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**HANFORD SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 2012
DOE/RL-2013-18**

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HANFORD SITE ENVIRONMENTAL REPORT

FOR CALENDAR YEAR 2012



HANFORD SITE

ENVIRONMENTAL REPORT

FOR CALENDAR YEAR 2012

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

 U.S. DEPARTMENT OF
ENERGY | Richland Operations
Office
P.O. Box 550
Richland, Washington 99352

Approved for Public Release

Further Dissemination Unlimited

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Executive Summary

The U.S. Department of Energy (DOE) prepares this Hanford Site Environmental Report in accordance with [DOE O 231.1B](#), *Environment, Safety and Health Reporting* and [DOE O 458.1](#), *Radiation Protection of the Public and the Environment*. The report is the principal document for reporting annual site environmental and operating performance information that demonstrates the Hanford Site's compliance with [DOE O 458.1](#) requirements for calendar year (CY) 2012. The report is also a DOE resource for communicating environmental protection performance information to public, regulators, stakeholders, and other interested parties living near the Hanford Site. Individual sections provide detail on the following:

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

DOE has prepared the annual Hanford Site Environmental Report since 1959. All the annual environmental reports are available on the Internet through the Mission Support Alliance, LLC (MSA), available at <http://msa.hanford.gov/page.cfm/enviroreports>. The following is a brief summary of the [Hanford Site Environmental Report for Calendar Year 2012](#).

SECTION 1, INTRODUCTION. This section describes the Hanford Site and its current mission — to preserve the Hanford legacy, reduce the footprint (amount of land directly controlled by DOE), enable the cleanup, and manage post cleanup land use. The Hanford Site is located within the semiarid Pasco Basin of the Columbia Plateau in southeastern Washington State (Figure 1.1). In September 1999, DOE issued the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (HCP EIS) ([DOE/EIS-0222-F](#)). The HCP EIS analyzed the impacts of alternatives for implementing a land-use plan for the DOE's Hanford Site for at least the next 50-year planning period and lasting for as long as DOE retains legal control of some portion of the real estate.

The Hanford Meteorology Station is located at the Hanford Site Central Plateau. Researchers take meteorological measurements to support Hanford Site operations, emergency preparedness and response, and atmospheric dispersion calculations for dose assessments. Activities include weather forecasting and maintaining and distributing climatological data. Average temperature and precipitation totals were above normal. The average temperature for 2012 was 54.4°Fahrenheit (F) (12.4°Celsius [C]), which was 0.5°F (0.2°C) above normal (53.9°F [12.2°C]). Precipitation totaled 8.18 inches (20.8 centimeters), which is 115 percent of normal precipitation (7.14 inches [18.1 centimeters]). Snowfall for 2012 totaled 16.0 inches (40.6 centimeters), compared to normal snowfall of 15.2 inches (38.6 centimeters). Average wind speed was 7.9 miles per hour (3.5 meters per second), which was 0.4 mile per hour (0.2 meter per second) above normal.

DOE is responsible for operating the Hanford Site. The DOE Richland Operations Office (RL) and the DOE Office of River Protection (ORP) 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 ensure environmental regulatory compliance. RL serves as property owner of the Hanford Site and manages cleanup of legacy waste, related research, and other programs. 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 encourages information exchange and public involvement in discussions and decision making regarding Hanford Site cleanup and remediation actions. Active stakeholders 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 *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.

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), Washington State Department of Ecology (Ecology), 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 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. In addition, the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement [TPA], [Ecology et al. 1989](#)) commits DOE to comply with the remedial-action provisions of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) as well as with the *Resource Conservation and Recovery Act of 1976* ([RCRA](#)) treatment, storage, and disposal (TSD) unit regulations and corrective-action provisions, including Washington State's implementing regulations Washington Administrative Code ([WAC 173-303](#), *Dangerous Waste Regulations*). The TPA is an agreement among Ecology, EPA, and DOE to achieve compliance with the remedial action provisions in CERCLA and with TSD unit regulations and corrective action provisions in RCRA. The TPA has evolved to meet changing conditions as Hanford Site cleanup requirements have progressed. During 2012, 37 specific cleanup milestones were scheduled for completion; 30 were completed ahead of their scheduled date, one was completed on time, one was completed late, and five have a tentative agreement to modify the milestone scope and/or schedule.

SECTION 2, COMPLIANCE SUMMARY. This section describes the Hanford Site compliance with federal, state, and local laws and regulations. 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. In addition to Hanford Site permits, a key feature in the Hanford Site compliance program is the *Hanford Federal Facility Agreement and Consent Order*, also known as the TPA (see Section 1.6.1). No permit violations on the Hanford Site were reported in 2012. The 2012 compliance with federal, state, and local laws and regulations include the following:

- **CERCLA Compliance.** Field inspections of institutional controls were conducted in 2012 at waste sites on the Hanford Site. No public trespass events occurred and all approved excavation permits are in place for all active remediation activities. Assessment of institutional controls at 200-UP-1 Operable Unit, 221-U Facility, and 200-ZP-1 Operable Unit did not identify deficiencies with land-use management, entry restrictions, groundwater management, or warning signs.
- **RCRA Compliance.** Ecology performed 21 RCRA inspections on the Hanford Site in 2012 to assess compliance with applicable requirements. The Hanford Site received no notices of violation or warning letters of noncompliance that were based on those inspections.

- **Hanford Site Emission Sources.** The Washington State Department of Health, 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 2012, the regulatory agencies conducted over 30 *Clean Air Act* inspections at the Hanford Site; those inspections did not result in any violations being issued by regulatory agencies.
- **Pollution Prevention Program.** The Hanford Site Pollution Prevention Program (Section 2.6.2) reflects federal and DOE policies to reduce, reuse, and/or recycle wastes, as established by the [Pollution Prevention Act of 1990](#). The pollution prevention and waste minimization activities are documented, tracked, and reported in effort to reduce the quantity and toxicity of hazardous, radioactive, mixed, and sanitary waste generated at the Hanford Site. In fiscal year (FY) 2012, over 2,127 tons (1,930 metric tons) of sanitary and hazardous wastes were recycled through Hanford Site programs administered through the Mission Support Contract.
- **Environmental Occurrences.** Environmental releases of radioactive and regulated materials from the Hanford Site are reported to DOE and other federal and state agencies as legally required. The following 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 2012, there were no events for Category 1, 2, and 3; however, 27 Category 4 events occurred (discovery of legacy contamination) at the Hanford Site (Section 2.7).

SECTION 3, ENVIRONMENTAL MANAGEMENT SYSTEM. This section describes the Hanford Site Environmental Management System. Hanford Site environmental performance measures address the goals of [DOE O 436.1, Departmental Sustainability](#); Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*; and [Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance](#). 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 2012 were achieved for all performance measures except standard electricity use; and the acquisition target for alternative fuel vehicles was surpassed (Section 3.1). This section also provides information on the Hanford Site awards and recognition for environmental stewardship. The Hanford Site did not receive any other DOE, federal agency, state agency, or industry-sponsored environmental awards or recognition in 2012 however individual Hanford contractors won awards for environmental performance. As part of their EMS, several Hanford Site contractors developed internal environmental awards programs to recognize leadership in environmental, energy, and transportation stewardship (Section 3.2).

SECTION 4, RADIOLOGICAL INFORMATION. This section provides information on Hanford Site radiological program and doses, and cleanup activities as DOE progresses toward site closure and the likely transfer of property to other entities. The dose calculations are provided in Appendix D. Potential radiological doses from 2012 Hanford Site operations were evaluated in detail to determine compliance with pertinent regulations and limits (Section 4.2). Doses were assessed in terms of 1) total dose (multiple pathways) to the hypothetical, maximally exposed individual at an offsite location, evaluated by using a multimedia pathway assessment (DOE O 458.1, Section 4.1.1); 2) average dose to the collective population living within 50 miles (80 kilometers) of Hanford Site operating areas (Section 4.2.2); 3) dose to a maximally exposed individual for air pathways using EPA methods (Section 4.2.3); 4) doses from recreational activities including hunting and fishing (Section 4.2.4.1); 5) Dose to a worker consuming drinking water on the Hanford Site (Section 4.2.4.2); 6) doses from non-DOE industrial sources on and near the Hanford Site (Section 4.2.5).

External Radiation Measurements. During 2012, external radiation fields were monitored in the 100-K Area, 100-N Area, 100-N shoreline area (N Springs), the 200 Area, 300 Area, 400 Area, and 618-10 Burial Ground were similar to levels measured in 2011 (Section 4.1.1).

100-K Area. Cleanup activities for the K Basins Closure Project during 2012 resulted in continued decreases in the average dose rates at most TLD locations in the 100-K Area compared to 2011 (Figure 4.1). Dose-rate levels measured in 2012 at monitoring stations in the K-East Area were 27 percent lower than 2011 levels. Dose-rate levels measured in 2012 at monitoring stations at the Cold Vacuum Drying Facility (CVDF) and in the 100-K West Area were unchanged compared to 2011.

100-N Area. Average dose-rate levels observed in the 100-N Area during 2012 showed an overall increase (approximately 10 percent) compared to 2011 levels. This was primarily due to elevated first quarter measurements at the monitoring station located along/near the transportation route for disposal of radioactive waste. Due to overall decreases in dose rate levels at the individual TLD locations, during the fourth quarter of 2012, monitoring concluded at all monitoring stations except the shoreline location.

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 4.1). The 2012 average dose rate was unchanged compared to 2011, and was less than 100 millirem (1 millisievert) per year.

200-East and 200-West Areas. Dose rate levels measured during 2012 in the 200-East and 200-West Areas were slightly increased compared to 2011 (Figure 4.1). Average dose rates measured in 2012 at ERDF (located near the 200-West Area) were slightly higher than 2011 levels (approximately 9 percent).

200 North Area. One TLD monitoring site, located in the 200-North Area at the contaminated 212-R Railroad Car Disposition Area, continued to show a significant annual average dose rate decrease (approximately 65 percent) in 2012 compared to 2011 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 began to fall as the radiologically contaminated railroad cars were dispositioned.

300 and 400 Areas. The average dose rates in 2012 in the 300 and 400 Areas and at the 300 Area Treated Effluent Disposal Facility were comparable to 2011 levels (Figure 4.1).

618-10 Burial Ground. TLD monitoring was initiated during late-February 2010 at four locations at this project. The average dose rates in 2012 were comparable to 2011 levels.

Integrate Disposal Facility. The average dose rates in 2012 were slightly higher (7 percent) than 2011 levels.

Active and Inactive Waste Disposal Sites Radiological Surveys. During 2012, 744 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 MSA. 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 Hanford Site operational areas. These sites were posted as underground radioactive material areas, contamination areas, and soil contamination areas. The external dose rate at 80 percent 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 (Section 4.1.2).

Dose for the Maximally Exposed Individual. Dose calculations for 2012 releases indicate that the maximally exposed individual is located at the PNNL Physical Sciences Facility, an offsite business just to the south of the Hanford Site 300 Area at 638 Horn Rapids Road. Dose for the maximally exposed individual was 0.19 millirem (1.9 microSievert) per year (Section 4.2.1). The average individual dose from Hanford Site operations is based on the 50-mile (80-kilometer) radius population exposed to air emissions and the Tri-Cities populations exposed to water pathways releases to the Columbia River, was approximately 0.0056 millirem (0.056 microsievert). To place the average individual estimated dose into perspective, it may be compared with doses received from other routinely encountered sources of radiation. The National Council on Radiation

Protection issued Report 160 in March 2009 that estimated the overall average exposure to ionizing radiation for the average American to be 620 millirem (6,200 microsievert) per year (National Council on Radiation Protection and Measurements, 2009). Approximately 50 percent of the 620 millirem (6,200 microsievert) per year average annual dose is related to natural sources, with the remaining 50 percent attributable primarily to medical procedures.

Radiological Release of Property from the Hanford Site. No property with detectable residual radioactivity above authorized levels was released in 2012 from the Hanford Site (Section 4.3).

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. Approximately 72,000 pounds (33,700 kilograms) of resin was shipped offsite in 2012 for regeneration under these approved authorized limits (Section 4.3.2).

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. Approximately 18,000 pounds (8,200 kilograms) of granular activated carbon was shipped offsite in 2012 for regeneration under these approved modified authorized limits (Section 4.3.3).

SECTION 5, ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT. This section describes ongoing Hanford Site environmental restoration and mitigation, facility decommissioning activities, waste management, underground waste storage tank status, construction of the Waste Treatment and Immobilization Plant (WTP) and its associated facilities, and research activities related to waste cleanup. Hanford Site cleanup activities began in 1996, 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 2012, remediation activities continued in the 100, 200, and 300 Areas, and for Hanford Site groundwater and vadose zone sediments.

River Corridor. The River Corridor includes the Hanford Site 100 and 300 Areas, which border the Columbia River. The River Corridor includes nine deactivated plutonium-production reactors, numerous support facilities, and liquid and solid waste disposal sites. The River Corridor Baseline Risk Assessment human health and ecological risk assessments have been completed to evaluate the impacts from Hanford Site releases to the upland, riparian, and near shore areas of the River Corridor. The *River Corridor Baseline Risk Assessment, Volume II: Human Health Risk Assessment* (DOE/RL-2007-21, Vol. II, [Part 1](#) and [Part 2](#), Rev. 0) was issued in August 2011. The *River Corridor Baseline Risk Assessment, Volume I: Ecological Risk Assessment* (DOE/RL-2007-21, Vol. I, [Part 1](#) and [Part 2](#), Rev. 0) was issued in March 2012. 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. 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 (RI/FS) process for the River Corridor. The risk assessment results are reflected in the River Corridor RI/FS reports.

Remedial Investigation of Hanford Site Releases to the Columbia River. Human health and ecological risk assessments have been completed to evaluate potential impacts to the Columbia River from Hanford Site releases. The *Columbia River Component Risk Assessment, Volume I, Screening-Level Ecological Risk Assessment* (DOE/RL-2010-117, [Vol. I, Rev. 0](#)) was issued in June 2012; and *Columbia River Component Risk Assessment, Volume II, Baseline Human Health Risk Assessment* (DOE/RL-2010-117, [Vol. II, Rev. 0](#)) was issued in September 2012. The risk assessment results are being reflected in the River Corridor RI/FS reports.

River Corridor RI/FS Process. Field investigation activities and development of draft integrated source and groundwater RI/FS reports and proposed plan documents for the six River Corridor decision areas (100-B/C, 100-K, 100-N, 100-D/H, 100-F/IU-2/IU-6, and 300 Area) continued. Draft RI/FS reports for the 100-K Area ([DOE/RL-2010-97](#)) and 300 Area ([DOE/RL-2010-99](#)) decision areas were submitted for regulatory review in September and December 2011, respectively. Draft RI/FS reports for the 100-F ([DOE/RL-2010-98](#)) and 100-D/H ([DOE/RL-2010-95](#)) decision areas were submitted for regulatory review in December 2012. The draft RI/FS reports for 100-N Area are scheduled to be submitted to the regulators for review in June 2013. Delivery of a draft RI/FS report for the 100-B/C Area has been deferred to 2016 to allow for additional characterization groundwater before making recommendations on final cleanup actions. Public review of proposed actions and development of final action record of decisions (RODs) for the six decision areas are anticipated to range from 2013 to 2017.

