contractors met with and provided information to the Defense Nuclear Facility Safety Board and its technical staff to resolve commitments and review the following technical topics regarding the Hanford Tank Waste Treatment and Immobilization Plant Project:

- Participated in a Defense Nuclear Facilities Safety Board public meeting in Richland, Washington, which focused on technical areas of the Hanford Tank Waste Treatment and Immobilization Plant. Technical areas discussed included changes resulting from modification of material-at-risk; design strategies to address hydrogen in piping and ancillary vessels; safety-related concerns related to the pulse jet mixing system; reclassification of safety-related systems, structures, and components; and safety-related design aspects of new facilities or modifications of existing facilities needed to deliver high-level waste feed.
- Closed the commitment concerning structural steel analysis and design for the Hanford Tank Waste Treatment and Immobilization Plant. Summary structural design reports for the Pretreatment and High-Level Waste Facilities were finalized following modification of calculation methodologies based on revised ground motion criteria.
- Resolved and closed 31 issues evaluated by the external flowsheet review team.
- Implemented recommendations from the material-at-risk expert team, leading to an improved unit liter dose calculation and more realistic modeling of hydrogen generation.

In 2010, Bechtel National, Inc. assembled an independent review team to evaluate a new design approach for the hydrogen in piping and ancillary vessels of the Pretreatment Facility. The team charter was to review the design criteria and methodology developed to address safety-related issues and the effects of postulated hydrogen events in piping and components in the Pretreatment Facility. The review was intended to ensure the criteria and methodology provide a technically defensible and conservative approach to ensure the safety and reliability of the Hanford Tank Waste Treatment and Immobilization Plant design of piping and ancillary vessels. The independent review team concluded that "On the basis of its technical reviews described in subsequent chapters of this report [independent review team report], the IRT [independent review team] concludes that the new design approach for HPAV [hydrogen in piping and ancillary vessels] affected piping and components is acceptable provided BNI [Bechtel National, Inc.] improves the models, assumptions, and methodology involved in the approach to resolve the IRT's [independent review team's] findings." The independent review team identified 35 findings essential to improve the models, assumptions, and methodology of the hydrogen in piping and ancillary vessels design approach. These are currently being addressed by Bechtel National, Inc., and resolution of all findings is expected by June 2011.

6.7 Scientific and Technical Contributions to Hanford Site Cleanup

PR Bredt and MD Freshley

In 2010, Pacific Northwest National Laboratory addressed Hanford Site challenges in chemical and nuclear waste processing and subsurface science and remediation. Pacific Northwest National Laboratory researchers supported DOE and its contractors, as well as the DOE Office of Science and DOE Office of Technology Innovation and Development, by performing evaluations, analyzing data, providing reviews, preparing and operating special facilities, and creating new technologies to address site cleanup challenges.

Pacific Northwest National Laboratory researchers completed several investigations to assist with remediation of contaminated soils and groundwater at the Hanford Site in the area of subsurface science and remediation. Pacific Northwest National Laboratory developed the *Long-Range Deep Vadose Zone Program Plan* (DOE/RL-2010-89, Rev. 0). The plan summarizes DOE's state of knowledge about contaminant remediation challenges in the deep vadose zone beneath the Central Plateau of the Hanford Site and the approach to solving the challenges. This document provides the foundation for the formation of the Deep Vadose Zone Applied Field Research Initiative. Led by Pacific Northwest National Laboratory, this initiative is a collaborative effort that leverages DOE investments in basic science to address the most intractable characterization, monitoring, predictive modeling, and remediation challenges of the deep vadose zone. The initative will provide a technical basis to quantify, predict, and monitor natural and post-remediation contaminant discharge from the vadose zone to the groundwater and to facilitate developing in situ solutions that limit contaminant discharge into the underlying groundwater and protect water resources. This knowledge will be used to transform fundamental science innovation into practical applications deployed by site contractors at the Hanford Site and across the DOE complex. The framework of the Deep Vadose Zone Applied Field Research Initiative removes administrative obstacles, prevents duplication of effort, maximizes resources, and facilitates development of the scientific foundation needed to make sound and defensible remedial decisions that will successfully meet the targeted cleanup goals in a manner acceptable to regulatory agencies.

Pacific Northwest National Laboratory researchers completed studies assisting with the development, design, and implementation of a treatability test to address deep vadose zone contamination on the Hanford Site Central Plateau. Studies included laboratory and modeling efforts in support of evaluating soil desiccation (PNNL-20146), designing a field test for uranium sequestration (PNNL-20004), in situ grouting (PNNL-20051), and in situ soil flushing (PNNL-19938). Pacific Northwest National Laboratory assisted CH2M HILL Plateau Remediation Company with implementation of a field-scale desiccation test initiated in 2010. The phenomenon of vadose zone pore water extraction, as observed during desiccation field site characterization, was evaluated in a modeling study funded by the DOE Richland Operations Office (PNNL-SA-74945). Pacific Northwest National Laboratory also developed studies related to vapor-phase vadose zone contamination and its impact on groundwater and published the results in the open literature (Brusseau et al. 2010; Oostrom et al. 2010). Laboratory scientists also contributed to a treatability test plan to conduct mass flux tomographic characterization of carbon tetrachloride in the vadose zone (DOE/RL-2010-79, Revision 0). These efforts are supporting remediation activities for carbon tetrachloride vadose zone contamination in the 200-West Area.

Pacific Northwest National Laboratory performed treatability testing to quantify the ability of selected activated carbon products and ion-exchange resins to adsorb uranium and technetium from the 200-West Area groundwater. Pacific Northwest National Laboratory reports documenting the results were published in December 2010 (PNNL-20135, PNNL-20136) and February 2011 (Smith 2010[a]). The results of these investigations are being used by CH2M HILL Plateau Remediation Company for the development of a 200-West Area groundwater pump-and-treat system to remove radioactive and non-radioactive hazardous constituents from groundwater beneath the area.

Pacific Northwest National Laboratory researchers are developing a method for the treatment of uranium contamination in 300 Area groundwater by polyphosphate infiltration. A field tracer infiltration test conducted in fiscal year 2010 had limited success due to unexpectedly low surface soil permeability at the 300 Area test site. To aid in locating another test site, a ring infiltrometer was designed to rapidly evaluate surface permeability by calculating the spatial distribution of the surface infiltration properties. Parallel characterization efforts were also performed, based on the evaluation of available geologic logs and a survey of available geophysical information, in preparation for supplemental surface geophysical surveys. A new 300 Area test site was selected, and a draft treatability test plan was initiated. Concurrently, intermediate-scale laboratory tests continued. Five one-dimensional columns were run to compare long-term uranium leaching for untreated and phosphate-treated sediments. Preliminary results indicate uranium effluent for phosphate-treated sediments is three to five times lower than that for untreated sediment.

Due to the difficulties encountered with infiltrating phosphate reagents at the 300 Area, alternative phosphate delivery technologies were examined, including shear-thinning fluid delivery, foam delivery, and water mist delivery. Shear-thinning fluids were selected as the most promising method. During 2010, laboratory studies were conducted to evaluate design parameters of interest for emplacement of phosphate amendments in shear-thinning fluids.

Pacific Northwest National Laboratory researchers are testing phytoextraction using willow shrubs for potential use at the 100-N Area for extracting strontium-90 from the riparian zone. Results showed that coyote willows could be effective at producing enough biomass to efficiently remove strontium-90 from the riparian zone along the Columbia River. In the third year of growth (2009), the biomass of the willows exceeded projected growth by more than a factor of three. A final report was published in January 2010 (PNNL-19120). The remainder of 2010 was devoted to preparation of a phytoremediation treatability test plan for the 100-N Area (DOE/RL-2010-70, Draft A). The new test will be conducted at a site contaminated with strontium-90 in the 100-N Area.

Pacific Northwest National Laboratory continued research in the 300 Area as part of the DOE Office of Science Environmental Remediation Science Program to characterize the uranium-contaminated subsurface, examine fundamental science issues important to contaminant transport and groundwater remediation, and support future cleanup decisions at the Hanford Site and other DOE sites. Significant progress in 2010 included the quantification of wellbore flows in the fully screened wells and testing of mitigation methods; geostatistical model development of hydrologic and geochemical properties, including the distribution of uranium in sediments; development and assignment of parameters for a reactive transport model of the zone that supplies contaminant uranium to the groundwater plume; completion of a second passive experiment of the spring water table rise and fall event and an associated multi-point tracer test demonstrating a significant release of uranium into the groundwater; and model simulation of previous injection experiments. Efforts continued to assimilate geophysical and characterization data into a model of the Integrated Field Research Challenge site. Results are being used to update the conceptual model for uranium contamination in the 300 Area subsurface and will provide the technical basis for remediation strategies.

Pacific Northwest National Laboratory continued to provide support to the Hanford Tank Waste Treatment and

(a) Smith RM. 2010. "Final Report – Technetium-99 Adsorption on Ion-Exchange Resins – Batch Testing." Letter report to ME Byrnes (CH2M HILL Plateau Remediation Company) from RM Smith (Pacific Northwest National Laboratory), dated February 11, 2011, Richland, Washington.

Immobilization Plant by resolving waste processing and performance issues. Staff has provided the initial basic understanding of technetium-99 behavior in both high-level waste melters and in low-activity waste forms. Resolution of the fate of technetium-99 is one of the key issues facing the DOE Office of Environmental Management.

In addition, Pacific Northwest National Laboratory has conducted fundamental engineering development to support resolution of the mixing issues associated with the Hanford Tank Waste Treatment and Immobilization Plant. Staff is working with the Bechtel National, Inc. team to identify necessary and sufficient testing to demonstrate large-scale mixing. Pacific Northwest National Laboratory has led an effort develop fundamental models of the mixing process to facilitate a broader understanding of the processing of mixed metal oxide–hydroxide slurries. Finally, researchers have developed a transformational "lattice kinetics" high-performance computing model for multi-phase flow—including chemically reactive mixtures—to enable the design, construction, and optimization of slurry operations.

Progress was made on the Hanford Tank Waste Treatment and Immobilization Plant waste feed delivery process. Pacific Northwest National Laboratory researchers extended the principles of ultrasonics to develop three new methods—pulse echo, ultrasonic Doppler, and ultrasonic attenuation—to determine the motion of solids in a pipe in real time. This information is critical to transferring feed from the tank farms to the Hanford Tank Waste Treatment and Immobilization Plant without plugging the transfer piping. In addition to increasing cost and schedule, plugging represents a significant safety hazard to worker health and the environment.

During 2010, Pacific Northwest National Laboratory also completed essential characterization of K Basin sludge. Data are being used to establish the nuclear material accountability values for the K-West Basin floor and pit sludge inventory and to support the final design of equipment for sludge disposition.

6.8 References

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7.0 Hanford Site Closure Activities

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

7.0.1 Radiological Release of Property from the Hanford Site

WM Glines

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

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

No property with detectable residual radioactivity above authorized levels was released from the Hanford Site in 2010.

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

WM Glines

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

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

Accordingly, in May 2006, a request to DOE was submitted by Washington Closure Hanford, LLC, the prime contractor for the River Corridor Closure Contract, to increase the release criteria (authorized limits) for hard-to-detect radionuclides. The requested authorized limits would apply only to beta-gamma surface contamination on potentially contaminated equipment and materials, and exclude volumetric contamination (contamination that is distributed throughout the volume of the property), contamination in or on persons, unrestricted release of metals, and alpha-surface contamination. Detailed radiological analyses were performed to demonstrate these authorized limits would be protective of human health and the environment. Based on these analyses, the authorized limits would result in a dose of less than 1 millirem (10 microsievert) in any year to the maximally exposed individual and a collective dose of less than 10 person-rem (0.1 person-sievert) to any exposed population. These authorized limits (Table 7.0.1) were reviewed by DOE Richland Operations Office and DOE Headquarters personnel and approved for use by Washington Closure Hanford, LLC in May 2007.

In 2008, the DOE Richland Operations Office provided conditional approval to CH2M HILL Plateau Remediation Company and Fluor Hanford, Inc. to use the hard-to-detect authorized limits.

In June 2009, Washington River Protection Solutions LLC submitted a request to the DOE Office of River Protection for approval to use these hard-to-detect authorized limits. The DOE Office of River Protection provided conditional approval for this request in June 2009. In October 2009, Mission Support Alliance, LLC submitted a request to the DOE Richland Operations Office for approval to use these hard-to-detect authorized limits. The DOE Richland Operations Office provided conditional approval for this request in November 2009.

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

Average (dpm/100 cm^2)	Maximum (dpm/100 cm^2)	Removable (dpm/100 cm^2)
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.

In 2010, over 10,000 individual items (primarily small items such as flashlights, hard hats, radios, cameras, pens and pencils, respiratory protection [air-purifying respirator masks, powered air-purifying respirator blower packs, hoses, and belts]; radiological control instruments [hand-held survey instruments, supplemental dosimetry instruments, and air sampling equipment]; and industrial hygiene instruments [oxygen meters, temperature gauges, and air samplers]) were radiologically cleared using these hard-to-detect authorized limits. The estimated total residual radioactivity for these items was less than 5 curies, but no property with detectable residual radioactivity was released from the Hanford Site using these hard-to-detect authorized limits in 2010.

Radiological Clearance of Hanford Site Railroad Track

A specific use of these approved authorized limits for select hard-to-detect radionuclides in 2010 was the radiological clearance and release of Hanford Site railroad track. Because railcars transporting radioactive materials had traversed this railroad track, it was considered to potentially contain residual radioactivity and was required to be surveyed and released in accordance with the requirements of DOE Order 5400.5, Chg 2. These hard-to-detect authorized limits, in conjunction with the surface contamination guidelines provided in DOE

Order 5400.5, Chg 2, as modified by DOE (DOE/EH-412) (Table 7.0.2), were used to radiological clear approximately 21.5 miles of railroad track from various locations on the Hanford Site. This railroad track was subsequently released for use in refurbishment of vintage railroad tracks across the United States.

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

WM Glines

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

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

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

Requested authorized limits were developed using realistic and conservative radiation dose analyses based on the "likely

Table 7.0.2. Surface Contamination Values Used for Radiological Clearance of Hanford Site Railroad Track

Radionuclides	Average (dpm/100 cm^2)	Maximum (dpm/100 cm^2)	Removable (dpm/100 cm^2)
Transuranics, iodine-125, iodine-129, radium-226, actinium-227, radium-228, thorium-228, thorium-230, protactium-231	100	300	20
Thorium-natural, strontium-90, iodine-126, iodine-131, iodine-133, radium-223, radium-224, uranium-232, thorium-232	1,000	3,000	200
Uranium-natural, uranium-235, uranium-238, and associated decay products, alpha emitters	5,000	15,000	10,000
Exempted beta-gamma emitters: carbon-14, iron-55, nickel-59, nickel-63, selenium-79, technetium-99, palladium-107, europium-155	50,000	150,000	10,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except strontium-90, tritium, and others noted above and below	5,000	15,000	1,000
Tritium and tritiated compounds	N/A	N/A	10,000

N/A = Not applicable.

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

The DOE Richland Operations Office coordinated review of this authorized limit request with the U.S. Nuclear Regulatory Commission. Based on a review of DOE's process for developing authorized limits, the U.S. Nuclear Regulatory Commission established that coordination was appropriate to ensure that site-specific release limits and survey and review protocols were 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 exposure of less than 1 millirem/year (10 microsievert/year) to any individual and a minimal collective dose. The analyses performed for these authorized limits indicate that any actual releases would meet these criteria. Following review by the DOE Richland Operations Office and DOE Headquarters personnel, these authorized limits (Table 7.0.3) were approved for use by Fluor Hanford, Inc. in August 2007. In October 2008, CH2M HILL Plateau Remediation Company assumed responsibility from Fluor Hanford, Inc. for all Hanford Site groundwater remedial actions. In anticipation of this transfer of responsibility, in September 2008, CH2M HILL Plateau Remediation Company submitted a request to the DOE Richland Operations Office for approval to use the authorized limits for resin previously approved for Fluor Hanford, Inc. The DOE Richland Operations Office approved this request for CH2M HILL Plateau Remediation Company in October 2008.

Table 7.0.3. 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

In 2010, approximately 175,000 kilograms (386,000 pounds) of resin was shipped offsite for regeneration under these approved authorized limits.

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

WM Glines

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

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

Each of these systems use granular activated carbon canisters to capture the volatile organic compounds removed during

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

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

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

The DOE Richland Operations Office coordinated review of this authorized limit request with the U.S. Nuclear Regulatory Commission. Based on a review of DOE's process for developing authorized limits, the U.S. Nuclear Regulatory Commission established that coordination was appropriate to assure that site-specific release limits and survey and review protocols were 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 exposure of less than 1 millirem/year (10 microsievert/year) 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 by Fluor Hanford, Inc. in August 2007. In October 2008, CH2M HILL Plateau Remediation Company assumed responsibility from Fluor Hanford, Inc. for all Hanford Site groundwater remedial actions. In anticipation of this responsibility transfer, in September 2008 CH2M HILL Plateau Remediation Company submitted a request to the DOE Richland Operations Office for approval to use the authorized limits for granular activated carbon previously approved for Fluor Hanford, Inc. The DOE Richland Operations Office provided approval for this request to CH2M HILL Plateau Remediation Company in October 2008.

In June 2010, CH2M HILL Plateau Remediation Company submitted a request to the DOE Richland Operations Office to modify these approved authorized limits for offsite shipment and regeneration of granular activated carbon. This modification was requested because of a significant increase in groundwater treatment activities with a resultant increase in the amount of granular activated carbon requiring offsite shipment and regeneration. Following review by DOE Richland Operations Office and DOE Headquarters personnel, these modified authorized limits (Table 7.0.4) were approved for use by CH2M HILL Plateau Remediation Company in October 2010.

In 2010, approximately 56,200 kilograms (124,000 pounds) of granular activated carbon was shipped offsite for regeneration under these approved modified authorized limits.

Table 7.0.4. Approved Authorized Limits for Offsite Shipment and Regeneration of Granular Activated Carbon

Radionuclide	Authorized Limit (pCi/g)
Tritium	300,000
Carbon-14	3,000
Cobalt-60	21
Selenium-79	2,000
Strontium-90	100
Technetium-99	500
Iodine-129	50
Cesium-137	80
Europium-152	40
Europium-154	40
Europium-155	700
Protactinium-231	10
Thorium-232 plus progeny	6
Uranium-234	100
Uranium-235	100
Neptunium-237	50
Plutonium-238	26
Uranium-238 plus short-lived progeny	100
Plutonium-239	24
Plutonium-240	2,472
Americium-241	29

7.0.2 Columbia River Corridor Mission Completion

JA Lerch

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

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

The last two items are being addressed under the River Corridor Closure Contract by the Environmental Protection Mission Completion Project. Key project scope includes assessment and integration activities (http://www.washingtonclosure.com/projects/environmental_protection/mission_completion/assessment_integration/) and long-term stewardship transition support (http://www.washingtonclosure.com/projects/environmental_protection/mission_completion/long-term_stewardship/). Ongoing, open communication among the various parties interested in Hanford Site cleanup continued in 2010 as work progressed in these areas.

7.0.2.1 Assessment and Integration

JA Lerch

River Corridor Baseline Risk Assessment. DOE's cleanup process for the Columbia River Corridor is based on CERCLA requirements. In 1991, DOE, EPA, and the Washington State Department of Ecology (Tri-Party Agreement agencies) agreed that interim remedial actions in the 100 and 300 Areas could be implemented by relying on streamlined qualitative risk assessments to establish interim cleanup levels. A comprehensive, quantitative baseline risk assessment would be prepared at a later time to support final cleanup decisions. Waste-site cleanup under interim action records of decision was initiated during the mid-1990s and Washington Closure Hanford, LLC plans to complete this work by 2015. The contractor's current focus is to complete the remedial actions so the Tri-Party Agreement agencies can proceed to final CERCLA closeout of the 100 and 300 Areas.

A critical step in proceeding toward final CERCLA closeout is completing the River Corridor Baseline Risk Assessment, the quantitative baseline risk assessment that Washington Closure Hanford, LLC is conducting.

Collection of environmental and biological samples to support development of the River Corridor Baseline Risk Assessment was initiated in 2005 and completed in 2006. Additional sampling for the riparian and near-shore environments of the River Corridor within the reactor and operational areas was conducted in 2006 and 2007. Results from these sampling efforts, combined with relevant existing data, are being used in the preparation of the River Corridor Baseline Risk Assessment.

The human health risk assessment portion of the *River Corridor Baseline Risk Assessment* (DOE/RL-2007-21, Draft C, Vol. II) was released for regulatory and stakeholder review in late December 2010. The ecological risk assessment portion of the *River Corridor Baseline Risk Assessment* (DOE/RL-2007-21, Draft C, Vol I) is currently scheduled for regulatory and stakeholder review beginning in September 2011. Together, these reports present a comprehensive assessment of the River Corridor, addressing all relevant sources of contamination, exposure pathways, and contaminants. The reports also provide an analysis of relevant uncertainties and recommendations. Finally, preliminary remediation goals that are protective of human health and the environment are proposed to support development of final action cleanup decisions through the remedial investigation/feasibility study process for the River Corridor.

Remedial Investigation of Hanford Site Releases to the Columbia River. A remedial investigation under CERCLA has been initiated to evaluate the potential impacts to the Columbia River from Hanford Site-related hazardous substances released from waste sites along the River Corridor and to support final cleanup decisions. The *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River* (DOE/RL-2008-11) was completed in October 2008. The sampling, which included locations above Wanapum Dam, focused on areas within the Hanford Reach and Lake Wallula downstream to McNary Dam, including some locations in the vicinity of the Bonneville Dam, was completed in June 2010. Sample media included Columbia River water and incoming irrigation return discharges; pore water, sediment, soils on islands throughout the Hanford Reach; and collection and analysis of six different fish species. In 2008, workers initiated an evaluation of groundwater upwelling within the Hanford Reach of the Columbia River from the 100 Areas downriver to the 300 Area. The initial phases completed in 2009 included measurements of pore-water specific conductance, temperature, and a screening analysis of key Hanford Site indicator contaminants. The final phase of sampling of pore water, sediment, and river water at selected locations was initiated in fall 2009 and was completed in February 2010.

Following completion of field work in 2010 all analytical data was compiled and assessed for its suitability for use in risk assessments. Workers have initiated the process to conduct baseline ecological and human-health risk assessments to estimate the current risk to humans, animals, and plants; potential impacts from Hanford Site-related contaminants; and determine whether cleanup actions are needed. These assessments are scheduled to be available for regulatory review during 2011.

River Corridor Remedial Investigation/Feasibility Study Process. In 2010, Washington Closure Hanford, LLC supported the development of integrated source and groundwater remedial investigation/feasibility study work plans and sampling and analysis plans for the six River Corridor decision areas (100-B/C, 100-K, 100-N, 100-D, 100-H, 100-F/IU-2/IU-6), and the 300 Area. Work plans and associated sampling and analysis plans for 100-B/C (DOE/RL-2008-46-ADD3, Rev. 0; DOE/RL-2009-44, Rev. 0); 100-K (DOE/RL-2008-46-ADD2, Rev. 0; DOE/RL-2009-41, Rev. 0); 100-D/H (DOE/RL-2008-46-ADD1, Rev. 0; DOE/RL-2009-40, Rev. 0); 100-F/IU-2/IU-6 (DOE/RL-2008-46-ADD4, Rev. 0; DOE/RL-2009-43, Rev. 0); and the 300 Area (DOE/RL-2009-30, Rev. 0; DOE/RL-2009-45, Rev. 0) were approved in 2010. Field data collection and remedial investigation/feasibility study report preparation is ongoing and expected to continue through 2011. The 100-N work plan and sampling and analysis plan (DOE/RL-2008-46-ADD5, Rev. 0; DOE/RL-2009-42, Rev. 0) were approved in early 2011, and field activities are ongoing. Submittal of draft remedial investigation/feasibility study reports and proposed plans for all six decision areas are required by the end of calendar year 2012 in accordance with Tri-Party Agreement milestone M-015-00D.

7.0.2.2 River Corridor Long-Term Stewardship

CS Cearlock

The long-term stewardship transition task is focused 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 action reports for each CERCLA-source operable unit and development of long-term stewardship transition and turnover package documents. 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 2010, workers completed orphan site evaluations and issued reports for the 300 Area (OSR-2010-0002, Rev. 0); 400 Area (OSR-2010-0003, Rev. 0); Segment 1 of the 100-F/IU-2/IU-6 Area (OSR-2009-0002, Rev. 0); and Segment 2 of the 100-F/IU-2/IU-6 Area (OSR-2010-0001, Rev. 0). Workers also initiated evaluations for Segments 3, 4, and 5 of the 100-F/IU-2/IU-6 Area.

7.0.3 References

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8.0 Environmental and Resource Protection Programs

U.S. Department of Energy (DOE) Orders 450.1A and 5400.5, Chg 2 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 (Section 4.0). 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 implementation guidance for Hanford Site monitoring programs and projects. The plan contains the rationale for the required programs and projects, including design criteria, sampling locations and schedules, quality assurance requirements, program and project implementation procedures, analytical procedures, and reporting requirements. The early identification of—and appropriate response to—potentially adverse environmental and resource effects associated with DOE operations are confirmed by the following:

- Pre-operational environmental characterization, assessments, and evaluations
- Effluent and emissions monitoring
- Environmental monitoring and surveillance (as defined in DOE Order 5400.5, Chg 2 and in Appendix B of this report, "Glossary")
- Cultural resources monitoring
- Controlling and monitoring of contaminated and undesirable biota.

Objectives of the monitoring programs include the following:

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

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

- Complying with and confirming site compliance with DOE Orders and local, state, and federal laws and regulations
- Verifying the efficacy of waste-management practices at the Hanford Site

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

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

8.0.1 Effluent and Near-Facility Environmental Monitoring Programs

JJ 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.

8.0.1.1 Liquid Effluent and Airborne Emissions Monitoring

Hanford Site contractors perform real-time monitoring of liquid effluent and airborne emissions at each facility to assess the effectiveness of effluent and emissions treatment and control systems as well as pollution-management practices. Monitoring is also conducted to determine facility and site compliance with state and federal regulatory requirements. Section 8.3 and an annual environmental release report (e.g., HNF-EP-0527-20) summarize information about effluent discharged from Hanford Site facilities in 2010. Section 8.1 and other reports (e.g., DOE/RL-2011-12, Rev. 0) summarize air emissions data for 2010.

8.0.1.2 Near-Facility Environmental Monitoring

Near-facility environmental monitoring is conducted near DOE facilities and operations at 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; inactive nuclear facilities, such as N Reactor, the Plutonium Finishing Plant, 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 includes 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, Chg 1, 450.1A, and 5400.5, Chg 2; DOE Manual 231.1-1A, Chg 2; 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. Surface contamination and external radiation levels are also 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; disposal sites for stabilized waste; roads; and firebreaks in and around 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:

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

Contamination incidents investigated in 2010 focused on soil, vegetation, wildlife, and wildlife-related materials (e.g., bird nests, animal feces). Most materials were surveyed in the field to detect radioactive contamination. Some materials were sampled, and the samples were submitted for laboratory analysis. Laboratory analysis results and field survey readings for contamination incidents investigated in 2010 are available upon request (see Preface for contact information).

Sections 8.2, 8.9, 8.10, and 8.11 summarize information about contaminant concentrations or radiation levels measured onsite near facilities and operations during 2010. Table 8.0.1 summarizes the type and general locations of samples collected for near-facility monitoring during 2010. Sections 8.9 and 8.10 summarize information about contamination incidents investigated during 2010.

8.0.2 Public Safety and Resource Protection Program Projects

JP Duncan

In 2010, the Public Safety and Resource Protection Program for the Hanford Site was managed by Pacific Northwest National Laboratory for the DOE Richland Operations Office. Projects include the Ecological Monitoring and Compliance Project, the Meteorological and Climatological Services Project, the Surface Environmental Surveillance Project, and the Cultural Resources Project. These projects are designed to monitor the Hanford Site environment; reassure the public that the Hanford Site is operating in compliance with applicable environmental regulations; and conduct impact assessments to protect the public, worker safety, and cultural and ecological resources. Surveillance data concerning environmental effects 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.

Table 8.0.1. Routine Environmental Monitoring Samples and Locations Near Hanford Site Facilities and Operations, 2010

Sample Type	No. of Samples	Operational Area										
		100-K	100-N	100-D	100-F	100-H	200-East	200-West	300/400	200-North	600	ERDF[a]
Air	99	15	3	4	3	4	21	28	3	4	9	5
Soil	85	2	3	0	6	4	16	24	13	0	16	1
Vegetation	62	0	3	0	0	0	10	23	11	0	15	0
External radiation	119	18	5	0	0	0	43	24	21	1	4	3

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

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

8.0.2.1 Meteorological and Climatological Services Project

The Meteorological and Climatological Services Project provides support to DOE and Hanford Site contractors to reassure the public that activities conducted at the site that may be affected 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 and, if necessary, response actions.

Comprehensive meteorological records are maintained for other applications as well, including environmental impact statements, dose reconstruction, post-accident analyses, or building design. Section 8.16 summarizes meteorological data for 2010, including some historical climatological information.

8.0.2.2 Surface Environmental Surveillance Project

Surface Environmental Surveillance Project personnel are 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 for determining the potential effects of these materials to the environment and 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 at 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, if they occur, are reported to the DOE Richland Operations Office and appropriate facility managers on a timely basis.

Through the Surface Environmental Surveillance Project, personnel follow general requirements and objectives: monitor routine and non-routine contaminant releases to the environment from DOE facilities and operations, assess doses to members of the public, monitor potential impacts of contaminants on other biota, and alert DOE to the possible need for corrective action (DOE Orders 450.1A and 5400.5, Chg 2; *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* [DOE/EH-0173T]).

Specific objectives of the monitoring activities include the following:

- Collect and analyze samples, review and interpret analytical data, and maintain and oversee a long-term computer database for trend analysis
- Determine compliance with applicable environmental quality standards, public exposure limits, and applicable laws and regulations; requirements of DOE Orders; and environmental commitments made in environmental impact statements, environmental assessments, safety analysis reports, or other official DOE documents
- Perform pre-operational assessments
- Assess radiological doses to the public and environment
- Assess doses from other local sources
- Report alarm levels and potential doses exceeding exposure 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 trend predictions
- 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 in predicting environmental pollutant concentrations
- Detect and quantify unplanned releases
- Identify and quantify new environmental quality problems
- Maintain the capability to assess the consequences of accidental contaminant releases
- Reassure the public and addressing issues of concern to the public, stakeholders, regulatory agencies, and business community
- Increase 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 8.0.1.2 and the Soil and Groundwater Remediation Project (Section 8.0.3).

Sections 8.2, 8.4, 8.5, 8.8, 8.10, 8.11, and 8.12 summarize information on contaminant concentrations in project samples collected at site-wide and offsite locations during 2010. More detailed contaminant data are available upon request (see Preface). The types and general locations of samples collected for site-wide and offsite environmental surveillance during 2010 are summarized in Table 8.0.2.

8.0.2.3 Ecological Monitoring and Compliance Project

The Ecological Monitoring and Compliance Project has multiple objectives that support both activity-specific ecological compliance requirements and site-wide requirements to verify that natural resources at the Hanford Site are protected. Project personnel monitor the abundance, vigor, and distribution of plant and animal populations onsite

Table 8.0.2. Types and General Locations of Samples Collected for Site-Wide and Offsite Environmental Surveillance in 2010

		Sampling Locations						
						Columbia River		
Type	Total Number of Locations	Onsite	Site Perimeter	Nearby	Distant	Upstream	Hanford Reach	Downstream
Air	40	21	11	7	1	–	–	–
Spring water	16	–	–	–	–	–	15	1
Spring sediment	10	–	–	–	–	–	9	1
Columbia River water	46	–	–	–	–	5	30	11
Irrigation water	2	–	–	2	–	–	–	–
Drinking water	4	4	–	–	–	–	–	–
River sediment	8	–	–	–	–	2	3	3
Ponds	2	2	–	–	–	–	–	–
Pond sediment	1	1	–	–	–	–	–	–
Foodstuffs	5	–	3	2	–	–	–	–
Wildlife	12	5	1	–	6	–	–	–
Aquatic biota	3	–	–	–	–	1	2	–

and evaluate the cumulative impact of Hanford Site operations on these resources. In addition, project researchers perform baseline ecological resource surveys to document the occurrence of protected resources. The surveys help researchers 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 ensure that DOE fulfills its responsibilities to protect natural resources. This project also supports multiple objectives for completing the Hanford Site waste management and environmental restoration mission through the following activities:

- 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 characterization of 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.

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. Information concerning endangered and threatened species at the Hanford Site is summarized in Section 8.13. Ecosystem and compliance monitoring information for 2010 for Hanford Site plant and animal species and communities is summarized in Section 8.14.

8.0.2.4 Tribal Affairs and Cultural Resources Program

DOE Richland Operations Office's Tribal Affairs and Cultural Resources Program personnel oversee all cultural resource activities at the Hanford Site. 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 2010 is provided in Section 8.15.

8.0.3 Soil and Groundwater Remediation Project

DL Foss

DOE, with the concurrence of the Washington State Department of Ecology and the U.S. Environmental Protection Agency (EPA), issued the *Hanford Site Groundwater Strategy: Protection, Monitoring, and Remediation* (DOE/RL-2002-59) in February 2004. The document was prepared as a collaborative effort to present "a strategy for multiple regulatory authorities and government agencies to effectively protect and restore groundwater at the Hanford Site" (DOE/RL-2002-59).

The Hanford Site groundwater strategy focuses on three key areas: groundwater protection, groundwater monitoring, and remediation of contaminated groundwater. These strategic areas are implemented through the Soil and Groundwater Remediation Project. Activities performed by the project include an ongoing monitoring and assessment program to determine the distribution and movement of existing radiological and chemical contamination in the soil and groundwater beneath the Hanford Site. The project identifies and characterizes potential and emerging groundwater contamination problems in areas of interest that have been organized and referred to as operable units. Monitoring activities in and around these operable units are conducted to comply with a variety of state and federal regulations, including the *Atomic Energy Act of 1954*, the *Resource Conservation and Recovery Act of 1976* (RCRA), the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), DOE Orders (e.g., 450.1A), and Washington State regulations, as well as requirements for operational monitoring around retired reactors and chemical-processing facilities and requirements for environmental surveillance.

Groundwater samples were collected from 11 groundwater operable units and other portions of the Hanford Site involving 1,175 monitoring wells and 145 shoreline aquifer tubes during the 2010 reporting period (January 1, 2010, to December 31, 2010). Section 8.7 summarizes groundwater monitoring activities and analytical results.

8.0.4 Drinking Water Monitoring Project

LE Bisping and LM Kelly

Public drinking water supplies on sites operated by DOE or a DOE contractor are regulated by EPA. Radiation dose limits are directed by DOE Order 5400.5, Chg 2, 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 at the Hanford Site. Water supplies at the site are provided by the city of Richland and by DOE-owned, contractor-operated, water treatment systems that 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 from the Columbia River is monitored. Section 8.6 summarizes radiological monitoring results for the Hanford Site drinking water systems in 2010.

8.0.5 Biological Control Program

AR Johnson

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

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 (groups of underground radioactive waste storage tanks); radioactive waste pumping installations; industrial sites; power stations; along transmission lines, buildings, storage, and work areas; and along fence lines. Pest control prevents, limits, or removes undesirable plants or animals by applying chemicals or by cultural or mechanical methods.

Noxious weeds are controlled onsite during most years to prevent their spread and reduce or eliminate their populations; however, in 2010 a moratorium was placed on noxious weed control, with the exception of along roadways, which will require the completion of a *National Environmental Policy Act of 1969* environmental assessment (DOE/EA-1728). A noxious weed is a legal and administrative category designated by federal or state regulatory agencies (e.g., the U.S. Department of Agriculture or Washington State Department of Agriculture). Noxious weeds are non-native, aggressively invasive, and hard to control. Damage to natural ecosystems and loss of productive agricultural lands can occur unless control measures are taken. Control measures can be mechanical, chemical, or biological. Biological control may include preventive measures or measures in response to existing contamination spread.

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

In some cases, revegetation is necessary after cleanup and removal of contamination. Revegetation is a common activity

at the Hanford Site but has specific meanings and limitations when applied to biological control. Revegetation may include removing and replacing soil, revegetating the soil surface, or placing engineered barriers to stop biological intrusion (biological barriers). Such revegetation on radioactive waste sites is typically performed to prevent recurrence of surface radioactive contamination or colonization by unwanted biota. Section 8.10 provides a description of activities conducted for the Biological Control Program in 2010.

8.0.6 Washington State Department of Health Oversight Monitoring

JJ Dorian

The Environmental Radiation Monitoring and Assessment section of the Washington State Department of Health conducts an independent oversight program on Hanford Site environmental radiation monitoring conducted by DOE contractors. During 2010, the contractors were Pacific Northwest National Laboratory and Mission Support Alliance, LLC. 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. Washington State Public Health Laboratory personnel provide a check on contractor analyses and analyze Washington State Department of Health samples. Each year, the Washington State Department of Health compares the radioactivity measurements from their samples 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 320-053).

8.1 Air Emissions

DJ Rokkan

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

Emission data are documented in this and other reports, all of which are available to the public. For instance, DOE annually submits to EPA and the Washington State Department of Health a report of radionuclide air emissions from the site (e.g., DOE/RL-2011-12, Rev. 0 for calendar year 2010) in compliance with Subpart H of 40 CFR 61 and with WAC 246-247.

8.1.1 Radioactive Airborne Emissions

Small quantities of particulate and volatilized forms of radionuclides are emitted to the environment through state and federally permitted radioactive emission point sources (i.e., stacks). Tritium (i.e., hydrogen-3), strontium-90, iodine-129, cesium-137, plutonium-238, plutonium-239/240, plutonium-241, and americium-241 are the isotopes most commonly measured in the emissions. Emission points are monitored continuously if they have the potential to exceed 1% of the standard for public dose—10 millirem (100 microsievert) per year.

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

The continuous monitoring of radioactive emissions from facilities requires analyzing samples collected at points of discharge to the environment, usually a stack. Samples are analyzed for gross alpha and gross beta as well as for selected radionuclides. Specific radionuclides are selected for sampling, analysis, and reporting 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 2010, the prime sources of emissions and the number of emission points by operating area were as follows:

- In the 100 Areas, four radioactive emission points were active. Emissions originated from normal evaporation and cleanup activities at the water-filled 100-K West Fuel Storage Basin, which in previous years contained irradiated nuclear fuel, and from the Cold Vacuum Drying Facility.
- In the 200 Areas, 39 radioactive emission points were active. The primary sources of these emission points were the Plutonium Finishing Plant, T Plant, the Waste Encapsulation and Storage Facility, underground tanks storing high-level radioactive waste, waste evaporators, the Waste Receiving and Processing Facility, and the inactive Plutonium Uranium Extraction (PUREX) Plant.
- In the 300 Area, 10 radioactive emission points were active. The primary sources of these emissions were laboratories and research facilities, including the 324 Waste Technology Engineering Laboratory, 325 Applied Chemistry Laboratory, 331 Life Sciences Laboratory, and 340 Complex Vault and Tanks.
- In the 400 Area, three radioactive emission points were active. The sources of these emissions are three facilities that have been shut down: the Fast Flux Test Facility, the Maintenance and Storage Facility, and the Fuels and Materials Examination Facility.
- In the 600 Area, two radioactive emission points were active at the Waste Sampling and Characterization Facility where low-level radiological and chemical analyses are performed on various types of samples (e.g., particulate air filters, liquids, soil, and vegetation).

Air emissions data collected in 2010 were comparable to those collected in 2009. Table 8.1.1 summarizes Hanford Site radioactive airborne emissions in 2010.

8.1.2 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 8.1.2 summarizes the emissions of non-radioactive pollutants discharged to the atmosphere on the Hanford Site during 2010. (Note: The 100 and 400 Areas have no criteria or toxic air pollutants of regulatory concern).

In previous years, gaseous ammonia has been emitted from the Plutonium Uranium Extraction (PUREX) Plant, the 242-A Evaporator, the AP Tank Farm, and the AW Tank Farm, all located in the 200-East Area. Ammonia emissions are tracked only when activities at these facilities are capable of generating them. Table 8.1.2 also summarizes reportable ammonia emissions during 2010, which were only produced in the tank farms located in the 200 Areas.

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

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

Table 8.1.1. Radionuclides Discharged to the Atmosphere on the Hanford Site, 2010

		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	7.3×10^{1}	NM
Tritium (as HTO)	12.3 yr	NM	NM	NM	2.8×10^{2}	1.8×10^{-3}[b]
Argon-37	5,700 yr	NM	NM	NM	1.3×10^{-9}[c]	NM
Cobalt-60	5.3 yr	1.7×10^{-8}	NM	NM	3.2×10^{-8}[d]	NM
Krypton-83m	154.4 ns	NM	NM	NM	1.0×10^{-9}[c]	NM
Krypton-85	10.7 yr	NM	NM	NM	4.4×10^{-1}[c]	NM
Strontium-90	29.1 yr	1.0×10^{-4}	1.6×10^{-4}	2.8×10^{-5}	5.5×10^{-6}	NM
Yttrium-90	1.5 s	NM	NM	NM	1.1×10^{-4}[d]	NM
Technetium-99	211,100 yr	NM	NM	NM	4.0×10^{-6}[d]	NM
Iodine-125	59.4 d	NM	NM	NM	3.2×10^{-7}[c]	NM
Iodine-129	16,000,000 yr	NM	1.7×10^{-3}	NM	NM	NM
Xenon-131m	11.8 d	NM	NM	NM	1.0×10^{-8}[c]	NM
Xenon-133	5.2 d	NM	NM	NM	3.0×10^{-9}[c]	NM
Xenon-135	5.2 d	NM	NM	NM	1.0×10^{-10}[c]	NM
Barium-137m	2.6 m	NM	NM	NM	2.6×10^{-6}[d]	NM
Cesium-137	30 yr	2.5×10^{-5}	1.5×10^{-5}	1.8×10^{-5}	4.1×10^{-9}	4.1×10^{-7}[e]
Samarium-151	90 yr	NM	NM	NM	1.7×10^{-6}[d]	NM
Europium-154	8.6 yr	3.3×10^{-7}	ND	ND	ND	NM
Europium-155	4.8 yr	ND	2.4×10^{-9}	ND	6.5×10^{-7}[d]	NM
Tantalum-183	5.1 d	NM	NM	NM	7.8×10^{-19}[d]	NM
Tungstun-188	69.8 d	NM	NM	NM	1.5×10^{-8}[d]	NM
Radon-220	55.6 s	NM	NM	NM	9.0×10^{1}[f]	NM
Radon-222	3.8 d	NM	NM	NM	1.4×10^{-8}[c]	NM
Thorium-228	1.9 yr	NM	NM	NM	1.8×10^{-10}[d]	NM
Thorium-232	14.1 billion yr	NM	NM	NM	8.4×10^{-12}[d]	NM
Uranium-232	68.9 yr	NM	NM	NM	5.1×10^{-9}[d]	NM
Uranium-233	159,200 yr	NM	NM	NM	2.2×10^{-8}[d]	NM
Uranium-234	245,500 yr	NM	NM	5.2×10^{-8}	3.2×10^{-9}[d]	NM
Uranium-235	704,000,000 yr	NM	NM	3.4×10^{-9}	7.8×10^{-11}[d]	NM
Uranium-236	23,420,000 yr	NM	NM	NM	2.3×10^{-11}[d]	NM
Neptunium-237	2,144,000 yr	NM	NM	4.6×10^{-9}	1.3×10^{-7}[d]	NM
Plutonium-238	87.7 yr	3.0×10^{-6}	2.0×10^{-9}	3.9×10^{-8}	4.4×10^{-7}	NM
Uranium-238	4.7 billion yr	NM	NM	4.4×10^{-8}	4.0×10^{-9}[d]	NM
Plutonium-239/240	24,110 yr	5.1×10^{-5}	1.7×10^{-6}	3.5×10^{-5}	5.8×10^{-7}	9.1×10^{-15}[g]
Americium-241	432.2 yr	1.7×10^{-5}	1.4×10^{-7}	3.1×10^{-6}	7.4×10^{-9}	NM
Plutonium-241	14.4 yr	1.2×10^{-4}	ND	1.5×10^{-5}	4.3×10^{-7}	NM
Plutonium-242	375,000 yr	NM	NM	NM	2.6×10^{-10}[d]	NM
Americium-243	7,380 yr	NM	NM	NM	1.4×10^{-7}[d]	NM
Curium-243/244	29.1 yr	NM	NM	NM	ND	NM
Californium-252	2.6 yr	NM	NM	NM	5.0×10^{-14}[d]	NM
Gross alpha	NA	2.9×10^{-5}	1.5×10^{-6}	2.2×10^{-5}	3.9×10^{-7}	ND
Gross beta	NA	8.3×10^{-5}	1.2×10^{-4}	2.6×10^{-5}	5.3×10^{-6}	4.1×10^{-7}

(a) 1 Ci = 3.7×10^{10} becquerels.
(b) This value is calculated based on the sodium inventory in the primary coolant piping system of the long-deactivated Fast Flux Test Reactor.
(c) This value derives from release records, not actual sampling-analysis measurements.
(d) This value derives from estimated facility inventory and the use of release fractions of the Appendix D method of 40 CFR 61, Subpart H, not from actual sampling-analysis measurements.
(e) This release value derives from data on gross beta emissions from 400 Area stacks.
(f) This release value conservatively calculated, not actually measured.
(g) This release value derives from data on gross alpha emissions from 400 Area stacks.
HT = Elemental tritium.
HTO = Tritiated water vapor.
NA = Not applicable.
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.
ns = Nanosecond.

Table 8.1.2. Criteria and Toxic Air Pollutants Discharged to the Atmosphere on the Hanford Site, 2010

Constituent	Release kg	Release (lb)
Particulate matter-total	1,820	(4,000)
Particulate matter-10[a]	910	(2,000)
Particulate matter-2.5[b]	0	(0)
Nitrogen oxides	9,100	(20,000)
Sulfur oxides	0	(0)
Carbon monoxide	9,100	(20,000)
Lead	0	(0)
Volatile organic compounds[c,d]	13,600	(30,000)
Ammonia[e]	14,500	(32,000)
Total criteria pollutants[f]	49,100	(108,000)

(a) Particulate matter less than 10 micrometer diameter.
(b) Particulate matter less than 2.5 micrometer diameter.
(c) The estimate of volatile organic compounds does not include emissions from certain laboratory operations.
(d) From burning petroleum to produce steam and to power electrical generators; release value also includes calculated estimates from the 200-East and 200-West Areas tank farms; evaporation losses from fuel dispensing; 200 Area Effluent Treatment Facility; Central Waste Complex; T Plant Complex; and Waste Receiving and Processing Facility.
(e) Ammonia releases are calculated estimates from the 200-East and 200-West Areas tank farms and the 200 Area Effluent Treatment Facility; the release value also includes ammonia from burning petroleum to produce steam and to power electrical generators.
(f) Criteria pollutants include particulate matter—total, nitrogen oxides, sulfur oxides, carbon monoxide, lead, and volatile organic compounds.

8.2 Ambient-Air Monitoring

BG Fritz and CJ Perkins

Atmospheric releases of radioactive materials from Hanford Site facilities and operations to the surrounding region are potential sources of exposure to humans. 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 as well as in nearby and distant communities. Information about these ambient-air monitoring efforts, including detailed descriptions of air-sampling and analysis techniques, is provided in DOE's Hanford Site environmental monitoring plan (DOE/RL-91-50, Rev. 4). Section 8.0 of this report briefly summarizes the ambient-air monitoring objectives and the projects that support them.

Comparing measured radionuclide concentrations from locations on and around the Hanford Site to concentrations measured at upwind locations assumed to be uninfluenced by Hanford Site operations provides an evaluation of the impact of radionuclide air emissions from the Hanford Site on surrounding ambient air.

In addition to 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 Hanford Site locations. Results are primarily used for scientific studies to better understand windblown dust on and around the site.

8.2.1 Ambient-Air Monitoring Near Facilities and Operations

CJ Perkins

During 2010, a network of continuously operating samplers at 91 locations across the Hanford Site was used to monitor radioactive materials in air near site facilities and operations (Table 8.2.1). Most air samplers were located at or within approximately 500 meters (1,640 feet) of sites and facilities having the potential for, or a history of, environmental releases. The samplers were primarily located in the prevailing downwind direction. Samples were collected according to a schedule established before the 2010 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. A 7-day holding period is necessary to allow for the decay of naturally occurring, short-lived radionuclides that would otherwise obscure the detection of longer-lived radionuclides associated with emissions from nuclear facilities. The gross radioactivity measurements were used to indicate changes in trends in the near-facility environment.

For most specific radionuclide analyses, the amount of radioactive material collected on a single filter during a 2-week period was too small to be measured accurately. The samples were combined into either quarterly or semiannual composite samples for each location to increase the accuracy of the analysis. Composite samples were routinely analyzed for gamma-emitting isotopes, strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240. Americium-241 and plutonium-241 were analyzed at locations associated with spent nuclear fuel processing. In addition, thorium-228, thorium-230, and thorium-232 were analyzed in composite samples collected at the 100-F Field Remediation Project (Table 8.2.1).

Figure 8.2.1 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

Table 8.2.1. Monitoring Locations and Analyses for Ambient-Air Monitoring Samples Collected Near Hanford Site Facilities and Operations, 2010

Site	Number of Samplers	EDP Code[a]	Analyses	
			Biweekly	Composite[b]
100-D Area Field Remediation Project[c]	4	N467, N468, N514, N515	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium, americium-241
100-F Area Field Remediation Project[c]	3	N519, N520, N521	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic thorium, isotopic uranium
100-H Area Field Remediation Project[c]	4	N508, N509, N510, N574	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
100-K Basins Closure (100-K Area)[c]	12	N401, N402, N403,[d] N404, N476, N477, N478, N479, N575, N576, N577, N578	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium, americium-241, plutonium-241
118-K-1 Field Remediation Project (100-K Area)[c]	3	N403, N534, N535	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
100-N Area D4 Project	3	N102, N103, N106	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium, americium-241
200-East Area	17	N019, N158, N498, N499, N957, N967, N968, N969, N970, N972, N973, N976, N977, N978, N984,[d] N985, N999	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
BC Controlled Area (600 Area)[c]	4	N572, N573, N957, N978	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium, americium-241, plutonium-241
Canister Storage Building (200-East Area)	2	N480, N481	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium, americium-241, plutonium-241
Integrated Disposal Facility (200-East Area)	2	N532, N559	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
200-West Area	25	N155, N161, N165,[d] N168, N200, N304, N433, N441, N442, N449, N456, N457, N550, N551, N554, N555, N956, N963, N964, N965, N966, N974, N975, N987, N994	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
200-North Decontamination and Demolition Project	4	N563, N564, N567, N568	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
200-UW-1 Decontamination and Demolition Project (200-West Area)	4	N168, N550, N956, N963	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
300 Area D4 Project[c]	1	N557	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
300-FF-2 Field Remediation Project (300 Area)[c]	2	N130, N527	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
Environmental Restoration Disposal Facility (200-West Area)	5	N482,[d] N517, N518, N550, N963	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
600 Area (Wye Barricade)	1	N981[e]	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium
618-10 Burial Ground	4	N548, N549, N579, N580	Gross alpha, gross beta	GEA, strontium-90, isotopic plutonium, isotopic uranium

(a) Environmental data point (EDP) code = Sampler location code.
(b) GEA = Gamma energy analysis; isotopic plutonium (plutonium-238 and plutonium 238/240); isotopic thorium (thorium-228, thorium-230, and thorium-232); isotopic uranium (uranium-234, uranium-235, and uranium-238).
(c) Pacific Northwest National Laboratory air sampling station(s) provide supplemental air monitoring data. See Table 8.2.2 for a listing of locations.
(d) Collocated sampling location with Washington State Department of Health.
(e) Collocated sampling location with Washington State Department of Health and Pacific Northwest National Laboratory.

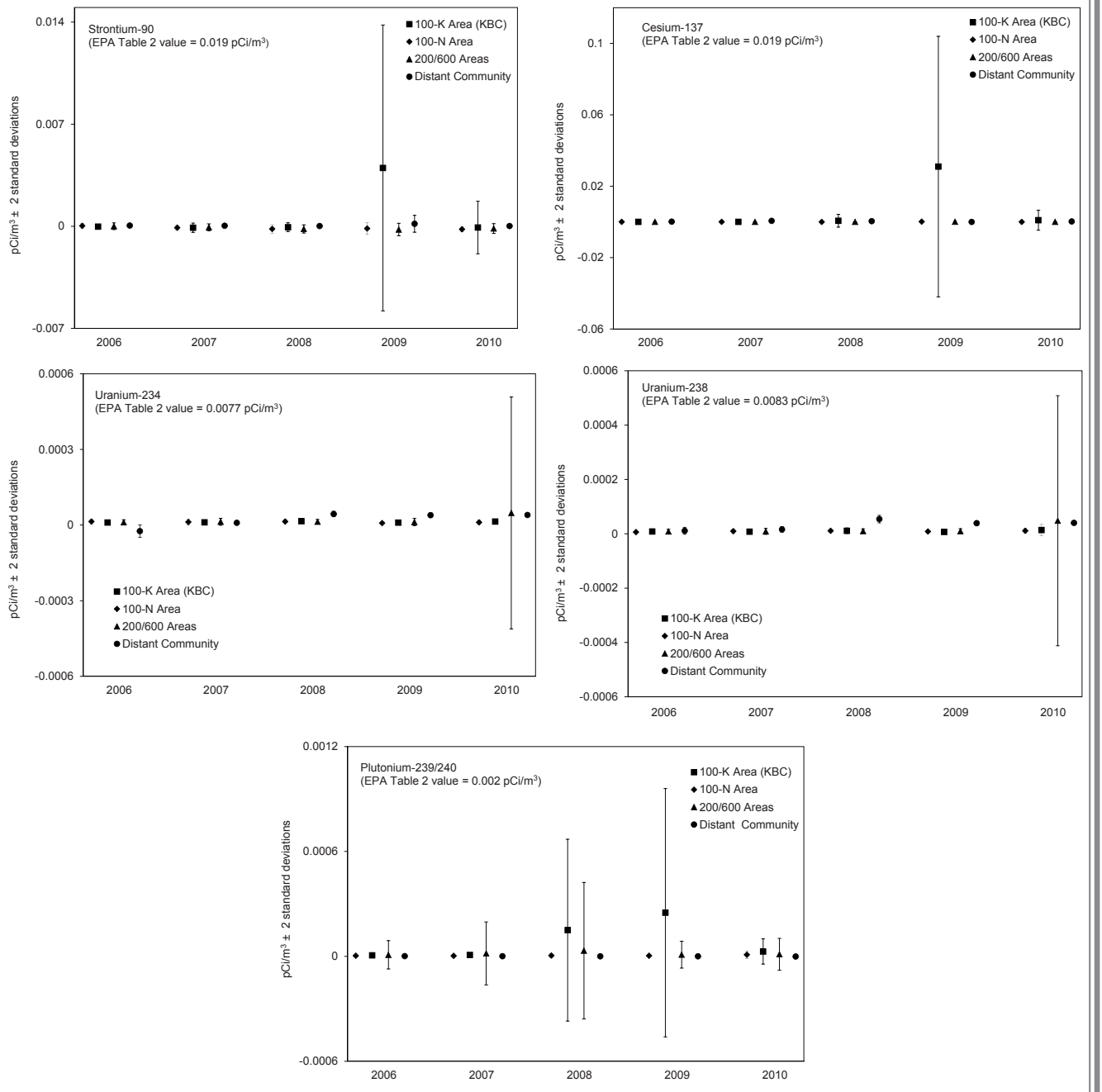

Figure 8.2.1. Average Concentrations of Selected Radionuclides in Ambient-Air Samples Collected at the Hanford Site Near Facilities and Operations Compared to Those Collected in Distant Communities, 2006 Through 2010. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol. KBC = K Basins Closure Project.

concentration values for environmental compliance (40 CFR 61, Appendix E, Table 2) are dose-based reference values used as indices 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 2010 data indicate a large degree of variability by location. Air samples collected from locations at or directly adjacent to Hanford Site facilities had higher radionuclide concentrations than samples collected farther away. In general, analytical results for most radionuclides were at or near Hanford Site background levels, which are much less than EPA concentration values but greater than those measured offsite. The data also show that concentrations of certain radionuclides were higher and widely variable within different onsite operational areas. Naturally occurring radionuclides beryllium-7 and potassium-40 were routinely identified. Appendix C, Table C.1 shows the annual average and maximum concentrations of radionuclides in air samples collected near facilities and operations during 2010.

Air monitoring results from the stations in the 100-D, 100-F, and 100-H Areas, and the 118-K-1 Field Remediation and 100-N D4 Projects were at or below typical Hanford Site levels in 2010. Uranium-234 and uranium-238 were consistently detected while plutonium-239/240 was detected in approximately 50% of the samples. The presence of americium-241 was analyzed in samples taken at the 100-D, 100-H, and 100-N Area stations and was detected in approximately 40% of those samples. Cesium-137 was detected in less than 10% of the samples and strontium-90 was not detected at any of the locations.

During 2010, ambient air was monitored at 12 locations in the 100-K Area. In June, four new monitoring locations were introduced to replace six pre-existing stations that, as the cleanup area expanded, had become too close to the work sites and as a result were producing biased ambient-air sample results. Uranium-234 and uranium-238 were consistently detected while plutonium-239/240 was detected in approximately 65% of the samples. Cesium-137 and americium-241 were detected in approximately 50% of the samples. Cesium-137 was only detected in approximately 2% of the samples collected at all other locations at the Hanford Site. During 2010, one air monitoring result (cesium-137 sampled at Station N575 in 100-K East) was greater than 10% of EPA's concentration value (40 CFR 61, Appendix E, Table 2) and was reported to the Washington State Department of Health. During the same time period, strontium-90 and cesium-137 results from the 118-K-1 station N403 were also greater than 10% of EPA's concentration value and these were reported to EPA.

Air sampling was conducted at 21 locations in the 200-East Area during 2010. Radionuclide levels measured in the 200-East Area ambient-air composite samples in 2010 were similar to those measured in previous years. Uranium-234 and uranium-238 were consistently detected while all other radionuclides were either detected in less than 10% of the samples or not at all.

Air sampling was conducted at 25 locations in the 200-West Area during 2010. Generally, radionuclide levels measured in the 200-West Area were similar to results for previous years. Uranium-234 and uranium-238 were detected in approximately 90% of the samples. Plutonium-239/240 was detected in approximately 40% of the samples. The plutonium-239/240 concentrations at air-sampling location N165 (near the 216-Z-9 Trench) were greater than 10% of the EPA concentration value (40 CFR 61, Appendix E, Table 2) for the composite samples collected during 2010. The elevated plutonium value at N165 is believed to originate from the nearby retired 216-ZP-9 Trench that received liquid waste from the Plutonium Finishing Plant until 1995. The uranium-234 and uranium-238 concentrations at air-sampling location N551 (near U Plant) were greater than 10% of the EPA concentration value (40 CFR 61, Appendix E, Table 2) for the composite samples collected during the second half of 2010. The elevated uranium results are believed to be associated with demolition activities at U Plant. Required notifications were made to the Washington State Department of Health.

Air monitoring results from the 200-North, 200-UW-1, and BC Controlled Area decontamination and demolition project stations were at or below typical Hanford Site levels for 2010. Uranium-234 and uranium-238 were consistently detected at each project, while plutonium-239/240 was detected in approximately 50% of the samples at the 200-UW-1 site.

Air sampling in support of remediation work in the 300-FF-2 Operable Unit (near the 300 Area) and decontamination and decommissioning activities at the 300 Area D4 Project continued in 2010. Uranium-234 and -238 were detected consistently and at levels similar to those measured in previous years.

Air sampling was conducted at five locations in 2010 at the Environmental Restoration Disposal Facility (200-West Area). Generally, radionuclide levels measured at this site were similar to typical Hanford Site levels. Uranium-234 and uranium-238 were detected consistently while plutonium-239/240 was detected in approximately 40% of the samples.

From mid-May through early-September 2010, air monitoring was conducted at four locations at the 618-10 Burial Ground Project (north of the 300 Area). The analytical results showed that only uranium-234 and uranium-238 were detected consistently and these were at or below typical Hanford Site levels for 2010.

8.2.2 Hanford Site-Wide and Offsite Ambient-Air Monitoring

BG Fritz

During 2010, airborne radionuclide samples were collected by 40 continuously operating samplers at or in the vicinity of the Hanford Site. The sampling stations were grouped into four location classifications: site-wide (onsite; 21 stations), perimeter (11 stations), nearby communities (7 stations), and distant community (1 station) (Figure 8.2.2 and Table 8.2.2). Air samplers at the Hanford Site were located primarily around major operational areas to maximize the capability to detect radiological contaminants resulting from site operations. Perimeter samplers were located around the site boundary with emphasis on the prevailing downwind directions to the south and east. Samplers located in Basin City, Benton City, Kennewick, Mattawa, Othello, Pasco, and Richland, Washington, provided data for the nearest population centers. A sampler in Yakima, Washington, provided background data from a community essentially unaffected by Hanford Site operations.

8.2.2.1 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-19079) and were analyzed for up to eight constituents (Table 8.2.2). 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, to allow for the decay of short-lived, naturally occurring radionuclides (e.g., radon gas decay products) that would otherwise obscure the detection of longer-lived radionuclides potentially present from Hanford Site emissions. The filters were then analyzed for gross beta radiation. Selected filters were also analyzed for gross alpha radiation. Historically, for most radionuclides, the amount of radioactive material collected on a filter during a 2-week period has been too small to accurately analyze individual radionuclides of concern. Biweekly samples were combined into quarterly composite samples to increase the sensitivity and accuracy of the analysis. The compositing procedure results in a 12-week average concentration for specific radionuclides present in the atmosphere as particulates. The quarterly composite samples were analyzed for gamma-emitting radionuclides, and most were also analyzed for strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240.

Atmospheric water vapor was collected for tritium analysis at 20 locations in 2010 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 by Patton et al. (1997). The collected water was distilled from the silica gel and analyzed for its tritium content.

8.2.2.2 Ambient-Air Monitoring Results for Site-Wide and Offsite Samples

All sample results showed very low radiological concentrations in air during 2010. All radionuclide concentrations (Table 8.2.3) were less than their respective

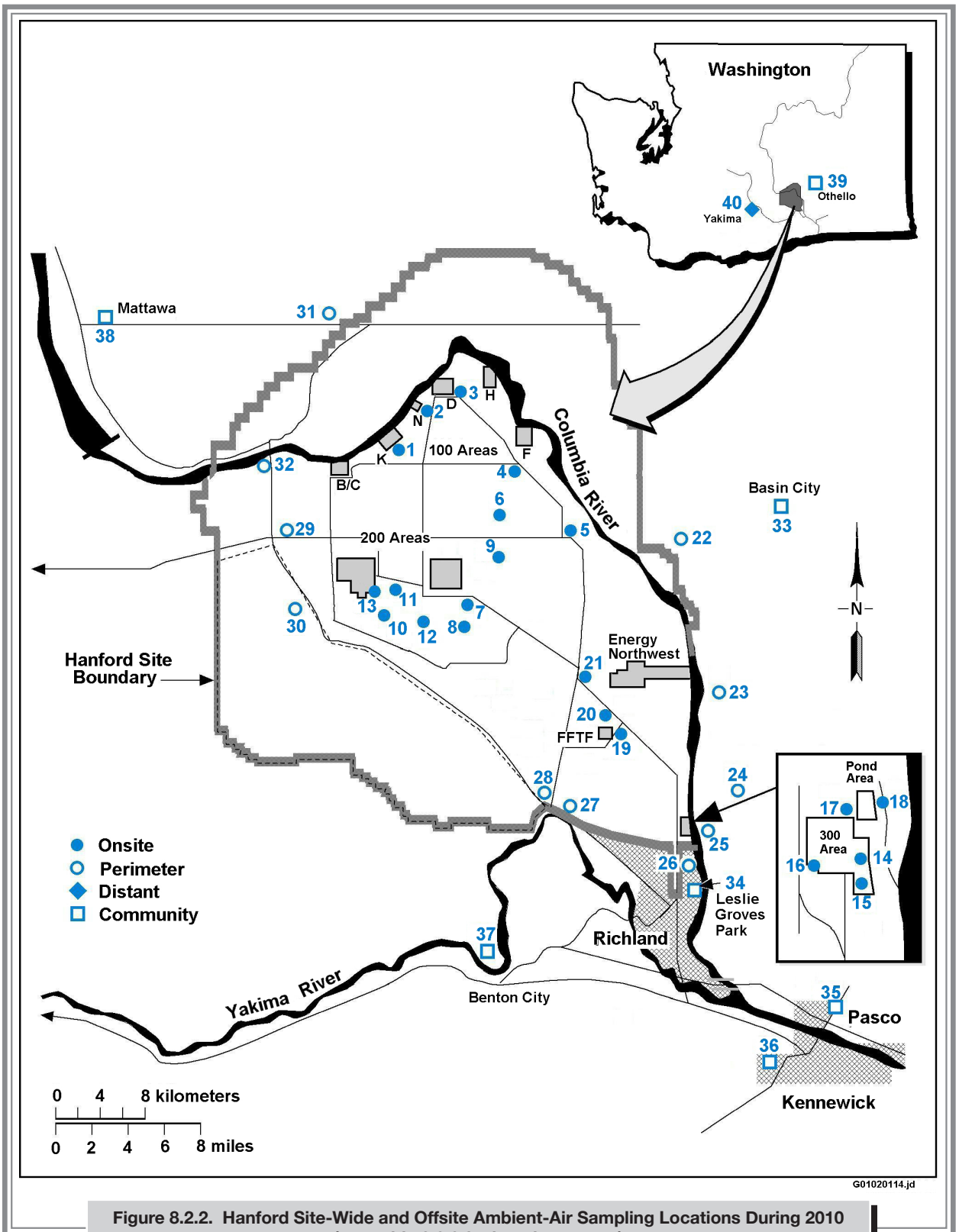

Figure 8.2.2. Hanford Site-Wide and Offsite Ambient-Air Sampling Locations During 2010 (see Table 8.2.2 for location names)

Table 8.2.2. Site-Wide and Offsite Ambient-Air Sampling Locations, Sample Composite Groups, and Analytes, 2010

Map Location[a]	Sampling Location[b]	Analytes[c]	Composite Group	Analytes[d]
Site-Wide (Onsite)				
1	100 K Area	Alpha, beta, tritium	100 Areas	Gamma, strontium, plutonium
2	100 N-1325 Crib	Alpha, beta, tritium		
3	100 D Area	Alpha, beta		
4	100 F Met Tower	Alpha, beta	Hanford Townsite	Gamma, strontium, plutonium
5	Hanford Townsite	Alpha, beta		
6	Gable Mt	Beta	Gable Mt	Gamma
7	200 ESE	Alpha, beta, tritium, iodine-129	200 E Area	Gamma, strontium, plutonium, uranium
8	S of 200 E	Alpha, beta		
9	B Pond	Alpha, beta	B Pond	Gamma, strontium, plutonium, uranium
10	Army Loop Camp	Alpha, beta	200 W South East	Gamma, strontium, plutonium, uranium
11	200 Tel. Exchange	Alpha, beta, tritium		
12	SW of B/C Crib	Alpha, beta		
13	200 W SE	Alpha, beta	200 West	Gamma, strontium, plutonium, uranium
14	300 Water Intake	Alpha, beta, tritium	300 Area	Gamma, strontium, plutonium, uranium
15	300 South Gate	Alpha, beta, tritium		
16	300 South West	Alpha, beta, tritium, uranium, gamma		
17	300 Trench	Alpha, beta, tritium	300 NE	Strontium, plutonium
18	300 NE	Alpha, beta, tritium, uranium, gamma		
19	400 E	Alpha, beta, tritium	400 Area	Gamma, strontium, plutonium
20	400 N	Alpha, beta		
21	Wye Barricade	Alpha, beta	Wye Barricade	Gamma, strontium, plutonium, uranium
22	Ringold Met Tower	Alpha, beta, tritium, iodine-129	Ringold Met Tower	Gamma, strontium, plutonium
Perimeter				
23	W End of Fir Road	Alpha, beta	W End of Fir Road	Gamma, strontium, plutonium, uranium
24	Dogwood Met Tower	Alpha, beta, tritium	Dogwood Met Tower	Gamma, strontium, plutonium, uranium
25	Byers Landing	Alpha, beta, tritium, iodine-129	Byers Landing	Gamma, strontium, plutonium, uranium
26	Battelle Complex	Alpha, beta, tritium	Battelle Complex	Gamma

Table 8.2.2. (contd)

Map[a] Location	Sampling Location[b]	Analytes[c]	Composite Group	Analytes[d]
27	Horn Rapids Substation	Alpha, beta	Prosser Barricade	Gamma, strontium, plutonium, uranium
28	Prosser Barricade	Alpha, beta, tritium		
29	Yakima Barricade	Alpha, beta	Yakima Barricade	Gamma, strontium, plutonium
30	Rattlesnake Springs	Alpha, beta		
31	Wahluke Slope	Alpha, beta, tritium	Wahluke Slope	Gamma, strontium, plutonium
32	S End Vernita Bridge	Alpha, beta		
Nearby Communities				
33	Basin City School	Alpha, beta, tritium	Basin City School	Gamma, strontium, plutonium, uranium
34	Leslie Groves-Richland	Alpha, beta, tritium	Leslie Groves-Richland	Gamma, strontium, plutonium, uranium
35	Pasco	Beta	Tri-Cities	Gamma, strontium, plutonium
36	Kennewick	Alpha, beta		
37	Benton City	Beta	Benton City	Gamma
38	Mattawa	Beta	Mattawa	Gamma
39	Othello	Beta	Othello	Gamma
Distant Communities				
40	Yakima	Alpha, beta, tritium, iodine-129	Yakima	Gamma, strontium, plutonium, uranium

(a) See Figure 8.2.2.
(b) Sampling location names are derived from the Hanford Environmental Information System database.
(c) Alpha (gross) and beta (gross) samples were collected and analyzed every 2 weeks; tritium samples were collected and analyzed every 4 weeks; and iodine-129 samples were collected every 4 weeks but were not analyzed because of an equipment problem at the analytical laboratory.
(d) Gamma spectroscopy, strontium-90, isotopic plutonium (plutonium-238 and plutonium-239/240), and isotopic uranium (uranium-234, uranium-235, and uranium-238) analyses were performed on quarterly composite samples.

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. Again, all radionuclide concentrations in air samples collected in 2010 were low enough to meet the EPA standard.

Gross alpha concentrations were essentially the same at Hanford Site-wide and offsite locations during 2010 (Figure 8.2.3). 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 2010 was observed at a perimeter location (8,200 aCi/m^3 [300 µBq/m^3]). The average gross alpha concentrations observed in individual location groups during 2010 were higher than the 10-year average concentrations observed from 1997 through 2006, while the maximum concentrations measured were generally lower than the maximum concentrations observed from 1997 through 2006 (Table 8.2.3). This increase in average concentrations probably resulted from samples collected in 2010 being analyzed at a different analytical laboratory than was used between

Table 8.2.3. Airborne Radionuclide Concentrations in the Environs of the Hanford Site, 2010 Compared to Previous Years

Radionuclide (approximate detection limit)	Location Group[a]	2010 No. of Samples	2010 No. of Detections[b]	2010 Maximum[c]	2010 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	78	62	48 ± 2.8	7.7 ± 16	603	492	25 ± 3.0	4.3 ± 7.6	100,000
	Site-wide	78	33	14 ± 2.5	2.9 ± 6.3	581	376	16 ± 2.4	2.3 ± 4.8	
	Perimeter	90	45	25 ± 4.2	4.2 ± 10	634	384	74 ± 10	3.4 ± 12	
	Nearby communities	26	15	25 ± 2.1	5.8 ± 14	345	215	61 ± 8.5	3.6 ± 12	
	Distant communities	13	6	16 ± 1.8	4.4 ± 11	235	98	24 ± 3.8	1.8 ± 5.0	
Gross beta (0.001 pCi/m³)	Site-wide	530	530	0.059 ± 0.0034	0.019 ± 0.016	5,166	5,156	0.14 ± 0.0089	0.016 ± 0.019	No standard
	Perimeter	278	278	0.055 ± 0.0028	0.019 ± 0.017	2,279	2,276	0.098 ± 0.010	0.016 ± 0.018	
	Nearby communities	174	174	0.051 ± 0.0030	0.018 ± 0.015	1,887	1,885	0.059 ± 0.0059	0.016 ± 0.018	
	Distant communities	24	24	0.034 ± 0.0019	0.016 ± 0.013	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	530	463	2,800 ± 880	680 ± 660	4,965	3,403	6,300 ± 3,300	600 ± 880	No standard
	Perimeter	278	245	8,200 ± 1,400	730 ± 1,200	2,188	1,577	5,100 ± 1,300	590 ± 810	
	Nearby communities	76	65	4,200 ± 2,200	700 ± 1,000	991	722	6,300 ± 1,700	630 ± 930	
	Distant communities	24	20	1,500 ± 580	620 ± 650	501	327	5,500 ± 1,900	550 ± 920	
Cobalt-60 (1,100 aCi/m³)	Site-wide	43	0	250 ± 570	-36 ± 480	471	5	3,800 ± 2,500	73 ± 740	80,000,000
	Perimeter	31	0	770 ± 760	15 ± 640	320	2	1,000 ± 530	18 ± 730	
	Nearby communities	24	0	630 ± 710	-66 ± 670	262	1	1,800 ± 3,600	43 ± 830	
	Distant communities	4	0	550 ± 810	-58 ± 830	88	2	730 ± 1,000	100 ± 580	
Strontium-90 (100 aCi/m³)	Site-wide	27	2	160 ± 49	17 ± 86	274	67	1,300 ± 280	23 ± 190	9,000,000
	Perimeter	23	1	310 ± 96	24 ± 140	189	24	390 ± 79	6.5 ± 100	
	Nearby communities	8	1	720 ± 180	96 ± 500	108	13	220 ± 190	13 ± 110	
	Distant communities	4	0	44 ± 56	4.6 ± 88	57	4	300 ± 100	-0.053 ± 130	
Cesium-137 (1,100 aCi/m³)	Site-wide	43	0	680 ± 820	-21 ± 510	471	6	3,500 ± 1,500	11 ± 670	400,000,000
	Perimeter	31	1	6,900 ± 1900	160 ± 2600	320	3	4,600 ± 1,300	36 ± 800	
	Nearby communities	24	0	820 ± 780	23 ± 590	262	2	2,100 ± 3,100	31 ± 650	
	Distant communities	4	0	640 ± 630	260 ± 700	88	1	520 ± 520	-4.9 ± 520	
Uranium-234 (10 aCi/m³)	Site-wide	32	31	110 ± 21	47 ± 49	217	188	150 ± 52	21 ± 44	90,000
	Perimeter	16	16	89 ± 19	57 ± 36	108	96	135 ± 32	25 ± 47	
	Nearby communities	16	16	75 ± 16	47 ± 24	81	71	58 ± 21	22 ± 37	
	Distant communities	4	4	43 ± 11	40 ± 7.3	57	48	41 ± 15	14 ± 29	
Uranium-235 (10 aCi/m³)	Site-wide	32	17	36 ± 41	4.9 ± 13	217	10	6.5 ± 8.5	0.32 ± 3.0	100,000
	Perimeter	16	5	6.7 ± 3.7	2.9 ± 4.1	108	7	6.0 ± 6.0	0.58 ± 3.3	
	Nearby communities	16	5	5.9 ± 3.7	2.7 ± 4.0	81	5	6.2 ± 5.6	0.25 ± 3.9	
	Distant communities	4	1	3.4 ± 2.8	1.9 ± 2.0	57	0	7.0 ± 9.3	-0.18 ± 4.2	

Table 8.2.3. (contd)

Radionuclide (approximate detection limit)	Location Group[a]	2010				1997-2006				Derived Concentration Guide[e]
		No. of Samples	No. of Detections[b]	Maximum[c]	Average[d]	No. of Samples	No. of Detections[b]	Maximum[c]	Average[d]	
				aCi/m^3[g]	aCi/m^3[g]			aCi/m^3[g]	aCi/m^3[g]	aCi/m^3[g]
Plutonium-238 (3 aCi/m^3)	Site-wide	43	2	30 ± 6.2	0.74 ± 9.4	274	16	13 ± 3.9	0.095 ± 2.3	30,000
	Perimeter	22	1	8.2 ± 3.7	0.26 ± 4.0	189	1	1.9 ± 1.4	-0.11 ± 1.1	
	Nearby communities	12	0	1.2 ± 1.4	0.082 ± 1.7	108	2	3.7 ± 3.6	0.0061 ± 1.5	
	Distant communities	4	0	0.0 ± 0.73	-0.47 ± 1.2	57	0	0.98 ± 1.4	-0.32 ± 1.1	
Uranium-238 (10 aCi/m^3)	Site-wide	32	32	110 ± 22	52 ± 38	217	201	160 ± 37	22 ± 40	100,000
	Perimeter	16	16	82 ± 17	58 ± 29	108	105	140 ± 32	27 ± 37	
	Nearby communities	16	16	78 ± 16	50 ± 24	81	78	56 ± 18	24 ± 22	
	Distant communities	4	4	50 ± 13	41 ± 26	57	56	33 ± 15	17 ± 13	
Plutonium-239/240 (3 aCi/m^3)	Site-wide	43	4	7.5 ± 2.6	0.56 ± 3.3	274	74	36 ± 6.4	1.4 ± 7.0	20,000
	Perimeter	22	0	0.86 ± 1.2	-0.31 ± 2.1	189	13	5.2 ± 2.5	0.31 ± 1.7	
	Nearby communities	12	0	0.26 ± 0.50	-0.45 ± 1.2	108	7	3.2 ± 4.6	0.39 ± 1.4	
	Distant communities	4	0	0.0 ± 1.3	-0.74 ± 1.4	57	2	3.2 ± 2.9	0.29 ± 1.7	

(a) Location groups are identified in Table 8.2.2.
(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).

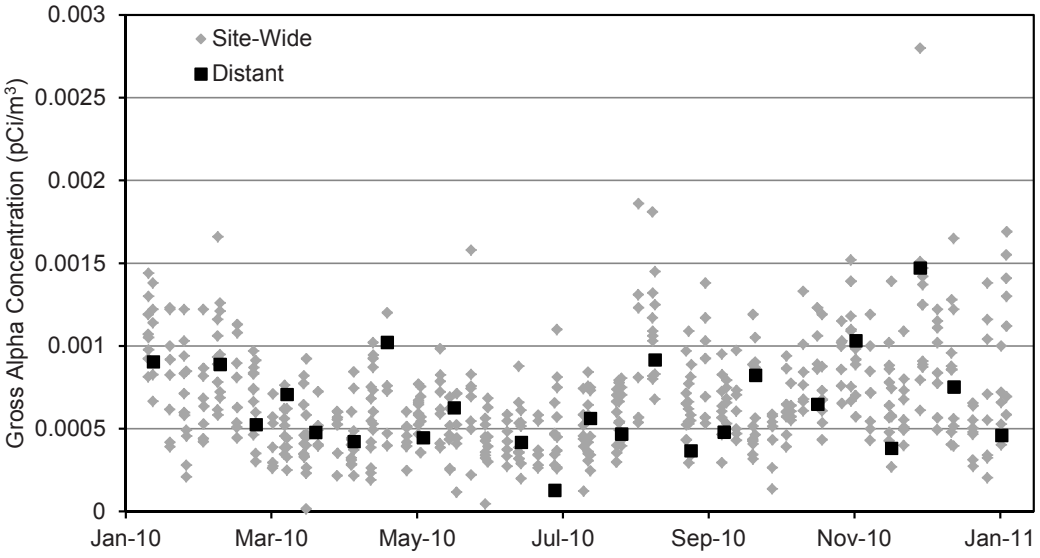

Figure 8.2.3. Gross Alpha Concentrations in Airborne Particulate Samples Collected at Hanford Site-Wide and Distant Locations During 2010 and Early 2011 (1 pCi = 0.037 Bq)

1997 and 2006 rather than any real change in atmospheric concentrations of radionuclides across the Hanford Site. A fixed 10-year window (1997–2006) was used as a comparison to the current year's results, providing a sizable time period so annual variations in long-term average concentrations are minimized. This window is used to provide consistent year-to-year "reference" values.

Gross beta concentrations in air peaked during the fall and winter months in 2010 (Figure 8.2.4), repeating a pattern of natural radioactivity fluctuations (Eisenbud 1987). The annual average gross beta concentrations at site-wide locations during 2010 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 2010 were higher than concentrations measured from 1997 through 2006 (Table 8.2.3). In 2004, gross beta concentrations were noted 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 2010 (Figure 8.2.4).

Plutonium-238 was detected in three air samples collected during 2010 (Table 8.2.3). The maximum reported plutonium-238 concentration in 2010 was 30 aCi/m^3 (1.1 µBq/m^3), which is 0.01% of the DOE-derived concentration guide. One sample collected at a perimeter location (Byers Landing) during the third quarter of 2010 exceeded the DOE-derived concentration guide. However, a review of gross alpha results indicated that this result was not possible, because all of the 2-week gross alpha concentrations at this location had concentrations less than the reported plutonium-238 concentration. A review by the laboratory identified potential sample contamination, and the result was removed from the database.

The annual average plutonium-239/240 concentration in air samples collected in 2010 at Hanford Site-wide locations was 0.56 aCi/m^3 (0.021 µBq/m^3). Of the 43 site-wide samples analyzed for plutonium-239/240, 4 had detectable concentrations (Table 8.2.3). The maximum reported concentration (7.5 aCi/m^3 [0.28 µBq/m^3]) was 2,600 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 2010 were higher than average concentrations measured from 1997 through 2006 for all location groups (Table 8.2.3). The 2010 annual average uranium-238 concentration at the site perimeter was 58 aCi/m^3 (2.2 µBq/m^3). The annual average site-wide and perimeter uranium-238

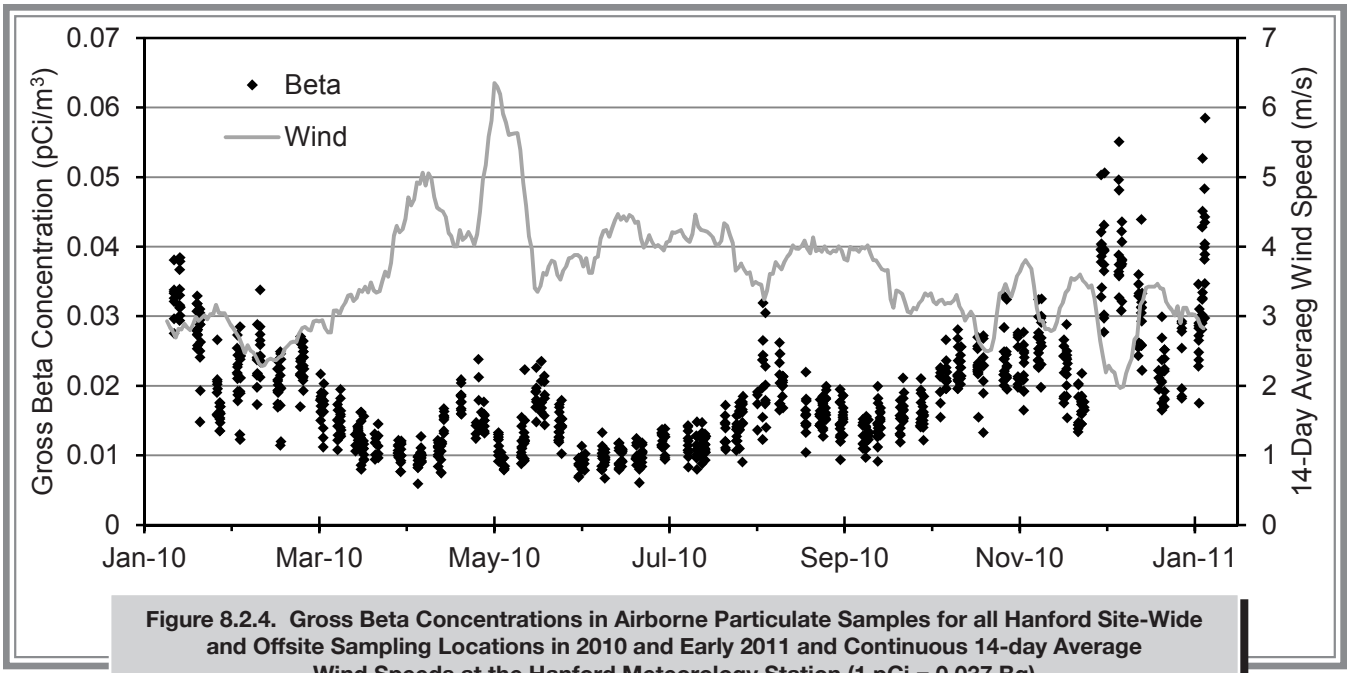

Figure 8.2.4. Gross Beta Concentrations in Airborne Particulate Samples for all Hanford Site-Wide and Offsite Sampling Locations in 2010 and Early 2011 and Continuous 14-day Average Wind Speeds at the Hanford Meteorology Station (1 pCi = 0.037 Bq)

concentrations were not statistically different from the concentration measured at the distant location (two-sample means t-test, 95% confidence level). The maximum uranium-238 concentration measured in 2010 (110 aCi/m^3 [4.1 µBq/m^3]) was only 0.11% of the DOE-derived concentration guide for uranium-238.

Sixty-two airborne particulate samples were analyzed for strontium-90 in 2010 (Table 8.2.3). Four of the samples collected had a detectable concentration, and the maximum measured concentration (720 aCi/m^3 [27 µBq/m^3]) was just 0.008% of the DOE-derived concentration guide for strontium-90.

All quarterly composite samples (n=102) collected in 2010 were examined with gamma spectroscopy. Naturally occurring beryllium-7 and potassium-40 were occasionally measured with detectable concentrations. The potential Hanford Site-origin, gamma-emitting, radionuclide cesium-137 was detected in a single site-wide sample. This sample, collected at Byers Landing during the third quarter of 2010, is considered suspect as a result of the laboratory contamination issue. No samples had detectable concentrations of cobalt-60.

8.3 Liquid Effluent from Hanford Site Facilities

DJ 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 and non-radioactive hazardous materials.

Contaminant data from liquid effluent sampling and analyses are reported to DOE annually in an environmental release report (e.g., HNF-EP-0527-20). The report includes summaries of monitoring results on liquid effluents discharged to the Columbia River, which are regulated by the National Pollutant Discharge Elimination System (NPDES) (40 CFR 122) permit and reported to EPA, and liquid effluent discharges to the soil, which are regulated by WAC 173-216 and reported to the Washington State Department of Ecology.

8.3.1 Radionuclides in Liquid Effluent

During 2010, facilities in the 200 Areas discharged radioactive liquid effluent to the ground at a single location, the 616-A Crib, also known as the State-Approved Land Disposal Site. Table 8.3.1 summarizes this effluent discharge.

Table 8.3.2 summarizes the liquid effluent discharged in the 100 Areas. 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 8.3.1. Radionuclides in 200 Areas Liquid Effluent Discharged to the State-Approved Land Disposal Site at the Hanford Site, 2010

Radionuclide	Half-Life	Release, Ci[(a)]
Tritium	12.35 yr	12.1

(a) 1 Ci = 3.7×10^{10} Bq.

Table 8.3.2. Radionuclides in Liquid Effluent from the 100-K Area Discharged to the Columbia River, 2010

Radionuclide	Half-Life	Release, Ci[(a)]
Strontium-90	29.1 yr	7.1×10^{-4}
Cesium-137	30 yr	4.0×10^{-3}
Plutonium-238	87.7 yr	1.7×10^{-6}
Plutonium-239/240	24,110 yr	3.8×10^{-5}

(a) 1 Ci = 3.7×10^{10} Bq.

8.3.2 Non-Radioactive Hazardous Materials in Liquid Effluent

Non-radioactive hazardous materials in liquid effluents are monitored in the 100, 200, and 400 Areas for selected non-radioactive hazardous materials. These effluents are discharged to the State-Approved Land Disposal Site and to the Columbia River. Effluent entering the environment at designated discharge points is sampled and analyzed to determine compliance with the NPDES (40 CFR 122) and state waste discharge permits (WAC 173-216) for the Hanford Site. The release totals are immediately reported to EPA if chemicals in liquid effluents exceed quantities reportable under CERCLA. If chemicals in effluents remain stable at predicted levels, these levels may be reported annually if EPA has approved this practice. Section 5.4.1 provides a brief synopsis of the NPDES and state waste discharge permits and their compliance status.

8.4 Surface-Water and Sediment Monitoring

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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 8.4.1). Aquatic sediment monitoring was conducted for the Columbia River and one onsite pond. Tables 8.4.1 and 8.4.2 summarize the sampling locations, types, and frequencies, as well as sample analyses included in surface-water and sediment monitoring during 2010. This section describes the monitoring efforts and summarizes the results for these aquatic environments. Detailed analytical results are available upon request (see Preface for contact information).

8.4.1 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 at the Hanford Site. The original selection of the Hanford Site for plutonium production was based partly on the abundant water supply offered by the river. The river flows through the northern portion of the site and forms part of the eastern boundary of the site. 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, waterskiing, and swimming.

Originating in the Rocky Mountains of eastern British Columbia, the Columbia River and its tributaries drain an area of approximately 670,000 square kilometers (260,000 square miles) before discharging to the Pacific Ocean. Three dams in Canada and 11 dams in the United States regulate the flow of the river; 4 of these 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 2010, the Columbia River had below normal flows; the average daily flow rate downstream of Priest Rapids Dam was 2,670 cubic meters (94,200 cubic feet) per second. The peak monthly average flow rate occurred during June (5,310 cubic meters [188,000 cubic feet] per second) (Figure 8.4.2). The lowest monthly average flow rate occurred during September (1,630 cubic meters [57,600 cubic feet] per second), based on mean daily flows. Daily average flow rates varied from 1,090 to 6,970 cubic meters (38,500 to 246,000 cubic feet) per second during 2010. 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

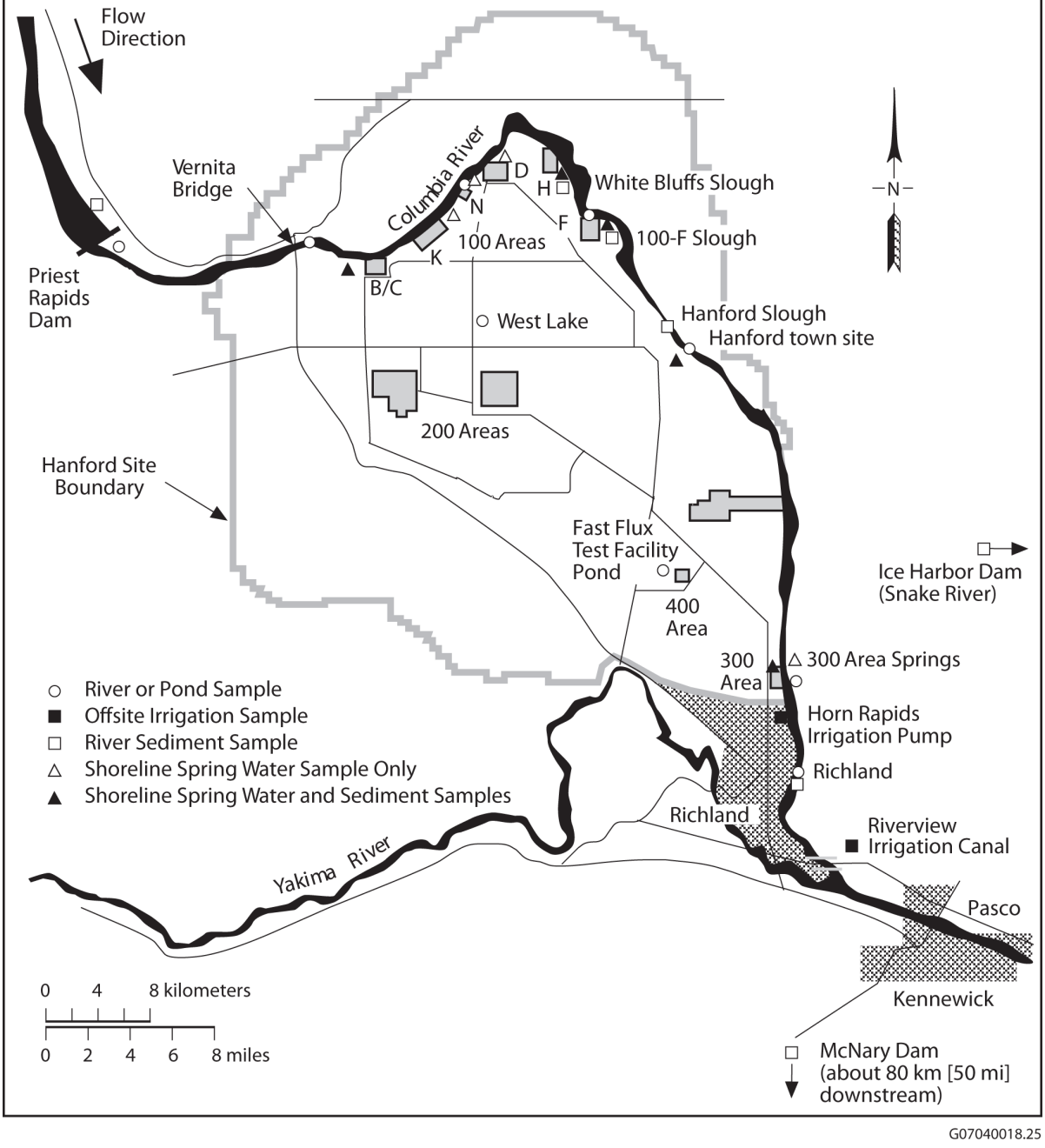

Figure 8.4.1. Surface-Water and Sediment Sampling Locations On and Around the Hanford Site, 2010

Table 8.4.1. Surface-Water Surveillance On and Near the Hanford Site, 2010

Location	Sample Type	Frequency	Analyses
Columbia River - Radiological			
Priest Rapids Dam and Richland	Cumulative	M Comp[a]	Alpha, beta, low tritium,[b] strontium-90, technetium-99, isotopic uranium[c]
	Particulate (filter)	M Cont[d]	Gamma energy analysis
		Q Cont[e]	Isotopic plutonium[f]
	Soluble (resin)	M Cont	Gamma energy analysis
		Q Cont	Isotopic plutonium
Vernita Bridge and Richland	Grab (transects)	Quarterly	Low tritium, strontium-90, isotopic uranium
100-N and 300 Areas and Hanford town site	Grab (transects)	Annually	Low tritium, strontium-90, isotopic uranium
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 calcium carbonate), calcium, potassium, chromium, manganese, nitrogen, iron, ammonia, nitrate + nitrite
	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, tritium, strontium-90, technetium-99, isotopic uranium, gamma energy analysis
Fast Flux Test Facility Pond	Grab	Quarterly	Alpha, beta, tritium, gamma energy analysis
Offsite Irrigation Water			
Riverview irrigation canal	Grab	3/year	Alpha, beta, tritium, strontium-90, isotopic uranium, gamma energy analysis
Horn Rapids	Grab	3/year	Alpha, beta, tritium, strontium-90, isotopic uranium, gamma energy analysis

(a) M Comp indicates river water was collected hourly and composited monthly for analysis.
(b) Low tritium = Low-level tritium analysis (10-pCi/L detection limit), which includes an electrolytic preconcentration.
(c) Isotopic uranium (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) Isotopic plutonium (plutonium-238 and plutonium-239/240).
(g) Numerous water quality analyses are performed by the U.S. Geological Survey under contract with Pacific Northwest National Laboratory.
(h) Because of high concentrations of suspended sediment, West Lake water is analyzed for tritium; all other analytes are for sediment samples.

Comp = Composite.
Cont = Continuous.
M = Monthly.
Q = Quarterly.

Table 8.4.2. Columbia River Sediment Surveillance, 2010

Location[a]	Frequency	Analyses
Priest Rapids Dam Two locations near the dam	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] isotopic plutonium,[c] metals, and total organic carbon
White Bluffs Slough	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] isotopic plutonium,[c] metals, and total organic carbon
100-F Slough	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] isotopic plutonium,[c] metals, and total organic carbon
Hanford Slough	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] isotopic plutonium,[c] metals, and total organic carbon
Richland	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] isotopic plutonium,[c] metals, and total organic carbon
McNary Dam Two locations near the dam	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] isotopic plutonium,[c] metals, and total organic carbon

(a) See Figure 8.4.1.
(b) Isotopic uranium (uranium-234, uranium-235, and uranium-238) analyzed by alpha spectrometry (alpha energy analysis).
(c) Isotopic plutonium (plutonium-238 and plutonium-239/240).

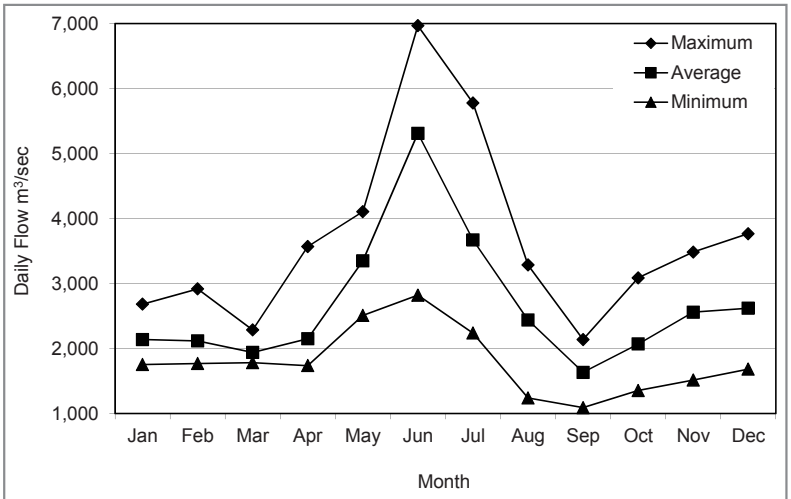

Figure 8.4.2. Monthly Average, Maximum, and Minimum Columbia River Flow Rates at Priest Rapids Dam, Washington, 2010 (multiply m³/sec by 35.31 to obtain ft³/sec)

by up to 3 meters (10 feet) within a few hours (PNL-10698). Seasonal changes of approximately the same magnitude are also observed. River-stage fluctuations measured at the 300 Area are approximately one-half the magnitude of those measured near the 100 Areas because of the effect of the pool behind McNary Dam (PNL-8580) and the relative distance of each area from Priest Rapids Dam. The width of the river varies from approximately 300 to 1,000 meters (980 to 3,300 feet) as it passes through the Hanford Site.

Pollutants from multiple sources are present in the Columbia River as it passes through the Hanford Reach. These sources include upstream industry, atmospheric fallout that collects in the river's drainage basin, runoff from agricultural operations, and discharge from the aquifers on either side of the river. Hanford Site pollutants, both radiological and chemical, enter the Columbia River along the Hanford Reach. Effluent from each direct discharge point is monitored routinely and reported by the responsible operating contractor (Section 8.3). Direct discharges are identified and regulated for non-radiological constituents under NPDES (40 CFR 122) in compliance with the *Clean Water Act of 1977* (Section 5.4.1). In addition to permitted direct discharges of liquid effluent from Hanford Site facilities, groundwater contaminants from past operational releases to the ground discharge into

the Columbia River (see Section 8.5 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.

8.4.1.1 Collection of Columbia River Water Samples and Analytes of Interest

During 2010, Columbia River water samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the city of Richland and analyzed for radionuclides. Cross-river transects and near-shore locations near Vernita Bridge, the 100-N Area, the Hanford town site, the 300 Area, and the city of Richland were analyzed for both radionuclides and chemicals (Figure 8.4.1). Samples were collected upstream from Hanford Site facilities at Priest Rapids Dam and Vernita Bridge to provide data from locations unaffected by site operations. Samples were collected from all other locations, including a municipal drinking water supply and points of withdrawal for irrigation water downstream of the Hanford Site, to identify any increase in contaminant concentrations attributable to the site. The sampling of irrigation water systems is discussed in Section 8.4.4.

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 at Priest Rapids Dam was used to obtain hourly unfiltered samples of Columbia River water (cumulative samples), which were composited for a period of 7 days. The automated sampler at Richland experienced technical problems at the city of Richland, so weekly grab samples were obtained. These weekly samples were combined into monthly and quarterly composite samples for radiological analyses (Table 8.4.1). The continuous flow system was used to collect particulate and soluble constituents in Columbia River water by passing water through a filter and then through a resin column. Filter and resin samples were exchanged approximately every 14 days and were combined into quarterly composite samples for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in DOE/RL-91-50, Rev. 4.

Radionuclides of interest were selected for analysis based on the following criteria:

- Their presence in effluent discharged from Hanford Site facilities or in near-river groundwater underlying the site
- Their importance in determining water quality, verifying facility effluent controls and monitoring systems, and determining compliance with applicable water quality standards.

Constituents of interest in Columbia River water samples collected at Priest Rapids Dam and the city of Richland included gamma-emitting radionuclides, tritium, strontium-90, technetium-99, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240. River water samples to be analyzed for iodine-129 were not collected in 2010 because the instrument used for this assay was not operational, and an alternative for this ultra-trace measurement capability was not available. Gross alpha and gross beta measurements were made as indicators of the general radiological quality of the river and provided a timely indication of change. Gamma-energy analysis provides the capability to detect numerous specific radionuclides (Appendix F). Analytical detection levels (defined as the laboratory-reported minimum detectable concentration) for all radionuclides were less than or equal to 10% of their respective Washington State water quality criteria levels (Appendix D, Tables D.3 and D.4). Unless otherwise noted in this section, the statistical tests for differences are paired sample comparisons and two-tailed t-tests, with alpha at a 5% significance level.

Transect sampling (i.e., multiple samples collected along a line across the Columbia River) was initiated as a result

of findings of a special study conducted during 1987 and 1988 (PNL-8531). That study concluded that, under certain flow conditions, contaminants entering the river from the Hanford Site are not completely mixed when sampled at routine monitoring stations located downriver. Incomplete mixing results in a slightly conservative (high) bias in the data generated using the routine, single-point, sampling system at the city of Richland drinking water intake. During 1999, the transect sampling strategy was modified; some of the mid-river sampling points were shifted to near-shore locations in the vicinity of the transect. For example, at the 100-N Area, instead of 10 evenly spaced cross-river transect samples, only 6 cross-river samples were collected, and the other 4 samples were obtained at near-shore locations (typically less than 5 meters [16 feet] from shore). This sampling pattern was used during 2010 and allowed the cross-river concentration profile to be determined and also provided information over a larger portion of the Hanford Site shoreline where the highest contaminant concentrations would be expected. Vernita Bridge and city of Richland transects and near-shore locations were sampled quarterly during 2010. 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 2010 were analyzed for both radiological and chemical contaminants (Table 8.4.1). Specific metals and anions were selected for analysis following reviews of existing surface-water and groundwater data, various remedial investigation/feasibility study work plans, and preliminary Hanford Site risk assessments (DOE/RL-92-67, Draft B; PNL-8073; PNL-8654; PNL-10400; PNL-10535). Grab samples of water collected along transects were radiologically and chemically analyzed. Metals analyses included both unfiltered and filtered samples.

Pacific Northwest National Laboratory also conducted water monitoring for potential Hanford Site contaminants, and the U.S. Geological Survey, under contract to Pacific Northwest National Laboratory, monitored basic water quality parameters (e.g., pH, dissolved oxygen, turbidity) and some chemical constituents. The U.S. Geological Survey collected samples four times per year along Columbia River transects at Vernita Bridge and the city of Richland (Appendix C, Table C.2). Samples were analyzed at the U.S. Geological Survey laboratory in Lakewood, Colorado.

8.4.1.2 Radiological Results for Columbia River Water Sample Analyses

Fixed-Location Samples. Results of radiological analyses of Columbia River water samples collected at Priest Rapids Dam and the city of Richland during 2010 are summarized in Appendix C (Tables C.3 and C.4). Appendix C tables list the maximum and average concentrations of selected radionuclides detected in Columbia River water in 2010 and for the previous 5 years. All individual radiological contaminant concentrations measured in Columbia River water during 2010 were less than 1/25 of the concentrations comparable to the DOE-derived concentration guides (DOE Order 5400.5, Chg 2; 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; 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 2010. Tritium, uranium-234, uranium-238, and naturally occurring beryllium-7 and potassium-40 were measured consistently in river water at levels greater than their reported minimum detectable concentrations. Strontium-90, uranium-235, plutonium-238, and plutonium-239/240 were occasionally detected, but all values were near the minimum detectable concentrations. Concentrations of all other radionuclides were typically less than the minimum detectable concentrations. Tritium, strontium-90, and plutonium 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 2010 average gross alpha and gross beta concentrations measured upstream and downstream of the Hanford Site

were similar to those observed during recent years (Figures 8.4.3 and 8.4.4). Statistical comparisons for gross alpha and gross beta concentrations at Priest Rapids Dam and the city of Richland were not performed because most of the concentrations were less than the 1- and 3-pCi/L (0.037- and 0.11-Bq/L) minimum detectable concentrations, respectively. All gross alpha and gross beta concentrations in Columbia River water at the city of Richland during 2010 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 2010 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 8.4.5). However, 2010 average tritium concentrations in Columbia River water collected at the city of Richland were only 0.15% 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 the Richland shoreline tend to be elevated when compared to 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 2010

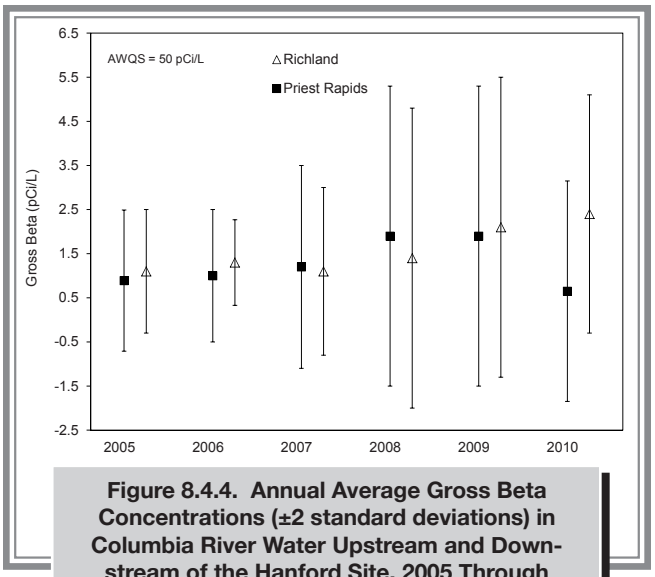

Figure 8.4.4. Annual Average Gross Beta Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2005 Through 2010 (AWQS = ambient water quality standard)

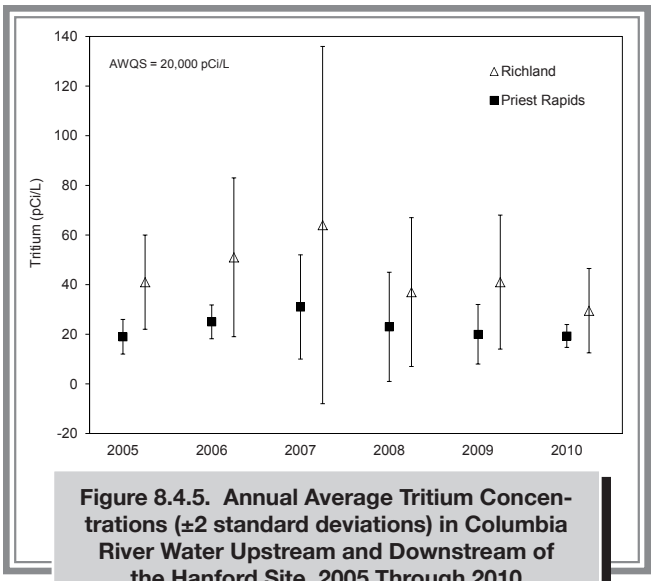

Figure 8.4.5. Annual Average Tritium Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2005 Through 2010 (AWQS = ambient water quality standard)

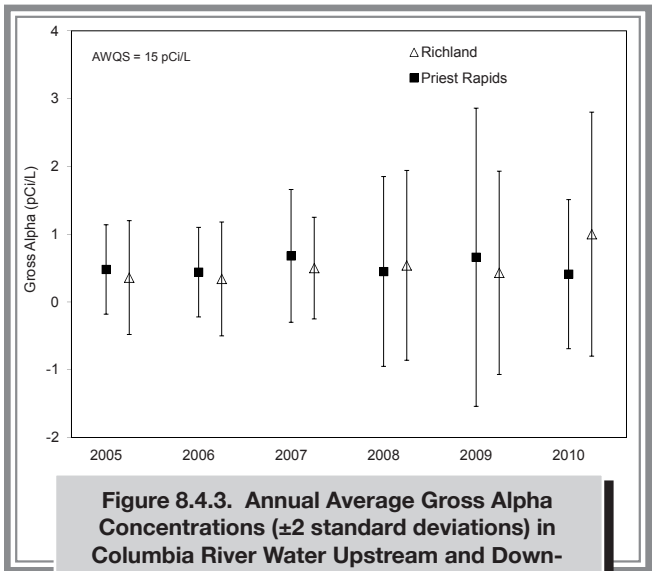

Figure 8.4.3. Annual Average Gross Alpha Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2005 Through 2010 (AWQS = ambient water quality standard)

confirmed the existence of a concentration gradient in the river under certain flow conditions and is discussed subsequently in this section. The extent to which samples taken at the city of Richland drinking water intake overestimate the average tritium concentrations in the Columbia River at this location is variable and appears to be related to the flow rate of the river just before and during sample collection.

Average strontium-90 levels measured in Columbia River water collected upstream and downstream of the Hanford Site during 2010 were similar to those reported previously (Figure 8.4.6). Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Areas. Some of the highest strontium-90 levels that have been found in onsite groundwater are the result of past discharges to the 100-N Area liquid waste-disposal facilities. Strontium-90 concentrations at Priest Rapids Dam were not statistically compared with the city of Richland because most of the concentrations were less than the minimum detectable concentration. Average strontium-90 concentrations in Columbia River water at the city of Richland were less than 0.25% 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 2010 were similar to those observed during recent years (Figure 8.4.7). Monthly total uranium concentrations measured at the city of Richland during 2010 were significantly higher than those measured at Priest Rapids Dam. Uranium is present in the groundwater beneath the 300 Area as a result of past Hanford Site operations. Uranium has been detected at elevated levels in shoreline springs at the 300 Area in the past (Section 8.5; PNNL-13692; PNNL-16805). Uranium from non-Hanford Site sources, such as fertilizer use, is also known to enter the Columbia River across from the Hanford Site via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the river (PNL-7500). Most phosphate fertilizers contain trace amounts of naturally occurring uranium. There is no Washington State ambient surface-water quality criterion directly applicable to uranium. However, total uranium levels in the river during 2010 were well below the EPA drinking water standard of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L], Appendix D, Table D.4).

Columbia River water samples were not collected for iodine-129 analysis in 2010 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

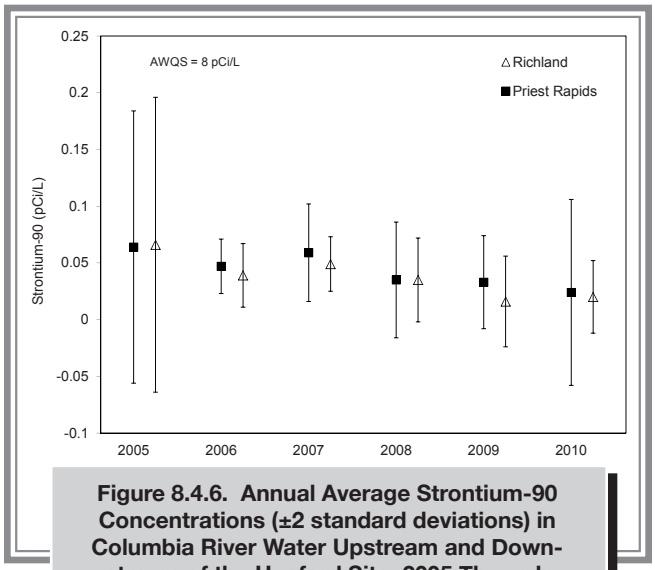

Figure 8.4.6. Annual Average Strontium-90 Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2005 Through 2010 (AWQS = ambient water quality standard)

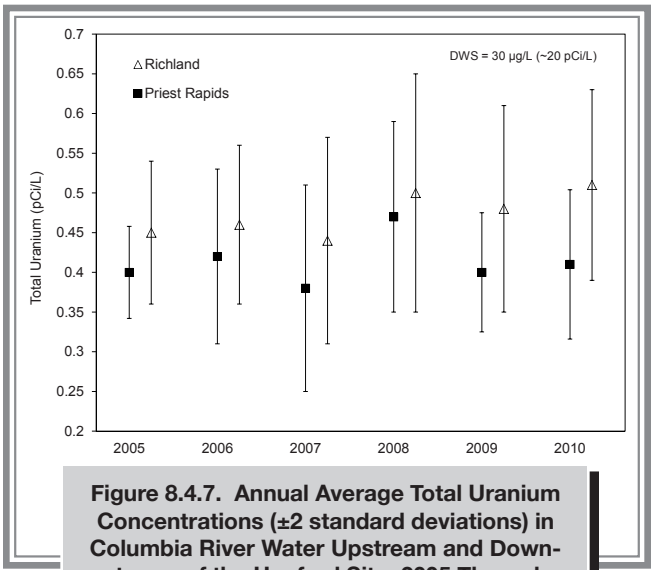

Figure 8.4.7. Annual Average Total Uranium Concentrations (±2 standard deviations) in Columbia River Water Upstream and Downstream of the Hanford Site, 2005 Through 2009 (DWS = drinking water standard)

(Section 8.5.2). The iodine-129 plume originated in the 200 Areas from past waste-disposal practices. In previous years, quarterly iodine-129 concentrations in Columbia River water at the city of Richland were significantly higher than those at Priest Rapids Dam, indicating a Hanford Site source of iodine-129. Past results have shown that iodine-129 values at Priest Rapids Dam are largely unaffected by river stages; however, the concentrations measured for river water at the city of Richland are inversely proportional to the river stage (i.e., during lower flow, the concentrations of iodine-129 are higher and vice versa). The influence of river stage on concentrations of iodine-129 at the city of Richland is reflected in the larger standard deviation, compared to the samples from Priest Rapids Dam, for the annual averages for 2004 through 2005.

Plutonium-239/240 concentrations for river water samples at the city of Richland were extremely low during 2010. All plutonium concentrations for the particulate and dissolved fractions of water samples were reported as undetected by the analytical laboratory. All concentrations and detection limits were well below the DOE-derived concentration guide of 30 pCi/L (1.1 Bq/L) (Appendix D, Table D.2). No Washington State ambient surface-water quality criterion exists for plutonium-239/240. Plutonium concentrations at Priest Rapids Dam were not statistically compared with the city of Richland because most of the concentrations were less than the reported minimum detectable concentrations.

Columbia River Transect and Near-Shore Samples. Radiological results from samples collected along Columbia River transects and at near-shore locations near Vernita Bridge, the 100-N Area, the Hanford town site, the 300 Area, and the city of Richland during 2010 are presented in Appendix C (Tables C.5 and C.6). Sampling locations were documented using a global positioning system receiver. Radionuclides consistently measured at concentrations greater than the minimum detectable activity included tritium, uranium-234, and uranium-238. Strontium-90 and uranium-235 were occasionally detected, but all values were near the minimum detectable concentrations. All measured concentrations of these radionuclides were less than the applicable Washington State ambient surface-water quality criteria.

Tritium concentrations measured along Columbia River transects at Vernita Bridge, the 100-N Area, the Hanford town site, the 300 Area, and the city of Richland pumphouse during August 2010 are depicted in Figure 8.4.8. The transect at Vernita Bridge is the most upstream location. Stations 1 and 10 are located along the Benton County and Grant-Franklin County shorelines, respectively. The 100-N Area, the Hanford town site, the 300 Area, and the city of Richland transects have higher tritium concentrations near the Hanford Site shore (Benton County) relative to the opposite shore. The presence of a tritium concentration gradient in the Columbia River at the city of Richland supports previous studies showing that contaminants in the 200 Areas groundwater plume entering the river at, and upstream of, the 300 Area are not completely mixed in the river at the city of Richland (HW-73672; PNL-8531). The gradient is most pronounced during periods of relatively low river flow. Since transect sampling began in 1987 (PNL-8531), the average tritium concentration measured along the city of Richland transect has been less than that measured in monthly composited samples from the fixed-location monitoring station in the city of Richland, illustrating the conservative bias (i.e., overestimate) of the fixed-location monitoring station. For samples collected in 2010, the highest tritium concentration measured in cross-river transect water was 160 ± 28 pCi/L (5.9 ± 1.0 Bq/L) at the Hanford town site (Appendix C, Table C.5). The highest tritium concentration measured in near-shore water samples was 1,450 ± 370 pCi/L (54 ± 14 Bq/L) from a sample collected at the 300 Area (Appendix C, Table C.6). Historically, the highest tritium concentrations for transect and near-shore samples have been measured at the Hanford town site; however, 2010 results for the Hanford town site were not as elevated compared to samples from Vernita Bridge as they were in past years. The riverbank spring water results (Section 8.5) for 2010 at the Hanford town site continued to show elevated tritium concentrations compared to samples from Vernita Bridge. Specific conductivity results for the 2010 transect and near-shore water samples collected at the Hanford town site indicate there was only limited mixing of groundwater into the river at the time of sample collection.

During 2010, strontium-90 concentrations in Hanford Reach river water for both transect and near-shore samples were similar to background concentrations for most locations. The maximum strontium-90 concentration for 2010 was 0.094 ± 0.042 pCi/L (0.0035 ± 0.0016 Bq/L) for a near-shore water sample collected along the Richland shoreline. The average

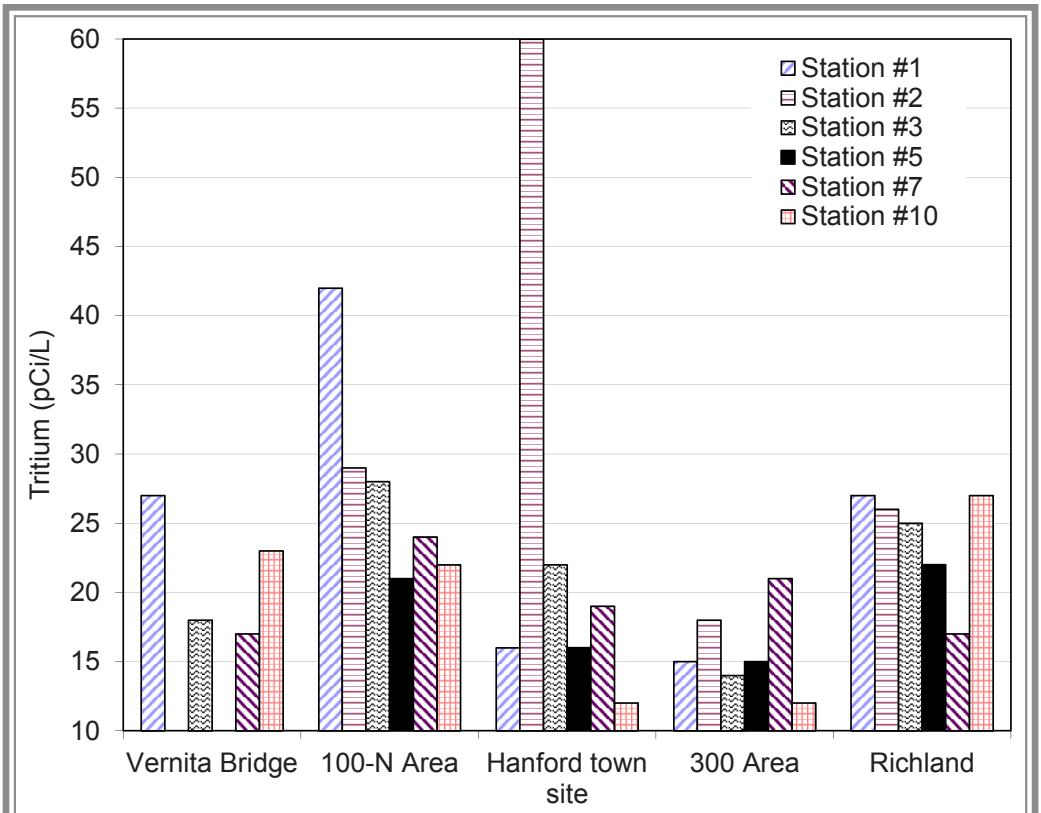

Figure 8.4.8. Tritium Concentrations in Cross-River Transect Water Samples from the Hanford Reach of the Columbia River, 2010. The Washington State ambient water quality standard for tritium is 20,000 pCi/L (740 Bq/L).

strontium-90 concentration found during transect sampling at the city of Richland was similar to those measured in monthly composite samples at the Richland pumphouse and at Priest Rapids Dam.

Total uranium concentrations in Hanford Reach water during 2010 were elevated along both the Benton County and Grant-Franklin Counties shorelines for transect and near-shore samples. In August 2010, the highest total uranium concentration was measured in samples from the Franklin County shoreline of the Richland transect, with a value of 0.80 ± 0.12 pCi/L (0.030 ± 0.0044 Bq/L) (Appendix C, Table C.6). However, this concentration was well below the drinking water standard. Elevated uranium concentrations on the Franklin County side of the Columbia 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).

8.4.1.3 Chemical and Physical Water Quality Results for Columbia River Water Samples

Pacific Northwest National Laboratory and the U.S. Geological Survey (under contract to Pacific Northwest National Laboratory) compiled chemical and physical water quality data for the Columbia River during 2010. A number of the parameters measured have no regulatory limits, but 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 of the Hanford Site.

Pacific Northwest National Laboratory Samples. Results of chemical analyses conducted by Pacific Northwest National

Laboratory on water collected at Columbia River transect and near-shore locations at Vernita Bridge, the 100-N Area, the Hanford town site, the 300 Area, and the city of Richland are available upon request (see Preface). The concentrations of metals and anions observed in river water during 2010 were similar to those observed in the past and remain below regulatory limits. Metals and anions were detected in Columbia River transect samples both upstream and downstream of the Hanford Site. Arsenic, antimony, cadmium, chromium, copper, lead, nickel, selenium, thallium, and zinc were detected in the majority of samples, with similar levels at most locations. Beryllium and silver were below the detection limits for all samples. Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; Appendix D, Table D.5). Increased water hardness (i.e., primarily higher concentrations of calcium and magnesium ions) can reduce the toxicity of some metals by limiting their absorption into aquatic organisms. Criteria for Columbia River water were calculated using a total hardness of 47 mg/L as calcium carbonate, the lowest value based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge and the city of Richland in recent years. The total hardness reported by the U.S. Geological Survey at those locations from 1992 through 2010 ranged from 47 to 77 mg/L as calcium carbonate. All metal and anion concentrations in river water were less than the Washington State ambient surface-water quality criteria for the protection of aquatic life (Appendix C, Table C.7 and Appendix D, Table D.5). Arsenic concentrations exceeded the EPA standard for the protection of human health for the consumption of water and organisms. However, this EPA value is approximately 10,500 times lower than the Washington State chronic toxicity value (Appendix D, Table D.5), and similar concentrations were found at Vernita Bridge and the city of Richland.

For samples collected on the cross-river transects, concentrations of nitrate, chloride, and sulfate were slightly elevated along the Grant-Franklin County shoreline at the Vernita Bridge, 100-N Area, 300 Area, and near the city of Richland. Nitrate concentrations were slightly elevated along the Benton County shoreline at the 100-N Area, Hanford town site, 300 Area, and the city of Richland. Chloride concentrations were slightly elevated along the Benton County shoreline at the 300 Area and city of Richland. Sulfate concentrations were slightly elevated along the Benton County shoreline at the 300 Area. In many cases, the highest anion concentrations were for samples collected along the Franklin County shoreline. These elevated results likely resulted from groundwater seepage associated with extensive irrigation 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, nitrate, and sulfate 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 contractually required detection limits for all samples, with no indication of a Hanford Site source.

Concentrations of chromium in the Hanford Reach are of interest because groundwater contaminated with chromium above the ambient water quality criterion intersects the Columbia River at several Hanford Site locations (Section 8.7). All river transect and near-shore filtered water samples for 2010 had chromium concentrations below the ambient water quality criterion (Appendix C, Table C.7). Some near-shore water samples collected at the 100-N Area, Hanford town site, Richland, and the 300 Area had slightly elevated chromium levels compared to upstream samples at Vernita Bridge.

U.S. Geological Survey Samples. Figure 8.4.9 illustrates U.S. Geological Survey Columbia River chemical and physical water quality data for samples collected at Vernita Bridge and the city of Richland for 2005 through 2010 (WDR-US-2007). Results for 2010 are summarized in Appendix C (Table C.2). The 2010 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 2010, there was no indication of any deterioration of water quality along the Hanford Reach of the Columbia River (Appendix D, Table D.3). For 2010, median concentrations of dissolved

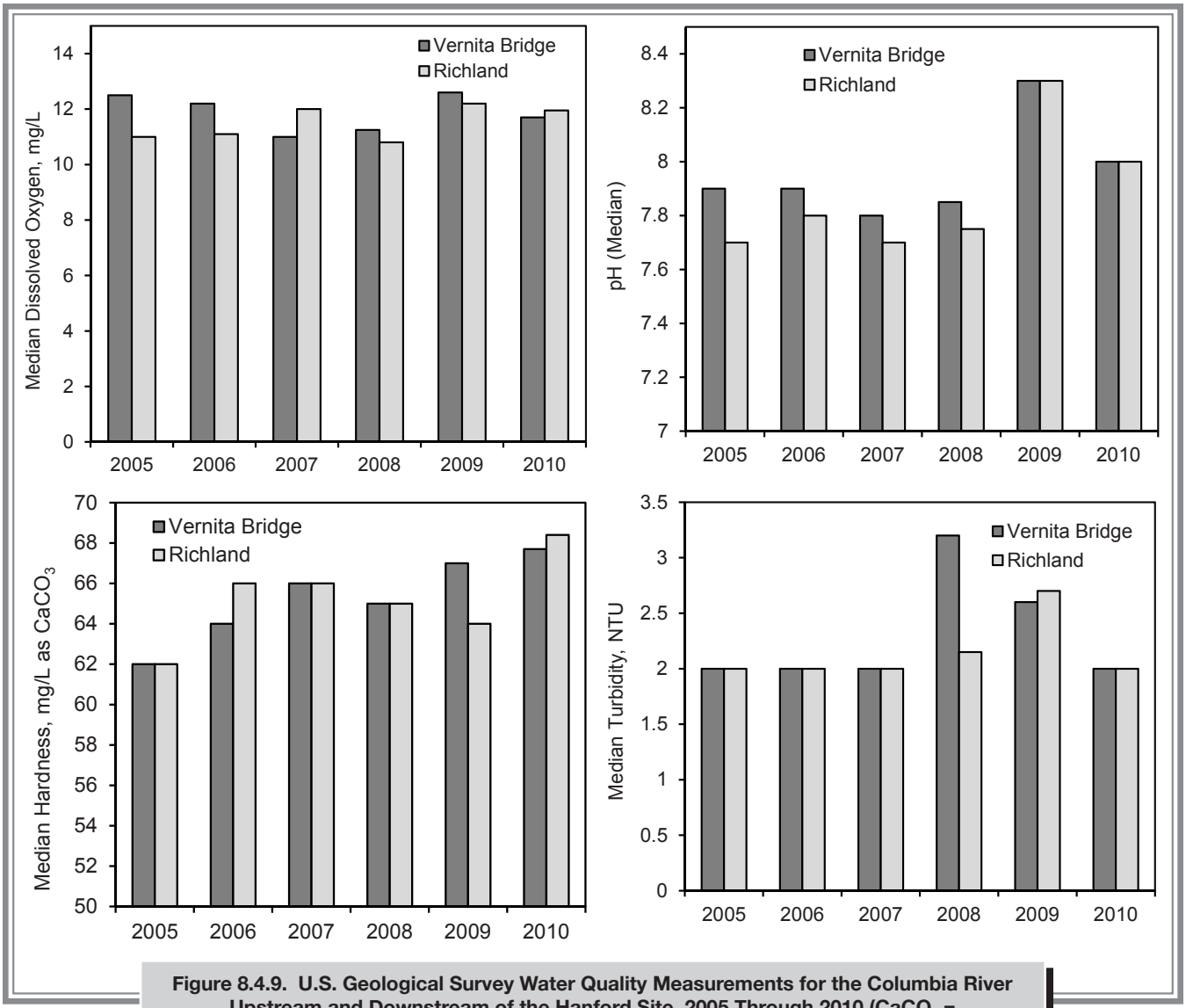

Figure 8.4.9. U.S. Geological Survey Water Quality Measurements for the Columbia River Upstream and Downstream of the Hanford Site, 2005 Through 2010 ($CaCO_3$ = calcium carbonate; NTU = Nephelometric Turbidity Units)

chromium were similar for water samples collected from near Vernita Bridge and the city of Richland and were well below the ambient water quality criterion.

8.4.2 Monitoring of Columbia River Sediment

During 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 the operation of upriver hydroelectric dams, annual spring high river flows, and occasional floods have resulted in resuspension, relocation, and subsequent redeposition

of sediment (BNWL-2305). Upper-layer sediment in the Columbia River downstream of the Hanford Site contains low concentrations of radionuclides, metals of Hanford Site origin, and radionuclides from nuclear weapons testing fallout as well as metals and other non-radioactive contaminants from mining and agricultural activities (Beasley et al. 1981; BNWL-2305; Cox et al. 2004; PNL-8148; PNL-10535; PNNL-13417; PNNL-16990). Periodic sediment sampling confirms that concentrations are low and that no significant changes in concentrations have occurred. The accumulation of radioactive materials in sediment can lead to human exposure from ingestion of aquatic organisms associated with the sediment or sediment resuspension into drinking water supplies. Sediment with accumulated radioactive materials can be an external radiation source, irradiating people who are fishing, wading, swimming, sunbathing, or participating in other recreational activities associated with the river or shoreline (DOE/EH-0173T).

Since the shutdown of the last single-pass reactor at the Hanford Site in 1971, the contaminant concentrations in Columbia River surface sediment near and downstream of the Hanford Site have been decreasing. This decrease is a result of radioactive decay and the deposition of uncontaminated material on top of the older sediment, which occurs in the reservoirs of the dams downstream of the Hanford Site (Cushing et al. 1981). However, discharges of some pollutants from the Hanford Site to the Columbia River still occur through permit-regulated liquid effluent discharges at the 100-K Area (Section 8.3) and through contaminated groundwater seepage (Section 8.5).

Several studies have been conducted to investigate the difference in sediment grain-size composition and total organic carbon content at routine Columbia River monitoring sites and the effect of grain size and organic content in measured contaminant concentrations (Beasley et al. 1981; PNL-10535; PNNL-13417). Physical and chemical sediment characteristics were found to be highly variable among monitoring sites along the Columbia River. Samples containing the highest percentage of silts, clays, and total organic carbon were generally collected from reservoirs behind dams upstream of the site and from the White Bluffs Slough on the Hanford Reach.

8.4.2.1 Collection of Columbia River Sediment Samples and Analytes of Interest

During 2010, samples of the surface layer of Columbia River sediment were collected at depths of 0 to 10 centimeters (0 to 4 inches) from six river locations that were permanently submerged (some Hanford Reach sampling locations may not be submerged during an extremely low river stage) (Figure 8.4.1 and Table 8.4.2). Sampling locations were documented using a global positioning system receiver. Surface sediment was collected with a dredge sampler, capturing several years of integrated deposits, including 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 those found above Priest Rapids Dam do not necessarily reflect a Hanford Site source. The confluences of the Columbia River with the Yakima, Snake, and Walla Walla Rivers lie between the Hanford Site and McNary Dam. Several towns, irrigation water returns, and factories in these drainages, as well as atmospheric fallout from nuclear weapons testing, may also contribute to the contaminant load found in McNary Dam sediment. Thus, sediment samples are taken periodically in the reservoir above Ice Harbor Dam (the first dam on the Snake River upstream of the river mouth) to assess Snake River input. Sediment samples were also collected along the Hanford Reach of the Columbia River, from slack-water areas where fine-grained material is known to deposit (e.g.,

the White Bluffs, 100-F Area, and Hanford Sloughs), and from the publicly accessible city of Richland shoreline that lies within the McNary Dam impoundment.

Monitoring sites in the reservoirs behind McNary and Priest Rapids dams consisted of two stations spaced approximately equidistant on a transect line crossing the Columbia River; the samples were collected near the boat-exclusion buoys immediately upstream of each dam. All other monitoring sites consisted of a single sampling location. Samples were collected using a clam-shell style sediment dredge; this sampling method is discussed in PNNL-16744. All sediment samples were analyzed for gamma-emitting radionuclides (Appendix F), strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, plutonium-239/240, and metals (DOE/RL-91-50, Rev. 4). The specific analytes selected for sediment samples were based on findings of previous Columbia River sediment investigations, reviews of past and present effluent contaminants discharged from site facilities, and reviews of contaminant concentrations observed in Hanford Site groundwater monitoring wells near the river.

8.4.2.2 Radiological Results for Columbia River Sediment Sample Analyses

Radionuclides consistently detected in river sediment adjacent to and downstream of the Hanford Site during 2010 included beryllium-7, potassium-40, cesium-137, uranium-234, uranium-235, uranium-238, plutonium-239/240, and decay products from naturally occurring radionuclides. The concentrations of all other radionuclides, including strontium-90, were below the reported minimum detectable concentrations for most samples. Cesium-137 and plutonium isotopes exist in worldwide fallout as well as in effluent from Hanford Site facilities. Beryllium-7, 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 2010 were similar to those reported for previous years, with the exception of cesium-137 (Appendix C, Table C.8), and there were no obvious differences between locations. Unusual cesium-137 values for sediment samples for 2004 through 2007, which were roughly two times higher than values from locations above Priest Rapids Dam, were sampled at the White Bluffs Slough. The 2010 values for cesium-137 at the White Bluffs Slough were slightly elevated compared to Priest Rapids Dam but lower than the 2004 through 2007 values. Previous studies of soils from the White Bluffs Slough detected elevated concentrations of cesium-137 (PNL-3127; PNL-8789). Average, maximum, and minimum concentrations of selected radionuclides measured in Columbia River sediment (2005 through 2010) are presented in Figure 8.4.10.

8.4.2.3 Chemical Results for Columbia River Sediment Sample Analyses

Detectable amounts of most metals were found in all river sediment samples (Figure 8.4.11; Appendix C, Table C.9). Maximum and average concentrations of most metals were higher for sediment collected in the reservoir upstream of Priest Rapids Dam than in sediment from either the Hanford Reach or McNary Dam. The concentrations of cadmium, lead, nickel, and zinc differed the most between locations and may be associated with upstream mining activity. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured values.

8.4.3 Monitoring of Onsite Pond Water and Sediment

Two onsite ponds, West Lake and the Fast Flux Test Facility Pond (Figure 8.4.1), located near facilities in various stages of remediation, were sampled periodically during 2010. 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

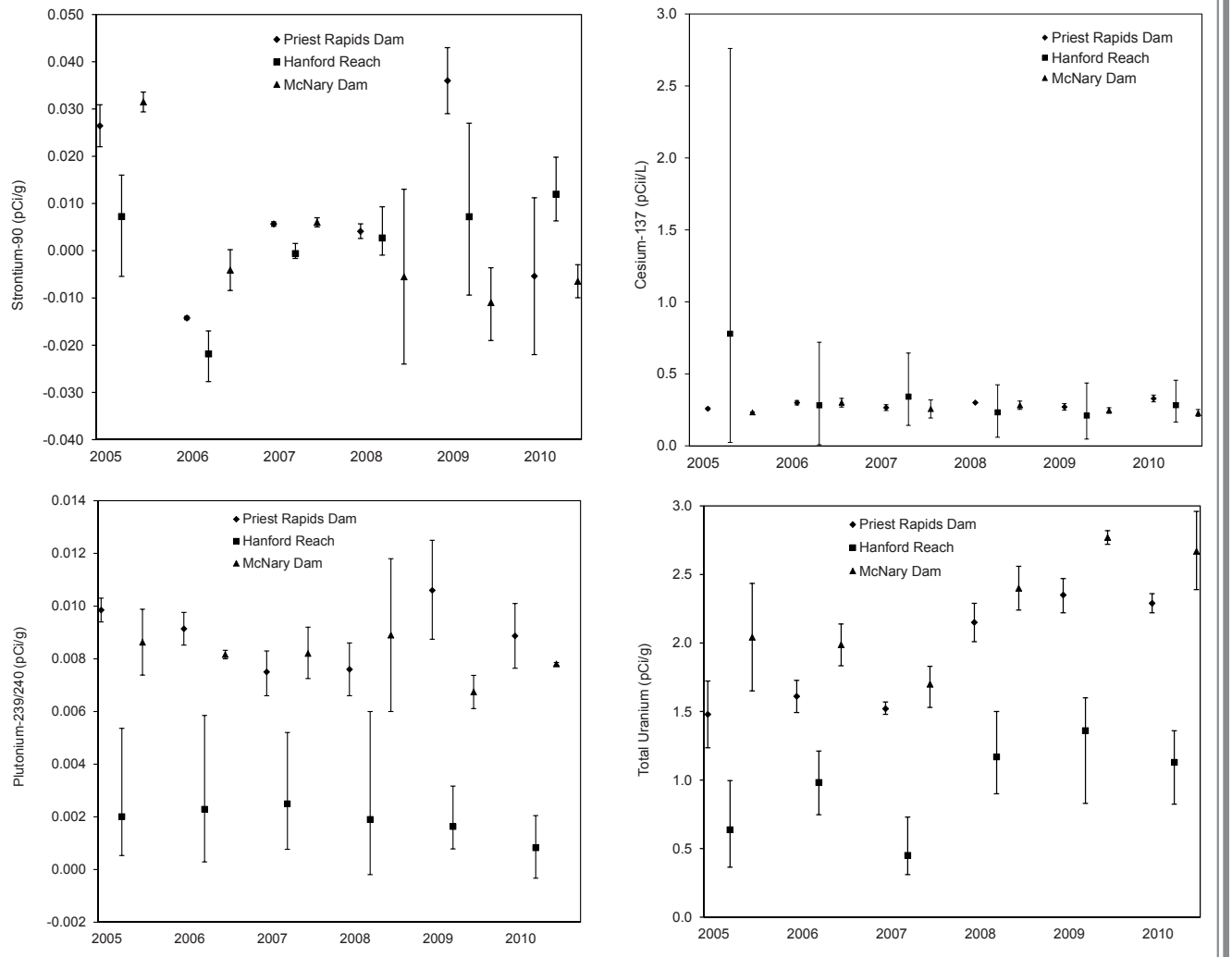

Figure 8.4.10. Average, Maximum, and Minimum Concentrations of Selected Radionuclides Measured in Columbia River Sediment, 2005 Through 2010. Most results for strontium-90 were below the detection limits.

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.

8.4.3.1 Collection of Pond Water, Sediment Samples, and Analytes of Interest

During 2010, 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 8.7), decreasing the size of West Lake and causing the suspended sediment loading to increase. Since 2002, it has not been practical for the analytical laboratory to process West Lake water samples for gross alpha, gross beta, strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238 because of the high sediment load. Consequently, sediment samples were submitted for these analytes. Radionuclides were chosen for analysis based on their presence in local groundwater and their potential to contribute to the overall radiation dose to biota that frequent the ponds.

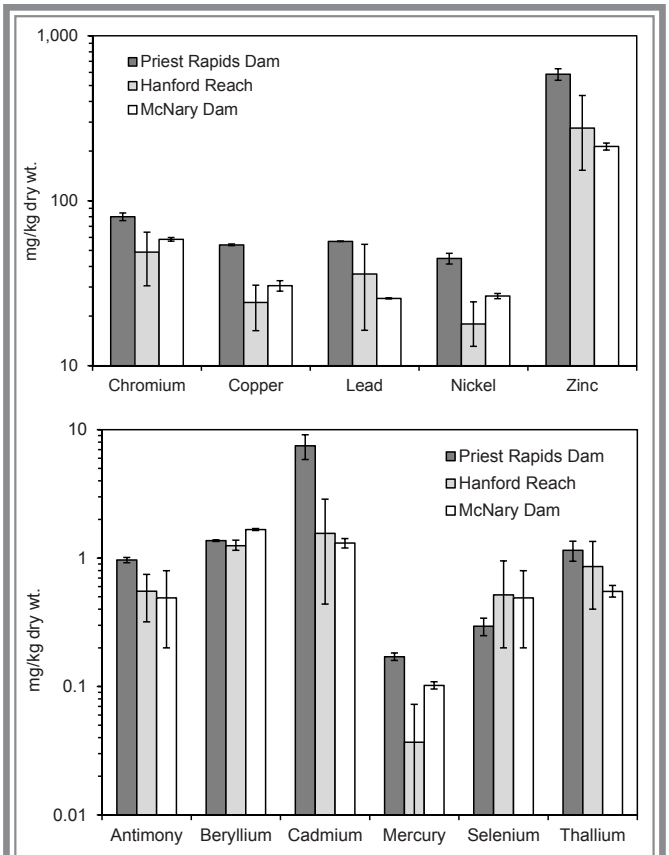

Figure 8.4.11. Average, Maximum, and Minimum Concentrations of Selected Metals Measured in Columbia River Sediment (Washington and Oregon), 2010. The upper and lower bars represent maximum and minimum values. For some metals, the maximum and minimum results are similar to the average and are not visible in the figure.

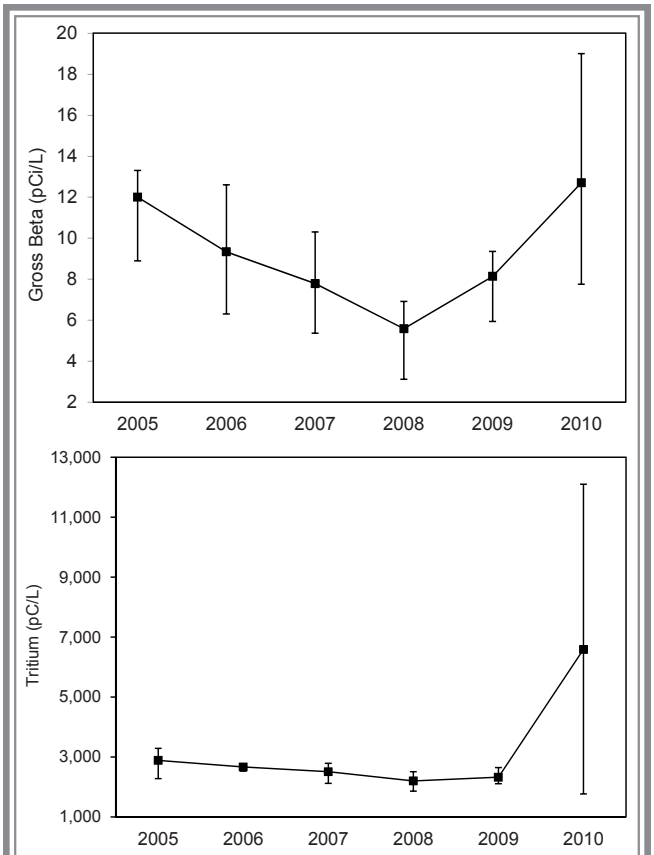

Figure 8.4.12. Average, Maximum, and Minimum Gross Beta and Tritium Concentrations in Water Samples from the Fast Flux Test Facility Pond at the Hanford Site, 2005 Through 2010

8.4.3.2 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, Chg 2; Appendix D, Table D.2) and Washington State ambient surface-water quality criteria (WAC 173-201A; 40 CFR 141; Appendix D, Tables D.3 and D.4).

Figure 8.4.12 shows the annual average gross beta and tritium concentrations in Fast Flux Test Facility Pond water from 2005 through 2010. Average levels of both constituents increased in 2010. The average tritium concentration in Fast Flux Test Facility Pond water during 2010 was 33% 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 in the 400 Area that supply water to facility operations.

Tritium concentrations in West Lake water during 2010 were similar to those observed in the past (Figure 8.4.13). All results for 2010 are below the laboratory-reported detection limits.

Samples of West Lake upper-layer sediment in 2010 had the following values:

- Gross alpha—7.3 ± 2.9 pCi/g (0.27 ± 0.11 Bq/g)
- Gross beta—22 ± 3.4 pCi/g (0.0.81 ± 0.13 Bq/g)

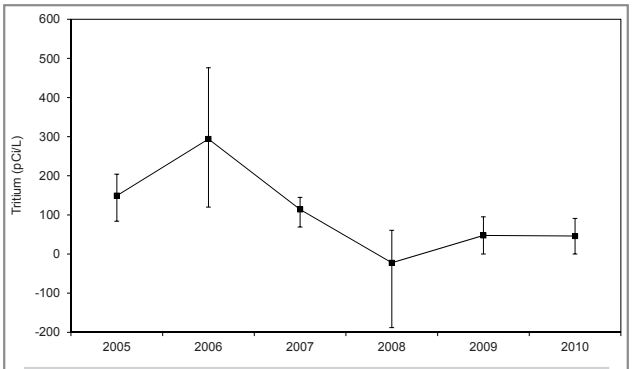

Figure 8.4.13. Average, Maximum, and Minimum Concentrations of Tritium in Water Samples from West Lake at the Hanford Site, 2005 Through 2010

- Potassium-40—19 ± 2.0 pCi/g (0.70 ± 0.074 Bq/g)
- Strontium-90—0.40 ± 0.090 pCi/g (0.015 ± 0.0033 Bq/g)
- Cesium-137—1.4 ± 0.13 pCi/g (0.052 ± 0.0048 Bq/g)
- Uranium-234—1.4 ± 0.20 pCi/g (0.052 ± 0.0074 Bq/g)
- Uranium-235—0.072 ± 0.025 pCi/g (0.0027 ± 0.00092 Bq/g)
- Uranium-238—1.3 ± 0.20 pCi/g (0.048 ± 0.0074 Bq/g).

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

8.4.4 Monitoring of Offsite Irrigation Water

As a result of public concern about the potential for Hanford Site-associated contaminants in offsite water, sampling was conducted in 2010 to document the levels of radionuclides in water used by the public. The 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 8.12).

8.4.4.1 Collection and Analysis of Offsite Irrigation Water Samples

During 2010, 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 8.4.1). Water from the Riverview irrigation canal and the Horn Rapids irrigation pumping station was sampled three times during the 2010 irrigation season. Unfiltered samples were analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, uranium-234, uranium-235, and uranium-238.

8.4.4.2 Analytical Results for Offsite Irrigation Water Samples

During 2010, most radionuclide concentrations measured in irrigation water were at the same levels detected in Columbia River water samples collected upstream of the Hanford Site. At the Horn Rapids irrigation pumping station, the tritium results were slightly higher than Columbia River water samples collected upstream of the Hanford Site. All radionuclide concentrations were less than their respective DOE-derived concentration guides and Washington State ambient surface-water quality criteria (DOE Order 5400.5, Chg 2; WAC 173-201A; 40 CFR 141).

8.5 Columbia River Shoreline Springs Monitoring

GW Patton

Samples of Columbia River shoreline spring water and associated sediment were collected along the Hanford Reach and analyzed to determine the potential impact of radiological and chemical contaminants from the Hanford Site on the public and the aquatic environment. Sections 8.5.1 and 8.5.2 discuss the collection, analysis, and results for Columbia River shoreline spring water and sediment samples.

8.5.1 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 that have leached into groundwater from past waste-disposal practices to the Columbia River (DOE/RL-92-12, Rev. 1; PNL-5289; PNL-7500; WHC-SD-EN-TI-006). Contaminated groundwater enters the Columbia River via surface and subsurface discharge. Discharge zones, located above the water level of the river, are identified in this report as shoreline springs. Routine monitoring of shoreline springs offers the opportunity to characterize the quality of groundwater being discharged to the river and assess the potential human and ecological risk associated with the spring water. In addition, contaminants in groundwater near the Columbia River are monitored using shoreline groundwater-sampling tubes (aquifer tubes) (Section 8.7; BHI-01153, Rev. 0; PNNL-14444; PNNL-16805; PNNL-16894; SGW-41497, Rev. 0).

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). These researchers reported that the predominant areas of riverbank springs at that time were in the vicinity of the 100-N Area, Hanford town site, and the 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 N Reactor operations, have reduced discharge from the 100-N Area springs.

The presence of shoreline springs also varies with river stage (river-level elevation). The water table near the Hanford Reach is strongly influenced by river-stage fluctuations. The river stage in the Hanford Reach is controlled by upriver conditions and operations at upriver dams. As river water levels fluctuate, groundwater levels change, which causes the presence of shoreline springs in the Hanford Reach to vary. At the 300 Area, the river stage is also influenced by the elevation of the McNary Dam pool. Columbia River water moves into the Hanford Site aquifer as the river stage rises (bank storage) and then discharges from the aquifer in the form of shoreline springs as the river stage falls. Following an extended period of low river flow, groundwater discharge zones above the water level of the river may cease to exist when the level of the aquifer comes into equilibrium with the river level. Thus, springs are most readily identified immediately following a decline in river stage.

Bank storage of river water affects the contaminant concentration of the springs. Spring water discharged immediately following a river stage decline generally consists of river water or a mixture of river water and groundwater. The percentage of groundwater in the spring water discharge increases over time following a drop in river stage. Measuring the specific conductance of the spring water discharge provides

an indicator of the extent of bank storage because Hanford Site groundwater has a higher specific conductance than Columbia River water.

The effect of bank storage on groundwater discharges and contaminant concentration variations in aquifer thickness, porosity, and plume concentrations makes it difficult to accurately estimate the volume of contaminated groundwater discharging via springs to the Columbia River within the Hanford Reach. Studies of shoreline springs conducted during 1983 (PNL-5289), 1988 (PNL-7500), and 1991 (DOE/RL-92-12, Rev. 1; WHC-EP-0609) and results of near-shore studies in 1997 (PNNL-11933) and 2001 (PNNL-13692) noted that discharges from the springs had only localized effects on Columbia River contaminant concentrations.

8.5.1.1 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 8.5.1 and 8.5.2 and Figure 8.4.1 summarize the sampling locations and frequencies, as well as sample types and analyses included in shoreline springs monitoring during 2010. This section describes the monitoring efforts and summarizes the results for these aquatic environments. Detailed analytical results are available upon request (see Preface for contact information). 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 2010 were analyzed for gamma-emitting radionuclides, gross alpha, gross beta, and tritium. Samples from selected springs were analyzed for strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238. Selected riverbank spring water samples were analyzed for iodine-129 using a gamma spectroscopy method. Most samples were analyzed for metals and anions. Samples from selected locations were analyzed for volatile organic compounds. Only unfiltered samples were analyzed, except for metals analyses, in which case both filtered and unfiltered samples were analyzed (Appendix C, Table C.10).

Table 8.5.1. Hanford Reach Shoreline Springs Water Monitoring, 2010

Spring Location[a]	Sample Type	Sampling Frequency	Analyses
100-B Area	Grab	Annually	Alpha, beta, tritium, strontium-90, technetium-99, gamma energy analysis, metals (filtered and unfiltered), anions, VOC[b]
100-K Area	Grab	Annually	Alpha, beta, tritium, strontium-90, gamma energy analysis, metals (filtered and unfiltered), anions, VOC[b]
100-N Area	Grab	Annually	Alpha, beta, tritium, strontium-90, gamma energy analysis, metals (filtered and unfiltered), anions
100-D Area	Grab	Annually	Alpha, beta, tritium, strontium-90, gamma energy analysis, metals (filtered and unfiltered), anions
100-H Area	Grab	Annually	Alpha, beta, tritium, strontium-90, technetium-99, isotopic uranium,[c] gamma energy analysis, metals (filtered and unfiltered), anions
100-F Area	Grab	Annually	Alpha, beta, tritium, strontium-90, isotopic uranium,[c] gamma energy analysis, metals (filtered and unfiltered), anions, VOC[b]
Hanford town site	Grab	Annually	Alpha, beta, tritium, technetium-99, iodine-129, isotopic uranium,[c] gamma energy analysis, metals (filtered and unfiltered), anions
300 Area	Grab	Annually	Alpha, beta, tritium, strontium-90, iodine-129, isotopic uranium,[c] gamma energy analysis, metals (filtered and unfiltered), anions, VOC[b]

(a) See Figure 8.4.1.
(b) VOC = Volatile organic compounds.
(c) Isotopic uranium (uranium-234, uranium-235, and uranium-238) analyzed by alpha spectrometry (alpha energy analysis).

Table 8.5.2. Hanford Reach Shoreline Springs Sediment Monitoring, 2010

Spring Location[a]	Sampling Frequency	Analyses
100-B Area	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] metals
100-K Area	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] metals
100-H Area	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] metals
100-F Area	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] metals
Hanford town site	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] metals
300 Area	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] metals
Richland Spring	Annually	Gamma energy analysis, strontium-90, isotopic uranium,[b] metals

(a) See Figure 8.4.1.
(b) Isotopic uranium (uranium-234, uranium-235, and uranium-238) analyzed by alpha spectrometry (alpha energy analysis).

8.5.1.2 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 2010. Gross alpha, gross beta, tritium, strontium-90, technetium-99, and total uranium (uranium-234, uranium-235, and uranium-238) were detected in spring water (Appendix C, Table C.10). All samples analyzed for iodine-129 in 2010 were below the laboratory-reported detection limit. All radiological contaminant concentrations measured in shoreline springs during 2010 were less than applicable DOE-derived concentration guides, but exceeded the Washington State ambient water quality criteria for gross alpha at some 300 Area locations and for tritium at the Hanford town site. In addition, uranium concentrations at some 300 Area locations exceeded the drinking water standard (DOE Order 5400.5, Chg 2; Appendix D, Table D.2).

Figure 8.5.1 depicts 6-year trend plots of selected radionuclide concentrations in 300 Area shoreline spring water (Spring 42-2 and Spring DR 42-2) from 2005 through 2010. Radionuclide concentrations in 300 Area shoreline springs in 2010 were similar to concentrations measured in previous years. Radionuclide concentrations in shoreline spring water vary over the years with changes in the degree of Columbia River water and groundwater mixing (i.e., bank storage effect). Elevated gross alpha, gross beta, and uranium concentrations measured in the 300 Area riverbank springs are indicators of the contaminated groundwater plume originating at the 300 Area. Elevated tritium levels measured in 300 Area shoreline springs are indicators of the contaminated groundwater plume from the 200 Areas (Section 5.9 in PNL-10698).

Figure 8.5.2 provides concentrations of selected radionuclides in shoreline spring water near the Hanford town site (Spring 28-2 and Spring DR 28-2) from 2005 through 2010. 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).

In 2010, gross beta concentrations in shoreline spring water at locations in the 100 Areas, the Hanford town site, and the 300 Area were elevated compared to gross beta concentrations in Columbia River water at Priest Rapids Dam (Appendix C, Table C.3), but were below the Washington State ambient water quality criterion. The highest gross beta concentration measured in shoreline springs was at the Hanford town site (45 ± 4.8 pCi/L [1.66 ± 0.178 Bq/L]), which was 90% of the Washington State ambient surface water quality criterion of 50 pCi/L (1.85 Bq/L) (WAC 173-201A; 40 CFR 141), followed by 44 ± 5.0 pCi/L (1.63 ± 0.185 Bq/L) in the 300 Area.

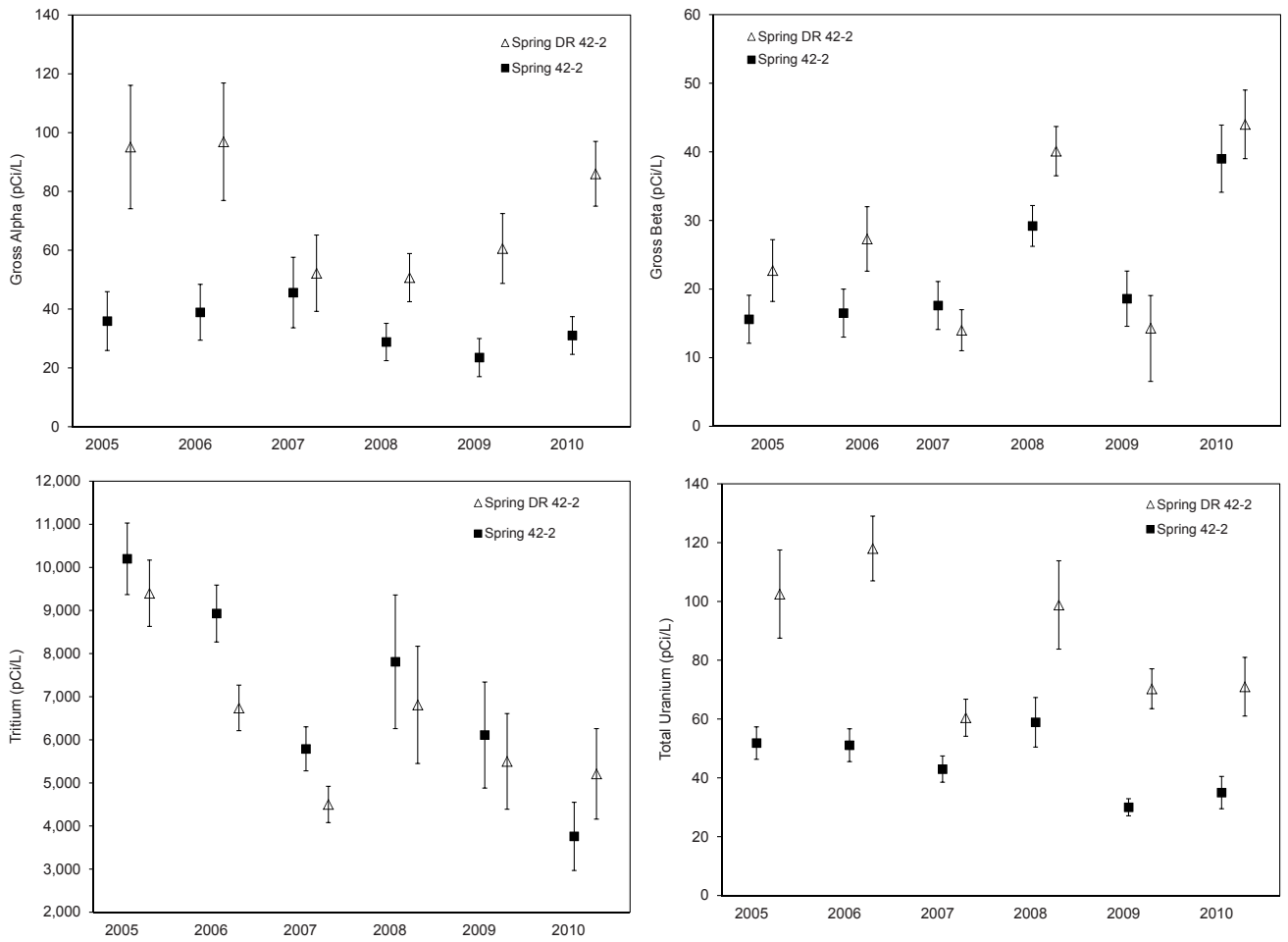

Figure 8.5.1. Concentrations (results ±2 total propagated analytical uncertainty) of Selected Radionuclides in Water from Columbia River Shoreline Springs Near the Hanford Site 300 Area, 2005 Through 2010. Note: DR refers to downriver; thus, DR 42-2 is a spring located downriver from Spring 42-2.

Tritium concentrations varied widely with location. The highest tritium concentration measured in shoreline springs was at the Hanford town site (37,000 ± 7,200 pCi/L [1,369 ± 266 Bq/L]), which was 185% of the Washington State ambient surface water quality criterion of 20,000 pCi/L (740 Bq/L) (WAC 173-201A; 40 CFR 141), followed by 5,200 ± 1,000 pCi/L (192 ± 37 Bq/L) in the 300 Area, and 3,600 ± 750 pCi/L (133 ± 27.7 Bq/L) in the 100-N Area. Tritium concentrations in most shoreline spring water samples were elevated compared to the 2010 Columbia River water concentrations at Priest Rapids Dam (Appendix C, Table C.3).

Water samples from shoreline springs were analyzed for strontium-90 in the 100 and 300 Areas. The highest strontium-90 concentration detected in shoreline spring water was at the 100-H Area (6.3 ± 0.98 pCi/L [0.233 ± 0.0363 Bq/L]). This value was 79% of the Washington State 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

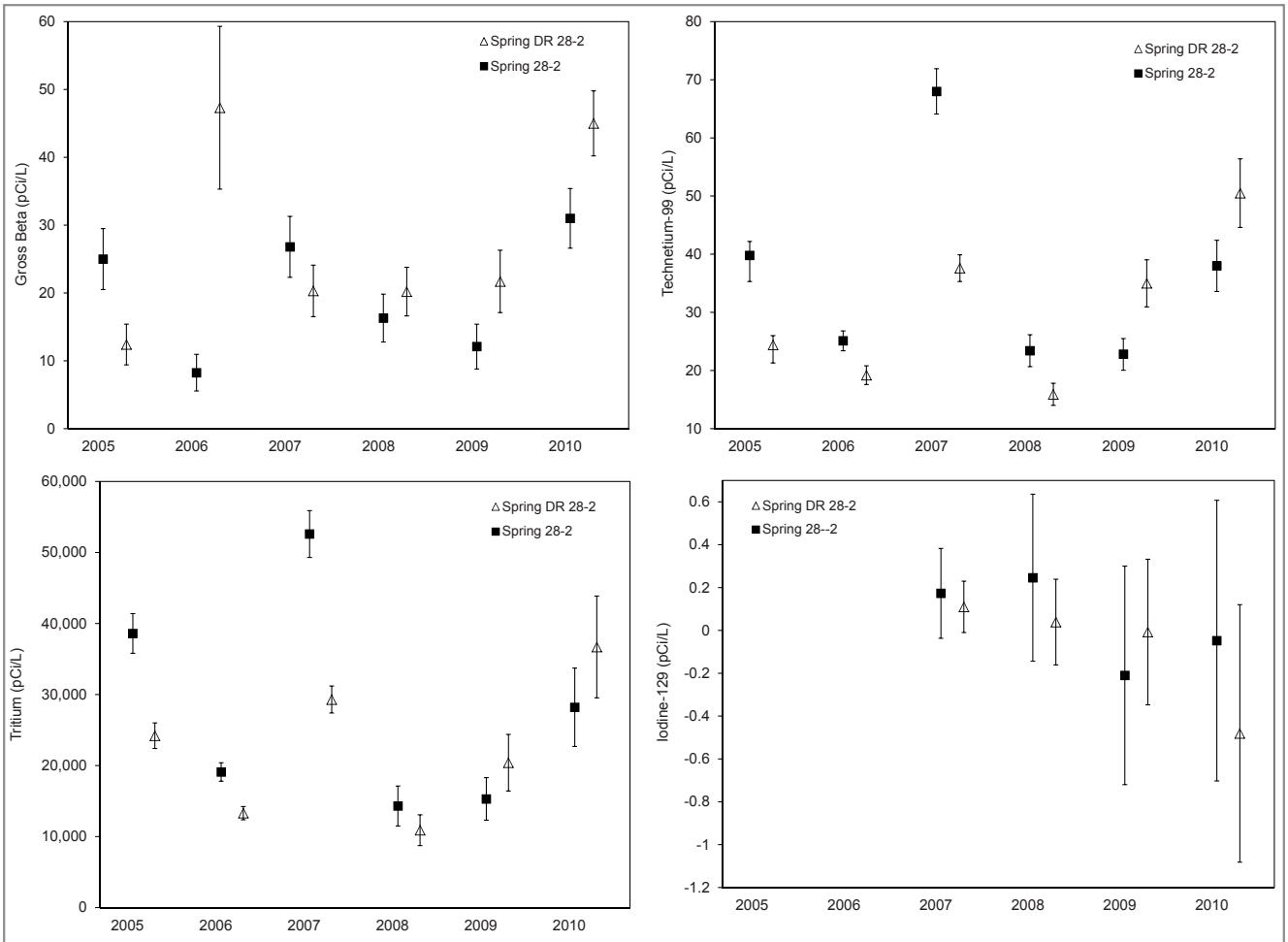

Figure 8.5.2. Concentrations (results ±2 total propagated analytical uncertainty) of Selected Radionuclides in Columbia River Shoreline Springs Water at the Hanford town site (Spring 28-2 and Spring DR 28-2), 2005 Through 2010. Note: DR refers to downriver; thus, DR 28-2 is a spring located downriver from Hanford town site Spring 28-2. Samples for iodine-129 from 2005 and 2006 were not analyzed; samples for 2007, 2008, 2009, and 2010 were analyzed using a method with a higher detection limit than the previous samples.

concentration was found in shoreline spring water from the Hanford town site (50 ± 5.9 pCi/L [1.85 ± 0.218 Bq/L]).

Water samples from shoreline springs at the Hanford town site and the 300 Area were collected in 2005 and submitted to a laboratory for iodine-129 analyses using a method capable of detecting extremely low concentrations. However, since 2005, the unique instrument used for this assay has not been operational, and an alternative for this ultra-trace measurement capability is not available. The highest concentrations were measured in water samples from the Hanford town site springs in 2005, with all values below the Washington State surface water quality criterion of 1 pCi/L (0.037 Bq/L) (Appendix D, Table D.4). Riverbank spring water samples were analyzed for iodine-129 for 2007 to 2010 with traditional gamma spectrometry, which has a higher detection limit than the ultra-trace method. All samples analyzed for iodine-129 for 2007 to 2010 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 2010 (Figure 8.4.1). The highest total uranium level was found in 300 Area spring water (71 ± 10 pCi/L [2.63 ± 0.37 Bq/L] or approximately 107 ± 10.6 µg/L), which was collected at Spring DR 42-2 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 20 pCi/L [0.74 Bq/L]). Spring DR 42-2 in the 300 Area had an elevated gross alpha concentration (86 ± 11 pCi/L [3.18 ± 0.407 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 2005 through 2010 parallel uranium concentrations and are likely associated with its presence. Concentrations of radionuclides in 300 Area shoreline springs in 2010 were similar to concentrations measured in previous years and varied with changes in riverbank storage.

8.5.1.3 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 2010. Metals and anions of interest (chloride, nitrate, and sulfate) were detected in spring water. Concentrations of volatile organic compounds were near or below the analytical laboratory's required detection limits in all samples. Trace amounts of trichloroethene—a chlorinated organic compound—were detected for Spring 77-1 in the 100-K Area. Traces of trichloroethene that were below the analytical laboratory's required detection limit were found for the 300 Area. Trichloroethene has been consistently detected at trace concentrations in 300 Area shoreline spring water, which is a result of contaminated groundwater in the shallowest part of the unconfined aquifer near the Columbia River. Relatively high concentrations recently discovered at depth in the unconfined aquifer, which greatly exceeded regulatory standards (PNNL-16435), were not observed in the riverbank springs.

Table 8.5.3 presents concentration ranges of selected chemicals measured in shoreline spring water during 2004 through 2010. For most locations, the 2010 chemical sample results were similar to those previously reported (PNNL-14687). Nitrate concentrations for 2004 through 2010 were highest in spring water samples from the 100-F Area. Dissolved chromium concentrations in shoreline springs for 2004 through 2010 were highest in the 100-D, 100-B, 100-H, and 100-K Areas. Hanford Site groundwater monitoring results for 2010 indicated similar contaminant concentrations at shoreline areas near the discharge locations for the springs (Section 8.7, Figures 8.7.6, 8.7.8, and 8.7.9).

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, shoreline spring water criteria were calculated using the same 47-mg/L calcium carbonate hardness listed in Appendix D, Table D.5. Concentrations of most metals measured in water collected from springs along the Hanford Site shoreline during 2005 through 2010 were below Washington State ambient surface water chronic toxicity levels (WAC 173-201A). However, for 2004 through 2010, the maximum concentrations of dissolved chromium in shoreline spring water from the 100-B, 100-K, 100-D, 100-H, and 100-F Areas were above the Washington State ambient surface water chronic and acute toxicity levels; concentrations from the 100-N Area were above the Washington State ambient surface water chronic toxicity levels only (Appendix D, Table D.5). For 2010, dissolved chromium was at or above the Washington State ambient surface water level for chronic and acute toxicity levels at the 100-B, 100-K, 100-H, and 100-F Areas. The riverbank spring in the 100-D Area that is adjacent to the location with the highest chromium concentrations in near-shore groundwater had no observed flow during multiple attempts to collect the sample in 2010. 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 shoreline spring locations were below the drinking water standard (Appendix D, Table D.4).