Long-Term Stewardship. The long-term stewardship task is focused on achieving interim closure and transition of surveillance and maintenance responsibilities within the River Corridor from the cleanup contractor to the site service contractor, which administers the long-term stewardship program for DOE. 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. Transition and turnover packages were completed in 2012 for Segment 3 of the 100-F/IU-2/IU-6 Area. The package describes the completion of site assessment activities, removal of facilities, removal of miscellaneous debris, and site remediation to interim action RODs for a specific parcel of land. An interim remedial action report also was prepared and issued for Segment 3 of the 100-F/IU-2/IU-6 Area ([DOE/RL-2012-14](#)) (Section 5.1.2).

K Basins Closure Activities. For nearly 30 years, the K Basins stored 2,300 tons (2,100 metric 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 2012, K Basins cleanup continued with the demolition of multiple buildings, basins, and storage facilities, as well as debris removal from the K-West Basins. Construction of the 189-K Water Treatment Facility was completed and brought on line, leading the way to the deactivation and demolition of the much larger water treatment facilities used originally to support the operation of the K Reactors. Further information on K Basins remediation and closure activities is in Section 5.1.4.2.

A total of 1,089,500 tons (988,400 metric tons) of contaminated soil from 100 Area remediation activities during 2012 were disposed at ERDF. 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.

Central Plateau. The Central Plateau is a 75-square-mile (194-square-kilometer) 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-E](#)) and ROD ([64 FR 61615](#)) as the Industrial-Exclusive Area, a rectangular area of about 20 square miles (52 square kilometers) in the center of the Central Plateau. The Industrial-Exclusive Area contains the 200-East and 200-West Areas, used primarily for the Hanford Site nuclear fuel processing and waste management and disposal activities. The Central Plateau also encompasses the CERCLA 200 Area National Priorities List (NPL) 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. As a result of the goals established in the *Hanford Site Cleanup Completion Framework* ([DOE/RL-2009-10](#)), the Tri-Party Agencies developed changes to the TPA that reflect the path forward for Central Plateau cleanup.

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 10 square miles (26 square kilometers) 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. Completing cleanup for the approximately 65-square-mile (168-square-kilometer) Outer Area will reduce the active footprint of cleanup for the Central Plateau to the Inner Area.

The Central Plateau Operable Unit structure is depicted in Section 5.0, Table 5.1.

Facility Decommissioning Activities. Decommissioning activities continues in the 100, 200, 300, and 400 areas of the Hanford Site (Section 5.2).

100 Areas Facilities Decommissioning. Deactivation, decontamination, decommissioning, and demolition activities in the 100 Area included demolition actions at 100-N Area, 100-D Area, and 100-H Area, which were conducted as non-time-critical removal actions under CERCLA. (Section 5.2.1).

200 Area (Central Plateau) Facilities Decommissioning. Central Plateau facilities include 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 (Section 5.2.2).

Workers at the Plutonium Finishing Plant (PFP) complex completed a large and multi-faceted effort in 2004 to stabilize, immobilize, repackage, and/or properly dispose of nearly 19.8 tons (18 metric 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. All special nuclear materials and remaining stored fuel elements were removed from the plant by the end of 2009, and security was downgraded. In addition, the removal and disposal of process equipment, chemicals, glove boxes, and hoods from the buildings continued through 2012.

Other Central Plateau facilities include interim-status RCRA TSD units awaiting closure are the: 1) Canyon buildings (Plutonium Uranium Extraction [PUREX] Plant, B Plant, Reduction-Oxidation [REDOX] Plant, and U Plant); 2) three operating major air emission stacks; and 3) one operating minor emission stack.

300 Area Facilities Decommissioning. 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/RL-2010-22](#)) authorized deactivation, decontamination, decommissioning, and demolition activities for a portion of the 337 Complex (Section 5.2.3).

400 Area Facilities – Fast Flux Test Facility (FFTF) Deactivation. 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, the facility deactivation was completed in June 2009. The FFTF remains in a long-term surveillance and maintenance condition. Routine surveillances are performed on an annual basis. The FFTF decommissioning was included in the *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* ([DOE/EIS-0391](#)) that was issued on November 12, 2012. The final decommissioning of FFTF is dependent on the issuance of the ROD, which will determine the final end state for FFTF (Section 5.2.4.1).

Waste Management. Hanford Site cleanup activities generate non-regulated, radioactive, nonradioactive, mixed, and hazardous waste. Mixed waste contains both radioactive and hazardous nonradioactive 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.

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.

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. Onsite solid waste facilities include the Central Waste Complex (CWC), Waste Receiving and Processing Facility (WRAP), T Plant Complex, Low-Level Burial Grounds, Waste Encapsulation and Storage Facility (WESF), and ERDF. These facilities are operated and maintained in accordance with state and federal regulations and facility permits and are discussed in Section 5.3.3.

Central Waste Complex. Located in the 200-West Area, the CWC receives waste from Hanford Site sources and any offsite sources authorized by DOE to ship waste to the site for TSD. Ongoing cleanup and research and development activities at the Hanford Site generate most of the waste received at the CWC. Waste received includes low-level, transuranic, or mixed waste, and radioactive waste contaminated with polychlorinated biphenyls (PCBs). The CWC can store as much as 735,000 cubic feet (20,800 cubic meters) of low-level mixed waste and transuranic waste (Section 5.3.3.1). The volume of waste stored at this complex in 2012 totaled approximately 378,714 cubic feet (10,724 cubic meters).

Waste Receiving and Processing Facility (WRAP, currently not operational). Located in the 200-West Area, this 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. In response to budget constraints, actions were taken in late 2011 and 2012 to place the WRAP Facility into a lay-up status until future funding is available to restart the facility. The layup actions during the interim period maintain facility safety, environmental compliance, and operational viability to enhance the transition to operational status at the end of the layup period (Section 5.3.3.2).

T Plant Complex. Located in the 200-West Area, T Plant provides waste treatment, storage, and decontamination services for the Hanford Site, as well as for offsite facilities (Section 5.3.3.3).

Canister Storage Building (CSB). The CSB is a large, 42,000-square-foot facility located in the 200-East Area, which stores about 2,300 tons (2,086 metric tons) of spent nuclear fuel packaged in approximately 400 multi-canister overpacks that came from the 100-K Basins, 100-N Reactor, and T Plant. The multi-canister overpacks are stored in 220 carbon steel tubes within a below grade concrete vault. The irradiated fuel was cleaned, packaged, dried, and relocated to the CSB in 2004 to provide safe interim storage in a consolidated location, allowing for cleanup of the older facilities to support reducing the cleanup footprint of the Hanford Site and reduce risk. The CSB has a design life of 40 years, and will safely store the multi-canister overpacks in the tubes until they are permanently placed in a National Repository. Adjacent to the CSB is the Interim Storage Area which also contains spent nuclear fuel packaged in various containers. This spent nuclear fuel will be subsequently repackaged and also sent to the National Repository (Section 5.3.3.4).

Low-Level Burial Grounds. 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 2012, a total of 9,817 cubic feet (278 cubic meters) of waste were disposed in Trenches 31 and 34 (Section 5.3.3.5). Two defueled U.S. Navy reactor compartment were received in 2012 and placed in low-level waste burial ground, Trench 94 (218-E-12B Burial Ground), bringing the total number of reactor compartments received to 125 (Section 5.3.3.5.2).

Waste Encapsulation and Storage Facility (WESF). Located in the 200-East Area, this 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 WESF did not generate regulated wastes in 2012 (Section 5.3.3.6).

Integrated Disposal Facility (IDF, currently not operational). Located in the south-central 200-East Area, this facility 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 WTP. The process design disposal capacity listed in the RCRA permit is 2.89 million cubic feet (82,000 cubic meters) (Section 5.3.3.7).

Environmental Restoration Disposal Facility (ERDF). Located near the 200-West Area, ERDF is a massive landfill regulated by the EPA. ERDF serves as the central disposal site for contaminated waste removed during Hanford Site cleanup operations conducted under CERCLA regulations. The total constructed trench capacity of ERDF is over 16.4 million tons (14.9 million metric tons); Cells 1 through 4 are full with an interim cover, Cells 5 and 6 are being filled and near operational capacity, Cells 7 and 8 are over half-full, and disposal in Super Cells 9 and 10 continues. The interim cover over Cells 1 and 2 was extended an additional 500 feet (152 meters) to cover Cells 3 and 4 at the end of 2012 (Section 5.3.3.8).

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. Liquid waste management facilities include 200 Area Effluent Treatment Facility (ETF), Liquid Effluent Retention Facility (LERF), 200 Area Treated Effluent Disposal Facility, and the 242-A Evaporator. Liquid effluent is managed in facilities to comply with federal and state regulations and facility permits (Section 5.3.4).

200 Area Effluent Treatment Facility (200 Area ETF). Located in the 200-East Area, the facility treats liquid effluent to remove toxic metals, radionuclides, and ammonia, in addition to destroying 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 in 2012 was approximately 9.4 million gallons (35.8 million liters). This wastewater was primarily CERCLA-regulated wastewater (groundwater from the 200-UP-1 and 200-ZP-1 Operable Units in the 200-West Area) (Section 5.3.4.1).

Liquid Effluent Retention Facility (LERF). Located in the 200-East Area, the facility consists of three RCRA-compliant surface basins used to store temporarily process condensate from the 242-A Evaporator, groundwater from various operable unit pump-and-treat systems, leachate from ERDF and from low-level waste burial ground Trenches 31 and 34, and other aqueous waste. The volume of wastewater received for LERF basin storage in 2012 was approximately 7.5 million gallons (28.4 million liters). The majority of wastewater received at the LERF was pipeline-transported contaminated groundwater from operable unit pump-and-treat systems, totaling approximately 4.2 million gallons (15.9 million liters). Another major contributor to wastewater received into LERF during 2012 was the CERCLA-regulated leachate from ERDF, totaling approximately 2.9 million gallons (11.0 million liters). Approximately 0.34 million gallons (1.3 million liters) of wastewater were received from various facilities by tanker trucks that included approximately 147,000 gallons (0.56 million liters) of leachate from LLW burial Trenches 31 and 34. No process condensate was received from the 242-A Evaporator in 2012 (Section 5.4.4.2).

200 Area Treated Effluent Disposal Facility (TEDF). Located east of the 200-East Area, the 200 Area Treated Effluent Disposal Facility is a collection and disposal system for non-RCRA waste streams that consists of approximately 11 miles (18 kilometers) of buried pipelines connecting three pumping stations, the 6653 Building (known as the disposal sample station), and 5-acre (2-hectare) disposal ponds. The volume of unregulated effluent disposed in 2012 was 21.8 million gallons (82.4 million liters) (Section 5.3.4.3).

242-A Evaporator. Located in the 200-East Area, the 242-A Evaporator concentrates dilute liquid tank waste by evaporation. This process reduces the volume of liquid waste sent to double-shell tanks (DSTs) for storage and reduces the potential need for additional DSTs. Waste volume reduction activities at the 242-A Evaporator are managed in accordance with the *Hanford Facility Dangerous Waste Permit (WA7890008967)*; however, in 2012 the 242-A Evaporator did not perform waste volume reduction activities (Section 5.3.4.4). Table ES-1 provides the waste summary data for 2012.

Table ES-1. Hanford Site Waste Summary

Activity	Waste Type	Amount (tons)	Amount (metric tons)
Solid waste generated during onsite cleanup activities	Solid mixed waste	305	277,000
	Radioactive waste	343	311,000
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	66	60,000
	Radioactive waste	82	74,000
Dangerous waste shipped off the Hanford Site	See Table 5.4	129	116,100
Waste disposed of at the ERDF	Solid waste	1,089,500	988,400
Activity	Waste Type	Amount (cubic feet)	Amount (cubic meters)
Waste disposed of in Trenches 31 and 34	Mixed low-level solid waste	9,817	278
Activity	Waste Type	Amount (gallons)	Amount (liters)
Waste volume pumped from underground single-shell waste storage tanks to double-shell waste storage tanks (includes flush/dilution water)	Liquid waste	237,700	899,700
Waste added to underground double-shell waste storage tanks	Liquid waste	632,000	2,392,000
Waste volume in underground double-shell waste storage tanks	Liquid waste	26,700,000	98,000,000
Aqueous waste volume received at the LERF	Wastewater containing low levels of organic compounds and tritium	15,200,000	57,500,000
Volume of waste water treated and disposed at the 200 Area ETF	Wastewater containing toxic metals, radionuclides, ammonia, and organic compounds	9,400,000	35,800,000
Effluent volume disposed of at the 200 Area Treated Effluent Disposal Facility	Untaminated, treated liquid waste	21,800,000	82,400,000

Underground Waste Storage Tanks. Most Hanford Site waste is stored in 149 large underground single-shells (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.

Single-Shell Tank System. There are 149 single-shell tanks, 83 single-shell tanks are located in the 200-West Area, with another 66 single-shell tanks in the 200-East Area. As part of the TPA, crews must remove at least 99 percent of the material in every tank, or at least as much waste that can be removed based on available technology. Approximately 237,700 gallons (899,700 liters) of radioactive and hazardous waste were removed from single-shell tanks C-104, C-107, C-108, and C-111 in 2012 and transferred to safer DSTs storage, leaving approximately 29.3 million gallons (111 million liters) of waste in the single-shell tanks (Section 5.4.1).

Double-Shell Tank System. There are 28 DSTs; 3 DSTs are in the 200-West Area, with another 25 DSTs in the 200-East Area. At the end of 2012, there were 26.7 million gallons (98 million liters) of waste in the DSTs (Section 5.4.2).

Waste Treatment and Immobilization Plant. The WTP is being built on 65 acres (26 hectares) located on the Central Plateau in the 200-East Area to treat radioactive and hazardous waste currently stored in 177 underground tanks. The WTP comprises four major facilities 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 (balance of facilities). Construction of the WTP is managed in accordance with the *Hanford Facility Dangerous Waste Permit (WA7890008967)* (Section 5.5).

Scientific and Technical Contributions to Hanford Site Cleanup. Scientific and technical contributions addressing Hanford Site challenges in chemical and nuclear waste processing and subsurface science and remediation included performing evaluations, analyzing data, providing reviews, preparing and operating special facilities, and creating new technologies to address site cleanup challenges. The 2012 contributions to Hanford Site Cleanup are provided in Section 5.6.

SECTION 6, AIR MONITORING. This section provides information on the Hanford Site monitoring and compliance with environmental, public health, and resource protection laws, regulations, and DOE orders.

Air Emissions. 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. Nonradioactive constituents and parameters are monitored directly, sampled and analyzed, or estimated based upon inventory usage. DOE annually submits to EPA and the Washington State Department of Health a report of Hanford Site radionuclide air emissions in compliance with Subpart H of [40 Code of Federal Regulations \(CFR\) 61](#), *National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities* and with [WAC 246-247](#), “Radiation Protection – Air Emissions”.