Table 8.5.3. Concentration Ranges for Selected Chemicals in Water Monitoring Samples from Columbia River Shoreline Springs on the Hanford Site, 2004 Through 2010

	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		12	9	7	13	13	7	21	20
Dissolved Metals (µg/L)									
Antimony	NA	0.12 - 0.25	0.094 - 0.29	0.16 - 0.29	0.14 - 0.30	0.13 - 0.39	0.099 - 0.22	0.15 - 0.34	0.14 - 0.45
Arsenic	190	0.42 - 1.3	0.35 - 1.8	1.5 - 2.5	0.49 - 2.5	0.33 - 2.6	0.38 - 2.2	0.99 - 4.0	0.87 - 6.3
Cadmium	0.59	0.0040 - 0.029	0.0083 - 0.025	0.0090 - 0.025	0.0074 - 0.054	0.0020 - 0.038	0.018 - 0.12	0.0073 - 0.028	0.014 - 0.038
Chromium	10[b]	2.2 - 18	0.59 - 72	4.9 - 11	0.49 - 54	0.76 - 37	0.83 - 16	0.52 - 2.7	1.5 - 3.5
Copper	6	0.20 - 1.6	0.25 - 0.73	0.18 - 0.39	0.32 - 1.1	0.40 - 0.89	0.23 - 0.58	0.24 - 0.70	0.30 - 0.68
Lead	1.1	0.15 - 1.4	0.14 - 0.39	0.090 - 0.27	0.0087 - 0.91	0.12 - 1.0	0.051 - 0.36	0.0060 - 0.29	0.0040 - 0.41
Nickel	83	0.091 - 2.1	0.11 - 2.6	0.010 - 2.0	0.22 - 6.4	0.099 - 2.7	0.12 - 2.6	0.046 - 1.4	0.17 - 3.0
Silver	0.94[c]	0.0014 - 0.0050	0.0014 - 0.0050	0.0014 - 0.0050	0.0014 - 0.0050	0.0014 - 0.0070	0.0014 - 0.0050	0.0014 - 0.015	0.0014 - 0.0050
Thallium	NA	0.0010 - 0.024	0.0038 - 0.016	0.0028 - 0.0081	0.0066 - 0.030	0.0010 - 0.017	0.0010 - 0.013	0.0032 - 0.019	0.0040 - 0.018
Zinc	55	0.43 - 17	1.1 - 3.1	1.2 - 1.7	1.5 - 5.3	0.68 - 4.8	1.1 - 4.2	0.74 - 2.7	0.78 - 4.1
No. of Samples		102	10	7	13	13	7	20	19
Total Recoverable Metals (µg/L)									
Chromium	96[d]	5.4 - 250	0.83 - 74	5.0 - 13	1.5 - 270	0.89 - 58	2.3 - 59	0.69 - 24	1.8 - 30
Mercury	0.012[e]	0.00022 - 0.11	0.00071 - 0.050	0.00040 - 0.0094	0.00047 - 0.30	0.00052 - 0.064	0.0016 - 0.060	0.00057 - 0.018	0.00054 - 0.047
Selenium	5	0.30 - 1.3	0.10 - 2.1	0.65 - 1.0	0.10 - 2.4	0.10 - 1.3	0.16 - 2.0	0.38 - 1.7	1.2 - 3.9
No. of Samples		10	8	6	13	13	7	21	25
Anions (mg/L)									
Nitrate	45[e]	0.37 - 2.2	0.054 - 7.1	2.7 - 4.7	0.10 - 3.4	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.

8.5.2 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 the 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 the 300 Area. Sampling of shoreline springs sediment in the 100-B, 100-K, and 100-F Areas began during 1995 and in 2004 in the 100-H Area. Substrates at the shoreline springs in the 100-N and 100-D Areas consist predominantly of large cobble, which is unsuitable for sampling. During 2010, sediment samples were collected at shoreline springs in the 100-B, 100-H, 100-K, 100-F, and 300 Areas and the Hanford town site.

8.5.2.1 Radiological Results for Sediment Samples from Columbia River Shoreline Springs

Results for 2010 samples were similar to those observed for previous years (Appendix C, Table C.11). Potassium-40, cesium-137, and uranium isotopes were the only radionuclides reported above the minimum detectable concentrations. During 2010, 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).

8.5.2.2 Chemical Results for Sediment Samples from Columbia River Shoreline Springs

Concentrations of metals in shoreline spring sediment samples during 2010 were similar to concentrations in Hanford Reach Columbia River sediment samples (Appendix C, Table C.9). Lead concentrations in riverbank spring sediment were slightly elevated at the 100-H Area, and chromium levels were slightly elevated at the 100-B Area and the Hanford town site. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured values.

8.6 Radiological Monitoring of Hanford Site Drinking Water

LE Bisping and LM Kelly

Pacific Northwest National Laboratory scientists conducted radiological monitoring of drinking water supplied to Hanford Site facilities by DOE-owned pumps and water treatment facilities during 2010. Mission Support Alliance, LLC the site water-compliance organization, conducted routine chemical, physical, and microbiological monitoring of onsite drinking water. Individual water systems operated by Mission Support Alliance, LLC; CH2M HILL Plateau Remediation Company; 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.

"Group A Public Water Supplies" (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 are available upon request (see Preface for contact information). 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, as well as to Mission Support Alliance, LLC, but are not published.

All DOE-owned Hanford Site drinking water systems were in compliance with drinking water standards for radiological, chemical, and microbiological contaminant levels during 2010. Contaminant concentrations measured during the year were similar to those observed in recent years (PNNL-19455; PNNL-18427).

8.6.1 Hanford Site Drinking Water Systems

Nine DOE-owned, contractor-operated, public water systems supplied drinking water during 2010 to DOE facilities at the Hanford Site (Table 8.6.1). 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. Mission Support Alliance, LLC operated five of the public water systems; two systems were operated by Washington Closure Hanford, LLC; and two systems were operated by CH2M HILL Plateau Remediation Company. The 300 Area system distributed water supplied by the city of Richland. In addition to the 300 Area, the city of Richland provided drinking water to the Richland North Area and the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER) in 2010.

Table 8.6.1. Hanford Site Drinking Water Systems and System Operators

System[a]	Operator
200-West Area	Mission Support Alliance, LLC
100-K Area	CH2M HILL Plateau Remediation Company
100-N Area	Washington Closure Hanford, LLC
300 Area	Washington Closure Hanford, LLC
400 Area	CH2M HILL Plateau Remediation Company
200-East Area	Mission Support Alliance, LLC
609 Fire Station	Mission Support Alliance, LLC
Wye Barricade	Mission Support Alliance, LLC
Yakima Barricade	Mission Support Alliance, LLC

(a) 400 Area system water is from 400 Area groundwater wells. Water for all other systems is from the Columbia River.

8.6.2 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 8.6.1). Water for the 100-K, 100-N, and 200-West Areas facilities was obtained from the Columbia River. In September 2010, the water treatment facility in the 100-N Area was shut down permanently. Water treated in the 400 Area was pumped from wells. The 400 Area used emergency backup well 499-SO-8 (P-14) as the source of drinking water for the first 6 months of 2010. Primary supply well 499-S1-8J (P-16) supplied the system for the

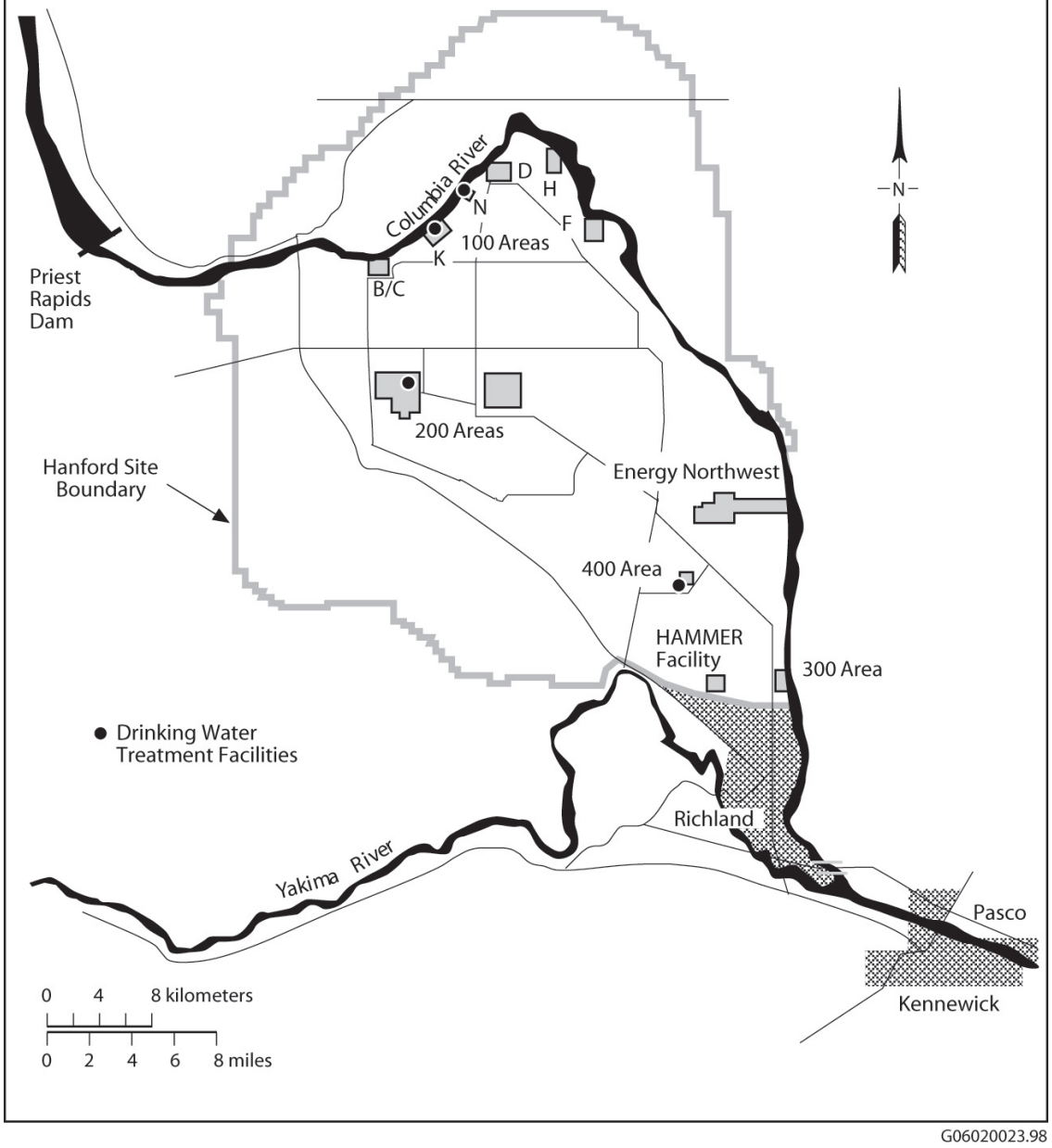

Figure 8.6.1. Hanford Site Drinking Water Treatment Facilities and Sampling Locations, 2010

remaining 6 months of 2010. Backup well 499-S0-7 (P-15) did not supply water to 400 Area consumers during 2010. The three wells furnished water to a common header that supplies two above-ground storage tanks.

8.6.3 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 Area, Richland North Area, and at the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER) was not routinely monitored for radiological contaminants by DOE contractor personnel. However, personnel from Pacific Northwest National Laboratory's Surface Environmental Surveillance Project routinely collected water samples from the Columbia River at the city of Richland river water intake. The Columbia River is a major source of the city of Richland's drinking water. The radiological analytical results for these river water samples are summarized in Section 8.4 and tabulated in Appendix C (Table C.4). The city of Richland 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 annual water quality report is mailed to all utility consumers as an insert with a monthly utility bill. The water quality report is also available on the city of Richland website at http://www.ci.richland.wa.us/DocumentView.aspx?DID=1818.

8.6.4 Radiological Results for Hanford Site Drinking Water Samples

Drinking water samples collected for radiological analysis in 2010 were analyzed for gross alpha, gross beta, tritium, and strontium-90 (Table 8.6.2). Individual analytical results are available upon request (see Preface). The maximum amount of beta-gamma radiation from manmade radionuclides allowed in drinking water by Washington State and EPA is an annual average concentration that will not

Table 8.6.2. Annual Average Concentrations (pCi/L)[a] of Selected Radiological Constituents in Hanford Site Drinking Water, 2010

Constituent	No. of Samples Analyzed from Each Location	Systems				
		100-K Area	100-N Area[b]	200-West Area	400 Area	Standard
Gross alpha[c]	4[d]	0.64 ± 0.63[e]	-0.02 ± 1.56[e]	0.44 ± 1.05[e]	1.30 ± 1.43[e]	15[f,g]
Gross beta[c]	4[h]	-0.25 ± 1.77[e]	0.81 ± 0.89[e]	0.91 ± 4.19[e]	10.27 ± 8.93	50[g]
Tritium[c]	4[d]	~	~	~	5,863 ± 8,533	20,000[g]
Tritium	1[i]	-142 ± 315[d,j]	-261 ± 309[d,j]	101 ± 338[d,j]	~	20,000[g]
Strontium-90	1[i]	0.176 ± 0.73[d,j]	0.22 ± 0.802[d,j]	-0.032 ± 0.768[d,j]	-0.268 ± 0.756[d,j]	8[f,g]

(a) Multiply pCi/L by 0.037 to convert to Bq/L.
(b) 100-N Area water system permanently shut down in September 2010; fourth quarter samples not collected.
(c) Annual average ±2 times the standard deviation.
(d) Samples were collected and analyzed quarterly (n=4). The exception was the 100-N Area—due to shutdown, only three samples were analyzed.
(e) Analytical results for all samples were below the detection limit.
(f) WAC 246-290.
(g) 40 CFR 141.
(h) Samples were collected monthly, composited, and analyzed quarterly (n=4). Due to shutdown, only three samples from the 100-N Area were analyzed.
(i) Samples were collected quarterly, composited, and analyzed annually.
(j) Single result ±2 total propagated analytical error.

produce an annual dose equivalent to the whole body or any internal organ greater than 4 millirem (0.04 millisievert). Maximum contaminant levels for gross alpha (excluding radon and uranium) is 15 pCi/L (0.56 Bq/L). The maximum allowable annual average limit for tritium is 20,000 pCi/L (740 Bq/L) (40 CFR 141; WAC 246-290). These concentrations are assumed to produce a total body or organ dose of 4 millirem (0.04 millisievert) per year. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any internal organ must not exceed 4 millirem (0.04 millisievert).

Annual average concentrations of all monitored radionuclides in Hanford Site drinking water were below state and federal maximum allowable contaminant levels during 2010. The gross alpha, gross beta, tritium, and strontium-90 results from the four facilities where drinking water was obtained from the Columbia River were all below their minimum detectable concentrations (i.e., concentrations were too low to measure). With the 400 Area emergency backup well 499-SO-8 (P-14) being the source of drinking water for the first 6 months of 2010, the tritium values were higher than typically seen, but still below the drinking water standard. In the second half of the year when the primary supply well 499-S1-8J (P-16) returned to service, tritium results were consistent with levels observed previously. 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 8.6.2).

Soil and Groundwater Remediation Project personnel collected and analyzed raw (untreated) water samples from all three 400 Area drinking water wells (one primary well and two backup wells). A tritium plume that originates in the 200-East Area extends under the 400 Area and has historically affected tritium concentrations in all 400 Area drinking water wells. During 2010, 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 8.6.3; Figure 8.6.2).

Table 8.6.3. Tritium Concentrations (pCi/L)[a] in Hanford Site 400 Area Drinking Water Wells, 2010[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)
July 7, 2010	1,700 ± 380	3,100 ± 650	6,900 ± 1,400
August 11, 2010	1,900 ± 410	1,800 ± 390	1,900 ± 410
November 11, 2010	1,700 ± 380	1,800 ± 410	2,000 ± 440

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

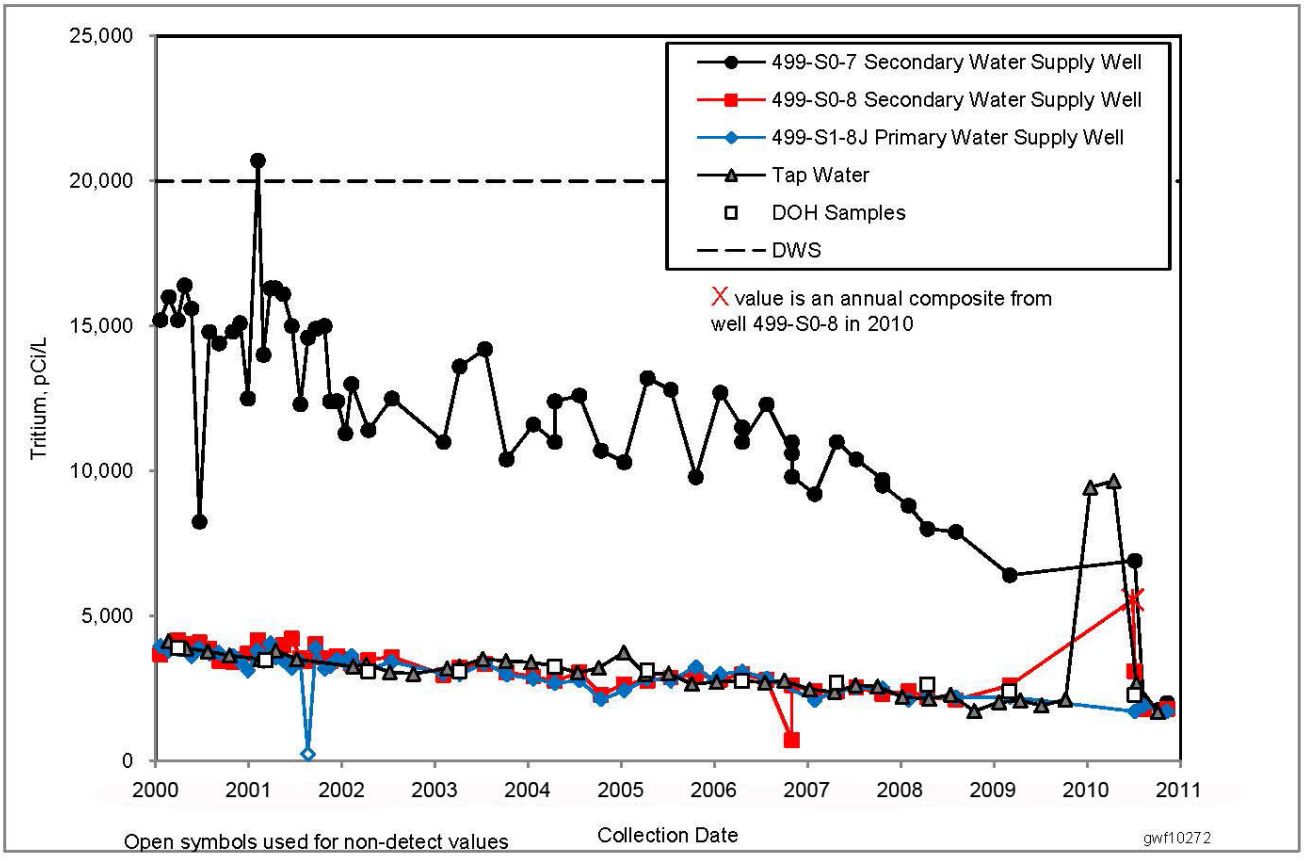

Figure 8.6.2. Tritium Concentrations in Drinking Water from Three Wells in the Hanford Site 400 Area, 2000 Through 2010 (DOH = Washington State Department of Health; DWS = drinking water standard). Multiply pCi/L by 0.037 to convert to Bq/L.

8.7 Groundwater Monitoring

CJ Martin

Groundwater—water beneath the earth's surface that creates a zone of saturation in porous materials such as sand, gravel, or fractured rock—can be extracted by pumping it to the earth's surface. Where groundwater can be pumped to the surface, the porous material is defined as an aquifer, which exists in two conditions: unconfined and confined. In an unconfined aquifer, the groundwater surface (water table) is exposed to the atmosphere through open pores in the porous material. In confined aquifers at the Hanford Site, low permeability to nearly impermeable geologic materials (e.g., clay or basalt, respectively) occurs between the water of the aquifer and the ground surface. This can locally isolate (confine) the aquifer from atmospheric influences. A well drilled into a confined aquifer may have a higher water level than nearby wells completed in the unconfined water table.

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 being released to the ground (DOE/RL-2007-20, Rev. 0). Some of the contaminants in this wastewater have reached the groundwater. Hazardous chemicals in the groundwater include carbon tetrachloride, chromium, and cyanide. Radioactive contaminants include tritium, strontium-90, technetium-99, iodine-129, and uranium. Currently, groundwater contaminant levels are greater than regulatory drinking water standards beneath approximately 12.2% of the Hanford Site area (DOE/RL-2011-01, Rev. 0). Area plume dimensions reported for 2010 reflect an increase in total area, compared with estimates reported in previous years. Advancements in the methods used to determine and measure plume contour lines have increased dimension precision and accuracy. With the exception of the carbon tetrachloride plume in the 200-West Area, which is larger as a result of dispersion in the aquifer, plume coverage has not increased.

Groundwater beneath the Hanford Site is currently used as a water supply for drinking water or irrigation in a very limited capacity. Contaminants carried by groundwater moving from the site can be detected in the near-shore Columbia River environment and, in some locations, at levels that exceed relevant environmental standards. However, contaminants in groundwater have not been shown to adversely affect offsite water supply, such as the Columbia River and municipal water supply wells.

The *Hanford Integrated Groundwater and Vadose Zone Management Plan* (DOE/RL-2007-20, Rev. 0) describes steps for cleaning up groundwater and the vadose zone. DOE developed the plan in consultation with EPA and the Washington State Department of Ecology. The primary elements associated with managing the Hanford Site's groundwater and vadose zone are to 1) protect the Columbia River and groundwater; 2) develop a cleanup decision process; and 3) attain final cleanup. The following paragraphs describe these elements in further detail.

Protect the Columbia River and Groundwater. Many actions have already been taken to address the principal threats to the Columbia River and groundwater. These actions include the following:

- Discontinuing discharge of all unpermitted liquids in the central Hanford Site
- Cleaning up the former liquid waste sites in the 100 and 300 Areas to reduce the potential for future contamination to groundwater
- Containing groundwater plumes and reducing the mass of primary contaminants through remedial actions such as pump-and-treat systems.

Develop a Process for Cleanup Decisions. Final decisions will be based on processes outlined in CERCLA and/or RCRA. Five key elements will support final decisions:

- Assure sufficient characterization data are gathered, focusing on waste sites with deep contamination that pose a future risk to groundwater.
- Evaluate the performance of early actions (waste site remediation along the River Corridor and groundwater interim actions) to help guide future cleanup activities.
- Identify cleanup goals for waste sites that support long-term groundwater remediation.
- Identify new technologies to reduce the mobility of deep contamination and limit its movement to groundwater.
- Improve integration of cleanup decisions for waste sites and groundwater.

Attain Final Cleanup. DOE, EPA, and the Washington State Department of Ecology are committed to completing the cleanup of past-practice waste sites by September 2024. Substantial progress has been made toward cleanup of the 100 and 300 Areas. Strategies used for making final decisions in the 100 and 300 Areas will provide a basis for attaining similar final decisions for the 200 Areas.

In July 2010, DOE issued the *Hanford Site Cleanup Completion Framework* (DOE/RL-2009-10, Rev. 0) to define the path forward for cleanup at the Hanford Site. The draft framework document defines the main components of cleanup and two main geographic areas—the River Corridor and the Central Plateau.

The Central Plateau component of cleanup includes the Inner Area, containing the major nuclear fuel processing, waste management, and disposal facilities; and the Outer Area, containing areas of the Central Plateau beyond the boundary of the Inner Area (Figure 8.7.1). The Inner Area, estimated to be approximately 26 square kilometers (10 square miles) or less in size, is the proposed final footprint area of the Hanford Site, and will be dedicated to permanent waste management and containment of residual contamination. The Inner Area will remain under federal ownership and control for as long as potential hazards exist. Completion of cleanup for the approximately 168-square-kilometer (65-square-mile) Outer Area will reduce the active footprint of cleanup for the Central Plateau to the Inner Area.

The following sections are summarized from the *Hanford Site Groundwater Monitoring Report for 2010* (DOE/RL-2011-01, Rev. 0).

8.7.1 Highlights and Items of Interest

This section briefly describes some of the high-priority groundwater accomplishments and issues for 2010.

River Corridor Baseline Risk Assessment. To support the decision-making process for final CERCLA remedial actions within the River Corridor, DOE is conducting a CERCLA remedial investigation, including a baseline risk assessment for the River Corridor portion of the Hanford Site. The risk assessment consists of three components: 1) the 100 Area and 300 Area Component, 2) the Inter-Area Component, and 3) the Columbia River Component. The 100 Area and 300 Area Component and the Inter-Area Component will be integrated with groundwater and source operable unit data into a series of final CERCLA remedial investigation reports for the operational areas of the River Corridor.

Remedial Investigation/Feasibility Study. In 2010, DOE began intensive field studies under remedial investigation/feasibility study work plans and associated sampling and analysis plans for the six River Corridor decision areas. Field studies included the drilling boreholes and the installation of groundwater monitoring wells and aquifer tubes. Other studies included conducting aquifer tests, evaluating groundwater and soil samples for contaminants of potential concern, and refining geologic and hydrologic models. The data will be used to select methods for remediating soil and groundwater. The selection of the final remedial actions will be documented in records of decision.

100-HR-3 Operable Unit Remedial Process Optimization. In 2010, new wells were connected to the KR-4 and KX pump-and-treat systems for extraction or injection. Several existing wells were realigned as extraction wells for different treatment systems. Notably, the KR-4 system began extracting from three wells formerly aligned with the KX system, sited at a hot spot near the southwest end of the 116-K-2 trench. In late 2010, two KX wells were disconnected as extraction wells due to successful treatment of a part of the plume near the N Reactor fence line and were converted to monitoring wells.

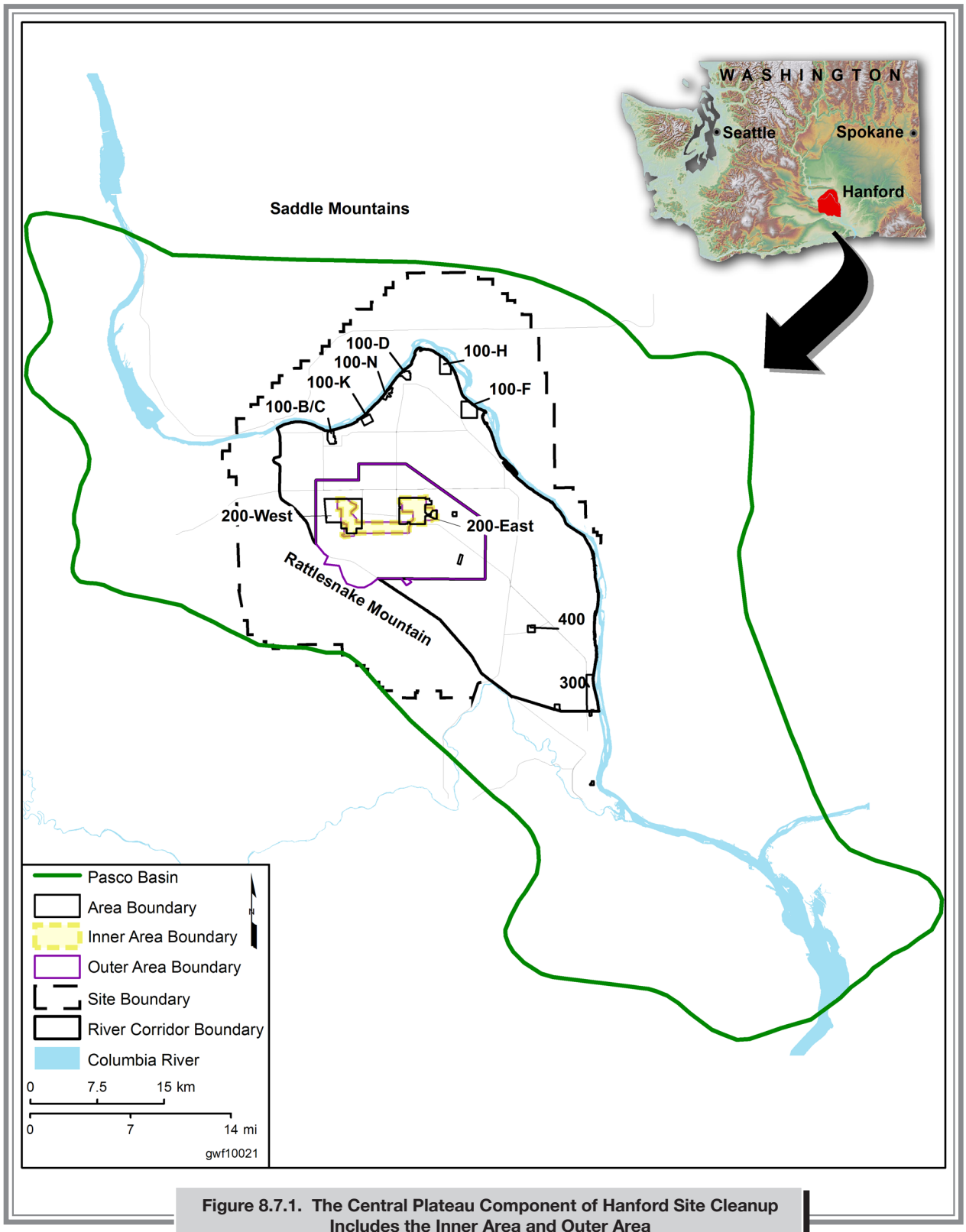

Figure 8.7.1. The Central Plateau Component of Hanford Site Cleanup Includes the Inner Area and Outer Area

200-ZP-1 Operable Unit Pump-and-Treat Expansion. During 2010, the two interim pump-and-treat systems at the 200-ZP-1 Operable Unit and Waste Management Area T continued operations to reduce contamination for the primary contaminants carbon tetrachloride and technetium-99, respectively. Extraction well 299-W15-44 was removed from the 200-ZP-1 extraction well network and well 299-W15-225 was added. The new well is screened over a longer interval compared to other interim extraction wells that only produce from the upper 15 meters (49 feet) of the unconfined aquifer. Extraction well 299-W15-225 accounted for 52% of the cumulative production for this pump-and-treat system and contributed to a 60% increase in the mass of carbon tetrachloride removed during 2010 relative to 2009. Work continued on installation of additional injection and extraction wells and construction of a new effluent processing plant that is identified as the final remedy in the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* (EPA et al. 2008). Well installation and plant construction are scheduled for completion at the end of 2011.

300-FF-5 Studies. Treatability testing using polyphosphate solutions was performed during 2009 and continued through 2010 at a second test site, with the focus on immobilizing uranium in the vadose zone.

Columbia River Monitoring. In 2010, DOE and Washington Closure Hanford, LLC continued evaluating Hanford Site contaminant releases to the Columbia River. The information obtained from this investigation will ultimately be used to help make final cleanup decisions for Hanford Site contaminants that exist in and along the Columbia River. Field sampling concluded in 2010, and study results were published in early 2011 in the *Data Summary Report for the Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington* (WCH-398).

Site-Wide Groundwater Sampling Stop Work. Groundwater sampling was stopped between September 27, 2010, and November 8, 2010, when a safety-related stop work order closed down all sampling activity performed by CH2M HILL Plateau Remediation Company's Soil and Groundwater Remediation Project staff. A recovery plan was established to address required sampling at RCRA treatment, storage, and disposal units (TRAC-1373). The recovery plan identified 70 agreed-upon priority wells out of 130 wells scheduled and affected by the stop work order during the last quarter of 2010. The collection of most groundwater samples was delayed until December and six wells were sampled in January 2011. Groundwater sampling operations collected 68 of the 70 RCRA treatment, storage, and disposal unit samples agreed upon in the recovery plan (2 required maintenance). An additional 50 RCRA wells not in the recovery plan were sampled. Of the remaining 12 RCRA treatment, storage, and disposal wells that were sampled, 6 were completed in the first week of January 2011. Thus of the original 130 wells that were scheduled for sampling in the fourth quarter of 2010, only 6 were not sampled.

Groundwater Data. Workers sampled 1,311 monitoring wells and 145 aquifer tubes between January 1, 2010, and December 31, 2010. Many of the wells and aquifer tubes were sampled more than once during the period; 4,277 sampling events were performed. These numbers do not include special groundwater sampling associated with remediation and research. Tables 8.7.1 and 8.7.2 list the number of wells sampled and analyses by groundwater interest area and monitoring purpose.

8.7.2 Groundwater Flow

Groundwater flow directions are illustrated on the water-table map for March 2010 (Figure 8.7.2). Groundwater flow directions are 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 moves to the east, eventually discharging into the Columbia River. Additional water infiltrates through the vadose zone beneath the Hanford Site. Hydrologists estimate the total discharge of groundwater from the Hanford Site aquifer to the Columbia River is in the range of 0.08 to 2.5 cubic meters (3 to 88 cubic feet) per second. This rate of discharge is less than one-tenth of a percent compared to the average flow of the river, which is approximately 3,400 cubic meters (120,000 cubic feet) per second.

As seen in Figure 8.7.2, the water table beneath the 200-East Area is relatively flat (no contours), because the aquifer is primarily within the highly permeable sediments of the Hanford formation at the water table. Groundwater enters

Table 8.7.1. A Summary of Hanford Site Groundwater Monitoring by Groundwater Interest Area, 2010[a,b]

	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	1,320	44	29	178	95	88	306
Number of sampling events	4,212	151	86	576	236	1,038	510
Number of analyses	52,237	3,503	2,312	4,924	2,969	6,109	5,751
Number of results	289,094	21,804	15,985	26,780	19,589	31,020	34,385
Percent of results non-detected	65	71	74	66	70	62	62
	1100-EM-1	200-BP-5	200-PO-1	200-UP-1	200-ZP-1	300-FF-5	
Number of wells and aquifer tubes	26	147	132	71	104	100	
Number of sampling events	37	372	295	203	395	313	
Number of analyses	530	8,461	5,195	2,814	5,544	4,122	
Number of results	5,405	35,433	27,666	14,826	26,055	30,146	
Percent of results non-detected	79	60	65	56	59	69	

(a) Date range reported is from January 1, 2010, through December 31, 2010.
(b) These numbers do not include special sampling associated with remediation and research.

Table 8.7.2. A Summary of Hanford Site Groundwater Monitoring by Monitoring Purpose,[a] 2010[b]

	Restoration[c]	Waste Management[d]	Environmental Surveillance[e]
Number of wells and aquifer tubes	1,152	700	949
Number of sampling events	2,972	866	1,282
Number of analyses	31,302	15,192	19,632
Number of results	178,983	63,563	111,033
Percent of results non-detected	67	56	67

(a) Because of the co-sampling among groundwater monitoring programs, the wells monitored, sampling events, analyses, results, and non-detectable results overlap among monitoring purposes. Totals exclude special sampling.
(b) Date range reported is from January 1, 2010 through December 31, 2010.
(c) Wells associated with remediation activities.
(d) Wells sampled to determine impact, if any, of a waste management unit (e.g., RCRA) on groundwater.
(e) Wells sampled to detect impact, if any, of site operations on groundwater over the entire Hanford Site and adjacent offsite areas.
RCRA = *Resource Conservation and Recovery Act of 1976*.

the 200-East Area vicinity from the west and southwest. The flow of groundwater divides as it approaches the central portion of the 200-East Area, some flowing to the north through a gap (Gable Gap) between Gable Butte and Gable Mountain, and some moving to the southeast toward the central part of the Hanford Site. This groundwater divide may be located near the north-central part of the 200-East Area, but its precise location is unknown. Ongoing studies are helping to determine the direction of groundwater flow in this very flat water-table region. In the southern part of the Hanford Site, groundwater enters the 300 Area from the northwest, west, and southwest.

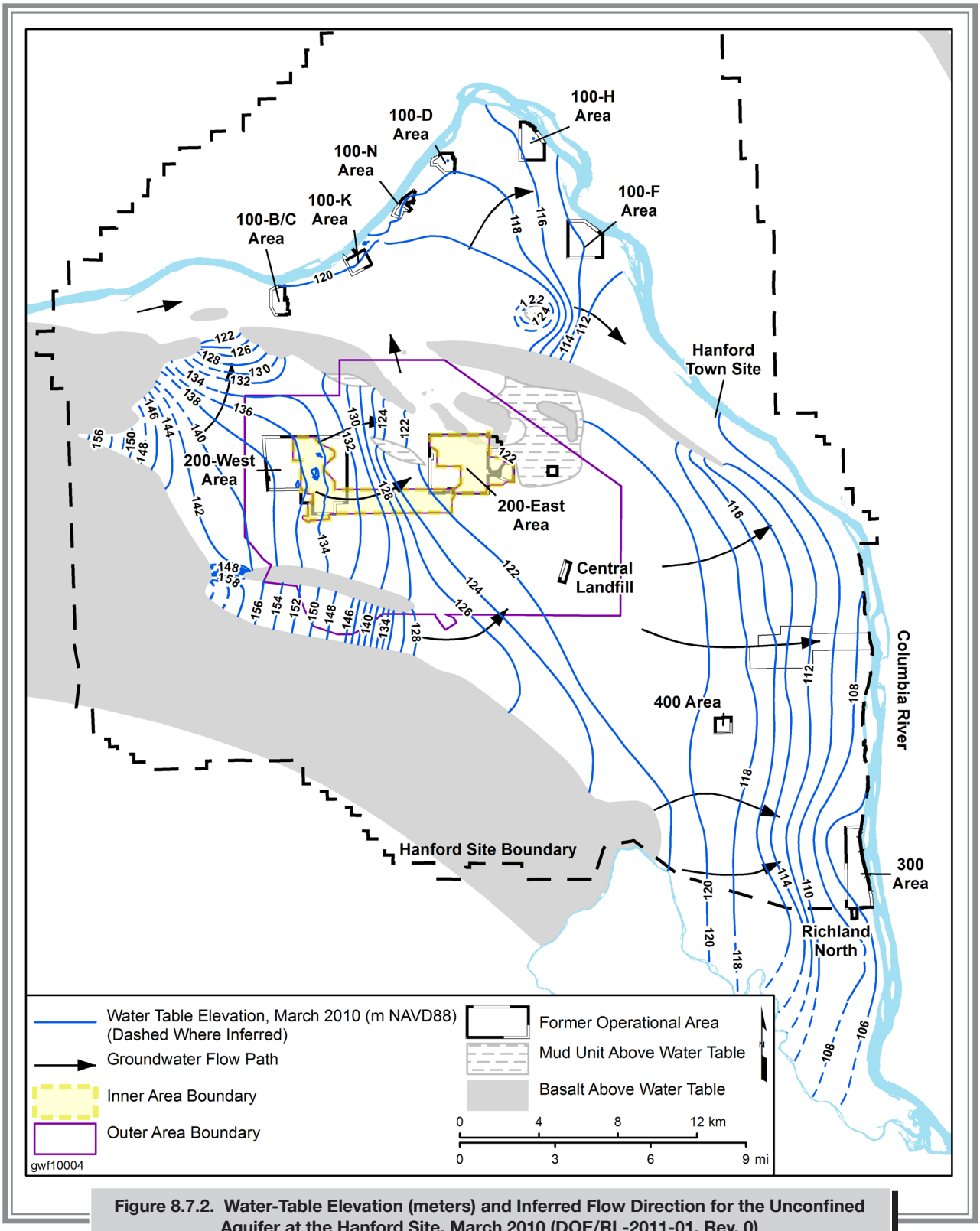

Figure 8.7.2. Water-Table Elevation (meters) and Inferred Flow Direction for the Unconfined Aquifer at the Hanford Site, March 2010 (DOE/RL-2011-01, Rev. 0)

The natural pattern of groundwater flow was altered during the Hanford Site's operating years by water-table mounds. The mounds were created by the discharge of large volumes of wastewater to the ground surface and were present in each reactor area and beneath the 200 Areas. Since the site-wide decrease in effluent disposal in the 1990s, these mounds have dissipated in the reactor areas and have declined considerably in the 200 Areas. Currently, cleanup-derived wastewater is discharged to the ground at two permitted locations: the State-Approved Land Disposal Site, north of the 200-West Area, and the Treated Effluent Disposal Facility, east of the 200-East Area.

Groundwater flow in the unconfined aquifer is 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 for treatment. After treatment, water is injected back into the aquifer through injection wells. The injection wells are strategically placed to enhance the movement of groundwater contaminants toward the extraction wells. However, for the 100-HR-3 DX system, several injection wells are located within the contaminant plume to "split" the plume and allow for down-gradient capture by extraction wells. This allows the contaminant plume to be managed effectively and expedites cleanup time.

In most places, the base of the unconfined aquifer is the Ringold Formation Lower Mud Unit. Along the river corridor the Ringold Formation Upper Mud Unit defines the base of the unconfined aquifer. Where these units are absent, the dense interior portion of the uppermost basalt flow is usually the base of the unconfined aquifer. In some locations the unconfined aquifer has been shown to occur in the fractured basalt flow top. The overlying aquifer may extend a few feet to a few tens of feet below the top of basalt in many places at the Hanford Site where a fractured, rubble flow top is present.

A confined aquifer occurs within the sand and gravel of the basal sedimentary unit of the Ringold Formation. It is confined between the upper-most basalt and a thick layer of silt and clay known as the Ringold Lower Mud Unit. The unconfined aquifer does not extend east of the 200-East Area because the Ringold Lower Mud Unit is above the water table (Figure 8.7.2), so the Ringold Formation confined aquifer is the uppermost aquifer in this area. Beneath the Ringold Formation confined aquifer is the upper basalt-confined aquifer, which exists mainly in the Rattlesnake Ridge interbed. This is a widespread sedimentary layer between basalt flows. Groundwater within these confined aquifers is influenced by a residual recharge mound near the B Pond. Several wells north and east of the 200-East Area have shown evidence of groundwater exchange (intercommunication) between the upper basalt-confined aquifer and the overlying unconfined aquifer. The intercommunication has been attributed to erosion of the upper Saddle Mountains Basalt and downward groundwater movement in the area near B Pond. Because upward groundwater movement exists elsewhere in the 200-East Area/Gable Gap region, the upper basalt-confined aquifer likely discharges to the overlying unconfined aquifer, especially within Gable Gap where the Elephant Mountain Basalt was removed by erosion.

8.7.3 Groundwater Monitoring and Remediation

DOE monitors Hanford Site groundwater to fulfill a variety of state and federal regulations, including the *Atomic Energy Act of 1954*, RCRA, CERCLA, and various rules of the *Washington Administrative Code*.

DOE Order 450.1A, "Environmental Protection Program," implements requirements of the *Atomic Energy Act of 1954*. This Order requires environmental monitoring to detect, characterize, and respond to releases from DOE facilities, assess impacts, and characterize exposure pathways. The Order provides recommendations for implementing a site-wide approach for groundwater protection and requires compliance with other applicable environmental protection requirements.

To assist with the efficient implementation of the CERCLA cleanup process, the Hanford Site is divided into groupings of similar waste units within geographic areas (termed an operable unit). Most operable units are source operable units focusing on areas where waste was actually disposed of while others are groundwater operable units. The concept of the groundwater operable unit was adopted to allow separate characterization of the waste sites and the groundwater. Separate classification of source and groundwater operable units recognizes differences between contaminants in the

soil column at the disposal sites and the more widespread contamination in groundwater that is often mixed from several disposal sites. Monitoring wells are located and sampled to define the nature and extent of the contamination in the groundwater. Groundwater is also monitored under CERCLA to assess the effectiveness of groundwater remediation efforts. Figure 8.7.3 shows the boundaries of the groundwater operable units. These regulatory-defined groundwater operable units are characterized by the presence of contamination above a specific level and therefore 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 the regions between (Figure 8.7.3).

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.

The requirements of WAC 173-303-400 at interim status facilities discuss groundwater monitoring under one of three possible programs:

- ***Contamination Indicator Evaluation*** – Initially, researchers use a contamination indicator evaluation program that uses groundwater data from four specific contamination indicator parameters (pH, specific conductance, total organic carbon, and total organic halogen) to determine and monitor the impact, if any, of the facility on groundwater. A contamination indicator evaluation monitoring program continues until a permit is issued or until monitoring results indicate a statistically significant change in one of the specified indicator parameters.
- ***Assessment*** – If the contamination indicator evaluation monitoring results indicate a statistically significant change in groundwater chemistry, an assessment phase of monitoring begins. If assessment program staff identify groundwater impacts from dangerous constituents, monitoring continues under groundwater quality assessment. If no impact is found, the facility returns to indicator parameter monitoring. If groundwater quality assessment program staff confirm that an impact to groundwater has occurred, the objectives change from looking for contamination to assessing the levels, rate, and extent of contaminant migration.
- ***Corrective Action*** – If the source of the contamination is determined to be the RCRA unit and the contaminant concentration(s) exceeds applicable limits, the Washington State Department of Ecology may require corrective action. Groundwater is then monitored to determine whether the corrective action has been effective.

The requirements of WAC 173-303-645 (permitted or final status) are also conducted under one of three programs:

- ***Detection Monitoring*** – A facility operating permit includes requirements for the final status detection monitoring program. Analogous to the interim status program, this program looks for statistically significant changes in parameter concentrations. However, instead of the four general indicator parameters, site-specific indicator parameters are compared in downgradient wells to a value that is statistically derived from the background (upgradient) wells. Determination of a statistically significant change is made by comparing the concentrations of site-specific indicator parameters in downgradient wells to the statistically derived value from the background wells (usually upgradient wells unless intra-well comparisons are made). The derivation of comparison values is detailed in PNNL-13080. If a statistically significant change in one or more of the specified indicator parameters is confirmed and dangerous constituents from the site have affected groundwater, then the facility is required to move to the second phase of monitoring.
- ***Compliance Monitoring*** – When detection monitoring data confirm dangerous constituent(s) from the site have affected groundwater, a compliance monitoring program is implemented. Under this program, the objectives are to determine the levels and extent of contamination, and whether a groundwater concentration limit is exceeded. If the concentration limit is exceeded, corrective action may be required.
- ***Corrective Action*** – Groundwater corrective action may be required if the concentration limits established under compliance monitoring are exceeded. This phase

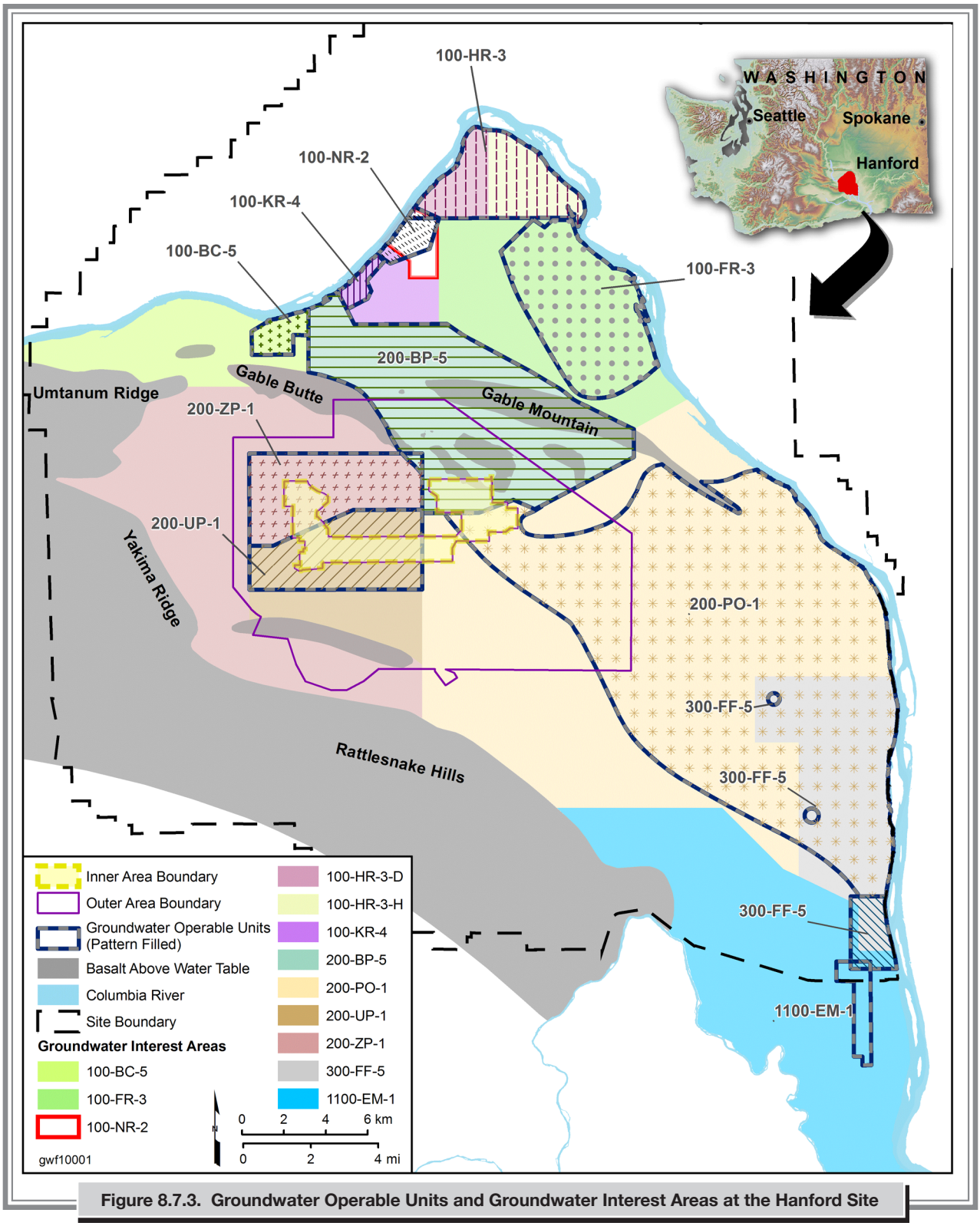

Figure 8.7.3. Groundwater Operable Units and Groundwater Interest Areas at the Hanford Site

of monitoring is performed to determine whether the corrective action is effective.

In 2009, detection monitoring at three RCRA sites indicated these sites may have affected groundwater quality. Concentrations of the indicator parameter total organic carbon exceeded threshold values at Low-Level Waste Management Area 4 and the Nonradioactive Dangerous Waste Landfill, while the threshold value for specific conductance was exceeded at Waste Management Area C. Assessment monitoring found that the Low-Level Waste Management Area 4 and the Nonradioactive Dangerous Waste Landfill had not impacted groundwater, and they were returned to contaminant indicator evaluation monitoring. Assessment results at Waste Management Area C showed the unit had impacted groundwater; therefore, assessment monitoring continued at this site through 2010. Groundwater monitoring at the other RCRA sites continued under previously established programs. Table 8.7.3 lists Hanford Site RCRA units and 2010 status highlights; Figure 8.7.4 shows their locations.

8.7.4 Overview

The Hanford Site's principal groundwater contaminant plumes are shown in Figure 8.7.5. The total area of all contaminant plumes with concentrations above drinking water standards was approximately 186 square kilometers (72 square miles) in 2010 (Table 8.7.4). This area is about 12.2% of the total area of the Hanford Site. As stated previously, the increase in plume area is due to advancement in contour measurement precision. Table 8.7.5 lists the highest levels of contaminants by groundwater interest area.

Tritium and iodine-129 plumes have the largest areas with concentrations above drinking water standards, with regard to radioactive contaminants. These dominant plumes, which had sources in the 200-East Area, extend toward the east and southeast. Less extensive tritium and iodine-129 plumes are also present in the 200-West Area. Technetium-99 has much smaller plumes that exceed drinking water standards in the 200-East and 200-West Areas. One technetium-99 plume extends northward, beyond the 200-East Area. Uranium moves slower in groundwater than tritium, technetium-99, or iodine-129; plumes containing uranium are found in the 200-East, 200-West, and 300 Areas. Strontium-90 exceeds the drinking water standard in the 100 Areas, 200-East Area, and beneath the former Gable Mountain Pond. Cesium-137 and plutonium exceed drinking water standards, but only in a few wells in the 200-East Area.

Nitrate is the most widespread chemical contaminant in Hanford Site groundwater; plumes originate from the 100 and 200 Areas and from offsite industrial and agricultural activities. Carbon tetrachloride is the most widespread organic contaminant at the Hanford Site, forming a large plume beneath the 200-West Area. Other organic contaminants include chloroform (found in the 200-West Area) and trichloroethene. The 100-F and 200-West Areas have plumes of trichloroethene that show declining concentrations. The 100-K Area has one well that exceeded the trichloroethene drinking water standard. Researchers detected trichloroethene at levels above the drinking water standard at wells completed in a fine-grained layer beneath the 300 Area. Hexavalent chromium at levels above the 100-µg/L drinking water standard underlies portions of the 100-K and 100-D Areas. Hexavalent chromium also exceeds Washington State's 10-µg/L aquatic water quality criteria in these areas and portions of the 100-B/C, 100-H, 100-F, and 600 Areas. Local plumes of chromium contamination are also present in the 200 Areas.

The following sections discuss groundwater contamination, monitoring, and remediation for each of the groundwater operable units or interest areas and in the confined aquifers.

8.7.4.1 Groundwater Monitoring Results for the 100-BC-5 Operable Unit

The CERCLA monitoring requirements for the 100-BC-5 Operable Unit are driven by the *Sampling and Analysis Plan for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units Remedial Investigation/Feasibility Study* (DOE/RL-2009-44, Rev. 0) for remedial investigation studies and *100-BC-5 Operable Unit Sampling and Analysis Plan* (DOE/RL-2003-38, Rev. 0) for routine groundwater monitoring. All wells were sampled as scheduled during the reporting period.

A remedial investigation/feasibility study work plan (DOE/RL-2008-46, Rev. 0) and addendum (DOE/RL-2008-46-ADD3, Rev. 0) were implemented in 2010 to collect additional data needed to support final CERCLA cleanup decisions. When field studies are complete in 2011, 10

Table 8.7.3. *Resource Conservation and Recovery Act of 1976* Units Requiring Groundwater Monitoring at the Hanford Site, 2010[a]

RCRA Unit	2010 Status
116-N-1 (1301-N) Facility	Continued indicator evaluation[b]
120-N-1, 120-N-2 (1324-N/NA) Facilities	Continued indicator evaluation[b]
116-N-3 (1325-N) Facility	Continued indicator evaluation[b]
116-H-6 (183-H) Evaporation Basins	Corrective action alternative program during interim remedial action; chromium and nitrate
216-A-29 Ditch	Continued indicator evaluation[b]
216-B-3 Pond	Continued indicator evaluation[b]
216-B-63 Trench	Continued indicator evaluation[b]
216-S-10 Pond and Ditch	Continued indicator evaluation;[b] completion of first year of RCRA analyses for three new wells; establishment of new background threshold values
316-5 (300 Area) Process Trenches	Compliance/corrective action; organics
Integrated Disposal Facility	Not yet in use; monitoring results added to background data set
Liquid Effluent Retention Facility	Two new wells monitor the top of the fractured basalt. DOE and Washington State Department of Ecology pursuing agreement for monitoring
Low-Level Waste Management Area 1	Continued indicator evaluation[b]
Low-Level Waste Management Area 2	Continued indicator evaluation[b]
Low-Level Waste Management Area 3	Statistical evaluations suspended until upgradient wells installed and background values established. New monitoring plan (DOE/RL-2009-68) implemented in 2010.
Low-Level Waste Management Area 4	Total organic carbon exceeded threshold value in August 2008 and returned to indicator evaluation status in 2009; remaining upgradient wells went dry in 2010. New monitoring plan (DOE/RL-2009-69) implemented in 2010.
Nonradioactive Dangerous Waste Landfill	Assessment showed elevated total organic carbon to be related to constituents other than dangerous waste constituents; total organic carbon returned to indicator evaluation status in 2010.
PUREX Cribs	Started 2010 in assessment; nitrate. 216-A-10 dropped from Hanford Site RCRA Permit. Separate new plans written for 216-A-36B and 216-A-37-1. New plans implemented January 1, 2011, in indicator evaluations status.
SST Waste Management Area A-AX	Assessment (first determination) showed site responsible for nickel contamination; continued in assessment; new assessment plan under review by the Washington State Department of Ecology.
SST Waste Management Area B-BX-BY	Continued assessment: cyanide
SST Waste Management Area C	Specific conductance exceeded threshold value in July 2009; initiated groundwater quality assessment monitoring in December 2009; cyanide, primary dangerous waste constituent.
SST Waste Management Area S-SX	Continued assessment: chromium
SST Waste Management Area T	Continued assessment: chromium
SST Waste Management Area TX-TY	Continued assessment: chromium
SST Waste Management Area U	Continued assessment: chromium

(a) Date range reported is from January 1, 2010, through December 31, 2010.
(b) Analysis of RCRA contamination indicator parameters provided no evidence of groundwater contamination with hazardous constituents from the unit.

DOE = U.S. Department of Energy.
PUREX = Plutonium Uranium Extraction Plant.
RCRA = *Resource Conservation and Recovery Act of 1976*.
SST = Single-shell tanks.

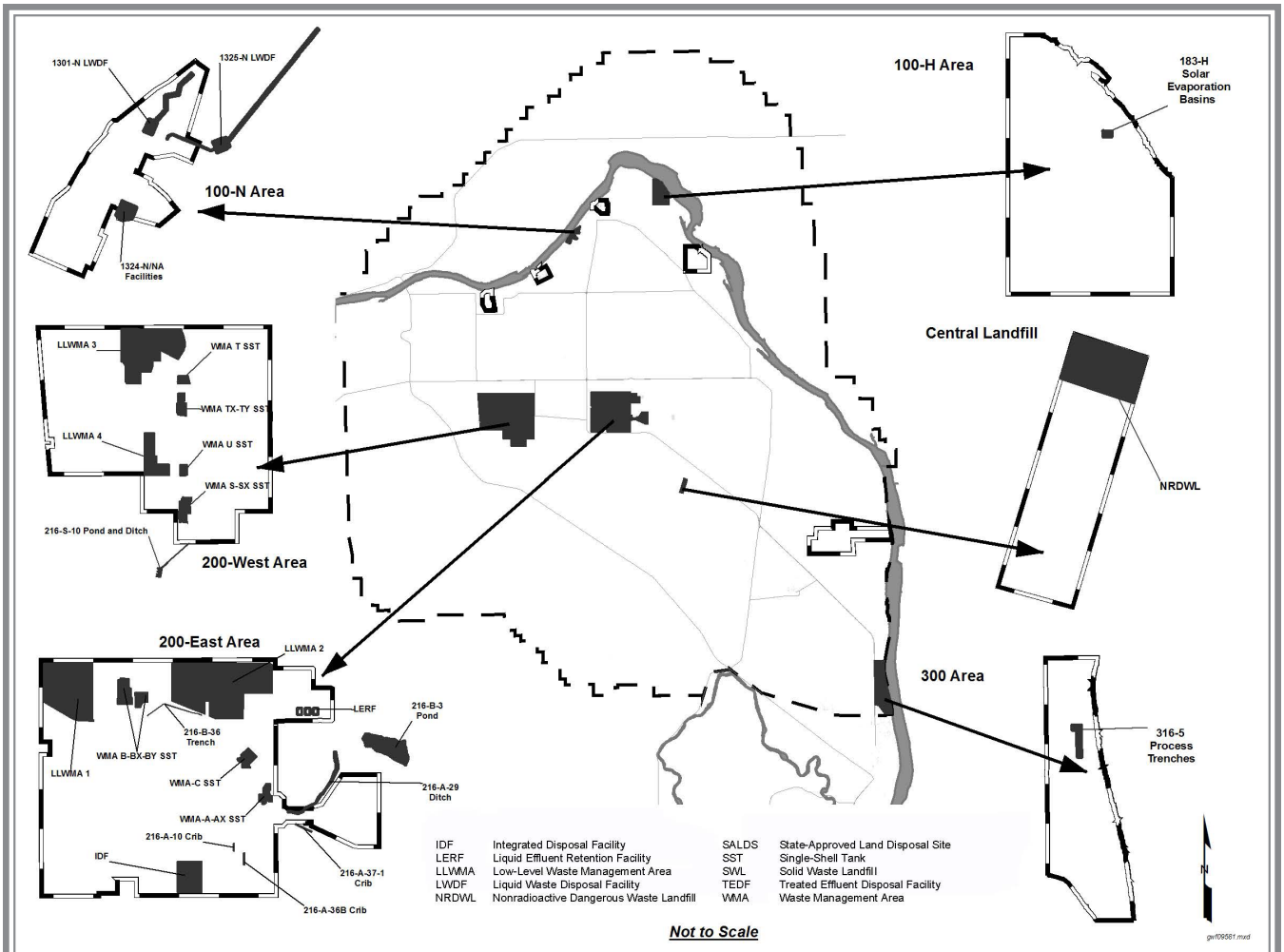

Figure 8.7.4. Locations of the *Resource Conservation and Recovery Act of 1976* Units at the Hanford Site

new groundwater wells and 9 aquifer tubes will have been installed. These new wells and aquifer tubes are helping define the extent of contamination areally and vertically.

8.7.4.2 Groundwater Monitoring Results for the 100-KR-4 Operable Unit

The principal groundwater issues in the 100-KR-4 Operable Unit include cleaning up hexavalent chromium in groundwater, tracking plumes from past-practice sites, and monitoring groundwater near the K-East and K-West Basins. Interim remedial action involves three pump-and-treat systems that remove hexavalent chromium from groundwater.

Interim Remedial Action. Two pump-and-treat systems, KR-4 and KX, are in place for removing hexavalent chromium from the aquifer beneath the 116-K-2 Trench (Figure 8.7.6). Approximately 47 kilograms (104 pounds) of hexavalent chromium were removed by these systems in 2010. New wells installed in 2009 indicate that one portion of the plume with concentrations above 100 µg/L is larger than previously known. Chromium concentrations in most of the compliance wells near the Columbia River have decreased. The concentration goal for the interim remedial action is 20 µg/L.

In 2010, workers completed installation of new extraction and injection wells begun in 2009. Other wells were realigned to improve remediation. Two extraction wells were removed from operations due to declining hexavalent chromium concentrations below the drinking water standard. The expanded systems have increased the amount of

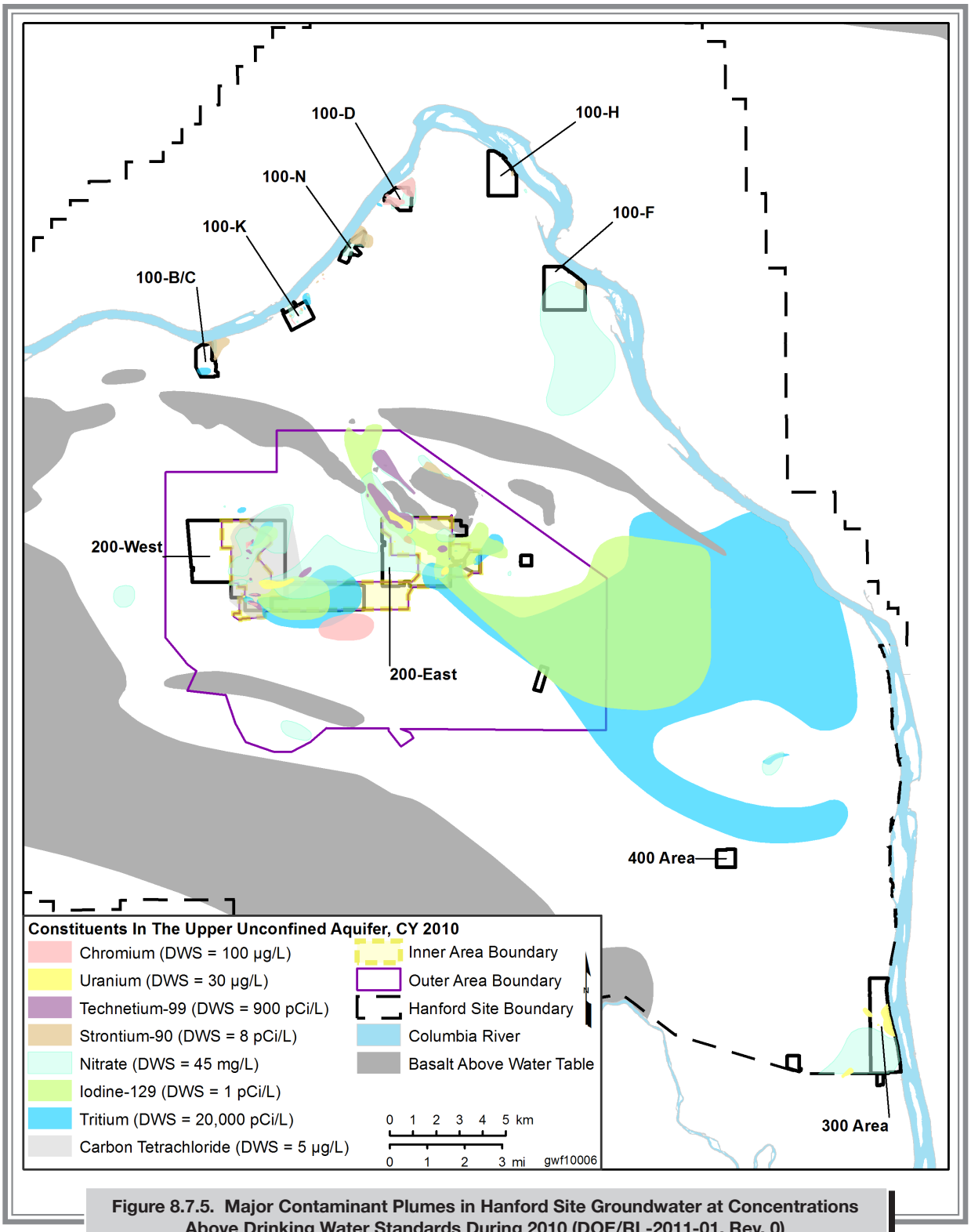

Figure 8.7.5. Major Contaminant Plumes in Hanford Site Groundwater at Concentrations Above Drinking Water Standards During 2010 (DOE/RL-2011-01, Rev. 0)

Table 8.7.4. Areas of Contaminant Plumes at the Hanford Site at Levels Above Drinking Water Standards, 2010[a] (DOE/RL-2011-01, Rev. 0)

Constituent	Drinking Water Standard	Area, km² (mi²)	Constituent	Drinking Water Standard	Area, km² (mi²)
Tritium	20,000 pCi/L	129.1 (49.8)	Dissolved chromium	100 µg/L	3.1 (1.2)
Iodine-129	1 pCi/L	66.6 (25.7)	Strontium-90	8 pCi/L	1.6 (0.6)
Nitrate	45 mg/L	36.3[b] (14.0)	Technetium-99	900 pCi/L	2.8 (1.1)
Carbon tetrachloride	5 µg/L	11.5 (4.4)	Total uranium	30 µg/L	1.4 (0.5)
Trichloroethene	5 µg/L	0.8 (0.3)	Combined plumes		186.3[b,c] (71.9)

(a) Date range reported is from January 1, 2010 through December 31, 2010.
(b) Excludes nitrate from offsite sources.
(c) 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 8.7.5. Summary of Maximum Contaminant Concentrations in Hanford Site Wells by Groundwater Interest Area, 2010[a] (DOE/RL-2011-01, Rev. 0)

	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)	1,600,000	69,000	3,800	9,900	9,000	280,000	17,500
Iodine-129 (pCi/L)	39.6	NA	NA	NA	NA	NA	NA
Nitrate (mg/L)	2,830,000	44,200	139,000	99,200	43,700	84,600	500,000
Carbon tetrachloride (µg/L)	2,900	NA	NA	NA	0.16	NA	4.2
Trichloroethene (µg/L)	20	3.3	20	0.33	0.44	7.4	0.29
Dissolved chromium (µg/L)	5,730	56.1	93	5,730	128	997	192
Strontium-90 (pCi/L)	19,000	49	19	3.2	28	45	19,000
Technetium-99 (pCi/L)	65,000	26	110	16	94	55	45
Total uranium (µg/L)	3,670	ND	15.4	4.82	11	9.5	8.18
	1100-EM-1	200-BP-5	200-PO-1	200-UP-1	200-ZP-1	300-FF-5	
Tritium (pCi/L)	315	35,000	590,000	71,000	1,600,000	900,000	
Iodine-129 (pCi/L)	NA	6.51	9.68	8.7	39.6	NA	
Nitrate (mg/L)[b]	338,000	1,540,000	172,000	1,080,000	2,830,000	136,000	
Carbon tetrachloride (µg/L)	ND	0.22	NA	1,200	2,900	7.4	
Trichloroethene (µg/L)	ND	3.9	2.8	8.8	12	3	
Dissolved chromium (µg/L)	1.81	333	288	1,180	732	28.2	
Strontium-90 (pCi/L)	NA	4,200	16	2.1	1.4	NA	
Technetium-99 (pCi/L)	13	38,000	5,300	65,000	9,900	210	
Total uranium (µg/L)	26.5	3,670	75.4	417	26.3	188	

(a) Date range reported is from January 1, 2010, through December 31, 2010.
(b) Nitrate from offsite sources.
NA = Not analyzed.
ND = Not detected.

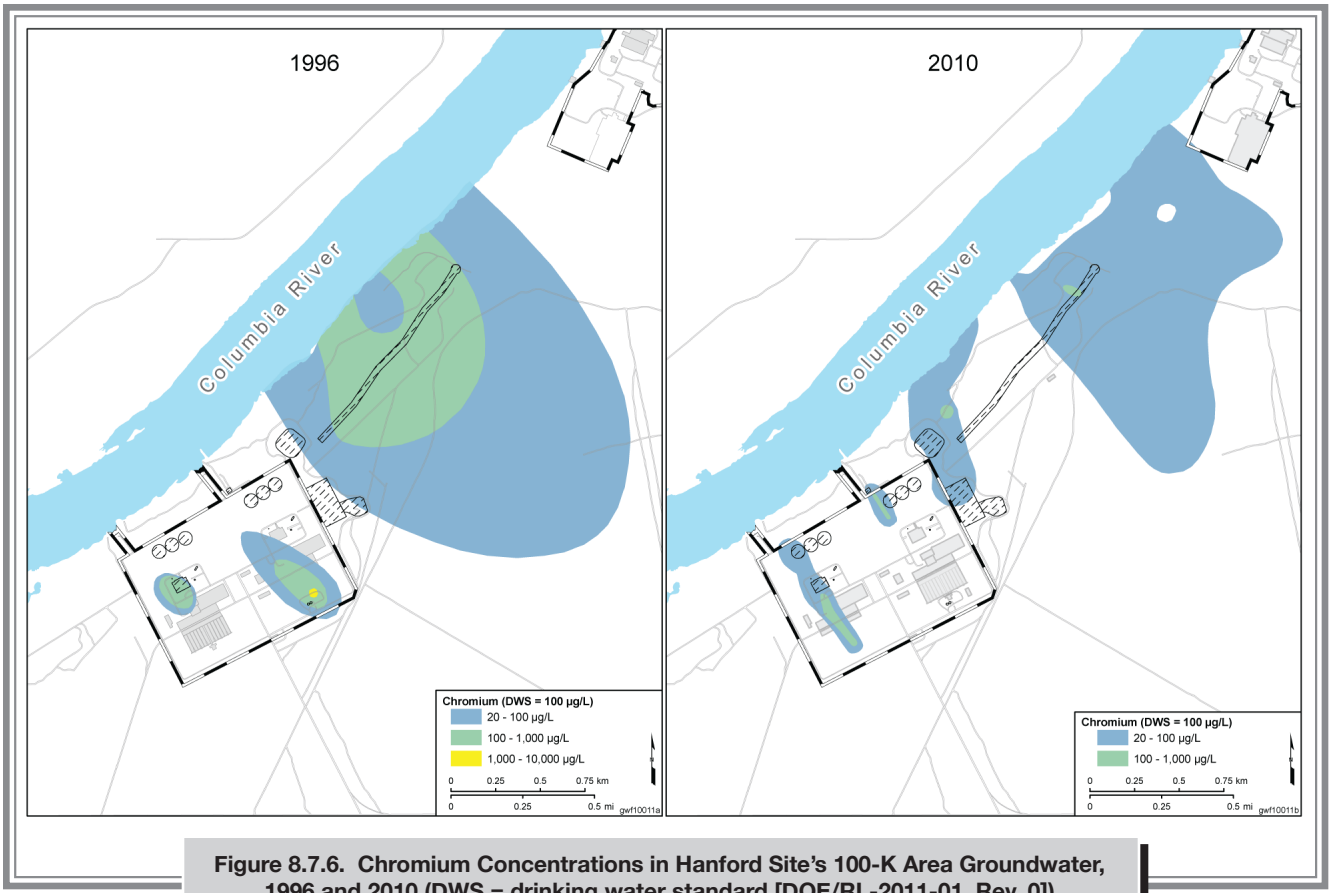

Figure 8.7.6. Chromium Concentrations in Hanford Site's 100-K Area Groundwater, 1996 and 2010 (DWS = drinking water standard [DOE/RL-2011-01, Rev. 0])

contaminated groundwater being treated and are preventing the plume from moving downgradient into the 100-N Area.

Chromium concentrations in groundwater near the K-West Reactor began to rise during 1998. Concentrations in this plume are the highest in the 100-K Area. DOE has operated a pump-and-treat system to clean up the plume since 2007. The system has removed 139 kilograms (306 pounds) of chromium from the aquifer, and concentrations in the extraction wells have declined. The K-West system was expanded in 2009 and operated continuously through 2010. The pump-and-treat system has successfully reduced chromium in the core of the plume.

Monitoring Past-Practice Waste Sites. Other contaminants of potential concern in the 100-KR-4 Operable Unit are carbon-14, strontium-90, nitrate, trichloroethene, and tritium, where levels remained above drinking water standards. These contaminants are addressed in the remedial investigation/feasibility study work plan (DOE/RL-2008-46, Rev. 0; DOE/RL-2008-46, ADD2, Rev. 0) and will be addressed in the upcoming final record of decision.

Tritium concentrations in two new wells near the south end of the 116-K-2 Trench are much higher than in surrounding wells. The tritium source at this location is uncertain but appears to be related to the 118-K-1 Burial Ground.

K-East and K-West Basins. These concrete basins are integral parts of each reactor building. From the late 1970s through 2004, they were used to store irradiated fuel from the last run of the 100-N Reactor, as well as miscellaneous fuel fragments recovered during remedial actions at other reactor areas. Groundwater issues associated with these units are related to leaks at and around the basins themselves. Shielding water was removed from the K-East Basin, and demolition of the basin was completed in 2009. Remediation of soil and sediments around the former K-East Basin

was nearing completion in 2010 (Section 6.1.2.3); following completion, the groundwater monitoring strategy will be reviewed.

8.7.4.3 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 8.7.7). Chromium, iron, manganese, tritium, nitrate, petroleum hydrocarbons, and sulfate also are present in 100-N Area groundwater.

Interim Remedial Action. DOE is applying an in situ technology, apatite sequestration, for treatment of strontium-90 contamination in the 100-N Area. The goal is to create a permeable, reactive barrier in the aquifer that will capture strontium-90 as groundwater flows through it to the Columbia River. Apatite-forming chemicals were injected into a line of wells along the river shore in 2006, 2007, and 2008. As the injected chemicals reacted with the aquifer and sediments, strontium-90 levels initially increased in downgradient wells and aquifer tubes. However, since injections ceased in July 2008, a general steady decline has been observed for strontium-90 and gross beta levels in the wells being sampled, with very few exceptions. Concentrations in the injection and downgradient wells have been reduced by as much as 90% from pre-injection concentrations.

Other forms of remediation being investigated at the 100-N Area include jet injection of apatite-forming chemicals, passive infiltration of apatite-forming chemicals, and phyto-extraction (using plants) to treat contamination.

1301-N, 1324-N, 1324-NA, and 1325-N Facilities. These four RCRA units are located in the 100-N Area. During 2010, the sites remained in contaminant indicator evaluation monitoring programs. The indicator parameter of specific conductance continued to exceed the threshold value at the 1325-N Crib and the 1324-NA Pond. This exceedance is the

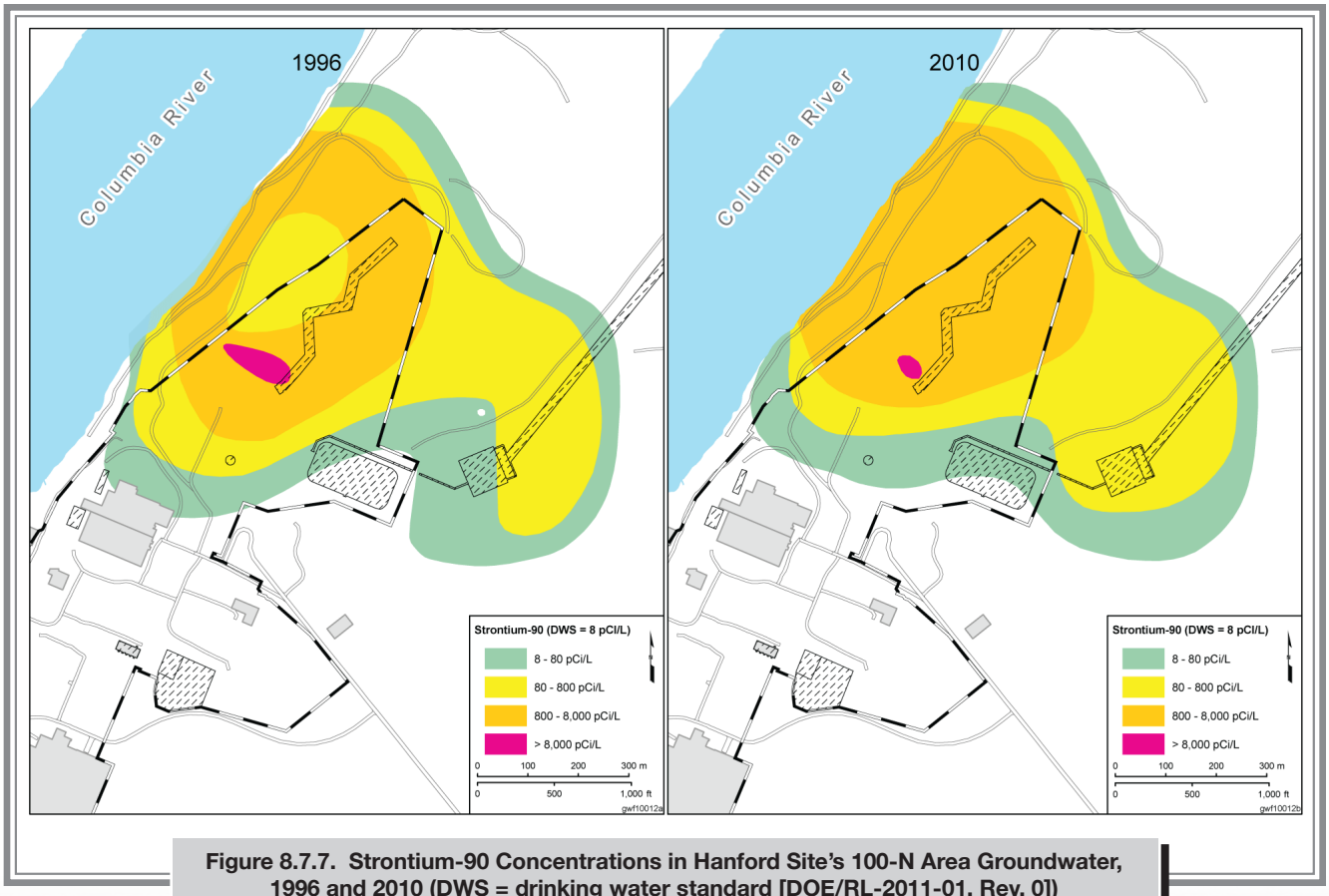

Figure 8.7.7. Strontium-90 Concentrations in Hanford Site's 100-N Area Groundwater, 1996 and 2010 (DWS = drinking water standard [DOE/RL-2011-01, Rev. 0])

result of elevated sulfate and sodium (both non-regulated constituents under RCRA/WAC) associated with releases to the 1324-NA Pond. *Atomic Energy Act of 1954* and CERCLA monitoring continued to track tritium and strontium-90 plumes from the 1301-N and 1325-N facilities and sulfate from the 1324-NA Percolation Pond.

8.7.4.4 Groundwater Monitoring Results for the 100-HR-3 Operable Unit

The 100-HR-3 Operable Unit underlies the 100-D Area, 100-H Area, and the region between them, often referred to as the Horn area. Hexavalent chromium is the principal contaminant of concern in groundwater. A principal cause for this contamination was the routine disposal of reactor coolant, which contained sodium dichromate as a corrosion inhibitor. In addition, periodic spills, leaks, and discharges of sodium dichromate stock solution to the ground are potential sources of hexavalent chromium contamination. Hexavalent chromium is distributed in northern and southern plumes in the 100-D Area (Figure 8.7.8), underlying the Horn area, and the 100-H Area (Figure 8.7.9). Other contaminants include strontium-90 and sulfate.

Interim Remedial Actions. Hexavalent chromium is the target of two pump-and-treat systems designed to reduce the amount of hexavalent chromium in the groundwater entering the Columbia River in the 100-D and 100-H Areas. In 2010, hexavalent chromium concentrations remained above the 20-µg/L remedial-action goal in compliance wells for the pump-and-treat system. During 2010, the HR-3 and the DR-5 extraction systems removed a combined 106 kilograms (234 pounds) of hexavalent chromium from the unconfined aquifer. Pilot testing at the new DX pump-and-treat facility removed an additional 18.4 kilograms (41 pounds) of hexavalent chromium in December 2010. The southern 100-D Area hexavalent chromium plume is also being remediated using a permeable chemical barrier that immobilizes hexavalent chromium in the aquifer. However, data from recent years indicate that hexavalent

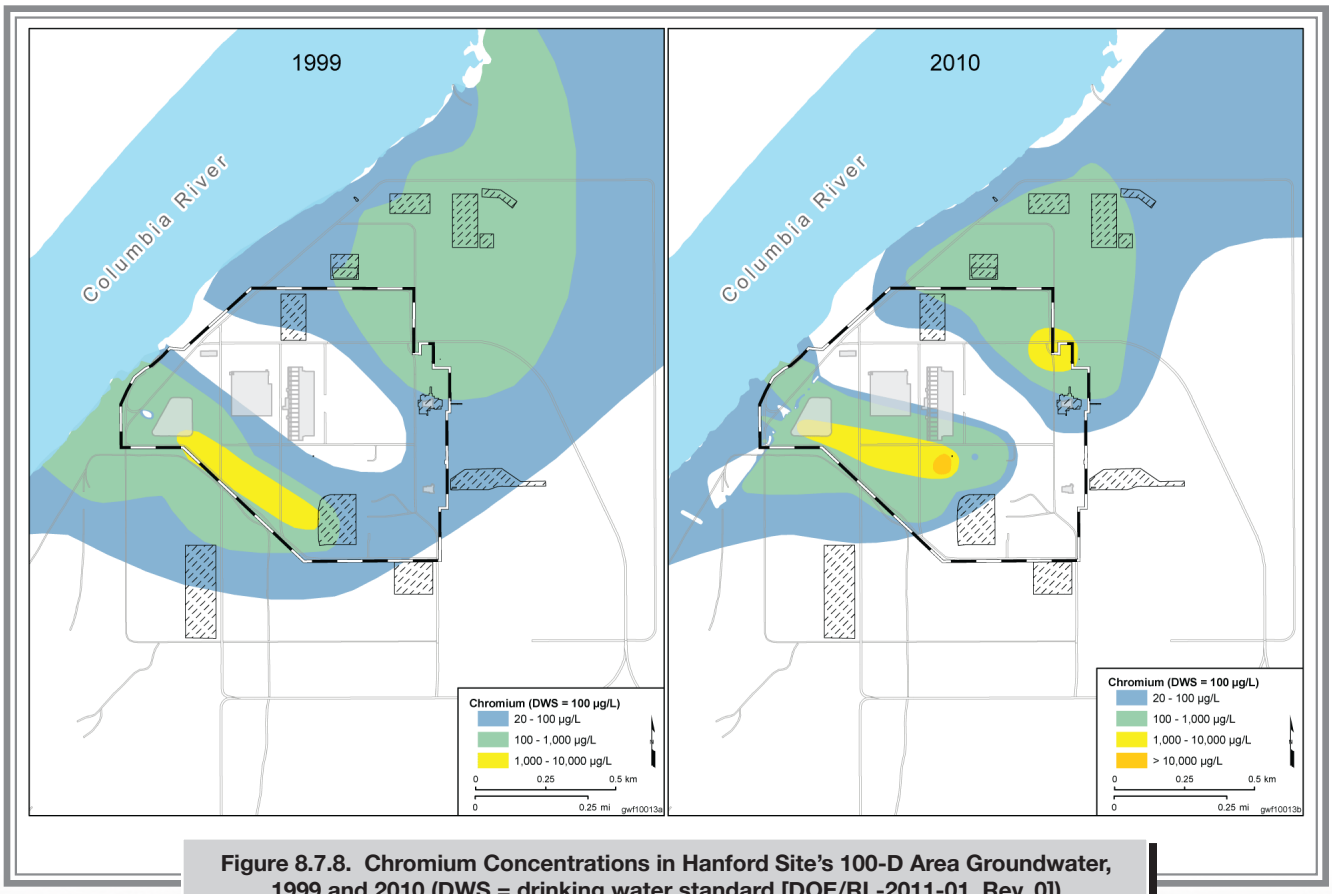

Figure 8.7.8. Chromium Concentrations in Hanford Site's 100-D Area Groundwater, 1999 and 2010 (DWS = drinking water standard [DOE/RL-2011-01, Rev. 0])

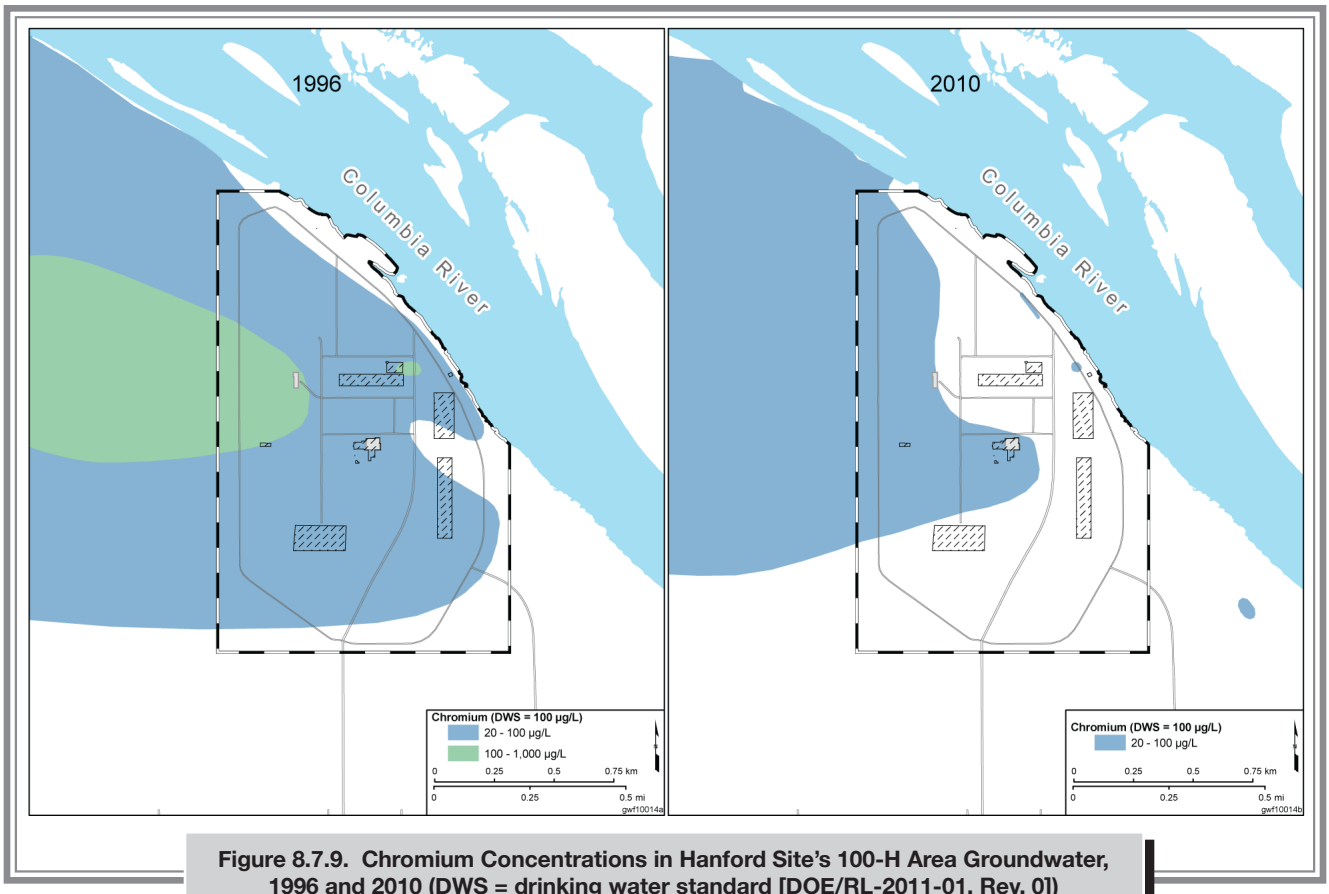

Figure 8.7.9. Chromium Concentrations in Hanford Site's 100-H Area Groundwater, 1996 and 2010 (DWS = drinking water standard [DOE/RL-2011-01, Rev. 0])

chromium is breaking through in some areas of the barrier. At the end of 2010, concentrations in barrier wells ranged from below detection limits to 2,960 µg/L. Most of the elevated concentrations are in the northeastern half of the barrier. Downgradient of the barrier, the 20-µg/L remedial-action goal was met at two of the seven compliance wells.