Ambient-Air Monitoring. A network of continuously operating samplers at 74 locations across the Hanford Site was used during 2012 to monitor radioactive materials in air near site facilities and operations: (Section 6.2.1). 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.

The 2012 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 (Section 6.2.1).

Air sampling was conducted at 25 locations in the 200-West Area during 2012. 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 42 percent of the samples. Plutonium-239/240 was detected in approximately 33 percent of the samples. The plutonium-239/240 concentration at air-sampling location N165 (near the 216-Z-9 Trench) was greater than 10 percent of the EPA concentration value ([40 CFR 61](#), Appendix E, Table 2) for the composite sample collected during the first-half of 2012. This elevated plutonium value is believed to originate from the nearby retired 216-ZP-9 Trench that received liquid waste from PFP until 1995. Required notifications were made to the Washington State Department of Health.

SECTION 7, WATER MONITORING. This section discusses the drinking water systems on the Hanford Site. Nine DOE-owned, contractor-operated, public water systems supply drinking water to DOE facilities on the Hanford Site. Drinking water for the 200-East Area is supplied from the 200-West Area 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. The city of Richland supplied water for the 300 Area. In addition to the 300 Area, the city of Richland provided drinking water to the Richland North Area and the Hazardous Materials Management and Emergency Response Training Facility (HAMMER). Samples at all three drinking water treatment facilities were collected monthly and analyzed quarterly or annually for radiological contaminants. All were samples of treated water collected before the water was distributed for general use.

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. 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 MSA, but are not published.

All DOE-owned Hanford Site drinking water systems were in compliance with drinking water standards (DWSs) for radiological, chemical, and microbiological contaminant levels during 2011. Contaminant concentrations measured during the year were similar to those observed in recent years ([PNNL-20548](#); [PNNL-19455](#)).

Radiological Monitoring. Scientists conducted radiological monitoring of Hanford Site drinking water at one DOE-owned pump and three water treatment facilities during 2012. In addition, routine chemical, physical, and microbiological monitoring of onsite drinking water and process monitoring (including chemical and physical sampling) at the water treatment plants and distribution systems to determine compliance with applicable regulations was performed. Annual average concentrations of all monitored radionuclides in Hanford Site drinking water in 2012 were below state and federal maximum allowable contaminant levels (Section 7.1.3). The gross alpha, gross beta, tritium, and strontium-90 results from the two 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). The 400 Area source of drinking water for 2012 was well 499-S1-8J (P-16). Gross beta and tritium were found in all 400 Area water samples, but still below the maximum allowable contaminant level. Gross alpha and strontium-90 were not detected in 400 Area water samples (Table 7.2).

Surface Water Monitoring. Samples of surface water 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.

Columbia River Water. Pollutants from multiple sources are present in the Columbia River as it passes through the Hanford Reach (Section 7.2). 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. Columbia River water samples were collected from fixed-location monitoring stations at Priest Rapids Dam and at the city of Richland in 2012 and analyzed for radionuclides. Cross-river transects and near-shore locations near Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland were analyzed for both radionuclides and chemicals (Figure 7.3). Samples were collected upstream from the Hanford Site at Priest Rapids Dam and Vernita Bridge to provide data from locations unaffected by Hanford 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 7.6.

Fixed-Location Samples. Results of radiological analyses of Columbia River water samples collected at Priest Rapids Dam and the city of Richland are summarized in Appendix C. All individual radiological contaminant concentrations measured in Columbia River water during 2012 were less than 1/25 of the concentrations comparable to the DOE-derived concentration guides (Appendix D).

Radionuclide Results. Radionuclide concentrations monitored in Columbia River water were low throughout 2012. Tritium, uranium-234, uranium-238, and naturally occurring beryllium-7 and potassium-40 were consistently measured in river water at levels greater than their reported minimum detectable concentrations. Strontium-90, technetium-99, 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.

Columbia River Sediment Monitoring. Samples of Columbia River sediment samples were collected along the Hanford Reach and analyzed for Hanford Site-associated radiological and chemical contaminants present in groundwater beneath the site (Section 7.3).

Radionuclide Results. Radionuclides consistently detected in river sediment adjacent to and downstream of the Hanford Site during 2012 included 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 past Hanford Site operations. Potassium-40, and uranium isotopes occur naturally in the environment, and uranium isotopes have been present in past releases of 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](#)). Uranium concentrations were slightly elevated at the White Bluffs Slough and McNary Dam locations as compared to values measured in 2007 through 2011. Other radionuclide concentrations reported in river sediment were similar to those reported for previous years, with the exception of cesium-137 (see Appendix D), and there were no obvious differences between locations. The values for cesium-137 at the White Bluffs Slough were not elevated compared to Priest Rapids Dam, and were lower than elevated values measured in 2004 through 2007, and 2011. Previous studies of soils from the White Bluffs Slough detected elevated concentrations of cesium-137. The average, maximum, and minimum concentrations of selected radionuclides measured in Columbia River sediment (2007 through 2012) are presented in Figures 7.12, 7.13, and 7.14.

Chemical Results. Detectable amounts of most metals were found in all river sediment samples (Figure 7.15). 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, copper, nickel, and zinc differed the most between locations, which may be associated with upstream mining activities. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured values.

Pond Water and Sediment. Two onsite ponds, West Lake and the FFTF Pond, were sampled. Water samples were collected quarterly in 2012 from the FFTF Pond water and twice a year from West Lake Pond water. Water samples collected from the FFTF Pond were analyzed for gross alpha, gross beta, and gamma-emitting radionuclides. Average gross beta levels increased slightly during 2012 as compared to 2011. Tritium concentrations in FFTF Pond water were slightly lower in 2012 than they were in 2011. West Lake was analyzed for tritium, uranium-234, uranium-235, and uranium-238. Figure 7.17 shows the annual average concentrations of uranium-234 and uranium-238 in West Lake Pond water from 1998 through 2012 (Section 7.5).

Offsite Irrigation Water. Water samples were collected in 2012 from an irrigation canal located east of the Columbia River and from a location downstream of the Hanford Site at Riverview. Samples of the water supply from the Horn Rapids irrigation pumping station (Figure 7.3) were collected from the irrigation valve at the Battelle sporting complex. Each location was sampled three times during the 2012 irrigation season. Unfiltered samples were analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, uranium-234, uranium-235, and uranium-238. Most radionuclide concentrations measured in irrigation water in 2012 were at similar 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. Beta results from the Riverview area were slightly higher than levels detected in the Columbia River while strontium-90 results had a similar juxtaposition between irrigation and upstream water samples. All radionuclide concentrations were within the historical range and were less than their respective DOE-derived concentration guides and Washington State ambient surface-water quality criteria ([DOE O 458.1](#), Chg. 2; [WAC 173-201A](#); [40 CFR 141](#)). (Section 7.6).

Liquid Effluent Monitoring. Liquid effluents were discharged to ground disposal units from a few facilities in 2012 at the Hanford Site. Only one of those waste streams is permitted for radioactive constituents; however, all are sampled and analyzed for select radioactive parameters and nonradioactive hazardous materials. The only active discharge point for radioactive liquid effluent to the ground in 2012 is the 616-A Crib, also known

as the State-Approved Land Disposal Site. Table 7.8 summarizes the analysis results on this effluent discharge point for 2012 (Section 7.7).

SECTION 8, GROUNDWATER MONITORING. At the Hanford Site, liquid waste released to the ground over many years has reached the groundwater. section presents the results of Hanford Site groundwater monitoring for 2012. It describes monitoring results for RCRA TSD units, CERCLA groundwater operable units, and the requirements of *Atomic Energy Act of 1954*. DOE publishes details on CERCLA remediation activities (for example, pump-and-treat operations) in separate reports that are summarized and referenced in this report. The data presented in this section—and information on well locations, construction, and screened intervals—can be found through the DOE’s Environmental Dashboard Application at <http://environet.hanford.gov/EDA/>.

SECTION 9, SOIL MONITORING. This section summarizes soil monitoring efforts conducted at and around the Hanford Site. Soil samples are 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 are 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 2011 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 2011 were higher in 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 9.3).

SECTION 10, BIOTA MONITORING. This section summarizes the agricultural; and plant and animal communities contaminant monitoring on the Hanford Site. Results of sample analyses are used to assess the amounts of Hanford Site contaminants. 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.

Agricultural Monitoring. Food and farm products (alfalfa, cherries, leafy vegetables, milk, potatoes, tomatoes, and wine) were collected in 2012 at locations near the Hanford Site. Samples were analyzed to determine radiological contaminant concentrations. Radionuclide concentrations in most food and farm product samples in 2012 were below levels that could be detected by analytical laboratories; however, some contaminants that potentially could have originated from the Hanford Site (e.g., tritium and uranium) were found at low levels in some samples (Section 10.1). Radiological doses associated with possible site-produced contaminants are discussed in Section 4.0. Where possible, the measured concentrations are compared to the applicable unusual concentration reporting levels.

Animal 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. 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 ensure that consumption of fish and wildlife obtained from the site environs does not pose a threat to humans.

In 2012, the fish and wildlife species sampled and analyzed for Hanford Site operations-produced contaminants included Smallmouth bass (*Micropterus dolomieu*), Mule Deer (*Odocoileus hemionus*), Elk (*Cervus elaphus*), and California quail (*Callipepla californica*). Monitoring fish and wildlife for uptake and exposure to Hanford Site operations-produced contaminants ensures that consumption of fish and wildlife obtained from Hanford Site environs does not pose a threat to human health, while providing long-term contamination trends. These species were selected and monitored because the species provide a potential pathway for offsite human consumption. Figure 10.2 shows the locations on and around the Hanford Site where fish and wildlife were collected. Samples from the fish and wildlife were analyzed for selected (suspected or known to be present at the Hanford Site) radionuclides and metals (Table 10.2). In addition, samples were collected from locations distant from the Hanford Site to obtain reference (background)

contaminant measurements. All fish and wildlife samples were monitored for strontium-90 contamination and analyzed by gamma spectrometry to detect a number of gamma emitters, including cesium-137 (refer to Appendix D). Since the 1990s, strontium-90 and cesium-137 have been the most frequently measured radionuclides in fish and wildlife samples. Most fish and wildlife samples are collected on and around the Hanford Site and analyzed for human-pathway exposure every 2 to 3 years, with samples obtained at locations determined not to be affected by Hanford Site effluents and emissions approximately every 5 years.

Plant 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. Hanford Site 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 (Section 10.3).

Monitoring Results. 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 through the roots of vegetation growing on or near former waste disposal sites. The number and location of Hanford Site vegetation samples collected during 2012 are summarized in Table 10.4. Only those radionuclides with concentrations consistently above analytical detection limits are discussed in this section. Vegetation samples from offsite locations were last collected in 2008 ([PNNL-18427](#), *Hanford Site Environmental Surveillance Data Report for Calendar Year 2008*).

Monitoring of rabbitbrush and sagebrush leaves and stems provides information about atmospheric deposition of radioactive materials in uncultivated areas and at Hanford Site locations that potentially could be affected by contaminants from Hanford Site operations. Vegetation samples have been collected on and around the Hanford Site for more than 50 years.

Vegetation Control. 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 4,087 acres (1,654 hectares) were treated with herbicides in 2012 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 (Section 10.4.2)

Waste Site Remediation and Revegetation. In 2012, approximately 150 acres (61 hectares) of waste sites in 200-East and 200-West Areas were seeded with perennial bunch grass seed. This was done to repair and improve existing vegetative caps on the sites. An unusually wet fall allowed good germination of the seed, and high expectations of success for the seeding efforts (Section 10.5).

SECTION 11, RESOURCE PROTECTION. This section summarizes the ecological monitoring, endangered and threatened species, and cultural and historic resources at the Hanford Site. 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.

Ecological Protection. The Hanford Site is a relatively undisturbed area of shrub steppe that supports a rich diversity of plant and animal species adapted to the semiarid environment of the Columbia Plateau. The Hanford Site contains biologically diverse shrub-steppe plant communities that have been protected from most disturbances, except for fire, for more than 65 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. Project personnel survey and monitor resources and key biota to assess the abundance, health, and distribution of populations and species at the Hanford Site. Data collection and analysis are integrated with environmental surveillance monitoring of biotic and abiotic media and analytical results are used to characterize any potential risk or impact to the biota.

Inventory and monitoring activities help protect 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. The Hanford Site contains biologically diverse shrub-steppe plant communities that have been protected from most disturbances, except for fire, for more than 65 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 in order to develop baseline information and monitor any changes resulting from Hanford Site operations.

Endangered and Threatened Species. 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 USFWS in [50 CFR 17.11](#), *Endangered and Threatened Wildlife* and [50 CFR 17.12](#), *Endangered and Threatened Plants*. State lists are maintained by the Washington Natural Heritage Program ([WNHP 2012](#)) and WDFW ([WDFW 2013](#)).

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 occur regularly on the Hanford Site (Table 11.5). One additional fish species (bull trout [*Salvelinus confluentus*]) was recorded at the Hanford Site but scientists believe this species is transient. Two plant species, the Umtanum desert buckwheat (*Eriogonum codium*) and the White Bluffs bladderpod (*Physaria douglasii* ssp. *tuplashensis*) were listed as threatened species under the *Endangered Species Act of 1973* in April 2013 ([78 FR 23984](#)). 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 one mammal species and one bird species are currently candidates for federal listing (Table 11.5). 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 33 state-level sensitive and candidate species of insects and animals and 15 sensitive plant species occurring or potentially occurring on the Hanford Site (Table 11.5).

Cultural and Historic Resource Protection. The Hanford Cultural and Historic Resources Program (CHRP), which is managed by DOE, ensures cultural and historic resources entrusted to DOE are managed responsibly and in accordance with applicable regulatory requirements. 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 ensure that important cultural resources are identified and effects to those resources are evaluated so that mitigation measures can be conducted.

Hanford Site archaeologists completed 133 Section 106 reviews. Sixty-two proposed projects did not involve ground disturbance and were determined exempt by Hanford Site archaeologists after an initial review, or had satisfied the requirements of Section 106 under a prior review. Hanford Site archaeologists reviewed and completed 13 projects under an emergency declaration (i.e., post-review) in accordance with Section 5.1.1 of [DOE/RL-98-10](#) (Figure 11.12). Most projects cleared under expedited reviews occurred in the 200 Areas of the Hanford Site (Figure 11.12). Hanford Site archaeologists reviewed 58 undertakings in 2012 that had the potential to affect cultural resources, which included efforts to identify cultural resources that might be affected by project activity, an assessment of potential impacts, and the development of mitigation, if

necessary¹. Of the 58 undertakings, 39 identified as *no historic properties affected*; 17 had *no adverse effects* to historic properties; and 2 resulted in *adverse effects*. However, the *adverse effects* were avoided by taking specific actions to minimize impacts, including avoidance, following treatment plan guidelines, and archaeological monitoring. The two undertakings resulting in adverse effects to historic properties required mitigation measures as documented in a project-specific Memorandum of Agreement. Approximately 1,090 acres (441 hectares) of new ground was surveyed for cultural resources because 34 undertakings had the potential to affect physically cultural resources. In addition, some undertakings required *National Register of Historic Places* eligibility evaluations, including archaeological testing.

SECTION 12, QUALITY ASSURANCE. This section summarizes the comprehensive quality assurance programs, which include various quality control practices and methods to verify data, are maintained by monitoring and surveillance projects to ensure data quality. The programs are implemented through quality assurance plans designed to meet requirements of the American National Standards Institute, the American Society of Mechanical Engineers (ASME), 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 inter-laboratory crosschecks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories.

¹ This number does not reflect all full cultural resources reviews initiated in 2012. Additional reviews were initiated in 2012, but completed in 2013, and are not included in this report.

Acronyms

AEA	Atomic Energy Act
ALARA	as low as reasonably achievable
AR/PIR	Administrative Record/Public Information Repository
ARAR	applicable or relevant and appropriate requirement
ASME	American Society of Mechanical Engineers
BNI	Bechtel National, Inc.
Bq	Becquerel
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CHPRC	CH2M HILL Plateau Remediation Company
CHRP	Cultural and Historic Resources Program
CLUP-EIS	Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement, DOE/EIS-0222-F
CSB	Canister Storage Building
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CVDF	Cold Vacuum Drying Facility
CWC	Central Waste Complex
CY	Calendar Year
DOE	U.S. Department of Energy (also USDOE)
DOE-CAP	DOE Consolidated Audit Program
DOE-HQ	U.S. Department of Energy, Headquarters
dpm	disintegrations per minute
DNFSB	Defense Nuclear Facility Safety Board
DST	Double-Shell Tank
DWS	Drinking Water Standard
Ecology	Washington State Department of Ecology
ETF	200 Area Effluent Treatment Facility
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FETF	Fast Flux Test Facility
FONSI	Finding of No Significant Impact
FR	Federal Register
FY	fiscal year
HAMMER	Hazardous Materials Management and Emergency Response Training Facility
HEPA	High efficiency particulate absorber
HLW	High-level waste
ICRP	International Commission on Radiological Protection
IDF	Integrated Disposal Facility
kg	kilogram
lb	pound
LERF	Liquid Effluent Retention Facility
LLW	Low-Level Waste
LLWMA	Low-Level Waste Management Area

MAPEP	Mixed Analyte Performance Evaluation Program
MRAD	Environmental Resource Associates
MSA	Mission Support Alliance, LLC
mg/L	milligrams per liter
mrem	millirem
NEPA	National Environmental Policy Act
NRDWL	Nonradioactive Dangerous Waste Landfill
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
ORP	U.S. Department of Energy, Office of River Protection
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyls
pCi/L	picocuries per liter
PFP	Plutonium Finishing Plant
ppm	parts per million
PQL	practical quantitation limit
PUREX	Plutonium/Uranium Extraction (Plant)
RCRA	Resource Conservation and Recovery Act of 1976
RCW	revised code of Washington
REDOX	reduction/oxidation (Plant)
rem	roentgen equivalent in man
RESRAD	RESidual RADioactive
RI/FS	remedial investigation/feasibility study
RFI/CMS	RCRA facility investigation/corrective measures study
RL	U.S. Department of Energy, Richland Operations Office
ROD	record of decision
RPD	relative percent difference
SDWA	Safe Drinking Water Act
SST	Single-Shell Tank
Sv	sievert
SWL	Solid Waste Landfill
TEDF	Treated Effluent Disposal Facility
TLD	thermoluminescent dosimeter
TPA	Hanford Federal Facility Agreement and Consent Order, aka Tri-Party Agreement
TRIDEC	Tri-Cities Economic Development Council
TSD	treatment, storage, and disposal
µg/L	micrograms per liter
USC	United States Code
WAC	Washington Administrative Code
WCH	Washington Closure Hanford, LCC
WESF	Waste Encapsulation and Storage Facility
WMA	waste management area
WRAP	Waste Receiving and Processing (Facility)
WRPS	Washington River Protection Solutions, LLC
WSCF	Waste Sampling and Characterization Facility
WTP	Waste Treatment and Immobilization Plant

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1.0 Introduction

SA Thompson

This environmental report provides information and analytical data related to the Hanford Site for calendar CY 2012 and includes a brief *History of the Hanford Site 1943-1990* (DOE/RL 1990) and its mission; compliance with applicable federal, state, and local environmental laws, regulations, permits, executive orders, 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](http://msa.hanford.gov/msa/index.cfm/env_reports_1959_-_2000); and reports from 2001 to present are available at [http://msa.hanford.gov/msa/index.cfm/env_reports_2001 - latest](http://msa.hanford.gov/msa/index.cfm/env_reports_2001_-_latest). The reports include 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.

Additional detail is provided in Section 13, References, and descriptions of specific analytical and sampling methods used in the monitoring efforts are provided in the *Environmental Monitoring Plan, United States Department of Energy, Richland Operations Office* (DOE/RL-91-50).

1.1 Hanford Site Mission

Prior to 1988, the primary Hanford Site mission was the production of plutonium for national defense. With the signing of the TPA by the three parties (DOE, EPA, and Ecology, the primary mission shifted to cleanup of the extensive contamination remaining due to the legacy of production. The Hanford Site's mission now focuses on environmental restoration, which includes remediation of contaminated areas, decontamination and decommissioning of Hanford Site facilities, waste management, and related scientific and environmental research and development of waste management technologies.

1.2 Hanford Site Location

The Hanford Site is located within the semiarid Pasco Basin of the Columbia Plateau in southeastern Washington State (Figure 1.1). The site occupies an area of approximately 586 square miles (1,517 square kilometers) north of the city of Richland. 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. In September 1999, DOE issued the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (HCP EIS) (DOE/EIS-0222-F). The HCP EIS analyzed the impacts of alternatives for implementing a land-use plan for the DOE's Hanford Site for at least the next 50-year planning period and lasting for as long as DOE retains legal control of some portion of the real estate.

1.2.1 Operational, Research, and Administrative Areas

Areas within and surrounding the Hanford Site includes the following:

- **100 Area** – The 100 Areas consist of four distinct sites (100-B/C, 100-D, 100-H, 100-K, and 100-N) that are located along the shore of the Columbia River in the northern portion of the Hanford Site. These areas were the location of nine nuclear reactors that have since been retired. Collectively, the 100 Areas occupy approximately 4 square miles (11 square kilometers). The B Reactor, a National Historic Landmark, is located in the 100-B Area. As the world's first industrial-scale nuclear reactor, B Reactor produced plutonium for the first atomic explosion (Trinity Test) and the atomic bomb that was detonated over Nagasaki, Japan. DOE offers scheduled tours of the B Reactor facility.
- **200 Area** – The 200-East and 200-West Areas cover approximately 6 square miles (16 square kilometers) and are located on the Central Plateau, approximately 5 and 7 miles (8 and 11 kilometers) south and west, respectively, of the Columbia River. The plateau surface is approximately 328 feet (100 meters) above the level of the Columbia River and about 280 feet (85 meters) 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 4 to 7.5 miles (7 to 12 kilometers) south of the 100 Areas. The 200 North Area covers approximately 58.6 acres (23.7 hectares) and operations were mainly related to irradiated nuclear fuel interim storage. Thermal cooling of the spent fuel required water, which was disposed 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 0.6 square mile (1.5 square kilometers). From the early 1940s until the advent of the environmental contamination cleanup mission in 1989, nuclear fuel fabrication and research and development activities were performed at the 300 Area. Remediation of waste sites and decommissioning of 300 Area facilities is ongoing.
- **400 Area** – The 400 Area is located northwest of the 300 Area, and covers approximately 0.23 square mile (0.61 square kilometer). This area includes the FFTF, a nuclear reactor designed and used to test various types of nuclear fuel, produce medical and industrial isotopes, and conduct cooperative international research. The FFTF operations were discontinued in 1992, and the facility is now in a low-cost long-term surveillance and maintenance condition.
- **600 Area** – The 600 Area includes all of the Hanford Site not occupied by the 100, 200, 300, and 400 Areas.
- **1100 Area** – The 1100 Area is located between the 300 Area and the city of Richland and covers 1.2 square miles (3.1 square kilometers). In October 1998, this area was transferred to the Port of Benton as part of DOE's Richland Operations Office (RL) 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 (PNNL) 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 (known as HAMMER)** – This worker safety training facility is located on the Hanford Site near the city of Richland and is used by site contractors, federal and state agencies, tribal governments, and private industry. The facility consists of a 0.12-square-mile (0.31-square-kilometer) main site and a 15.6-square-mile (40.4-square-kilometer) law enforcement and security-training site.

- **Non-DOE Operations and Activities on Hanford Site Leased Land** – Operation of commercial nuclear power production by Energy Northwest at the Columbia Generating Station, located north of the 300 Area, on 1,090 acres (440 hectares). Operation of a commercial low-level radioactive waste burial site, located west of the 200-East Area, on 99 acres (40 hectares), and is operated by US Ecology Washington, Inc. The Laser Interferometer Gravitational-Wave Observatory, located west of the 400 Area, on 148 acres (60 hectares), 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** – AREVA NP, Inc., operates a commercial nuclear fuel fabrication facility located near the southern boundary of the Hanford Site; and Perma-Fix Northwest, Inc. operates a low-level and mixed low-level radioactive waste processing facility located immediately adjacent to the southern boundary of the Hanford Site on 53 acres (21 hectares). Westinghouse Electric Company operates the Richland Service Center, located in north Richland, and provides chemical cleaning, chemical decontamination, and related chemical and waste processing services to the nuclear industry.
- **Hanford Reach National Monument** – The Hanford Reach National Monument (Figure 1.1), established by a Presidential Proclamation in June 2000 ([65 FR 37253, *Establishment of the Hanford Reach National Monument*](#)), covers 305 square miles (789 square kilometers) along the River Corridor. The purpose of the monument is to protect the nation’s only non-impounded stretch of the Columbia River upstream of Bonneville Dam and to protect the remaining shrub-steppe ecosystem that once blanketed the Columbia River Basin. The U.S. Fish and Wildlife Service (USFWS) manage regions of the Hanford Reach National Monument, to include Rattlesnake Mountain, under an agreement with DOE.

Figure 1.1. Hanford Site and Surrounding Areas



1.3 Climate and Meteorology

KW Burk

The Hanford Meteorology Station is located at the Hanford Site Central Plateau. Researchers take meteorological measurements to support Hanford Site operations, emergency preparedness and response, and atmospheric dispersion calculations for dose assessments. Support is provided through weather forecasting and by maintaining and distributing climatological data. Forecasting is provided to help manage weather-dependent operations. Climatological data are provided to help plan weather-dependent activities and 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 30 feet (9 meters) high and 3 towers that are 200 feet (61 meters) 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 in Canada protect the region from severe, cold polar air masses moving southward across Canada and winter storms associated with them.

Prevailing wind direction in the Central Plateau 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 6 to 7 miles per hour (3 meters per second), and highest during summer, averaging about 8 to 9 miles per hour (4 meters per second). Wind speeds well above average are usually associated with southwesterly winds. However, summertime drainage winds are generally northwesterly and frequently exceed 30 miles per hour (13 meters per second). These winds are most prevalent over the northern portion of the Hanford Site. Figure 1.2 shows the 2011 wind roses (i.e., diagrams showing direction and frequencies of wind) measured at a height of 30 feet (9 meters) 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 percent 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 percent of the time). Occasionally, there are extended periods of poor dispersion conditions, primarily during winter, that are associated with stagnant air in stationary high-pressure systems.

1.3.1 Historical Climatological Information

The following are climatological records set on the Hanford Site. From 1945 through 2012, the record maximum temperature was 113.0° Fahrenheit (F) [45° Celsius (C)] recorded in August 1961, July 2002, and July 2006. The record minimum temperature was -23.1°F (-30.6°C) in February 1950. Normal monthly average temperatures ranged from a low of 31.1°F (-0.5°C) in December to a high of 77.1°F (25.1°C) in July. During winter, the highest monthly average temperature at the Hanford Meteorology Station was 44.4°F (6.9°C) in February 1991, and the record lowest was 12.1°F (-11.1°C) in January 1950. During summer, the record maximum monthly average temperature was 82.2°F (27.9°C) in July 1985, and the record minimum was 63.0°F (17.2°C) in June 1953. The normal annual relative humidity at the Hanford Meteorology Station is 55 percent. Humidity is highest during winter, averaging approximately 76 percent and lowest during summer, averaging approximately 36 percent.

Normal annual precipitation at the Hanford Meteorology Station is 7.14 inches (18.1 centimeters). The wettest year on record, 1995, received 12.31 inches (31 centimeters) of precipitation; the driest, 1976, received 2.99 inches (7.6 centimeters). Most precipitation occurs during late autumn and winter, with more than half of the annual amount occurring from November through February. The record snowfall in 1992-1993 was 56.1 inches (142.5 centimeters). Daily and monthly averages and extremes of temperature, dew point temperature, and relative humidity for 1945 through 2004 are reported in *Climatological Summary 2004 with Historical Data* ([PNNL-15160](#)).

1.3.2 Monitoring

Average temperature and precipitation totals in 2012 were above normal. The average temperature for 2012 was 54.4°F (12.4°C), which was 0.5°F (0.2°C) above normal (53.9°F [12.2°C]). Six months during 2012 were warmer than normal; six months were cooler than normal. December had the greatest positive departure at 5.3°F (2.9°C). June had the greatest negative departure at 3.5°F (2.0°C) below normal.