Remedial Investigation/Feasibility Study Activities. A remedial investigation/feasibility study is being conducted to support the final record of decision for the 100-D/H Area. Characterization activities began in 2009 as described in the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 1: 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2008-46-ADD1, Rev. 0) and implemented through the *Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study* (DOE/RL-2009-40, Rev. 0). The remedial investigation/feasibility study addresses contaminant sources (e.g., site history), contaminant flow and transport, and exposure assessment, and supports risk characterization, remedial-action selection, performance monitoring, and site closure. Data gaps have been identified and are currently being addressed through additional data collection and other investigations that will support final remediation decisions. A series of 15 monitoring wells, 10 vadose zone boreholes, and 5 test pits constitute subsurface characterization activities. Fieldwork was initiated in 2010, and more than 50% of the work was completed by year's end. Fieldwork is scheduled for completion by December 2011, with the remedial investigation/feasibility study draft report scheduled for submittal in November 2011.

Chromium in the Ringold Upper Mud Unit. Aquifer tests were performed in 2009 to gather additional data on hexavalent chromium contamination in the first water-bearing unit within the Ringold Upper Mud Unit. Aquifer tests were performed using existing monitoring wells in the 100-H Area, grouped into three sets of wells with each set containing three wells. The results are summarized in

Aquifer Testing and Rebound Study in Support of the 100-H Deep Chromium Investigation (SGW-47776, Rev. 0) and suggest the likely explanation for the origin of the hexavalent chromium in the Ringold Upper Mud Unit at the 100-H Area is from large volumes of contaminated cooling water from the 105-H Reactor that was subsequently discharged to the ground. This water formed a mound that provided sufficient hydraulic driving force to push the contaminated wastewater through what appears to be a more eroded relatively thinner area of the Ringold Upper Mud Unit. Hexavalent chromium concentrations are not observed in the first water-bearing layer within the Ringold Upper Mud Unit upgradient (toward the Columbia River). The contaminated zone appears to correlate with the groundwater mound that developed during operations near the cooling water retention basins. Chromium concentrations are also consistent with a cooling water origin of less than 700 µg/L.

An evaluation of hexavalent chromium concentration versus time showed no clear concentration trends for hexavalent chromium in unconfined aquifer monitoring wells subsequent to the temporary shutdown of the 100-HR-3 pump-and-treat system. There was, therefore, no support for any significant "rebound" of hexavalent chromium concentrations.

183-H Solar Evaporation Basins. The former 183-H Solar Evaporation Basins are the only RCRA site located in the 100-HR-3 Operable Unit. Leaks from the basins contaminated groundwater with chromium, fluoride, nitrate, technetium-99, and uranium. Although not regulated under RCRA, technetium-99 and uranium were included in the monitoring plan for completeness and were incorporated by reference in the Hanford Facility RCRA Permit. Concentrations of total chromium were above the permit concentration limit in one of the four RCRA monitoring wells in 2010. Concentrations of other contaminants (i.e., nitrate, fluoride, technetium-99, and uranium) at the 183-H Solar Evaporation Basins remained below applicable concentration limits. The site is monitored in accordance with RCRA corrective action regulatory requirements (WAC 173-303-645) during the post-closure period to track contaminant trends during operation of the CERCLA interim action for chromium.

8.7.4.5 Groundwater Monitoring Results for the 100-FR-3 Operable Unit

The 100-FR-3 Operable Unit covers groundwater beneath the former 100-F Reactor area along the Columbia River. The principal groundwater issues for this operable unit are related to the disposal of both solid and liquid wastes associated with operation of the water-cooled F Reactor. Contaminants present include both non-radioactive (nitrate, chromium, and trichloroethene) and radioactive (strontium-90) constituents.

Groundwater activities during the reporting period included remedial investigation studies (DOE/RL-2009-43, Rev. 0, *Sampling and Analysis Plan for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units Remedial Investigation/ Feasibility Study*) and routine groundwater monitoring (DOE/RL-2003-49, Rev. 0, *100-FR-3 Operable Unit Sampling and Analysis Plan*).

Three new groundwater monitoring wells were installed in 2010 as part of the remedial investigation. Data from these wells helped to refine geologic and hydrologic knowledge of the site, and better define groundwater contaminant plumes. Studies also include vadose zone boreholes, which provide data on soil contamination and mobility beneath former waste sites. Nitrate concentrations in groundwater exceed the drinking water standard beneath much of the 100-F Area and the downgradient region. One well in the eastern 100-F Area has strontium-90 concentrations above the drinking water standard. Three wells in the southwestern 100-F Area exceed the drinking water standard for trichloroethene, but concentrations are declining. Chromium exceeds the 10-µg/L aquatic water quality criterion in wells located near the 116-F-14 Retention Basins and 116-F-9 Trench.

8.7.4.6 Groundwater Monitoring Results for the 200-BP-5 Operable Unit

This operable unit includes groundwater beneath the northern 200-East Area and the region northwest to the Columbia River, where mobile contaminants, including tritium and technetium-99, historically moved northward between Gable Mountain and Gable Butte. Most of the groundwater contamination originated in facilities in the northwestern corner of the 200-East Area, known as the B Complex.

The water table in the northern 200-East Area is virtually flat, making it difficult to determine groundwater flow direction. Studies in recent years suggest that groundwater continues to flow slowly to the northwest from the B Complex area.

Constituents of concern defined in the *Groundwater Sampling and Analysis Plan for the 200-BP-5 Operable Unit* (DOE/RL-2001-49, Rev. 1) include cyanide, nitrate, tritium, cobalt-60, strontium-90, technetium-99, iodine-129, cesium-137, plutonium-239/240, and uranium. Tritium and technetium-99 plumes extend northward between Gable Mountain and Gable Butte. Uranium forms a narrow plume that extends northwest of the 200-East Area (Figure 8.7.10). Nitrate forms a plume that extends to the north and likely originated from multiple sources within the 200-East Area. Other contaminant plumes include localized cyanide and sulfate plumes.

During 2010, DOE continued the 200-BP-5 Operable Unit remedial investigation/feasibility study. Chemical and physical analyses were completed and reported on three new wells during 2010 (PNNL-SA-72699; PNNL-SA-72700; PNNL-SA-72701).

Low-Level Waste Management Area 1. Low-Level Waste Management Area 1 continued to be monitored under RCRA interim status contaminant indicator monitoring requirements as specified in the revised monitoring plan, *Interim Status Groundwater Monitoring Plan for LLBG WMA-1*, (DOE/RL-2009-75, Rev. 0). Like last year, specific conductance continued to exceed its threshold value. These exceedances were previously reported in 1999 (PNNL-13788) and do not indicate contamination from the waste management area. All other indicator parameters were below their respective threshold values. A recent low-gradient water level evaluation supports a predominantly northwestern groundwater flow direction. A gradient reversal, with subsequent erratic gradient measurements, was observed at Low-Level Waste Management Area 1 from the summer of 2008 until the spring of 2009. The northwestern flow direction was

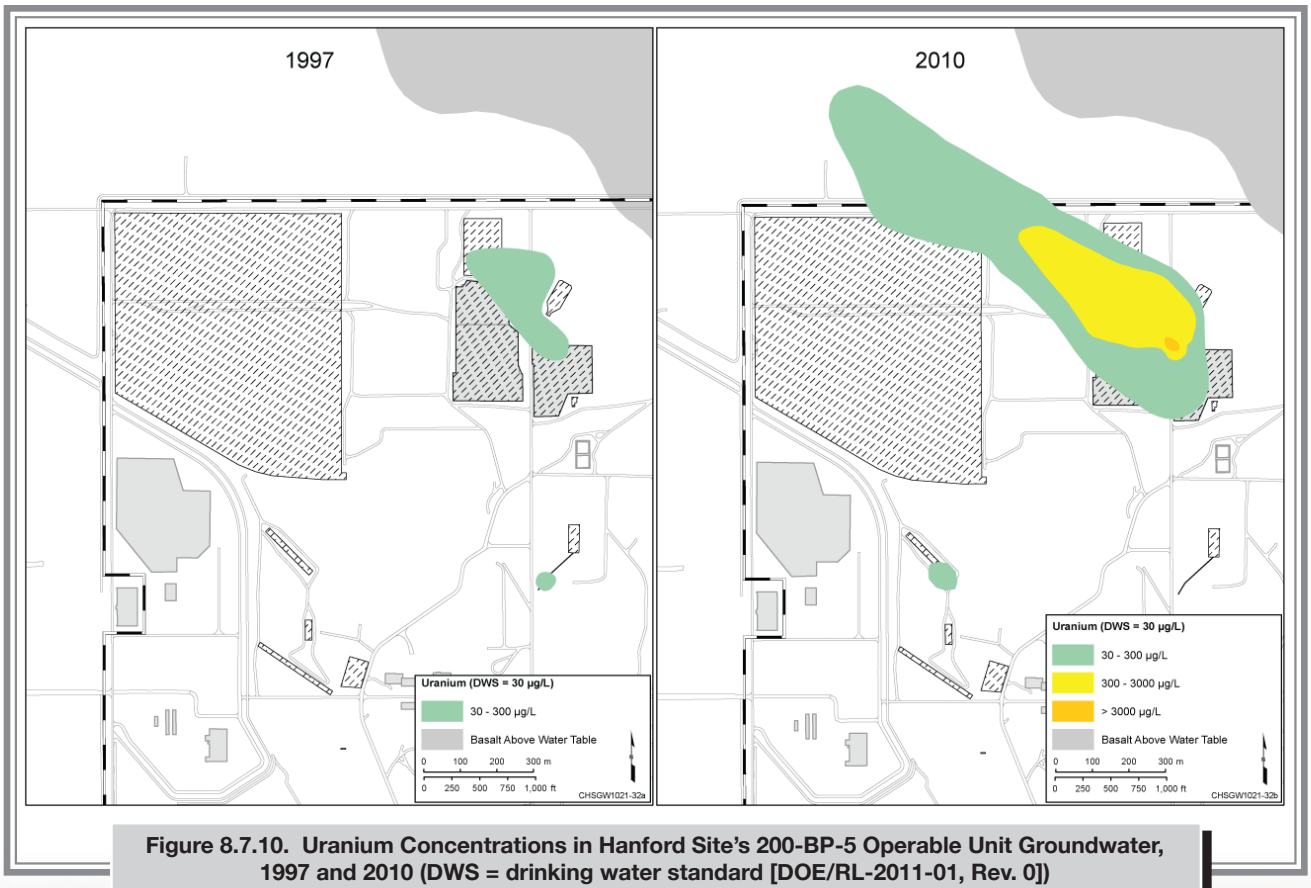

Figure 8.7.10. Uranium Concentrations in Hanford Site's 200-BP-5 Operable Unit Groundwater, 1997 and 2010 (DWS = drinking water standard [DOE/RL-2011-01, Rev. 0])

statistically re-established by July 2009. Two additional wells were installed in anticipation of shrinking the footprint of the waste management area.

Low-Level Waste Management Area 2. Low-Level Waste Management Area 2 continued to be monitored under RCRA interim status contaminant indicator monitoring requirements in 2010 as specified in the revised monitoring plan, the *Interim Status Groundwater Monitoring Plan for LLBG WMA-2* (DOE/RL-2009-76, Rev. 0). All RCRA indicator parameters were below their respective threshold values. Although the water table gradient in this area is less than the measurement error, the monitoring network is believed by DOE to be capable of detecting constituents migrating from the facility because wells are located along the west and south boundaries, while the elevation of the basalt rises above the aquifer to the north and east.

Waste Management Area B-BX-BY. RCRA groundwater quality assessment monitoring continued at this site. Contaminants of interest include cyanide and chromium (both dangerous constituents under WAC 173-303-400); however, both constituents have their sources from nearby cribs, not the waste management area. The non-RCRA contaminants nitrate, uranium, and technetium-99 are also monitored regularly to support CERCLA investigations. Contaminants show a clear migration to the northwest for more than 20 years, with the most mobile constituents (nitrate and technetium-99) having moved some 2 kilometers (1 mile) from their source area. Five new wells installed under the 200-BP-5 Operable Unit remedial investigation/feasibility study (SGW-44071) were also sampled and the results were evaluated. The current network, with the addition of the 200-BP-5 remedial investigation/feasibility study wells, is believed by DOE to be capable of evaluating the rate and extent of contaminant migration sourced from Waste Management Area B-BX-BY.

Waste Management Area C. RCRA groundwater quality assessment monitoring continued at this site in 2010 as detailed in *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area C* (DOE/RL-2009-77, Rev. 0). Cyanide, a dangerous constituent, was determined to be associated with releases from Waste Management Area C. Metals and volatile organics continue to be evaluated. Although the groundwater gradient is within the measurement error, alternative measures determined the groundwater has flowed to the southwest for nearly 4 years at an approximate rate of 0.064 meter (2.5 inches) per day. Two wells were added to the well network in 2010 and provided sufficient information to establish the extent of the cyanide. Four CERCLA constituents of concern were reported above the drinking water standard at Waste Management Area C: nitrate, sulfate, iodine-129, and technetium-99.

Liquid Effluent Retention Facility. The Liquid Effluent Retention Facility operates under final status permit conditions. A revised monitoring plan was drafted in 2010 and includes two new wells, for a total of four wells in the monitoring network. Although this plan is not yet in the permit, all four of the wells in the network were sampled twice during 2010. Nitrate exceeded the drinking water standard in wells 299-E26-10 and 299-E26-77, with maximum concentrations of 50.9 and 53.9 mg/L, respectively. Nitrate has been increasing in well 299-E26-10 since 2003, and in wells south and east of the Liquid Effluent Retention Facility. The regional increase of anions and cations is evident in wells located in the central and eastern portions of the 200-East Area. Statistical evaluations of monitoring data from the new wells have not yet been implemented.

216-B-63 Trench. This RCRA site continued to be monitored under a RCRA interim status contaminant indicator evaluation monitoring program. All indicator parameters were below their threshold values. A revised interim status groundwater monitoring plan was issued for implementation in June 2010, the *Interim Status Groundwater Monitoring Plan for the 216-B-63 Trench* (DOE/RL-2008-60, Rev. 0). The new monitoring plan reduced the number of wells from 12 to 7 and established semiannual sampling at these wells. DOE believes the revised monitoring network is capable of detection of indicator constituents from the treatment, storage, and disposal unit.

8.7.4.7 Groundwater Monitoring Results for the 200-PO-1 Operable Unit

This operable unit encompasses the southern portion of the 200-East Area and a large region to the east and southeast to the Columbia River where groundwater is contaminated with tritium (Figure 8.7.11) and iodine-129. Concentrations

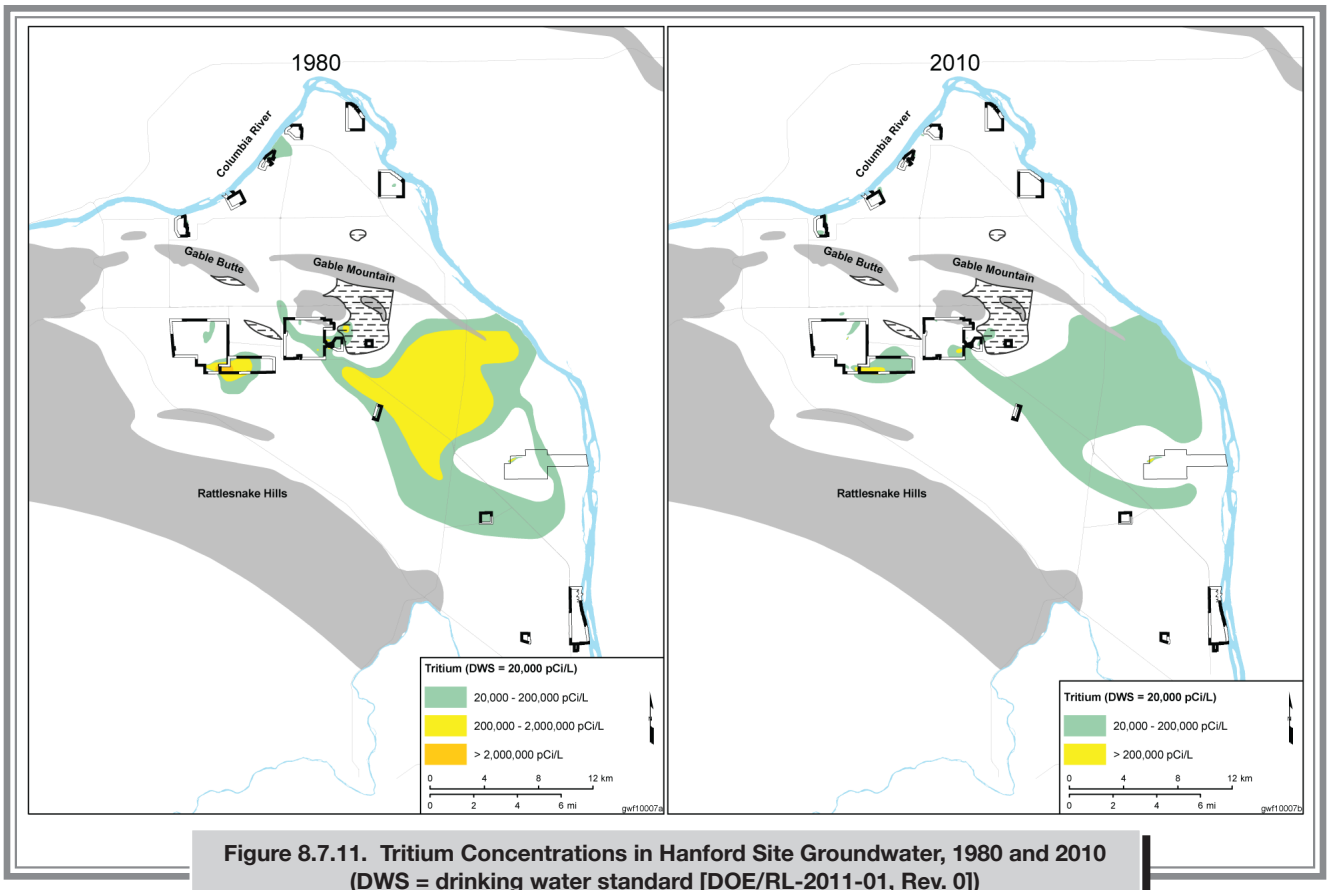

Figure 8.7.11. Tritium Concentrations in Hanford Site Groundwater, 1980 and 2010 (DWS = drinking water standard [DOE/RL-2011-01, Rev. 0])

of tritium continued to decline as the plume attenuates naturally because of radioactive decay, advection, and dispersion. The iodine-129 plume above the 1-pCi/L isopleth has changed very little, but the maximum concentrations have declined significantly as a result of dispersion; the mass of contamination remains the same, thus the volume of contaminated groundwater has increased. Nitrate also forms a large plume but typically at levels below the 45-mg/L drinking water standard. Other contaminants include strontium-90, technetium-99, and uranium, but these are limited to smaller areas near their respective sources.

During 2010, routine monitoring continued under the *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit* (DOE/RL-2003-04, Rev. 1). Contaminants of concern listed in the sampling and analysis plan include nitrate, iodine-129, strontium-90, technetium-99, tritium, and uranium. Other contaminants of potential interest are arsenic, chromium, manganese, and vanadium.

Groundwater is monitored at eight regulated units in the 200-PO-1 Operable Unit; six facilities are monitored under RCRA; one wastewater discharge facility is covered by a state waste discharge permit; and one solid waste landfill is regulated under Washington State solid waste regulations. Water supply wells in the 400 Area, which fall within the 200-PO-1 Operable Unit footprint, are also monitored.

Integrated Disposal Facility. The Integrated Disposal Facility is an expandable, lined, RCRA-compliant landfill. The unit is not currently operational; thus, results from monitoring are being added to a baseline data set. A permit modification approved in June 2010 allows sample collection on an annual frequency during the pre-active life of the Integrated Disposal Facility.

Plutonium-Uranium Extraction (PUREX) Cribs. The 216-A-10, 216-A-36B, and 216-A-37-1 Cribs are monitored under a RCRA interim status groundwater quality assessment program, in conjunction with CERCLA and *Atomic*

Energy Act of 1954 requirements. The cribs have contributed to widespread contaminant plumes in the area, including the non-RCRA contaminants nitrate, tritium, and iodine-129; tritium and nitrate have migrated to the Columbia River. The nitrate and tritium plumes are generally attenuating throughout most of the area. The iodine-129 plume appears to be mostly stable. During 2010, the 216-A-10 Crib was officially closed and removed from Part A of the Hanford Facility Dangerous Waste Permit. The two remaining cribs, 216-A-36B and 216-A-37-1, will remain in RCRA interim status. Separate RCRA groundwater monitoring plans were written for these cribs (DOE/RL-2010-92, Rev. 0; DOE/RL-2010-93, Rev. 0), and they will return to indicator evaluation programs. Both new plans will be implemented in 2011.

Waste Management Area A-AX. RCRA groundwater quality assessment monitoring continued in 2010 for this waste management area after installation of a new well in 2008. Results of the "first determination" assessment indicated the tank farm had impacted groundwater quality with dangerous waste or dangerous waste constituents (nickel). A new groundwater quality assessment monitoring plan, *Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX* (DOE/RL-2009-70, Draft A) was written, as required by WAC 173-303-400, which will continue the path forward in an interim status groundwater quality assessment program. The plan is currently under review by the Washington State Department of Ecology and is expected to be approved in 2011.

216-A-29 Ditch. The groundwater beneath this site continued to be monitored as required under RCRA interim status indicator evaluation regulations. Indicator parameters have continued on historic trends, with specific conductance exceeding the threshold values; the elevated specific conductance is caused by non-dangerous constituents. Groundwater quality beneath the ditch is similar to the regional groundwater composition, and the site remains in indicator evaluation monitoring. Groundwater flow direction is changing from southwest to the south and southeast beneath the 216-A-29 Ditch as a result of the declining impact of the B Pond groundwater mound. This change in groundwater flow direction is sufficient to warrant changing the upgradient well from well 699-43-45 to well 299-E26-12. An additional upgradient well, 299-E26-13, was included and well 299-E25-34 was dropped from the network. These changes were implemented with the issuance of a revised groundwater monitoring plan in March 2010, *Interim Status Groundwater Monitoring Plan for the 216-A-28 Ditch* (DOE/RL-2008-58, Rev. 0).

216-B-3 Pond. The groundwater beneath this site continued to be monitored as required by RCRA interim status indicator evaluation regulations. None of the threshold values were exceeded during the reporting period. DOE believes the monitoring network is capable of detecting and evaluating indicator constituents from the treatment, storage, and disposal unit. A revised and updated monitoring plan, including the well network, constituents of concern, sampling and analysis procedures, and a conceptual model, was completed and issued in September 2010 (DOE/RL-2008-60, Rev. 0).

Nonradioactive Dangerous Waste Landfill. This RCRA site is located in the 600 Area, within the footprint of regional tritium and iodine-129 plumes. Monitoring for interim status indicator parameters continued during 2010. The critical mean for specific conductance was exceeded during 2010, but the exceedance did not require verification sampling or regulatory notification. Exceedance of this indicator parameter occurred in 2007 at the Nonradioactive Dangerous Waste Landfill and was determined to be caused by non-hazardous waste groundwater constituents (DOE/RL-2008-01, Rev. 0). Volatile organic compounds were not detected in downgradient Nonradioactive Dangerous Waste Landfill wells during 2010.

During 2010, a new combination RCRA groundwater monitoring plan was written combining the Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill (DOE/RL-2010-28, Rev. 1). Because the two landfills are adjacent to one another, combining the ultimate remedial action for the two landfills was considered a reasonable option to maximize available resources. In the new plan, the Nonradioactive Dangerous Waste Landfill groundwater monitoring will move into RCRA final status under WAC 173-303-645. This plan is under review by the Washington State Department of Ecology, and until approved, the Nonradioactive Dangerous Waste Landfill will continue to be monitored under the current interim status plan.

Solid Waste Landfill. This facility is adjacent to the Nonradioactive Dangerous Waste Landfill, and is regulated under Washington State solid waste handling regulations. As in previous years, some of the downgradient wells showed higher concentrations of regulated constituents than the statistically calculated background threshold values. Background threshold values exceeded during 2010 included coliform bacteria, pH, specific conductance, sulfate, and temperature.

A new RCRA groundwater monitoring plan was written in 2010 combining the groundwater monitoring plan with the Nonradioactive Dangerous Waste Landfill (DOE/RL-2010-28, Rev. 1). At the Solid Waste Landfill, closure and post-closure groundwater monitoring is subjected to the requirements of WAC 173-350-500; however, compliance with groundwater monitoring requirements for the Solid Waste Landfill are proposed to be achieved through deferral under WAC 173-303-645. The new monitoring plan is under review by the Washington State Department of Ecology, and until approved, the Solid Waste Landfill will continue to be monitored under the existing groundwater monitoring plan (PNNL-13014).

200 Areas Treated Effluent Disposal Facility. A state waste discharge permit governs groundwater sampling and analysis in the three monitoring wells at this facility. None of the permit criteria for constituents in groundwater were exceeded in 2010.

400 Area Water Supply Wells. Three water supply wells provide drinking water and serve as an emergency water supply for the 400 Area. Because the 400 Area is in the path of the Hanford Site-wide tritium plume, the wells are routinely monitored for tritium. These wells are screened deep in the unconfined aquifer, just above the Ringold Lower Mud Unit. Tritium concentrations in all samples were below the drinking water standard during the reporting period.

8.7.4.8 Groundwater Monitoring Results for the 200-UP-1 Operable Unit

This operable unit occupies the southern portion of the 200-West Area and adjacent areas to the east and south. The principal contaminants of concern are carbon tetrachloride, nitrate, tritium, technetium-99, iodine-129, and uranium. Arsenic, cadmium, chromium, and strontium-90 plumes also have sources in this operable unit. Carbon tetrachloride, chloroform, and trichloroethene in the 200-UP-1 Operable Unit originated from sources in the 200-ZP-1 Operable Unit. During calendar year 2010, DOE began groundwater monitoring under the remedial investigation/feasibility study work plan for the 200-UP-1 Operable Unit (DOE/RL-92-76, Rev. 1).

The 200-UP-1 Operable Unit contains one CERCLA interim action pump-and-treat system, three facilities monitored under RCRA (in conjunction with CERCLA and the *Atomic Energy Act of 1954*), and one CERCLA disposal site.

Interim Remedial Action. Since 1994, DOE has operated an interim remedial-action pump-and-treat system to remove technetium-99 and uranium from the groundwater near U Plant. At all wells, the technetium-99 concentrations were below the remedial-action objectives of 9,000 pCi/L during 2010. Uranium declined below the remedial-action objective of 300 µg/L in all wells except well 299-W19-18, located upgradient by the 216-U1/2 Cribs and beyond the influence of the pump-and-treat system. The pump-and-treat system operated about one-third of the time during 2010; downtime was due to facility upgrades at the Effluent Treatment Facility and well rehabilitation. Flow rates from the extraction wells remained low (fewer than 30 liters [8 gallons] per minute combined) and rehabilitation attempts to increase flow were not successful. During 2010, the pump-and-treat system removed a total of 0.9 kilograms (2 pounds) of uranium, 1.47 grams (0.05 ounce) of technetium-99, 0.9 kilograms (2 pounds) of carbon tetrachloride, and 2,092 kilograms (4,600 pounds) of nitrate from the 4.9 million liters (1.3 million gallons) of groundwater pumped (Figures 8.7.12 and 8.7.13).

Waste Management Area S-SX. RCRA groundwater quality assessment monitoring continued at this waste management area in 2010. Groundwater beneath Waste Management Area S-SX is contaminated with tank waste constituents, including nitrate, chromium, and technetium-99, which are attributed to two general source areas within the waste management area. Chromium is the only dangerous waste constituent subject to RCRA requirements. These contaminants have migrated as much as 600 meters (1,970 feet) downgradient from the treatment, storage, and disposal unit at

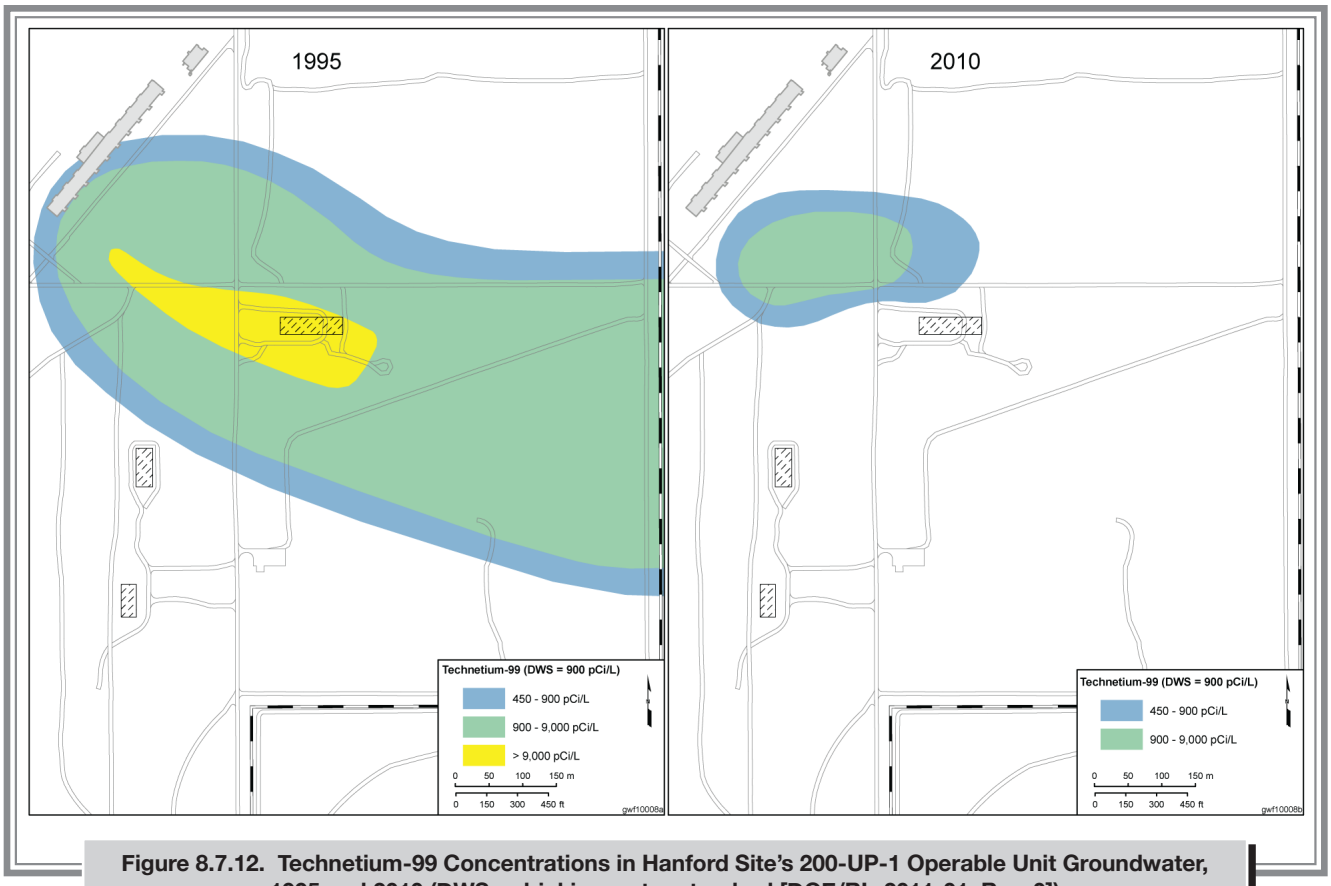

Figure 8.7.12. Technetium-99 Concentrations in Hanford Site's 200-UP-1 Operable Unit Groundwater, 1995 and 2010 (DWS = drinking water standard [DOE/RL-2011-01, Rev. 0])

concentrations above drinking water standards. All three contaminants were above their respective drinking water standards during the reporting period. A new well was installed during 2010 to define the southwest boundary of the contamination.

Waste Management Area U. RCRA groundwater quality assessment monitoring at Waste Management Area U continued during 2010. This waste management area has been identified as the source of groundwater contamination that is limited to the downgradient (east) side of the unit. Constituents of interest include the non-RCRA contaminants nitrate and technetium-99. During the reporting period, both contaminants were above their respective drinking water standards.

216-S-10 Pond and Ditch. The 216-S-10 Pond and Ditch continued to be monitored under a RCRA interim status contaminant indicator evaluation monitoring program during 2010. One upgradient well and two downgradient wells, installed in 2008 as part of the 200-UP-1 remedial investigation/feasibility study work plan (DOE/RL-2009-122, Draft A), were sampled quarterly beginning in October 2008; additional quarterly samples were collected during 2010. It was anticipated that the new upgradient well would be used for statistical comparisons beginning in 2010; however, due to extreme variability in the total organic carbon results (standard deviation of 2,371) only pH, specific conductance, and total organic halides were reevaluated from the new well. Total organic carbon concentrations in the well vicinity have begun to stabilize and are anticipated to be sampled in 2011. No threshold values for indicator parameters were exceeded during the reporting period. DOE believes the monitoring network is capable of continued detection and evaluation of indicator constituents from the treatment, storage, and disposal unit. A revised monitoring plan, *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch* (DOE/RL-2008-61, Rev. 0), was issued and implemented in March 2010.

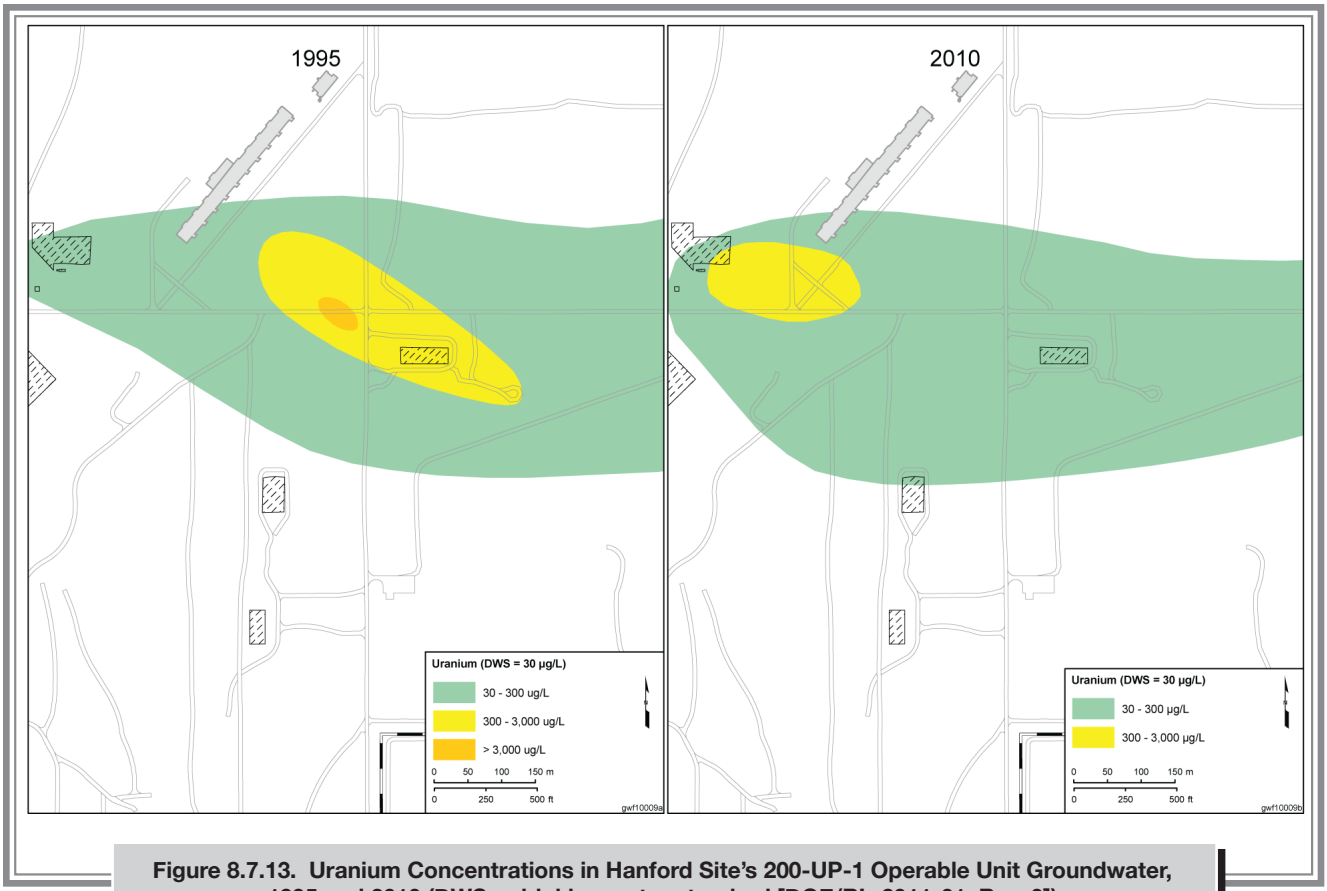

Figure 8.7.13. Uranium Concentrations in Hanford Site's 200-UP-1 Operable Unit Groundwater, 1995 and 2010 (DWS = drinking water standard [DOE/RL-2011-01, Rev. 0])

Environmental Restoration Disposal Facility. This low-level, mixed waste facility is used for disposal of waste generated from surface remedial actions and other activities at the Hanford Site. The facility was constructed under CERCLA and is designed to meet all hazardous waste landfill standards. Gross alpha concentrations in groundwater show a slight long-term decrease, and gross beta concentrations show an increase in most downgradient wells. Gross alpha and gross beta in groundwater will be closely monitored in the future. The results of groundwater monitoring continue to indicate that the facility has not adversely affected groundwater quality.

8.7.4.9 Groundwater Monitoring Results for the 200-ZP-1 Operable Unit

This operable unit encompasses the northern and central portions of the 200-West Area and adjacent areas to the north and east. The principal contaminant of concern is carbon tetrachloride (Figure 8.7.14). Other contaminants include hexavalent chromium, nitrate, trichloroethene, tritium, technetium-99, iodine-129, and uranium.

During 2010, DOE published the *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action* (DOE/RL-2009-115, Rev. 0). This document serves to guide groundwater monitoring data collection activities associated with 200-ZP-1 Operable Unit remedial action.

Carbon tetrachloride contamination occurs at increasing depth to the east (downgradient) of the known source areas. In this area, natural and artificial recharge may have led to reduced carbon tetrachloride concentrations in the upper portion of the aquifer. Carbon tetrachloride is denser than water, which also affects its vertical distribution. The 200-ZP-1 Operable Unit feasibility study (DOE/RL-2007-28, Rev. 0) illustrates the areal extent of carbon tetrachloride at different depths. The maximum extent of the plume at all depths (i.e., the plume footprint) extends beyond the contours shown in Figure 8.7.14.

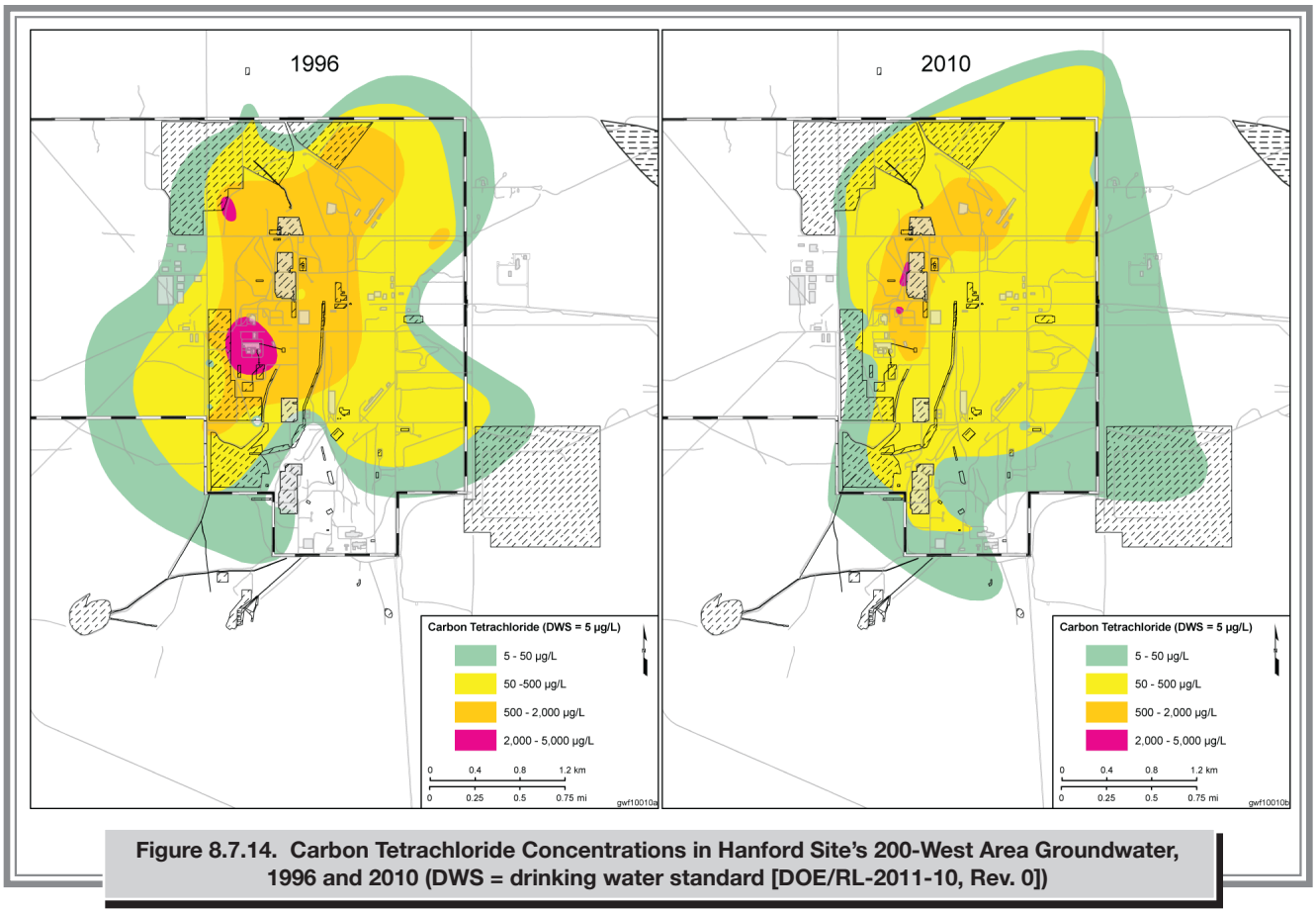

Figure 8.7.14. Carbon Tetrachloride Concentrations in Hanford Site's 200-West Area Groundwater, 1996 and 2010 (DWS = drinking water standard [DOE/RL-2011-10, Rev. 0])

The 200-ZP-1 groundwater interest area contains two CERCLA interim action pump-and-treat systems for groundwater, one soil-vapor remediation system for the vadose zone, four facilities monitored under RCRA (in coordination 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 is limiting movement of the shallow, high-concentration portion of the plume but does not address contamination deeper in the aquifer and at the periphery of the plume. It has removed approximately 12,650 kilograms (approximately 27,880 pounds) of carbon tetrachloride from groundwater since 1994.

A second pump-and-treat system (241-T) for the removal of technetium-99 at Waste Management Area T came online in 2007 as part of a designed interim remediation activity. During 2010, the two extraction wells pumped a total of 52.2 million liters (13.8 million gallons) allowing for removal of 16.3 grams (0.57 ounce, or 278 curie) of technetium-99, for a total 72.7 grams (2.56 ounces) removed since system startup.

Soil-Vapor Extraction. Soil vapor is extracted from the vadose zone and treated to remove carbon tetrachloride. The system has removed approximately 79,800 kilograms (176,000 pounds) of carbon tetrachloride from the vadose zone since operations started in 1991. A new system came online at the 216-Z-18 and 216-Z-1A Well Field in 2010. During 2010, both the new and existing vapor extraction systems removed a total of 193 kilograms (425 pounds) of carbon tetrachloride from the vadose zone.

Low-Level Burial Grounds Waste Management Area 3. RCRA groundwater monitoring continued under interim status indicator evaluation requirements in 2010. There are no upgradient monitoring wells for Low-Level Burial

Grounds Waste Management Area 3, but construction of a new well is planned in 2011. A new interim status groundwater monitoring plan was issued during 2010, the *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3* (DOE/RL-2009-68, Rev. 0). Until the new upgradient well is installed and background conditions are established, statistical evaluations have been suspended.

Low-Level Burial Grounds Waste Management Area 4. RCRA groundwater monitoring continued under interim status indicator evaluation requirements in 2010. The remaining upgradient well went dry in early 2010. Statistical evaluations will continue, using critical means calculated from the most recent several years of data. Construction of an upgradient well is not expected until the hydraulic effects of the enhanced 200-ZP-1 Operable Unit pump-and-treat system are known. The results of the first determination were completed in July 2009 and did not find dangerous waste/dangerous waste constituents in the groundwater at Low-Level Burial Grounds Waste Management Area 4; therefore, monitoring returned to indicator evaluation monitoring. This unit continued under indicator evaluation monitoring throughout 2010. A new interim status groundwater monitoring plan was issued during 2010, the *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4* (DOE/RL-2009-69, Rev. 1).

Waste Management Area T. RCRA groundwater quality assessment monitoring for this waste management area continued in 2010. A new interim status assessment monitoring plan, drafted and approved in 2010, was issued in February 2011 (DOE/RL-2009-66, Rev. 0). Sources in Waste Management Area T have contaminated groundwater with the dangerous waste constituent chromium. In addition, technetium-99, nitrate, and other non-RCRA tank waste contaminants from the waste management area and adjacent waste-disposal facilities have affected the unconfined aquifer in the area. Chromium contamination in groundwater extends at least 2.5 kilometers (1.5 miles) downgradient. Two extraction wells in the 200-ZP-1 pump-and-treat system, installed for technetium-99 remediation, operate immediately east and downgradient of the waste management area. Concentrations of the non-RCRA contaminant technetium-99 have fluctuated as a result of these extraction activities. Concentrations greater than those found beneath this unit are found in wells upgradient of the waste management area.

Waste Management Area TX-TY. RCRA groundwater quality assessment monitoring continued during 2010. A new monitoring plan, drafted and approved in 2010, was issued in February 2011 (DOE/RL-2009-67, Rev. 0). Sources in Waste Management Area TX-TY have contaminated the groundwater with chromium (a dangerous waste constituent) and other non-RCRA tank waste constituents such as technetium-99 and nitrate. Mobile contaminants have migrated to wells approximately 250 meters (820 feet) downgradient of the waste management area. The operation of the 200-ZP-1 pump-and-treat system has affected the groundwater flow rate and direction beneath Waste Management Area TX-TY. Extraction wells operate south and west (upgradient) of the waste management area.

State-Approved Land Disposal Site. This active liquid waste-disposal facility is regulated under a state waste discharge permit. The disposal site receives treated groundwater containing tritium from the Effluent Treatment Facility in the 200-East Area. Groundwater is monitored for tritium and 15 other constituents. Concentrations of all constituents considered in the permit did not exceed enforcement limits during 2010.

8.7.4.10 Groundwater Monitoring Results for the 300-FF-5 Operable Unit

This operable unit includes three geographic regions: the 300 Area, the 618-11 Burial Ground region, and the 618-10 Burial Ground/316-4 Cribs region. The operable unit is currently regulated under a record of decision for interim remedial action (EPA/ROD/R10-96/143) that requires groundwater monitoring and institutional controls on groundwater usage.

Contaminants of concern in 300 Area groundwater are uranium, cis-1,2-dichloroethene, and trichloroethene. Monitoring and plume characterization activities indicate relatively constant or gradually decreasing levels for these contaminants, with a few exceptions. Uranium is the principal contaminant of concern and remains above the drinking water standard of 30 µg/L beneath part of the

300 Area (Figure 8.7.15). Also a new area of localized uranium contamination developed to the southeast of the former 618-7 Burial Ground as a result of remediation activities in 2007 and 2008. The plume has migrated downgradient and is merging with the larger uranium plume.

Trichloroethene continued to be below the 5-µg/L drinking water standard in wells monitoring the top portion of the unconfined aquifer. However, higher concentrations were detected in a deeper, fine-grained unit within a limited area of the Ringold Upper Mud Unit. Because of the very low yield from this interval and the likely ineffectiveness of pumping samples, none of the monitoring wells have been screened in this sediment. However, at aquifer tube sites along the Columbia River, at least one tube is screened in this interval and has produced samples that reveal trichloroethene contamination.

Groundwater downgradient of the 618-11 Burial Ground is contaminated by a high-concentration tritium plume, likely originating from irradiated material in the burial ground. Concentrations at a well adjacent to the burial ground have decreased from the peak values observed in 1999 and 2000. Concentrations are stable in the central portion of the plume, while increasing slightly at the downgradient edge, reflecting migration to the east. Characterization activities in preparation for remediation of the 618-11 Burial Grounds were conducted during calendar year 2010.

Uranium Treatability Test. After an aquifer test in June 2007, groundwater monitoring indicated that the injection of polyphosphate solutions has not performed as well as anticipated in permanently sequestering uranium on aquifer solids. A final report on the aquifer injection test is provided in *300 Area Uranium Stabilization Through Polyphosphate Injection: Final Report* (PNNL-18529). Additional treatability testing of potential methods to immobilize uranium in the vadose zone using alternative polyphosphate solutions was conducted during 2009 and continued during 2010 at a second test site.

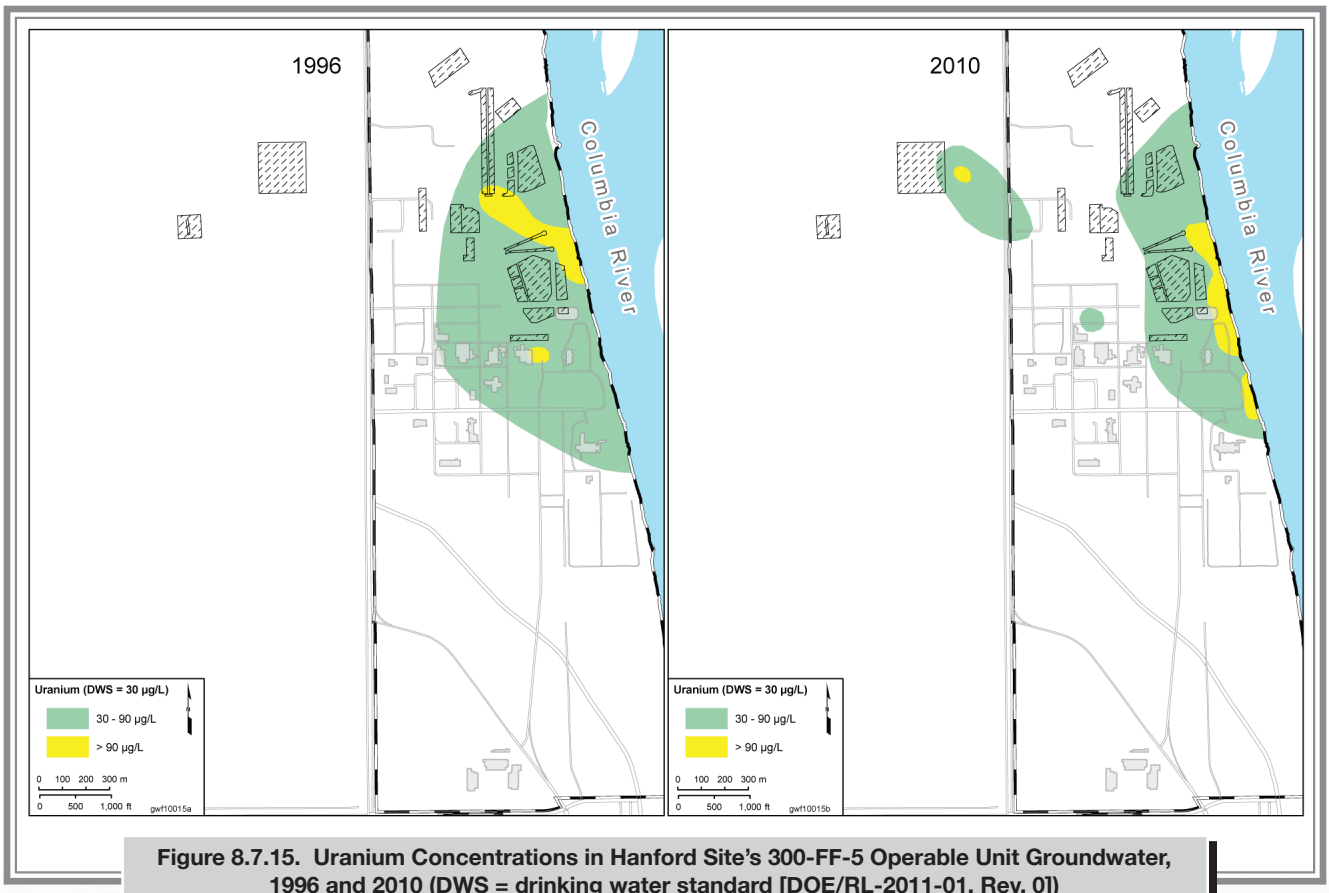

Figure 8.7.15. Uranium Concentrations in Hanford Site's 300-FF-5 Operable Unit Groundwater, 1996 and 2010 (DWS = drinking water standard [DOE/RL-2011-01, Rev. 0])

Integrated Field-Scale Research Challenge Program. DOE's Office of Biological and Environmental Research (Office of Science) is supporting field research involving uranium mobility through a program referred to as the Integrated Field-Scale Research Challenge. The Hanford Site 300 Area is one of three DOE sites where field and laboratory research activities are being performed. A highly instrumented, three-dimensional array of sensors was installed in the vadose zone and upper portion of the aquifer beneath a portion of the former South Process Pond liquid waste-disposal site. A closely associated project uses a variety of near-surface geophysical methods to characterize preferential pathways for groundwater movement and discharge to the Columbia River channel. The project is in its third year, and the results were published in 2010 (Slater et al. 2010).

DOE has also funded a groundwater flow and uranium transport modeling project for the 300 Area via the Scientific Discovery Through Advanced Computing Program. This project involves parallel, high-speed computing and conducts calculations that would otherwise require exceedingly long computing times using conventional computer equipment. Two reports on the initial results of the project were published in 2010 and early 2011 (Hammond and Lichtner 2010; Hammond et al. 2011).

300 Area Process Trenches. This former liquid waste-disposal site was the last site in the 300 Area to receive uranium-bearing effluent, which ended in 1985; all other discharges ended in December 1994. The site, which has been remediated, is regulated under RCRA and the groundwater is monitored in accordance with post-closure corrective action requirements (WAC 173-303-645(11)); the remedial activities are currently deferred to CERCLA. Uranium currently exceeds the drinking water standard in wells downgradient from the waste site. Cis-1,2-dichloroethene concentrations exceed the drinking water standard at downgradient well 399-1-16B, which is completed near the bottom of the unconfined aquifer. Most results for trichloroethene and tetrachloroethene were below detection limits during the reporting period, with the exception of two trichloroethene detections in samples from well 399-1-16B and one trichloroethene detection from well 399-1-17A; however, concentrations were near the detection limit.

8.7.4.11 Groundwater Monitoring Results for the 1100-EM-1 Groundwater Interest Area

The 1100-EM-1 groundwater interest area is located in the southern part of the Hanford Site. It includes the former 1100-EM-1 Operable Unit, which was removed from the National Priorities List (40 CFR 300, Appendix B) and is no longer classified as a CERCLA operable unit. Groundwater is also monitored south of the Hanford Site, including the areas formerly designated as the 1100 and 3000 Areas of the site, the city of Richland's sanitary landfill, and the North Richland Well Field. This operable unit was deleted from the CERCLA National Priorities List because waste was left in place; however, continued groundwater monitoring is required under the most recent revision of the *Sampling and Analysis Plan Update for Groundwater Monitoring – 1100-EM-1 Operable Unit* (PNNL-12220), change notice TPA-CN-163, and *Atomic Energy Act of 1954* requirements.

Trichloroethene was the principal contaminant of concern in the former 1100-EM-1 Operable Unit. Concentrations of trichloroethene remained below the 5-µg/L drinking water standard in 2010. Contaminants also flow into the area from offsite sources (e.g., nitrate from agricultural and industrial activities). The final alternative selected for groundwater was monitored natural attenuation of volatile organic compounds.

Wells in the North Richland Well Field are monitored frequently to detect 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; however, low levels of tritium, similar to those detected in Columbia River water, continued to be detected in 2010.

Elevated levels of gross alpha occur downgradient of an offsite industrial facility and DOE's inactive Horn Rapids Landfill. Uranium concentrations have been slowly increasing since 1996, but remained below the drinking water standard in 2010. The presence of uranium at these locations is likely associated with the plume moving northeast from the AREVA Federal Services, LCC facility.

8.7.4.12 Groundwater Monitoring Results for the Confined Aquifers

Although most of the Hanford Site's groundwater contamination is in the unconfined aquifer, DOE monitors wells in deeper aquifers because of the potential for downward migration of contamination and the potential migration of contamination offsite through the basalt-confined aquifer. No evidence of offsite migration via the confined aquifer has been detected.

The Ringold Formation confined aquifer occurs within fluvial sand and gravel comprising the lowest sedimentary unit of the Ringold Formation. It is confined below by basalt and above by the Ringold Lower Mud Unit. Groundwater in this aquifer flows generally west to east near the 200-West Area. In the central portion of the Hanford Site, flow in this confined aquifer appears to converge into the 200-East Area from the west, south, and east. Some groundwater discharges from the confined aquifer to the overlying unconfined aquifer, where the confining Ringold Lower 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 confined aquifer. During 2010, seven wells were sampled that were completed in the Ringold confined aquifer. No contaminants exceeded primary drinking water standards.

In 2010, 20 upper basalt-confined aquifer wells were sampled. Tritium continued to be detected at low levels in some wells, primarily in wells located in or near the 200-East Area.

8.7.5 Shoreline Groundwater Monitoring

DOE uses aquifer tubes to monitor groundwater near the Columbia River. An aquifer tube is a small-diameter, flexible tube with a screened end that is placed in the shallow aquifer and natural seep points or springs along the riverbank.

Concentrations of strontium-90 continued to exceed the 8-pCi/L (0.3-Bq/L) drinking water standard in aquifer tubes in the 100-B/C, 100-N, and 100-H Areas. In the 100-N Area, this high concentration represented a brief spike in response to the nearby injection of apatite-forming chemicals.

Tritium concentrations exceeded the 20,000-pCi/L (740-Bq/L) drinking water standard in one tube in the 100-B/C Area and one tube in the 100-D Area. The source is believed to be the 100-N Area plume. Tritium also exceeded the standard in springs and aquifer tubes at the Hanford town site in the 200-PO-1 Operable Unit.

Uranium concentrations exceeded the 30-µg/L drinking water standard in the 300 Area aquifer tubes and springs.

Hexavalent chromium concentrations in aquifer tubes or springs exceeded the 10-µg/L aquatic water quality criterion in the 100-B/C, 100-K, 100-D, 100-H, and 100-F Areas.

Nitrate concentrations exceeded the 45-mg/L drinking water standard in aquifer tubes in the 100-K, 100-N, and 100-H Areas. An aquifer tube in the southern 300 Area also exceeded the standard; the source of this nitrate is a plume from offsite sources.

Trichloroethene was detected in several aquifer tubes in the 300 Area and continued to exceed the 5-µg/L drinking water standard in some tubes monitoring a deep fine-grained unit.

River Sediment Porewater Sampling. DOE and Washington Closure Hanford, LLC completed an investigation of Hanford Site contaminant releases to the Columbia River in 2010. Samples were collected of porewater (i.e., groundwater upwelling beneath the river bottom into the space between rocks and sediment of the river bed), river sediment, river water, fish, and island soil. Porewater in some locations was contaminated with hexavalent chromium, strontium-90, tritium, or uranium. The results of this investigation are documented in *Field Summary Report for Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington* (WCH-387, Rev. 1).

8.7.6 Well Installation, Maintenance, and Decommissioning

In 2010, DOE installed 282 new wells, 26 new wells on the Central Plateau, and 256 new wells along the River Corridor.

DOE installs new wells when needed for monitoring or characterization, maintains wells to repair problems, and decommissions wells that are no longer needed by a program or that can no longer be used. DOE, EPA, and the Washington State Department of Ecology (the Tri-Party Agreement agencies) work together to develop an annual prioritized list of new wells needed to meet requirements of various groundwater monitoring regulations.

During 2010, 90 temporary characterization boreholes were installed around the Hanford Site to support various projects. The temporary boreholes are installed for subsurface characterization of radiological constituents, volatile organic elements (e.g., carbon tetrachloride), or hydrogeologic property determination (e.g., moisture, grain size distribution). While typically installed to characterize the vadose zone, boreholes can be drilled to groundwater to obtain a one-time sample and then be decommissioned.

Approximately 10,979 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. A total of 3,841 unique well identification numbers were documented as "in use" through December 2010. To date, 4,272 of these, or approximately 41% of the total, have been either administratively removed from the well inventory or decommissioned (sealed with grout). Wells are decommissioned when they are no longer needed; are in poor condition; are in the path of intended remediation or construction activities; or pose an environmental, safety, or public health hazard. DOE maintains a list of wells that are candidates for decommissioning, which must be reviewed and approved by potential well users before a well is decommissioned. During 2010, a total of 186 soil tube well installations were physically decommissioned.

Staff performed maintenance on 929 wells from January 1 through December 31, 2010. Surface maintenance included labeling wells, maintaining well caps, and repairing surface casing, wiring, or pump-discharge fittings. Subsurface tasks included repairing and replacing sampling pumps, performing camera surveys, retrieving pumps and equipment, and replacing discharge tubing.

8.8 Food and Farm Products Monitoring

BG Fritz

An assortment of food and farm products was collected at locations near the Hanford Site during 2010 (Figure 8.8.1). Samples analyzed to determine radiological contaminant concentrations were obtained from the following locations:

- Locations generally downwind (east and southeast) of the Hanford Site where airborne emissions or contaminated dust from the site would potentially be deposited
- Locations generally upwind of and distant from the Hanford Site to provide information about reference (background) contaminant levels
- Farms irrigated with water taken from the Columbia River downstream of the Hanford Site.

Results of sample analyses are used to assess the amounts of Hanford Site contaminants in food and farm products by 1) comparing analytical results obtained from similar samples collected from the same regions over long periods of time; 2) comparing analytical results from samples collected at downwind locations to results from samples obtained from generally upwind or distant locations; and 3) comparing analytical results from samples collected in areas irrigated with water withdrawn from the Columbia River downstream from the Hanford Site to analytical results from samples obtained from locations irrigated with water from other regional sources.

Radionuclide concentrations in most food and farm product samples in 2010 were below levels that could be detected by analytical laboratories. However, some contaminants that potentially could have originated from the Hanford Site (e.g., tritium and strontium-90) were found at low levels in some samples. These findings are presented in the following sections. Data for naturally occurring potassium-40 are included to show the amounts of this natural radioactive element in food products relative to concentrations of contaminants potentially from the Hanford Site. Radiological doses associated with possible site-produced contaminants are discussed in Section 8.12. 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).

8.8.1 Collection of Food and Farm Product Samples

Several food and farm product samples are collected each year on quarterly or annual schedules; others are sampled every 2 or 3 years. The rationale for sampling and analyzing some media more frequently than others is discussed in the *Hanford Site Environmental Monitoring Plan* (DOE/RL-91-50, Rev. 4). The types and numbers of samples scheduled for collection in any given year are documented in the annual Hanford Site environmental surveillance master sampling schedule (e.g., PNNL-20121). Typically, enough crop material for two samples is collected at each location. A portion of this material is submitted to a laboratory for analysis, and the remainder is archived at Pacific Northwest National Laboratory in case the analytical laboratory needs additional material for confirmatory or follow-up analyses. Table 8.8.1 shows the products, sampling locations, and analytes evaluated during 2010. Most samples were obtained from commercial producers; however, some were obtained from residential gardens because commercial growers could not be located.

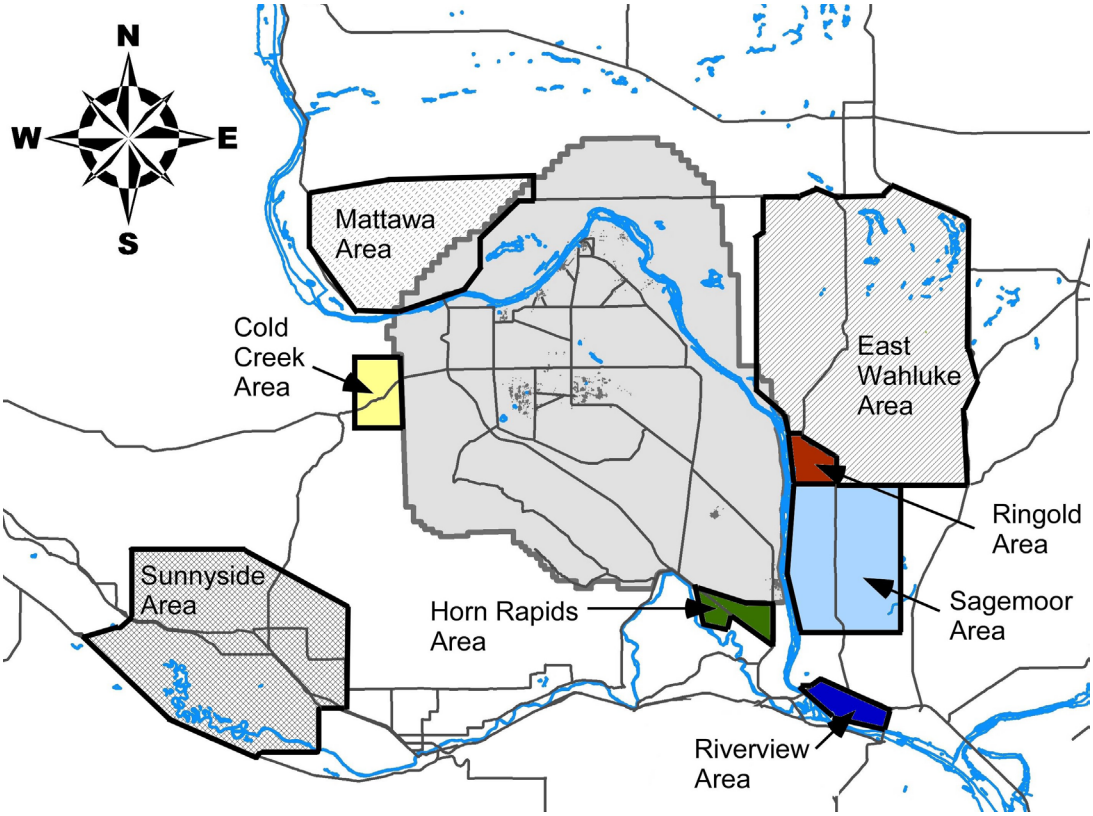

Figure 8.8.1. Food and Farm Product Sampling Locations, 2010

Table 8.8.1. Sampling Locations and Analytes for Food and Farm Products Sampled Around the Hanford Site in 2010

Product	Sampling Locations	Analytes
Grapes	Cold Creek, Riverview, Sagemoor, Sunnyside	Gamma, strontium-90
Leafy vegetables	Riverview, Sunnyside	Gamma, strontium-90
Milk	East Wahluke, Sagemoor, Sunnyside	Tritium, gamma, strontium-90
Potatoes	East Wahluke, Riverview, Sunnyside	Gamma, strontium-90
Tomatoes	Riverview, Sunnyside	Tritium, gamma, strontium-90

8.8.2 Milk

During 2010, 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 Hanford Site. If milk was obtained from more than one dairy within a sampling area, the milk samples were combined and the composite sample was analyzed. All samples were analyzed for gamma-emitting radionuclides, tritium, and strontium-90. Milk sampling was conducted because Hanford Site-produced radionuclides have the potential to move through the air-pasture-cow-milk or water-pasture-cow-milk food chains to humans. In recent years, levels of Hanford Site-produced radiological contaminants

in milk samples have diminished, and concentrations in samples obtained from dairies downwind of the site are now similar to levels measured in samples obtained from the dairy generally upwind of the site.

Tritium – Tritium was detected in all but one of the milk samples collected in 2010. Concentrations ranged from a maximum of 55 pCi/L (2.0 Bq/L) in a Sagemoor area sample to 1.9 pCi/L (0.07 Bq/L) in an East Wahluke area sample. Annual average concentrations for the three sampling areas were 44 pCi/L (1.6 Bq/L) for Sagemoor (n = 4); 22 pCi/L (0.81 Bq/L) for East Wahluke (n = 4); and 23 pCi/L (0.85 Bq/L) for Sunnyside (n = 4). These concentrations are consistent with concentrations historically measured in these areas. The unusual concentration reporting level for tritium in milk is an annual average of 54,000 pCi/L (2,000 Bq/L).

Potassium-40 – Potassium-40 was detected in all milk samples collected in 2010. Potassium-40 is a naturally occurring radionuclide found in soil and in fertilizers applied to soil. It is the predominant radionuclide in foods and human tissues (Eisenbud 1987). Concentrations ranged between 1,300 pCi/L (48 Bq/L) and 1,600 pCi/L (59 Bq/L).

Strontium-90 – Strontium-90 was not measured at detectable concentrations in any milk samples collected in 2010. The nominal analytical detection limit for strontium-90 in milk was 1.4 pCi/L (0.05 Bq/L), or 19 times below the unusual concentration reporting level for strontium-90 in milk (27 pCi/L [1.0 Bq/L]).

Cesium-137 – No manmade gamma emitters were detected in milk samples collected and analyzed in 2010.

8.8.3 Fruits and Vegetables

Samples of grapes, leafy vegetables (e.g., lettuce), potatoes, and tomatoes were collected from upwind and downwind sampling areas during the 2010 growing season (Figure 8.8.1). All samples were analyzed for gamma-emitting radionuclides and strontium-90. Tomato samples were also analyzed for tritium (Table 8.8.1). Naturally occurring potassium-40 was detected in all of the fruit and vegetable samples collected, and naturally occurring beryllium-7 was measured at a detectable concentration in the leafy vegetable sample collected from the Sunnyside area. Only one fruit or vegetable sample had a detectable concentration of any potential Hanford origin radionuclides. The leafy vegetable sample collected in the Riverview area had a measured strontium-90 concentration (0.015 pCi/g [0.56 mBq/g]) approximately 20 times lower than the unusual concentration reporting level for strontium-90 in leafy vegetables (0.27 pCi/g [10 mBq/g]). Radionuclide concentrations in other fruit and vegetable samples collected in 2010 were below analytical detection limits.

8.9 Soil Monitoring

The following sections summarize soil monitoring efforts conducted in 2010 at 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:

- Determine the effectiveness of effluent monitoring and controls within facilities
- Assess the adequacy of containment at waste-disposal sites
- Detect and monitor unusual conditions
- Provide 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 that document onsite and offsite levels of manmade radionuclides in Hanford Site soils. These data provide a baseline against which unplanned releases can be compared. For further information about the purpose of soil monitoring efforts and the programs that support them, see Section 8.0 and DOE/RL-91-50, Rev. 4.

8.9.1 Soil Monitoring Near Hanford Site Facilities and Operations

JW Wilde

Soil samples are collected near facilities and operations to evaluate long-term trends in the environmental accumulation of radioactive materials, and to detect potential migration and deposition of facility emissions. Soil contamination can occur as the result of direct deposition from facility emissions, resuspension and movement of contaminants from radiologically contaminated surface areas, uptake of contaminants into plants whose roots contact below-ground waste, or translocation of buried waste by intruding animals.

8.9.1.1 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 2010 are summarized in Table 8.9.1. Only radionuclides with concentrations consistently above analytical detection

Table 8.9.1. Number and Locations of Soil Samples Collected Near Hanford Site Facilities and Operations, 2010

Number of Samples	Operational Area									
	100-N	100-K	100-F	100-H	200-West	200-East	600	300	400	ERDF
85	3	2	6	4	24[a]	16[a]	16[a]	12[a]	1	1

(a) Number of samples includes one or more replicate samples.
ERDF = Environmental Restoration Disposal Facility (200-West Area).

limits are discussed in this section. A comprehensive presentation of the analytical data from these samples is available upon request (see Preface for contact information).

Each 1-kilogram (2.2-pound) soil sample represents a composite of five plugs of soil, each 2.5 centimeters (1 inch) deep and 10 centimeters (4 inches) in diameter. Soil samples were sieved in the field to remove rocks and plant debris, and then dried in 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. 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 assure 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 ensures 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 list of these values is provided in Table 8.9.2.

8.9.1.2 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 2010 were higher than the concentrations in samples collected farther away, including concentrations measured offsite. The data also show, as expected, that concentrations of certain radionuclides in 2010 were higher within different operational areas when compared to concentrations measured in distant communities in previous years. Generally, the predominant radionuclides detected were activation and fission products in the 100 Areas, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas.

Cesium-134, cesium-137, plutonium-239/240, and uranium were detected consistently in the samples taken in 2010. Concentrations of these radionuclides were elevated near and within facility boundaries when compared to historical concentrations measured offsite at distant communities. Figure 8.9.1 shows the average concentrations of selected radionuclides in soil samples collected during 2010 and the preceding 4 years. Some individual levels demonstrate a high degree of variability, although overall trends are stable.

Table 8.9.3 provides a summary of selected analytical results for near-facility soil samples collected and analyzed in 2010. The average and maximum results are reported for six operational areas, along with comparative data for the

Table 8.9.2. Accessible Soil Concentration Limits (pCi/g[a] dry wt.) for Selected Radionuclides

	Cobalt-60	Strontium-90	Cesium-137	Uranium-234	Uranium-235	Uranium-238	Plutonium-239/240
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.

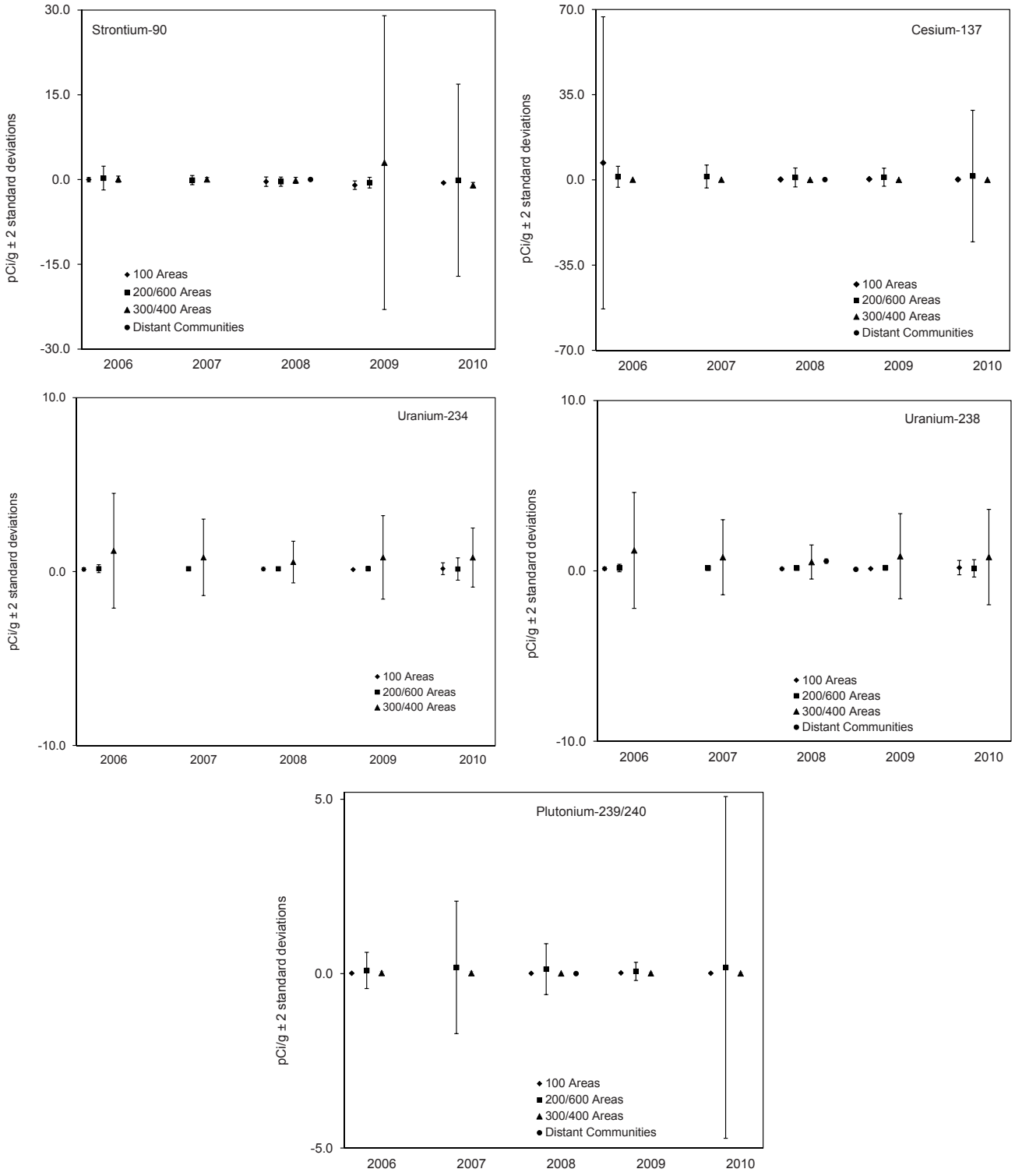

Figure 8.9.1. Average Concentrations of Selected Radionuclides in Soil Samples Collected at the Hanford Site Near Facilities and Operations, 2006 Through 2010, and Those Collected in Distant Communities, 2008. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

Table 8.9.3. Concentrations of Selected Radionuclides (pCi/g dry wt.)[a] in Near-Facility Soil Samples, 2010 Compared to Previous Years

		2010				2005-2009			
		Number of				Number of			
Radionuclide	Hanford Site Area	Samples	Detections[b]	Average[c]	Maximum[d]	Samples	Detections[b]	Average[c]	Maximum[d]
Cobalt-60	100	15	1	8.0E-03 ± 5.0E-02	9.8E-02 ± 1.9E-02	67	15	2.5E-01 ± 4.0E+00	1.6E+01 ± 1.5E+00
	200-East	16	0	-2.5E-03 ± 1.1E-02	7.7E-03 ± 1.2E-02[e]	73	0	3.0E-04 ± 7.4E-03	1.0E-02 ± 7.8E-03[e]
	200-West[f]	25	0	-1.1E-03 ± 9.6E-03	7.3E-03 ± 1.3E-02[e]	139	1	4.4E-04 ± 8.7E-03	1.1E-02 ± 9.6E-03[e]
	300	12	0	1.9E-03 ± 7.4E-03	9.7E-03 ± 8.5E-03[e]	77	0	-6.0E-04 ± 7.3E-03	8.3E-03 ± 6.3E-03[e]
	400	1	0	1.7E-03[g]	1.7E-03 ± 1.2E-02[e]	5	0	7.4E-04 ± 5.9E-03	5.2E-03 ± 6.9E-03[e]
	600	16	0	1.6E-03 ± 1.3E-02	1.4E-02 ± 1.3E-02[e]	86	0	-1.6E-02 ± 2.8E-01	1.2E-02 ± 1.3E-02[e]
Strontium-90	100	15	0	-5.8E-01 ± 8.8E-01	8.4E-02 ± 7.1E-01[e]	67	3	-1.7E-01 ± 8.0E-01	8.3E-01 ± 2.9E-01
	200-East	16	1	5.7E-01 ± 8.5E+00	1.7E+01 ± 2.2E+00	73	5	-1.8E-01 ± 9.9E-01	1.3E+00 ± 3.2E-01
	200-West[f]	25	2	-2.3E-01 ±5.0E+00	1.1E+01 ± 1.4E+00	139	14	-1.2E-01 ± 1.7E+00	8.1E+00 ± 1.6E+00
	300	12	0	-1.0E+00 ± 6.3E-01	-4.8E-01 ± 6.0E-01[e]	77	5	6.3E-01 ± 1.2E+01	5.5E+01 ± 7.1E+00
	400	1	0	-1.30E+00[g]	-1.3E+00 ± 1.3E+00[e]	5	0	2.0E-02 ± 3.6E-01	2.8E-01 ± 2.6E-01[e]
	600	16	0	-6.4E-01 ± 4.5E-01	-1.8E-01 ± 4.0E-01[e]	86	5	-1.6E-01 ± 7.6E-01	1.2E+00 ± 5.0E-01
Cesium-137	100	15	14	1.9E-01 ± 3.1E-01	5.8E-01 ± 7.5E-02	67	66	2.5E+00 ± 3.5E+01	1.4E+02 ± 2.6E+01
	200-East	16	16	1.4E+00 ± 3.8E+00	6.5E+00 ± 8.0E-01	73	73	1.8E+00 ± 6.4E+00	1.4E+01 ± 2.2E+00
	200-West[f]	25	25	1.4E+00 ± 3.5E+00	6.5E+00 ± 8.6E-01	139	137	1.5E+00 ± 4.1E+00	1.4E+01 ± 2.3E+00
	300	12	10	6.6E-02 ± 8.8E-02	1.4E-01 ± 2.4E-02	77	65	6.9E-02 ± 1.5E-01	3.6E-01 ± 6.4E-02
	400	1	1	3.9E-02[g]	3.9E-02 ± 2.5E-02	5	5	2.4E-02 ± 9.8E-03	3.2E-02 ± 1.1E-02
	600	16	16	2.0E+00 ± 1.3E+01	2.7E+01 ± 3.6E+00	86	81	1.5E+00 ± 2.0E+01	9.4E+01 ± 1.7E+01
Thorium-228	100	8	8	6.2E-01 ± 6.9E-01	1.2E+00 ± 4.9E-01	0	0	NA	NA
Thorium-230	100	8	8	8.6E-01 ± 1.9E+00	3.2E+00 ± 8.9E-01	0	0	NA	NA
Thorium-232	100	8	8	6.9E-01 ± 1.0E+00	1.7E+00 ± 6.4E-01	0	0	NA	NA
Uranium-234	100	15	15	1.7E-01 ± 1.5E-01	3.4E-01 ± 1.1E-01	66	66	1.3E-01 ± 8.3E-02	3.2E-01 ± 9.9E-02
	200-East	16	16	1.4E-01 ± 7.6E-02	2.1E-01 ± 6.9E-02	73	73	1.7E-01 ± 1.8E-01	8.4E-01 ± 2.8E-01
	200-West[f]	25	25	1.6E-01 ± 6.0E-02	2.1E-01 ± 6.9E-02	139	139	1.7E-01 ± 1.4E-01	5.1E-01 ± 1.4E-01
	300	12	12	8.6E-01 ± 1.7E+00	2.8E+00 ± 7.6E-01	77	77	8.4E-01 ± 2.4E+00	5.3E+00 ± 1.4E+00
	400	1	1	1.2E-01[g]	1.2E-01 ± 4.3E-02	5	5	1.7E-01 ± 1.1E-01	2.4E-01 ± 7.4E-02
	600	16	16	1.5E-01 ± 2.6E-01	6.4E-01 ± 1.8E-01	86	86	1.7E-01 ± 9.8E-02	3.2E-01 ± 9.6E-02
Uranium-235	100	15	6	1.4E-02 ± 1.9E-02	3.4E-02 ± 1.9E-02	64	41	1.2E-02 ± 1.2E-02	2.5E-02 ± 1.7E-02
	200-East	16	12	1.5E-02 ± 1.5E-02	3.0E-02 ± 1.8E-02	73	39	1.3E-02 ± 1.3E-02	3.3E-02 ± 1.9E-02
	200-West[f]	25	15	1.6E-02 ± 1.6E-02	3.6E-02 ± 2.2E-02	139	76	1.5E-02 ± 2.1E-02	5.4E-02 ± 2.4E-02
	300	12	10	5.7E-02 ± 9.0E-02	1.5E-01 ± 5.7E-02	77	59	5.6E-02 ± 1.5E-01	3.5E-01 ± 1.0E-01
	400	1	1	1.5E-02[g]	1.5E-02 ± 1.2E-02	5	2	1.5E-02 ± 1.6E-02	2.9E-02 ± 1.8E-02
	600	16	10	1.7E-02 ± 2.5E-02	6.1E-02 ± 2.7E-02	86	43	1.4E-02 ± 1.7E-02	4.5E-02 ± 2.3E-02

Table 8.9.3. (contd)

Radionuclide	Hanford Site Area	2010 Number of Samples	2010 Number of Detections[b]	2010 Average[c]	2010 Maximum[d]	2005-2009 Number of Samples	2005-2009 Number of Detections[b]	2005-2009 Average[c]	2005-2009 Maximum[d]
Plutonium-238	100	15	1	6.3E-03 ± 3.8E-02	4.8E-02 ± 2.9E-02	67	0	-5.9E-04 ± 3.6E-02	3.9E-02 ± 3.9E-02[e]
	200-East	16	0	3.6E-03 ± 2.6E-02	5.1E-02 ± 4.1E-02[e]	73	1	3.9E-03 ± 4.4E-02	1.2E-01 ± 5.5E-02
	200-West[f]	25	2	6.0E-03 ± 4.5E-02	8.0E-02 ± 4.7E-02	139	8	1.3E-02 ± 5.9E-02	2.1E-01 ± 5.9E-02
	300	12	0	1.8E-03 ± 3.0E-02	2.5E-02 ± 3.4E-02[e]	77	2	4.0E-03 ± 4.3E-02	1.6E-01 ± 6.1E-02
	400	1	0	1.7E-03[g]	1.7E-03 ± 7.6E-03[e]	5	0	-6.0E-04 ± 2.7E-02	1.1E-02 ± 3.8E-02[e]
	600	16	2	2.8E-02 ± 1.8E-01	3.7E-01 ± 1.1E-01	86	2	4.3E-03 ± 2.7E-02	7.6E-02 ± 3.9E-02
Uranium-238	100	15	15	1.9E-01 ± 1.5E-01	4.2E-01 ± 1.2E-01	67	67	1.3E-01 ± 7.3E-02	2.9E-01 ± 9.3E-02
	200-East	16	16	1.3E-01 ± 5.9E-02	1.9E-01 ± 6.3E-02	73	73	1.7E-01 ± 1.7E-01	7.7E-01 ± 2.6E-01
	200-West[f]	25	25	1.5E-01 ± 7.8E-02	2.5E-01 ± 8.0E-02	139	139	1.6E-01 ± 1.5E-01	5.3E-01 ± 1.5E-01
	300	12	12	8.6E-01 ± 1.7E+00	2.8E+00 ± 7.6E-01	77	77	8.4E-01 ± 2.4E+00	5.3E+00 ± 1.4E+00
	400	1	1	1.6E-01[g]	1.6E-01 ± 5.4E-02	5	5	1.6E-01 ± 6.9E-02	2.1E-01 ± 6.9E-02
	600	16	16	1.5E-01 ± 1.9E-01	5.1E-01 ± 1.5E-01	86	86	1.6E-01 ± 9.0E-02	2.9E-01 ± 8.7E-02
Plutonium-239/240	100	15	7	1.4E-02 ± 1.5E-02	2.5E-02 ± 1.7E-02	67	15	1.1E-02 ± 3.0E-02	1.1E-01 ± 4.1E-02
	200-East	16	6	1.1E-02 ± 2.3E-02	5.1E-02 ± 2.4E-02	73	21	1.2E-02 ± 3.0E-02	9.7E-02 ± 3.9E-02
	200-West[f]	25	21	1.9E-01 ± 7.9E-01	1.5E+00 ± 3.3E-01	139	103	1.9E-01 ± 1.4E+00	7.3E+00 ± 1.9E+00
	300	12	3	1.1E-02 ± 1.7E-02	2.7E-02 ± 1.5E-02	77	26	1.5E-02 ± 4.0E-02	7.6E-02 ± 2.8E-02
	400	1	0	-1.7E-03[g]	-1.7E-03 ± 3.4E-03[e]	5	0	2.7E-03 ± 2.4E-03	4.7E-03 ± 9.5E-03[e]
	600	16	9	3.2E-01 ± 2.4E+00	4.9E+00 ± 1.3E+00	86	47	5.2E-02 ± 2.2E-01	7.0E-01 ± 2.0E-01

(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.
NA = Not applicable.

preceding 5 years. Complete lists of radionuclide concentrations for all soil samples collected during 2010, as well as sampling location maps, are available upon request (see Preface).

Soil samples collected in 2010 at locations in the 100 Areas, 200-East, 200-West, 400, and 600 Areas were comparable to previous years. Soil samples collected in the 300 Area showed concentrations of uranium-234 and uranium-238 that were comparable to historical data but remained higher than those measured in the 200 Areas. The higher uranium levels in the 300 Area were expected because of uranium releases to the environment during past fuel-fabrication operations in the 300 Area. Plutonium-238 and plutonium-239/240 were found at higher levels in a small number of soil samples in the 200, 600, and 300 Areas. Uranium isotopes were also elevated in a small number of samples from the 200-West and 300 Areas.

Various non-routine soil samples from the 100 Areas were taken in support of environmental restoration contractor projects in 2010. Six soil samples were taken from three locations in the 100-F Area; four samples were collected at the field remediation project in the 100-H Area; two from the 100-K Area; three from the 100-N Area; and one from the Environmental Restoration Disposal Facility. Analytical results from each of these locations were comparable to those observed at other near-facility sampling locations at the Hanford Site. Table 8.9.4 provides a summary of selected analytical results for samples from these sites. A complete list of the data is available upon request (see Preface).

8.9.1.3 Investigations of Radioactive Contamination in Soil Near Hanford Site Facilities and Operations

SM McKinney, MC Dorsey, RC Roos, and AR Johnson

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.

Twenty-two instances of radiological contamination in soil samples were collected during investigations in 2010. Of the 22, 10 were identified as speck contamination, and 17 of the 22 were cleaned up and disposed of onsite in licensed burial grounds; the remaining 5 were controlled in a posted area. None of the soil samples was submitted for radioisotopic analysis. The number of soil investigation contamination incidents and range of radiation dose levels in 2010 were generally within historical values (WHC-MR-0418).

Table 8.9.5 summarizes the number and general locations of soil contamination incidents investigated during 2010. Table 8.9.6 provides the number of contamination incidents investigated in 2010 and during the previous 11 years.

8.9.2 Soil Monitoring at Hanford Site-Wide and Offsite Locations

BG Fritz

Soil monitoring provides information about long-term contamination trends and baseline environmental radionuclide activities at undisturbed locations both on and off the Hanford Site (DOE/RL-91-50, Rev 4.). Soil samples, collected on and around the Hanford Site for more than 50 years, have been added to a large database documenting onsite and offsite levels of manmade radionuclides in soil at specific locations. This database contains baseline data against which data from unplanned contaminant releases from the Hanford Site can be compared. Soil samples are collected every 3 to 5 years, and were last collected in 2008 (PNNL-18427).

Table 8.9.4. Radionuclide Concentrations (pCi/g[a] dry wt.)[b] in Environmental Restoration Contractor Field Remediation Projects' Soil Samples, 2010

Hanford Site Area	Sample Location[c]	Sample Date	Cobalt-60	Strontium-90	Cesium-137	Uranium-234	Uranium-238	Plutonium-239/240
ERDF	D146	06/14/10	1.1E-03 ± 5.4E-03	-5.0E-01 ± 7.0E-01	5.0E-02 ± 1.4E-02	1.9E-01 ± 6.3E-02	2.2E-01 ± 7.0E-02	-2.0E-03 ± 6.9E-03
100-F	D154	09/13/10	-1.4E-03 ± 6.9E-03	-8.5E-01 ± 8.5E-01	1.7E-01 ± 2.5E-02	3.3E-01 ± 9.9E-02	4.2E-01 ± 1.2E-01	2.4E-02 ± 2.1E-02
	D154	12/09/10	-1.2E-03 ± 7.4E-03	-6.4E-01 ± 7.0E-01	4.0E-01 ± 5.2E-02	3.4E-01 ± 1.1E-01	2.8E-01 ± 8.7E-02	1.6E-02 ± 1.3E-02
	D155	09/13/10	-2.3E-03 ± 6.2E-03	-1.7E-01 ± 4.9E-01	1.7E-01 ± 2.5E-02	2.1E-01 ± 6.7E-02	1.9E-01 ± 6.3E-02	2.3E-03 ± 2.3E-03
	D155	12/09/10	6.8E-04 ± 6.2E-03	-1.4E+00 ± 1.4E+00	2.0E-01 ± 3.0E-02	9.5E-02 ± 3.8E-02	1.3E-01 ± 4.7E-02	1.2E-02 ± 1.1E-02
	D170	09/13/10	-6.8E-04 ± 6.8E-02	-5.8E-01 ± 5.8E-01	6.3E-02 ± 1.3E-02	1.6E-01 ± 5.4E-02	2.0E-01 ± 6.6E-02	8.1E-03 ± 1.5E-02
	D170	12/09/10	-2.7E-03 ± 6.8E-03	-1.2E+00 ± 1.2E+00	8.3E-02 ± 1.7E-02	1.9E-01 ± 6.3E-02	1.3E-01 ± 4.5E-02	2.7E-03 ± 2.7E-03
100-H	D152	01/19/10	-4.6E-03 ± 1.3E-02	-3.4E-01 ± 4.5E-01	4.1E-01 ± 6.2E-02	1.1E-01 ± 4.3E-02	1.1E-01 ± 4.4E-02	2.5E-02 ± 1.7E-02
	D176	01/19/10	1.1E-02 ± 9.5E-03	-1.3E-01 ± 4.8E-01	2.7E-01 ± 4.0E-02	1.1E-01 ± 4.2E-02	1.4E-01 ± 5.0E-02	1.7E-02 ± 1.7E-02
	D177	01/19/10	5.6E-03 ± 5.9E-03	-4.6E-01 ± 5.0E-01	8.5E-03 ± 6.8E-03	2.4E-01 ± 7.7E-02	2.4E-01 ± 7.9E-02	6.7E-03 ± 1.0E-02
	D178	01/19/10	-1.0E-02 ± 1.1E-02	5.9E-02 ± 4.9E-01	6.7E-02 ± 2.1E-02	1.2E-01 ± 4.6E-02	1.3E-01 ± 4.9E-02	2.2E-03 ± 2.2E-03
100-K	D166	12/08/10	9.2E-03 ± 9.1E-03	-9.1E-01 ± 9.1E-01	2.1E-01 ± 3.1E-02	1.5E-01 ± 5.3E-02	2.0E-01 ± 6.6E-02	1.5E-02 ± 1.2E-02
	D167	12/08/10	1.2E-03 ± 9.4E-03	8.4E-02 ± 7.1E-01	5.8E-01 ± 7.5E-02	1.7E-01 ± 5.8E-02	1.7E-01 ± 5.8E-02	1.8E-02 ± 1.4E-02
100-N	D156	07/26/10	8.6E-03 ± 9.5E-03	-1.0E+00 ± 1.0E+00	7.9E-02 ± 2.5E-02	1.2E-01 ± 4.3E-02	1.6E-01 ± 5.4E-02	2.4E-02 ± 1.6E-02
	D158	07/26/10	9.8E-02 ± 1.9E-02	-3.0E-01 ± 5.9E-01	2.0E-01 ± 3.7E-02	1.1E-01 ± 4.1E-02	1.5E-01 ± 5.1E-02	1.9E-02 ± 1.4E-02
	D183	07/26/10	8.5E-03 ± 5.9E-03	-8.8E-01 ± 8.8E-01	1.2E-02 ± 6.8E-03	1.3E-01 ± 4.5E-02	1.4E-01 ± 4.8E-02	1.3E-02 ± 1.2E-02
Accessible soil concentration[d]			7.1	2,800	30	630	370	190

(a) 1 pCi = 0.037 Bq.
(b) ± total analytical uncertainty.
(c) Sampling location code.
(d) Hanford Site soil that is not behind security fences (WHC-SD-EN-TI-070).
ERDF = Environmental Restoration Disposal Facility (200-West Area).

Table 8.9.5. Number and Locations of Soil Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 2010

Locations	Number of Incidents
200-East Area	
Tank farms	5
Burial grounds	2
Cribs, ponds, and ditches	1
Fence lines	0
Roads and railroads	0
Unplanned release sites	0
Underground pipelines	1
Miscellaneous	0
200-West Area	
Tank farms	3
Burial grounds	0
Cribs, ponds, and ditches	1
Fence lines	0
Roads and railroads	0
Unplanned release sites	2
Underground pipelines	0
Miscellaneous	0
Cross-site transfer line	1
200-BC cribs and trenches	0
200-North Area	0
100 Areas	4
300 Area	0
400 Area	0
600 Area	2
Former 1100 Area	0
Total	**22**

Table 8.9.6. Annual Number of Soil Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 1999 Through 2010

Year	Number of Incidents	Year	Number of Incidents
1999	42	2005	20
2000	25	2006	25
2001	20	2007	17
2002	22	2008	16
2003	30	2009	28
2004	19	2010	22

8.10 Contaminant Monitoring of Plant and Animal Communities

Vegetation, fish, and wildlife monitoring conducted on and around the Hanford Site in 2010 are summarized in the following sections. Included are discussions of surveys and monitoring of Hanford Site plant populations, monitoring contaminants in perennial vegetation growing near facilities and operations, control of contaminated or unwanted vegetation, and fish and wildlife monitoring.

Plant populations and habitats that occur on the Hanford Site are surveyed and monitored to assess the abundance, vigor or condition, and distribution of populations and species. These data can be integrated with contaminant monitoring results and used to help characterize potential risks or impacts to biota. Vegetation near onsite facilities and operations is monitored for radiation to determine the effectiveness of effluent monitoring and controls within facilities, assess the adequacy of containment at waste-disposal sites, and detect and monitor unusual conditions. Site-wide and offsite vegetation samples are analyzed for information about 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 remove 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 8.0 in this report or DOE/RL-91-50, Rev. 4.

Fish and wildlife on and around the Hanford Site are monitored for site-produced contaminants. Monitoring various biota for uptake and exposure to radionuclides both near and distant from Hanford Site operations continues to assure that consumption of fish and wildlife obtained from the site environs does not pose a threat to humans. Monitoring also provides long-term contamination trends in selected ecosystem components. Fish and wildlife sampled and analyzed during 2010 for radioactive constituents included common carp (*Cyprinus carpio*), Nuttall's cottontail (*Sylvilagus nuttallii*), California quail (*Callipepla californica*), mule deer (*Odocoileus hemionus*), black-tailed deer (*Odocoileus hemionus columbianus*), and Rocky Mountain elk (*Cervus elaphus*). The monitored species provide a potential pathway for offsite human consumption.

8.10.1 Vegetation Monitoring Near Hanford Site Facilities and Operations

JW Wilde

Vegetation samples were collected on or adjacent to waste-disposal sites and from locations downwind and near or within the boundaries of operating facilities and remedial-action sites. Samples were collected to evaluate long-term trends in environmental accumulation and potential migration of radioactive material. Contamination in vegetation can occur as the result of surface deposition of radioactive materials from other radiologically contaminated sources or by absorption of radionuclides by the roots of vegetation growing on or near former waste-disposal sites.

The number and location of vegetation samples collected near facilities and operations during 2010 are summarized in Table 8.10.1. 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 is available upon request (see Preface for contact information).

Table 8.10.1. Number and Locations of Vegetation Samples Collected Near Hanford Site Facilities and Operations in 2010

Number of Samples	Operational Area					
	100-N	200-East	200-West	300	400	600
62	3	10	23[(a)]	10[(a)]	1	15[(a)]

(a) Number of samples includes one or more replicate samples.

8.10.1.1 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 2008 by Pacific Northwest National Laboratory personnel at offsite sampling locations in Yakima, Benton, and Franklin Counties (PNNL-18427). 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.

8.10.1.2 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 2010 were higher than concentrations in samples collected farther away, including concentrations measured offsite. Generally, the predominant radionuclides were activation and fission products in the 100 Areas, fission products in the 200 and 600 Areas, and uranium in the 300 and 400 Areas.

Uranium was detected consistently, and strontium-90, cesium-137, plutonium-238, and plutonium-239/240 were detected occasionally in samples taken in 2010. Concentrations of these radionuclides were elevated near and within facility boundaries compared to historic concentrations measured at distant communities. Figure 8.10.1 shows the average concentrations of selected radionuclides in vegetation samples collected near Hanford Site facilities and operations during 2010 and the preceding 4 years, as well as results for 2008 at distant communities. The results demonstrate a high degree of variability in concentrations.

Table 8.10.2 provides a summary of selected radionuclides detected in vegetation samples collected and analyzed in 2010 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 2010 radionuclide concentrations, as well as sampling location maps, are available upon request.

Vegetation samples collected in 2010 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-235 that were comparable to 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 that area. Plutonium-238 and plutonium-239/240 were found at higher levels in a small number of vegetation samples in the 200-West, 600,

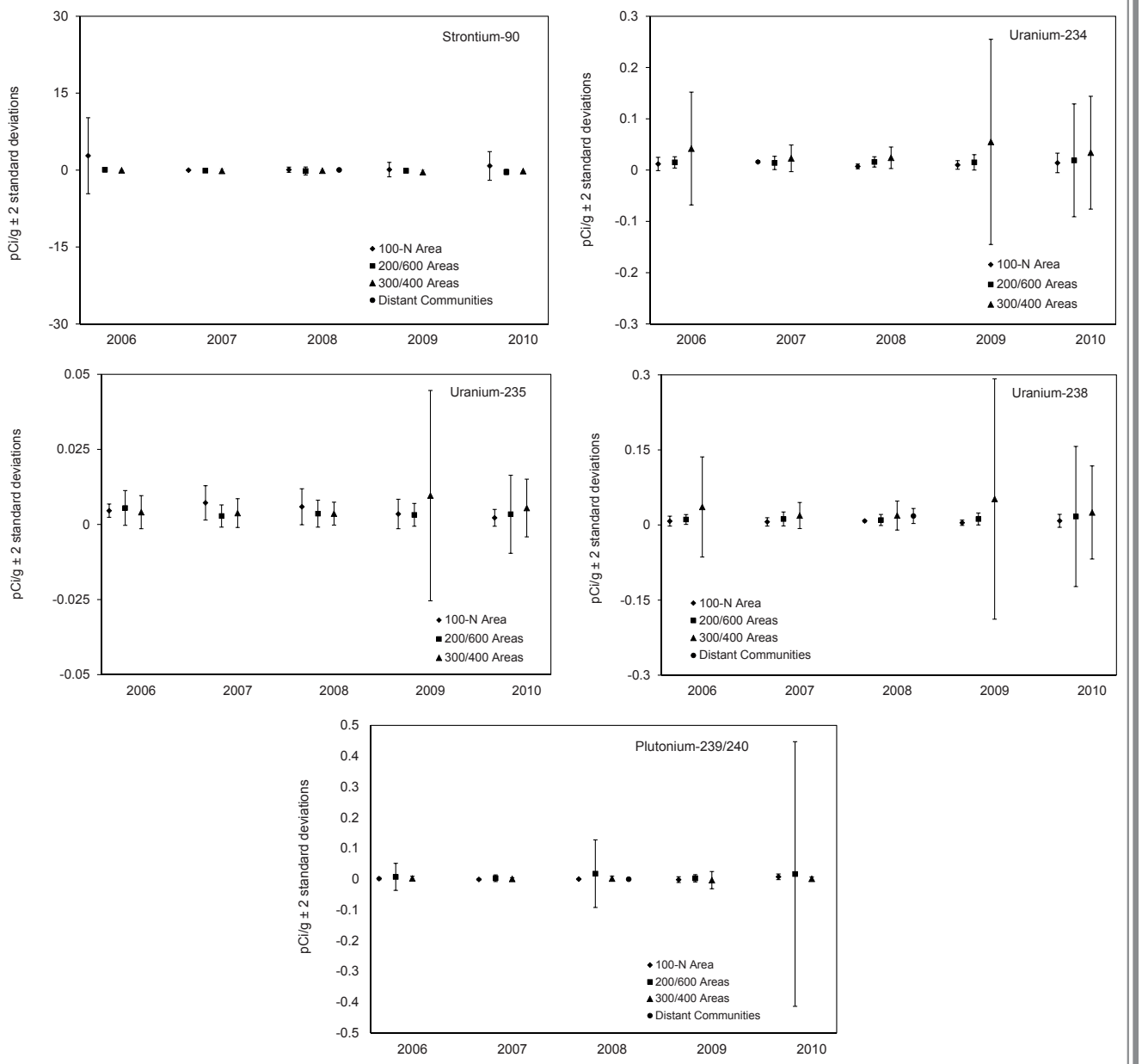

Figure 8.10.1. Average Concentrations of Selected Radionuclides in Vegetation Samples Collected Near Hanford Site Facilities and Operations, 2006 Through 2010, and Those Collected in Distant Communities, 2008. Radionuclide concentrations below analytical detection limits are not shown. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

Table 8.10.2. Concentrations of Selected Radionuclides (pCi/g dry wt.)[a] in Near-Facility Vegetation Samples, 2010 Compared to Previous Years

		2010				2005-2009			
		Number of				Number of			
Radionuclide	Hanford Site Area	Samples	Detections[b]	Average[c]	Maximum[d]	Samples	Detections[b]	Average[c]	Maximum[d]
Cobalt-60	100-N	3	0	2.9E-02 ± 1.8E-02	3.6E-02 ± 8.8E-02[e]	17	0	7.9E-03 ± 5.6E-02	7.9E-02 ± 8.9E-02[e]
	200-East	10	0	-1.3E-02 ± 8.1E-02	4.8E-02 ± 8.1E-02[e]	47	0	-7.2E-03 ± 6.4E-02	5.2E-02 ± 7.4E-02[e]
	200-West	23	0	-2.4E-03 ± 6.3E-02	5.4E-02 ± 8.6E-02[e]	110	0	-2.3E-03 ± 7.7E-02	1.1E-01 ± 9.5E-02[e]
	300	10	0	5.2E-03 ± 9.1E-02	7.4E-02 ± 1.0E-01[e]	72	0	-1.9E-02 ± 1.5E-01	7.5E-02 ± 5.8E-02[e]
	400	1	0	-4.10E-02[f]	-4.1E-02 ± 6.3E-02[e]	5	0	1.0E-02 ± 2.4E-02	2.5E-02 ± 3.8E-02[e]
	600	15	1	1.4E-02 ± 1.5E-01	2.6E-01 ± 1.3E-01	79	0	-4.2E-03 ± 1.1E-01	9.5E-02 ± 7.7E-02[e]
Strontium-90	100-N	3	1	8.1E-01 ± 2.8E+00	2.8E+00 ± 5.6E-01	17	5	2.0E+00 ± 1.1E+01	2.2E+01 ± 3.3E+00
	200-East	10	2	-5.3E-01 ± 1.8E+00	5.2E-01 ± 3.5E-01	47	9	2.1E-02 ± 5.5E-01	1.3E+00 ± 2.6E-01
	200-West	23	0	-2.6E-01 ± 3.7E-01	4.2E-02 ± 2.6E-01[e]	110	5	-7.0E-02 ± 9.6E-01	3.3E+00 ± 6.6E-01
	300	10	0	-2.0E-01 ± 2.5E-01	6.9E-02 ± 2.4E-01[e]	72	0	-1.6E-01 ± 3.9E-01	1.7E-01 ± 2.0E-01[e]
	400	1	0	-2.6E-01[f]	-2.6E-01 ± 2.6E-01[e]	5	0	-2.0E-04 ± 3.5E-01	1.7E-01 ± 1.4E-01[e]
	600	15	0	-4.3E-01 ± 1.1E+00	1.7E-01 ± 3.7E-01[e]	79	5	-2.1E-02 ± 3.8E-01	6.0E-01 ± 2.4E-01
Cesium-137	100-N	3	0	3.0E-02 ± 8.3E-02	8.7E-02 ± 8.5E-02[e]	17	0	-4.3E-03 ± 6.9E-02	6.2E-02 ± 4.7E-02[e]
	200-East	10	2	8.9E-02 ± 2.0E-01	3.3E-01 ± 1.4E-01	47	8	3.1E-02 ± 1.5E-01	3.0E-01 ± 9.7E-02
	200-West	23	3	8.0E-02 ± 1.3E-01	2.2E-01 ± 1.4E-01	110	16	4.6E-02 ± 2.5E-01	1.2E+00 ± 2.1E+00[e]
	300	10	0	3.3E-03 ± 5.5E-02	6.7E-02 ± 8.2E-02[e]	72	0	-2.1E-02 ± 2.8E-01	7.2E-02 ± 8.5E-02[e]
	400	1	0	2.30E-02[f]	2.3E-02 ± 9.2E-02[e]	5	0	-2.8E-02 ± 4.0E-02	5.8E-04 ± 5.8E-03[e]
	600	15	2	2.7E-02 ± 9.0E-02	1.4E-01 ± 6.3E-02	79	4	3.6E-02 ± 4.1E-01	1.7E+00 ± 2.2E+00[e]
Uranium-234	100-N	3	3	1.4E-02 ± 9.6E-03	1.9E-02 ± 9.7E-03	17	9	9.7E-03 ± 1.1E-02	2.1E-02 ± 1.1E-02
	200-East	10	10	1.6E-02 ± 8.4E-03	2.4E-02 ± 1.1E-02	47	41	1.4E-02 ± 1.1E-02	2.6E-02 ± 1.2E-02
	200-West	23	23	2.3E-02 ± 3.9E-02	1.1E-01 ± 3.5E-02	110	100	1.5E-02 ± 1.3E-02	4.1E-02 ± 1.6E-02
	300	10	9	3.6E-02 ± 7.0E-02	1.1E-01 ± 3.5E-02	72	66	3.7E-02 ± 1.2E-01	4.4E-01 ± 1.8E-01
	400	1	0	1.10E-02[f]	1.1E-02 ± 9.5E-03[e]	5	3	1.1E-02 ± 1.1E-02	2.0E-02 ± 1.0E-02
	600	15	11	1.7E-02 ± 3.7E-02	8.4E-02 ± 2.8E-02	79	63	1.3E-02 ± 1.2E-02	3.0E-02 ± 1.3E-02
Uranium-235	100-N	3	0	2.2E-03 ± 9.0E-04	2.8E-03 ± 3.3E-03[e]	17	6	4.6E-03 ± 5.6E-03	1.0E-02 ± 7.5E-03
	200-East	10	0	3.7E-03 ± 4.4E-03	9.0E-03 ± 9.0E-02[e]	47	12	3.9E-03 ± 5.5E-03	1.6E-02 ± 9.3E-03
	200-West	23	9	3.7E-03 ± 6.1E-03	1.3E-02 ± 7.9E-03	110	25	3.5E-03 ± 4.5E-03	8.8E-03 ± 6.3E-03
	300	10	5	5.5E-03 ± 4.7E-03	9.6E-03 ± 6.5E-03	72	15	5.2E-03 ± 1.8E-02	7.9E-02 ± 7.1E-02[e]
	400	1	1	6.1E-03[f]	6.1E-03 ± 5.2E-03	5	0	3.0E-03 ± 1.5E-03	3.9E-03 ± 4.9E-03[e]
	600	15	1	2.8E-03 ± 5.3E-03	1.1E-02 ± 7.7E-03	79	21	4.1E-03 ± 5.5E-03	1.3E-02 ± 8.4E-03

Table 8.10.2. (contd)

Radionuclide	Hanford Site Area	2010 Number of Samples	2010 Number of Detections[b]	2010 Average[c]	2010 Maximum[d]	2005-2009 Number of Samples	2005-2009 Number of Detections[b]	2005-2009 Average[c]	2005-2009 Maximum[d]
Plutonium-238	100-N	3	0	-4.0E-03 ± 2.8E-02	6.4E-03 ± 1.4E-02[e]	17	0	1.3E-03 ± 1.9E-02	1.9E-02 ± 1.8E-02[e]
	200-East	10	0	2.6E-03 ± 1.2E-02	1.5E-02 ± 1.8E-02[e]	47	2	6.3E-04 ± 1.9E-02	3.5E-02 ± 1.4E-02
	200-West	23	1	-8.1E-04 ± 1.4E-02	1.2E-02 ± 2.4E-02[e]	110	6	1.6E-03 ± 1.8E-02	6.4E-02 ± 2.9E-02
	300	10	0	1.4E-04 ± 9.5E-03	6.9E-03 ± 1.7E-02[e]	72	5	3.4E-03 ± 3.6E-02	8.7E-02 ± 4.7E-02
	400	1	0	-5.70E-03[f]	-5.7E-03 ± 1.3E-02[e]	5	0	4.6E-03 ± 1.2E-02	1.3E-02 ± 1.8E-02[e]
	600	15	0	4.0E-03 ± 1.4E-02	1.5E-02 ± 2.0E-02[e]	79	1	2.0E-03 ± 1.8E-02	2.4E-02 ± 2.1E-02[e]
Uranium-238	100-N	3	2	8.4E-03 ± 7.7E-03	1.3E-02 ± 7.3E-03	17	11	6.5E-03 ± 7.1E-03	1.4E-02 ± 8.1E-03
	200-East	10	10	1.2E-02 ± 5.2E-03	1.7E-02 ± 9.3E-03	47	36	1.0E-02 ± 8.6E-03	2.3E-02 ± 1.1E-02
	200-West	23	22	2.1E-02 ± 5.3E-02	1.4E-01 ± 4.3E-02	110	94	1.2E-02 ± 1.3E-02	4.2E-02 ± 1.7E-02
	300	10	9	2.7E-02 ± 5.3E-02	9.3E-02 ± 3.0E-02	72	68	3.2E-02 ± 1.3E-01	5.2E-01 ± 1.9E-01
	400	1	1	5.6E-03[f]	5.6E-03 ± 4.8E-03	5	5	9.1E-03 ± 6.4E-03	1.4E-02 ± 9.2E-03
	600	15	13	1.6E-02 ± 2.6E-02	6.1E-02 ± 2.1E-02	79	61	9.5E-03 ± 9.5E-03	2.5E-02 ± 1.2E-02
Plutonium-239/240	100-N	3	2	8.0E-03 ± 3.2E-03	9.2E-03 ± 7.3E-03	17	0	1.8E-04 ± 5.2E-03	3.5E-03 ± 4.2E-03[e]
	200-East	10	0	1.1E-03 ± 2.3E-03	2.2E-03 ± 2.6E-03[e]	47	4	2.1E-03 ± 1.8E-02	5.9E-02 ± 2.2E-02
	200-West	23	16	3.1E-02 ± 1.7E-01	4.3E-01 ± 9.9E-02	110	35	1.3E-02 ± 8.1E-02	3.6E-01 ± 9.7E-02
	300	10	0	1.6E-03 ± 4.6E-03	5.8E-03 ± 5.7E-03[e]	72	5	9.6E-04 ± 1.5E-02	1.6E-02 ± 1.0E-02
	400	1	0	-9.4E-04[f]	-9.4E-04 ± 1.9E-03[e]	5	1	4.7E-03 ± 6.4E-03	9.8E-03 ± 6.3E-03
	600	15	3	4.4E-03 ± 9.2E-03	1.3E-02 ± 6.8E-03	79	8	2.7E-03 ± 1.2E-02	3.6E-02 ± 1.6E-02

(a) 1 pCi = 0.037 Bq.
(b) Number of samples with measurable concentrations of contaminant.
(c) Average ± two standard deviations.
(d) Maximum ± analytical uncertainty.
(e) Maximum value reported is a non-detect.
(f) Average cannot be calculted from a single sample.

and 300 Areas. One sample from the 200-West Area had a uranium-234 concentration higher than historical levels. These elevated values may be due to facility operations in each area.

8.10.1.3 Investigations of Radioactive Contamination in Vegetation Near Hanford Site Facilities and Operations

SM McKinney, MC Dorsey, and RC Roos

Investigations of 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 2010, radiological contamination was found in 36 vegetation samples collected during investigations. Thirty-four of the samples were tumbleweeds (Russian thistle) or tumbleweed fragments, one sample was sagebrush, and one sample was rabbitbrush. None of the samples was analyzed for specific radionuclides, and all were disposed of at a licensed facility.

Table 8.10.3 summarizes the number and general locations of vegetation contamination incidents investigated during 2010. Table 8.10.4 provides the numbers of contamination incidents investigated in 2010 and during the previous 11 years. Section 8.10.3 provides a discussion of vegetation control efforts at the Hanford Site during 2010.

Table 8.10.3. Number of Vegetation Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 2010

Location	Number of Incidents
200-East Area	
Tank farms	4
Burial grounds	9
Cribs, ponds, and ditches	3
Fence lines	0
Roads and railroads	0
Unplanned release sites	4
Underground pipelines	2
Miscellaneous	2
200-West Area	
Tank farms	3
Burial grounds	3
Cribs, ponds, and ditches	3
Fence lines	1
Roads and railroads	0
Unplanned release sites	0
Underground pipelines	1
Miscellaneous	0
Cross-site transfer line	0
200-BC cribs and trenches	1
200-North Area	0
100 Areas	0
300 Area	0
400 Area	0
600 Area	0
Former 1100 Area	0
Total	**36**

Table 8.10.4. Annual Number of Vegetation Contamination Incidents Investigated Near Hanford Site Facilities and Operations, 1999 Through 2010

Year	Number of Incidents	Year	Number of Incidents
1999	85	2005	66
2000	66	2006	75
2001	31	2007	62
2002	16	2008	127
2003	32	2009	109
2004	60	2010	36

8.10.2 Vegetation Monitoring at Hanford Site-Wide and Offsite Locations

BG Fritz

Monitoring of rabbitbrush and sagebrush leaves and stems provides information about 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 on and around the Hanford Site for more than 50 years. Data from these samples are maintained in a

database to document onsite and offsite levels of manmade radionuclides in vegetation at specific locations. This database contains baseline data against which data from unplanned contaminant releases from the Hanford Site can be compared. Vegetation samples are collected every 3 to 5 years, and were last collected in 2008 (PNNL-18427).

8.10.3 Vegetation Control Activities

RC Roos, JM Rodriguez, AR Johnson, JS Finley, and KC Kilpatrick

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 regrowth of plants in contaminated or potentially contaminated areas onsite, and monitoring and removing unwanted (noxious) plant species.

Approximately 3,500 hectares (8,700 acres) were treated with herbicides in 2010 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.

8.10.3.1 Waste Site Remediation and Revegetation During 2010

Biobarrier®[(a)], an engineered fabric impregnated with herbicide, is used to stop root penetration; it can also serve as a physical barrier to burrowing insects. Biobarrier was not used on the Hanford Site in 2010 because more cost-effective means (e.g., herbicide applications) were used. Thirty-nine areas have been covered with Biobarrier since 1999, comprising a total area of approximately 14,000 square meters (151,000 square feet).

Larger areas, incorporating 40 hectares (100 acres) and including two entire waste sites, were reseeded with bunchgrass in 2010 to inhibit the growth of deep-rooted noxious vegetation (e.g., tumbleweed) and control erosion. Wildland fires denuded approximately 500 hectares (1,200 acres) and no revegetation was attempted on those areas. In 2010, approximately 30,500 native shrub seedlings were planted on approximately 900 hectares (2,200 acres) to control wind erosion on areas prone to blowing sand and dust.

8.10.3.2 Noxious Weed Control

Noxious weeds are controlled at the Hanford Site to prevent their spread and eliminate populations. A noxious weed is a legal and administrative category designated by federal or state regulatory agencies (e.g., the 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 35 hectares (90 acres) on the Hanford Site, all along roadways, were treated in 2010. The environmental assessment delineating noxious weed control by herbicides that was mandated in 2008 was undergoing DOE review in 2010 (DOE/EA-1728).

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 2010 control activities.

Yellow Starthistle (*Centaurea solstitialis*). Yellow starthistle represents the most rapidly expanding weed infestation in the western United States. Since 1995, yellow starthistle has been the highest priority weed for the Hanford Site noxious-weed control program because yellow starthistle has the potential to invade the entire site and have a dramatic impact on the ecology of the site and neighboring lands.

Control measures for yellow starthistle have included spot treatments and broadcast herbicide applications by ground equipment and aerial sprayers, biological control, and hand-weeding in critical locations. Major populations near the Hanford town site have been reduced to scattered individual plants, mostly near live trees where aerial herbicide applications were not made.

Yellow starthistle seeds are known to remain viable for 10 years in the soil. The small number of seedlings found over much of the area of infestation indicates the seed bank

(a) Biobarrier is a registered trademark of Fiberweb Inc., Old Hickory, Tennessee.

is being exhausted. Careful control efforts over the next few years at the Hanford Site should result in yellow starthistle changing from a major infestation to a monitoring and eradication effort.

Biological control agents for yellow starthistle are widely distributed across the infested area and have been highly effective during the early part of the flowering season. However, the adult phase of the control agent's annual life cycle is completed before the end of the flowering season. Consequently, flowers opening late in the season are largely spared the effects of insect predation.

Rush Skeletonweed (*Chondrilla juncea*). Rush skeletonweed is scattered over large areas at the Hanford Site. Areas of dense rush skeletonweed infestation have largely been eliminated. Nevertheless, considerable rush skeletonweed remains as scattered individual plants. Populations of rush skeletonweed have increased in some areas burned by past wildfires.

The deep and extensive root system of rush skeletonweed makes it extremely difficult to eliminate. The area north of the Volpentest Hazardous Materials Management and Emergency Response Training and Education Center (HAMMER) facility has been treated with herbicides in the past and will continue to be monitored for sprouts emerging from roots remaining in the ground. Additional aerial applications will likely be needed to reduce the population of rush skeletonweed to the level that ground applications will be able to control the infestation.

Biological control agents are commonly found in rush skeletonweed at the Hanford Site, but they have not significantly reduced plant populations.

Medusahead (*Taeniatherum asperum*). No medusahead plants were discovered in 2010. The Hanford Site will continue to be monitored for several years to verify the seed bank has been eradicated.

Babysbreath (*Gypsophila paniculata*). There were no efforts to control babysbreath in 2010 at the Hanford town site. Babysbreath is resistant to control by herbicides; however, the above-ground portion of the plant can be killed by some herbicides. Using these herbicides, flowering and population growth can be prevented. These plants should ultimately be eradicated by continually removing the top portions through herbicide use.

Dalmatian Toadflax (*Linaria genistifolia* ssp. *Dalmatica*). A small population of dalmatian toadflax plants was found growing east of Energy Northwest at the Hanford Site in 2010. 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 2010. The site will continue to be monitored for several years to ensure viable seeds and roots have been eliminated from the soil. Cooperative efforts with neighboring landowners continue to eliminate spotted knapweed near the Hanford Site. No biological controls have been released specifically for spotted knapweed. Most biological controls for diffuse knapweed are also effective for spotted knapweed.

Diffuse Knapweed (*Centaurea diffusa*). Aerial applications for control of diffuse knapweed have been effective in the past. In 2010, no areas were sprayed aerially for control of diffuse knapweed. Spot treatment of scattered individuals continues. The population of diffuse knapweed near the high-water mark of the Columbia River has not been actively controlled by herbicides because of the biological sensitivity of the area. Biological controls are established and monitored to observe their effectiveness in controlling the weed.

Russian Knapweed (*Acroptilon repens*). Biological controls for Russian knapweed are limited, and their success has been poor in the arid climate of the Hanford Site. Chemicals and other control techniques are being developed that promise to be effective with this difficult-to-control species.

Saltcedar (*Tamarix* spp.). Several individual plants of saltcedar are found at the Hanford Site. Most are the remainders 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 along the Hanford Site are monitored for purple loosestrife. Populations are found on many islands

and along the north and east bank of the river. Individual plants are found along the south and west bank of the river.

Under good ecological conditions, biological controls are effective for controlling purple loosestrife. However, rapidly fluctuating water levels along the Columbia River kill the control organisms that overwinter on the ground in the weed populations. Winter mortality prevents an effective population of control agents from developing. Hanford Site personnel are working with neighboring land managers along the Columbia River to identify effective controls for purple loosestrife along the Hanford Reach. No control measures were applied for purple loosestrife in 2010.

8.10.4 Monitoring of Fish and Wildlife for Hanford Site-Produced Contaminants

RE Durham and JA Stegen

In 2010, several types of wildlife and fish were collected from locations at and around the Hanford Site as part of routine monitoring for site-produced contaminants (Figure 8.10.2). Samples from these organisms were analyzed for selected radionuclides and metals that are suspected or known to be present at the Hanford Site (Table 8.10.5). Samples were also collected from locations distant from the site to obtain reference (background) contaminant measurements.

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.

All fish and wildlife samples collected in 2010 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 samples.

Strontium-90 is present in the Hanford Site environs as a result of past site operating and waste-disposal practices. Contaminated groundwater entering the river through shoreline springs in the 100-N and 100-H Areas is the primary source of measurable site-produced strontium-90 in the Columbia River. However, the current contaminant contribution relative to historical fallout from atmospheric weapons testing is small (less than 2%) (PNL-8817). 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, but since it does not accumulate in the edible portions of fish and wildlife it generally does not contribute much to human dose (National Council on Radiation Protection and Measurements 1991).

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 (less than 200 days in muscle and less than 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 are generally too low to measure, or the concentrations measured are 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 2010 fish and wildlife samples are available upon request (see Preface).

Plutonium isotopes are found at slightly elevated concentrations on Hanford's Central Plateau; however, concentrations are low and similar to background levels associated with atmospheric fallout from past nuclear weapons testing programs. Plutonium accumulates in bone and liver. Liver samples from some of the organisms collected in 2010 were chosen for analysis and comparison with historical plutonium isotope data.

A number of trace metals associated with Hanford Site operations have the potential to accumulate in certain fish

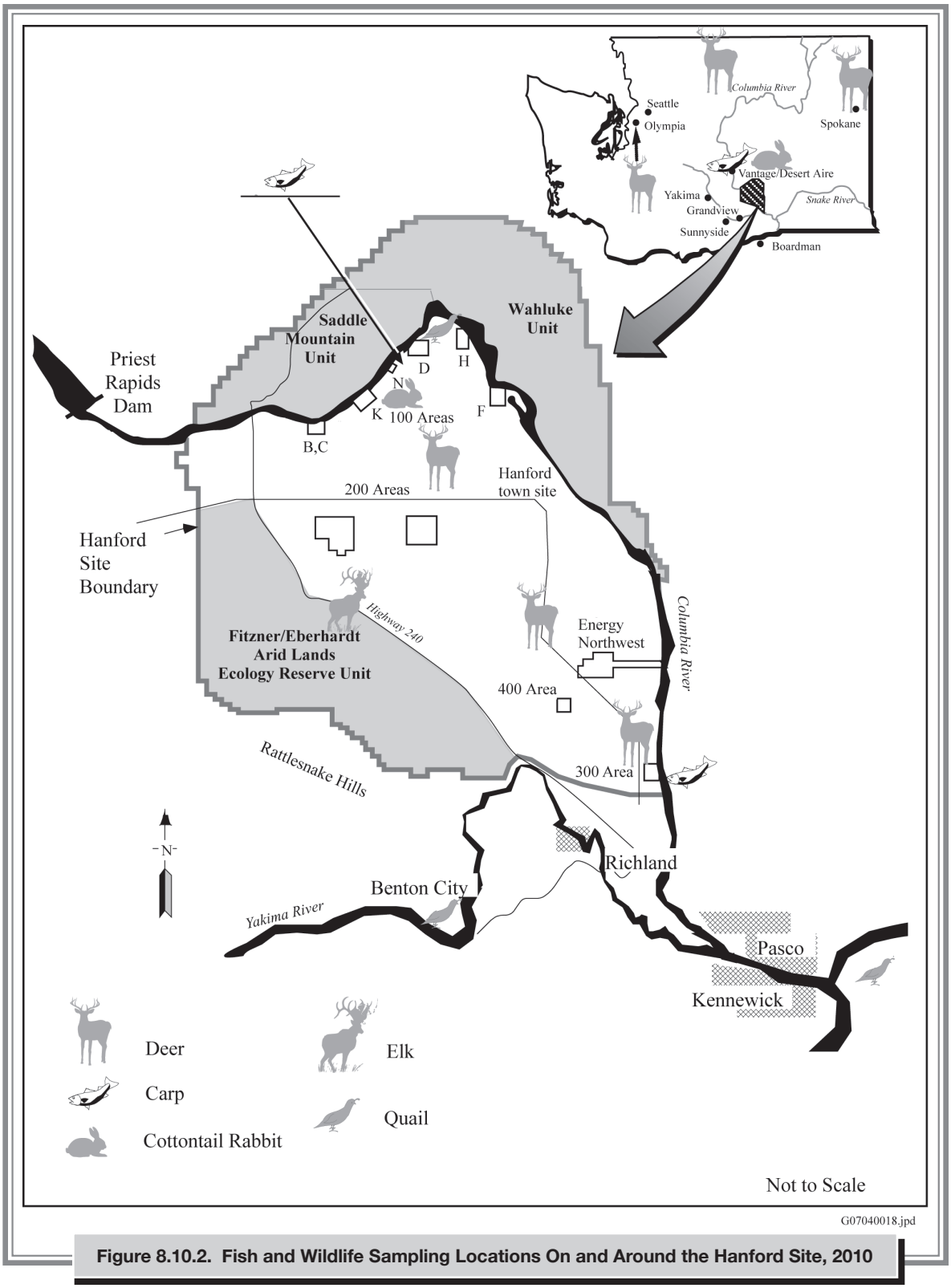

Figure 8.10.2. Fish and Wildlife Sampling Locations On and Around the Hanford Site, 2010

Table 8.10.5. Number of Fish and Wildlife Sampling Locations and Analyses On and Around the Hanford Site, 2010

Biota	No. of Offsite Locations	No. of Onsite Locations	No. of Analyses			
			Gamma	Strontium-90	Trace Metals	Plutonium-238, Plutonium-239/240
Fish (common carp)	1[a]	2	15	15	15	0
Rabbits	1[b]	1	3	3	3	1
Upland game birds (quail)	2[c]	1	7	7	7	0
Big game (deer and elk)	3[d]	4	7	7	1	1

(a) Samples collected above Wanapum Dam, Washington.
(b) Samples collected near Moses Lake, Washington.
(c) Samples collect near Burbank and Benton City, Washington.
(d) One black-tailed deer donated by Washington State Department of Health, collected near Olympia, Washington. Two hunter-donated mule deer: one collected near Deer Park, and one collected near Winthrop, Washington.

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 trace-metal emissions in a variety of forms. Liquid and solid wastes were placed in various disposal sites, including trenches, cribs, ditches, ponds, and underground storage tanks (PNNL-13487). In the past, fly ash, produced from burning coal in 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 soil surfaces around the reactor areas.

Other sources have contributed trace metals to the Hanford Site environment as well. Trace metals, generated from upriver mining and smelting, have been transported down the Columbia River and into the Hanford Reach (Johnson et al. 2005). Contaminants associated with past and present agricultural practices have also contributed to the metals inventory at the Hanford Site (Yokel and Delistraty 2003); one example is arsenic. Lead arsenate was once the most commonly used insecticide in fruit orchards. The presence of arsenic at some Hanford Site locations is likely associated with the historical applications of this lead arsenate insecticide on fruit orchards that were common on the site prior to World War II. Studies that examined the extent of arsenic contamination in pre-World War II orchard soil near the 100 Areas found elevated levels of arsenic when 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 trace-metal concentrations 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, trace-metal concentrations and organism exposures can vary between locations. This variability can produce some uncertainty in terms of identifying the source of trace-metal concentrations found in a given organism. To determine Hanford Site contributions to trace-metal levels identified in biota that are sampled onsite or in the Hanford Reach, fish and wildlife have been collected from upstream of the site and from background areas distant from the site. Trace-metal concentrations measured in the upstream and background samples are compared with those found in the samples collected from the Hanford Site environs. This comparison could indicate increases in concentrations of trace metals potentially due to onsite activities. The utility of this evaluation is limited by a somewhat small set of data for wildlife and fish that have been sampled from the Hanford Reach, the Hanford Site, and from background locations. Sample sizes have been relatively small for targeted organisms in these areas, and sampling events have alternated by organism type, resulting in usually three to possibly four sampling events over an 8-year period.

Small sample sizes taken over a relatively short period of time, along with the spatial variability inherent in an organism's exposure, underlie to some degree the inconsistency found in the metals data presented in the following discussions. The addition of future sampling data may reduce this variability and therefore enhance its utility for determining potential Hanford Site contributions to trace-metal concentrations in organisms sampled from the site environment.

Fish and wildlife species sampled and analyzed during 2010 for radionuclides and/or trace metals included: common carp, Nuttall's cottontail, California quail, mule deer, black-tailed deer, and Rocky Mountain elk (Figure 8.10.2). Data results are summarized in the following discussions. Individual results and their associated uncertainties are available upon request (see Preface).

8.10.4.1 Analytical Results for Fish

Fishing is a popular activity along the Hanford Reach of the Columbia River. Fish, such as the common carp, are sometimes harvested for food and could potentially contribute to human exposure. Carp are bottom feeders that are likely moving up and down the Hanford Reach, and therefore may be exposed to trace metals and persistent radionuclides in the Columbia River environment.

Ten carp were collected from two locations in the Hanford Reach during 2010: five from the region between the 100-N and 100-D Areas and five from near the 300 Area. Five additional carp were collected from an upriver background location near Desert Aire, Washington (Figure 8.10.2). Fillets and the eviscerated remains (carcasses) of carp were analyzed for a variety of radiological contaminants, and liver samples were analyzed for 17 metals.

Cesium-137. Manmade gamma-emitting radionuclides, including cesium-137, were not found above the reporting limit (0.03 pCi/g [0.001 Bq/g] wet weight) in any of the muscle samples analyzed in 2010. These results are consistent with those reported throughout the past 15 years in bottom-feeding fish both at background locations and near the Hanford Site.

Strontium-90. Strontium-90 was not discovered above the reporting limit (0.05 pCi/g [0.0019 Bq/g] wet weight) in carp samples collected from the Hanford Reach or upriver background locations in 2010. These results are consistent with those reported throughout the past 15 years for bottom-feeding fish collected from background and Hanford Site sampling locations.

Trace Metals. Liver samples were measured for trace-metal concentrations in all carp samples collected along the Hanford Reach and the upriver background site during 2010 (Appendix C, Table C.12). Data were compared by location and were evaluated against the historical trace-metal concentrations reported for carp and sucker samples collected in 2004, 2006, and 2008 (PNNL-15222, APP. 1; PNNL-16623, APP. 1; PNNL-18427, APP. 1). Beryllium was not detected above the analytical detection limit at any location in 2010. Maximum and median concentrations of aluminum, antimony, copper, lead, selenium, silver, thorium, and zinc in carp liver samples collected from the Hanford Reach were less than or similar to the concentrations found in the carp livers collected from the upriver background location in 2010. Maximum manganese concentrations were also elevated in carp livers collected from the background location, but median concentrations were greater in the samples collected from both Hanford Reach sampling locations. Maximum chromium levels were elevated in samples from the 100-N to 100-D Areas (0.711 µg/g dry weight) compared to samples from the 300 Area (0.47 µg/g dry weight) in 2010. The maximum chromium values reported in 2010 for samples from the 100-N to 100-D Areas were similar to those reported for this location in 2006 (0.783 µg/g dry weight), but they were much lower than the maximum value reported for this location in 2004 (11.9 µg/g dry weight). Maximum and median mercury concentrations were elevated in samples collected from both Hanford Reach sampling locations compared to those collected from the upriver background location in 2010. Nickel was found in the highest concentration in carp livers collected from the 100-N to 100-D Areas, but these maximum levels were less than those reported for the upriver background location in 2006 and 2008. Thallium was also found in the highest concentration in a liver collected from the 100-N to 100-D Areas, but the median values reported for both Hanford Reach sampling locations were less than the maximum thallium concentration measured in a sample collected from the upriver background location in 2010. Maximum and median uranium concentrations were elevated in the

livers collected from the 300 Area compared to the samples collected from the 100-N to 100-D Areas in 2010. Samples from the 300 Area had uranium levels that were elevated in 2010 compared to the values reported for this and all other sampling locations in 2008, but they were similar or less than those reported for this location in both 2004 and 2006. Maximum cadmium concentrations were elevated in samples collected from both Hanford Reach locations compared to those collected from the upriver background location in 2010, and somewhat elevated compared to all sampling locations in 2006 and 2008; however, the maximum and median values reported for 2010 were much lower than those reported for both Hanford Reach sampling locations in 2004 and the background location in 2002 (PNNL-15222, Table C.11).

Surveillance data sets for trace-metal concentrations in fish, both on and near the Hanford Site, are relatively small and the results are variable. At this time, no established state or federal adverse-effects values (i.e., benchmark criteria) are available for trace-metal concentrations in fish tissue. Identifying Hanford Site contributions to trace-metal concentrations or drawing conclusions about the effects of this contribution are limited by the factors above. Monitoring fish for uptake and exposure to radionuclides and metals at locations both near to and distant from the Hanford Site will continue to provide important information for tracking the extent and long-term trends of contamination in the Hanford Reach environment.

8.10.4.2 Analytical Results for Rabbits

Cottontail 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 Hanford Site. During 2010, two cottontail rabbits were collected near the Hanford Site 100-N Area, and one was collected from a background location near Moses Lake, Washington (Figure 8.10.2). The rabbits were monitored for cesium-137 and other manmade gamma-emitting radionuclides in muscle tissue, strontium-90 in bones, and 17 trace metals in the liver. In addition, plutonium-238 and plutonium-239/240 were monitored in the rabbit liver obtained from the background location near Moses Lake, Washington.

Cesium-137. Cesium-137 concentrations were below the analytical detection limit (0.03 pCi/g [0.0011 Bq/g] wet weight) in all cottontail rabbit muscle samples collected from all locations in 2010.

Strontium-90. Strontium-90 concentrations in bone tissues collected from rabbits in 2010 were above the analytical detection limit (0.05 pCi/g [0.0019 Bq/g] wet weight) (Figure 8.10.3). Maximum strontium-90 concentrations (12.4 pCi/g [0.46 Bq/g] wet weight) were elevated in the rabbits collected from the 100-N Area compared to the maximum concentration in background samples in 2010 (0.175 pCi/g [0.0065 Bq/g] wet weight). Strontium-90 concentrations in the samples collected from the 100-N Area were less than the maximum value reported in 1999 from samples collected at the 100-N Area (144 pCi/g [5.3 Bq/g] wet weight). Concentrations reported for the sample collected at the background location near Moses Lake were somewhat elevated compared to the previous background sampling event in 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 found in rabbit bone tissues have not been apparent over the past decade (Figure 8.10.3).

Plutonium. One rabbit liver from the background location near Moses Lake was submitted for plutonium-238 and plutonium-239/240 analysis in 2010. Plutonium-238 was detected at 0.00163 pCi/g (0.000060 Bq/g) wet weight. Plutonium-239/240 was detected at 0.000845 pCi/g (0.000031 Bq/g) wet weight. No Hanford Site liver samples were submitted for plutonium analysis in 2010.

Trace Metals. Liver samples from rabbits collected from the 100-N Area and the background location near Moses Lake were analyzed for 17 trace metals in 2010 (Appendix C, Table C.13). Arsenic, beryllium, silver, thallium, and uranium were not detected above method detection limits in samples from either sampling location. The maximum concentrations of most trace metals found in the rabbit samples collected onsite were less than or similar to the maximum concentrations of these metals in the sample collected near Moses Lake in 2010. Antimony and lead were elevated in the liver samples collected from the 100-N Area

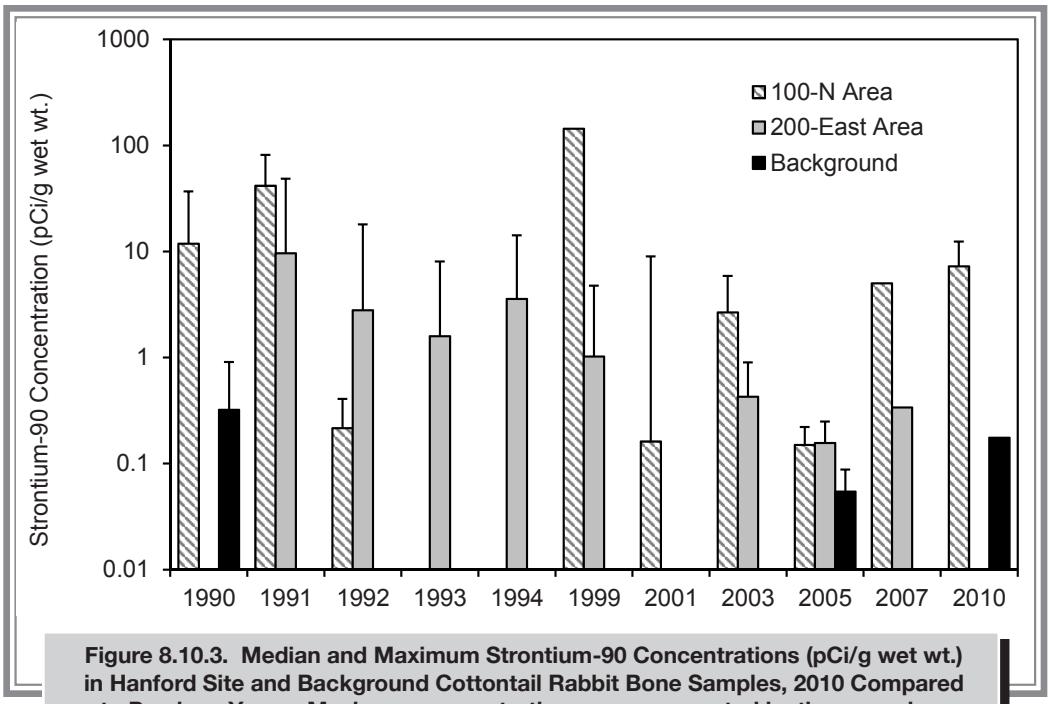

Figure 8.10.3. Median and Maximum Strontium-90 Concentrations (pCi/g wet wt.) in Hanford Site and Background Cottontail Rabbit Bone Samples, 2010 Compared to Previous Years. Maximum concentrations are represented by the upper bar.

compared to the sample collected at the background location and were also elevated compared to the maximum levels reported for 100-N Area samples in 2007 (PNNL-17603, APP. 1), but they were less than the levels reported for this location in 2005 (PNNL-15892, APP. 1). Zinc levels were somewhat elevated in the samples collected from the 100-N Area in 2010 compared to levels reported for this location in 2007 (PNNL-17603, APP. 1), but they were less than those reported for both this and the background location, near Prosser, Washington, in 2005 (PNNL-15892, APP. 1).

8.10.4.3 Analytical Results for Upland Game Birds

California quail are one of the most prevalent upland game birds found at the Hanford Site. Most quail that reside onsite are found along the Columbia River where trees and shrubs provide shelter. Quail forage for seeds, other plant parts, and grit in grassy and weedy places not far from cover. Ordinarily, quail do not travel far from where they hatch. Individual birds at the Hanford Site may spend their entire lives near one of the retired reactors. Quail can be exposed to metals and persistent radionuclides when they forage on materials from plants that have roots in contact with contaminated groundwater or soil, drink contaminated water, or ingest contaminated grit. Three California quail were collected from the Hanford Site from the region between the 100-D and 100-H Areas in 2010. Four additional background samples were collected from background locations near Burbank (n=1), and Benton City (n=3), Washington. All quail were monitored for cesium-137 in muscle, strontium-90 in bone, and 17 trace metals in liver tissues. Radionuclide levels found in muscle and bone samples analyzed during 2010 were compared to levels measured in upland game bird samples collected at the Hanford Site during the past 15 years, and to samples collected from background locations in 2000 and 2004 (PNNL-13487, APP. 1; PNNL-15222, APP. 1). Results for 2010 are available upon request (see Preface).

Cesium-137. Manmade gamma-emitting radionuclides, including cesium-137, were below the detection limit (0.03 pCi/g [0.001 Bq/g] wet weight) for all upland game bird muscle samples analyzed in 2010. These results are consistent with those reported over the past 15 years illustrating the continued downward trend in worldwide levels of cesium-137 fallout resulting from materials released to the atmosphere during the nuclear weapons testing era (1950s through the 1970s).

Strontium-90. Strontium-90 concentrations were below the analytical detection limit (0.05 pCi/g [0.0019 Bq/g] wet weight) in all quail bone samples collected in 2010. Comparisons of the maximum and median strontium-90 concentrations reported for game bird bone samples collected at the Hanford Site since 1996 and background locations in 2004 and 2006 are consistent with these results which do not indicate elevated levels of strontium-90 (Figure 8.10.4).

Trace Metals. All quail livers collected in 2010 were analyzed for 17 trace metals (Appendix C, Table C.14). Antimony, beryllium, and uranium were not detected above method detection limits in any sample regardless of sampling location in 2010. Maximum concentration levels measured from samples collected at the Hanford Site for chromium, lead, and nickel were similar or below those collected from the background locations.

Median and maximum concentrations of aluminum, arsenic, cadmium, copper, manganese, mercury, selenium, silver, thallium, thorium, and zinc were elevated or somewhat elevated in the quail liver samples collected between the 100-D and 100-H Areas compared to the median and maximum concentrations measured in the samples collected from the background locations in 2010. However, with the exception of aluminum, mercury, silver, and zinc, the maximum trace-metal concentrations in 2010 were lower than those reported in both 2004 and 2006 for the 100-D to 100-H Area sampling location. Arsenic, cadmium, and thallium concentrations were also lower in 2010 than those reported for the background area near Grandview, Washington, in 2004 (PNNL-15222, APP. 1). Maximum and median aluminum concentrations were elevated in quail livers collected from the 100-D to 100-H Areas in 2010 compared to the levels reported for all samples regardless of location in both 2004 and 2006.

8.10.4.4 Analytical Results for Deer

Studies of mule deer populations residing at the Hanford Site indicate their division into three relatively distinct populations (Tiller and Poston 2000): north (deer that live in the 100 Areas); south (deer that reside from the Hanford town site south to the 300 Area); and central (deer living around the 200 Areas, away from the Columbia River). Deer can be exposed to metals and persistent radionuclides when they forage on plants whose roots have access to contaminated

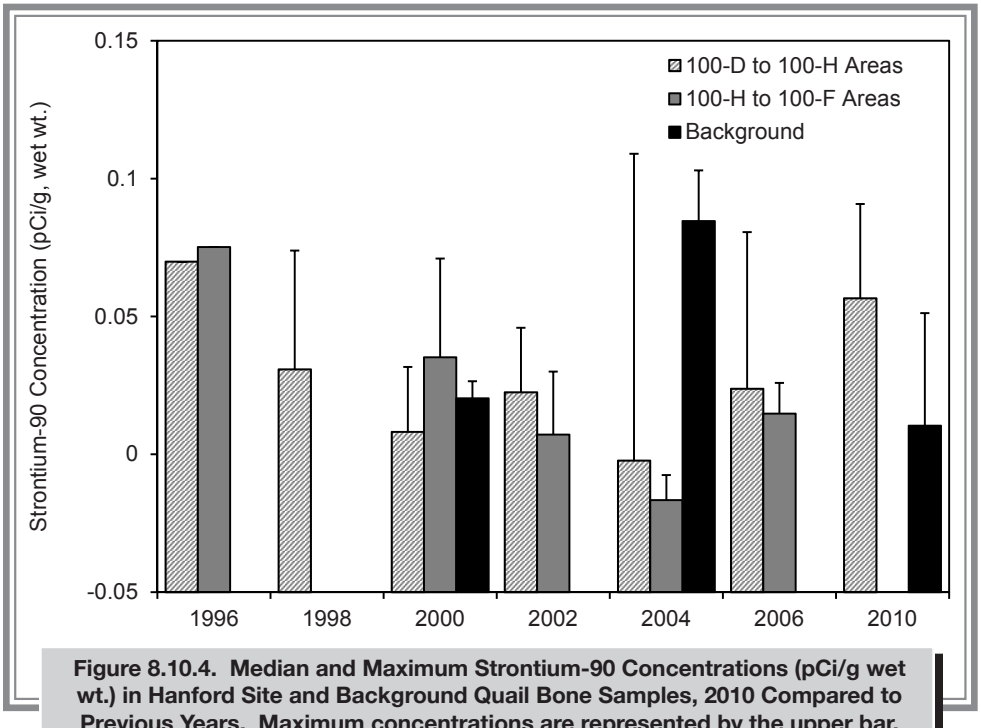

Figure 8.10.4. Median and Maximum Strontium-90 Concentrations (pCi/g wet wt.) in Hanford Site and Background Quail Bone Samples, 2010 Compared to Previous Years. Maximum concentrations are represented by the upper bar.

groundwater or soil, drink contaminated water, or incidentally ingest contaminated soil. Deer hunting is not allowed above the high-water mark on the Benton County side of the Columbia River (at the Hanford Site), but the river is not a barrier to deer movements. Deer captured and tagged at the Hanford Site have been legally killed by hunters on the Hanford Reach shoreline below the high-water mark and across the Columbia River in Franklin County. Harvesting deer for food could potentially contribute to human exposure to contaminants.

Radionuclide levels in three mule deer collected at the Hanford Site in 2010 were compared to levels found in one black-tailed deer collected by the Washington Department of Fish and Wildlife near Olympia, Washington, and two hunter-donated mule deer; one from Winthrop, Washington, and one from the vicinity of Deer Park, Washington. Hanford Site deer were from the northern population (n=1) and the southern population (n=2). Results from deer collected in 2010 were compared to samples collected in previous years from background locations distant from the site and to results reported for deer collected from the Hanford Site over the past 15 years.

Cesium-137. Cesium-137 was detected in the muscle tissue collected at the background location near Deer Park (0.147 pCi/g [0.0054 Bq/g] wet weight). Cesium-137 was not found above detection limits (0.03 pCi/g [0.001 Bq/g] wet weight) in the other deer muscle samples submitted for analysis in 2010. These results are consistent with a decline in cesium-137 levels in wildlife examined from the preceding 15 years.

Strontium-90. Concentrations of strontium-90 measured in deer bone samples collected at the Hanford Site in 2010 ranged from 0.177 pCi/g (0.0065 Bq/g) wet weight to 0.182 pCi/g (0.0067 Bq/g) wet weight; the highest value was from a sample collected from the southern population. Strontium-90 concentrations measured in bone samples from background locations ranged from 0.138 pCi/g (0.0051 Bq/g) wet weight to 0.763 pCi/g (0.028 Bq/g) wet weight; the highest of these and all other samples measured in 2010 (both on and off site) was found in the black-tailed deer bone collected near Olympia, Washington (Figure 8.10.5).

Plutonium. Plutonium-238 and plutonium-239/240 results were below the analytical detection limits (0.0004 pCi/g

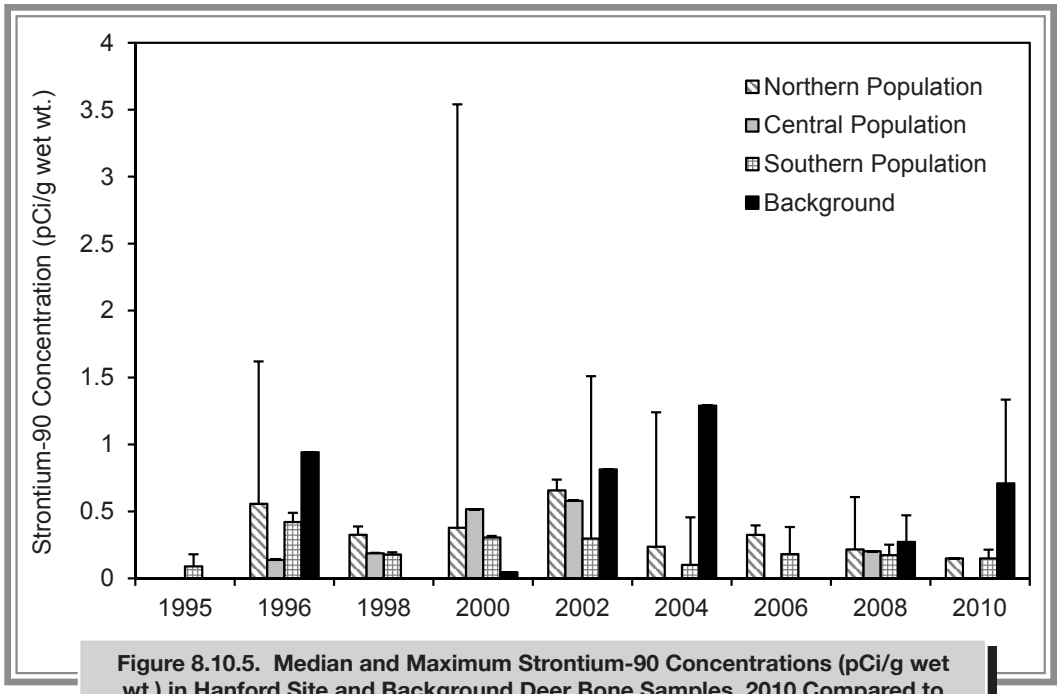

Figure 8.10.5. Median and Maximum Strontium-90 Concentrations (pCi/g wet wt.) in Hanford Site and Background Deer Bone Samples, 2010 Compared to Previous Years. Maximum concentrations are represented by the upper bar.

[0.00001 Bq/g] wet weight) in the black-tailed deer liver sample obtained during 2010 from near Olympia, Washington. No other deer were submitted for plutonium isotope analysis in 2010.

Trace Metals. Trace metals were analyzed in the black-tailed deer collected near Olympia, Washington, in 2010; no Hanford Site samples were submitted (Appendix C, Table C.15). Concentrations measured in deer from the background location were compared to concentrations reported for black-tailed deer collected in 2002, 2004, and 2008 near Olympia, Washington, and to historical concentrations reported for the Hanford Site (PNNL-15222, APP. 1; PNNL-16623; PNNL-18427, APP. 1).

Four metals (antimony, arsenic, beryllium, and uranium) were not found above analytical detection limits in 2010. With the exception of cadmium and mercury, all other trace-metal concentrations in 2010 were similar to, or less than, the levels previously reported for deer collected near Olympia, Washington. Cadmium levels in 2010 were elevated above those previously reported for both the Olympia and Hanford Site sampling locations. Mercury was elevated compared to historical mercury levels reported for the background locations and was somewhat elevated compared to 2008 Hanford Site data (PNNL-18427, APP. 1).

8.10.4.5 Analytical Results for Elk

Elk can be exposed to metals and persistent radionuclides when they forage on plants whose roots have access to contaminated groundwater or soil, drink contaminated water, or incidentally ingest contaminated soil. In 2010, samples of elk muscle and bone were collected from one elk killed along State Route 240 near the Hanford Site. Radionuclide levels were compared to historical radionuclide levels reported since 1998 for elk collected on or near the Hanford Site and from a background location in central Idaho.

Cesium-137. Cesium-137 was not above detection limits (0.03 pCi/g [0.001 Bq/g] wet weight) in the elk muscle collected near the Hanford Site in 2010. This is consistent with historical data and with trends observed in a Hanford Site wildlife summary report (PNL-10174).

Strontium-90. Strontium-90 was detected in the elk bone samples analyzed in 2010 (0.262 pCi/g [0.0097 Bq/g] wet weight). The levels reported are consistent with those previously reported for elk bone samples collected from the Hanford Site, road kills near the Hanford Site along State Route 240, and from the Fitzner/Eberhardt Arid Lands Ecology Reserve. The measured levels in bone do not present a viable human exposure pathway by ingestion. The highest concentrations of strontium-90 (2.33 pCi/g [0.086 Bq/g] wet weight) were found in background samples collected in 1999 from central Idaho (Figure 8.10.6).

8.10.5 Control of Pests and Contaminated Biota

AR Johnson, RC Roos, JM Rodriguez, RF Giddings, JW Wilde, JS Finley, and KC Kilpatrick

Animal species such as the domestic pigeon (*Columba livia*), Northern pocket gopher (*Thomomys talpoides*), house mouse (*Mus musculus*), and deer mouse (*Peromyscus maniculatus*) must be controlled when they become a nuisance or a health problem, or if they become contaminated with radioactivity. Biological control personnel responded to approximately 29,000 animal control requests (ranging from requests to remove animals within radioactive waste facilities to insect invasions of work areas) from Hanford Site employees in 2010. Approximately 2,500 trap or bait stations were used to control populations of animals in and near site facilities and offices. During 2010, 1,689 animals were captured as part of pest control and 4 were radiologically contaminated.

During 2010, 24 contaminated animal-related materials were discovered (e.g., urine or feces). This is approximately 52% less than the peak number of 46 in 1999 and 11 less than the total for 2009. Of the 24 animal contamination incidents in 2010, there were only 2 contaminated rabbit feces. A study to determine where rabbit species (black-tailed jackrabbit [*Lepus californicus*] or mountain [Nuttall's] cottontail [*Sylvilagus nuttallii*]) had been ingesting radioactive contamination and spreading it via their fecal material was ongoing in 2010 and will continue in 2011. No contaminated rabbits were captured in 2010, making it likely that the source or sources of contamination have been neutralized within the waste sites.

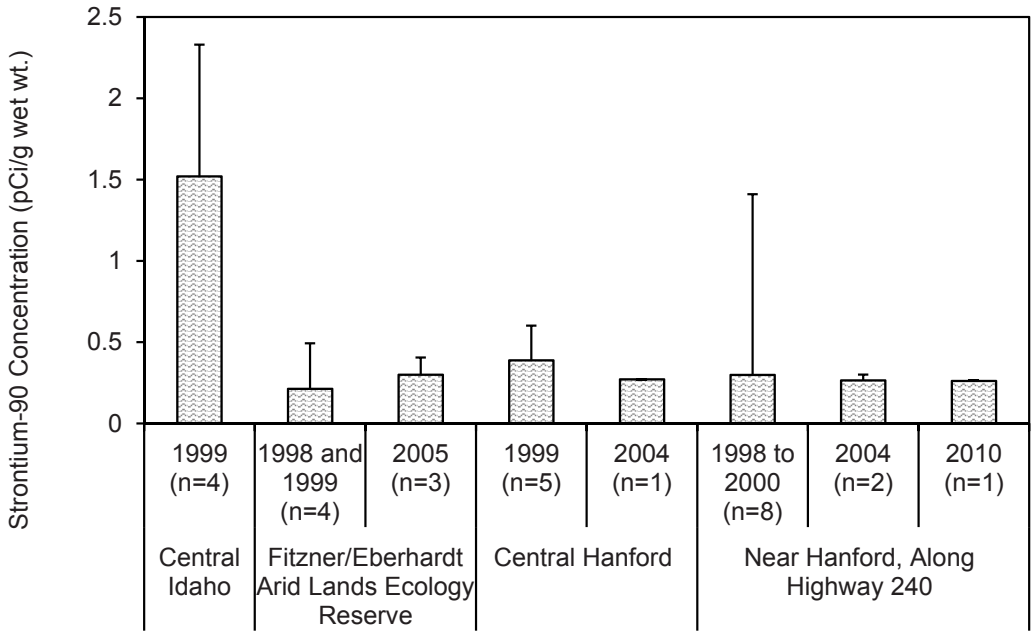

Figure 8.10.6. Historical Median and Maximum Strontium-90 Concentrations (pCi/g wet wt.) in Elk Bone Samples Collected Near the Hanford Site and from Central Idaho Since 1998. Maximum concentrations are represented by the upper bar.

Flying insects and insect-related materials (e.g., harvester ants and mud-dauber wasp nests) collected during operations on the Hanford Site are also monitored for radiological contaminants. Eleven legacy mud dauber wasp nests were found and removed for proper disposal during cleanup activities in the 100-H Area (n=1), 100-K Areas (n=9), and 100-N Area (n=1). The only other insect-related contamination was an ant mound on an inactive, stabilized process ditch in the 200-East Area that was treated to eliminate the ants and covered with clean backfill.

One notable contamination incident in 2010 was the discovery of decades-old legacy coyote feces containing rodent bones near the Environmental Restoration Disposal Facility. Contamination readings up to 240,000 disintegrations per minute beta-gamma per 100 cubic centimeters and 120,000 disintegrations per minute alpha per 100 cubic centimeters were measured. The feces and bone were collected and properly disposed.

8.11 External Radiation Monitoring

External radiation is defined as radiation originating from a source external to the human body. In 2010, external radiation at the Hanford Site was monitored onsite in relative proximity to known 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 activities; 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™(a) thermoluminescent dosimeter (TLD) system is used to measure external radiation on the Hanford Site. This system includes the Harshaw 8800-series dosimeter and the Harshaw 8800 reader. The Harshaw 8800-series environmental dosimeter consists of two TLD-700 chips and two TLD-200 chips and provides both shallow- and deep-dose measurement capabilities using filters in the dosimeter. Data obtained from the two TLD-700 chips were used to determine the average total environmental dose at each location during 2010. The two TLD-200 chips were included to determine doses in the event of a radiological emergency and were not used in calculating average total environmental dose. The average daily dose rate was determined by dividing the average total environmental dose by the number of days the dosimeter was exposed. Daily dose equivalent rates (millirem per day) at each location were converted to annual dose equivalent rates (millirem per year) by averaging the daily dose rates and multiplying by 365 days per year. The TLDs were positioned approximately 1 meter (3.3 feet) above 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 2010 included underground radioactive material areas, contamination areas, soil contamination areas, high-contamination areas, roads, and fence lines.

8.11.1 External Radiation Monitoring Near Hanford Site Facilities and Operations

CJ Perkins

During 2010, external radiation fields were monitored with TLDs at 119 locations near Hanford Site facilities and operations. The TLD results were used individually or averaged to determine dose rates in a given area for a specific sampling period. Table 8.11.1 compares 2009 and 2010 results for TLDs located near waste-handling facilities at the Hanford Site. Individual TLD results and detailed maps of monitoring locations are available upon request (see Preface for contact information).

8.11.1.1 External Radiation Measurements Onsite Near Facilities and Operations

100-K Area. Cleanup activities for the K Basins Closure Project during 2010 resulted in noticeable decreases in the

(a) Harshaw is a trademark of Thermo Fisher Scientific, Inc., Waltham, Massachusetts.

Table 8.11.1. Thermoluminescent Dosimeter Results (mrem/yr)[a] Near Hanford Site Operations in 2009 and 2010

Hanford Site Locations	Number of Dosimeters	2009		2010		
		Maximum[b]	Average[c,d]	Maximum[b]	Average[c,d]	% Change[e]
100-K Area	14	1,525 ± 2,814	278 ± 735	187 ± 131	109 ± 68	-60
100-N Area	5	133 ± 64	96 ± 47	152 ± 201	94 ± 65	-1
200-East Area	42	285 ± 55	102 ± 78	480 ± 187	107 ± 127	5
200-West Area	24	189 ± 21	99 ± 50	219 ± 49	98 ± 62	<1
200-North Area (212-R)	1	1,697 ± 254[f]	1,552 ± 323	1,508 ± 226	1,329 ± 397	-14
300 Area	8	101 ± 9	82 ± 17	113 ± 22	87 ± 28	6
300 Area TEDF	6	84 ± 13	80 ± 5	83 ± 3	81 ± 4	<1
400 Area	7	92 ± 8	79 ± 13	88 ± 6	79 ± 8	<1
618-10 Burial Ground	4			77 ± 20	76 ± 2	N/A
CVDF	4	243 ± 316	138 ± 149	80 ± 10	73 ± 9	-46
ERDF	3	91 ± 23	85 ± 12	80 ± 10	78 ± 2	-6
IDF	1	93 ± 14[f]	88 ± 7	88 ± 13	84 ± 8	-5

(a) To convert to international metric system units, multiply mrem/yr by 0.01 to obtain mSv/yr.
(b) Maximum values are ± analytical uncertainty.
(c) ±2 standard deviations.
(d) Each dosimeter is collected and read quarterly.
(e) Numbers indicate a decrease (-) or increase from the 2009 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).
N/A = Not applicable.
TEDF = Treated Effluent Disposal Facility.

average dose rates at all TLD locations in the 100-K Area compared to 2009 (Figure 8.11.1). Dose-rate levels measured in 2010 at monitoring stations in the K-East and K-West Areas, and at the Cold Vacuum Drying Facility were, respectively, 40%, 49%, and 47% lower than 2009 levels.

100-N Area. Average dose-rate levels observed in the 100-N Area during 2010 showed a slight decrease (1%) compared to 2009 levels.

100-N Area Shoreline (N Springs). Dose rates were measured along the Columbia River shoreline in the 100-N Area (N Springs) to determine potential external radiation doses to onsite workers and to the public accessing the river. Cleanup activities at the retired 116-N-1 and 116-N-3 Trenches (located near the Columbia River) have decreased dose rates notably over the past few years (Figure 8.11.1). The 2010 average dose rate was unchanged compared to 2009, and was less than 100 millirem (1 millisievert) per year.

200-East and 200-West Areas. Dose rate levels measured during 2010 in the 200-East Area were slightly increased (5%) compared to 2009, while the average dose rate levels in the 200-West Area were similar to those measured in 2009 (Figure 8.11.1).

Average dose rates measured in 2010 at the Environmental Restoration Disposal Facility (located near the 200-West Area) were approximately 6% lower than 2009 levels.

200-North Area. One TLD monitoring site, located in the 200-North Area at the contaminated 212-R Railroad Car Disposition Area, showed an annual average dose rate decrease of 14% in 2010 compared to 2009 levels. This TLD location was established in 2000 to monitor expected high radiation levels emitted from contaminated railroad cars. During the fourth quarter of 2010, dose rate levels fell approximately 40% as the radiologically contaminated railroad cars were dispositioned.