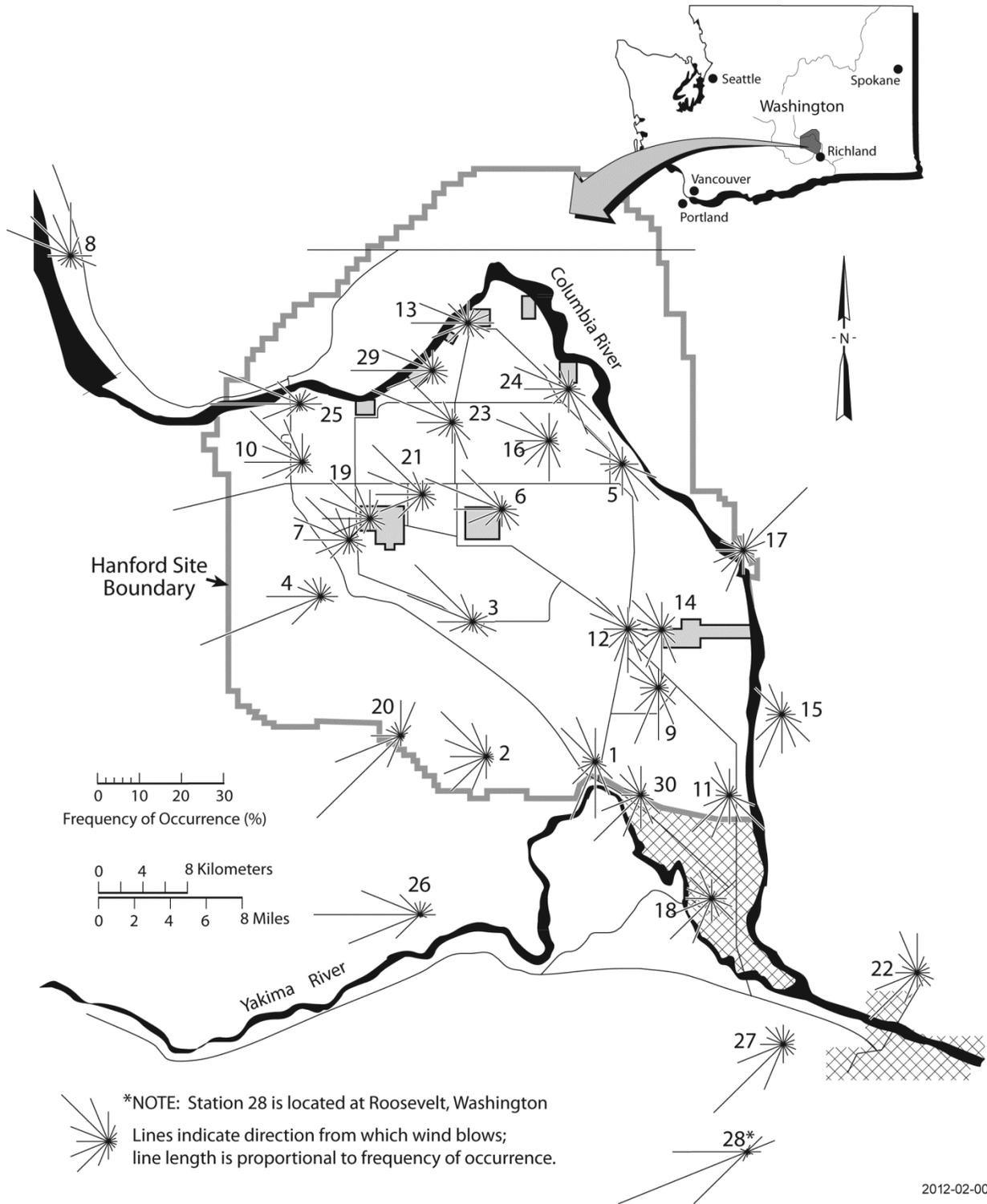
Precipitation totaled 8.18 inches (20.8 centimeters), which is 115 percent of normal precipitation (7.14 inches [18.1 centimeters]). Snowfall for 2012 totaled 16.0 inches (40.6 centimeters), compared to normal snowfall of 15.2 inches (38.6 centimeters).

Average wind speed was 7.9 miles per hour (3.5 meters per second), which was 0.4 mile per hour (0.2 meter per second) above normal. The peak gust for the year was 67 miles per hour (29.9 meters per second) on December 17, 2012. In addition, two dust storms were recorded at the Hanford Meteorology Station; the Hanford Meteorology Station has averaged four dust storms per year since the entire period of record (1945-2012).

Monthly and annual climatological data collected at the Hanford Meteorology Station is provided in Table 1.1. Real-time and historical data from the Hanford Meteorology Station are available at <http://www.hanford.gov/hms>. The website data includes hourly weather observations, 15-minute data from the Hanford Meteorological Monitoring Network, monthly climatological summaries, and historical data.

Figure 1.2. Meteorological Monitoring Network Wind Roses

Measured at a height of 30 feet [9 meters]



2012-02-0033

Table 1.1. Meteorology Station Monthly and Annual Climatological Data

*Hanford Meteorology Station 2011, 25 miles (40 kilometers) northwest of Richland, Washington
latitude 46° 34'N, longitude 119° 35'W, elevation 733 feet (223 meters)*

Month	Temperatures, °F								Precipitation (inches)				Relative Humidity (percent)		15-m Wind ²				
	Averages				Extremes				Total	Departure ²	Snowfall		Average	Departure ²	Average Speed (mph)	Departure ²	Peak Gusts		
	Daily Maximum	Daily Minimum	Monthly	Departure ²	Highest	Date	Lowest	Date			Total	Departure ²					Speed (Mph)	Direction	Date
Jan	42.2	22.4	32.3	-1.1	60	29	12	19 ⁴	1.09	+0.15	9.3	+4.7	74.6	-5.2	7.3	+1.0	49	WSW	Jan-25
Feb	48.0	27.3	37.7	-0.5	66	21	14	28	0.67	-0.03	1.5	-0.8	73.9	+3.2	7.1	+0.2	53	W	Feb-22
Mar	57.0	34.4	45.7	-0.8	74	9	24	7	0.64	+0.07	0.8	+0.4	54.4	-2.8	10.4	+2.5	56	WSW	Mar-5
Apr	68.0	41.6	54.8	+1.4	90	23	28	7	0.61	+0.06	0	0	51.3	+3.0	8.9	+0.4	46	SW	Apr-30
May	75.0	47.2	61.1	-1.0	96	15	35	6	0.22	-0.29	0	0	37.7	-5.5	9.5	+0.7	42	SW	May-3
Jun	79.4	52.8	66.1	-3.5	92	21 ⁴	42	7	1.51	+1.00	0	0	46.8	+7.2	9.4	+0.4	48	SW	Jun-17
Jul	94.3	61.7	78.0	+0.9	108	8	50	2	0.15	-0.08	0	0	37.8	+3.7	7.9	-0.7	46	SSW	Jul-8
Aug	94.7	61.0	77.8	+2.0	107	7	49	25	T ³	-0.18	0	0	30.6	-5.1	8.1	+0.1	48	WNW	Aug-23
Sep	83.8	51.3	67.5	+1.1	91	19 ⁴	41	12	0.03	-0.28	0	0	39.2	-3.8	6.3	-1.0	39	WNW	Sep-9
Oct	65.3	40.3	52.8	-0.3	87	1	29	23	1.05	+0.56	0	0	62.2	+6.1	7.0	+0.3	53	W	Oct-16
Nov	49.0	34.9	42.0	+1.5	66	5	20	11	0.80	-0.15	0.4	-1.6	82.5	+8.6	6.0	-0.7	51	SSE	Nov-19
Dec	42.3	30.4	36.5	+5.3	60	4	21	19	1.41	+0.21	4.0	-1.9	81.8	+0.6	7.4	+1.5	67	SSW	Dec-17
Year ⁵	66.6	42.1	54.4	+0.5	108	Jul 8	12	Jan 19 ⁴	8.18	+1.04	16.0	+0.8	56.1	+0.9	7.9	+0.4	67	SSW	Dec 17

Note: Refer to Appendix A, Table A.2, Conversion Table, in the Helpful Information section for unit conversion information.

¹ Measured on a tower 50 feet (15 meters) above ground

² Departure columns indicate positive or negative departure of meteorological parameters from 30-year (1981-2010) climatological normals.

³ Trace

⁴ Latest of multiple occurrences

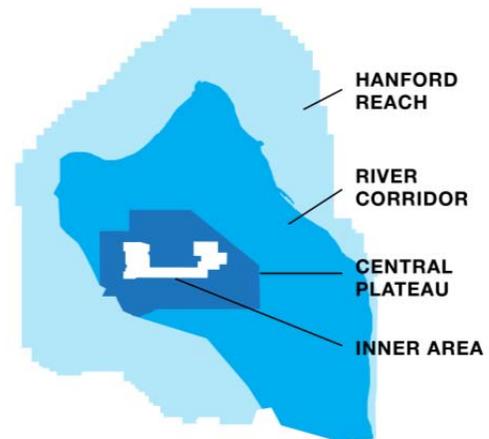
⁵ Yearly averages, extremes, and totals.

1.4 Hanford Site Management

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DOE is responsible for operating the Hanford Site. RL and the DOE Office of River Protection (ORP) 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 ensure environmental regulatory compliance. DOE, the USFWS, and the Washington Department of Fish and Wildlife each manage portions of the Hanford Reach National Monument.

RL serves as property owner of the Hanford Site and oversees cleanup along the Columbia River and in Hanford's Central Plateau, including groundwater and waste site cleanup, management of solid waste, spent nuclear fuel and sludge; facility cleanout, deactivation and demolition, environmental restoration; plutonium management; and all site support services. The principal contractors for RL and their respective responsibilities include the following:



- [Mission Support Alliance, LLC](#) (MSA). This prime contractor was awarded the Mission Support Contract for the Hanford Site in 2009. MSA is a joint venture between Lockheed Martin, Jacobs Engineering; and Wackenhut Services, Inc., and is responsible for safely and effectively managing and operating the infrastructure of the Hanford Site. MSA provides a robust array of services, including training, site security, roads and utilities, logistics and transportation, information resources, information technology and other services, enabling Hanford contractors to focus on their cleanup efforts.
- [CH2M HILL Plateau Remediation Company](#) (CHPRC). This prime contractor was awarded the Plateau Remediation Contract in 2008, is responsible for the safe, environmental cleanup of the Central Plateau at the Hanford Site. This task includes decommissioning and demolishing the Plutonium Finishing Plant (PFP) that once stored secret material for the nation's defense, cleaning up plumes of contaminated groundwater beneath the site, and removing highly radioactive "sludge" away from the Columbia River.
- [Washington Closure Hanford, LLC](#) (WCH). This contractor was awarded the River Corridor Closure Contract in March 2005. WCH is a limited liability company owned by Washington Division of URS Corporation; Bechtel National, Inc. (BNI); and CH2M HILL Hanford Group, Inc., and manages the 220-square-mile (572-square-kilometer) River Corridor Closure Project for the RL at the Hanford Site. The Project is the largest environmental cleanup project in the nation. The company is responsible for demolishing 328 contaminated buildings, cleaning up an estimated 560 waste sites, placing two former plutonium production reactors and one nuclear facility in interim safe storage, and managing the ERDF. WCH is expected to complete this mission by 2015.
- [HPMC Occupational Medical Services](#). This contractor is the occupational medical contractor for the Hanford Site. The company provides occupational health services; risk-based medical surveillance examinations and monitoring evaluations, evaluation and first aid care of injury or illness, occupational medicine and nursing, psychological counseling and evaluations, employee assistance counseling, substance abuse testing, ergonomic assessment, exercise physiology and work conditioning, monitored care and case management, fitness for duty evaluations, health education and wellness promotion, infection control, emergency and disaster preparedness and support, and work site field and facility visits.

RL also manages portions of the Hanford Reach National Monument. The portion of the monument administered by RL includes the 14-square-mile (36.4-square-kilometer) 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 0.25-mile- (0.4-kilometer-) wide strip of land along the Hanford Reach shoreline from the Vernita Bridge to just north of the 300 Area. This 39-square-mile (101-square-kilometer) unit in Benton, Franklin, and Grant Counties also includes the 9.9-square-mile (25.6-square-kilometer) Hanford Site dunes area north of Energy Northwest (Figure 1.1).

ORP was established by Congress in 1998 as a field office to manage the retrieval, treatment and disposal of Hanford's 56 million gallons (213 million liters) of radioactive tank waste, currently stored in 177 underground tanks in the central part of the site. In support of this mission, ORP manages the Tank Operations Contract and the WTP Project. The principal contractors for ORP and their respective responsibilities include the following:

- [BNI](#) is the prime contractor and URS, Inc., is the major subcontractor, to design, construct, and commission the DOE (WTP located on a 0.1-square-mile (0.26-square-kilometer) site on the Central Plateau of the Hanford Site. This mammoth construction project is the largest of its kind in the world. When complete, the WTP will be used to transform the 56 million gallons (213 million liters) of radioactive and chemical wastes being stored in underground tanks at Hanford into a stable glass form for permanent disposal. The 10-year contract for this work was awarded in December 2000. In 2009, the WTP contract was modified and extended to August 15, 2019.
- [Washington River Protection Solutions LLC](#) (WRPS). This contractor was awarded the Tank Operations Contract for the Hanford Site in 2008 to maintain the underground waste storage tanks. This organization is responsible for storing and retrieving the approximately 56 million gallons (213 million liters) of nuclear and chemical waste stored in 177 underground storage tanks in the 200 Areas at the Hanford Site. WRPS is owned by URS Corporation and Energy Solutions, with AREVA as the primary subcontractor.
- [Advanced Technologies and Laboratories International, Inc.](#) This contractor operates the 222-S Laboratory complex, the primary onsite laboratory for analysis of highly radioactive samples in support of all 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 DOE Office of Science manages DOE's science and technology programs, goals, and objectives. The principal contractor for the DOE Office of Science and their respective responsibilities included the following:

- [PNNL](#). This contractor is operated by Battelle Memorial Institute and is located in Richland, Washington. PNNL is one among 10-DOE national laboratories managed by DOE's Office of Science. Work scope includes delivering scientific solutions from multiple scientific disciplines to solve energy, environmental, and national security challenges for not only DOE, but for the U.S. Department of Homeland Security, the National Nuclear Security Administration, other government agencies, universities, and industry.

USFWS. This agency, through permits and a memorandum of understanding with DOE, manages regions of the Hanford Reach National Monument, including administering three major management units (Figure 1.1) totaling about 258 square miles (668 square kilometers). These included the following:

- Fitzner/Eberhardt Arid Lands Ecology Reserve Unit, a 120-square-mile (311-square-kilometer) tract of land in Benton County with no general public access, is located in the southwestern portion of the Hanford Site
- Saddle Mountain Unit, a 50-square-mile (130-square-kilometer) tract of land in Grant County with no general public access, is located north-northwest of the Columbia River
- Wahluke Unit, an 89-square-mile (230-square-kilometer) tract of land with access, is located north of the Columbia River 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 1.25-square-miles (3.2-square-kilometers) 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.

1.5 Stakeholder Involvement

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.

1.5.1 Role of Native American Tribes

JA Conrad

The role of Native American tribes at the Hanford Site is guided by [DOE O 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. DOE 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 O 144.1](#), Attachment 3, “Offices of Environmental Management, Science, Nuclear Energy, and the National Nuclear Security Administration Framework for Implementing the Department of Energy’s American Indian and Alaska Native Policy,” provides additional 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 (NEPA)*, 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.

DOE works primarily with four Native American tribes. The Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation ([CTUIR](#)), 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 that is now Hanford 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, among other rights. The Wanapum Band, now located in Priest Rapids, once resided on the lands that are now the Hanford Site, have historic ties to the site and a longstanding relationship with DOE.

DOE provides financial assistance through cooperative agreements with the Confederated Tribes and Bands of the Yakama Nation, [CTUIR](#), and the Nez Perce Tribe to support tribal involvement in decisions made at Hanford. 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. Further information regarding the Tribal Affairs Program is available on the following website: www.hanford.gov/page.cfm/inp.

1.5.2 Cultural and Historic Resource Consultations

MK Wright

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.

DOE's CHRP consults with the Washington State Historic Preservation Officer, the Confederated Tribes and Bands of the Yakama Nation, the [CTUIR](#), 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, Benton County Historical Society, East Benton County Historical Museum, and Franklin County Historical and Museum Society.

1.5.3 Hanford Natural Resource Trustee Council

TC Post

The *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) ([42 United States Code \(USC\) 9601](#)) and implementing regulations in [40 CFR 300](#), *National Oil and Hazardous Substances Pollution Contingency Plan*, establish DOE as both the CERCLA lead response agency at 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*, 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.