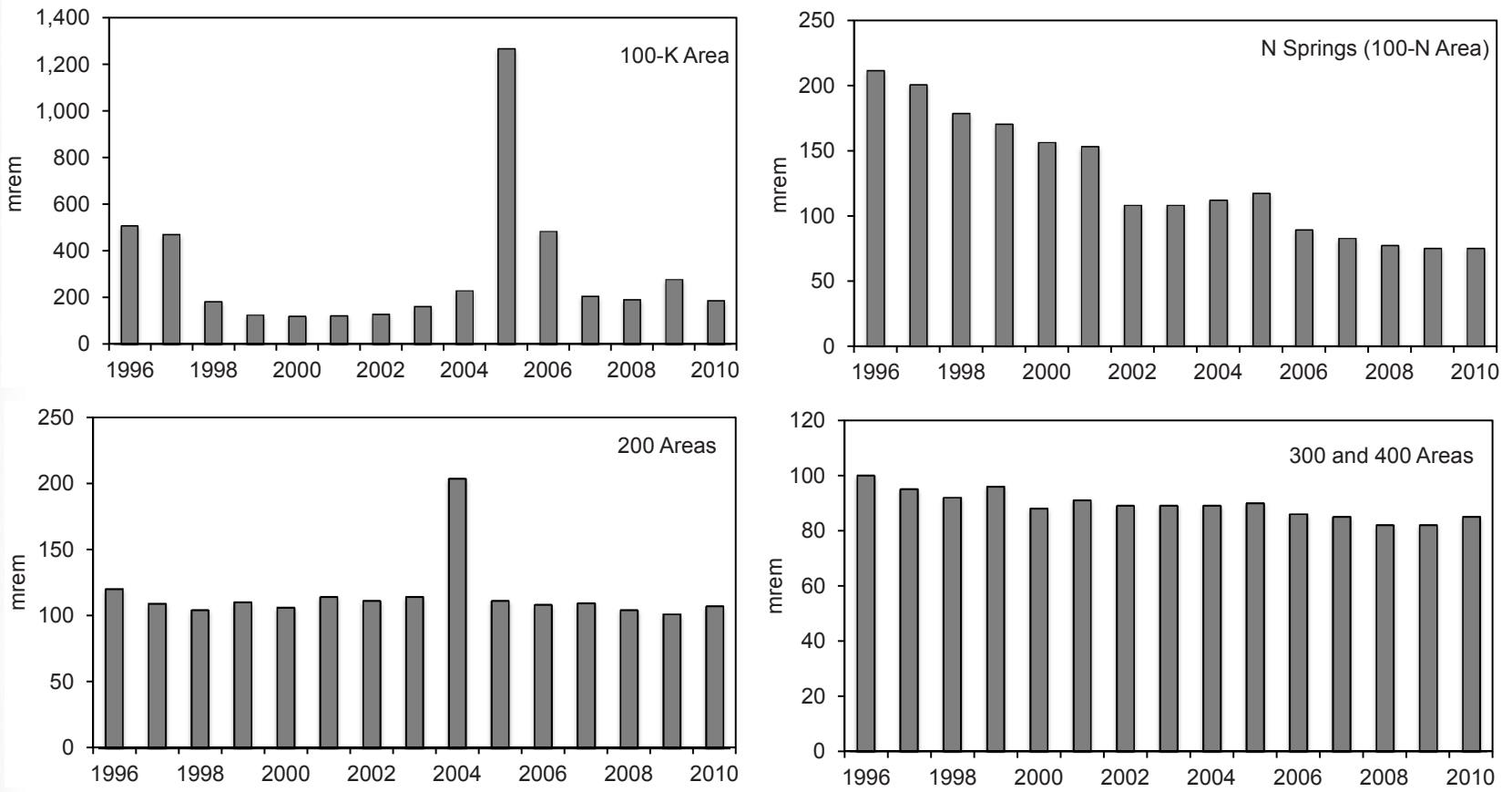

Figure 8.11.1. Annual Average Thermoluminescent Dosimeter Results in Selected Areas Near Facilities and Operations at the Hanford Site, 1996 Through 2010

300 and 400 Areas. The average dose rates at the 300 Area Treated Effluent Disposal Facility and in the 400 Area in 2010 were comparable to 2009 levels (Figure 8.11.1). Facility deactivation, decontamination, and decommissioning activities continued during 2010 in the 300 Area and average dose rates were approximately 6% higher than in 2009.

8.11.1.2 Radiological Surveys at Active and Inactive Waste-Disposal Sites

SM McKinney and MC Dorsey

During 2010, 632 environmental radiological surveys were conducted at active and inactive waste-disposal sites and the surrounding terrain to detect and characterize radioactive surface contamination. Vehicles equipped with radiation detection devices and global positioning systems were used to accurately measure the extent of contamination. Area measurements were entered into the Hanford Geographical Information System, a computer database maintained by Mission Support Alliance, LLC. Routine radiological survey locations included former waste-disposal cribs and trenches, retention basin perimeters, ditch banks, solid waste-disposal sites (e.g., burial grounds), unplanned release sites, tank farm perimeters, stabilized waste-disposal sites, roads, and firebreaks in and around the site operational areas. These sites were posted as underground radioactive material areas, contamination areas, and soil contamination areas. The external dose rate at 80% of the outdoor contamination areas was estimated to be less than 1 millirem (0.01 millisievert) per hour, although direct dose-rate readings from isolated radioactive specks could have been higher.

Underground radioactive material areas are regions where radioactive materials occur below the soil surface. These areas are typically stabilized cribs, burial grounds, covered ponds, trenches, and ditches. Barriers have been placed over the contamination sources 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 available upon request – see Preface). In addition, onsite paved roadways are surveyed annually, and the intersections along the Environmental Restoration Disposal Facility haul routes are surveyed quarterly.

During 2010, the Hanford Site had approximately 3,580 hectares (8,850 acres) of outdoor contaminated areas of all types and approximately 560 hectares (1,390 acres) that contained underground radioactive materials, not including active facilities. Table 8.11.2 lists the contamination areas, underground radioactive material areas, and interim-closed waste sites as well as their status and general locations. No new areas of significant size were discovered during 2010. 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 2010, approximately 18 hectares (43 acres) of previously posted contamination and/or underground radioactive material areas underwent remediation action and were interim closed. Table 8.11.3 summarizes the change in status of outdoor contamination areas during 2010.

8.11.2 External Radiation Monitoring at Hanford Site-Wide and Offsite Locations

JP Duncan

External radiation monitoring and radiation surveys at site-wide, offsite, and Columbia River shoreline locations were discontinued by Pacific Northwest National Laboratory at the end of calendar year 2005 because of DOE funding reductions. Data collected at these locations for many years

Table 8.11.2. Status of Outdoor Contamination Areas on the Hanford Site, 2009

Area	Contamination Area,[a] ha (acres)		Underground Radioactive Materials Area,[b] ha (acres)		Interim Closed Area, ha (acres)	
100-B/C	0	(0)	17	(42)	29	(72)
100-D/DR	0	(0)	18	(46)	10	(24)
100-F	0	(0)	3	(7)	19	(47)
100-H	0	(0)	7	(17)	7	(17)
100-K	5	(12)	45	(111)	20	(49)
100-N	0.4	(1)	16	(40)	27	(66)
200-East[c]	71	(175)	141	(348)	0	(0)
200-West[c]	27	(67)	224	(554)	0	(0)
300	0	(0)	41	(101)	23	(57)
400	0	(0)	0	(0)	0	(0)
600[d]	3,478	(8,594)	49	(120)	6	(16)
Totals	**3,581**	**(8,849)**	**561**	**(1,386)**	**141**	**(348)**

(a) Includes areas posted as contamination/soil contamination or as radiologically controlled and areas that had both underground radioactive material and contamination/soil contamination.
(b) Includes areas with *only* underground contamination.
(c) Includes tank farms.
(d) Includes BC Controlled Area, Environmental Restoration Disposal Facility, and waste-disposal facilities outside the 200-East and 200-West Areas boundaries.

Table 8.11.3. Change in Status of Outdoor Contamination Areas on the Hanford Site, 2010

Area	Change	Area, ha (acres)	
100	CA/URM to interim closed[a]	14	(34)
200-East	None to report	0	(0)
200-North	CA/URM to rejected[a]	3	(6)
200-West	None to report	0	(0)
300	CA/URM to interim closed[a]	1	(3)
400	None to report	0	(0)
600	None to report	0	(0)
Totals		**18**	**(43)**

(a) Change due to remediation activities.
CA = Contamination/soil contamination area.
URM = Underground radioactive material area.

indicate that current radiation levels are at or near background levels and are stable or decreasing as onsite cleanup activities progress. Readers interested in reviewing measurement and survey readings obtained in 2005 or earlier should refer to previous Hanford Site environmental reports and related data appendices (see http://msa.hanford.gov/msa/index.cfm/Env._Reports_2001_-_Latest; http://msa.hanford.gov/msa/index.cfm/Env._Reports_1959_-_2000).

In response to DOE discontinuing the site-wide and offsite monitoring program in 2006, Washington State Department of Health added 26 TLD sites along the Columbia River to the original sites monitored by Pacific Northwest National Laboratory and began an independent monitoring program. Annual environmental radiation monitoring and assessment reports are available at http://www.doh.wa.gov/ehp/rp/rp-publ.htm#envrad.

8.12 Potential Radiological Doses from 2010 Hanford Site Operations

EJ Antonio and SF Snyder

During 2010, 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 2010 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, Chg 2; Section 8.12.1)
- Collective dose to the population residing within 80 kilometers (50 miles) of Hanford Site operation areas (Section 8.12.2)
- 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 8.12.3)
- Dose to a worker consuming drinking water on the Hanford Site (Section 8.12.4.2)
- Doses from non-DOE industrial sources on and near the Hanford Site (Section 8.12.5)
- Absorbed dose received by organisms exposed to radionuclide releases to the Columbia River and to radionuclides in onsite surface water bodies (Section 8.12.6).

Radiological dose assessments are generally based on direct measurements of radiation dose rates and radionuclide concentrations. However, amounts of most radioactive materials released in 2010 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 caused by fallout and naturally occurring uranium and its decay products. Therefore, in nearly all instances, offsite doses were estimated using *GENII Version 2 Software Design Document* (PNNL-14584, Rev. 3) and the Hanford Site-specific parameters listed in Appendix E.

Calculations of radiation dose require the use of biological and radiological models of the behavior of radioactive material in the human body and in the environment. Scientific understanding of these processes has improved over time. For many decades, researchers reported calculated doses for the Hanford Site to the public. In the 1960s, the annual environmental reporting at the Hanford Site used the recommendations and methodologies of the International Commission on Radiological Protection (ICRP) Report 2 (ICRP 1959). Similar techniques were used through the mid-1970s when the annual reports began to follow the newer recommendations in ICRP Reports 26 and 30 (ICRP 1977, 1979), and later incorporated the radiation weighting factors and tissue weighting factors in ICRP Publication 42 (ICRP 1984), along with dose factors from the EPA in Federal Guidance Reports 11 and 12 (EPA 520/1-88-020; EPA 402-R-93-081). The GENII Version 1 computer code, used at the Hanford Site since 1988, uses ICRP 26/30 methods (ICRP 1977, 1979), ICRP 42 weighting factors (ICRP 1984), and EPA dose factors. The computer code,

GENII Version 2 (PNNL-14584, Rev. 3)—first used for Hanford Site dose estimation for 2009 emissions—incorporates the internal dosimetry models recommended in ICRP Reports 60 and 72 (ICRP 1991, 1996) and the radiological risk estimating procedures of Federal Guidance Report No. 13 (EPA 402-R-99-001) along with recently updated versions of environmental pathway analysis models. GENII Version 2.10 was used for 2010 dose estimations (PNNL-14583, Rev 3a).

Radiological doses from the water pathway were calculated based on known releases to the Columbia River from the 100 Areas (see Table 8.3.2) and the differences in radionuclide concentrations between upstream and downstream sampling points on the Columbia River (considered the contribution from the 200 Areas). 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 8.5 and 8.7). During 2010, tritium and uranium isotopes were found in the Columbia River downstream of the Hanford Site at greater levels than predicted, based on river sampling; in addition, strontium-90, cesium-137, and plutonium isotopes entered the river from direct discharges from the 100-K Area (Section 8.3 and Appendix C). All other radionuclide concentrations in river water were lower than those predicted from known releases. No direct discharge of radioactive materials from the 300 Area to the Columbia River was reported during 2010.

8.12.1 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 any member of the public would have received a higher radiological dose from Hanford Site releases during 2010. 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, Chg 2). 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 8.12.1). During 2010, the dose assessment determined that the maximally exposed individual was located across the Columbia River (east of

Historically at the Hanford Site, there has been one primary expression of radiological risk to an offsite individual—this is the maximally exposed individual dose. However, the maximally exposed individual dose is currently calculated by two different methods in response to two different requirements. One maximally exposed individual dose computation is required by DOE Order 5400.5, Chg 2 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 the Hanford Site'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 the site's stack emissions and emissions from diffuse and unmonitored sources (e.g., windblown dust).

Because the DOE and EPA computer codes use different input parameters, the location and predicted dose of each agency's maximally exposed individual may be different. However, the estimated doses from both methods have historically been significantly lower than health-based exposure criteria.

Recently, 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.

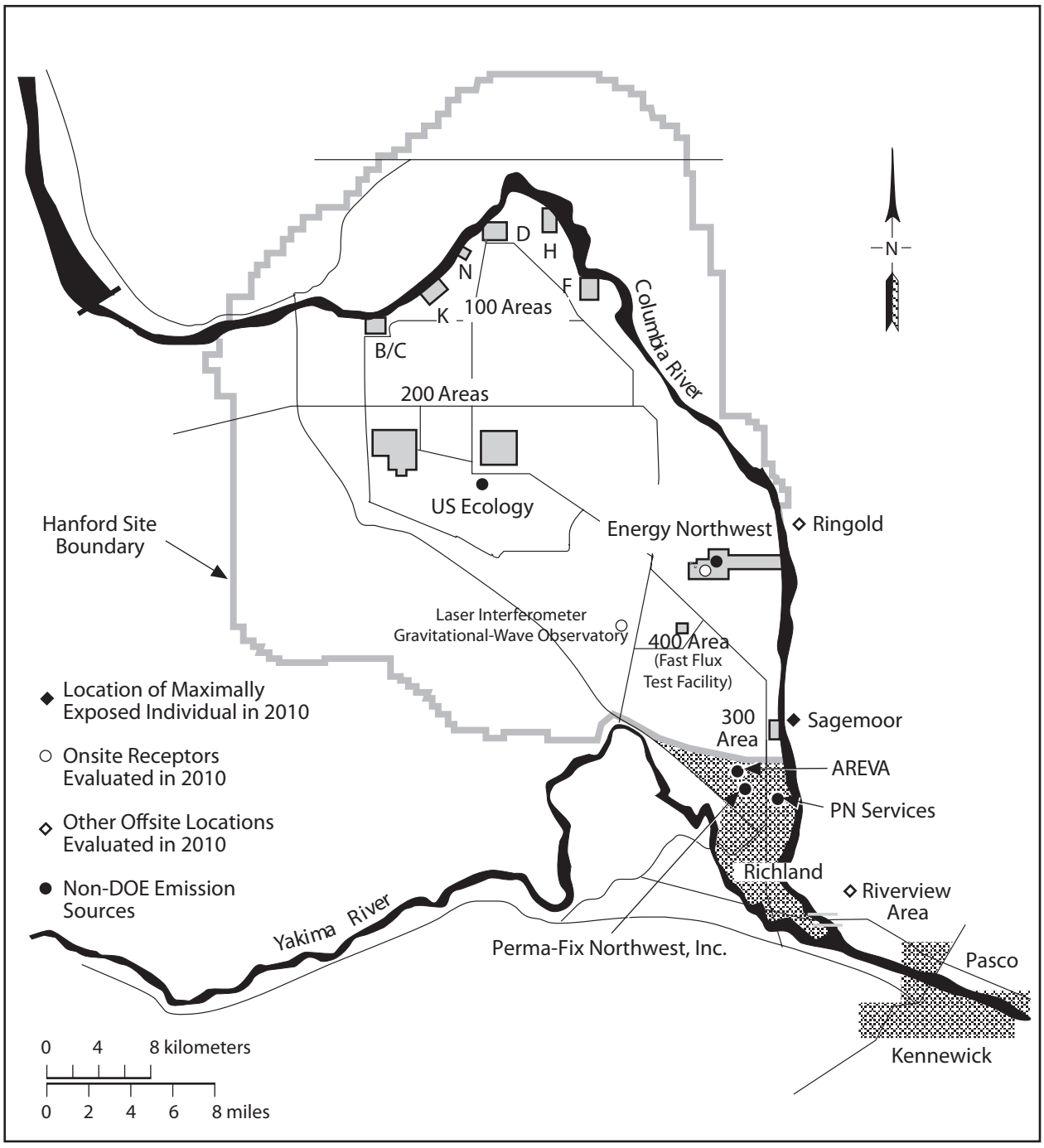

Figure 8.12.1. Locations Important to Dose Calculations at the Hanford Site, 2010

the Hanford Site) at Sagemoor. For the calculation, it was assumed this individual had performed the following:

- Inhaled and was immersed in airborne radionuclides
- Received external exposure to radionuclides deposited on the ground
- Ingested locally grown food products irrigated with Columbia River water and/or containing radionuclides deposited from the air
- Used the Columbia River near the Hanford Site for recreational purposes, resulting in direct exposure from radionuclides in water and radionuclides deposited on the shoreline
- Consumed locally caught Columbia River fish.

Doses were calculated using Hanford Site air emissions and liquid effluent data (Tables 8.1.1 and 8.3.2) and the calculated quantities of radionuclides assumed to be present in the Columbia River. 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 (Appendix C, Tables C.3 and C.4, respectively). These radionuclides were assumed to originate from historical releases of contaminants to the ground in the 100 and 200 Areas, and to have entered the Columbia River through shoreline groundwater springs between the 100-B/C Area and the 300 Area.

During 2010, the total dose to the maximally exposed individual at Sagemoor (Figure 8.12.1) was calculated to be 0.18 millirem (1.8 microsievert) per year (Table 8.12.1; Figure 8.12.2). This dose was 0.18% of the 100-millirem (1,000-microsievert) per-year standard specified in DOE Order 5400.5, Chg 2. The primary pathways (Appendix E, Tables E.1 through E.4) contributing to this dose (and the percentage of all pathways) were as follows:

- Inhalation of air downwind from the Hanford Site (9%) and the consumption of food products grown downwind from the Hanford Site (approximately 60%), resulting from exposure to airborne releases of tritium and radon from the 300 Area
- Consumption of food irrigated with Columbia River water withdrawn downstream from the Hanford Site (12%) and consumption of fish from the Columbia River (20%), resulting primarily from exposure to uranium isotopes in the river.

8.12.2 Collective Dose

Collective dose is defined as the sum of doses to all individual members of the public within a defined distance of a specific location. The regional collective dose from 2010 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

Table 8.12.1. Dose to the Hypothetical, Maximally Exposed Individual Residing at Sagemoor from 2010 Hanford Site Operations (using GENII Version 2.10)

		Dose Contributions from Operating Areas, mrem[a]				
Effluent	Pathway	100 Areas	200 Areas	300 Area	400 Area	Pathway Total
Air	External	4.6×10^{-9}	1.4×10^{-7}	2.3×10^{-4}	1.6×10^{-9}	2.3×10^{-4}
	Inhalation	7.1×10^{-6}	1.4×10^{-5}	1.6×10^{-2}	6.7×10^{-10}	1.6×10^{-2}
	Foods	1.8×10^{-6}	1.8×10^{-4}	1.1×10^{-1}	4.6×10^{-8}	1.1×10^{-1}
	Subtotal air	**8.9×10^{-6}**	**1.9×10^{-4}**	**1.2×10^{-1}**	**4.8×10^{-8}**	**1.2×10^{-1}**
Water	Recreation	9.2×10^{-7}	2.1×10^{-4}	0.0	0.0	2.1×10^{-4}
	Foods	1.8×10^{-5}	2.1×10^{-2}	0.0	0.0	2.1×10^{-2}
	Fish	2.0×10^{-4}	3.5×10^{-2}	0.0	0.0	3.5×10^{-2}
	Subtotal water	**2.2×10^{-4}**	**5.6×10^{-2}**	**0.0**	**0.0**	**5.6×10^{-2}**
Combined total		**2.2×10^{-4}**	**5.6×10^{-2}**	**1.2×10^{-1}**	**4.8×10^{-8}**	**1.8×10^{-1}**

(a) To convert millirem (mrem) to microsievert, multiply by 10.

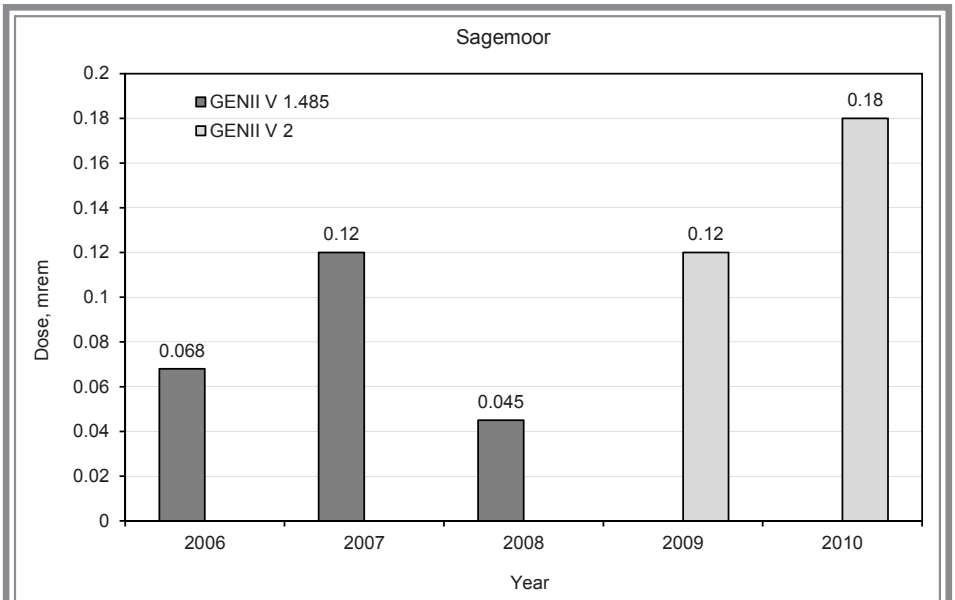

Figure 8.12.2. Calculated Dose to the Hypothetical, Maximally Exposed Individual Near the Hanford Site, 2006 Through 2010 (to convert mrem to microsievert, multiply by 10)

(Appendix E, Tables E.5 and E.6). During 2010, the collective dose calculated for the population using GENII Version 2.10 was 1.1 person-rem (0.011 person-sievert) per year (Table 8.12.2; Figure 8.12.3), which is slightly greater than the 2009 collective dose of 1.0 person-rem (0.01 person-sievert) (PNNL-19455).

Primary pathways contributing to the 2010 collective dose (and the percentage of all pathways) included the following:

- Consumption of food grown downwind of the Hanford Site (approximately 22%) and inhalation of radionuclides (6%) that were released to the air, principally tritium and radon from the 300 Area and iodine-129 from the 200 Areas
- Consumption of water withdrawn from the Columbia River downstream of the Hanford Site (69%) and foods irrigated with water withdrawn from the Columbia River downstream of the site (approximately 2%) containing tritium, strontium-90, cesium-137, uranium-234, uranium-235, plutonium-238, uranium-238, and plutonium-239/240.

Collective doses reported for 2010 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.

The average individual dose from Hanford Site operations, based on the population exposed to emissions from all evaluated air and water release points, was approximately 0.0022 millirem (0.022 microsievert) in 2010. To place the average individual 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 8.12.4). In March 2009, the National Council on Radiation Protection issued Report 160, which concluded that Americans were exposed to more than seven times as much ionizing radiation from medical procedures as was the case in the 1980s, causing the overall average exposure to ionizing radiation for the average American to rise from 360 to 620 millirem (3,600 to 6,200 microsievert) per year (National Council on Radiation Protection and Measurements 2009). The estimated annual average individual dose (0.0022 millirem [0.022 microsievert]) to members of the public from Hanford Site sources in 2010 was approximately 0.0007% of the

Table 8.12.2. Collective Dose to the Population from 2010 Hanford Site Operations (using GENII Version 2.10)

		Dose Contributions from Operating Areas, person-rem[a]				
Effluent	Pathway	100 Areas	200 Areas	300 Area	400 Area	Pathway Total
Air	External	1.7×10^{-6}	1.3×10^{-5}	9.2×10^{-4}	5.7×10^{-8}	9.3×10^{-4}
	Inhalation	1.8×10^{-3}	2.3×10^{-3}	5.6×10^{-2}	4.1×10^{-8}	6.0×10^{-2}
	Foods	2.4×10^{-4}	1.8×10^{-2}	2.2×10^{-1}	1.8×10^{-6}	2.4×10^{-1}
	Subtotal air	**2.0×10^{-3}**	**2.1×10^{-2}**	**2.8×10^{-1}**	**1.8×10^{-6}**	**3.0×10^{-1}**
Water	Recreation	4.0×10^{-6}	1.2×10^{-3}	0.0	0.0	1.2×10^{-3}
	Foods	2.7×10^{-5}	2.2×10^{-2}	0.0	0.0	2.2×10^{-2}
	Fish	7.4×10^{-5}	1.3×10^{-2}	0.0	0.0	1.3×10^{-2}
	Drinking water	1.5×10^{-4}	7.4×10^{-1}	0.0	0.0	7.4×10^{-1}
	Subtotal water	**2.5×10^{-4}**	**7.8×10^{-1}**	**0.0**	**0.0**	**7.8×10^{-1}**
Combined total		**2.3×10^{-3}**	**8.0×10^{-1}**	**2.8×10^{-1}**	**1.8×10^{-6}**	**1.1×10^{0}**

(a) To convert person-rem to person-sievert, divide by 100.

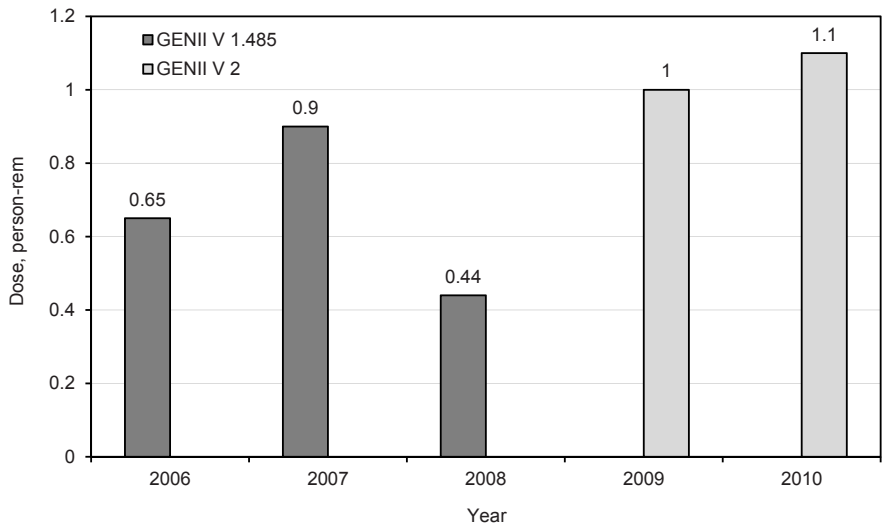

Figure 8.12.3. Collective Dose to the Population within 80 Kilometers (50 miles) of Hanford Site Operating Areas, 2006 Through 2010 (to convert person-rem to person-sievert, divide by 100)

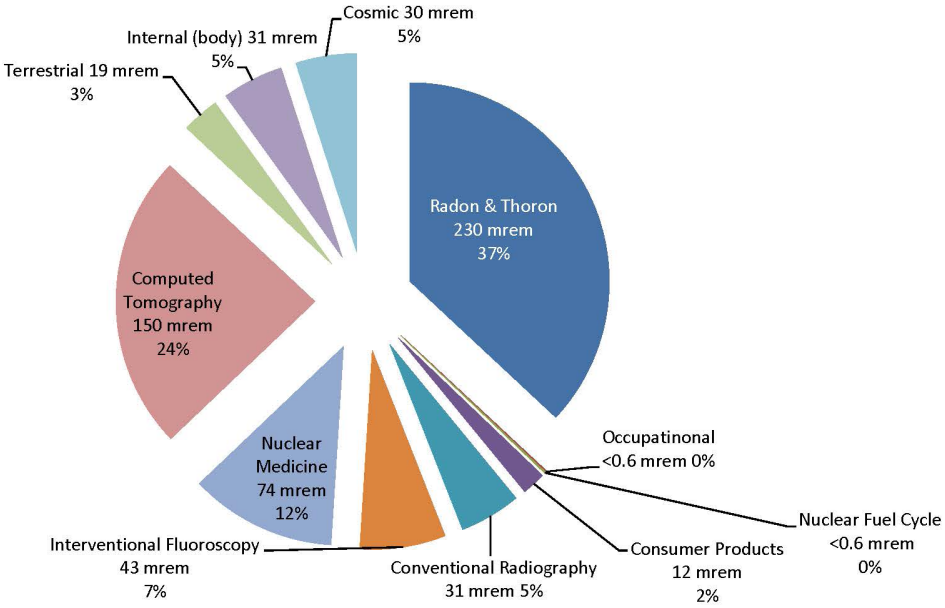

Figure 8.12.4. Annual National Average Radiological Doses from Various Sources (National Council on Radiation Protection and Measurements 2009)

estimated annual individual dose received from natural background sources (approximately 310 millirem [3,100 microsievert]). The calculated radiological doses from Hanford Site operations in 2010 were a small percentage of the federal standards and of doses from natural background sources (Table 8.12.3).

8.12.3 Compliance with *Clean Air Act* Standards

In addition to complying with the all-pathways dose limits established by DOE Order 5400.5, Chg 2, officials managing DOE facilities are required to demonstrate their facilities comply with standards established by EPA for airborne radionuclide emissions under the *Clean Air Act* in 40 CFR 61, Subpart H. This regulation specifies that no member of the public shall receive a dose greater than 10 millirem (100 microsievert) per year from exposure to airborne radionuclide emissions (other than radon) released at DOE facilities. Whereas DOE uses the GENII computer code at the Hanford Site to determine dose to the all-pathways maximally exposed individual, 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 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 8.12.1).

The EPA regulation also requires that an annual report for each DOE facility be submitted to EPA that supplies information about atmospheric emissions for the preceding year and any potential contributions to offsite dose. For more detailed information about 2010 air emissions at the Hanford Site, refer to the DOE's report to EPA, *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2010* (DOE/RL-2011-12).

8.12.3.1 Dose to an Offsite Maximally Exposed Individual

Using EPA-specified methods, the maximally exposed offsite individual for air pathways in 2010 was in the Sagemoor area of Franklin County, approximately 1.4 kilometers

Table 8.12.3. Comparison of Doses to the Public from Hanford Site Effluent and Emissions to Federal Standards and Natural Background Levels, 2010

Dose Limit or Natural Background Level	Hanford Site Dose	Percent of Standard or of Background Dose
Federal Standard		
DOE - 100 mrem/yr[a] all pathways MEI[b]	0.18 mrem	0.18
EPA - 10 mrem/yr[a] air pathway MEI[c]	0.067 mrem	0.67
Background Dose		
Natural background individual - 310 mrem/yr average from natural background U.S. individual[d]	0.0022 mrem	0.0007
Natural background population - 150,700 person-rem/yr to population within 80 km (50 mi)[e]	1.1 person-rem	0.0007

(a) To convert the dose values to microsievert, multiply by 10.
(b) DOE Order 5400.5, Chg 2.
(c) 40 CFR 61.
(d) National Council on Radiation Protection and Measurements (2009).
(e) To convert the dose values to person-sievert, divide by 100.
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.
MEI = Maximally exposed individual.

(0.8 mile) east of the 300 Area, across the Columbia River (Figure 8.12.1). The potential air pathway dose from stack emissions (excluding radon) to a maximally exposed individual at that location calculated using the CAP-88 computer code was determined to be 0.053 millirem (0.53 microsievert) per year, which represented less than 1% of the EPA standard. The dose from radon-220 and radon-222 was 0.014 millirem (0.14 microsievert) in 2010.

Radon is not included in the dose calculated for compliance with the EPA standard in 40 CFR 61, but is regulated by the 10-millirem (100-microsievert) per year standard established by Washington State in WAC 246-247. The total dose from stack emissions was therefore 0.067 millirem (0.67 microsievert) per year, including radon, which represented about 0.7% of the Washington State standard. This is similar to the offsite individual doses calculated in previous years and to the air pathway doses for stack emissions in Table 8.12.1.

8.12.3.2 Maximum Dose to Non-U.S. Department of Energy Workers at the Hanford Site

The EPA Region 10 Office and the Washington State Department of Health provided guidance to the DOE Richland Operations Office that, when demonstrating compliance with 40 CFR 61 standards, it should evaluate potential doses to non-DOE employees who work at facilities within the Hanford Site but who are not under direct DOE 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 2010 EPA air emissions report (DOE/RL-2011-12). 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 8.12.1). 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 0.0054 millirem (0.054 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 2010, the estimated doses to all non-DOE onsite workers were lower than the dose to an offsite maximally exposed individual.

8.12.3.3 Dose from Diffuse and Fugitive Radionuclide Emissions

The December 15, 1989, revisions to the *Clean Air Act* (40 CFR 61, Subpart H) required DOE facilities to estimate the dose to a member of the public for radionuclides released from all potential sources of airborne radionuclides. DOE and EPA interpreted the regulation to include diffuse (widespread) and fugitive (unintended) emissions, as well as emissions from monitored point sources (i.e., stacks). EPA has not specified or approved standardized methods to estimate diffuse air-emissions because of the wide variety of sources at DOE sites. The method developed at the Hanford Site to estimate potential diffuse emissions is based on environmental monitoring measurements of airborne radionuclides at the site perimeter (DOE/RL-2011-12).

During 2010, 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 0.0081 millirem (0.081 microsievert) per year. This is somewhat lower than results for recent years, where the dose from diffuse emissions has been comparable to the dose from stack emissions. 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 2010 was well below the EPA 10-millirem (100-microsievert) per year standard for either onsite or offsite members of the public.

8.12.4 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. Two scenarios that could have potentially led to larger doses included 1) an individual who consumed contaminated wildlife that migrated from the Hanford Site, and 2) an individual who drank water at the Fast Flux Test Facility in the 400 Area. The potential doses resulting from these scenarios are examined in the following sections.

8.12.4.1 Outdoor Recreationalist Dose

Wildlife have access to Hanford Site areas that are contaminated with radioactive materials and have the potential to acquire radioactive contamination and migrate off the site. Wildlife sampling was conducted at the Hanford 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 2010 included potassium-40, a primordial radioisotope not of Hanford Site origin; strontium-90, an anthropogenic radionuclide produced in the fission process and present in worldwide fallout from historic nuclear weapons tests; cesium-137, another anthropogenic radionuclide produced in the fission process and present in worldwide fallout; uranium-234 and uranium-238, primordial radionuclides; and plutonium-238 and plutonium-239, an anthropogenic radionuclide that is present in worldwide fallout. The maximum detectable concentration of strontium-90 (12.4 pCi/g [459 Bq/kg]) was measured in a cottontail rabbit bone sample collected onsite at the 100-N Area. Because bone is not normally consumed by humans, it is not considered further. The maximum detectable concentration of cesium-137 (0.147 pCi/g [5.44 Bq/kg]) was in a mule deer muscle sample donated by a hunter from an offsite, distant location. The maximum uranium-234 (0.0017 pCi/g [0.063 Bq/kg]) was detected in a carp muscle sample collected from the Columbia River from around the 300 Area. The maximum detectable concentration of uranium-238 (0.00186 pCi/g [0.069 Bq/kg]) was found in a different carp muscle sample also collected from the Columbia River from around the 300 Area. The maximum detectable concentration of plutonium-238 (0.00163 pCi/g [0.060 Bq/kg]) was detected in a cottontail rabbit liver sample collected

near Moses Lake, Washington. The maximum detectable concentration of plutonium-239/240 (0.000845 pCi/g [0.0313 Bq/kg]) was detected in a cottontail rabbit liver sample collected near Moses Lake. Because cottontail rabbit liver is not normally consumed by humans, it is not considered further.

Listed below are estimates of the radiological doses that could have resulted if wildlife containing the maximum concentrations measured in 2010 were consumed.

- The dose from eating 1 kilogram (2.2 pounds) of deer meat that contains the maximum concentration of cesium-137 (0.147 pCi/g [5.4 Bq/kg]) measured in a mule deer harvested near Deer Park, Washington, is estimated to be 0.63 millirem (6.3 microsievert).
- The dose from eating 1 kilogram (2.2 pounds) of carp muscle that contains the maximum concentration of uranium-234 (0.0017 pCi/g [0.063 Bq/kg]) measured in 2010 is estimated to be 0.31 microrem (3.1 nanosievert).
- The dose from eating 1 kilogram (2.2 pounds) of carp muscle that contains the maximum concentration of uranium-238 (0.00186 pCi/g [0.069 Bq/kg]) measured in 2010 is estimated to be 0.33 microrem (3.3 nanosievert).

The methodology for calculating doses from consumption of wildlife was to multiply the maximum concentration measured in edible tissue by the amount consumed (1 kilogram [2.2 pounds]) and an ingestion dose conversion factor for that radionuclide taken from Federal Guidance Report 13 (EPA 402-R-99-001).

8.12.4.2 Onsite Drinking Water

During 2010, 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 2010 were below applicable drinking water standards. Tritium was the only radionuclide identified above detection limits and only in the 400 Area drinking water samples.

Based on the annual average tritium concentration of 5,863 pCi/L (217 Bq/L), the potential annual dose to a worker at the Fast Flux Test Facility (400 Area) in 2010 would be approximately 0.2 millirem (2 microsievert) (Appendix E, Table E.7). This dose estimate was derived by using dose factors based on Federal Guidance Report 13 (EPA 402-R-99-001), assuming a consumption rate of 1 liter (0.26 gallon) per day for 250 working days. This estimate well below the drinking water dose limit of 4 millirem (40 microsievert) per year for public drinking water supplies.

8.12.5 Doses from Non-U.S. Department of Energy Sources

DOE Order 5400.5, Chg 2, 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 2010, 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, Inc.; 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 8.12.1).

DOE maintains an awareness of these other sources of radiation, which, if combined with the DOE sources, might have the potential to cause a dose exceeding 10 millirem (100 microsievert) per year to any member of the public. With information gathered from these companies through various communication methods and annual reporting, it was conservatively estimated that the total 2010 individual dose from non-DOE source activities was about 0.004 millirem (0.04 microsievert) per year. Therefore, the combined annual dose from non-DOE and DOE sources on and near the Hanford Site to a member of the public for 2010 was well below any regulatory dose limit.

8.12.6 Dose to Non-Human Biota

Upper estimates of the radiological dose to aquatic organisms were made in accordance with the DOE Order 5400.5,

Chg 2 interim requirement for management and control of liquid discharges. The current dose limit for native-aquatic animal organisms is 1 rad (10 milligray) per day. The proposed dose limit for terrestrial biota is 0.1 rad (1 milligray) 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 milligray] per day for aquatic biota). For samples containing multiple radionuclides, a sum of fractions is calculated to account for the contribution to dose from each radionuclide relative to the dose guideline. If the sum of fractions exceeds 1.0, then the dose guideline has been exceeded. If the initial estimated screening value (Tier 1) exceeds the guideline (sum of fractions more than 1.0), another screening calculation is performed (Tier 2) to more accurately evaluate exposure of the biota to the radionuclides. The process may culminate in a site-specific assessment requiring additional sampling and study of exposure. Biota-dose screening assessments were conducted using surveillance data collected in 2010 from on and around the Hanford Site.

Researchers used the RESRAD-BIOTA computer code to evaluate potential effects on biota from the maximum concentrations of radionuclides measured in sediment, onsite pond water, and Columbia River shoreline spring water as tabulated in Appendix C. 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 listed in Table 8.12.4 show the concentrations in all water and sediment samples passed the Tier 1 screen, indicating that the calculated doses were below dose limits and guidelines (sum of fractions less than 1.0).

Table 8.12.4. Results of Using the RESRAD-BIOTA[a] Computer Code to Estimate Radiological Doses to Biota On and Around the Hanford Site, Using 2010 Onsite Pond Water, Columbia River Shoreline Spring Water, and River and Pond Sediment

Location	Tier 1 Screen, Sum of Fractions[b]	Pass or Fail
100-B Area	0.12	Pass
100-D Area	0.00056	Pass
100-F Area	0.019	Pass
100-H Area	0.029	Pass
100-K Area	0.099	Pass
100-N Area	0.000014	Pass
300 Area Springs	0.35	Pass
Hanford town site	0.028	Pass
McNary Dam	0.29	Pass
Priest Rapids Dam	0.24	Pass
Richland Spring/River	0.015	Pass
West Lake	0.38	Pass
White Bluffs Slough	0.15	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.

8.12.7 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 greater than radiation from current Hanford Site releases, increases each individual's probability or chance of developing a detrimental health effect.

Scientists do not fully agree on how to translate the available data on health effects into the numerical probability (risk) of detrimental effects from low radiological doses. Some scientific studies have indicated that low radiological doses result in beneficial effects (Sagan 1987). Because cancer and hereditary diseases in the general population are caused by many sources (e.g., genetic defects, sunlight, chemicals, and background radiation), some scientists doubt that the risk from low-level radiation exposure can ever be conclusively proven. In developing *Clean Air Act* regulations, 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 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). 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 8.12.5 compares the estimated risks from various radiological doses to the risks of some activities encountered in everyday life. Some activities that are estimated to be approximately equal in risk to that from the dose received by the maximally exposed individual from monitored Hanford Site effluents and emissions during 2010 are shown in Table 8.12.6.

Table 8.12.5. Estimated Risk from Various Activities and Exposures[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 (310 mrem [3,100 µSv])	0 to 190×10^{-6}
Flying as an airline passenger (cross-country roundtrip – radiation)	0 to 8×10^{-6}
Dose of 1 mrem (10 µSv) for 70 yr	0 to 40×10^{-6}
Dose to the hypothetical, maximally exposed individual living near the Hanford Site	0 to 0.1×10^{-6}

(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 8.12.6. Activities Comparable in Risk to the 0.18-mrem (1.8-µSv) Dose Calculated for the Hanford Site Maximally Exposed Individual in 2010

Driving or riding 26 km (16 mi) in a car	Eating 4.4-kg (9.8-lb) of charcoal-broiled steak
Smoking 1/5 of a cigarette	Drinking 26 L (6.9 gal) of chlorinated tap water
Flying ~140 km (86 mi) on a commercial airliner	Drinking 1.4 L (47 oz) of beer or 0.5 L (16 oz) of wine
Eating 20 Tbsp (~290 mL) of peanut butter	Exposed to the U.S. national average background dose for 5 hours

8.13 Endangered and Threatened Species on the Hanford Site

MR Sackschewsky and MA Simmons

This section describes federal and state endangered and threatened species, candidate or sensitive plant and animal species, and other species of concern potentially found at 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 near 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. State lists are maintained by the Washington Natural Heritage Program (WNHP 2011) and the Washington Department of Fish and Wildlife (WDFW 2011).

The purposes of the *Endangered Species Act of 1973*, as amended, are to 1) provide a means to conserve critical ecosystems; 2) provide a program for the conservation of endangered and threatened species; and 3) ensure appropriate steps are taken to achieve the purposes of the treaties and conventions established under the Act. Washington State regulations also list 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's National Marine Fisheries Service (NOAA 2008) has the responsibility for federal listing of anadromous fish (i.e., fish 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 at the Hanford Site. Table 8.13.1 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 [*Oncorhynchus tshawytscha*] and steelhead [*Oncorhynchus mykiss*]) on the federal list of endangered and threatened species are known to regularly occur on the Hanford Site (Table 8.13.1). One additional fish species (bull trout [*Salvelinus confluentus*]) was recorded at the Hanford Site but scientists believe this species is transient. No other plants or animals known to occur on the Hanford Site are currently on the federal list of endangered and threatened species (50 CFR 17), but two plant species, one mammal species, and one bird species are currently candidates for listing under the *Endangered Species Act of 1973* (Table 8.13.1). In addition, 13 plant species and 4 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 32 state-level sensitive and candidate species of insects and animals and 14 sensitive plant species occurring or potentially occurring on the Hanford Site (Table 8.13.1).

Washington State officials maintain additional lower-level lists of species, including a monitor list for animals (WDFW 2011) and review and watch lists for plants (WNHP 2011). 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 as needed by the state to prevent them from becoming endangered, threatened, or sensitive. However, an abundance of these species may be indicative of an ecosystem with relatively high native diversity. Approximately 48 Washington State monitor list animal and insect species occur or potentially occur on the Hanford Site (Table 8.13.2), and 23 watch or review list plant species are potentially found on the Hanford Site (Table 8.13.3).

Table 8.13.1. 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
chaffweed	*Anagallis* (= *Centunculus*) *minimus*		Threatened
Columbia milkvetch	*Astragalus columbianus*	Species of concern	Sensitive
Columbia yellowcress	*Rorippa columbiae*	Species of concern	Endangered
coyote tobacco	*Nicotiana attenuata*		Sensitive
desert cryptantha	*Cryptantha scoparia*		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	*Aliciella* (= *Gilia*) *leptomeria*		Threatened
Hoover's desert parsley	*Lomatium tuberosum*	Species of concern	Sensitive
loeflingia	*Loeflingia squarrosa* var. *squarrosa*		Threatened
lowland toothcup	*Rotala ramosior*		Threatened
Piper's daisy	*Erigeron piperianus*		Sensitive
rosy pussypaws	*Cistanthe* (= *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
river lamprey[c]	*Lampetra ayresi*	Species of concern	Candidate
spring-run Chinook salmon	*Oncorhynchus tshawytscha*	Endangered	Candidate
steelhead	*Oncorhynchus mykiss*	Threatened	Candidate

Table 8.13.1. (contd)

Common Name	Scientific Name	Federal Status[a]	State Status[a]
Amphibians and Reptiles			
sagebrush lizard	*Sceloporus graciosus*	Species of concern	Candidate
striped whipsnake	*Masticophis taeniatus*		Candidate
western toad	*Bufo boreas*	Species of concern	Candidate
Birds			
American white pelican	*Pelecanus erythrorhynchos*		Endangered
bald eagle	*Haliaeetus leucocephalus*	Species of concern	Sensitive[d]
burrowing owl	*Athene cunicularia*	Species of concern	Candidate
Clark's grebe	*Aechmophorus clarkii*		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 lewis*		Candidate
loggerhead shrike	*Lanius ludovicianus*	Species of concern	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	*Aechmophorus 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 of 1973*, 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.

Table 8.13.2. Washington State Monitor Species Occurring or Potentially Occurring on the Hanford Site

Common Name	Scientific Name	Common Name	Scientific Name
Mollusks		**Birds (contd)**	
Oregon floater	*Anodonta oregonensis*	bobolink[a]	*Dolichonyx oryzivorus*
western floater	*Anodonta kennerlyi*	Caspian tern	*Sterna caspia*
western pearlshell	*Margaritifera falcata*	Forster's tern	*Sterna forsteri*
Insects		grasshopper sparrow	*Ammodramus savannarum*
Bonneville skipper	*Ochlodes sylvanoides bonnevilla*	gray flycatcher	*Empidonax wrightii*
juba skipper	*Hesperia juba*	great blue heron	*Ardea herodias*
Nevada skipper	*Hesperia nevada*	great egret	*Ardea alba*
Pasco pearl	*Phyciodes cocyta pascoensis*	gyrfalcon[a]	*Falco rusticolus*
Persius' duskywing	*Erynnis persius*	horned grebe	*Podiceps auritus*
purplish copper	*Lycaena helloides*	lesser goldfinch	*Carduelis psaltria*
ruddy copper	*Lycaena rubida perkinsorum*	long-billed curlew	*Numenius americanus*
viceroy	*Limenitis archippus lahontani*	osprey	*Pandion haliaetus*
Fish		prairie falcon	*Falco mexicanus*
Pacific lamprey[b]	*Lampetra tridentata*	red-necked grebe[a]	*Podiceps grisegena*
piute sculpin	*Cottus beldingi*	snowy owl	*Nyctea scandiaca*
reticulate sculpin	*Cottus perplexus*	Swainson's hawk	*Buteo swainsoni*
sand roller	*Percopsis transmontana*	turkey vulture[a]	*Cathartes aura*
Amphibians and Reptiles		western bluebird	*Sialia mexicana*
night snake	*Hypsiglena torquata*	**Mammals**	
short-horned lizard	*Phrynosoma douglassii*	badger	*Taxidea taxus*
Woodhouse's toad	*Anaxyrus woodhousii*	long-legged myotis[b]	*Myotis volans*
Birds		northern grasshopper mouse	*Onychomys leucogaster*
Arctic tern[a]	*Sterna paradisaea*	pallid bat	*Antrozous pallidus*
ash-throated flycatcher[a]	*Myiarchus cinerascens*	sagebrush vole	*Lagurus curtatus*
black tern[b]	*Chlidonias niger*	small-footed myotis[b]	*Myotis leibii*
black-crowned night-heron	*Nycticorax nycticorax*	western pipistrelle	*Pipistrellus hesperus*
black-necked stilt	*Himantopus mexicanus*		

(a) Reported, but seldom observed on the Hanford Site.
(b) Federal species of concern.

Table 8.13.3. 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 milkvetch	*Astragalus conjunctus var. rickardii*	Watch list
bristly combseed	*Pectocarya setosa*	Watch list
Columbia River mugwort	*Artemisia lindleyana*	Watch list
crouching milkvetch	*Astragalus succumbens*	Watch list
false pimpernel	*Lindernia dubia var. 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* =(*Anthoxanthm hirtum*)	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.

8.14 Ecological Monitoring on the Hanford Site

The Hanford Site is a relatively undisturbed area of shrub steppe supporting a rich diversity of plant and animal species adapted to the semi-arid environment of the Columbia Plateau. To assist the DOE Richland Operations Office in complying with legal and regulatory requirements for the biological resources found at the Hanford Site, and to protect sensitive resources and habitats, Ecological Monitoring and Compliance Project personnel collect and summarize ecological data and information needed to monitor, assess, and conserve the resources found at the site. Project personnel survey and monitor resources and key biota to assess the abundance, vigor (condition), and distribution of populations and species at the Hanford Site. Data collection and analysis are integrated with environmental monitoring of biotic and abiotic media under the Surface and Environmental Surveillance Project and analytical results are used to characterize any potential risk or impact to the biota. Ecological monitoring and ecological compliance support the Hanford Site's waste management and environmental restoration mission through the following activities:

- Assure the Hanford Site's 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*, as well as compliance with Executive and DOE Orders
- Provide data for environmental impact and ecological risk assessments
- Provide information and maps of the distribution and condition of biological resources at the Hanford Site
- Support Hanford Site land-use planning and stewardship.

Inventory and monitoring activities conducted under the Ecological Monitoring and Compliance Project 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. Such activities also provide information useful to the Hanford Site natural resource stakeholders and the public on the status of some of the site's most highly valued biological resources.

This section provides inventory, monitoring, and survey information for species and communities found at the Hanford Site during 2010, and presents this information in context with historical data and trend information. Ecological compliance activities and efforts related to inventory and management of threatened and endangered species are also included in this section.

8.14.1 Population Monitoring

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 and animal species to thrive at the Hanford Site that are displaced elsewhere in the Columbia Basin by agriculture and development. Population level surveys are conducted to monitor fish, wildlife, and plants to develop baseline information and to monitor any changes resulting from Hanford Site operations.

Plant populations monitored at the Hanford Site include taxa classified by Washington State regulations as endangered, threatened, or sensitive (see Section 8.13) and those species listed as Review Group 1 (i.e., taxa in need of additional field work before status can be determined) (WNHP 2008). Species monitored during 2010 included Umtanum buckwheat (*Eriogonum codium*), a candidate for federal listing, and gray cryptantha (*Cryptantha leucophaea*) and Columbia yellowcress (*Rorippa columbiae*), which are federal species of concern.

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.

8.14.1.1 Rare Plant Monitoring

JL Downs

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). 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, Hoover's desert parsley (*Lomatium tuberosum*), and Columbia yellowcress. Two species, Umtanum desert buckwheat and White Bluffs bladderpod (*Physaria douglasii* ssp. *tuplashensis*), are candidates for federal listing as endangered and threatened, respectively (WNHP 2008). In addition, several areas on the Hanford Site are designated as special habitats with regard to potential occurrence of plant species of concern listed by Washington State regulations. These areas potentially support populations of rare annual forbs that have been documented in adjacent habitats.

Umtanum desert buckwheat grows only on Umtanum ridge at elevations of 335.3 to 396.2 meters (1,100 to 1,300 feet) on pumice-like basalt substrates at the ridge crest. This species occurs on exposed basalt from the Lolo Flow of the Wanapum Basalt Formation in patches along a narrow band approximately 2.5 kilometers (1.5 miles) long by less than 30 meters (100 feet) wide (Dunwiddie et al. 2001). Monitoring has been conducted over the past 13 years by the Nature Conservancy, the U.S. Fish and Wildlife Service, and the Washington State Department of Natural Resources' Natural Heritage Program as well as volunteers to these agencies. Monitoring data indicate the population of approximately 5,000 plants is likely in decline (Kaye 2007).

Limited surveys were conducted in the spring of 2010 to revisit and map several populations of gray cryptantha that occur on stabilized sand dunes outside the current boundaries of the Hanford Reach National Monument. Populations were relocated, and the numbers of individuals found were relatively unchanged from previous surveys.

Columbia yellowcress grows in cobbly substrates on the Columbia River shorelines. Surveys for Columbia yellowcress were conducted during 2010 along the Columbia River shoreline near the 100-F Area (Figure 8.14.1). Data collected in 2010 show an increase in the numbers of stems found at the 100-F Beach survey areas (Table 8.14.1). 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. Variations in numbers of stems over the past 18 years are believed to be related to river-level fluctuations that inundate habitat for this species during a large part of the growing season. Surveys are conducted during September and early October when water levels are lower than river elevations that occur during spring and summer months. Fewer than 5% of the stems are found flowering or setting seed, which indicates most of the populations increase through vegetative propagation. During the time period these populations were surveyed, the locations at which the plants were found were at higher elevations along the cobble shorelines than the original survey locations. This indicates that where suitable habitat is available, Columbia yellowcress populations have migrated up the shoreline in response to increased water levels through the growing season.

8.14.1.2 Chinook Salmon

RP Mueller

Chinook salmon are an important resource in the Pacific Northwest; they are caught commercially and for recreation and are culturally important to local Native American tribes. The most important natural spawning area for fall Chinook salmon in the mainstem Columbia River 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 8.14.2). In the early 1990s, redd estimates declined to approximately one-third of the 1989 peak. The number of redds peaked again in 1996 and 1997 and then declined before rising again in 2001. This trend continued through 2003 when an estimated 9,400 redds were counted, which was the highest count since monitoring began in 1948.

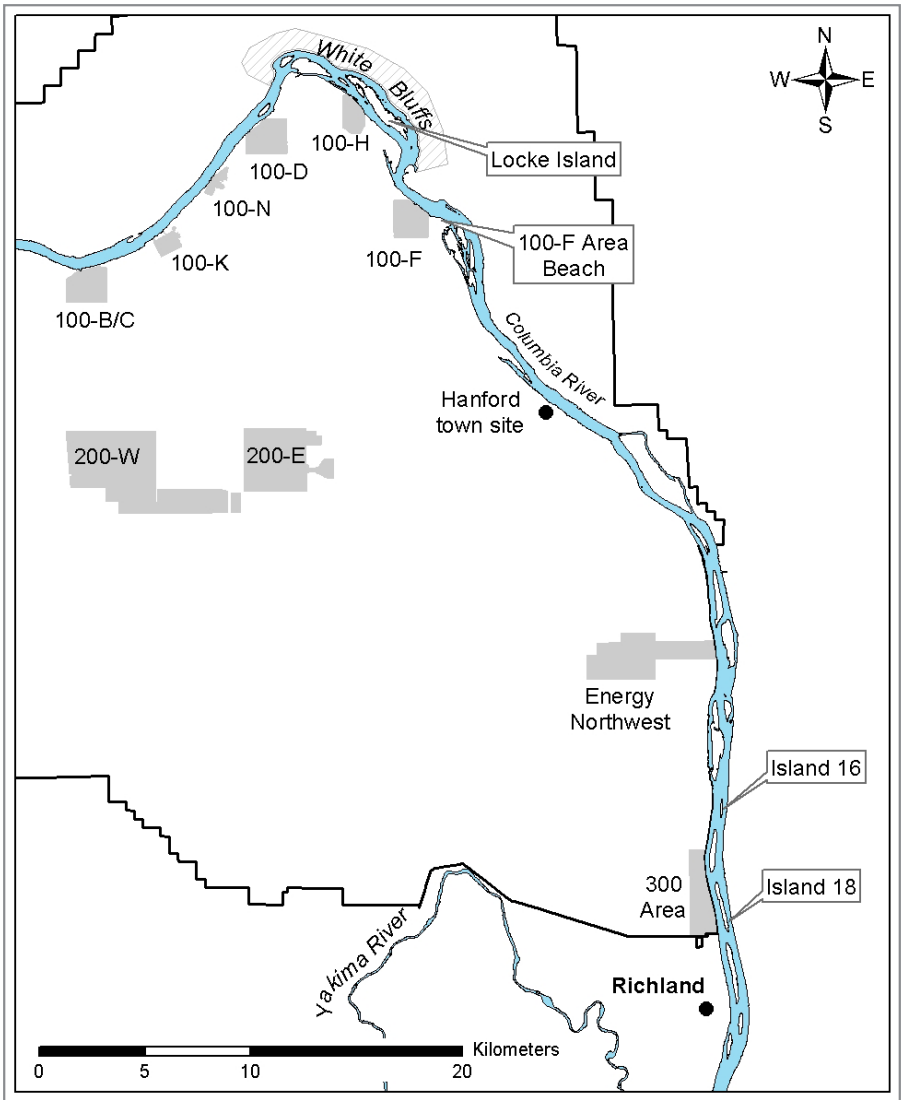

Figure 8.14.1. Survey Locations for Columbia Yellowcress (*Rorippa columbiae*) Monitoring Along the Hanford Reach

Six aerial survey flights were conducted during the fall of 2010. The majority of the flights occurred on the weekends when outflows at Priest Rapids Dam were near 50,000 cubic feet per second. The peak redd count for fall Chinook salmon in the Hanford Reach during fall 2010 was estimated at 8,817 (Figure 8.14.2). This count was 3,821 redds above the count recorded in 2009 and 2,178 redds above the 10-year average (2000-2009) of 6,639. The count for 2010 was the third highest since redd counts started in 1948. The main spawning areas observed from 2010 counts were located in the following regions, in order of abundance: Vernita Bar (Area 10), Locke Island complex (Areas 4 and 5), Islands 8-10 (Areas 2 and 3), Island 2 (Area 7), and the Ringold Area (Area 1) (Figure 8.14.3). The general locations of the spawning areas have not changed significantly over the past few years.

Aerial surveys do not yield absolute salmon redd counts because environmental conditions vary, such as water depth, water turbidity, and sun angle. 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 (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) (additional information is available on the StreamNet website at http://www.streamnet.org/).

Table 8.14.1. Number of Columbia Yellowcress (*Rorippa columbiae*) Stems Counted Along the Hanford Reach in Surveys Conducted from 1994 Through 2010

Year Surveyed	Survey Location		
	100-F Beach	Locke Island	Island 18[a]
1994	>15,000	>10,000	>10,000
1995	70	117	0
1999	94	Not surveyed[b]	Not surveyed[b]
2000	196	1,038	19
2001	17	1,793	0
2004	Not surveyed[b]	1,800	Not surveyed[b]
2005	130	Not surveyed[b]	Not surveyed[b]
2006	639	2,220	0
2007	Not surveyed[b]	Not surveyed[b]	Not surveyed[b]
2008	1,007	4,265	Not surveyed[b]
2009	1,044	>3,028	Not surveyed
2010	1,775	Not surveyed	Not surveyed

(a) Located in the Columbia River near the 300 Area.
(b) High water levels prevented access to populations.

8.14.1.3 Steelhead

RP Mueller

Steelhead within the Hanford Reach are considered part of the upper Columbia River Evolutionarily Significant Unit and are listed as endangered under the *Endangered Species Act of 1973*. In April and May 2010, two aerial observation flights were flown over the Hanford Reach from north Richland (river kilometer 547 [river mile 340]) to near the Vernita Bridge (river kilometer 624 [river mile 388]) to document the occurrence of any steelhead spawning along the shoreline regions. Flight environmental conditions were very good with clear skies and light winds. River flows were approximately 1,840 cubic meters (65,000 cubic feet) per second for both flights. 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. One possible steelhead redd was observed during both flights and located near the island region of Area #2 near river kilometer 586 (river mile 364; Figure 8.14.3).

8.14.1.4 Bald Eagle

RE Durham, MR Sackschewsky, and CA Duberstein

The bald eagle was removed from the federal threatened and endangered species list in July 2007 and its status changed from threatened to sensitive in Washington State in January 2008. Federal protection is afforded the bald eagle through the *Bald and Golden Eagle Protection Act* and the *Migratory Bird Treaty Act*. A revised *Bald Eagle Management Plan for the Hanford Site, South-Central Washington*, was published in 2009 to direct Hanford Site activities in accordance with current federal and state regulations and guidelines (DOE/RL-94-150, Rev. 1). This management plan

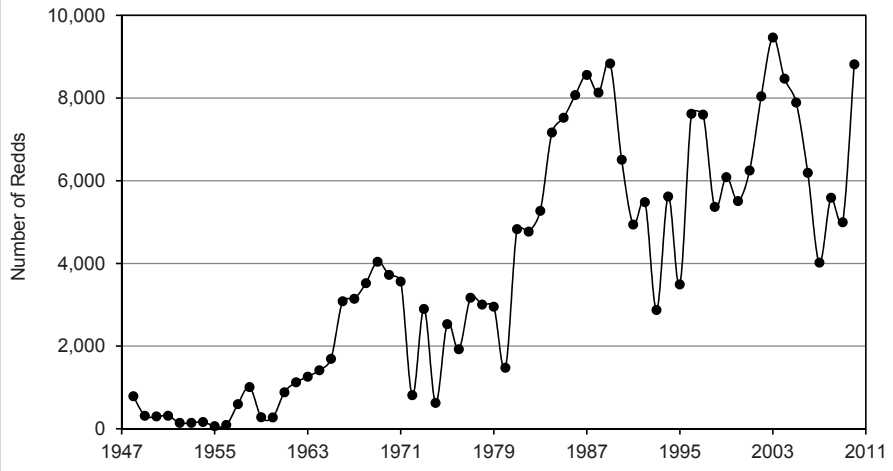

Figure 8.14.2. Number of Fall Chinook Salmon Redds in the Hanford Reach of the Columbia River, 1948-2010

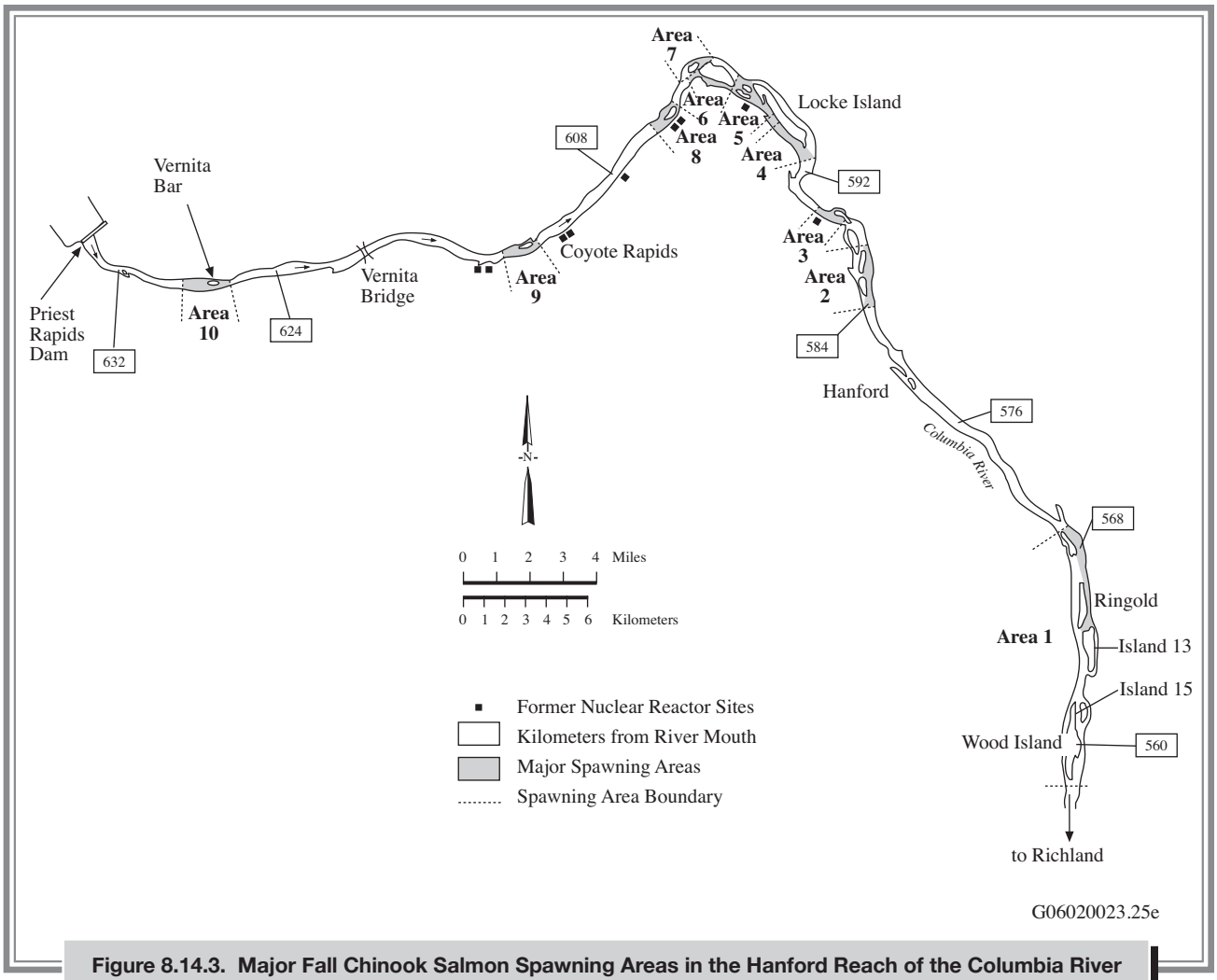

Figure 8.14.3. Major Fall Chinook Salmon Spawning Areas in the Hanford Reach of the Columbia River

outlines seasonal access restrictions around documented nesting and communal roosting sites at the Hanford Site between November 15 and March 15, and establishes guidelines for the protection of perches, roosts, and alternative nest sites located near the boat launch at the former White Bluffs town site (Figure 8.14.4).

A total of 104 surveys were conducted between mid-November 2010 and the end of March 2011. Fifty-five surveys were conducted to document eagle behavior and perch use at the 100-K Area communal night roost in response to preparatory activities and eventual demolition of the 181-KW river intake structure. In addition, 49 driving surveys were conducted to investigate possible nest-building activities and to document the number and age class of bald eagles observed using perch sites located within established protection buffers at the 100-H Area, the historical nest site, the 100-F Area, and the Hanford town site (Figure 8.14.4).

The historical nest site, located in the White Bluffs vicinity, was not occupied in 2010, marking the third consecutive winter season without an occupied bald eagle nest at the Hanford Site. Federal guidelines characterize a nest site as active up to 5 years beyond the last occupancy. Conditions along the Hanford Reach may not be suitable for nesting. Factors that potentially affect nesting activity include adverse weather, food availability, increased human activity near potential nest sites, and inter-specific competition (recorded observations include hazing and harassment by magpies and ravens, and the springtime assertion of great blue herons and Canada geese for nest site possession).

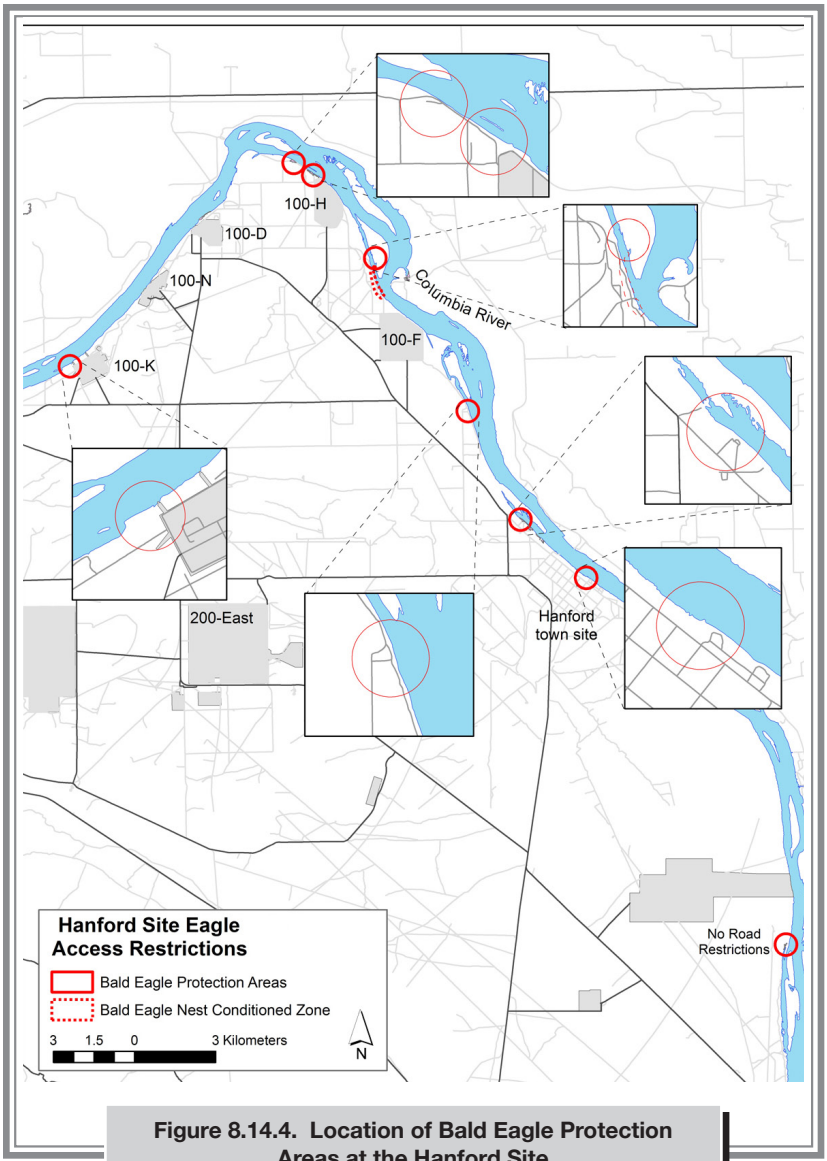

Figure 8.14.4. Location of Bald Eagle Protection Areas at the Hanford Site

8.14.1.5 Mule Deer

KD Hand

Population characteristics of mule deer on the Hanford Site have been monitored since 1994. Roadside surveys are conducted from mid-November to mid-January to assess age and sex ratios and the frequency of testicular atrophy in males. The survey route extends from near the 300 Area in the south to the 100-B/C Area in the north and is divided at the Hanford town site into northern and southern regions. Tiller and Poston (2000) found little overlap in the home ranges of deer occupying these two regions.

Three surveys were conducted in December 2010 and January 2011, the post-hunting period. A combined total of 381 deer observations were made over the three 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. In 2010, the fawn-to-doe mean estimate was 35.3 fawns per 100 does for the northern region and 23.7 for the southern region (Figure 8.14.5). For both regions, these ratios were similar to both the previous year and the 10-year average. The 10-year average has remained steady, ranging between 31.9 and 36.2 fawns per 100 does in the northern region and between 28.0 and 34.0 in the southern region. In general, the fairly steady trend in fawn-to-doe ratios indicates a stable mule deer population. Hanford Site fawn-to-doe ratios for all survey years (1994 through 2010) are weighted averages, using the total number of fawns and does seen per survey as the weighting factor.

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 the southern region in 1998 to a low of 0% in both regions in 2003 (Figure 8.14.6). Recently, the 10-year averages have shown steady (northern region) or declining (southern region) trends at 6% or less. In 2010, observations of affected male deer were

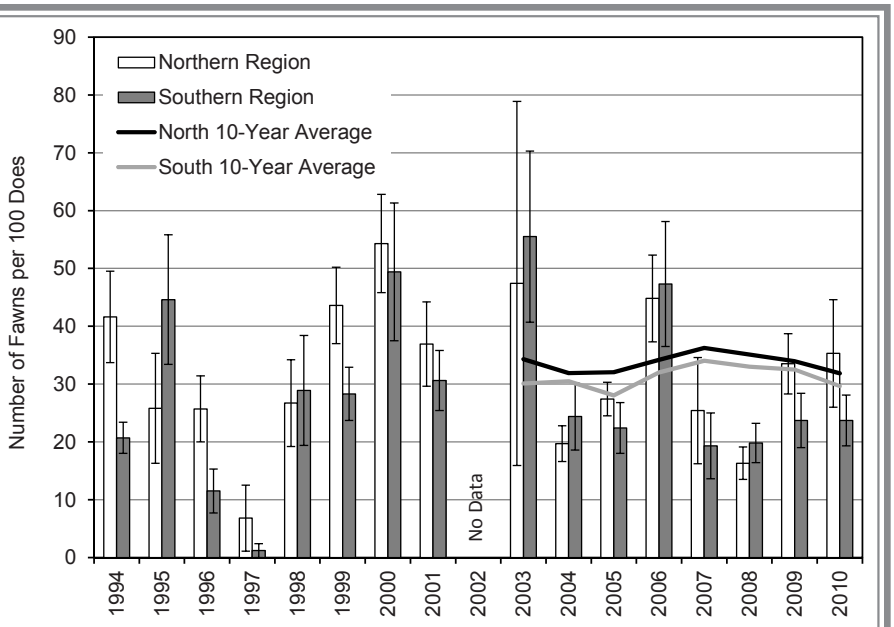

Figure 8.14.5. Estimates of the Number of Fawns per 100 Mule Deer Does in the Post-Hunting Period (Winter) on the Hanford Site, 1994 Through 2010 (mean ±1 standard error)

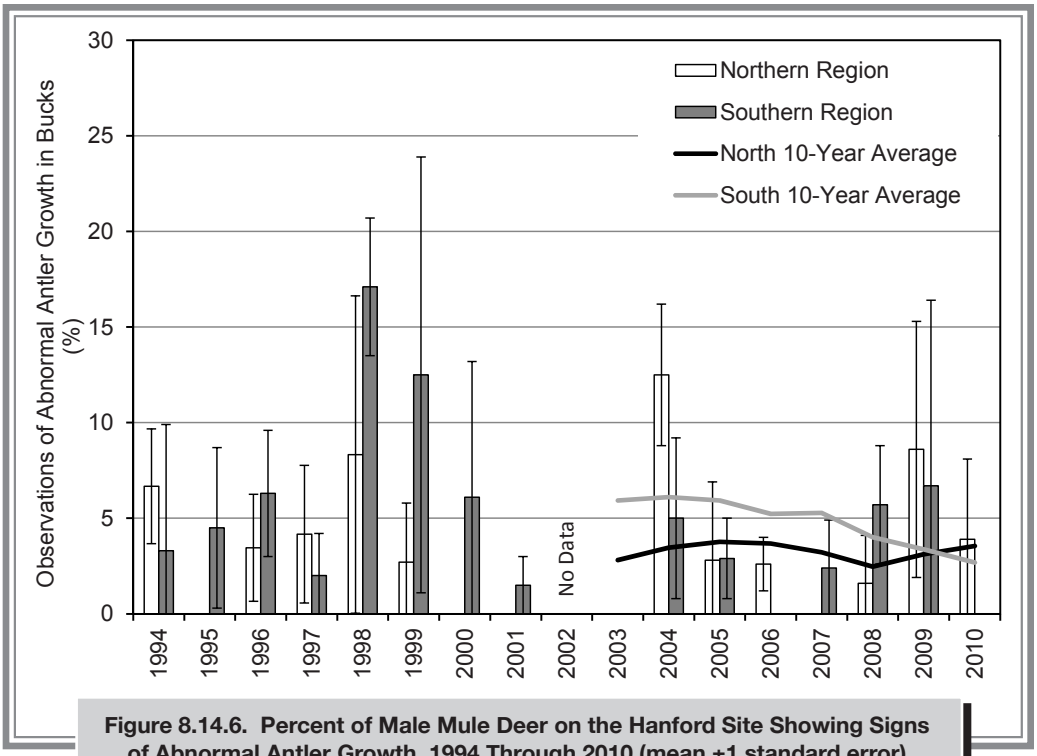

Figure 8.14.6. Percent of Male Mule Deer on the Hanford Site Showing Signs of Abnormal Antler Growth, 1994 Through 2010 (mean ±1 standard error)

low; the observed frequency of antler abnormality was 3.9% in the northern region and no bucks with abnormal antlers were seen in the southern region. These frequencies need to be interpreted with caution because the small sample sizes may not fully reflect population conditions. In general, recent data indicate the health of the male mule deer on the Hanford Site has not changed substantially.

8.15 Cultural and Historic Resources Monitoring

SS Hughes, EP Kennedy, and TE Marceau

Cultural and historic resources monitoring at DOE-managed portions of the Hanford Site is conducted under the auspices of the DOE Richland Operations Office's Tribal Affairs and Cultural Resources Program to assure site compliance with federal cultural resources laws and regulations (see Section 5.5.2). Program activities in 2010 included the following:

- Performed cultural resource reviews for federal undertakings conducted at the Hanford Site in accordance with Section 106 of the *National Historic Preservation Act of 1966* and the *National Environmental Policy Act of 1969*
- Monitored cultural resources conditions to assure important resources are protected
- Maintained a database of cultural resources site records, project records, and regional ethnohistory
- Maintained archaeological and historical collections
- Identified and evaluated new cultural resources so they are appropriately managed
- Consulted with Native American tribes and other stakeholders to gather input on the identification, documentation, and management of cultural resources important to them.

The DOE Richland Operations Office's Tribal Affairs and Cultural Resources Program personnel oversee all cultural resource activities at the Hanford Site. During 2010, Pacific Northwest National Laboratory archaeological staff continued to manage the cultural resources project for DOE, which included maintaining databases, archives, collections, and administering the cultural resources protections program. Most Section 106 compliance work in 2010 was performed for DOE by archaeologists from Pacific Northwest National Laboratory; Washington Closure Hanford, LLC; and CH2M HILL Corporate.

8.15.1 Cultural Resources Reviews

Pursuant to the *National Environmental Policy Act of 1969* and Section 106 of the *National Historic Preservation Act of 1966*, DOE conducts cultural resources reviews of federal undertakings at the Hanford Site. Section 106 reviews assure that important cultural resources are identified and effects to those resources are evaluated so that mitigation measures can be conducted.

During 2010, Section 106 reviews were completed for 273 undertakings by Hanford Site archaeologists. CH2M HILL Corporate staff completed 37 Section 106 reviews; Pacific Northwest National Laboratory staff completed 133 reviews; and Washington Closure Hanford, LLC staff completed 103 reviews. A total of 239 proposed projects were determined not to be the type to cause effects to cultural resources. Of these, CH2M HILL Corporate staff completed 25 reviews; Pacific Northwest National Laboratory staff completed 122; and Washington Closure Hanford, LLC staff completed 92 (Figure 8.15.1). This type of undertaking is defined in the *Hanford Site Cultural Resources Management Plan* (DOE/RL-98-10, Rev. 0) as a routine maintenance activity that occurs in areas away from culturally sensitive zones in areas previously disturbed by existing infrastructure. Most projects determined not to have the potential to cause effects to cultural resources occurred in the 100 Areas of the Hanford Site (Figure 8.15.2).

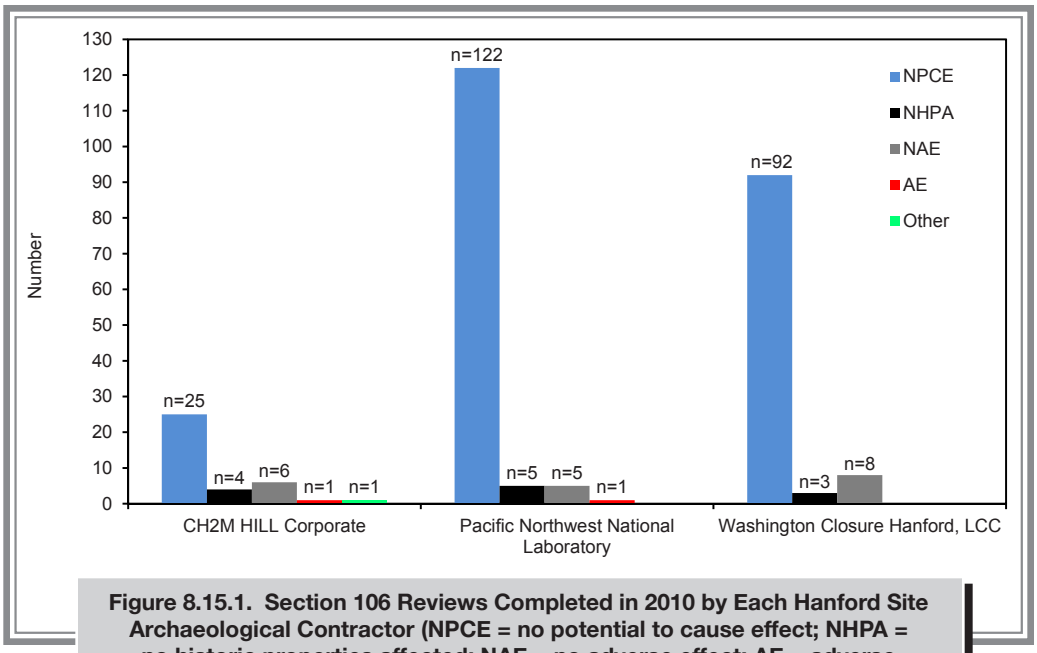

Figure 8.15.1. Section 106 Reviews Completed in 2010 by Each Hanford Site Archaeological Contractor (NPCE = no potential to cause effect; NHPA = no historic properties affected; NAE = no adverse effect; AE = adverse effect; n = number of reviews)

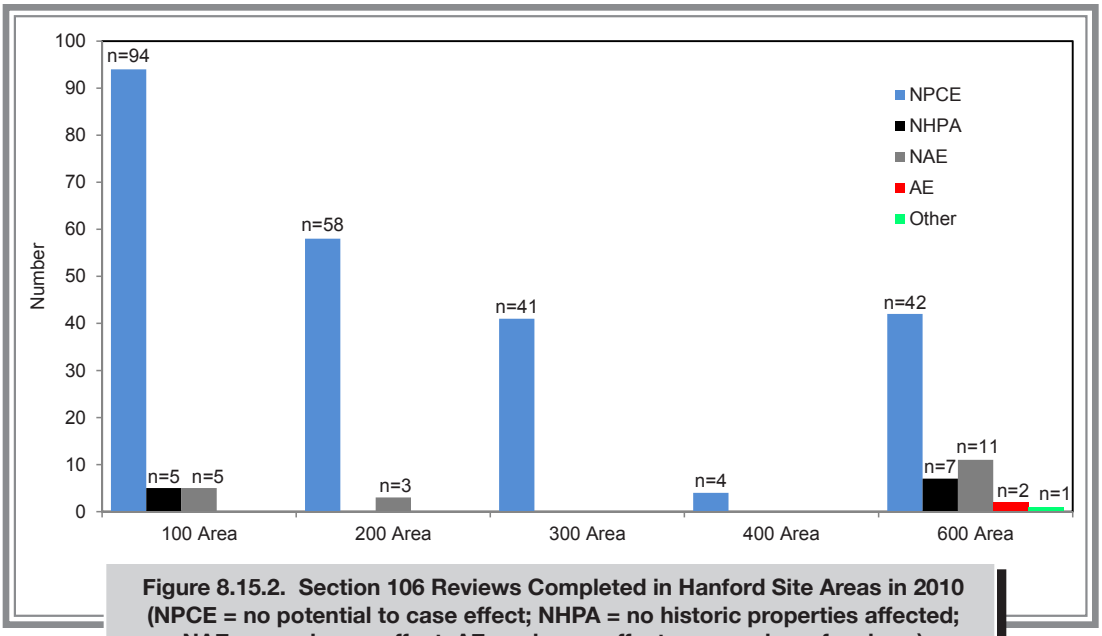

Figure 8.15.2. Section 106 Reviews Completed in Hanford Site Areas in 2010 (NPCE = no potential to case effect; NHPA = no historic properties affected; NAE = no adverse effect; AE = adverse effect; n = number of reviews)

An additional 34 undertakings with the potential to affect cultural resources were reviewed in 2010. Reviews included efforts to identify cultural resources that might be affected by project activity, assessment of potential impacts, and mitigation, if necessary.[a] CH2M Hill Corporate archaeologists completed 12 cultural reviews, Pacific Northwest National Laboratory staff completed 11, and Washington Closure Hanford, LLC staff completed 11. Of the 33 undertakings, 12 were identified as "no historic properties affected"; 19 had no adverse effects to historic properties; and 2 resulted in adverse effects. Adverse effects were avoided by taking specific actions to minimize impacts, including avoidance, following treatment plan guidelines, and archaeological monitoring. Two undertakings resulted in adverse effects to historic properties and required mitigation measures. Approximately 2,480 hectares (6,130 acres) of new ground was surveyed for cultural resources as a result of these 34 reviews. In addition, some undertakings required National Register of Historic Places eligibility evaluations and archaeological testing and data recovery.

American Recovery and Reinvestment Act of 2009 stimulus funding accelerated cleanup on the Hanford Site in late 2009 and throughout 2010, resulting in a backlog of cultural reviews. In response, DOE hired a full-time archaeologist in August to oversee the Cultural Resources Program and archaeologists with Mission Support Alliance, LLC provided additional technical support. In 2010, the DOE Richland Operations Office merged the Cultural Resources Program and Tribal Affairs Program to create the Tribal Affairs and Cultural Resources Program. In addition, a decision was made in September 2010 to transfer the Cultural Resources Project to Mission Support Alliance, LLC in 2011.

The DOE Richland Operations Office conducted two workshops in 2010 to standardize reporting procedures amongst all Hanford Site archaeological contractors. A desk reference was created for all contractors, with contact information for the DOE Richland Operations Office and tribal personnel, and templates for standardized reporting.

8.15.2 Cultural Resources Protections

Activities to assure protection of Hanford Site cultural resources are conducted to comply with Section 110 of the *National Historic Preservation Act of 1966*, the *Native American Graves Protection and Repatriation Act of 1990*, and the *Archaeological Resources Protection Act of 1979*. A monitoring program has been in place since 1987 to assess effects of weathering and erosion and/or unauthorized excavation and collection of significant cultural resources at the Hanford Site. Activities include onsite inspections to monitor site conditions, assess impacts, and identify protective measures, if necessary. In 2010, 10 pre-contact archaeological sites were monitored at the Hanford Site.

Site visits are conducted with the participation of tribal cultural resources personnel. Although no major impacts were noted at any sites inspected in 2010, minor impacts as a result of natural erosion, recreational activities, and/or animal disturbance were recorded. In 2010, a trip to Locke Island in the Hanford Reach revealed a 6.0-centimeter (2.4-inch) decrease in the rate of erosion relative to the 2008 rate. Examination of eroded areas revealed two possible causal variables: high-water levels and water fluctuation.

In 2010, no incidents of unauthorized excavation were noted within archaeological sites, although two incidents of off-road driving within site boundaries were reported. The first occurred on the upper terrace in the 100-K Area within the boundaries of site 45BN1382, a historic site not eligible for listing on the National Register of Historic Places. An impact assessment of the site revealed no adverse effect to historic properties. The second incident involved off-road driving at Rattlesnake Springs on *Laliik*, a significant traditional cultural property. Only minor impacts occurred to site 45BN1605, a potentially eligible pre-contact site. The site form was updated and the site boundary was expanded.

A number of previously recorded archaeological sites that were burned by wildfires in 2009 were revisited in 2010.

(a) This number does not reflect all full cultural resources reviews initiated in calendar year 2010. Additional reviews initiated in 2010 but completed in 2011 are not included in this report.

Field efforts focused on assessing fire damage at McGee Ranch, Gable Mountain, Gate 106 (Rattlesnake Mountain), and Routes 11 and 2. A total of 49 previously documented archaeological sites were visited and their site forms updated. Field observations indicated the fires burned irregularly, but generally moved fast and were not exceptionally hot. Sites containing wood artifacts or structures were most severely impacted.

Three post-review findings occurred during project inspections in 2010. Two involved buried segments of wood stave water lines encountered during blading or trenching activities: 1) approximately 37 meters (120 feet) of stave water line was destroyed during blading of a project staging area adjacent to the National Register-eligible Hanford Irrigation Canal (45BN309H); and 2) a previously unknown section of stave water line paralleling Beloit Avenue in the 200-West Area was destroyed. The third post-review finding revealed a pre-contact site during remediation of a waste site in the 100-K Area. In all cases, work stopped immediately, and steps were taken to evaluate and mitigate adverse effects to the sites pursuant to 36 CFR 800.13.

To enhance protections in the highly sensitive 100-K Area of the Hanford Site, the 100-KR-4 Pump-and-Treat Project treatment plan was updated in 2010 (SGW-46017, Rev. 0). The revised treatment plan recommended archaeological testing and monitoring of any projects proposed for the lower terrace of the Columbia River, as well as cultural sensitivity briefings and off-road driving restrictions across the 100-K Area.

8.15.2.1 Identification and Evaluation Activities

Identification and evaluation activities are performed to comply with Sections 106 and 110 of the *National Historic Preservation Act of 1966*. In 2010, 36 new archaeological sites or isolated finds were recorded (Table 8.15.1). Of the 28 newly recorded sites, National Register of Historic Places evaluations were completed on 18 and 2 were determined eligible for listing in the National Register of Historic Places. One Historic Property Inventory Form was completed for the Army Loop Road, which was determined not eligible for listing in the National Register of Historic Places. Archaeological site forms for 67 previously recorded archaeological sites were updated and 20 were evaluated for National Register eligibility. Of these, 11 sites were determined eligible for inclusion in the National Register of Historic Places.

Two historic districts were established in 2010: the White Bluffs Historic District and Hanford town site, and Hanford Construction Camp Historic District.

8.15.2.2 Data Recovery Activities

Archaeological data recovery was conducted at two sites (45BN1506 and 45BN1514) adversely impacted by reseeding efforts following the 2008 Wautoma Fire. To adequately evaluate site impacts and eligibility for the National Register of Historic Places, a research design for testing and data collection was implemented. Bone and lithic materials were analyzed along with a suite of environmental and geophysical data. Results suggest these sites represent inland hunting camps, two of a number of similar sites positioned on the western edge of Cold Creek Bar dating 2000 and 5000 years ago. A report on these findings is planned for release in 2011.

8.15.2.3 Management of Artifact and Data Collections

During 2010, Pacific Northwest National Laboratory managed Hanford Site archaeological collections, DOE cultural resources records, a reference library, an electronic database

Table 8.15.1. Sites and Isolates Recorded or Updated in 2010

	Eligible	Not Eligible	Unevaluated	Total
Updates	11	9	47	67
New sites	2	15	10	27
New isolates	0	2	6	8
Historic Property Inventory Form	0	1	0	1
Total	**13**	**27**	**63**	**103**

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 Richland Operations Office's Tribal Affairs and Cultural Resources Program. Files from more than 1,500 cultural sites and curated archaeological collections from more than 80 sites were stored in an archive room at Pacific Northwest National Laboratory. During 2010, temperature and humidity levels within the archive room remained within the appropriate limits for storage of numerous types of archived materials. In 2009, the cultural resources site database was transitioned to a geodatabase that was completed in 2010. The geodatabase and geographic information system are continually updated and have become important research tools for project staff. The Pacific Northwest National Laboratory's Total Records Information Management database (accessible only to Pacific Northwest National Laboratory Cultural Resources staff) was used for efficient retrieval of representative site photos, site monitoring photos, historic photos, and archived electronic documents produced by project activities.

The Columbia River Exhibition of History, Science, and Technology Museum staff manages the Hanford Site Manhattan Project and Cold War artifact collection. Efforts to generate additional items for the collections are conducted as stipulated in the programmatic agreement for the built (human-made) environment at the Hanford Site (DOE/RL-96-77, Rev. 0), which directs DOE personnel to assess the contents of site historical buildings and structures prior to the commencement of deactivation, decontamination, or decommissioning activities. Assessments identify and preserve any artifacts (e.g., control panels, signs, scale models, machinery) that may have value as interpretive or educational exhibits within national, state, or local museums. No walkthroughs or assessments were conducted in 2010.

8.15.3 Cultural Resources Consultations and Public Involvement

The DOE Richland Operations Office conducts formal consultations with the Washington State Historic Preservation Office, Native American tribes, and other interested parties for cultural resources reviews to comply with Section 106 of the *National Historic Preservation Act of 1966* and the *National Environmental Policy Act of 1969* (see Section 2.0.2). In 2010, DOE consulted with the Washington State Historic Preservation Office and Native American tribes on 32 full cultural reviews.

In 2010, Tribal Affairs and Cultural Resources Program staff held 11 meetings with tribal cultural resources staff from the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Colville Reservation, the Nez Perce Tribe, and the Wanapum. Discussions focused on the full cultural resources reviews completed and initiated in 2010; proposed undertakings within traditional cultural properties boundaries and view sheds; results of onsite *Archaeological Resources Protection Act of 1979* violations; and approaches to protecting threatened archaeological sites and places containing Native American human remains.

In December 2010, the DOE Richland Operations Office, archaeological contractors, Native American tribes, and the Washington State Historic Preservation Office met to discuss the *Hanford Cultural Resources Management Plan* "no potential to cause effect" reviews (DOE/RL-98-10, Rev. 0). These reviews have come under increasing scrutiny and criticism by local Native American tribes and the Washington State Historic Preservation Office. Discussions will continue in 2011.

8.16 Climate and Meteorology

KW Burk

Researchers take meteorological measurements to support Hanford Site operations, emergency preparedness and response, and atmospheric dispersion calculations for dose assessments (Appendix E, Table E.5). 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 and used to help plan weather-dependent activities, and as a resource to assess the environmental effects of site operations.

Hanford Meteorology Station staff 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 through radio telemetry every 15 minutes. There are 27 towers that are 9-meters (30-feet) high and 3 towers that are 61-meters (200-feet) high. Meteorological information collected at these stations includes wind speed, wind direction, temperature, precipitation, atmospheric pressure, and relative humidity; however, not all of these data are collected at all stations.

Regional temperatures, precipitation, and winds are affected by mountain barriers. The Cascade Range, beyond Yakima to the west, greatly influences the climate of the Hanford Site because of its rain-shadow effect. The Rocky Mountains and ranges in southern British Columbia protect the region from severe, cold polar air masses moving southward across Canada and winter storms associated with them.

Real-time and historical data from the Hanford Meteorology Station are available at http://www.hanford.gov/page.cfm/HMS. 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 at the Hanford Site Central Plateau, where the prevailing wind direction is from the northwest all year long. The secondary wind direction is from the southwest. Summaries of wind directions indicate that winds from the northwestern quadrant occur most often during winter and summer. During spring and fall, the frequency of southwesterly winds increases, with a corresponding decrease in the northwesterly flow. Monthly average wind speeds are lowest during winter months, averaging about 3 meters per second (6 to 7 miles per hour), and highest during summer, averaging about 4 meters per second (8 to 9 miles per hour). Wind speeds well above average are usually associated with southwesterly winds. However, summertime drainage winds are generally northwesterly and frequently exceed 13 meters per second (30 miles per hour). These winds are most prevalent over the northern portion of the Hanford Site. Figure 8.16.1 shows the 2010 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 located at 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 atmospheric dispersion 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 poor dispersion conditions,

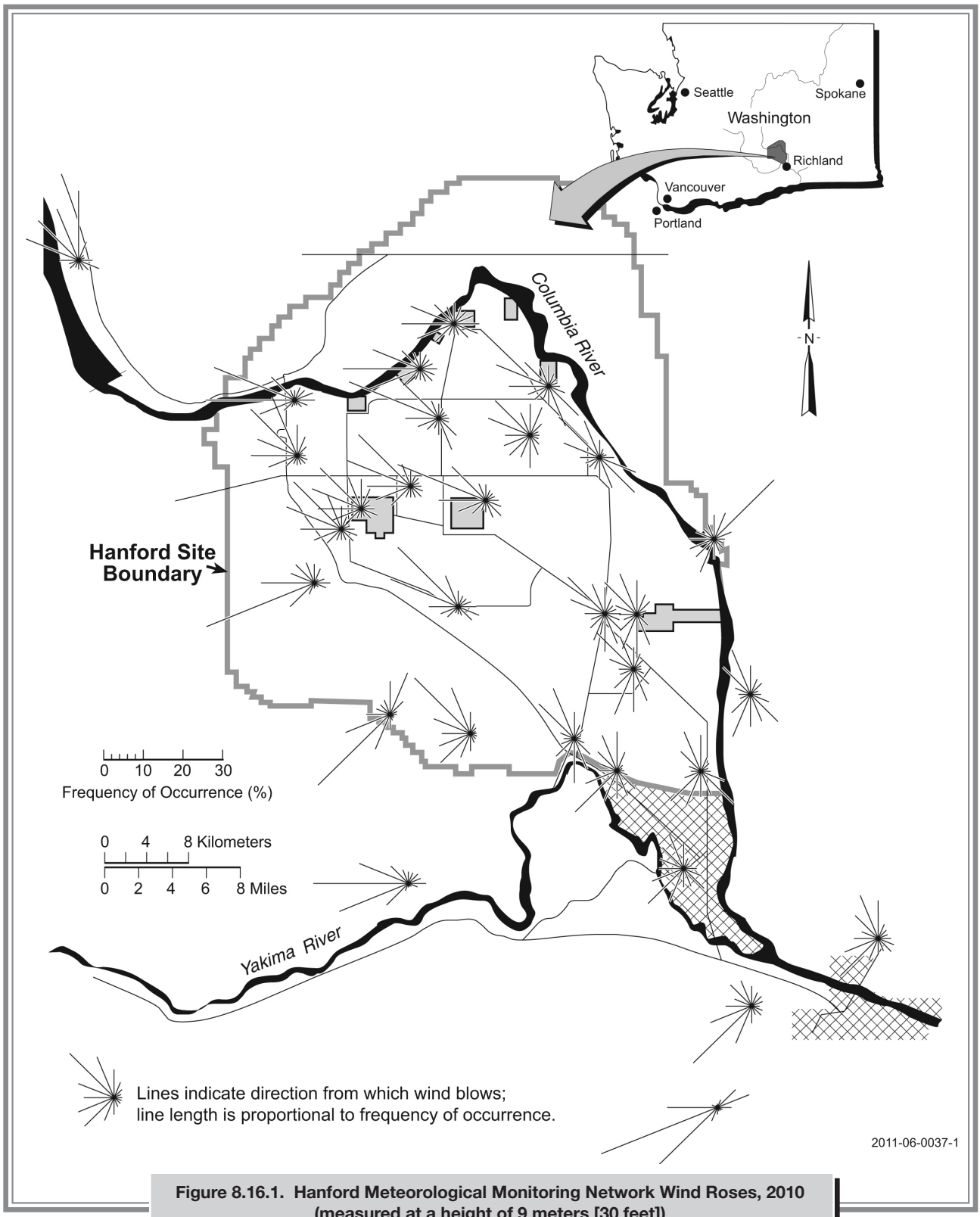

Figure 8.16.1. Hanford Meteorological Monitoring Network Wind Roses, 2010 (measured at a height of 9 meters [30 feet])

primarily during winter, that are associated with stagnant air in stationary high-pressure systems.

8.16.1 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 2010, the record maximum temperature was 45°C (113.0°F) recorded in August 1961, July 2002, and July 2006. The record minimum temperature was -30.6°C (-23.1°F) in February 1950. Normal monthly average temperatures ranged from a low of -0.2°C (31.7°F) in December to a high of 24.6°C (76.3°F) in July. During winter, the highest monthly average temperature at the Hanford Meteorology Station was 6.9°C (44.4°F) in February 1991, and the record lowest was -11.1°C (12.1°F) in January 1950. During summer, the record maximum monthly average temperature was 27.9°C (82.2°F) in July 1985, and the record minimum was 17.2°C (63.0°F) in June 1953. The normal annual relative humidity at the Hanford Meteorology Station is 54%. Humidity is highest during winter, averaging approximately 76%, and lowest during summer, averaging approximately 36%. Normal annual precipitation at the Hanford Meteorology Station is 17.7 centimeters (6.98 inches). The wettest year on record, 1995, received 31 centimeters (12.31 inches) of precipitation; the driest, 1976, received 7.6 centimeters (2.99 inches). Most precipitation occurs during late autumn and winter, with more than half of the annual amount occurring from November through February. The snowiest winter on record, 1992–1993, received 142.5 centimeters (56.1 inches) of snow.

8.16.2 Results of 2010 Monitoring

The 2010 average temperature and precipitation totals were above normal.

The average temperature for 2010 was 12.1°C (53.9°F), which was 0.1°C (0.3°F) above normal (12.0°C [53.6°F]). Six months during 2010 were warmer than normal; 6 months were cooler than normal. January had the greatest positive departure at 3.4°C (6.2°F). May had the greatest negative departure at 2.2°C (3.9°F) below normal.

Precipitation during 2010 totaled 25.9 centimeters (10.19 inches), which is 146% of normal precipitation (17.7 centimeters [6.98 inches]). Snowfall for 2010 totaled 40.4 centimeters (15.9 inches), compared to normal snowfall of 39.1 centimeters (15.4 inches).

The average wind speed during 2010 was 3.6 meters per second (8.1 miles per hour), which was 0.2 meter per second (0.5 mile per hour) above normal. The peak gust for the year was 28.6 meters per second (64 miles per hour) on May 3.

One dust storm was recorded at the Hanford Meteorology Station during 2010. There has been an average of five dust storms per year at the Hanford Meteorology Station during the entire period of record (1945-2010).

Table 8.16.1 provides monthly and annual climatological data collected at the Hanford Meteorology Station during 2010.

Table 8.16.1. Monthly and Annual Climatological Data for 2010 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	6.5	0.1	3.3	+3.4	12.2	15	6.7	7	3.1	+0.9	T[c]	-10.7	84.5	+5.9	2.9	+0.1	19.2	SW	15
F	10.3	0.8	5.6	+2.3	15.6	25	6.7	22	1.4	-0.3	0	0	78.0	+7.0	2.6	-0.5	17.9	SW	12
M	15.1	1.4	8.3	+0.5	20.6	16	-5.0	9	0.5	-1.0	0	0	54.4	-2.9	3.7	+0.2	22.4	WSW	29[d]
A	18.6	4.9	11.8	-0.1	27.2	19	-3.9	4	1.5	+0.4	0	0	46.1	-1.7	4.8	+0.9	21.5	W	8
M	21.4	7.3	14.4	-2.2	30.6	16[d]	0	7	3.4	+2.0	0	0	48.6	+4.9	4.1	+0.1	28.6	WSW	3
J	26.6	12.2	19.4	-1.3	35.0	28	6.7	5	2.9	+1.9	0	0	46.2	+6.6	4.2	+0.1	19.2	WNW	14[d]
J	33.6	16.1	24.8	+0.2	40.6	9	9.4	4	1.2	+0.5	0	0	33.5	-1.3	3.9	+0.1	22.8	W	31
A	32.0	15.3	23.7	-0.4	39.4	17	9.4	31	0.3	-0.4	0	0	36.3	+0.1	3.8	+0.3	20.6	WNW	26
S	25.9	11.7	18.8	0	32.2	28	6.7	12	2.4	+1.6	0	0	54.8	+11.2	3.5	+0.2	21.0	NW	4
O	18.7	5.8	12.3	+0.6	29.4	1	-1.7	17	1.6	+0.4	0	0	62.1	+6.8	3.1	+0.2	20.1	SW	24
N	7.1	-1.8	2.6	-1.9	20.0	2	-22.2	24	2.9	+0.4	20.8	+15.0	78.4	+4.1	2.9	0	24.6	W	16
D	4.2	-2.3	0.9	+1.1	15.0	12	-11.1	31	4.6	+1.8	19.6	+4.9	83.6	+3.7	3.1	+0.4	22.4	SW	14
Y[e]	18.3	5.9	12.1	+0.2	40.6	Jul 9	-22.2	Nov 24	25.9	+8.2	40.4	+1.3	58.9	+3.7	3.6	+0.2	28.6	WSW	May 3

Note: See Appendix A, Table A.2, Conversion Table, in the Helpful Information section for unit conversion information.
(a) Measured on a tower 15 meters (50 feet) above the ground.
(b) Departure columns indicate positive or negative departure of meteorological parameters from 30-year (1971-2000) climatological normals.
(c) Trace.
(d) Latest of several occurrences.
(e) Yearly averages, extremes, and totals.

8.17 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 2010 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 for analysis.

Quality assurance/quality control for Hanford Site environmental monitoring and surveillance programs also include procedures and protocols to perform the following:

- Document instrument calibrations
- Conduct program-specific activities in the field
- Maintain groundwater wells to ensure representative samples are collected
- Avoid cross-contamination by using dedicated well sampling pumps.

8.17.1 Hanford Site-Wide and Offsite Environmental Surveillance and Environmental Monitoring

EA Lepel, DS Sklarew, and BK Lasorsa

During 2010, comprehensive quality assurance programs, including various quality control practices, were maintained to assure the quality of data collected through the Pacific Northwest National Laboratory Surface Environmental Surveillance Project. The samples collected by project staff were submitted to General Engineering Laboratories, LLC, in Charleston, South Carolina, for radiochemical and chemical analyses.

Samples for inorganic analyses were submitted primarily to the Marine Sciences Laboratory, located at the Pacific Northwest National Laboratory's Sequim Marine Research Operations in Sequim, Washington.

8.17.1.1 Project Management Quality Assurance

Site environmental monitoring and related activities (such as performing dose calculations) were subject to an overall quality assurance program. This program implements the requirements of DOE Order 414.1C, "Quality Assurance." Quality assurance plans, which are maintained by project personnel, describe the specific quality assurance elements that apply to each project. These plans were approved by the Pacific Northwest National Laboratory quality assurance organizations that monitor compliance with the plans. Work performed through contracts, such as sample analyses, must meet the same quality assurance requirements. Potential equipment and service suppliers are audited before service contracts are approved and awarded, or materials are purchased that could have a significant impact on quality within the projects.

8.17.1.2 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, biota, and water (Table 8.17.1). Acceptable water field duplicates consisted of 12 Columbia River water samples and 2 onsite pond water samples. There were four acceptable field biota duplicates of cow's milk. Nine acceptable field duplicate air samples were collected for tritium analyses. A field duplicate is used to assess sampling and measurement precision. Analytical results were reviewed against the criterion that the result must be greater than the minimum detectable activity value or the method detection limit to be evaluated. To be an acceptable result, the relative percentage difference of the routine sample and duplicate must be less than 30%. Of the evaluated results, 87% of the total 2010 field duplicates analyzed by General Engineering Laboratories, LLC for radiochemistry were acceptable and 100% of the chemistry field duplicates were acceptable.

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:

$$RPD = \left(\frac{|S - D|}{\left(\frac{S + D}{2} \right)} \right) \times 100$$

In addition, the Marine Sciences Laboratory performed laboratory duplicate analyses (Table 8.17.2). To be an acceptable result, the relative percentage difference of the routine

Table 8.17.1. Summary of Field Duplicate Sample Results for Samples Submitted to General Engineering Laboratories, LLC for the Surface Environmental Surveillance Project, 2010

Media (Number of Samples)	Analytes	Number of Results Reported[a]	Number of Results Within Control Limits[b]
	Radionuclides		
Air (26)	Hydrogen-3	9	2
Water (4)	Hydrogen-3	2	2
Water (4)	Uranium-234	2	2
Water (4)	Uranium-238	2	2
Water (2)	Gross beta	1	1
Biota-Milk (6)	Hydrogen-3	4	4
	Anions		
Water (3)	Chloride	2	2
	Fluoride	1	1
	NO_3-N	2	2
	Sulfate	2	2

(a) Number of reported results for radiological are those results greater than the minimum detectable activity. Number of reported results for chemistry are those results greater than or equal to the method detection limit.
(b) Number of reported results within control limits for radiological analysis are those results with the relative percent difference value less than 30%, and the result is greater than the minimum detectable activity. Number of reported results within control limits for chemical analysis are those results with the relative percent difference value less than 30%, and the result is greater than or equal to the method detection limit.
ICP = Inductively coupled plasma.

Table 8.17.2. Summary of Marine Sciences Laboratory Performance on Laboratory Sample Duplicates for Inductively Coupled Plasma Metals and Cold Vapor Atomic Absorption/Cold Vapor Atomic Florescence Collected for the Surface Environmental Surveillance Project, 2010

Media	Metal	Number of Results Reported[a]	Number of Results Within Control Limits[b]
Water	Antimony, arsenic, cadmium, copper, lead, nickel, thallium, zinc (9 samples × 8 metals)	72	69
	Beryllium, silver (2 samples × 2 metals)	4	4
	Mercury (4 samples × 1 metal)	4	4
	Selenium (6 samples × 1 metal)	6	6
	Chromium (3 samples × 1 metal)	3	3
Sediment	Antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, zinc (2 samples × 13 metals)	26	26
Biota (Rabbit)	Antimony, aluminum, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, zinc (1 sample × 11 metals)	11	11
Biota (Carp)	Aluminum, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, uranium, zinc (1 sample × 14 metals)	14	14
Biota (Deer and Quail)	Aluminum, arsenic, cadmium, chromium, copper, lead, manganese, nickel, selenium, silver, zinc (1 sample × 11 metals)	11	10

(a) Number of reported results for chemistry are those results greater than or equal to the method reporting limit.
(b) Number of reported results within control limits are those results with the relative percent difference value less than 25%, and the result is greater than or equal to the method reporting limit.

sample and duplicate must be less than 25%. Ninety-seven percent of the laboratory chemical analysis duplicates analyzed by the Marine Sciences Laboratory were acceptable.

8.17.1.3 Analytical Results Quality Assurance and Quality Control

Routine chemical analyses of water samples were performed at General Engineering Laboratories, LLC for the Surface Environmental Surveillance Project. Laboratory personnel participated in the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation Studies conducted by Environmental Resource Associates in Arvada, Colorado. General Engineering Laboratories, LLC maintained an internal quality control program that met the requirements in EPA (1986). The program was audited by DOE Consolidated Audit Program staff.

Routine metals analyses were performed by the Marine Sciences Laboratory. 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. In 2010, water sample results from one general trace metal study (including mercury) and two additional trace mercury studies (trace mercury only) were reported. The acceptance criteria were met by 100% of the reported results from the water samples. Results also were reported from two soil studies in 2010; 100% of these results were acceptable. Results are summarized in Table 8.17.3.

Routine radiochemical analyses of samples for the Environmental Surveillance Monitoring Project were performed

Table 8.17.3. Summary of Marine Sciences Laboratory Performance on NSI Solutions, Inc. Proficiency Testing Program Samples (seven studies), 2010

Media	Analytes	Number of Results Reported	Number of Results Within Control Limits
Soil	Aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, zinc	2	2
Water	Mercury	3	3
	Antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, zinc	1	1

Blind-spiked sample – A sample of known activity and/or concentration submitted to the analytical service laboratory but not necessarily in the same physical geometry as the typical samples submitted.

by General Engineering Laboratories, LLC, who also participated in the DOE Mixed Analyte Performance Evaluation Program (DOE 2004). A quality control blind-spiked sample program was also conducted by the Pacific Northwest National Laboratory. General Engineering Laboratories, LLC maintains an internal quality control program. Additional information on these quality control efforts is provided in the following sections.

8.17.1.4 U.S. Department of Energy and U.S. Environmental Protection Agency Comparison Studies

Blind-spiked water and soil samples were distributed to participating laboratories as part of the EPA and DOE performance evaluation programs. These blind-spiked samples contained specific organic and inorganic analytes that had concentrations unknown to the analyzing laboratories. Results were compared with known values and findings from other participating laboratories. Results were obtained for seven studies from Environmental Resource Associates, two studies from Resource Technology Corporation, and two studies from the DOE Mixed Analyte Performance Evaluation Program. All components and methods that were reported in these studies were tabulated for the summary (Table 8.17.4). The acceptance criteria were met by 99% of the performance assessment sample results.

The DOE Mixed Analyte Performance Evaluation Program conducted by the Radiological and Environmental Sciences Laboratory in Idaho Falls, Idaho, provided standard samples of environmental media (e.g., air filters, soil, vegetation, and water) containing specific amounts of one or more radionuclides unknown to the participating laboratory. After analysis, the results were forwarded to the Radiological and Environmental Sciences Laboratory (two studies) or Environmental Resource Associates (five studies) for comparison with known values and results from other laboratories. The Radiological and Environmental Sciences Laboratory and Environmental Resource Associates established criteria for evaluating the accuracy of results as defined by the National Standards for Water Proficiency Testing Studies, Criteria Document (NERL-Ci-0045). The Radiological and Environmental Sciences Laboratory evaluated the DOE Mixed Analyte Performance Evaluation Program radiological and inorganic samples results for accuracy by determining if each result was within ±30% of a reference value. Summaries of the 2010 results are provided in Tables 8.17.5 and 8.17.6. The DOE Mixed Analyte Performance Evaluation Program provided General Engineering Laboratories, LLC with two sets of performance evaluation samples for analysis consisting of air filters, soil, vegetation, and water. Acceptable control limits, as defined by the DOE Mixed Analyte Performance Evaluation Program, were met by 90% of the DOE performance assessment sample results. The acceptable control limit range (NERL-Ci-0045) was met by 87% of the Environmental Resource Associates samples.

Table 8.17.4. Summary of Chemical Results for General Engineering Laboratories, LLC Performance on Samples from Seven Environmental Resource Associates Studies, Two Resource Technology Corporation Studies, and Two DOE Mixed Analyte Performance Evaluation Program Studies, 2010

Analyte	Number of Results Reported	Number of Results Within Control Limits
Antimony, arsenic, barium, cadmium, chromium, lead, nickel, selenium, zinc	38	38
Beryllium	38	36
Silver	36	34
Copper, thallium, vanadium	32	32
Aluminum, boron, iron, manganese, molybdenum	28	28
Cobalt	26	26
Strontium	22	22
Naphthalene	20	20
1,2,4-Trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, calcium, magnesium, mercury, nitrate + nitrite (as N)	18	18
1,3-Dichlorobenzene	18	15
2,4-Dinitrotoluene, 2,6-dinitrotoluene, hexachlorobutadiene, nitrobenzene	17	17
Potassium, sodium	15	15
Titanium	15	12
Acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluorene, nitrate (as N), phenanthrene, pyrene, tin	14	14
Fluoranthene, indeno(1,2,3-c,d)pyrene	14	13
Total cyanide	13	13
2-Chloronaphthalene, 2-methylnaphthalene, 4-bromophenyl-phenylether, 4-chlorophenyl-phenylether, bis(2-chloroethoxy)methane, bis(2-chloroethyl) ether, bis(2-chloroisopropyl)ether, butylbenzylphthalate, chloride, dibenzofuran, diethylphthalate, dimethylphthalate, di-n-butylphthalate, di-n-octylphthalate, fluoride, hexachlorobenzene, hexachlorocyclopentadiene, hexachloroethane, isophorone, sulfate	12	12
Bis(2-ethylhexyl)phthalate, pH	11	11
Orthophosphate (as P)	11	10
Nitrite (as N), pentachlorophenol	10	10
2,4,5-Trichlorophenol, 2,4,6-trichlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2,4-dinitrophenol, 2,6-dichlorophenol, 2-chlorophenol, 2-methylphenol, 2-nitrophenol, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, 4,6-dinitro-2-methylphenol, 4-chloro-3-methylphenol, 4-nitrophenol, aldrin, alpha-BHC, beta-BHC, conductivity at 25°C, delta-BHC, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, gamma-BHC (lindane), heptachlor, heptachlor epoxide, methoxychlor, phenol, total organic carbon (TOC)	9	9
1,2,4,5-Tetrachlorobenzene, 2-amino-1-methylbenzene, 2-nitroaniline, 3,3'-dichlorobenzidine, 3-nitroaniline, 4-chloroaniline, 4-nitroaniline, aniline, Aroclor 1016, Aroclor 1242, Aroclor 1254, Aroclor 1260, benzidine, benzyl alcohol, bromide, carbazole, hexavalent chromium, N-nitrosodiethylamine, N-nitrosodimethylamine, N-nitrosodi-n-propylamine, N-nitrosodiphenylamine, pentachlorobenzene, pyridine, total hardness (as $CaCO_3$)	8	8

Table 8.17.4. (contd)

Analyte	Number of Results Reported	Number of Results Within Control Limits
1,1,1,2-Tetrachloroethane, 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane,1,1,2-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethylene, 1,2-dichloroethane, 1,2-dichloropropane, 3&4-methylphenol, alkalinity (as $CaCO_3$), alpha chlordane, benzene, bromodichloromethane, bromoform, bromomethane, carbon tetrachloride, chlorobenzene, chlorodibromomethane, chloroethane, chloroform, chloromethane, cis-1,2-dichloroethylene, cis-1,3-dichloropropene, dibromomethane, dichlorodifluoromethane, ethylbenzene, gamma chlordane, methylene chloride, silica (as SiO_2), styrene, tert-butyl methyl ether, tetrachloroethylene, toluene, total dissolved solids at 180°C, total residual chlorine, trans-1,2-dichloroethylene, trans-1,3-dichloropropene, trichloroethylene, turbidity, vinyl chloride, xylenes (total)	6	6
1,2,3-trichloropropane, 1,3,5-trinitrobenzene, 1,3-dinitrobenzene, 2,3,4,6-tetrachlorophenol, 2,4,6-trinitrotoluene, 2-amino-4,6-dinitrotoluene, 2-nitrotoluene, 3-nitrotoluene, 4-amino-2,6-dinitrotoluene, 4-nitrotoluene, Aroclor 1221, Aroclor 1232, Aroclor 1248, benzoic acid, biochemical oxygen demand (BOD), chlordane (technical), dibromochloropropane, ethylene dibromide, HMX, perchlorate, RDX, tetryl, total Kjeldahl nitrogen, total solids at 105°C	5	5
Total phenolics	5	2
1,2,3-Trichloropropane, ammonia (as N), bromobenzene, calcium hardness (as $CaCO_3$), COD, ignitability/flashpoint, isopropylbenzene, non-filterable residue (TSS), settleable solids	4	4
1,1-Dichloropropene, 1,2,3-trichlorobenzene, 1,2,4-trimethylbenzene, 1,2-dibromoethane, 1,3,5-trimethylbenzene, 1,3-dichloropropane, 2,2-dichloropropane, 2-butanone, 2-chloroethyl vinyl ether, 2-chlorotoluene, 2-hexanone, 4-chlorotoluene, 4-isopropyltoluene, 4-methyl-2-pentanone, 4-methylphenol, acetone, acetonitrile, acrolein, bromochloromethane, carbon disulfide, corrosivity (pH), fluorotrichloromethane, lithium, n-butylbenzene, n-propylbenzene, sec-butylbenzene, tert-butylbenzene, total phosphorus (as P), toxaphene, trichlorofluoromethane	3	3
1,2-Dibromo-3-chloropropane, 2,4,5-T, 2,4,5-TP (silvex), 2,4-D, 2,4-DB, acidity (as $CaCO_3$), acrylonitrile, CBOD, color, cyanide, dalapon, dicamba, dichlorprop, dinoseb, filterable residue (TDS), MCPA, MCPP, oil & grease (gravimetric), phosphate (as P), sulfide, surfactants – MBAS, total organic halides, total residue, vinyl acetate, volatile solids	2	2
1,1-Dibromo-3-chloropropane, bromoacetic acid, bromochloroacetic acid, chloroacetic acid, dibromoacetic acid, dichloroacetic acid, heterotrophic plate count, mercury (low level), reactive cyanide, total petroleum hydrocarbons (gravimetric), total phosphorus, trichloroacetic acid	1	1
Chlorate	1	0

8.17.1.5 Pacific Northwest National Laboratory Evaluations

Eight double-blind spiked samples were submitted for analyses by the Surface Environmental Surveillance Project, including air filters, soil, vegetation, and water (Table 8.17.7). One water matrix study was not included due to a mix-up with the submitted sample. Therefore, for the seven remaining samples (two air filter, two soil, two vegetation, and one water), 86% of General Engineering Laboratories, LLC radiochemistry blind-spiked determinations were within the control limit (±30%) of the known value. Two plutonium-238 analyses (one vegetation and one air filter); two plutonium-239/240 analyses (one vegetation and one soil); one cesium-137 analysis (soil sample); one strontium-90 analysis (air filter); and one americium-241 analysis (air filter) were not within control limits. Of all analyses, the plutonium analysis was least accurate.

Table 8.17.5. Summary of General Engineering Laboratories, LLC Performance on Eight Performance Evaluation Program Samples Provided by the DOE Mixed Analyte Performance Evaluation Program, 2010

Media	Radionuclides	Number of Results Reported	Number of Results Within Control Limits[a]
Air filters	Gross alpha, gross beta, cobalt-57, zinc-65, strontium-90, plutonium-238	2	2
	Manganese-54, cobalt-60, cesium-134, cesium-137, uranium-234, uranium-238, plutonium-239/240, americium-241	2	1
Soil	Potassium-40, manganese-54, iron-55, cobalt-57, cobalt-60, nickel-63, zinc-65, strontium-90, technetium-99, cesium-134, cesium-137, uranium-234, uranium-238, americium-241	2	2
	Plutonium-238, plutonium-239/240	2	1
Vegetation	Manganese-54, cobalt-57, cobalt-60, zinc-65, strontium-90, cesium-134, cesium-137, uranium-234, plutonium-238, uranium-238, plutonium-239/240, americium-241	2	2
Water	Gross alpha, gross beta, hydrogen-3, potassium-40, manganese-54, iron-55, cobalt-57, cobalt-60, nickel-63, zinc-65, strontium-90, technetium-99, cesium-134, cesium-137, uranium-234, uranium-238, plutonium-239/240, americium-241	2	2
	Plutonium-238	2	0
	Potassium-40	1	1

(a) Control limits are from DOE (2004).

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.

8.17.1.6 Laboratory Internal Quality Assurance Programs

Analytical laboratories are required to maintain an internal quality assurance and control program. Laboratories are audited at least annually for compliance to the quality assurance and control programs. At General Engineering Laboratories, LLC, the quality control program met the quality assurance and control criteria as specified in EPA (1986). The laboratory was also required to maintain a system to review and analyze the results of the quality control samples to detect problems that may have arisen from contamination, inadequate calibrations, calculation errors, or improper procedure performance. Detection levels for each analytical method were determined at least annually.

The internal quality control program at General Engineering Laboratories, LLC involved routine calibrations of counting instruments, yield determinations of radiochemical procedures, frequent radiation-check sources and background counts, replicate and spiked sample analyses, 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,

Table 8.17.6. Summary of General Engineering Laboratories, LLC Performance on Three Multimedia Radiochemistry Performance Testing Samples and One RadChem Proficiency Testing Samples Provided by the Environmental Resource Associates Proficiency Testing Program, 2010

Media	Radionuclides	Number of Results Reported	Number of Results Within Control Limits[a]
Water	Uranium-total (mass)[b]	13	9
	Uranium-total[c]	12	9
	Gross alpha	9	9
	Gross beta, iodine-131	8	8
	Zinc-65	8	6
	Strontium-90	8	4
	Uranium-238	7	5
	Cesium-134, cesium-137, radium-228, americium-241	6	6
	Strontium-89	6	4
	Cobalt-60	5	5
	Hyrdogen-3, manganese-54, uranium-234	4	4
	Radium-226	4	3
	Plutonium-239	2	2
	Plutonium-238	2	0
Soil	Uranium-238	9	8
	Americium-241, uranium-total (mass)	6	6
	Uranium-234	5	4
	Potassium-40, manganese-54, cobalt-60, zinc-65, cesium-134, cesium-137, lead-212, bismuth-214, lead-214, thorium-234	4	4
	Strontium-90	3	3
	Bismuth-212, plutonium-238, plutonium-239	2	2
Vegetation	Uranium-238	4	3
	Uranium-total (mass)	3	3
	Americium-241	3	2
	Potassium-40, manganese-54, cobalt-60, zinc-65, strontium-90, cesium-134, cesium-137, uranium-234, plutonium-238, plutonium-239, uranium-total	2	2
	Curium-244	1	1
Air filters	Uranium-total (mass)	8	8
	Uranium-238	6	4
	Gross beta, americium-241	4	4
	Gross alpha	4	0
	Uranium-234, uranium-total	3	3
	Manganese-54, iron-55, cobalt-60, zinc-65, strontium-90, cesium-134, cesium-137, plutonium-238, plutonium-239	2	2

(a) Control limits are from NERL-Ci-0045.
(b) Uranium reported on a mass basis (µg/L).
(c) Uranium reported as activity concentration (pCi/L).

Table 8.17.7. Summary of General Engineering Laboratories, LLC Performance on Double-Blind Spiked Samples Submitted by Pacific Northwest National Laboratory for the Surface Environmental Surveillance Project, 2010

Media	Radionuclides	Number of Results Reported	Number of Results Within Control Limits[a]
Air filters	Cesium-134, uranium-234, uranium-238, plutonium-239/240	2	2
	Strontium-90, plutonium-238	2	1
	Manganese-54, cobalt-57, cobalt-60, cesium-137	1	0
Soil	Potassium-40, uranium-234, uranium-238	2	2
	Cesium-137, plutonium-239/240	2	1
	Cobalt-57, cobalt-60, strontium-90, antimony-125, cesium-134, plutonium-238, americium-241	1	1
Vegetation	Cobalt-60, strontium-90	2	2
	Plutonium-239/240	2	1
	Potassium-40, cobalt-57, cesium-134, cesium-137, americium-241	1	1
	Plutonium-238	1	0
Water	Hydrogen-3, cesium-137, uranium-234, plutonium-238, uranium-238, plutonium-239/240	1	1

(a) Control limit ±30%.

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 96% 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 f or 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 2010, an audit of General Engineering Laboratories, LLC was conducted by the DOE Consolidated Audit Program.

The scope of DOE Consolidated Audit Program audits included the following specific functional areas: 1) quality assurance management systems and general laboratory practices; 2) data quality for organic analyses; 3) data quality for inorganic and wet chemistry analyses; 4) data quality for radiochemistry analyses; 5) laboratory information management systems (electronic data management); 6) hazardous and radioactive materials management; and 7) verification of corrective-action implementation from previous audit findings.

One new Priority II finding (requiring some corrective action by the laboratory) and seven observations were noted during the DOE Consolidated Audit Program audit of General Engineering Laboratories, LLC. A Priority II finding is defined as the following:

> "...factual statement issued from a DOECAP [DOE Consolidated Audit Program] audit to document a deficiency which in of itself does not represent a concern of sufficient magnitude to render the audited facility unacceptable to provide services to DOE. An observation is defined as a factual statement resulting from a DOECAP audit to document an isolated deficiency, deviation from Best Management Practices, or an opportunity for improvement, which does not warrant issuance of a Priority II finding."

Eight previous Priority II finding were closed and none remain open.

The new Priority II finding is as follows:

- Periodic review of control charts for out of control specification values by the quality assurance department is not clearly established or well defined.

The seven new observations are as follows:

- Quality assurance management and general laboratory practices
  1. The AlphaLIMS software[(a)] equipment monitoring page for temperature did not have the upper and lower control limits locked or protected.
  2. The AlphaLIMS software training records were not up-to-date.
  3. The General Engineering Laboratories, LLC organizational structure chart was out of date.
- Data quality for organic analyses
  4. The thermometer identification was not updated in the logbook when the thermometer was replaced in the liquid semi-volatile organic acid preparation area.
- Laboratory information management systems (electronic data management)
  5. The tritium quench curve calculation spreadsheet for a Beckman liquid scintillation counter was not locked.
  6. A volatile organic acid organic compound report was released with an incorrect result and qualifier.
- Hazardous and radioactive materials management
  7. The current Laboratory Waste Management plan does not include the procedure for conducting evaluations for vendor or treatment, storage, and disposal facility evaluations.

Corrective actions for all the audit findings were accepted, and verification of the corrective actions will be performed in future audits.

The DOE Consolidated Audit Program internal audit "... found that GEL [General Engineering Laboratories, LLC] meets established requirements necessary to produce data of acceptable and documented quality through analytical operations that follow approved and technically sound methods and that DOE samples and analysis-derived waste are handled in a manner that is protective of human health and the environment."

Internal laboratory quality control program data were reported with analytical results. Pacific Northwest National Laboratory scientists summarized results quarterly. For the Surface Environmental Surveillance Project, General Engineering Laboratories, LLC met contract-specified requirements for each quarter in 2010.

8.17.1.7 Media Audits and Comparisons

Additional audits and comparisons were conducted on several specific sample types. The Washington State Department of Health routinely analyzed co-samples of various environmental media during 2010 as part of its oversight monitoring program (see Section 3.0.4). Media that were analyzed for radionuclides included irrigation water from 2 locations, water from 14 locations along and across the

(a) AlphaLIMS is the laboratory information management systems software used by General Engineering Laboratories, LLC.

Columbia River, water from 10 Columbia River shoreline springs, and water from 3 onsite drinking water locations. Soil samples analyzed included one sediment sample from a pond, five Columbia River sediment samples, and five Columbia River shoreline spring samples. Biota samples analyzed for radionuclides were two Concord grape samples, two leafy vegetable samples, and two potato tuber samples. Three carp were obtained for whole organ and carcass analysis, three mule deer were obtained for muscle and bone analyses, and two quail collected for whole organism analyses.

No comparison data were available at the time this report was written.

8.17.2 Effluent Monitoring and Environmental Monitoring Near Facilities and Operations Quality Assurance Programs

JJ Dorian

The Effluent Monitoring and Near-Facility Environmental Monitoring Programs are subject to the quality assurance requirements specified in DOE/RL-96-68, Rev. 3. These quality assurance programs complied with DOE Order 414.1C, using standards from the American Society of Mechanical Engineers (ASME NQA-1-2008) 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 have a quality assurance program plan describing applicable quality assurance elements. The plan was approved by the contractor quality assurance group, who monitored compliance with the plan. Work, such as sample analyses performed through contracts, had to meet plan requirements. Suppliers were audited before the contract selection was made for equipment and services that may have significantly affected project quality.

8.17.2.1 Sample Collection Quality Assurance

Samples for the Effluent Monitoring and Near-Facility Environmental Monitoring Programs were collected by personnel trained in accordance with approved procedures. Established sampling locations were accurately identified and documented to ensure continuity of data.

8.17.2.2 Analytical Results Quality Assurance

HK Meznarich and EJ Wyse

Samples for the Effluent Monitoring and Near-Facility Environmental Monitoring Programs were analyzed by up to four different analytical laboratories. Use of these laboratories depended on the Hanford Site contractor collecting the samples. Table 8.17.8 provides a summary of the analytical laboratories used for analyzing Hanford Site effluent monitoring and near-facility monitoring samples in 2010.

Analytical data quality was assured by several methods. 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.

Participation of Hanford Site analytical laboratories in DOE and EPA laboratory performance evaluation programs served to ensure data quality. EPA evaluation studies were provided by Environmental Resource Associates.

Performance of the Waste Sampling and Characterization Facility was evaluated by its participation in the following laboratory performance intercomparison studies in 2010: EPA studies (i.e., soil, water pollution, and water tritium), DOE Mixed Analyte Performance Evaluation Program studies, and the National Institute of Standards and Technology Radiochemistry Intercomparison Program study. Waste Sampling and Characterization Facility laboratory staff received and analyzed samples containing 451 different analytes and compounds during participation in Environmental Resource Associates Water Pollution Studies 180 and 186, and Soil Studies 69, 70, and 71. Of the 451 reported analytes, 445 results were acceptable for a total acceptable rate of 99%. For the Environmental Resource Associates water

Table 8.17.8. A Summary of Hanford Site Laboratories Used by Site Contractors and Types of Effluent Monitoring and Near-Facility Monitoring Samples Analyzed, 2010

	Effluent Monitoring Samples					Near-Facility Environmental Monitoring Samples		
	Mission Support Alliance, Inc.		Pacific Northwest National Laboratory	Bechtel National, Inc. and Washington Closure Hanford, LLC		Mission Support Alliance, LLC (RJ Lee Group, Inc.)		
Analytical Laboratory	Air	Water	Air	Air	Water	Air	Water	Other
Waste Sampling and Characterization Facility[a]	X	X		X	X	X	X	X
Advanced Technologies and Laboratories International, Inc.				X				X
General Engineering Laboratories, LLC, Charleston, South Carolina	X	X	X	X	X			
Radiochemical Processing Laboratory[b]	X	X	X					

(a) Operated by Mission Support Alliance (RJ Lee Group, Inc.).
(b) Operated by Pacific Northwest National Laboratory.

tritium studies (RAD 80 and RAD 82), two tritium results were submitted and were acceptable (a 100% acceptable rate). For the DOE Mixed Analyte Performance Evaluation Program studies (MAPEP-10-Studies 22 and 23), samples containing 398 different radionuclides and analytes were submitted to the Waste Sampling and Characterization Facility for analysis. Of the 398 reported radionuclide analytes, 377 results were acceptable while 21 were unacceptable, for a total acceptable rate of 95%. In the National Institute of Standards and Technology Radiochemistry Intercomparison Program study, samples containing strontium-90, americium-241, isotopic plutonium, and isotopic uranium in filters and soils were submitted to the Waste Sampling and Characterization Facility for different analyses (i.e., five samples of each radionuclide for each medium). All radionuclide results for both filters and soils were acceptable, for a total acceptance rate of 100%. Performance evaluation results for the Waste Sampling and Characterization Facility are presented in Table 8.17.9.

Advanced Technologies and Laboratories International, Inc., the 222-S Laboratory Analytical Services and Testing Contractor in the 200-West Area of the Hanford Site, maintains accreditations from the American Industrial Hygiene Association and the Washington State Department of Ecology. Analytical performance was evaluated by its participation in six different laboratory proficiency testing studies in 2010, which included Environmental Resource Associates Water Pollution Studies 183 and 189; Environmental Resource Associates Soil Studies 69 and 71; Environmental Resource Associates MRAD Study 12 and a "Quik™ Response" study; and Mixed Analyte Performance Evaluation Program Studies 22 and 23. In addition, Advanced Technologies and Laboratories International, Inc. participated in the American Industrial Hygiene Association Industrial Hygiene Proficiency Analytical Testing, Beryllium Proficiency Analytical Testing, and Workplace Analysis Scheme for Proficiency testing programs to maintain its accreditation.

Advanced Technologies and Laboratories International, Inc. reported 272 different analytes and compounds during participation in the Environmental Resource Associates water pollution studies in 2010. Of the 272 reported analytes,

Table 8.17.9. The Hanford Site's Waste Sampling and Characterization Facility[a] Performance on RAD, DOE Mixed Analyte Performance Evaluation Program Samples, and National Institute of Standards and Technology Radiochemistry Intercomparison Program Samples, 2010

Media	Program	Radionuclide	Number of Results Reported	Number of Results Within Control Limits
Air filters	MAPEP	Manganese-54, cobalt-57, cobalt-60, zinc-65, strontium-90, cesium-134, cesium-137, uranium-233/234, plutonium-238, plutonium-239/240, americium-241, gross alpha, gross beta	28	28
	NRIP	Strontium-90, uranium-233/234, plutonium-238, uranium-238, plutonium-240, americium-241	6	6
Soil	MAPEP	Potassium-40, manganese-54, cobalt-57, cobalt-60, zinc-65, strontium-90, technetium-99, cesium-134, cesium-137, uranium-233/234, plutonium-238, uranium-238, plutonium-239/240, americium-241	28	21[b]
	NRIP	Strontium-90, uranium-233/234, plutonium-238, uranium-238, plutonium-240, americium-241	6	6
Vegetation	MAPEP	Manganese-54, cobalt-57, cobalt-60, zinc-65, strontium-90, cesium-134, cesium-137, uranium-233/234, plutonium-238, uranium-238, plutonium-239/240, americium-241	24	19[c]
Water	MAPEP	Potassium-40, manganese-54, cobalt-57, cobalt-60, zinc-65, strontium-90, technetium-99, cesium-134, cesium-137, uranium-233/234, plutonium-238, uranium-238, plutonium-239/240, americium-241, gross alpha, gross beta	31	31
Water	RAD	Hydrogen-3	2	2
Soil	MRAD	Plutonium-238, plutonium-239/240	2	2[d]

(a) Onsite laboratory operated by Mission Support Alliance (RJ Lee Group, Inc.).
(b) Failed plutonium-238 and plutonium-239/240 in both Study 22 and 23 soil samples, due to high organic matter in both soil samples. There was no impact on the Hanford Site sample; corrective action is ongoing to address high organic matter. Plutonium-238 and plutonium-239/240 results in NRIP and an ERA make-up sample (MRAD 021811C) were acceptable. Failed cobalt-57, uranium-233/234, and uranium-238 in Study 22.
(c) Manganese-54, cobalt-57, cesium-134, cesium-137, and zinc-65 were reported with the wrong units. All except zinc-65 were acceptable after units were corrected.
(d) MRAD 021811C (make-up performance evaluation sample for MAPEP Soil Studies 22 and 23).
MAPEP = Mixed Analyte Performance Evaluation Program.
NRIP = National Institute of Standards and Technology Radiochemistry Intercomparison Program.
RAD = Radiochemistry Program provided by Environmental Resource Associates, Inc., a Waters Corporation.

270 results were acceptable and 2 were unacceptable, for a total acceptance rate of 99.3%. For the soil studies, a total of 326 analytes were reported of which 323 were acceptable, for an overall score of 99.1%. There were a combined 52 radionuclides reported on the two MRAD studies, of which 48 were acceptable, for an overall score of 92.3%; all of the misses were related to reporting at or near the detection limit. For the two Mixed Analyte Performance Evaluation Program studies, 95 of 97 radionuclide results (including uranium isotopes, analyzed by inductively coupled plasma mass spectrometry) were acceptable, for an acceptable rate of 97.9%. Performance evaluation results are presented in Tables 8.17.10 and 8.17.11.

Table 8.17.10. Advanced Technologies and Laboratories International, Inc.'s Performance on DOE's Mixed Analyte Performance Evaluation Program Samples, 2010[a]

Media	Radionuclide	Number of Results Reported	Number of Results Within Control Limits
Air filters	Manganese-54, cobalt-60, strontium-90, cesium-134, cesium-137, uranium-235, plutonium-238, uranium-238, plutonium-239/240, americium-241, uranium-total, gross alpha, gross beta	13	13
	Manganese-54, cobalt-57, cobalt-60, strontium-90, cesium-134, cesium-137, uranium-235, plutonium-238, uranium-238, plutonium-239/240, uranium-total, gross alpha, gross beta	13	13
Soil	Potassium-40, manganese-54, cobalt-57, cobalt-60, strontium-90, cesium-134, cesium-137, uranium-235, uranium-238, uranium-total	10	10
	Potassium-40, manganese-54, cobalt-60, strontium-90, technetium-99, cesium-134, cesium-137, uranium-235, uranium-238, uranium-total	10	10
Vegetation	Cobalt-60, zinc-65, strontium-90, cesium-134, cesium-137, uranium-235, uranium-238, americium-241, uranium-total	9	8[b]
	Manganese-54, cobalt-57, zinc-65, strontium-90, cesium-134, cesium-137, uranium-235, uranium-238, uranium-total	9	9
Water	Hydrogen-3, manganese-54, cobalt-57, nickel-63, zinc-65, strontium-90, technetium-99, cesium-137, uranium-235, plutonium-238, uranium-238, plutonium-239/240, americium-241, uranium-total, gross alpha, gross beta	16	16
	Hydrogen-3, cobalt-57, cobalt-60, nickel-63, zinc-65, strontium-90, technetium-99, cesium-134, cesium-137, uranium-235, plutonium-238, uranium-238, plutonium-239/240, americium-241, uranium-total, gross alpha, gross beta	17	16[c]

(a) These data represent combined values from the MAPEP-22 and MAPEP-23 studies.
(b) Incorrect value for americium-241.
(c) False positive reported for americium-241. The value would have normally been reported as a "less-than" but MAPEP's reporting protocol will not accept "less-than" values. A value was determined, but because the corresponding uncertainty was relatively low, MAPEP scored the value as incorrect.
MAPEP = Mixed Analyte Performance Evaluation Program.

Table 8.17.11. Advanced Technologies and Laboratories International, Inc.'s Performance on EPA Laboratory Water Pollution Inorganic and Organic Studies, 2010

Laboratory	Water Pollution Study (WP-183) June 2010 % Acceptable	Water Pollution Study (WP-189) December 2010 % Acceptable
Advanced Technologies and Laboratories International, Inc.	100[a]	97.9[b]

(a) 177 of 177 analytes were evaluated as acceptable.
(b) 93 of 95 analytes were evaluated as acceptable.

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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 selected mathematical 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

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

Symbol	Name
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

summarizes and defines the terms and corresponding symbols (metric and non-metric). A conversion table is also provided in Table A.2.

Radioactivity Units

Much of this report provides data on 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.

Table A.2. Conversion Table

Multiply	By	To Obtain	Multiply	By	To Obtain
cm	0.394	in.	in.	2.54	cm
m	3.28	ft	ft	0.305	m
km	0.621	mi	mi	1.61	km
kg	2.205	lb	lb	0.454	kg
L	0.2642	gal	gal	3.785	L
m^2	10.76	ft^2	ft^2	0.093	m^2
ha	2.47	acre	acre	0.405	ha
km^2	0.386	mi^2	mi^2	2.59	km^2
m^3	35.31	ft^3	ft^3	0.0283	m^3
m^3	1.308	yd^3	yd^3	0.7646	m^3
pCi	1,000	nCi	nCi	0.001	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 × 9/5) + 32	°F	°F	(°F -32) ÷ 9/5	°C
oz	28.349	g	g	0.035	oz
ton	0.9078	tonne	tonne	1.1	ton

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)	mBq	millibecquerel (1×10^{-3} Bq)
µCi	microcurie (1×10^{-6} Ci)	kBq	kilobecquerel (1×10^{3} Bq)
nCi	nanocurie (1×10^{-9} Ci)	MBq	megabecquerel (1×10^{6} 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).

Radiological Dose Units

Radiological dose in this report is usually written in terms of total 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.

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 1.0 millirem (10 microsievert) 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 310 mrem (3.1 mSv; National Council on Radiation Protection and Measurements 2009). Medical and dental x-rays and air travel add to this total. Table A.5 includes selected conversions from rem to sievert.

Also used in this report is the term **rad**, with the corresponding unit **gray (Gy)** in parenthesis or footnoted. The rad (gray) is a measure of the energy absorbed by any material, whereas a rem relates to both the amount of radiation energy absorbed by humans and its consequence. The gray can be converted to rad by multiplying by 100. The conversions in Table A.5 can also be used to convert grays to rads.

A **roentgen (R)** is a measure of exposure to electromagnetic radiation (i.e., gamma and x-radiation). One roentgen is equivalent to a charge release of 258 microcoulombs per kilogram of air.

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.

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.

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.

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)
nSv	nanosievert (1×10^{-9} 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)

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.

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 hr
^{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	$\sim 4.5 \times 10^{9}$[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 hr	^{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-99-001.
(b) Natural uranium is a mixture dominated by uranium-238; thus, the half-life is $\sim 4.5 \times 10^{9}$ years.

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		

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.

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. 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 radio-active 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.

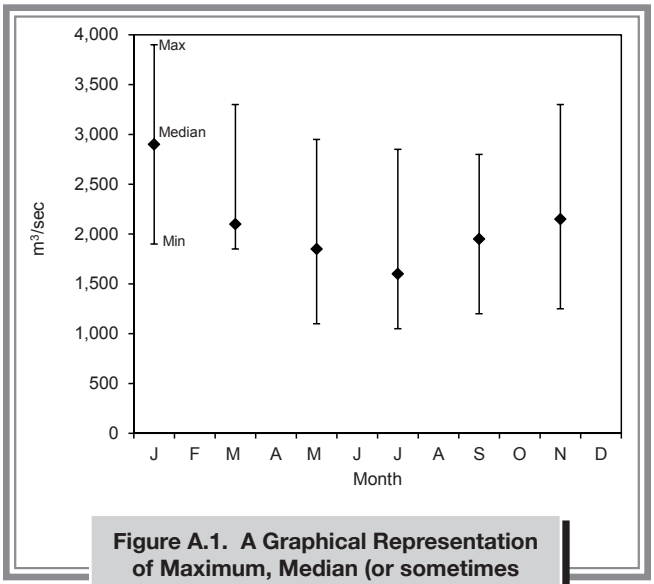

Figure A.1. A Graphical Representation of Maximum, Median (or sometimes average), and Minimum Values

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 seen in graphics 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. 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

(a) Assuming the data are normally distributed.

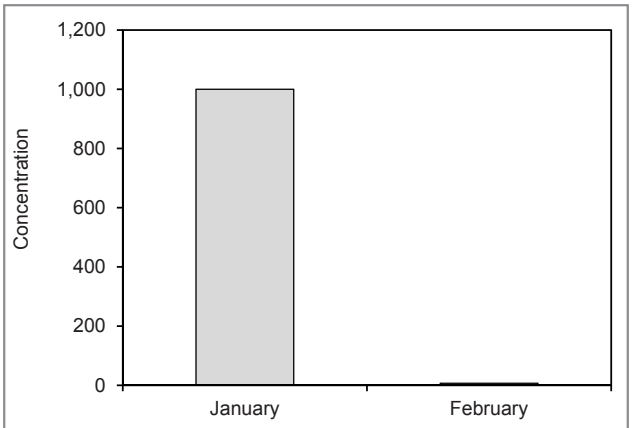

Figure A.2. Data Plotted Using a Linear Scale

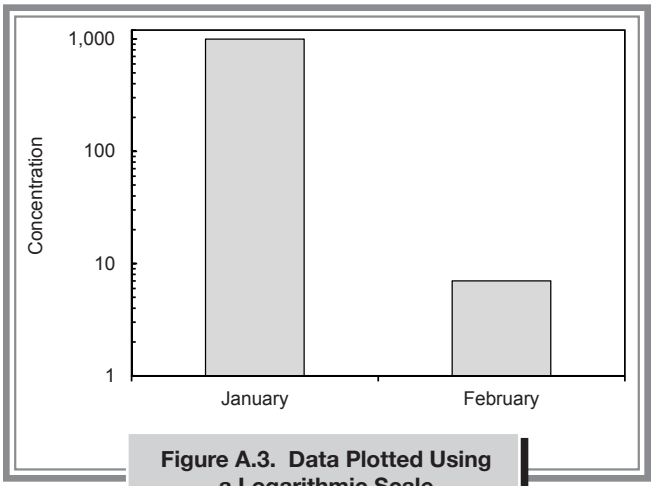

Figure A.3. Data Plotted Using a Logarithmic Scale

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.

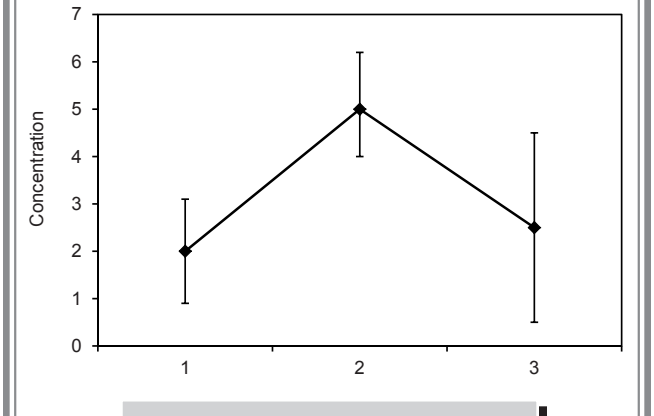

Figure A.4. Data with Error Bars Plotted Using a Linear Scale

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.

References

EPA 402-R-99-001. 1999. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*. Federal Guidance Report No. 13, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C.

National Council on Radiation Protection and Measurements. 2009. *Ionizing Radiation Exposure of the Population of the United States*. NCRP Report No. 160, Washington, D.C.

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* type 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 (1 *gray* = 100 *rad*).

activation product – Material made radioactive by *exposure* to *radiation*, principally by neutron radiation as in metals in a nuclear reactor (e.g., cobalt-60 from cobalt-59 in stainless steel).

adsorption – The accumulation of gases, liquids, or solutes on the surface of a solid or liquid.

alpha particle – A positively charged particle composed of two protons and two neutrons ejected spontaneously from the nuclei of some *radionuclides*. It has low penetrating power and short range. The most energetic alpha will generally fail to penetrate the skin. Alpha particles are hazardous when an alpha-emitting *isotope* is introduced into the body.

anion – A negatively charged ion.

apatite – A mineral that has the capability to capture and retain radioactive metal contaminants.

aquifer – Underground sediment or rock that stores and/or transmits water.

aquifer tube – A small-diameter, flexible plastic tube used to sample shallow *aquifers*, natural seepage areas, or springs.

background radiation – *Radiation* in the natural environment, including cosmic rays from space and *radiation* from naturally occurring radioactive elements in the air, in the earth, and in human bodies. It also includes *radiation* from worldwide *fallout* from historical atmospheric nuclear weapons testing. In the United States, the average person receives approximately 310 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.

black cell – A section of the Hanford Tank Waste Treatment and Immobilization Plant where high-level nuclear waste will be routed that will never be accessible to humans because of its high *radiation* levels.

cation – A positively charged ion.

clean closed – A facility is classified as "clean closed" under *Resource Conservation and Recovery Act of 1976* regulations when all dangerous waste has been removed and *groundwater* monitoring is no longer required.

collective total effective dose (equivalent) (also referred to as "collective dose") – Sum of the *total effective dose* for individuals comprising a defined population. Collective dose is expressed in units of *person-rem* or *person-sievert*.

committed dose equivalent – The *dose equivalent* to organs or tissues that will be received from an intake of radioactive material by an individual during the 50-year period following intake.

committed effective dose equivalent – The sum of the *committed dose equivalent* to various tissues in the body, each multiplied by the appropriate weighting factor.

composite sample – Sample formed by mixing discrete samples taken at different times or from different locations.

confined aquifer – An *aquifer* bounded above and below by less-permeable layers. *Groundwater* in the confined aquifer is under a pressure greater than atmospheric pressure.

continuous sample – Sample formed by the continuous collection of the medium or contaminants within the medium during the entire sampling period.

cosmic radiation – High-energy subatomic particles and electromagnetic *radiation* from outer space that bombard the earth. Cosmic radiation is part of natural *background radiation*.

crib – An underground structure designed to receive liquid waste that percolates into the soil directly or percolates into the soil after having traveled through a connected tile field. These structures are no longer used at the Hanford Site.

curie (Ci) – A unit of *radioactivity* equal to 37 billion (3.7×10^{10}) nuclear transformations per second (*becquerels*).

decay – The decrease in the amount of any radioactive material (disintegration) with the passage of time. See *radioactivity*.

decay product – The atomic nucleus or nuclei that are left after radioactive transformation of a radioactive material. Decay products may be radioactive or non-radioactive (stable). They are informally referred to as daughter products. See *radioactivity*.

deep-dose equivalent – The *dose equivalent* at a tissue depth of 1 centimeter from *radiation* originating outside of the body.

derived concentration guide (DCG) – Concentrations of *radionuclides* in air and water that an individual could continuously consume, inhale, or be immersed in at average annual rates and not receive a *total effective dose (equivalent)* of greater than 100 *millirem* per year.

desiccation – A process whereby water or moisture is removed, resulting in dryness.

detection level (or limit) – Minimum amount of a substance that can be measured with a specified or implied confidence that the analytical result is greater than a specific value (e.g., zero).

direct-push technology – A cost-effective means of collecting subsurface samples; this technology uses a hydraulic hammer to drive a hollow rod into the soil either vertically or at an angle. Sensors can be deployed within the rod to detect radioactive contaminants, soil moisture, and other sampling criteria.

dispersion – Process whereby *effluent* or *emissions* are spread or mixed when they are transported by *groundwater*, surface water, or air.

dose equivalent – Product of the *absorbed dose*, a quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of *radiation* on a common scale. The unit of dose equivalent is the *rem*.

dose rate – The rate at which a dose is delivered over time (e.g., *dose equivalent* rate in *millirem* per hour [mrem/hr]).

dosimeter – Portable device for measuring the accumulated *exposure* or *absorbed dose* from specific types or energies of ionizing *radiation* fields.

effective dose (equivalent) – The sum of products of *dose equivalent* to selected tissues of the body and appropriate tissue weighting factors. The tissue weighting factors put doses to various tissues and organs on an equal basis in terms of health *risk*.

effluent – Liquid material released from a facility.

effluent monitoring – Sampling or measuring specific liquid *effluent* streams for the presence of pollutants.

emission – Gaseous stream released from a facility.

exposure – The interaction of an organism with a physical agent (e.g., *radiation*) or a chemical agent (e.g., arsenic) of interest. Also used as a term for quantifying x- and *gamma-radiation* fields. See *roentgen*.

external radiation – *Radiation* originating from a source outside the body.

fallout – Typically refers to radioactive materials that are released into the earth's atmosphere following a nuclear explosion or atmospheric release and that eventually fall to earth.

fission – The splitting or breaking apart of a nucleus into at least two other nuclei, accompanied with a release of a relatively large amount of energy.

fission products – *Nuclides* formed from fissioning. Many fission products are radioactive.

found fuel – Incomplete pieces of spent nuclear fuel elements too small to have been located and removed during previous debris removal.

fully institutionalized – To incorporate into a formalized, structured system and be implemented and fully functional.

gamma radiation – High-energy electromagnetic *radiation* (*photons*) originating in the nucleus of decaying *radionuclides*. Gamma radiation is substantially more penetrating than *alpha* or *beta particles*.

grab sample – A short-duration sample (e.g., air, water, and soil) that is grabbed from the collection site.

ground truth – Direct physical observations that are used to test indirect interpretations.

groundwater – Subsurface water that is in the pores of sand and gravel or in the cracks of fractured rock.

gray (Gy) – Unit of *absorbed dose* in the International System of Units (SI) equal to the absorption of 1 joule per kilogram. The common unit of *absorbed dose*, the *rad*, is equal to 0.01 Gy.

half-life – Length of time in which a radioactive substance will lose one half of its *radioactivity* by *decay*. Half-lives range from a fraction of a second to billions of years, and each *radionuclide* has a unique half-life.

high-activity waste – See *high-level waste*.

high-level waste – Highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains *fission products* and other *radioisotopes* in sufficient concentrations to require permanent isolation.

institutional controls – Long-term actions or restrictions including *monitoring*, periodic sampling, access controls, and land-use restrictions designed to mitigate any *risks* posed by contamination following *remediation*. Institutional controls alone may be sufficient to reduce risks posed by low levels of contamination.

internal radiation – *Radiation* from radioactive material inside the body.

ion exchange – The reversible exchange of one species of ion for a different species of ion within a medium.

ion exchange resin – High molecular weight insoluble polymers containing functional groups that are capable of undergoing exchange reactions with ions in a solution with which it is in contact.

irradiation – *Exposure* to *radiation*.

isotopes – *Nuclides* of the same chemical element with the same number of protons but a differing number of neutrons.

isotopic plutonium – Any of two or more atoms of the chemical element *plutonium* with the same atomic number and position in the periodic table and nearly identical chemical behavior but with differing atomic mass number and different physical properties. Plutonium-239 is produced by neutron *irradiation* of uranium-238.

isotopic uranium – Any of two or more atoms of the chemical element uranium with the same atomic number and position in the periodic table and nearly identical chemical behavior but with differing atomic mass number and different physical properties. Uranium exists naturally as a mixture of three *isotopes* of mass 234, 235, and 238 in the proportions of 0.006%, 0.71%, and 99.27%, respectively.

legacy waste – Waste that was generated before the Hanford Site's nuclear materials production mission was terminated.

low-activity waste – See *low-level waste*.

low-level waste – Radioactive waste that is not high-level radioactive waste, spent nuclear fuel, *transuranic waste*, byproduct material, or naturally occurring radioactive material.

material at risk – The inventory of radioactive material that could potentially be released to the environment from an accident.

maximally exposed individual – A hypothetical member of the public residing near the Hanford Site who, by virtue of location and living habits, would reasonably receive the highest possible *radiation* dose from materials originating from the site.

mean (or average) – Average value of a series of measurements. The mean is computed using the following equation:

$$\text{mean} = \frac{\sum x}{n}$$

where n is the number of measurements, and Σ_x is the sum of all measurements.

median – Middle value in an odd-numbered set of results when the data are ranked in increasing or decreasing order or the *average* of two central values in an even number set of results.

millirem – A unit of *radiation dose equivalent* that is equal to one one-thousandth (1/1000) of a *rem*.

minimum detectable amount or concentration – Smallest amount or concentration of a chemical or radioactive material that can be reliably detected in a sample.

mitigation – Prevention or reduction of expected *risks* to workers, the public, or the environment.

mixed waste – A U.S. Environmental Protection Agency or state-designated dangerous, extremely hazardous, or acutely hazardous waste that contains both a nonradioactive hazardous component and a radioactive component.

monitoring – As defined in DOE Order 5400.5, Chg 2, 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, radon, 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.

phytoremediation – Use of plants to degrade or immobilize pollutants or toxins from the environment.

plume – The cloud of a pollutant in air, surface water, or *groundwater* formed after the pollutant is released from a source.

plutonium – A heavy, radioactive, metallic element consisting of several *isotopes*. One important isotope is plutonium-239, which is produced by the *irradiation* of uranium-238. Routine analysis cannot distinguish between the plutonium-239 and plutonium-240 *isotopes*; hence, the term plutonium-239/240 as used in this report is symbolic of the presence of one or both of these *isotopes* in the analytical results.

primordial radionuclide – A radioactive material in the earth's crust that has a very long *half-life* and has existed since the beginning of the planet.

quality assurance – Actions that provide confidence that an item or process meets or exceeds a user's requirements and expectations.

quality control – Comprises all those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements. Quality control is an element of *quality assurance*.

rad – The unit of *absorbed dose*. 1 rad = 0.01 *gray* (Gy).

radiation – The energy emitted in the form of *photons* or particles (e.g., *alpha* and *beta particles*) such as that from transforming *radionuclides*. For this report, radiation refers to ionizing types of radiation; not radiowaves, microwaves, radiant light, or other types of non-ionizing radiation.

radioactivity – Property possessed by *radioisotopes* emitting *radiation* (such as *alpha* or *beta particles*, or high-energy *photons*) spontaneously in their decay process; also, the *radiation* emitted.

radioisotope – An unstable *isotope* of an element that *decays* or disintegrates spontaneously, emitting *radiation* (Shleien 1992).

radiologically controlled area – An area to which access is controlled to protect individuals from *exposure* to *radiation* or radioactive materials.

radionuclide – A species of atoms having a particular number of protons (Z), a particular number of neutrons (A), and a particular atomic weight (N = Z + A) that happens to emit *radiation*. Carbon-14 is a radionuclide but carbon-12, which is not radioactive, is referred to simply as a *nuclide*.

recruitment – Survival from one life form or stage to the next or from one age class to the next.

redox – A chemical reaction involving oxidation and reduction.

refractory – A material that has a high melting point (i.e., heat resistant).

refugium (refugia) – An area that has not experienced ecological changes that have affected surrounding regions, providing a habitat for species that were once more widespread.

rem – A unit of *dose equivalent* and *total effective dose (equivalent)*.

remediation – Reduction (or cleanup) of known *risks* to the public and environment to an agreed-upon level.

risk – The probability that a detrimental health effect will occur.

risk-based disposal approval – A written application to the U.S. Environmental Protection Agency intended to manage and dispose of *Toxic Substances Control Act*-regulated polychlorinated biphenyl waste not addressed suitably within the regulations. The risk-based disposal approval process applies to any person wishing to sample, clean up, or dispose of waste in a manner other than as prescribed in 40 CFR 761. For polychlorinated biphenyl remediation waste, the requirements for a risk-based disposal approval are specified in 40 CFR 761.61(c). A written approval from the U.S. Environmental Protection Agency is required before waste management activities are performed.

roentgen (R) – The unit of x-ray or gamma *photon exposure* as measured in air, historically used to describe *external radiation* levels. An *exposure* of 1 roentgen typically causes an *effective dose* of 1 *rem*.

shrub-steppe – A drought-resistant shrub and grassland ecosystem.

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, Chg 2, 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.

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*.

total uranium – The sum of concentrations of the *isotopes* uranium-234, uranium-235, and uranium-238.

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).

tritium – The heaviest radioactive *isotope* of hydrogen (hydrogen-3) with a 12.3-year half life.

unconfined aquifer – An *aquifer* containing *groundwater* that is not confined above by relatively impermeable rocks. The pressure at the top of the unconfined aquifer is equal to that of the atmosphere. At the Hanford Site, the unconfined aquifer is the uppermost *aquifer* and is most susceptible to contamination from site operations.

vadose zone – Underground area from the ground surface to the top of the *water table* or *aquifer*.

volatile organic compounds – Lightweight organic compounds that vaporize easily; used in solvents and degreasing compounds as raw materials.

water table – The top of the *unconfined aquifer*.

wind rose – A diagram showing how often winds of various speeds blow from different directions, usually based on yearly averages.

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Appendix C
Additional Monitoring Results for 2010

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This appendix contains additional information on 2010 monitoring results, supplementing data summarized in the main body of the report. More detailed information is available upon request (see Preface for contact information).