Natural resource trustees are government officials who act on behalf of the public when there is injury to, destruction of, loss of, or threat to natural resources (for which they have management responsibility) because of the release of a contaminant. Federal, State, and Tribal entities are authorized to act as trustees pursuant to [CERCLA](#), Section 301(c), which covers Natural Resource Damage Assessment.

The trustees for the Hanford Site include:

- DOE on behalf of the U.S. Federal Government
- U.S. Department of Interior through the USFWS
- U.S. Department of Commerce through the National Oceanic and Atmospheric Administration
- State of Washington (through Ecology) in consultation with the Washington Department of Fish and Wildlife

- State of Oregon through the Oregon Department of Energy
- Confederated Tribes and Bands of the Yakama Nation (Yakama Nation)
- [CTUIR](#)
- Nez Perce Tribe.

The Hanford Natural Resource Trustee Council (Council) was established in 1996 via a Memorandum of Agreement, 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.

Hanford natural resource damage assessment and restoration work through 2012 was focused primarily on Phase II of the injury assessment planning process. Key *Phase II Hanford Natural Resource Damage Assessment Ecological Data Gap Report* products prepared by Industrial Economics, Incorporated ([IEC](#) 2012) for the Council include: 1) draft Injury Assessment Plan (IAP) and related products/activities such as the Data Gap Report and draft Preliminary Estimate of Damages (PED); 2) four expert panels; 3) development of recommendations for initial studies/resource review reports; 4) development of preliminary thresholds and tests; and 5) preparation of public involvement materials. Work in CY2013 will begin the transition to implement more comprehensive injury studies identified in Phase II planning documents such as the IAP, Data Gap Report, and Resource Review Reports.

One injury study, Contaminated Biota Study was completed and two other studies, Groundwater Contaminant Plume Mapping, and Mussel Toxicity Study were initiated. A statement of work was developed and proposal received for the planning of an Upwelling Study.

A significant potential early restoration project was identified and the Council drafted a crediting plan for acquisition of McWhorter Ranch, which would preserve and protect over 14,000 acres (5,670 hectares) of mostly high quality native shrub-steppe habitat, including portions of Rattlesnake Mountain, directly adjacent to the Hanford Site. The project also evaluated crediting for potential future habitat restoration to return portions of the land that were used for agricultural purposes to natural habitat. Unfortunately, the land was purchased by a private party prior to the analysis being completed. Nevertheless, it was considered a beneficial, cooperative exercise by the trustees, including DOE-Headquarters (HQ) management. It provided a framework for the efforts needed to complete comprehensive crediting methodologies acceptable to all parties.

The Council continued to meet on a monthly basis to plan, organize, control, and direct Hanford natural resource damage assessment and restoration activities. The Senior Trustees met periodically to review progress and address issues elevated from the Council. The Council provided formal advice to DOE, and as appropriate to EPA, Ecology and the Hanford Advisory Board on Trustee guiding principles, 100-K Area RI/FS, natural resource damage assessment and restoration integration and vegetation management. A strategic planning effort was initiated to identify the mission, vision, goals, limitations, strengths, and solutions/strategies to complete substantially a Hanford natural resource damage assessment and restoration plan within 10 years.

Six Technical Work Groups (TWGs) met on a regular basis to assist in study development, review environmental/contaminant release data, and make recommendations to the Council.

The Council developed a statement of work (SOW) for Hanford natural resource damage assessment and restoration data management and received a proposal for implementing and maintaining the data management system.

In December 2012, litigation concerning funding the natural resource damage assessment at Hanford was settled. The settlement agreement expresses a commitment to proceed with and fund a cooperative injury assessment. It describes a transparent process for the Trustees to develop an annual budget for technical work in a rolling, 3-year timeframe.

Information about the Council, including its objectives, history, and projects, is available on the following website: <http://www.hanford.gov/page.cfm/hnrhc>.

1.5.4 Public Involvement in Hanford Site Decisions

TL Nguyen

RL and ORP believe public involvement is essential to the ultimate success of Hanford Site cleanup. Both field offices have staff that coordinate, plan, and schedule public participation activities for DOE on the Hanford Site.

The *Hanford Public Involvement Plan (TPA 2012)*, previously known as the *Community Relations Plan*, outlines the public participation processes used by the Tri-Party Agencies (Ecology, EPA, and DOE) and outlines ways the public can be involved in Hanford Site cleanup decision-making processes and serves as the overall guidance document for public participation and outreach activities at Hanford. The first plan was developed and approved with public input in 1990 and was last revised in 2002. In October 2011, the Tri-Party Agencies issued a revised plan for a 45-day public comment period. The proposed changes will be the fifth revision to the 2002 plan. The Tri-Party Agencies reviewed comments received on the draft plan, revised where necessary, and issued the final plan and the Response to Comment document in 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 at (800) 321-2008 respond to information requests about the TPA cleanup activities. The Tri-Party Agencies strive to provide a timely response to all requests. The line is advertised frequently in a variety of ways, including all TPA announcements; media information such as newspaper articles, brochures, and meeting notices; and Hanford Site fact sheets.
- Mailing List – The Tri-Party 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 TPA 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 – Hanford Site Events Calendar is available at the following website: <http://www.hanford.gov/pageaction.cfm/calendar>. 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.
- Tri-Party Agencies Public Involvement Calendar for the Hanford Site is available at the following website: http://www.ecy.wa.gov/programs/nwp/pi/pdf/tpa_pi_calendar.pdf. 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 TPA 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 TPA Administrative Record website: <http://www5.hanford.gov/arpir/>; and for proposed changes to the TPA that underwent public comment, on the TPA website: www.hanford.gov/?page=86.

- Informational Public Meetings – All TPA quarterly public involvement planning meetings, semiannual meetings, special meetings, and workshops are open to the public. In addition, the Tri-Party 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 public through the TPA 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 [Ecology et al. 1989](#), CERCLA, RCRA, and the NEPA; Hanford Advisory Board meetings; State of the Hanford Site presentation; and other Hanford Site-related public involvement and information meetings, workshops, or activities.

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

RL	(509) 376-7501
ORP	(509) 372-8656
Hanford Site Cleanup Line/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>.

1.5.5 State of Oregon

CH Salony

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. RL and ORP entered into a [Memorandum of Understanding](#) in 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.

1.5.6 Hanford Advisory Board

TL Nguyen

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 Hanford Advisory Board was created in 1994 by the Tri-Party Agencies and ultimately chartered as one of nine environmental management site-specific advisory boards across the country. The Hanford Advisory Board is comprised of 31 members and their alternates, including representatives from the Nez Perce Tribe and the Confederated Tribes and Bands of the Yakama Nation. A representative of the [CTUIR](#) 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>.

1.6 Hanford Site Regulatory Oversight

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 EPA, Ecology, 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 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.

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

TW Noland

The TPA ([Ecology et al. 1989](#)) is an agreement among the Tri-Party Agencies to achieve environmental regulation compliance on the Hanford Site with CERCLA and RCRA TSD unit regulations and corrective action provisions. The TPA is an interagency agreement under CERCLA, Section 120, a corrective action order under RCRA, and a consent order under the Washington State [Hazardous Waste Management Act of 1976](#) (revised code of Washington [RCW] 70.105) 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 TPA is the *Hanford Federal Facility Agreement and Consent Order Hanford Public Involvement Plan* (2012). This plan describes how public information and involvement activities are conducted for TPA decisions.

The TPA has evolved as Hanford Site cleanup has progressed. Since its publication in 1989, the Tri-Party Agencies negotiate changes to the agreement 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. A new Revision 8 was published in 2011. Revision 8 is current as of July 18, 2011, and incorporates 124 sets of modifications (Change Control Forms) that have been approved since publication of the last revision. Revision 8 is a snapshot in time. As new Change Control Forms are approved through the TPA change control process, they are incorporated into the TPA and available on line at: <http://www.hanford.gov/?page=81>. Printed copies of Revision 8 of the TPA 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 TPA information, call the Hanford Cleanup Line at (800) 321-2008 or send an e-mail to hanford-info@listserv.wa.gov.

1.6.1.1 Tri-Party Agreement Milestone Status

The TPA commits DOE to comply with the remedial-action provisions of CERCLA as well as with RCRA TSD unit regulations and corrective-action provisions, including Washington State's implementing regulations (Washington Administrative Code [[WAC](#)] [173-303](#), *Dangerous Waste Regulations*). From 1989 through 2012, a total of 1,177 TPA milestones were completed and 322 target dates were met. During 2012, 37 specific cleanup milestones were scheduled for completion; 30 were completed ahead of their scheduled date, one was completed on time, one was completed late and five have a tentative agreement to modify the milestone scope and/or schedule.

1.6.1.2 Tri-Party Agreement Approved Modifications

During 2012, 19 negotiated Change Control Forms to the [TPA](#) were approved; these changes can be viewed at the TPA website: <http://www.hanford.gov/c.cfm/tpa/>.

1.6.2 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](#), Subpart A (*General Provisions*), and [Subpart H](#) (*National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities*). [Subpart H](#), is enforced along with the state standards and requirements of *Radiation Protection -Air Emissions* ([WAC 246-247](#)), and *Ambient Air Quality Standards and Emission Limits for Radionuclides* ([WAC 173-480](#)), issued under the authority of the *Washington Clean Air Act* ([RCW 70.94](#)). 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 (ALARA) 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.

1.7 Hanford Site Websites

SA Thompson

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

- Advanced Technologies and Laboratories International, Inc.: <http://www.atlintl.com/>
- BNI: <http://www.hanfordvitplant.com/>
- CHPRC: <http://www.platauremediation.hanford.gov/>
- DOE Office of Science: <http://science.energy.gov/>
- DOE Science and Innovation: <http://www.energy.gov/sciencetech/>
- Eberline Services Hanford, Inc.: http://www.eberlineservices.com/page_field.htm
- EnergySolutions: <http://www.energysolutions.com/?id=otuy>
- ERDF: <http://www.hanford.gov/page.cfm/erdf>
- HAMMER Facility: <http://www.hammertraining.com/>
- Hanford Reach National Monument: http://www.fws.gov/refuge/Hanford_Reach/
- Hanford Site Tours: <http://www.hanford.gov/page.cfm/hanfordsitetours>
- HPMC Occupational Medical Services: <http://www.hanford.gov/health/>
- 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/>
- MSA: <http://msa.hanford.gov/msa/>

- ORP: http://www5.rl.gov/rw_doe/orp/
- RL: <http://www.hanford.gov/rl/>
- URS Corporation: <http://www.urscorp.com/>
- Wackenhut Services, Inc.: <http://www.wsihq.com/>
- WCH: <http://www.washingtonclosure.com/>
- WRPS: <http://www.wrpstoc.com/>

Information about PNNL can be access at the following website:

- Battelle Memorial Institute: <http://www.battelle.org/>
- Environmental Molecular Sciences Laboratory: <http://www.emsl.pnl.gov/emslweb/>
- PNNL: <http://www.pnl.gov/>
- DOE Office of Science, Pacific Northwest Site Office: <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.aveva.com/en/operations-925/areva-inc--richland-nuclear-fuel-production.html>
- 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/
- PN Services:
http://www.westinghousenuclear.com/products_&_services/nuclear_services/richland_service_center.shtm
- US Ecology, Inc.: <http://www.americanecology.com/richland.htm>

2.0 Compliance Summary

SA Thompson

DOE policy mandates that all activities at the Hanford Site are performed in compliance with applicable federal, state, and local environmental laws and regulations; DOE orders and executive orders; Secretary of Energy Notices; DOE HQ and site operations office directives, policies, and guidance. This includes specific requirements, actions, plans, and schedules identified in the TPA and other compliance or consent agreements. RL and ORP recognize the importance of maintaining a proactive program of self-assessment and regulatory reporting to ensure environmental compliance is achieved and maintained at the Hanford Site. This report also includes the requirements for reporting annual compliance status with environmental standards provided in *Environment, Safety and Health Reporting* ([DOE O 231.1B](#)).

This section summarizes the various laws and regulations that affect 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 discussed, as well as notices of violations and notices of noncompliance issued by EPA or Ecology. Notices of violation are the regulatory means of informing organizations that their work activities are not meeting requirements. Notices of noncompliance are informal notifications of regulatory violations.

2.1 Hazardous Materials 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.

2.1.1 Resource Conservation and Recovery Act of 1976

JK Perry

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 TSD. Ecology has the authority to enforce RCRA requirements in the state under [WAC 173-303](#).

2.1.1.1 Hanford Facility Dangerous Waste Permit

The Hanford Site dangerous waste activities are subject to applicable provisions of [WAC 173-303](#) (including provisions of the Chapter as they have been applied in the TPA). In accordance with these requirements, the Hanford Site has been assigned a single EPA identification number for permitting purposes (WA7890008967). Accordingly, the Hanford Site is considered a single RCRA facility, although there are numerous TSD units spread over large geographic areas of the Hanford Site.

[WAC 173-303](#) requires Ecology to reissue a permit after a term of up to 10 years. The initial *Hanford Facility Dangerous Waste Permit* ([WA7890008967, 1994](#)) was issued for a 10-year term on September 27, 1994. DOE submitted a permit renewal application on March 30, 2004. The Permit ([WA7890008967](#)) expired on September 27, 2004, since that time, Ecology has been endeavoring to prepare and issue a new permit. Until a new permit is issued, DOE continues to operate under the expired Permit ([WA7890008967, Rev. 8C](#)) until a new permit is in effect.

In May 2012, Ecology issued a draft *Hanford Facility Dangerous Waste Permit* ([WA7890008967, Rev. 9](#)), incorporating the remaining TSD units not previously clean closed. Ecology received more than 4,000 comments on the draft *Hanford Facility Dangerous Waste Permit* during the comment period held from May 1 to October 22, 2012 that included approximately 1,800 comments from the public and 3,000 comments from the DOE. Issues were brought up during the comment period that raised substantial new questions, Ecology plans to modify the draft Permit to address substantial new questions raised and reopen the comment

period for the draft Permit. Ecology expects this effort to take about 2 years to perform the following activities:

- Review and evaluate the comments received from the May 1, 2012 through October 22, 2012 public involvement period
- Revise the Permit based on significant information and issues raised
- Re-issue the permit with revisions and responses to the original comments
- Reopen the comment period for sections that were changed
- Prepare responses to the next round of public comments
- Issue the final Permit.

There are 14 TSD units incorporated in the existing Permit ([WA7890008967, Rev. 8C](#)). The Permit is issued to eight Permittees: RL and ORP as the owners/operators; and six of their contractors: BNI; CHPRC; MSA; PNNL; WCH; and WRPS, as co-operators. No TSD unit additions or deletions occurred during 2012. However, unit-specific Permit conditions for the following TSD units were modified in 2012 pursuant to following [WAC 173-303-830](#), *Permit changes*:

- Plutonium Uranium Extraction (PUREX) Storage Tunnels (Operating Unit 2)
- LERF and 200 Area ETF (Operating Unit 3)
- WTP, (Operating Unit 10)
- IDF (Operating Unit 11)
- 400 Area Waste Management Unit (Operating Unit 16).

2.1.1.2 RCRA Inspections

DL Hagel

Ecology performed 21 RCRA inspections on the Hanford Site in 2012 to assess compliance with applicable requirements. The Hanford Site received no notices of violation or warning letters of noncompliance that were based on those inspections.