Table C.1. Concentrations of Selected Radionuclides (pCi/m³)[a] in Near-Facility Air Samples, 2010 Compared to Previous Years

		2010					2005-2009				
		Number of				Sampler	Number of				EPA
Radionuclide	Site	Samples	Detections[b]	Average[c]	Maximum[d]	Number	Samples	Detections[b]	Average[c]	Maximum[d]	Table 2[e,f]
Gross alpha	100-D FR	104	94	1.1E-03 ± 1.1E-03	3.4E-03 ± 9.5E-04	N467	300	272	1.1E-03 ± 1.1E-03	3.1E-03 ± 8.5E-04	2.0E-02
	100-F FR	27	22	1.8E-03 ± 1.7E-03	4.6E-03 ± 2.9E-03	N520	364	322	1.2E-03 ± 1.3E-03	3.9E-03 ± 1.3E-03	
	100-H FR	103	88	1.1E-03 ± 1.1E-03	3.0E-03 ± 8.3E-04	N510	149	143	1.3E-03 ± 1.1E-03	2.8E-03 ± 8.1E-04	
	100-K KBC	188	172	1.1E-03 ± 1.2E-03	4.3E-03 ± 2.0E-03	N576	1,040	947	1.4E-03 ± 2.6E-03	2.0E-02 ± 2.5E-03	
	100-N	78	71	1.2E-03 ± 1.2E-03	3.3E-03 ± 1.0E-03	N106	393	375	1.3E-03 ± 1.3E-03	3.9E-03 ± 1.1E-03	
	118-K-1 FR	52	47	1.0E-03 ± 1.1E-03	2.6E-03 ± 8.2E-04	N534	154	135	1.2E-03 ± 1.8E-03	7.5E-03 ± 1.6E-03	
	200-East	545	507	1.2E-03 ± 1.2E-03	3.4E-03 ± 8.9E-04	N957	2,706	2,517	1.2E-03 ± 1.3E-03	5.0E-03 ± 1.1E-03	
	200-North	104	90	1.2E-03 ± 1.1E-03	2.4E-03 ± 7.8E-04	N568	102	92	1.2E-03 ± 1.3E-03	3.7E-03 ± 1.2E-03	
	200-UW-1	128	113	1.8E-03 ± 2.8E-03	7.4E-03 ± 5.6E-03	N550	573	531	1.2E-03 ± 1.3E-03	5.0E-03 ± 2.1E-03	
	200-West	625	557	1.4E-03 ± 1.8E-03	7.4E-03 ± 5.6E-03	N550	3,150	2,908	1.3E-03 ± 1.5E-03	1.2E-02 ± 4.6E-03	
	300 Area D&D	26	24	1.2E-03 ± 9.9E-04	2.2E-03 ± 7.4E-04	N557	127	118	1.2E-03 ± 1.6E-03	7.3E-03 ± 1.7E-03	
	300-FF-2 FR	34	32	1.1E-03 ± 9.9E-04	2.2E-03 ± 7.7E-04	N130	247	237	1.2E-03 ± 1.2E-03	4.8E-03 ± 1.3E-03	
	600 Area (WYE)	26	25	1.4E-03 ± 1.7E-03	4.3E-03 ± 1.0E-03	N981	131	122	1.3E-03 ± 1.2E-03	3.3E-03 ± 9.2E-04	
	618-10 FR	36	32	8.7E-04 ± 7.8E-04	1.9E-03 ± 6.7E-04	N579	8	2	6.0E-04 ± 8.3E-04	1.4E-03 ± 6.6E-04	
	BCCA	104	92	1.2E-03 ± 1.3E-03	3.4E-03 ± 8.9E-04	N957	299	276	1.2E-03 ± 1.4E-03	4.6E-03 ± 1.2E-03	
	ERDF	130	111	1.4E-03 ± 2.3E-03	7.4E-03 ± 5.6E-03	N550	659	588	1.1E-03 ± 1.2E-03	4.7E-03 ± 2.9E-03	
Gross beta	100-D FR	104	104	1.7E-02 ± 1.6E-02	3.8E-02 ± 4.5E-03	N468	300	300	1.7E-02 ± 1.8E-02	4.9E-02 ± 4.6E-03	9.0E+00
	100-F FR	27	27	2.2E-02 ± 1.4E-02	3.8E-02 ± 3.8E-03	N521	364	364	1.7E-02 ± 2.1E-02	7.1E-02 ± 7.6E-03	
	100-H FR	103	102	1.7E-02 ± 1.7E-02	3.6E-02 ± 4.1E-03	N574	149	148	2.1E-02 ± 2.1E-02	5.3E-02 ± 4.9E-03	
	100-K KBC	188	188	1.8E-02 ± 3.1E-02	1.5E-01 ± 1.2E-02	N403	1,040	1,040	2.6E-02 ± 1.2E-01	1.2E+00 ± 8.4E-02	
	100-N	78	78	1.6E-02 ± 1.5E-02	4.0E-02 ± 4.0E-03	N103	393	393	1.7E-02 ± 1.9E-02	6.8E-02 ± 6.1E-03	
	118-K-1 FR	52	52	1.8E-02 ± 1.9E-02	3.9E-02 ± 4.4E-03	N535	154	154	1.7E-02 ± 2.2E-02	7.8E-02 ± 7.9E-03	
	200-East	545	545	1.7E-02 ± 1.6E-02	4.8E-02 ± 4.6E-03	N973	2,706	2,706	1.7E-02 ± 2.0E-02	9.6E-02 ± 7.8E-03	
	200-North	104	104	1.7E-02 ± 1.7E-02	3.9E-02 ± 4.4E-03	N563	102	102	1.6E-02 ± 1.7E-02	5.2E-02 ± 5.5E-03	
	200-UW-1	128	128	1.8E-02 ± 2.4E-02	9.6E-02 ± 1.6E-02	N550	573	573	1.7E-02 ± 2.0E-02	7.4E-02 ± 6.9E-03	
	200-West	625	624	1.7E-02 ± 1.9E-02	1.0E-01 ± 2.3E-02	N994	3,150	3,147	1.7E-02 ± 2.1E-02	1.7E-01 ± 2.0E-02	
	300 Area D&D	26	26	1.8E-02 ± 2.0E-02	4.7E-02 ± 5.1E-03	N557	127	127	1.8E-02 ± 2.2E-02	6.4E-02 ± 6.8E-03	
	300-FF-2 FR	34	34	1.7E-02 ± 1.6E-02	3.7E-02 ± 3.7E-03	N527	247	247	1.8E-02 ± 2.1E-02	8.1E-02 ± 7.2E-03	
	600 Area (WYE)	26	26	1.7E-02 ± 1.6E-02	3.7E-02 ± 3.9E-03	N981	131	131	1.7E-02 ± 1.9E-02	6.5E-02 ± 5.8E-03	
	618-10 FR	36	36	1.2E-02 ± 9.0E-03	2.3E-02 ± 3.0E-03	N580	8	8	1.0E-02 ± 5.7E-03	1.5E-02 ± 2.1E-03	
	BCCA	104	104	1.6E-02 ± 1.5E-02	4.0E-02 ± 3.9E-03	N978	299	298	1.7E-02 ± 2.0E-02	6.2E-02 ± 5.8E-03	
	ERDF	130	129	1.6E-02 ± 2.4E-02	9.6E-02 ± 1.6E-02	N550	659	658	1.6E-02 ± 2.0E-02	6.6E-02 ± 5.9E-03	

Table C.1. (contd)

Radionuclide	Site	2010 Number of Samples	2010 Number of Detections[b]	2010 Average[c]	2010 Maximum[d]	Sampler Number	2005-2009 Number of Samples	2005-2009 Number of Detections[b]	2005-2009 Average[c]	2005-2009 Maximum[d]	EPA Table 2[e,f]
Cobalt-60	100-D FR	8	0	2.1E-05 ± 5.6E-05	5.8E-05 ± 6.3E-05	N467	24	0	4.4E-06 ± 8.7E-05	8.4E-05 ± 9.0E-05	1.7E-03
	100-F FR	3	0	5.4E-06 ± 1.4E-04	7.0E-05 ± 1.4E-04	N521	31	0	-2.7E-06 ± 1.1E-04	1.4E-04 ± 3.2E-04	
	100-H FR	8	0	3.4E-05 ± 7.0E-05	1.0E-04 ± 1.2E-04	N574	12	0	2.4E-05 ± 9.0E-05	1.5E-04 ± 2.0E-04	
	100-K KBC	17	0	7.3E-06 ± 1.5E-04	2.8E-04 ± 5.6E-04	N576	80	1	1.1E-05 ± 8.1E-05	1.2E-04 ± 1.1E-04	
	100-N	6	0	2.7E-05 ± 9.4E-05	7.6E-05 ± 8.8E-05	N106	30	4	2.5E-05 ± 1.8E-04	2.8E-04 ± 1.5E-04	
	118-K-1 FR	4	1	9.0E-05 ± 3.7E-04	4.0E-04 ± 1.6E-04	N534	16	0	4.5E-05 ± 3.2E-04	5.5E-04 ± 5.7E-04	
	200-East	42	0	2.3E-06 ± 7.6E-05	9.1E-05 ± 8.9E-05	N999	208	1	4.4E-06 ± 9.4E-05	1.7E-04 ± 2.7E-04	
	200-North	8	0	1.2E-05 ± 8.2E-05	6.8E-05 ± 9.1E-05	N564	12	1	4.5E-05 ± 1.7E-04	2.5E-04 ± 1.2E-04	
	200-UW-1	10	0	2.8E-05 ± 1.2E-04	1.3E-04 ± 2.3E-04	N550	44	0	-2.2E-06 ± 7.1E-05	9.0E-05 ± 8.4E-05	
	200-West	49	0	3.0E-06 ± 1.0E-04	1.3E-04 ± 2.3E-04	N550	243	0	3.7E-07 ± 8.7E-05	1.5E-04 ± 1.5E-04	
	300 Area D&D	4	0	-4.9E-05 ± 3.2E-04	1.2E-04 ± 2.0E-04	N557	20	0	-4.3E-05 ± 2.2E-04	1.3E-04 ± 1.4E-04	
	300-FF-2 FR	3	0	7.1E-06 ± 4.9E-05	4.0E-05 ± 8.8E-05	N130	19	0	-1.3E-05 ± 9.3E-05	8.0E-05 ± 9.2E-05	
	600 Area (WYE)	2	0	1.9E-06 ± 4.9E-05	2.6E-05 ± 6.3E-05	N981	10	1	1.6E-05 ± 1.1E-04	1.4E-04 ± 6.3E-05	
	618-10 FR	8	0	-3.0E-06 ± 1.8E-04	1.2E-04 ± 1.9E-04	N548	4	0	-3.7E-05 ± 1.4E-03	1.1E-03 ± 1.3E-03	
	BCCA	8	0	-1.5E-05 ± 8.0E-05	7.3E-05 ± 8.7E-05	N978	24	0	1.2E-05 ± 1.1E-04	1.0E-04 ± 1.2E-04	
	ERDF	10	0	1.3E-05 ± 1.2E-04	1.3E-04 ± 2.3E-04	N550	50	0	3.4E-06 ± 9.0E-05	1.5E-04 ± 1.2E-04	
Strontium-90	100-D FR	8	0	-1.1E-04 ± 6.1E-05	-7.0E-05 ± 7.3E-05	N468	24	1	-1.1E-04 ± 3.5E-04	2.9E-04 ± 2.4E-04	1.9E-03
	100-F FR	3	0	-4.5E-04 ± 2.1E-04	-3.2E-04 ± 3.3E-04	N520	31	1	-8.8E-05 ± 2.6E-04	2.7E-04 ± 1.3E-04	
	100-H FR	8	0	-1.2E-04 ± 2.0E-04	2.9E-05 ± 1.5E-04	N508	12	0	-1.6E-04 ± 2.9E-04	2.3E-04 ± 2.4E-04	
	100-K KBC	17	3	-6.1E-05 ± 1.9E-03	3.1E-03 ± 9.4E-04	N403	80	15	7.6E-04 ± 5.4E-03	1.5E-02 ± 4.4E-03	
	100-N	6	0	-2.0E-04 ± 1.9E-04	-6.9E-05 ± 7.1E-05	N106	30	3	-6.4E-05 ± 3.3E-04	2.0E-04 ± 1.2E-04	
	118-K-1 FR	4	0	-1.9E-04 ± 1.5E-04	-7.8E-05 ± 8.1E-05	N535	16	2	-3.0E-05 ± 7.8E-04	9.5E-04 ± 4.3E-04	
	200-East	42	2	-1.1E-04 ± 3.5E-04	2.8E-04 ± 1.9E-04	N969	208	9	-7.8E-05 ± 3.0E-04	5.0E-04 ± 1.8E-04	
	200-North	8	0	-1.6E-04 ± 2.9E-04	8.1E-05 ± 2.1E-04	N564	12	0	-5.0E-04 ± 1.1E-03	1.0E-04 ± 1.8E-04	
	200-UW-1	10	0	-2.0E-04 ± 3.5E-04	2.6E-05 ± 2.4E-04	N956	44	3	-7.8E-05 ± 3.9E-04	6.6E-04 ± 2.6E-04	
	200-West	49	0	-1.8E-04 ± 3.1E-04	1.8E-04 ± 2.1E-04	N966	243	9	-8.6E-05 ± 3.5E-04	6.6E-04 ± 2.6E-04	
	300 Area D&D	4	0	-5.3E-04 ± 5.6E-04	-2.2E-04 ± 2.2E-04	N557	20	0	-1.9E-04 ± 5.0E-04	3.8E-04 ± 4.7E-04	
	300-FF-2 FR	3	0	-3.1E-04 ± 3.8E-04	-1.8E-04 ± 1.8E-04	N130	10	0	-1.1E-04 ± 2.7E-04	4.1E-05 ± 1.4E-04	
	600 Area (WYE)	2	0	-1.2E-04 ± 1.7E-04	-3.3E-05 ± 3.4E-05	N981	10	0	-9.0E-05 ± 1.8E-04	3.7E-05 ± 1.1E-04	
	618-10 FR	8	0	-3.6E-04 ± 7.1E-04	2.1E-04 ± 5.6E-04	N549	0	0	Not Applicable		
	BCCA	8	0	-2.1E-04 ± 3.2E-04	-1.7E-05 ± 1.8E-05	N957	24	0	-1.1E-04 ± 2.5E-04	4.5E-05 ± 1.7E-04	
	ERDF	10	0	-2.4E-04 ± 3.1E-04	-2.5E-05 ± 2.6E-05	N963	50	2	-5.1E-05 ± 3.3E-04	6.7E-04 ± 2.7E-04	

Table C.1. (contd)

Radionuclide	Site	2010 Number of Samples	2010 Number of Detections[b]	2010 Average[c]	2010 Maximum[d]	Sampler Number	2005-2009 Number of Samples	2005-2009 Number of Detections[b]	2005-2009 Average[c]	2005-2009 Maximum[d]	EPA Table 2[e,f]
Cesium-137	100-D FR	8	0	9.0E-06 ± 8.1E-05	6.4E-05 ± 8.1E-05	N467	24	0	2.1E-05 ± 8.2E-05	9.6E-05 ± 7.4E-05	1.9E-03
	100-F FR	3	0	4.4E-05 ± 6.0E-05	7.1E-05 ± 1.3E-04	N520	31	1	-7.3E-06 ± 9.5E-05	1.2E-04 ± 1.0E-04	
	100-H FR	8	0	1.9E-05 ± 5.2E-05	8.0E-05 ± 8.1E-05	N510	12	0	1.5E-05 ± 7.6E-05	9.4E-05 ± 6.2E-05	
	100-K KBC	17	9	1.1E-03 ± 6.1E-03	1.3E-02 ± 4.0E-03	N403	80	23	6.4E-03 ± 4.1E-02	1.2E-01 ± 3.9E-02	
	100-N	6	0	-5.4E-06 ± 1.0E-04	8.2E-05 ± 6.6E-05	N103	30	4	4.9E-05 ± 1.3E-04	2.4E-04 ± 1.5E-04	
	118-K-1 FR	4	2	4.4E-04 ± 9.5E-04	1.2E-03 ± 4.0E-04	N535	16	3	6.9E-05 ± 3.5E-04	6.6E-04 ± 2.6E-04	
	200-East	42	3	3.5E-05 ± 9.9E-05	1.7E-04 ± 1.3E-04	N973	208	25	7.2E-05 ± 4.2E-04	2.3E-03 ± 7.7E-04	
	200-North	8	0	2.3E-05 ± 1.2E-04	1.2E-04 ± 7.5E-05	N568	12	0	5.8E-05 ± 1.1E-04	1.5E-04 ± 1.6E-04	
	200-UW-1	10	0	1.3E-05 ± 9.4E-05	6.1E-05 ± 7.3E-05	N956	44	11	9.1E-05 ± 1.9E-04	4.0E-04 ± 2.1E-04	
	200-West	49	0	1.0E-05 ± 7.0E-05	6.1E-05 ± 7.3E-05	N956	243	22	4.3E-05 ± 1.4E-04	4.0E-04 ± 2.1E-04	
	300 Area D&D	4	0	3.7E-05 ± 5.4E-05	6.3E-05 ± 1.6E-04	N557	20	0	1.4E-05 ± 1.3E-04	1.2E-04 ± 3.1E-04	
	300-FF-2 FR	3	0	1.4E-05 ± 3.5E-05	3.8E-05 ± 9.4E-05	N527	19	0	2.4E-06 ± 4.3E-05	5.0E-05 ± 5.6E-05	
	600 Area (WYE)	2	0	2.4E-05 ± 4.8E-05	4.9E-05 ± 7.2E-05	N981	10	0	2.4E-05 ± 5.2E-05	5.9E-05 ± 7.3E-05	
	618-10 FR	8	0	2.3E-05 ± 2.1E-04	1.6E-04 ± 1.5E-04	N579	4	0	-3.6E-05 ± 6.4E-04	2.0E-04 ± 5.0E-04	
	BCCA	8	0	2.4E-05 ± 8.1E-05	8.4E-05 ± 7.7E-05	N572	24	3	2.7E-05 ± 1.4E-04	2.0E-04 ± 1.0E-04	
	ERDF	10	0	2.2E-05 ± 9.6E-05	7.7E-05 ± 8.2E-05	N518	50	8	7.5E-05 ± 1.7E-04	3.8E-04 ± 1.5E-04	
Uranium-234	100-D FR	8	7	8.5E-06 ± 4.0E-06	1.2E-05 ± 6.9E-06	N467	24	21	1.1E-05 ± 7.8E-06	1.8E-05 ± 1.0E-05	7.7E-04
	100-F FR	3	1	9.1E-06 ± 8.0E-06	1.5E-05 ± 9.4E-06	N520	31	27	1.3E-05 ± 1.0E-05	2.9E-05 ± 2.0E-05	
	100-H FR	8	5	9.3E-06 ± 1.3E-05	2.5E-05 ± 1.2E-05	N574	12	11	1.5E-05 ± 2.0E-05	4.0E-05 ± 2.1E-05	
	100-K KBC	17	13	1.5E-05 ± 2.2E-05	4.7E-05 ± 3.0E-05	N575	80	71	1.1E-05 ± 9.0E-06	2.4E-05 ± 1.2E-05	
	100-N	6	6	1.1E-05 ± 8.5E-06	1.6E-05 ± 8.9E-06	N106	30	28	1.2E-05 ± 9.2E-06	2.2E-05 ± 1.1E-05	
	118-K-1 FR	4	2	1.0E-05 ± 8.1E-06	1.5E-05 ± 7.9E-06	N535	16	13	2.0E-05 ± 3.8E-05	8.4E-05 ± 4.3E-05	
	200-East	42	37	1.1E-05 ± 1.4E-05	4.4E-05 ± 2.0E-05	N967	208	193	1.2E-05 ± 9.5E-06	3.3E-05 ± 1.6E-05	
	200-North	8	7	1.1E-05 ± 5.2E-06	1.5E-05 ± 8.9E-06	N563	12	12	2.0E-05 ± 2.4E-05	5.4E-05 ± 2.4E-05	
	200-UW-1	10	8	3.3E-04 ± 1.3E-03	2.2E-03 ± 7.4E-04	N551	44	42	1.9E-05 ± 2.4E-05	6.3E-05 ± 2.8E-05	
	200-West	49	45	7.9E-05 ± 6.2E-04	2.2E-03 ± 7.4E-04	N551	243	220	1.3E-05 ± 1.5E-05	6.3E-05 ± 2.8E-05	
	300 Area D&D	4	1	1.1E-05 ± 5.4E-06	1.6E-05 ± 1.2E-05	N557	20	20	3.0E-05 ± 4.0E-05	1.1E-04 ± 5.3E-05	
	300-FF-2 FR	3	3	1.3E-05 ± 4.9E-06	1.6E-05 ± 1.1E-05	N527	19	18	1.5E-05 ± 9.7E-06	2.4E-05 ± 1.3E-05	
	600 Area (WYE)	2	2	2.2E-05 ± 2.8E-05	3.6E-05 ± 1.7E-05	N981	10	8	1.0E-05 ± 1.1E-05	2.0E-05 ± 1.1E-05	
	618-10 FR	8	5	1.9E-05 ± 1.2E-05	2.7E-05 ± 1.8E-05	N579	4	2	9.7E-05 ± 1.2E-04	1.7E-04 ± 1.2E-04	
	BCCA	8	6	8.6E-06 ± 8.0E-06	1.4E-05 ± 8.5E-06	N978	24	22	1.3E-05 ± 1.2E-05	3.3E-05 ± 1.6E-05	
	ERDF	10	9	7.5E-05 ± 2.6E-04	4.7E-04 ± 1.6E-04	N550	50	50	2.2E-05 ± 2.4E-05	6.0E-05 ± 2.6E-05	

Table C.1. (contd)

Radionuclide	Site	2010 Number of Samples	2010 Number of Detections[b]	2010 Average[c]	2010 Maximum[d]	Sampler Number	2005-2009 Number of Samples	2005-2009 Number of Detections[b]	2005-2009 Average[c]	2005-2009 Maximum[d]	EPA Table 2[e,f]
Uranium-235	100-D FR	8	2	1.5E-06 ± 2.2E-06	3.2E-06 ± 3.2E-06	N514	24	3	2.4E-06 ± 3.2E-06	6.2E-06 ± 5.3E-06	7.1E-04
	100-F FR	3	0	3.2E-06 ± 2.9E-06	4.4E-06 ± 5.2E-06	N519	31	7	3.4E-06 ± 5.9E-06	1.4E-05 ± 1.4E-05	
	100-H FR	8	1	2.0E-06 ± 2.4E-06	3.9E-06 ± 3.5E-06	N508	12	0	2.1E-06 ± 2.7E-06	5.6E-06 ± 5.3E-06	
	100-K KBC	16	4	5.3E-06 ± 1.3E-05	2.6E-05 ± 2.1E-05	N576	80	14	2.6E-06 ± 3.8E-06	1.2E-05 ± 7.9E-06	
	100-N	6	0	2.1E-06 ± 2.6E-06	4.6E-06 ± 4.3E-06	N102	30	9	2.7E-06 ± 3.7E-06	8.2E-06 ± 6.9E-06	
	118-K-1 FR	4	0	1.4E-06 ± 1.7E-06	2.3E-06 ± 3.5E-06	N534	16	1	4.9E-06 ± 1.2E-05	2.3E-05 ± 2.3E-05	
	200-East	42	4	1.9E-06 ± 3.2E-06	6.9E-06 ± 5.4E-06	N978	208	48	2.6E-06 ± 4.0E-06	1.4E-05 ± 1.7E-05	
	200-North	8	2	2.8E-06 ± 2.7E-06	4.6E-06 ± 4.2E-06	N568	12	4	6.1E-06 ± 1.2E-05	2.1E-05 ± 1.5E-05	
	200-UW-1	10	5	3.4E-05 ± 1.2E-04	2.1E-04 ± 7.8E-05	N551	44	15	3.4E-06 ± 5.5E-06	9.7E-06 ± 7.3E-06	
	200-West	49	9	1.0E-05 ± 6.5E-05	2.1E-04 ± 7.8E-05	N551	243	52	2.7E-06 ± 4.7E-06	1.9E-05 ± 1.2E-05	
	300 Area D&D	4	0	3.6E-06 ± 2.3E-06	5.4E-06 ± 5.9E-06	N557	20	1	3.8E-06 ± 5.4E-06	8.8E-06 ± 9.8E-06	
	300-FF-2 FR	3	0	2.5E-06 ± 2.5E-06	3.4E-06 ± 3.6E-06	N130	19	4	2.6E-06 ± 4.1E-06	8.8E-06 ± 5.9E-06	
	600 Area (WYE)	2	0	1.2E-06 ± 6.4E-07	1.5E-06 ± 2.2E-06	N981	10	3	3.5E-06 ± 6.0E-06	1.1E-05 ± 7.7E-06	
	618-10 FR	8	0	3.7E-06 ± 7.8E-06	1.0E-05 ± 1.1E-05	N549	4	2	5.6E-05 ± 8.5E-05	1.3E-04 ± 8.9E-05	
	BCCA	8	2	2.5E-06 ± 4.8E-06	6.9E-06 ± 5.4E-06	N978	24	5	2.9E-06 ± 4.6E-06	1.0E-05 ± 6.8E-06	
	ERDF	10	2	7.4E-06 ± 2.1E-05	3.7E-05 ± 1.7E-05	N550	50	14	3.5E-06 ± 4.8E-06	1.0E-05 ± 7.4E-06	
Plutonium 238	100-D FR	8	0	3.6E-06 ± 9.8E-06	1.5E-05 ± 1.6E-05	N467	24	0	-5.2E-07 ± 1.5E-05	1.8E-05 ± 1.6E-05	2.1E-04
	100-F FR	3	1	3.6E-06 ± 1.0E-05	1.1E-05 ± 7.6E-06	N521	31	0	6.2E-07 ± 9.8E-06	1.4E-05 ± 1.3E-05	
	100-H FR	8	1	1.7E-06 ± 1.1E-05	1.1E-05 ± 1.5E-05	N508	12	0	-3.3E-06 ± 7.3E-06	5.0E-06 ± 1.4E-05	
	100-K KBC	17	0	1.7E-06 ± 2.4E-05	2.9E-05 ± 3.3E-05	N578	80	10	1.2E-05 ± 6.2E-05	1.5E-04 ± 7.1E-05	
	100-N	6	0	4.5E-06 ± 9.9E-06	1.2E-05 ± 1.6E-05	N106	30	0	2.1E-06 ± 1.3E-05	2.2E-05 ± 1.5E-05	
	118-K-1 FR	4	0	3.4E-06 ± 9.4E-06	1.1E-05 ± 1.4E-05	N535	16	1	4.3E-06 ± 2.8E-05	3.3E-05 ± 6.0E-05	
	200-East	42	0	1.2E-06 ± 1.0E-05	2.2E-05 ± 2.2E-05	N972	207	2	1.7E-06 ± 2.9E-05	1.9E-04 ± 6.8E-05	
	200-North	8	0	1.4E-06 ± 3.1E-06	3.7E-06 ± 4.1E-06	N568	12	1	-1.1E-06 ± 2.6E-05	1.8E-05 ± 5.9E-05	
	200-UW-1	10	1	1.3E-06 ± 1.0E-05	1.1E-05 ± 6.9E-06	N551	44	1	2.4E-06 ± 1.1E-05	1.6E-05 ± 8.3E-06	
	200-West	49	5	2.1E-06 ± 1.3E-05	3.4E-05 ± 1.7E-05	N987	243	2	2.2E-06 ± 1.3E-05	3.8E-05 ± 4.3E-05	
	300 Area D&D	4	0	1.2E-05 ± 1.5E-05	2.3E-05 ± 2.8E-05	N557	20	2	2.6E-06 ± 3.3E-05	5.5E-05 ± 4.4E-05	
	300-FF-2 FR	3	0	1.4E-06 ± 1.8E-05	1.2E-05 ± 1.8E-05	N130	19	2	8.1E-07 ± 9.4E-06	1.0E-05 ± 1.3E-05	
	600 Area (WYE)	2	0	9.2E-07 ± 3.0E-06	2.4E-06 ± 3.5E-06	N981	10	0	1.8E-06 ± 8.6E-06	1.1E-05 ± 1.0E-05	
	618-10 FR	8	0	-9.5E-08 ± 9.8E-06	7.0E-06 ± 3.3E-05	N548	4	0	3.1E-05 ± 1.7E-04	1.4E-04 ± 1.6E-04	
	BCCA	8	0	-3.9E-07 ± 5.3E-06	3.4E-06 ± 4.5E-06	N978	24	0	-1.8E-07 ± 1.3E-05	1.1E-05 ± 1.1E-05	
	ERDF	10	0	2.0E-07 ± 5.5E-06	3.9E-06 ± 9.6E-06	N550	50	1	2.0E-06 ± 1.2E-05	1.6E-05 ± 1.5E-05	

Table C.1. (contd)

Radionuclide	Site	2010 Number of Samples	2010 Number of Detections[b]	2010 Average[c]	2010 Maximum[d]	Sampler Number	2005-2009 Number of Samples	2005-2009 Number of Detections[b]	2005-2009 Average[c]	2005-2009 Maximum[d]	EPA Table 2[e,f]
Uranium-238	100-D FR	8	7	6.6E-06 ± 2.5E-06	8.3E-06 ± 5.4E-06	N515	24	21	9.3E-06 ± 6.1E-06	1.5E-05 ± 9.0E-06	8.3E-04
	100-F FR	3	2	8.7E-06 ± 1.5E-06	9.5E-06 ± 7.3E-06	N519	31	24	1.0E-05 ± 8.7E-06	2.0E-05 ± 1.8E-05	
	100-H FR	8	5	7.3E-06 ± 5.7E-06	1.1E-05 ± 6.4E-06	N508	12	11	1.2E-05 ± 1.2E-05	2.4E-05 ± 1.5E-05	
	100-K KBC	17	13	1.1E-05 ± 1.4E-05	2.5E-05 ± 2.1E-05	N575	80	71	8.5E-06 ± 7.9E-06	2.7E-05 ± 1.4E-05	
	100-N	6	6	6.6E-06 ± 3.5E-06	8.9E-06 ± 5.8E-06	N103	30	24	8.5E-06 ± 6.5E-06	1.7E-05 ± 9.2E-06	
	118-K-1 FR	4	3	1.0E-05 ± 7.1E-06	1.3E-05 ± 7.2E-06	N535	16	10	1.4E-05 ± 2.0E-05	3.9E-05 ± 2.6E-05	
	200-East	42	39	8.5E-06 ± 5.5E-06	1.8E-05 ± 9.5E-06	N976	208	182	8.8E-06 ± 7.9E-06	2.9E-05 ± 1.4E-05	
	200-North	8	8	8.4E-06 ± 4.5E-06	1.2E-05 ± 7.3E-06	N567	12	6	1.1E-05 ± 8.4E-06	1.7E-05 ± 1.8E-05	
	200-UW-1	10	10	2.9E-04 ± 1.1E-03	1.9E-03 ± 6.6E-04	N551	44	42	1.6E-05 ± 2.0E-05	4.7E-05 ± 2.1E-05	
	200-West	49	45	7.0E-05 ± 5.5E-04	1.9E-03 ± 6.6E-04	N551	243	209	1.0E-05 ± 1.2E-05	4.7E-05 ± 2.1E-05	
	300 Area D&D	4	3	1.3E-05 ± 1.0E-05	2.2E-05 ± 1.3E-05	N557	20	15	1.6E-05 ± 1.9E-05	3.6E-05 ± 2.0E-05	
	300-FF-2 FR	3	2	9.1E-06 ± 2.9E-06	1.0E-05 ± 7.1E-06	N130	19	18	1.2E-05 ± 1.1E-05	2.4E-05 ± 1.3E-05	
	600 Area (WYE)	2	2	1.4E-05 ± 1.8E-05	2.3E-05 ± 1.2E-05	N981	10	9	8.9E-06 ± 9.6E-06	2.1E-05 ± 1.4E-05	
	618-10 FR	8	6	1.7E-05 ± 1.5E-05	2.7E-05 ± 1.6E-05	N579	4	3	8.0E-05 ± 1.1E-04	1.5E-04 ± 1.0E-04	
	BCCA	8	6	8.6E-06 ± 4.3E-06	1.2E-05 ± 7.4E-06	N978	24	20	9.0E-06 ± 1.0E-05	2.9E-05 ± 1.4E-05	
	ERDF	10	10	7.3E-05 ± 2.4E-04	4.3E-04 ± 1.4E-04	N550	50	48	1.9E-05 ± 2.0E-05	4.7E-05 ± 2.1E-05	
Plutonium-239/240	100-D FR	8	2	3.0E-06 ± 3.1E-06	5.5E-06 ± 5.1E-06	N468	24	1	2.0E-06 ± 3.4E-06	5.9E-06 ± 5.2E-06	2.0E-04
	100-F FR	3	1	4.4E-06 ± 6.3E-06	8.6E-06 ± 6.7E-06	N521	31	1	1.0E-06 ± 2.9E-06	5.2E-06 ± 5.2E-06	
	100-H FR	8	4	6.5E-06 ± 1.5E-05	2.6E-05 ± 1.3E-05	N509	12	2	4.0E-07 ± 6.1E-06	5.8E-06 ± 4.6E-06	
	100-K KBC	17	11	3.3E-05 ± 7.8E-05	1.7E-04 ± 7.0E-05	N403	80	38	8.4E-05 ± 4.4E-04	1.2E-03 ± 4.7E-04	
	100-N	6	3	9.2E-06 ± 2.3E-05	3.3E-05 ± 1.6E-05	N102	30	11	4.6E-06 ± 7.0E-06	1.8E-05 ± 1.1E-05	
	118-K-1 FR	4	4	8.6E-06 ± 4.5E-06	1.2E-05 ± 8.2E-06	N535	16	3	7.7E-06 ± 3.4E-05	5.4E-05 ± 3.3E-05	
	200-East	42	5	1.9E-06 ± 3.9E-06	8.6E-06 ± 8.1E-06	N957	208	19	1.1E-05 ± 2.5E-04	1.8E-03 ± 6.5E-04	
	200-North	8	1	1.7E-06 ± 3.4E-06	5.1E-06 ± 4.2E-06	N564	12	3	3.5E-06 ± 7.1E-06	1.2E-05 ± 1.5E-05	
	200-UW-1	10	5	6.0E-06 ± 5.8E-06	1.2E-05 ± 7.4E-06	N956	44	14	6.8E-06 ± 2.7E-05	9.1E-05 ± 3.8E-05	
	200-West	49	19	2.0E-05 ± 1.2E-04	3.2E-04 ± 1.2E-04	N165	243	89	2.2E-05 ± 1.6E-04	7.1E-04 ± 2.7E-04	
	300 Area D&D	4	0	3.2E-06 ± 3.7E-06	6.3E-06 ± 6.9E-06	N557	20	3	6.3E-06 ± 2.3E-05	3.9E-05 ± 2.8E-05	
	300-FF-2 FR	3	0	1.7E-06 ± 4.0E-06	4.2E-06 ± 5.7E-06	N130	19	0	1.5E-06 ± 3.0E-06	5.9E-06 ± 5.9E-05	
	600 Area (WYE)	2	0	1.1E-06 ± 1.1E-06	1.7E-06 ± 2.0E-06	N981	10	1	1.6E-06 ± 7.1E-06	1.2E-05 ± 9.1E-06	
	618-10 FR	8	0	1.1E-06 ± 6.1E-06	6.0E-06 ± 7.1E-06	N548	4	1	1.6E-04 ± 5.2E-04	6.2E-04 ± 2.5E-04	
	BCCA	8	0	2.0E-06 ± 5.5E-06	8.6E-06 ± 8.1E-06	N957	24	1	8.7E-07 ± 3.6E-06	4.3E-06 ± 3.6E-06	
	ERDF	10	4	3.5E-06 ± 3.2E-06	5.8E-06 ± 8.9E-06	N550	50	19	5.1E-06 ± 9.8E-06	2.8E-05 ± 1.3E-05	

Table C.1. (contd)

Radionuclide	Site	2010 Number of Samples	2010 Number of Detections[b]	2010 Average[c]	2010 Maximum[d]	Sampler Number	2005-2009 Number of Samples	2005-2009 Number of Detections[b]	2005-2009 Average[c]	2005-2009 Maximum[d]	EPA Table 2[e,f]
Americium-241	100-D FR	8	3	7.2E-06 ± 1.0E-05	1.3E-05 ± 8.0E-06	N467	16	12	7.3E-06 ± 5.7E-06	1.4E-05 ± 7.6E-06	1.9E-04
	100-H FR	8	3	8.9E-06 ± 8.6E-06	1.6E-05 ± 1.8E-05	N510	4	3	8.5E-06 ± 8.4E-06	1.4E-05 ± 7.7E-06	
	100-K KBC	17	8	2.8E-05 ± 8.6E-05	1.2E-04 ± 4.4E-05	N403	80	58	9.6E-05 ± 4.7E-04	1.2E-03 ± 4.4E-04	
	100-N	6	3	1.4E-05 ± 2.5E-05	3.9E-05 ± 1.7E-05	N102	24	10	6.5E-06 ± 9.9E-06	1.7E-05 ± 9.5E-06	
	200-East	4	1	4.1E-06 ± 6.2E-06	9.5E-06 ± 6.0E-06	N480	20	7	5.9E-06 ± 7.0E-06	1.3E-05 ± 1.6E-05	
	200-West	2	2	5.3E-05 ± 4.4E-06	5.5E-05 ± 2.3E-05	N165	4	3	1.0E-04 ± 2.4E-04	3.1E-04 ± 1.1E-04	
Plutonium-241	100-K KBC	17	2	3.9E-04 ± 1.8E-03	1.9E-03 ± 1.2E-03	N401	80	13	7.3E-04 ± 3.3E-03	9.2E-03 ± 2.9E-03	1.0E-02
	200-East	4	0	1.4E-04 ± 4.7E-04	5.0E-04 ± 9.2E-04	N480	20	1	3.5E-05 ± 1.0E-03	1.0E-03 ± 6.3E-04	
	200-West	2	1	6.9E-04 ± 1.7E-03	1.5E-03 ± 8.8E-04	N165	4	1	8.6E-04 ± 1.2E-03	1.7E-03 ± 1.5E-03	

(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/year (40 CFR 61, Appendix E, Table 2).

BCCA = BC Controlled Area.
D&D = Decontamination and decommissioning.
DOE = U.S. Department of Energy.
ERDF = Environmental Restoration Disposal Facility.
FR = Field Remediation Project.
KBC = K Basins Closure.

Table C.2. Selected U.S. Geological Survey Columbia River Water Quality Data for Vernita Bridge and Richland, Washington, 2010

		Vernita Bridge (upstream)			Richland (downstream)			Washington Ambient Surface Water Quality Standard[a]
Analysis	Units	No. of Samples	Maximum	Minimum	No. of Samples	Maximum	Minimum	
Temperature	°C	4	19.0	4.4	4	19.1	4.6	20 (maximum)
Dissolved oxygen	mg/L	4	13.2	9.9	4	12.9	9.4	8 (minimum)
Turbidity	NTU	4	2.2[b]	<2.0	4	3.0[b]	<2.0[b]	5 + background
pH	pH units	4	8.4	7.5	4	8.3	7.4	6.5 - 8.5
Sulfate, dissolved	mg/L	4	10.8	8.3	4	11.0	8.5	–[c]
Dissolved solids, 180°C (356°F)	mg/L	4	85	81	4	98	81	–
Specific conductance	µS/cm	4	154	135	4	154	136	–
Total hardness, as $CaCO_3$	mg/L	4	72	61	4	72	61	–
Alkalinity	mg/L	3	63	60	4	64	52	–
Phosphorus, total	mg/L	4	<0.04	<0.04	4	<0.04	<0.02	–
Chromium, dissolved	µg/L	4	<0.12	0.06[b]	4	<0.12	0.06[b]	10
Dissolved organic carbon	mg/L	4	1.4	1.0	4	1.4	1.0	–
Iron, dissolved	µg/L	4	7	<3	4	<6	<3	–
Ammonia, dissolved (as nitrogen)	mg/L	4	<0.02	<0.01	4	<0.02	<0.01	–
Nitrite + nitrate, dissolved (as nitrogen)	mg/L	4	0.15	0.03[b]	4	0.15	0.04	–
Calcium, dissolved	mg/L	4	20.8	17.1	4	20.6	17.5	–
Magnesium, dissolved	mg/L	4	4.9	4.3	4	5.0	4.3	–
Potassium, dissolved	mg/L	4	0.90	0.68	4	0.87	0.71	–
Sodium, dissolved	mg/L	4	2.6	2.1	4	2.6	2.2	–
Chloride, dissolved	mg/L	4	1.4	0.99	4	1.4	1.1	–
Suspended sediment	mg/L	4	3	1	4	9	1	–

(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, 2010 Compared to Previous 5 Years

Radionuclide[a]		2010 No. of Samples	2010 Concentration,[b] pCi/L Maximum	2010 Concentration,[b] pCi/L Average	2005-2009 No. of Samples	2005-2009 Concentration,[b] pCi/L Maximum	2005-2009 Concentration,[b] pCi/L Average	Ambient Surface Water Quality Standard, pCi/L
Composite System								
Tritium		12	25 ± 8.9	19 ± 4.6	60	55 ± 26	25 ± 18	20,000[c]
Alpha (gross)		12	1.2 ± 1.1[d]	0.41 ± 1.1[d]	60	2.3 ± 1.6	0.54 ± 1.3	15[e,f]
Beta (gross)		12	2.0 ± 2.3[d]	0.65 ± 2.5[d]	60	6.8 ± 1.6	1.4 ± 2.6	50[e,f]
Strontium-90		12	0.13 ± 0.050	0.024 ± 0.081	60	0.24 ± 0.085	0.048 ± 0.068	8[e,f]
Technetium-99		12	0.48 ± 0.46[d]	0.036 ± 0.56[d]	60	1.1 ± 0.43	0.099 ± 0.56	900[c]
Uranium-234		12	0.28 ± 0.065	0.21 ± 0.068	60	0.30 ± 0.097	0.23 ± 0.072	–[g]
Uranium-235		12	0.028 ± 0.018	0.014 ± 0.016	60	0.031 ± 0.033[d]	7.1E-03 ± 0.021	–
Uranium-238		12	0.23 ± 0.058	0.18 ± 0.062	60	0.27 ± 0.072	0.18 ± 0.056	–
Uranium (total)		12	0.49 ± 0.085	0.41 ± 0.094	60	0.58 ± 0.13	0.41 ± 0.12	–
Continuous System								
Cesium-137	P	12	2.8E-03 ± 2.0E-03	3.8E-04 ± 2.2E-03	60	8.9E-03 ± 6.0E-03[d]	6.1E-04 ± 3.0E-03	200[c]
	D	12	4.2E-03 ± 5.0E-03[d]	1.1E-03 ± 4.6E-03[d]	60	7.8E-03 ± 7.0E-03[d]	7.1E-04 ± 3.9E-03[d]	
Plutonium-238	P	4	7.2E-05 ± 1.2E-04[d]	1.8E-05 ± 7.5E-05[d]	20	8.2E-05 ± 4.2E-05	5.2E-06 ± 5.8E-04	600[c]
	D	4	8.2E-05 ± 2.0E-04[d]	1.9E-05 ± 1.8E-04	20	2.3E-04 ± 4.1E-04[d]	-1.4E-04 ± 5.0E-04	
Plutonium-239/240	P	4	1.1E-04 ± 1.0E-04[d]	2.7E-05 ± 1.1E-04[d]	20	1.2E-04 ± 4.9E-05	2.6E-05 ± 6.3E-05	–
	D	4	7.2E-05 ± 7.1E-05	-2.4E-05 ± 1.9E-04	20	3.2E-04 ± 4.4E-04[d]	4.4E-05 ± 1.4E-04	

(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 8.4).
(b) Maximum values are ± total propagated analytical uncertainty (2 sigma). Averages are ±2 standard deviations of the mean. To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.
(c) WAC 173-201A-250 and EPA-570/9-76-003.
(d) Less than the laboratory reported detection limit.
(e) WAC 246-290.
(f) 40 CFR 141.
(g) Dashes indicate no concentration guides available.

Table C.4. Radionuclide Concentrations in Columbia River Water Samples Collected at Richland, Washington, 2010 Compared to Previous 5 Years

Radionuclide[a]		2010 No. of Samples	2010 Concentration,[b] pCi/L Maximum	2010 Concentration,[b] pCi/L Average	2005-2009 No. of Samples	2005-2009 Concentration,[b] pCi/L Maximum	2005-2009 Concentration,[b] pCi/L Average	Ambient Surface Water Quality Standard, pCi/L
Composite System								
Tritium		12	39 ± 5.2	29 ± 17	60	140 ± 32	49 ± 23	20,000[c]
Alpha (gross)		12	3.6 ± 1.9	1.0 ± 1.8	60	1.7 ± 2.0[d]	0.43 ± 1.0	15[e,f]
Beta (gross)		12	4.4 ± 2.3	2.4 ± 2.7	60	5.4 ± 2.6	1.4 ± 2.5	50[e,f]
Strontium-90		12	0.040 ± 0.033[d]	0.020 ± 0.032[d]	60	0.26 ± 0.059	0.041 ± 0.070	8[e,f]
Technetium-99		12	0.57 ± 0.47[d]	-0.015 ± 0.50[d]	60	0.81 ± 0.39	0.17 ± 0.53	900[c]
Uranium-234		12	0.35 ± 0.073	0.27 ± 0.069	60	0.32 ± 0.11	0.25 ± 0.067	–[g]
Uranium-235		12	0.026 ± 0.018	0.019 ± 0.010	60	0.045 ± 0.045	8.4E-03 ± 0.022	–
Uranium-238		12	0.29 ± 0.065	0.22 ± 0.058	60	0.30 ± 0.12	0.20 ± 0.067	–
Uranium (total)		12	0.66 ± 0.099	0.51 ± 0.12	60	0.63 ± 0.16	0.46 ± 0.12	–
Continuous System								
Cesium-137	P	12	1.3E-03 ± 1.4E-03[d]	-2.6E-04 ± 2.2E-03[d]	56	9.1E-03 ± 4.8E-03[d]	4.0E-04 ± 3.0E-03[d]	200[f]
	D	12	2.6E-03 ± 4.6E-03[d]	-9.2E-04 ± 4.4E-03[d]	56	7.9E-03 ± 5.6E-03[d]	6.9E-04 ± 4.5E-03[d]	
Plutonium-238	P	4	9.5E-05 ± 9.4E-05[d]	2.7E-05 ± 9.2E-05[d]	20	6.0E-05 ± 6.8E-05[d]	1.7E-06 ± 5.1E-05	600[f]
	D	4	2.3E-04 ± 2.3E-04	7.0E-05 ± 2.5E-04	20	3.3E-04 ± 9.6E-04[d]	-2.0E-04 ± 5.2E-04[d]	
Plutonium-239/240	P	4	9.5E-05 ± 8.6E-05[d]	2.5E-05 ± 9.4E-05[d]	20	6.8E-05 ± 1.3E-04[d]	6.1E-08 ± 1.6E-04	–
	D	4	1.2E-04 ± 1.8E-04[d]	6.6E-05 ± 1.2E-04	20	1.6E-04 ± 1.4E-04	2.6E-05 ± 1.1E-04	

(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 8.4).
(b) Maximum values are ± total propagated analytical uncertainty (2 sigma). Averages are ±2 standard deviations of the mean. To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.
(c) WAC 173-201A-250 and EPA-570/9-76-003.
(d) Less than the laboratory reported detection limit.
(e) WAC 246-290.
(f) 40 CFR 141.
(g) Dashes indicate no concentration guides available.

Table C.5. Radionuclide Concentrations Measured in Columbia River Water Samples Collected Along Transects of the Hanford Reach, 2010

Transect/Radionuclide	No. of Samples	Concentration,[a] pCi/L Maximum	Minimum
Vernita Bridge (HRM 0.3)			
Tritium	16	28 ± 7.4	7.9 ± 5.8[b]
Strontium-90	16	0.056 ± 0.039[b]	-0.0065 ± 0.031[b]
Uranium (total)	16	0.64 ± 0.11	0.38 ± 0.077
100-N Area (HRM 9.5)			
Tritium	6	31 ± 10	9.6 ± 4.7
Strontium-90	6	0.052 ± 0.038[b]	-0.019 ± 0.030[b]
Uranium (total)	6	0.61 ± 0.10	0.41 ± 0.047
Hanford town site (HRM 28.7)			
Tritium	6	160 ± 28	17 ± 6.5
Strontium-90	6	0.070 ± 0.038	-0.019 ± 0.024[b]
Uranium (total)	6	0.45 ± 0.079	0.36 ± 0.071
300 Area (HRM 43.1)			
Tritium	6	40 ± 8.2	18 ± 7.4
Strontium-90	6	0.076 ± 0.041	-0.0016 ± 0.027[b]
Uranium (total)	6	0.77 ± 0.10	0.38 ± 0.062
Richland (HRM 46.4)			
Tritium	24	95 ± 150[b]	14 ± 3.7
Strontium-90	24	0.050 ± 0.034[b]	-0.020 ± 0.026[b]
Uranium (total)	24	0.82 ± 0.12	0.37 ± 0.069

(a) Maximum and minimum values are ± total propagated analytical uncertainty (2 sigma). To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.
(b) Less than the laboratory-reported detection limit.
HRM = Hanford river marker.

Table C.6. Radionuclide Concentrations Measured in Columbia River Water Samples Collected at Near-Shore Locations in the Hanford Reach, 2010

Near-Shore/Radionuclide	No. of Samples	Concentration,[a] pCi/L Maximum	Minimum
Vernita Bridge (HRM 0.3)			
Tritium	4	17 ± 3.2	9.2 ± 3.6
Strontium-90	4	0.052 ± 0.037[b]	0.019 ± 0.033[b]
Uranium (total)	4	0.52 ± 0.087	0.39 ± 0.074
100-N Area (HRM 8.4 to 9.8)			
Tritium	5	31 ± 10	15 ± 5.9
Strontium-90	5	0.053 ± 0.038[b]	0.0024 ± 0.0032[b]
Uranium (total)	5	0.43 ± 0.079	0.40 ± 0.076
Hanford town site (HRM 26 to 30)			
Tritium	6	240 ± 140	8.7 ± 6.1[b]
Strontium-90	5	0.053 ± 0.033	0.030 ± 0.028[b]
Uranium (total)	6	0.48 ± 0.086	0.37 ± 0.072
300 Area (HRM 41.5 to 43.1)			
Tritium	5	1,450 ± 370	39 ± 8.7
Strontium-90	5	0.048 ± 0.035[b]	-0.00072 ± 0.030[b]
Uranium (total)	5	2.0 ± 0.25	0.46 ± 0.094
Richland (HRM 43.5 to 46.4)			
Tritium	20	86 ± 9.0	13 ± 3.5
Strontium-90	20	0.094 ± 0.042	-0.015 ± 0.032[b]
Uranium (total)	20	0.80 ± 0.12	0.40 ± 0.076

(a) Maximum and minimum values are ± total propagated analytical uncertainty (2 sigma). To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.
(b) Less than the laboratory-reported detection limit.
HRM = Hanford river marker.

Table C.7. Concentrations (µg/L) of Dissolved Metals in Columbia River Transect and Near-Shore Water Samples Collected Near the Hanford Site, September 2010

Location	Metal	No. of Samples	Maximum	Minimum	Average (± 2SD)	
Vernita Bridge	Antimony	4	0.18	0.14	0.16	(0.035)
	Arsenic	4	0.75	0.67	0.70	(0.069)
	Beryllium	4	0.014[(a)]	0.014[(a)]	0.014[(a)]	(0.0)
	Cadmium	4	0.011	0.0087	0.010	(0.0015)
	Chromium	4	0.080[(a)]	0.080[(a)]	0.080[(a)]	(0.0)
	Copper	4	0.87	0.73	0.80	(0.12)
	Lead	4	0.071	0.044	0.056	(0.029)
	Nickel	4	0.35	0.19	0.28	(0.14)
	Selenium	4	0.38	0.16	0.23	(0.20)
	Silver	4	0.0014[(a)]	0.0014[(a)]	0.0014[(a)]	(0.0)
	Thallium	4	0.017	0.014	0.015	(0.003)
	Zinc	4	1.6	1.1	1.3	(0.55)
100-N Area	Antimony	10	0.18	0.14	0.15	(0.028)
	Arsenic	10	0.72	0.67	0.69	(0.033)
	Beryllium	10	0.014[(a)]	0.014[(a)]	0.014[(a)]	(0.0)
	Cadmium	10	0.010	0.0066	0.0079	(0.0020)
	Chromium	10	0.094	0.080	0.082	(0.011)
	Copper	10	0.74	0.64	0.69	(0.072)
	Lead	10	0.046	0.023	0.032	(0.017)
	Nickel	10	0.55	0.15	0.27	(0.23)
	Selenium	10	0.32	0.23	0.29	(0.056)
	Silver	10	0.0014[(a)]	0.0014[(a)]	0.0014[(a)]	(0.0)
	Thallium	10	0.017	0.013	0.014	(0.0024)
	Zinc	10	1.4	0.87	1.1	(0.31)
Hanford town site	Antimony	10	0.20	0.14	0.16	(0.035)
	Arsenic	10	0.76	0.67	0.71	(0.049)
	Beryllium	10	0.014[(a)]	0.014[(a)]	0.014[(a)]	(0.0)
	Cadmium	10	0.011	0.0053	0.0078	(0.0034)
	Chromium	10	0.14	0.080	0.086	(0.039)
	Copper	10	0.76	0.65	0.69	(0.07)
	Lead	10	0.059	0.027	0.041	(0.021)
	Nickel	10	0.57	0.20	0.30	(0.25)
	Selenium	10	0.23	0.18	0.21	(0.034)
	Silver	10	0.0014[(a)]	0.0014[(a)]	0.0014[(a)]	(0.0)
	Thallium	10	0.017	0.013	0.015	(0.0028)
	Zinc	10	1.9	0.94	1.25	(0.56)
300 Area	Antimony	10	0.19	0.13	0.17	(0.038)
	Arsenic	10	1.3	0.72	0.84	(0.34)
	Beryllium	10	0.014[(a)]	0.014[(a)]	0.014[(a)]	(0.0)
	Cadmium	10	0.010	0.0063	0.0084	(0.0024)
	Chromium	10	0.41	0.080	0.15	(0.19)
	Copper	10	0.82	0.66	0.71	(0.085)
	Lead	10	0.065	0.025	0.039	(0.022)
	Nickel	10	0.40	0.21	0.31	(0.11)
	Selenium	10	0.64	0.22	0.30	(0.25)
	Silver	10	0.0019	0.0014	0.0015	(0.0003)
	Thallium	10	0.016	0.012	0.014	(0.0025)
	Zinc	10	1.1	0.73	0.87	(0.23)

Table C.7. (contd)

Location	Metal	No. of Samples	Maximum	Minimum	Average (± 2SD)	
Richland	Antimony	10	0.21	0.14	0.17	(0.039)
	Arsenic	10	0.95	0.70	0.78	(0.16)
	Beryllium	10	0.014[(a)]	0.014[(a)]	0.014[(a)]	(0.0)
	Cadmium	10	0.011	0.0046	0.0068	(0.0037)
	Chromium	10	0.13	0.080	0.088	(0.032)
	Copper	10	0.81	0.67	0.72	(0.089)
	Lead	10	0.049	0.022	0.038	(0.017)
	Nickel	10	0.39	0.17	0.28	(0.12)
	Selenium	10	0.36	0.23	0.28	(0.088)
	Silver	10	0.0014[(a)]	0.0014[(a)]	0.0014[(a)]	(0.0)
	Thallium	10	0.015	0.012	0.014	(0.0018)
	Zinc	10	2.4	0.85	1.3	(1.1)

(a) Values shown were below the limit of detection.
SD = Standard deviation.

Table C.8. Radionuclide and Total Organic Carbon Concentrations in Sediment from the Columbia River Near the Hanford Site, 2010 Compared to Previous 5 Years

Location and Total Organic Carbon Concentrations (2010 TOC Value)	Radionuclide	2010			2005-2009		
		No. of Samples	Concentration, pCi/g[a]		No. of Samples	Concentration, pCi/g[a]	
			Average[b]	Maximum[c]		Average[b]	Maximum[c]
Priest Rapids Dam (23,000-26,200 mg/kg)	Strontium-90	2	-5.4E-03 ± 0.047[c]	0.011 ± 0.020[d]	10	0.012 ± 0.038	0.043 ± 0.028[d]
	Cesium-137	2	0.33 ± 0.066	0.35 ± 0.038	10	0.28 ± 0.049	0.31 ± 0.055
	Uranium-234	2	1.1 ± 0.014	1.2 ± 0.19	10	0.99 ± 0.40	1.3 ± 0.20
	Uranium-235	2	0.047 ± 0.033	0.058 ± 0.026	10	0.049 ± 0.055	0.096 ± 0.026
	Uranium-238	2	1.1 ± 0.14	1.2 ± 0.19	10	0.86 ± 0.44	1.2 ± 0.43
	Plutonium-239/240	2	8.9E-03 ± 3.4E-03	0.010 ± 2.5E-03	10	8.9E-03 ± 3.4E-03	0.012 ± 3.6E-03
White Bluffs Slough (33,700 mg/kg)	Strontium-90	1		9.7E-03 ± 0.014[d]	5	-1.9E-03 ± 0.032[d]	0.016 ± 0.015[d]
	Cesium-137	1		0.46 ± 0.057	5	1.0 ± 2.0	2.8 ± 0.33
	Uranium-234	1		0.69 ± 0.12	5	0.59 ± 0.34	0.84 ± 0.12
	Uranium-235	1		0.040 ± 0.020	5	0.030 ± 0.041	0.061 ± 0.020
	Uranium-238	1		0.63 ± 0.11	5	0.50 ± 0.32	0.71 ± 0.11
	Plutonium-239/240	1		2.0E-03 ± 2.3E-03[d]	5	5.1E-03 ± 2.3E-03	6.0E-03 ± 2.6E-03
100-F Slough (1,250 mg/kg)	Strontium-90	1		0.020 ± 0.021[d]	5	2.6E-03 ± 0.034[d]	0.027 ± 0.025[d]
	Cesium-137	1		0.23 ± 0.034	5	0.26 ± 0.062	0.30 ± 0.043
	Uranium-234	1		0.36 ± 0.074	5	0.36 ± 0.40	0.60 ± 0.11
	Uranium-235	1		0.031 ± 0.018	5	0.023 ± 0.046	0.061 ± 020
	Uranium-238	1		0.43 ± 0.085	5	0.35 ± 0.36	0.60 ± 0.13
	Plutonium-239/240	1		7.6E-04 ± 1.5E-03[d]	4	1.1E-03 ± 1.1E-03	1.6E-03 ± 4.6E-04
Hanford Slough (14,900 mg/kg)	Strontium-90	1		0.015 ± 0.014[d]	5	-2.8E-03 ± 0.024[d]	8.5E-03 ± 0.020[d]
	Cesium-137	1		0.29 ± 0.036	5	0.082 ± 0.22	0.28 ± 0.041
	Uranium-234	1		0.60 ± 0.11	5	0.52 ± 0.48	0.74 ± 0.11
	Uranium-235	1		0.026 ± 0.016	5	0.022 ± 0.027	0.041 ± 0.021
	Uranium-238	1		0.62 ± 0.11	5	0.51 ± 0.50	0.78 ± 0.13
	Plutonium-239/240	1		4.3E-03 ± 1.5E-03	5	8.4E-04 ± 2.1E-03	2.6E-03 ± 6.8E-04

Table C.8. (contd)

Location and Total Organic Carbon Concentrations (2010 TOC Value)	Radionuclide	2010 No. of Samples	2010 Concentration, pCi/g[a] Average[b]	2010 Concentration, pCi/g[a] Maximum[c]	2005-2009 No. of Samples	2005-2009 Concentration, pCi/g[a] Average[b]	2005-2009 Concentration, pCi/g[a] Maximum[c]
Richland (722 mg/kg)	Strontium-90	1		6.3E-03 ± 0.014[d]	5	-2.1E-03 ± 0.024[d]	0.015 ± 0.020[d]
	Cesium-137	1		0.16 ± 0.052	5	0.14 ± 0.054	0.17 ± 0.020
	Uranium-234	1		0.55 ± 0.098	5	0.40 ± 0.47	0.79 ± 0.12
	Uranium-235	1		0.043 ± 0.020	5	0.014 ± 0.022	0.026 ± 0.016
	Uranium-238	1		0.62 ± 0.11	5	0.41 ± 0.49	0.80 ± 0.13
	Plutonium-239/240	1		-3.3E-04 ± 1.5E-03[d]	4	1.2E-03 ± 8.0E-04	1.6E-03 ± 4.6E-04
McNary Dam (11,900-18,800 mg/kg)	Strontium-90	2	-6.5E-03 ± 9.9E-03[d]	-3.0E-03 ± 0.014[d]	10	3.3E-03 ± 0.037	0.034 ± 0.047[d]
	Cesium-137	2	0.23 ± 0.066	0.25 ± 0.049	10	0.26 ± 0.090	0.33 ± 0.054
	Uranium-234	2	1.4 ± 0.27	1.5 ± 0.23	10	1.2 ± 0.47	1.6 ± 0.23
	Uranium-235	2	0.061 ± 0.040	0.075 ± 0.029	10	0.058 ± 0.056	0.12 ± 0.030
	Uranium-238	2	1.2 ± 0.51	1.4 ± 0.22	10	0.94 ± 0.42	1.2 ± 0.18
	Plutonium-239/240	2	7.8E-03 ± 1.6E-04	7.9E-03 ± 2.0E-03	10	8.1E-03 ± 3.5E-03	0.012 ± 3.3E-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, 2010

Metal	(n=2) Priest Rapids Dam	(n=4) Hanford Reach[a]	(n=2) McNary Dam	(n=7) Shoreline Springs[b]
Antimony	0.85 - 0.93	0.32 - 0.75	0.77 - 0.83	0.43 - 0.96
Arsenic	8.5 - 8.7	3.4 - 7.8	7.3 - 8.7	3.2 - 9.6
Beryllium	1.4 - 1.5	1.2 - 1.4	1.6 - 1.7	1.3 - 1.5
Cadmium	5.4 - 8.6	0.44 - 2.9	1.2 - 1.4	0.45 - 1.0
Chromium	72 - 81	30 - 64	57 - 60	45 - 120
Copper	42 - 43	16 - 31	28 - 33	14 - 25
Lead	51 - 51	16 - 54	25 - 26	18 - 66
Mercury	0.15 - 0.18	0.0096 - 0.073	0.096 - 0.11	0.0093 - 0.029
Nickel	37 - 44	13 - 24	26 - 27	15 - 22
Selenium	0.86 - 0.95	0.20 - 0.95	0.20 - 0.80	0.20 - 0.40
Silver	0.19 - 0.22	0.033 - 0.033	0.11 - 0.19	0.033 - 0.086
Thallium	0.75 - 1.2	0.40 - 1.4	0.50 - 0.61	0.44 - 0.59
Zinc	430 - 530	150 - 440	200 - 220	130 - 280

(a) White Bluffs Slough, 100-F Slough, Hanford Slough, and Richland.
(b) 100-B 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, 2010 Compared to Previous 5 Years

Location/ Radionuclide	2010 No. of Samples	2010 Concentration,[a] pCi/L Maximum	2010 Concentration,[a] pCi/L Average	2005-2009 No. of Samples	2005-2009 Concentration,[a] pCi/L Maximum	2005-2009 Concentration,[a] pCi/L Average	Washington State Ambient Surface Water Quality Standard,[b] pCi/L
100-B Area							
Alpha (gross)	2	3.5 ± 1.9	2.5 ± 27	8	14 ± 5.6	4.0 ± 9.2	15
Beta (gross)	2	17 ± 3.4	11 ± 17	8	23 ± 5.1	9.8 ± 12	50
Strontium-90	2	1.6 ± 0.29	0.85 ± 2.2	8	2.8 ± 0.42	1.1 ± 2.4	8
Technetium-99	2	5.7 ± 0.78	3.4 ± 6.6	8	7.8 ± 1.0	3.6 ± 5.1	900[c]
Tritium	2	2,100 ± 470	1,800 ± 850	8	2,800 ± 180	2,300 ± 980	20,000
100-K Area							
Alpha (gross)	2	3.0 ± 2.0	2.0 ±2.8	6	13 ± 4.8	3.3 ± 9.7	15
Beta (gross)	2	15 ± 3.4	11 ± 13	6	19 ± 5.2	8.6 ± 12	50
Strontium-90	2	1.4 ± 0.23	0.70 ± 1.9	6	2.7 ± 0.41	0.97 ± 2.3	8
Tritium	2	1,400 ± 340	710 ± 1,900	6	4,200 ± 370	1,400 ± 3,700	20,000
100-N Area							
Alpha (gross)	1	10 ± 4.0		5	2.3 ± 1.6	1.2 ± 1.7	15
Beta (gross)	1	18 ± 3.8		5	5.9 ± 1.7	3.9 ± 3.7	50
Strontium-90	1	0.017 ± 0.033[d]		5	0.048 ± 0.032[d]	0.019 ± 0.035	8
Tritium	1	3,600 ± 750		5	8,900 ± 390	6,400 ± 3,900	20,000
100-D Area							
Alpha (gross)	1	0.12 ± 0.92[d]		10	7.6 ± 2.9	2.7 ± 5.8	15
Beta (gross)	1	3.9 ± 2.4		10	10 ± 2.8	5.0 ± 6.3	50
Strontium-90	1	0.15 ± 0.053		10	1.3 ± 0.24	0.27 ± 0.76	8
Tritium	1	-22 ± 130[d]		10	6,200 ± 1,300	1,300 ± 4,600	20,000
100-H Area							
Alpha (gross)	2	2.8 ± 1.8	2.3 ± 1.5	9	3.8 ± 2.6	2.1 ± 2.8	15
Beta (gross)	2	19 ± 3.9	12 ± 19.4	9	22 ± 3.0	8.7 ± 15	50
Strontium-90	2	6.3 ± 0.98	3.1 ± 8.9	9	6.8 ± 1.1	2.2 ± 5.6	8
Technetium-99	2	3.6 ± 0.66	2.0 ± 4.5	9	1.7 ± 0.86	0.42 ± 1.0	900[c]
Tritium	2	1,600 ± 370	1,200 ± 1,100	9	4,100 ± 250	1,400 ± 2,600	20,000
Uranium (total)	2	1.3 ± 0.17	0.99 ± 0.74	9	5.0 ± 0.56	1.7 ± 3.4	-[e]

Table C.10. (contd)

Location/ Radionuclide	2010 No. of Samples	2010 Concentration,[a] pCi/L Maximum	2010 Concentration,[a] pCi/L Average	2005-2009 No. of Samples	2005-2009 Concentration,[a] pCi/L Maximum	2005-2009 Concentration,[a] pCi/L Average	Washington State Ambient Surface Water Quality Standard,[b] pCi/L
100-F Area							
Alpha (gross)	1	4.6 ± 2.3		5	28 ± 8.8	11 ± 21	15
Beta (gross)	1	4.7 ± 2.4		5	43 ± 9.6	15 ± 33	50
Strontium-90	1	-0.018 ± 0.032[d]		5	0.12 ± 0.050	0.021 ± 0.12	8
Tritium	1	750 ± 240		5	1,400 ± 190	1,100 ± 410	20,000
Uranium (total)	1	4.6 ± 0.50		5	20 ± 2.1	7.9 ± 13	–[e]
Hanford town site							
Alpha (gross)	3	6.6 ± 2.7	3.7 ± 5.2	15	14 ± 5.6	2.7 ± 6.6	15
Beta (gross)	3	45 ± 4.8	34 ± 20	15	47 ± 12	18 ± 21	50
Iodine-129[f]	3	-0.048 ± 0.66[d]	-0.35 ± 0.52[d]	9	0.65 ± 0.27[d]	0.12 ± 0.47	1
Technetium-99	3	50 ± 5.9	36 ± 30	15	68 ± 3.9	26 ± 30	900[c]
Tritium	3	37,000 ± 7,200	28,000 ± 19,000	15	53,000 ± 3,300	21,000 ± 25,000	20,000
Uranium (total)	3	2.6 ± 0.43	2.0 ± 1.1	15	5.6 ± 0.69	1.8 ± 2.5	–[e]
300 Area							
Alpha (gross)	3	86 ± 11	41 ± 83	20	120 ± 28	44 ± 65	15
Beta (gross)	3	44 ± 5.0	32 ± 31	20	40 ± 3.6	21 ± 17	50
Iodine-129[f]	2	0.30 ± 0.29[d]	0.014 ± 0.81[d]	6	0.26 ± 0.061[d]	0.0010 ± 0.28	1
Strontium-90	3	0.30 ± 0.074	0.13 ± 0.29	20	0.26 ± 0.061	0.090 ± 0.14	8
Tritium	3	5,200 ± 1,000	4,500 ± 1,400	20	12,000 ± 920	6,900 ± 5,800	20,000
Uranium (total)	3	71 ± 10	37 ± 68	20	120 ± 13	52 ± 78	–[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) No results were available for 2005 and 2006. Samples from 2007, 2008, 2009, and 2010 were analyzed using the gamma spectroscopy method, which has higher detection limits than the previous method.

Table C.11. Radionuclide Concentrations in Columbia River Shoreline Sediment for 2010 Compared to Previous 5 Years

		2010			2005-2009		
		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	Strontium-90	1		-1.3E-03 ± 9.6E-03[d]	4	4.3E-03 ± 7.7E-03[d]	8.0E-03 ± 0.020[d]
	Cesium-137	1		0.043 ± 0.027	4	0.057 ± 0.028	0.077 ± 0.032
	Uranium-234	1		0.52 ± 0.10	4	0.44 ± 0.52	0.83 ± 0.10
	Uranium-235	1		0.040 ± 0.022	4	0.020 ± 0.035	0.035 ± 0.016
	Uranium-238	1		0.61 ± 0.12	4	0.33 ± 0.37	0.49 ± 0.094
100-K Spring	Strontium-90	1		1.9E-05 ± 0.016[d]	2	7.4E-04 ± 9.7E-03[d]	2.7E-03 ± 4.5E-03[d]
	Cesium-137	1		0.11 ± 0.025	2	0.094 ± 1.1E-03	0.094 ± 0.016
	Uranium-234	1		0.49 ± 0.094	2	0.78 ± 1.5	1.3 ± 0.17
	Uranium-235	1		0.035 ± 0.021	2	0.064 ± 0.16	0.12 ± 0.031
	Uranium-238	1		0.47 ± 0.091	2	0.76 ± 1.6	1.3 ± 0.17
100-H Spring	Strontium-90	1		0.015 ± 0.011[d]	5	0.037 ± 0.076	0.10 ± 0.017
	Cesium-137	1		0.15 ± 0.031	5	0.14 ± 0.068	0.18 ± 0.027
	Uranium-234	1		0.70 ± 0.13	5	0.52 ± 0.65	1.0 ± 0.14
	Uranium-235	1		0.012 ± 0.014[d]	5	0.023 ± 0.050	0.067 ± 0.025
	Uranium-238	1		0.69 ± 0.12	5	0.45 ± 0.58	0.93 ± 0.13
100-F Spring	Strontium-90	1		8.3E-03 ± 0.011[d]	5	7.1E-03 ± 0.019[d]	0.020 ± 0.026[d]
	Cesium-137	1		0.15 ± 0.039	4	0.11 ± 0.022	0.12 ± 0.033
	Uranium-234	1		0.75 ± 0.13	5	0.65 ± 0.64	0.98 ± 0.13
	Uranium-235	1		0.057 ± 0.026	5	0.034 ± 0.055	0.081 ± 0.024
	Uranium-238	1		0.81 ± 0.14	5	0.62 ± 0.69	1.0 ± 0.13

Table C.11. (contd)

Location	Radionuclide	2010 No. of Samples	2010 Concentration, pCi/g[a] Average[b]	2010 Concentration, pCi/g[a] Maximum[c]	2005-2009 No. of Samples	2005-2009 Concentration, pCi/g[a] Average[b]	2005-2009 Concentration, pCi/g[a] Maximum[c]
Hanford Spring	Strontium-90	2	0.012 ± 0.015[d]	0.017 ± 0.016[d]	10	2.8E-03 ± 0.054	0.074 ± 0.013
	Cesium-137	2	0.15 ± 0.17	0.21 ± 0.035	10	0.14 ± 0.12	0.23 ± 0.090
	Uranium-234	2	1.0 ± 0.028	1.0 ± 0.16	10	0.78 ± 0.73	1.3 ± 0.19
	Uranium-235	2	0.076 ± 0.44	0.091 ± 0.027	10	0.031 ± 0.044	0.066 ± 0.021
	Uranium-238	2	0.87 ± 0.069	0.89 ± 0.14	10	0.66 ± 0.67	1.1 ± 0.16
300 Area Spring	Strontium-90	2	-6.5E-03 ± 8.9E-03[d]	-3.3E-03 ± 0.013[d]	10	9.3E-03 ± 0.019	0.027 ± 0.021[d]
	Cesium-137	3	0.13 ± 0.27	0.28 ± 0.057	19	0.12 ± 0.22	0.42 ± 0.040
	Uranium-234	3	2.4 ± 3.9	4.5 ± 0.72	19	1.4 ± 1.9	3.7 ± 0.59
	Uranium-235	3	0.15 ± 0.24	0.28 ± 0.094	19	0.073 ± 0.10	0.21 ± 0.042
	Uranium-238	3	2.4 ± 3.7	4.4 ± 0.70	19	1.3 ± 1.8	3.4 ± 0.54

(a) To convert to the International System of Units, multiply pCi/g by 0.037 to obtain Bq/g. All values are dry weight.
(b) Averages are ±2 standard deviations of the mean. Average values are not provided when only one sample was analyzed.
(c) Values are ± total propagated analytical uncertainty (2 sigma).
(d) Below detection limit.

Table C.12. Trace Metal Concentrations (µg/g dry wt.) in Livers from Common Carp Collected Along the Hanford Reach of the Columbia River and at an Upriver Reference Location Near Vantage, Washington, in 2010[a]

	Reference Site, Near Vantage, Washington (n=5)			100-N to 100-D Area, Hanford Reach (n=5)			300 Area, Hanford Site (n=5)		
Metal	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median
Aluminum	6.2[b,c]	1.4[b,c]	3.2	5.3[b,c]	1.5[b,c]	2.0	3.8[b,c]	2.0[b,c]	2.6
Antimony	0.097	0.027[d]	0.027	0.042	0.027[d]	0.027	0.045	0.027[d]	0.036
Arsenic	0.56	0.32	0.46	1.2	0.24	0.50	1.2	0.35	0.58
Beryllium	0.008[d]	0.008[d]	0.008	0.008[d]	0.008[d]	0.008	0.008[d]	0.008[d]	0.008
Cadmium	13	3.6	9.4	61	4.5	31	42	2.1	6.3
Chromium	0.45[c]	0.18	0.36	0.71[c]	0.16[c]	0.23	0.47[c]	0.38[c]	0.46
Copper	190	71	95	180	99	100	110	32	51
Lead	0.20	0.058	0.17	0.25	0.12	0.16	0.15	0.016[b]	0.067
Manganese	11	2.1	3.1	9.5	5.1	7.0	8.0	5.1	6.7
Mercury	0.25	0.11	0.19	0.41	0.25	0.35	0.50	0.12	0.25
Nickel	0.11[c]	0.049[b,c]	0.090	0.33	0.044[b,c]	0.083	0.18[c]	0.078[c]	0.15
Selenium	8.9	3.2	6.4	7.6	3.4	6.1	9.1	3.6	7.7
Silver	2.0	0.39	0.62	1.7	0.53	0.66	0.57	0.13	0.42
Thallium	0.061	0.022	0.028	0.12	0.054	0.059	0.081	0.0057[b]	0.036
Thorium	0.0068[b]	0.004[d]	0.0041	0.0041[b]	0.004[d]	0.004	0.0049[b]	0.004[d]	0.004
Uranium	0.046	0.0056[b]	0.025	0.093	0.020	0.061	0.35	0.064	0.12
Zinc	2300	550	920	2300	290	670	1800	270	980

(a) Data not blank corrected.
(b) Value less than required detection limit and greater than method detection limit (method detection limit reported).
(c) 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.
(d) Analyte not detected above the method detection limit.
n = Number of samples.

Table C.13. Trace Metal Concentrations (µg/g dry wt.) in Livers from Cottontail Rabbits Collected from the Hanford Reach of the Columbia River and at a Reference Location Near Moses Lake, Washington, in 2010[a]

	100-N Area (n=2)		Moses Lake, Washington (n=1)
Metal	Maximum	Minimum	Maximum
Aluminum	5.7	5.0	9.9
Antimony	0.23	0.027[b]	0.027[b]
Arsenic	0.17[b]	0.17[b]	0.17[b]
Barium	NA	NA	NA
Beryllium	0.008[b]	0.008[b]	0.008[b]
Cadmium	0.43	0.35	0.98
Chromium	0.20	0.17	0.26
Copper	13	11	17
Lead	0.9	0.40	0.30
Manganese	12	8.8	13
Mercury	0.13	0.093	0.13
Nickel	0.057	0.057	0.056
Selenium	0.82[c]	0.66[c]	0.82
Silver	0.002[b]	0.002[b]	0.002[b]
Thallium	0.01[b]	0.01[b]	0.01[b]
Thorium	0.019	0.019	0.025
Uranium	0.002[b]	0.002[b]	0.002[b]
Zinc	170	120	130

(a) Data not blank corrected.
(b) Analyte not detected above the method detection limit.
(c) 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.14. Trace Metal Concentrations (µg/g dry wt.) in Livers from California Quail Collected from the Hanford Reach of the Columbia River and at Reference Locations Near Benton City and Burbank, Washington, in 2010[a]

	Reference Sites Near Benton City and Burbank, Washington (n=4)			100-D to 100-H Area, Hanford Reach (n=3)		
Metal	Maximum	Minimum	Median	Maximum	Minimum	Median
Aluminum	2.3[b]	1.4[b]	1.6	47	1.4[b]	8.9
Antimony	0.027[c]	0.027[c]	0.027	0.027[c]	0.027[c]	0.027
Arsenic	0.17[c]	0.17[c]	0.17	0.56	0.17[c]	0.24
Beryllium	0.008[c]	0.008[c]	0.008	0.008[c]	0.008[c]	0.008
Cadmium	0.20	0.13	0.15	0.65	0.22	0.30
Chromium	0.36	0.28	0.32	0.35	0.32	0.34
Copper	17	13	15	20	19	20
Lead	1.3	0.029[b]	0.15	0.71	0.19	0.26
Manganese	17	11	12	18	17	17
Mercury	0.021[b,d]	0.010[b,d]	0.020	0.057	0.039[b,d]	0.044
Nickel	0.087	0.053	0.064	0.055	0.028[b]	0.045
Selenium	1.3[d]	0.78[d]	0.82	3.9	1.8	2.1
Silver	0.0059[b]	0.002[c]	0.0023	0.010	0.002[c]	0.0042
Thallium	0.002[c]	0.002[c]	0.002	0.0064[b]	0.0022[b]	0.0050
Thorium	0.0048[b]	0.004[c]	0.0041	0.025	0.0068[b]	0.013
Uranium	0.002[c]	0.002[c]	0.002	0.002[c]	0.002[c]	0.002
Zinc	100	78	87	110	100	100

(a) Data 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.15. Trace Metal Concentrations (µg/g dry wt.) in Deer Liver Collected at a Background Location Near Olympia, Washington, in 2010[a]

Metal	Background Location Near Olympia, Washington (n=1)
Aluminum	1.2[b]
Antimony	0.027[c]
Arsenic	0.17[c]
Beryllium	0.008[c]
Cadmium	1.1
Chromium	0.30
Copper	53
Lead	0.021[b]
Manganese	16
Mercury	0.032[b,d]
Nickel	0.021[b]
Selenium	0.23[d]
Silver	0.018
Thallium	0.0037[b]
Thorium	0.010
Uranium	0.002[c]
Zinc	200

(a) Data 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.

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Appendix D
Standards and Permits

GW Patton and JP Duncan

Permits required for regulated releases to water and air have been issued by the U.S. Environmental Agency (EPA) under the National Pollutant Discharge Elimination System of the *Clean Water Act of 1977* and the "Prevention of Significant Deterioration" requirements of *the Clean Air Act*. In addition, under authority granted through 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, Chg 2 established environmental radiation protection standards to limit public radiation dose and provide guidance for the reduction of public radiation exposure to levels as low as reasonably achievable. Table D.2 lists radiation standards from DOE Order 5400.5, Chg 2; 40 CFR Parts 9, 61, 141, and 142 (65 FR 76707); and WAC 246-290. These standards govern allowable exposure to radiation from DOE operations.

DOE Order 5400.5, Chg 2 also 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 millirem (1 millisievert) 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.3 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, the *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 2010 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. Not all of the new-use designations and associated

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 for both 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 two outfalls in the 100-K Area.

Permit WAR10B90F is a National Pollutant Discharge Elimination System Construction General Permit granted to CH2M HILL Plateau Remediation Company that became effective on June 3, 2009. It governs storm water discharges. This permit was terminated on March 18, 2010.

Permit CR-IU005 allows wastewater from the Environmental Molecular Sciences Laboratory to be discharged to the city of Richland's wastewater treatment facility.

Washington State Department of Ecology – State Wastewater Permits

Permit ST 4500 allows treated wastewater from the Effluent Treatment Facility to be discharged to the State-Approved Land Disposal Site. This permit expired August 1, 2005, and has not been reissued. The old permit will remain in effect until the new permit is issued.

Permit ST 4501 allows for the discharge of cooling water and other primarily uncontaminated wastewater from 400 Area facilities to two ponds located north-northeast of the 400 Area perimeter fence. This permit was effective October 1, 2003, and expired on October 1, 2008. It will remain in effect until a new permit is issued.

Permit ST 4502 allows treated effluent from the 200-East and 200-West Areas to be discharged to the 200 Area Treated Effluent Disposal Facility. This permit expired in May 2005 and has not been reissued. The old permit will remain in effect until the new permit is issued.

Permit ST 4507 allows domestic wastewater to be discharged to the 100-N Area sewage lagoon. This permit expired in May 2002. A renewal application has been submitted. The old permit will remain in effect until a new permit is issued.

Permit ST 4511 is a consolidation of permits: ST 4508, ST 4509, and ST 4510. This Categorical State Waste Discharge Permit authorizes the discharge of wastewater from maintenance, construction, and hydrotesting activities and allows for cooling water, condensate, and industrial storm water discharges at the Hanford Site. This permit was issued February 16, 2005, and expires February 16, 2010. A permit renewal application for ST 4511 was filed with the Washington State Department of Ecology in August 2009. The old permit will remain in effect until a new permit is issued.

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.

Washington State Department of Ecology – ***Resource Conservation and Recovery Act of 1976*** **Permit**

Permit WA7890008967 was issued on September 27, 1994, and has undergone several revisions. The permit expired on September 27, 2004, and a draft of Revision 9 of the permit is in progress, incorporating the Hanford Site's 43 treatment, storage, and disposal units. The current permit remains in effect until a new permit is issued.

Wildlife Sampling Permits

Scientific Collection Permit 09-832, issued by the Washington Department of Fish and Wildlife to Pacific Northwest National Laboratory for 2010; authorizes 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; authorizes the collection of migratory wildlife. This permit expires March 31, 2012.

Copies of the regulations concerning these permits may be obtained from the following organizations:

State of Washington
Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, WA 98101

U.S. Department of Energy
Richland Operations Office
825 Jadwin Avenue
Richland, WA 99352

Table D.2. Radiation Standards (Dose Limits[a]) for Protection of the Public from all Routine DOE Concentrations

All Pathways (limits from DOE Order 5400.5, Chg 2)

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, Chg 2)

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 (65 FR 76707); WAC 246-290; and DOE Order 5400.5, Chg 2)

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.

criteria have been approved. For those not yet approved, old criteria are still in effect. In 2010, the Hanford Reach was designated as bull trout critical habitat by the U.S. Fish and Wildlife Service (USFWS 2010).

A summary of currently applicable Washington State water quality criteria for the Hanford Reach is provided in Table D.4. Table D.5 summarizes federal and state drinking water standards in 40 CFR 141, "National Primary Drinking Water Regulations" and WAC 246-290, "Group A Public Water Systems." Select surface freshwater quality criteria for toxic pollutants as defined by WAC 173-201A-240 and 40 CFR 131.36 are included in Table D.6.

Table D.3. 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, Chg 2.

Table D.4. 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 gallon) (2) Not more than or equal to 10% of samples may exceed the geometric mean value of 200 colonies/100 milliliters (0.026 gallon)
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.5. Selected Drinking Water Standards

Constituent	Drinking Water Standard[a]		Agency[b]
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)[c]	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[d]	(11.1 Bq/L)	EPA
Beta particle and photon activity	4 mrem/yr[e]	(40 µSv/yr)	EPA, DOH
Carbon-14	2,000 pCi/L[d]	(74.1 Bq/L)	EPA
Cesium-137	200 pCi/L[d]	(7.4 Bq/L)	EPA
Cobalt-60	100 pCi/L[d]	(3.7 Bq/L)	EPA
Iodine-129	1 pCi/L[d]	(0.037 Bq/L)	EPA
Ruthenium-106	30 pCi/L[d]	(1.11 Bq/L)	EPA
Strontium-90	8 pCi/L[d]	(0.296 Bq/L)	EPA, DOH
Technetium-99	900 pCi/L[d]	(33.3 Bq/L)	EPA
Total alpha (excluding uranium)	15 pCi/L[d]	(0.56 Bq/L)	EPA, DOH
Tritium	20,000 pCi/L[d]	(740 Bq/L)	EPA, DOH
Uranium	30 µg/L	(0.03 ppm)	EPA, DOH

(a) Maximum contaminant level for drinking water supplies.
(b) 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.
(c) Standard is for total trihalomethanes (THM).
(d) 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).
(e) 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.

Table D.6. Selected Surface Freshwater Quality Criteria for Toxic Pollutants

Compound	Level that Yields Acute Toxicity[a] µg/L	ppm	Level that Yields Chronic Toxicity[a] µg/L	ppm	Level to Protect Human Health for the Consumption of Water and Organisms[b] µg/L	ppm
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 1992-2010 water samples collected near the Vernita Bridge by the U.S. Geological Survey is used. Parts per million (ppm) values are equivalent to the reported micrograms per liter (µg/L) concentrations shown.
(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.

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Appendix E
Dose Calculations

EJ Antonio and SF Snyder

The radiological dose that the public could have received in 2010 from the Hanford Site was calculated in terms of the "total effective dose." The total effective dose 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.

Calculation of the effective dose equivalent takes into account the long-term (50 years) internal exposure from radionuclides absorbed 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[b] 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.

Releases of radionuclides from Hanford Site facilities are usually too small to be measured. Therefore, 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 Hanford 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). GENII Version 1.485 was used for dose calculations through 2008. For 2009 dose calculations, both GENII Version 1.485 and GENII

(a) 1 rem (0.01 sievert) = 1,000 millirem (10 millisievert).
(b) The more recent International Commission on Radiological Protection 60 weighting factors were used in this year's calculations (ICRP 1991). International Commission on Radiological Protection 30 weighting factors had been used through calendar year 2008 calculations (ICRP 1979a, 1979b, 1980, 1981a, 1981b, 1982a, 1982b, 1988).

Version 2 dose results were presented for this transitional year, with GENII Version 2 dose considered the reported dose. For calendar year 2010, GENII Version 2.10 was used (PNNL-14583, Rev. 3a; PNNL-14584, Rev. 3; PNNL-19168). GENII Version 2.10 is a Microsoft Windows®-based version that incorporates some environmental modeling improvements (e.g., plume depletion during atmospheric transport). The assumptions and data used in the GENII calculations are described in the following paragraphs.

The RESRAD-BIOTA computer code was used to screen the 2010 radionuclide concentrations in water and sediment to see if they exceeded the 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 and 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, researchers compare 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 2010 air emissions report (DOE/RL-2011-12).

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, Chg. 2 requires the following:

- Effective dose equivalent must be used in estimating public doses.
- Calculations of doses to the public from exposures resulting from both routine and unplanned activities must be performed using EPA or DOE dose conversion factors or analytical models prescribed in regulations applicable to DOE operations.
- Doses to the public must be calculated using facility effluent data when environmental concentrations are too low to measure accurately.

The following types of radiological doses were estimated.

Maximally Exposed Individual Dose (mrem [µSv]). The maximally exposed individual is a hypothetical member of the public who lives at a location and has a lifestyle that makes it unlikely other individuals would receive higher doses. All potentially significant exposure pathways to this hypothetical individual were considered, including the following:

- Inhalation of airborne radionuclides
- Submersion in airborne radionuclides
- Ingestion of foodstuffs contaminated by radionuclides deposited on vegetation and the ground by both airborne deposition and irrigation water drawn from the Columbia River downstream of the 100-K Area
- External exposure to ground contaminated by both airborne deposition and irrigation water
- Consumption of fish from the Hanford Reach of the Columbia River
- Recreation along the Hanford Reach of the Columbia River, including fishing, boating, swimming, and other 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 Site facilities. Based on experience since 1990, three separate locations (Figure 8.12.1) 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 the city of Richland. Although the Ringold area is closer than the Riverview area to Hanford Site facilities that historically released airborne emissions, at Riverview the maximally exposed individual receives a higher dose rate from radionuclides in the Columbia River than a Ringold resident. The applicable exposure pathways for Ringold and Sagemoor are described in the following paragraphs. For the past several years, the hypothetical, maximally exposed individual has been located across the Columbia River from the 300 Area in the Sagemoor area (Figure 8.12.1).

2010 Results

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 from the Columbia River downstream of where contaminated groundwater originating from the 100 and 200-East Areas enters the river. This results in additional exposure from ingestion of potentially contaminated irrigated food products and potential external irradiation from radionuclides deposited on the ground by irrigation. Recreational use of the Columbia River is also considered for this individual, resulting in direct exposure from water, 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 Site facilities. For the calculation, it was assumed 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 individuals in the Riverview area irrigate their crops with water 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 Hanford Site operations from nuclear weapons production to the current mission of managing waste products, cleaning up legacy waste, 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 Site origin (EPS-87-367A). Because the farms located across from the 300 Area obtain irrigation water from the Columbia River upstream of the Hanford Site, researchers conservatively assumed that the diet of the Sagemoor area individual consisted entirely of food 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.

Eighty-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, Chg 2. The radiological dose to the collective population within 80 kilometers

(50 miles) of the site operations areas was calculated to confirm adherence to DOE environmental protection policies, and provide information to the public. The 80-kilometer (50-mile) collective dose is the sum of doses to all individual members of the public within 80 kilometers (50 miles) of Hanford Site operations areas.

Pathways similar to those used for the maximally exposed individual were used to calculate doses to the offsite population. In calculating the effective dose, 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 from the Columbia River downstream from the Hanford Site; the city of Kennewick obtains its municipal water indirectly from the river from nearby wells. Approximately 130,000 people in the Tri-Cities[(c)] are assumed to obtain all of 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 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 fishing, 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 consuming 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 needed to perform dose calculations are based on either measured upstream or 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-19455, 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. The transfer factors used for pathway and dose calculations are documented in PNNL-14584, Rev. 3.

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.

(c) The cities of Pasco, Kennewick, and Richland—known as the Tri-Cities—are located in southeastern Washington State.

Table E.1. Food Pathway Parameters Used in Hanford Site Dose Calculations, 2010

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-fed cattle	100[b]	100[b]	45	2	(4.41)	200	(53)
Pasture-fed cattle	0	0	30	1.5	(3.3)	200	(53)
Red meat	15	34	–	–	–	–	–
Hay-fed cattle	100[b]	100[b]	45	2	(4.41)	200	(53)
Grain-fed cattle	180[b]	180[b]	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) 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.

Dose Calculation Documentation

Procedures, models, and parameters previously developed for use at the Hanford Site, and subsequently approved by DOE and regulatory agencies, were used to calculate radiological doses for purposes of demonstrating compliance with regulatory standards. The methods and assumptions were documented in PNL-3777 and DOE/RL-2007-53.

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 2010 are provided in Table E.7.

Table E.2. Dietary Parameters Used in Hanford Site Dose Calculations, 2010

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).

Table E.3. Residency Parameters Used in Hanford Site Dose Calculations, 2010

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 rate: adult 270 cm^3/sec (16.5 $in.^3$/sec).

Table E.4. Columbia River Recreational Parameters Used in Hanford Site Dose Calculations, 2010

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 Hanford Site, 2010

Emission facilities	100-K Area, 200 Areas, 300 Area, 400 Area		
Releases (Ci)	See Table 8.1.1		
Computer code	GENII, Version 2.10, June 2010 (PNNL-14583, Rev. 3a)		
Meteorological conditions	2010 hourly data collected from 100-K Area, 200 Area Hanford Meteorological Station (HMS), 300 Area, and 400 Area stations		
Particulate $\overline{X}/Q$ dispersion factors		Maximally Exposed Individual (sec/m^3)	Population (person-sec/m^3)
	100-K Area (10-m [33-ft] release height)	4.45×10^{-9}	1.12×10^{-3}
	200 HMS (121 m [397-ft] release height)	1.79×10^{-8}	2.91×10^{-3}
	300 Area (10 m [33-ft] release height)	1.51×10^{-6}	5.72×10^{-3}
	400 Area (10 m [33-ft] release height)	5.14×10^{-8}	3.08×10^{-3}
Population, 80 km (50 mi)	100-K Area (~482,000), 200 HMS (~486,000), 300 Area (~349,000), 400 Area (~354,000) (PNNL-14428)		
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		
Dose calculation details	GENII, Version 1.458, Food Transfer Library (PNL-6584) GENII, Version 2.10 using ICRP 60 (ICRP 1991) weighting factors		

Table E.6. Technical Details of Liquid Release Dose Calculations for the Hanford Site, 2010

Release facilities	100-K Area, 200 Areas
Releases (Ci)	100-K Area – see Table 8.3.2 200 Areas – see Tables C.3 and C.4
Computer code	GENII, Version 2.10, June 2010 (PNNL-14583, Rev. 3a)
Mean river flow	2,668 m^3/sec (94,271 ft^3/sec)
Exposed population	130,000 for drinking water pathway 125,000 for aquatic recreation pathway 2,000 for irrigated food consumption pathway
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 irrigated farm products and aquatic foods (15,000 kg/yr [33,075 lb/yr] total harvest of Columbia River fish)
Dose calculation details	GENII, Version 1.458, Food Transfer Library (PNL-6584) GENII, Version 2.10, using ICRP 60 (ICRP 1991) weighting factors

Table E.7. Annual Dose to 400 Area Workers from Ingestion of Onsite Drinking Water, 2010

Radionuclide	Average Drinking Water Activity (pCi/L)	Intake (pCi/yr)	Ingestion Dose Factor (mrem/pCi)	Ingestion Dose (mrem/yr)
Tritium	5,863	1,465,750	1.6×10^{-7}	2.3×10^{-1}

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Appendix F
Radionuclides Measured by Gamma Spectroscopy (Gamma Scan)

EJ Antonio

Gamma rays, a form of high energy electromagnetic radiation that originates from the nucleus of an atom, 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 staff for Pacific Northwest National Laboratory environmental monitoring samples.

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