2.1.1.3 RCRA Groundwater Monitoring

MJ Hartman

RCRA groundwater monitoring is conducted under the Soil and Groundwater Remediation Project (Section 8). Fourteen RCRA TSD units were monitored to determine if contaminated groundwater with dangerous constituents was present. Seven sites were monitored to assess the extent of known contaminants and two sites are monitored under corrective action programs.

LERF is currently operating under the Permit ([WA7890008967, Rev. 8C](#)) and as cited in Section 2.1.2.1.

The IDF has been operating under the Permit ([WA7890008967, Rev. 8C](#)), since June 2006 and is under a unit-specific groundwater monitoring plan. Because the unit has not yet received waste, monitoring is performed under a Pre-Active Life Program (standby mode).

Other sites monitored under RCRA are scheduled for closure under the Permit ([WA7890008967, Rev. 8C](#)). A summary of groundwater monitoring activities for these sites during 2012 is provided in Section 8 and the detailed groundwater monitoring information for 2012 will be available in September 2013 with the release of *Hanford Site Groundwater Monitoring Report for 2012*.

Groundwater monitoring is required for three regulated, non-RCRA waste facilities. The 200 Area Treated Effluent Disposal Facility (TEDF) and the State-Approved Land Disposal Site are monitored under [WAC 173-216](#), *State Waste Discharge Permit Program*. 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 2012 for waste constituents specified in the facility permits.

2.1.2 Federal Facility Compliance Act of 1992

JK Perry

The Federal Facility Compliance Act of 1992 ([Public Law 102-386](#)), 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. A portion of the [Federal Facility Compliance Act of 1992](#) also requires DOE to provide mixed waste information to EPA and the states. DOE provides this information annually as part of the Hanford Site Mixed Waste Land Disposal Restrictions Summary Reports pursuant to TPA Milestone M-26. In 2012, the reporting requirement was met by the *Calendar Year 2011 Hanford Site Mixed Waste Land Disposal Restrictions Summary Report* ([DOE/RL-2012-12](#)).

2.1.3 Comprehensive Environmental Response, Compensation, and Liability Act of 1980

JW Cammann

CERCLA ([42 USC §9601](#)) 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* (see Section 2.1.4), 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](#)) for long-term evaluation and response actions. Federal facilities identified on the National Priorities List (NPL) ([59 FR 43314](#)) must enter into an interagency agreement (TPA) with EPA to remediate the sites. Under CERCLA, two types 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 life threatening. EPA is responsible for oversight of DOE's implementation of CERCLA regulations.

The Hanford Site was established in 1943 to produce nuclear materials for national defense. Many production activities resulted in the disposal of wastes containing hazardous constituents and/or radioactive materials. As a result, in July 1989, the EPA placed four areas (100, 200, 300, and 1100 Areas) on the NPL pursuant to CERCLA.

In anticipation of the NPL listing, the Tri-Party Agencies entered into the TPA in May 1989. This agreement established a procedural framework and schedule for developing, implementing, and monitoring CERCLA response actions on the Hanford Site. The agreement also addresses RCRA (42 USC 6901) compliance and permitting. The TPA is a legally binding agreement between DOE, EPA, and Ecology that establishes the guidelines and framework for achieving cleanup of the Hanford Site. Since the Hanford Site was placed on the NPL, DOE and its contractors have made considerable progress in the cleanup mission. This cleanup has led to the removal of portions of the 100 Areas from the EPA's NPL ([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 RCRA corrective action program (see Section 2.1.1). Many waste management units on the Hanford Site could be subject to cleanup under both programs. The CERCLA response action program is implemented through [40 CFR 300](#), which establishes procedures for characterization, evaluation, and remediation of waste sites. The TPA addresses implementation of both CERCLA response actions and RCRA corrective actions 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 (removal and remedial actions). The CERCLA regulatory framework for both removal and remedial actions consists of the following five general activities: 1) investigation, 2) evaluation, 3) decision, 4) implementation, and 5) closeout.

During the remedial action investigation phase, a preliminary assessment and site inspection is conducted 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 NPL ([59 FR 43314](#)), a more detailed site characterization is performed in accordance with the data quality objectives process, which includes an RI/FS work plan, sampling and analysis plan, field work plan, and quality assurance plan. The evaluation phase includes developing alternatives to eliminate the release or threat of release. DOE 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 preferred alternative is implemented and regulatory approval is obtained. Public involvement is encouraged by issuing a proposed plan 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 preferred alternative is implemented including preparing 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, a remedial site verification package is issued that documents remedial action goals, objectives, and applicable or relevant and appropriate requirements (ARARs) are achieved in accordance with the ROD.

Section 121(d) of CERCLA requires that remedial actions attain or waive federal environmental ARARs, or more stringent state environmental ARARs, upon completion of the remedial action. Also, [40 CFR 300](#) requires compliance with ARARs during remedial and removal actions to the extent practicable. The ARARs are identified on a site-by-site basis for all onsite response actions where CERCLA authority is the basis for cleanup.

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 that 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 generally 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 RI/FS 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 preparing an engineering evaluation and cost analysis of removal action alternatives, conducting community relations activities, and documenting the removal action decision in an action memorandum. The engineering evaluation and cost analysis process is comparable to the RI/FS process; however, it is less comprehensive. The action memorandum is comparable to a ROD; 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 NPL ([59 FR 43314](#)), then the remedy selected for the removal action must be consistent with the final remedy for the entire operable unit.

For waste sites where hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure, CERCLA requires a review every five-years to evaluate the implementation and performance of a remedy to determine if the remedy is or will be protective of human health and the environment. The five-year review requirement applies to all remedial actions selected under [CERCLA §121](#). The methods, findings, and conclusions of the five-year reviews are documented in a CERCLA Five-Year Review Report.

The *USDOE Hanford Site First Five-Year Review Report* ([EPA 2001](#)) documented the results of the first five-year review completed by EPA Region 10 in September 2000. This report covered all portions of the Hanford Site with a CERCLA decision document and included areas that contain hazardous substances, pollutants, or contaminants, which are to be remediated under CERCLA. The review concluded that in the 100 Areas, pump-and-treat remedial actions for capturing and treating chromium-contaminated groundwater plumes had not achieved required protectiveness criteria and system operations needed to be optimized. In the 200 Areas, remedial actions were found to be operating in an environmentally protective manner; vapor extraction of carbon tetrachloride was highly successful with removal efficiencies declining over time, while pump-and-treat for removing uranium and technetium from groundwater was partially successful with a need to enhance uranium removal. In the 300 Area, remedial actions were found to be proceeding in a protective manner with a need for an active and enforceable institutional control plan; and demonstration that soil cleanup levels are protective of groundwater, biological resources are not adversely affected, and natural attenuation processes are reducing groundwater contamination to acceptable concentrations in a reasonable time frame. All remedies were completed for the 1100 Area and it has been deleted from the NPL.

The *Second CERCLA Five-Year Review Report for the Hanford Site* ([DOE/RL-2006-20](#)) documented the results of the second five-year review completed by DOE in November 2006. The report evaluated the performance of the CERCLA remedies selected in interim RODs, including existing institutional controls to prevent exposure to the public and the environment. The review concluded that in the 100 Areas, with the completion of the River Corridor Baseline Risk Assessment, expansion of the pump-and-treat technology with potential application of supporting technologies to cover the plumes more thoroughly, and development of improved data on performance of the pump-and-treat and apatite sequestration technologies, the remedies selected in the final RODs will more completely address the human health and environmental risks. In the 200 Area, pump-and-treat systems to remove uranium and technetium from groundwater have met remedial action objectives; have concentrated on shallow portions of plumes and will be expanded to address deeper plumes; and vapor extraction systems for carbon tetrachloride removal have proven effective and will continue operations with improvements. In the 300 Area, selected interim remedies are or will be protective when completed; however, remediation of the groundwater uranium plume by natural attenuation has not achieved remedial action objectives, but will be protective of human health through institutional controls that will prevent groundwater use. All remedies were completed for the 1100 Area and it has been deleted from the NPL.

The *Third CERCLA Five-Year Review Report* ([DOE/RL-2011-56](#)) documented the results completed by DOE, which was transmitted to EPA on November 4, 2011, and published in March 2012. The report presented the five-year review of CERCLA response actions initiated, in progress, or completed at the Hanford Site where the action resulted in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure.

The report concluded that the completed interim remedies are protective of human health and the environment except for certain groundwater constituents in the 100 Areas (strontium-90 and chromium) where amendments to RODs were issued to modify the selected remedies, and chromium plumes at 100-N and 100 D/H areas. In the 200 Areas, soil vapor extraction systems to remove carbon tetrachloride continue to be effective and groundwater pump-and-treat systems for removal of uranium and technetium are being expanded with additional extraction wells to address all contaminants of concern. In the 300 Area, some remedial actions have been completed and determined to be protective because cleanup standards were met and are within the

acceptable risk range. All remedies were completed for the 1100 Area and it has been deleted from the NPL. Because contamination was left in place, the 1100 Area will continue to be included in future CERCLA five-year reviews. Final remedies are expected to be protective of human health and the environment upon completion and, in the interim, ensure exposure pathways that could result in unacceptable risks are being controlled. The remedies comply with the decision documents and are functioning as intended.

2.1.4 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 managing 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.

Congress enacted CERCLA on December 11, 1980, 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. The *Superfund Amendments and Reauthorization Act of 1986* was enacted on October 17, 1986, 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 six-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 ensure 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 NPL ([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 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](#), 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 included 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 noncompliance with the agreement; 2) 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) Mechanism for resolving disputes, with final authority resting with the EPA Administrator when staff of the agency and the departments cannot reach agreement on selecting the final remedy; and 5) Enforceability of the agreements by states and citizens. The *Superfund Amendments and Reauthorization*

Act of 1986 places restrictions on federal government property to ensure 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* (Section 2.6.1) also were established by the *Superfund Amendments and Reauthorization Act of 1986*. The *Emergency Planning and Community Right-To-Know Act of 1986*, also known as *Superfund Amendments and Reauthorization Act of 1986 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 percent of Superfund Program cleanup activities historically have been funded by potentially responsible parties who eventually may 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 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 year in which the U.S. Department of the Treasury collected the tax was FY1995. This fund was exhausted by the end of FY2003. Since then, funding for the cleanup of orphan sites has been appropriated by Congress out of general revenues.

Beginning in FY2010, EPA initiated a 3-year strategy called the *Integrated Cleanup Initiative* ([EPA 2011](#)) and issued the initiative on May 9, 2011. EPA established a website for the Integrated Cleanup Initiative. Included on the website are highlights and updates including Integrated Cleanup Initiative quarterly updates, fact sheets, and lessons learned. The Integrated Cleanup Initiative identifies and implements opportunities to integrate and leverage 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 examines opportunities for improvements of all EPA's land cleanup programs including Superfund Programs, the Brownfields Program, Federal Facilities Restoration and Reuse Office Programs, RCRA Programs, and the Underground Storage Tank Programs. The Integrated Cleanup Initiative includes a focus on enforcement activities that are critical to ensuring 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.

EPA's Office of Solid Waste and Emergency Response in partnership with the Office of Enforcement and Compliance Assurance launched a 3-year strategy to identify and implement improvements to EPA's land cleanup programs. Consistent with EPA's annual 2011 performance measure, remedial action project completions, a strong project management focus, and managing projects to completion are overarching principles for the Integrated Cleanup Initiative. With an enhanced project focus, EPA expects to further demonstrate progress at various stages of the cleanup and further optimize the work within the cleanup pipeline.

EPA also developed an implementation plan to further describe the goals and objectives of the Integrated Cleanup Initiative and to identify ongoing or new actions the EPA will advance with their partners during the next 3 years. EPA will use the three stages of the cleanup process common to all land cleanup programs; i.e., starting cleanups, advancing cleanups, and completing cleanups.

The 'starting cleanups' stage focuses on site identification and assessment activities in the early part of the cleanup continuum. The 'advancing cleanups' stage emphasizes coordination during cleanup activities, including enforcement strategies. The 'completing cleanup' stage focuses on pilot projects aimed at accelerating cleanup, reporting to the public, and leveraging revitalization efforts as cleanups are completed.

Throughout the continuum, there are opportunities for improved performance metrics, communication, and coordination among EPA's programs and partners.

2.1.5 National Environmental Policy Act of 1969

JW Cammann

The [*National Environmental Policy Act of 1969*](#) (NEPA) was enacted to ensure that potential environmental impacts as well as technical factors and costs are considered during federal agency decision-making. The NEPA requires that an environmental impact statement (EIS) be prepared for major federal agency actions that have the potential to significantly affect human health or the environment. A ROD documents decisions concerning a proposed action for which an EIS has been prepared. Once the final EIS is distributed, DOE waits a minimum of 30 days before issuing a ROD, which is published in the *Federal Register* (FR). The ROD notifies the public of the decision made on the proposed action and the reasons for the decision. In addition to potential environmental impacts, the ROD may include consideration of other decision factors such as technical feasibility, DOE statutory mission and national objectives, and cost. The NEPA process does not dictate that an agency select the most environmentally beneficial alternative. The purpose of the NEPA process is to ensure that accurate environmental analyses are performed; that there is public involvement; and that public officials, like those at DOE, make decisions based on an understanding of the environmental consequences of proposed actions.

An environmental assessment (EA) is prepared when it is uncertain if a proposed action would require the preparation of an EIS. A *finding of no significant impact* (FONSI) 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 EIS. Mitigated findings of no significant impact can result when a federal agency concludes its NEPA review with an EA that is based on a commitment to mitigate potential environmental impacts to keep them below a threshold of significance, so that a more detailed EIS is not required. However, federal agencies must ensure that appropriate levels of funding are available to mitigate potentially 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](#)) that describes the approach for implementing commitments made in an EIS and its associated ROD, or an EA and its mitigated FONSI, to mitigate potentially 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 supplemental EIS or a new EIS 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 EIS, which is published in the FR in accordance with DOE NEPA regulations ([10 CFR 1021.311](#)). The notice of intent describes the proposed action and alternatives DOE is considering; provides information on issues and potential impacts that will be analyzed in the EIS; and invites comments, questions, and suggestions (both written and oral) on the scope of the EIS. These scoping comments aid DOE in determining the alternatives, issues, and environmental impacts to be analyzed in the EIS. The EPA notice of availability is the official public notification published in the FR to announce the issuance and public availability of a draft or final EIS.

Certain proposed actions may be categorized into classes that have 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 EA or EIS requirements if certain eligibility criteria found at [10 CFR 1021.410](#) (i.e., proposed action fits classes of actions, proposed action has no extraordinary circumstances, and proposed action is not segmented into smaller actions to avoid significance or connected to other actions with potentially significant impacts) and conditions that are integral elements (found at [10 CFR 1021](#), Subpart D, Appendix B) 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 'one time annual' categorical exclusions because they are routinely conducted actions that not only satisfy the criteria in [10 CFR 1021.410](#), but also meet conditions that are 'integral elements' (e.g., do not threaten a violation of statutory, regulatory, or permit requirements; do not require siting, construction, or expansion of waste TSD facilities; do not disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum or natural gas products; do not adversely affect natural, cultural, or ecological resources; and do not involve genetically engineered organisms, synthetic biology, government designated noxious weeds or invasive species). The one-time annual categorical exclusions must be reapproved by the NEPA Compliance Officer each year and may be applied to proposed actions by individuals trained in NEPA determinations without further review and approval by the DOE NEPA Compliance Officer. Action-specific categorical exclusions that have not been pre-approved as one-time annual categorical exclusions may be approved by the DOE NEPA Compliance Officer as activity-specific categorical exclusions for non-routine, non-recurring, project-specific actions.

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 DOE's NEPA and CERCLA Policy, 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. The basis for the DOE's NEPA and CERCLA policies is a determination by the Department of Justice that there is a statutory conflict between NEPA and CERCLA, and that NEPA, as a matter of law, does not apply to CERCLA response actions.

DOE's approach to NEPA review for RCRA corrective actions is project-specific, allowing DOE to consider the circumstances associated with specific RCRA corrective actions and streamline the environmental review process accordingly. Based on DOE's experience to date, some RCRA corrective actions fall within the scope of a categorical exclusion ([10 CFR 1021](#), Subpart D, Appendix B, categorical exclusion B6.1 for small-scale, short-term cleanup actions under RCRA, the [AEA \[Public Law 105-394\]](#), or other authorities) and are subject to the categorical exclusion process previously discussed.

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 O 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 online at <http://www.hanford.gov/page.cfm/officialdocuments>.

The following subsections provide summary information regarding the status of NEPA documentation planned or underway at the Hanford Site (i.e., EISs, supplement analyses, EAs, categorical exclusions, etc.).

2.1.5.1 Hanford Site Environmental Impact Statements

2.1.5.1.1 *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (DOE/EIS-0391)*

A January 9, 2006, legal settlement required DOE to prepare the *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (DOE/EIS-0391)*. This EIS analyzes the following three key areas:

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

A notice of availability for the *Draft Tank Closure and Waste Management Environmental Impact Statement (DOE/EIS-0391)* was issued in the FR 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 EIS were held between January 26 and March 8, 2010, in Washington, Oregon, and Idaho. Since the draft EIS was published, EPA Region 10 and Ecology became cooperating agencies for the EIS.

Efforts during CY2011 focused on addressing public comments and clarifying the draft EIS. This included preparing a supplement analysis ([DOE/EIS-0391D-SA-01](#), *Supplement Analysis of the Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*) to the draft EIS. When preparing to issue the final EIS, including responses to public comments, DOE identified updates or modifications to the technical data analyzed in the draft EIS and expanded specific discussion areas based on comments received. This information did not change the proposed actions analyzed in the draft EIS; however, DOE found in some cases it was unclear as to whether the updated, modified, or additional information that become available since the draft EIS was issued could warrant a supplemental draft EIS. Accordingly, DOE prepared a supplement analysis to determine if a supplemental or new draft EIS was required.

Based on the analyses in the supplement analysis, DOE concluded that the updated, modified, or additional information developed subsequent to the publication of the draft EIS does not constitute significant new circumstances or information relevant to environmental concerns and bearing on the proposed actions in the draft EIS or their impacts. Also, DOE determined that substantial changes were not made in the proposed actions that are relevant to environmental concerns. Therefore, in accordance with Council on Environmental Quality regulations ([40 CFR 1502.9\(c\)](#)) and DOE regulations ([10 CFR 1021.314\(c\)](#)), DOE determined that a supplemental or new draft EIS is not required. The supplement analysis ([DOE/EIS-0391D-SA-01](#)) was issued in February 2012.

The Notice of Availability of the *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* was issued in the FR ([77 FR 74472](#)) on December 14, 2012. DOE will publish a ROD no sooner than 30-days after publication of the EPA Notice of Availability in the FR.

2.1.5.1.2 *Draft Environmental Impact Statement for a Natural Gas Pipeline to the Waste Treatment Plant and 242-A Evaporator, Richland, Washington (DOE/EIS-0467)*

DOE determined in 2010 that an EIS was needed to evaluate a proposed action to construct a natural gas pipeline to the WTP and 242-A Evaporator located on the Central Plateau of the Hanford Site. Steam is used for many operations on the Central Plateau. The 242-A Evaporator currently uses diesel-fueled boilers and the WTP is designed to use diesel-fueled boilers when it becomes operational.

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. Two lift stations (compressor stations), measuring approximately 10,000 square feet (930 square meters) 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.

Conversion from diesel fuel to natural gas boilers is expected to have several benefits including:

- Reduce lifecycle operating costs by over \$800 million
- Reduce lifecycle greenhouse gas emissions by approximately 1 million tons (907,000 metric tons)
- Eliminate approximately six diesel tanker trucks per day
- Increase operational reliability by having dual-fired boilers (natural gas and diesel).

Cascade Natural Gas has been retained by DOE to support preparation of the EIS and to begin the permitting process. Cascade Natural Gas would own, construct, operate, and maintain the pipeline using easements provided by DOE on property they own. An engineering feasibility study is underway to evaluate pipeline diameters, alternative pipeline routings, and contacting potentially affected landowners.

A notice of intent to prepare an EIS was published in the FR on January 23, 2012 ([77 FR 3255](#)). A public scoping meeting for the EIS was held in Pasco, Washington, on February 9, 2012. The draft EIS is planned for the spring of 2013 with the final EIS planned in the fall of 2013. The ROD would be issued no less than 30 days after issuance of the final EIS.

DOE proposes to analyze potential short-term health and environmental impacts, such as those from construction, and potential long-term health and environmental impacts of operating and maintaining the pipeline over a period assumed to be 100 years for the purposes of analysis, once service commences. DOE will analyze potential issues and impacts at a level of detail commensurate with their importance. Potential areas to be evaluated include, but are not limited to, impacts to public and worker health and safety; surface water, groundwater, floodplains, and wetlands; air quality; noise; biological and ecological resources; geology and soils; historic and cultural resources; socioeconomics; environmental justice; land-use; pollution prevention and waste management; irreversible and irretrievable commitment of resources; cumulative effects of past, present, and reasonably foreseeable actions; natural disasters; and compliance with applicable federal, state, and local statutes, regulations, and permits.

Efforts during FY2012 focused on preparing contracts for the engineering feasibility study and performing cultural and ecological resource reviews in support of future site characterization borehole drilling activities. Shallow and deep boreholes will be drilled to characterize potential pipeline route(s) for geologic, hydrologic, and geotechnical properties in support of pipeline design and construction. Information obtained from site characterization borehole drilling and other activities will be used in the engineering feasibility study that will support the EIS.

2.1.5.2 Hanford Site Environmental Assessments

2.1.5.2.1 *Draft Environmental Assessment for Closure of the Solid Waste Landfill and the Nonradioactive Dangerous Waste Landfill (DOE/EA-1707)*

DOE proposes to close the Solid Waste Landfill (SWL) and the Nonradioactive Dangerous Waste Landfill (NRDWL) located southeast of the Central Plateau off Army Loop Road. The two adjoining non-operating landfills are centrally located in the 600 Area of the Hanford Site. The NRDWL, which covers approximately 10.0 acres (4.05 hectares), received containerized nonradioactive, dangerous waste chemicals and asbestos-containing waste material until it ceased operation in 1988. The SWL covers approximately 68.0 acres (27.5 hectares) and received asbestos-containing material, as well as non-dangerous and nonradioactive solid waste until 1996 when operations ceased. After operations ended, both landfills were covered with an interim cover made up of local native soils that ranged in thickness from 2.0 to 10.0 feet (0.61 to 3.05 meters) and were revegetated with bunchgrasses.

The NRDWL, a RCRA facility, would be closed according to the requirements of [WAC 173-303](#). The SWL, a non-RCRA facility, would be closed according to the requirements of [WAC 173-350](#).

The proposed action is to close NRDWL and SWL by installing a final, permanent engineered surface barrier that would meet the state's regulations in WAC 173-303. Final grade of the cover would be completed to blend in with the existing surroundings to the extent practical. The site would be re-vegetated with native plants consistent with the *Hanford Site Biological Resources Management Plan* ([DOE/RL-96-32](#)). DOE would monitor the long-term performance of both landfills. The close proximity of NRDWL to SWL would allow both facilities to be closed simultaneously, taking advantage of cost and work efficiencies.

DOE issued the draft EA on May 13, 2010, 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 the draft EA. Ecology became a cooperating agency on the reissue draft EA.

In February 2011, [PNNL-20162](#), *Cultural Resources Review for Closure of the Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill in the 600 Area - HCRC #2010-600-018R*, was issued. The National Register of Historic Places ([36 CFR 60](#)) evaluation of Army Loop Road determined that the road is not eligible for listing on the National Register of Historic Places; therefore, proposed actions would result in no effect to historic properties. National Register-eligible archaeological sites (i.e., anti-aircraft artillery sites) would not be adversely affected by proposed actions because they would be avoided. Borrow Area C, the proposed borrow pit for barrier construction materials, is located within the National Register of Historic Places-eligible traditional cultural property of *Laliik*.

Efforts during FY2012 focused on responding to public comments from the 45-day public comment period (August 29, 2011 through October 13, 2011), and completing the revised draft EA in August 2011. The six recurring themes identified in the public comments included waste inventory, groundwater contamination, closure alternatives, barrier effectiveness, barrier design, and the use of Borrow Area C. During Tribal consultations, the Native American Tribes expressed opposition to the use of Borrow Area C, due to concerns regarding adverse impacts to the traditional cultural property. The Native American Tribes requested that DOE consider other borrow sources. In recognition of the Native American Tribe concerns; DOE proposed to analyze potential impacts of extracting mineral resources from Borrow Area C and other borrow sources on the Hanford Site in a separate NEPA document (refer to borrow pit EA below).

2.1.5.2.2 Final Environmental Assessment for Integrated Vegetation Management on the Hanford Site, Richland, Washington (DOE/EA-1728-F)

For decades, vegetation management on the Hanford Site has been implemented using NEPA categorical exclusions in an individual, localized, and project-specific manner; 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 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. The scope of the EA includes all land on the Hanford Site managed by DOE and excludes land managed by others under DOE permit (e.g., Hanford Reach National Monument managed by the USFWS).

On March 13, 2012, the DOE issued the final EA and FONSI for *Integrated Vegetation Management on the Hanford Site, Richland, Washington* ([DOE/EA-1728-F](#)).

2.1.5.2.3 Final Environmental Assessment on the Disposal of Decommissioned, Defueled Naval Reactor Plants from USS Enterprise (CVN 65) (DOE/EA-1889)

The U.S. Department of the Navy prepared and issued a draft EA on the Disposal of Decommissioned, Defueled Naval Reactor Plants from the USS Enterprise in September 2011. A public comment period for the draft EA ran from October 30, 2011 through November 30, 2011.

The world's first nuclear-powered naval aircraft carrier, USS Enterprise, is scheduled for decommissioning in 2013, following 51 consecutive years of service. Because the preferred alternative is to dispose of the USS Enterprise reactor plants at the Hanford Site, DOE is a cooperating agency for the EA.

The preferred alternative is to dispose of the USS Enterprise reactor plants via the existing program at Puget Sound Naval Shipyard and Intermediate Maintenance Facility in Bremerton, Washington. This includes removing defueled reactor compartments from inactivated nuclear powered ships, transporting these reactor compartments to the Hanford Site at Trench 94, and recycling the remainder of the ships. The eight defueled reactor compartments from the USS Enterprise would be similar to those evaluated in the *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants* (DOE/EIS-0259) dated April 1996 (DOE/EIS-0259-FEIS-01-1996). Placing the eight defueled reactor compartments from the USS Enterprise at Trench 94 would not exceed the total number of reactor compartments considered at Trench 94 under the final EIS.

On August 23, 2012, the DOE issued the final EA and FONSI for the *Disposal of Decommissioned, Defueled Naval Reactor Plants from the USS Enterprise* ([DOE/EA-1889](#)). Under the preferred alternative, the reactor compartments would be removed from the ship, packaged, and transported to Trench 94, which has received reactor compartments from the 114 nuclear-powered ships that have been similarly processed at Puget Sound Naval Shipyard and Intermediate Maintenance Facility under the Navy's ongoing program since 1986.

2.1.5.2.4 Draft Environmental Assessment for Hanford Land Conveyance and Notice of Potential Floodplain and Wetland Involvement at the Hanford Site, Richland, Washington (DOE/EA-1915)

On January 7, 2011, Congress passed the *Ike Skelton National Defense Authorization Act for Fiscal Year 2011* ([Public Law 111-383](#)). Section 3124 specifically states the Secretary of Energy may establish a program to permit the establishment of energy parks on former defense nuclear facilities ([50 U.S.C. 2814](#)). DOE established a task force on February 17, 2011, on the Asset Revitalization Initiative. The Asset Revitalization Initiative is a DOE complex-wide effort to advance the beneficial reuse of its unique and diverse mix of assets; including land, facilities, infrastructure, equipment, technologies, natural resources, and a highly skilled workforce. In addition to other things, one of the purposes of the Asset Revitalization Initiative is to facilitate discussions among DOE, local communities, nonprofit organizations, tribal communities, private sector entities, and other stakeholders to identify reuse approaches as environmental cleanup efforts reach completion.

The Tri-City Development Council (TRIDEC) along with the city of Richland, Port of Benton, and Benton County formally requested on May 31, 2011, a transfer of DOE land to the community. The site requested is approximately 1,341 acres (543 hectares) (i.e., Tract 1) located along the southern boundary of the Hanford Site directly west of Stevens Drive and north of Horn Rapids Road. TRIDEC and its partners propose dividing Tract 1 into a 900 acre (364.5 hectares) parcel and three smaller 100 to 200 acre (40.5 to 81 hectares) parcels. Tract 1 is the first of three land transfers TRIDEC plans to request over the next 5 years.

TRIDEC is identified as the recognized DOE Community Reuse Organization pursuant to [10 CFR 770](#), *Transfer of Real Property at Defense Nuclear Facilities for Economic Development*. The land transfer proposal recommends use of TRIDEC's wholly owned subsidiary, the Tri-Cities Asset Reinvestment Company, as the transfer entity. The Tri-Cities Asset Reinvestment Company was set up to receive personal and real property from DOE.

The *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (CLUP-EIS, [DOE/EIS-0222-F](#)), which establishes land use designations, calls for most land in the 586-square-miles (1,524-square-kilometers) comprising the Hanford Site to be used for preservation or conservation/mining as environmental cleanup is completed. However, approximately 10 percent of the land, including the parcel requested by TRIDEC, is designated for industrial use. As such, the land is identified for economic growth and development using existing infrastructure including transportation corridors, utilities, and buildings. DOE plans to prepare an EA in 2012 to analyze the proposed land transfer action.

On September 19, 2012, DOE published a *Notice of Intent to Prepare an Environmental Assessment and Notice of Potential Floodplain and Wetland Involvement for the Proposed Conveyance of Land at the Hanford Site, Richland, Washington* (DOE/EA-1915) in the FR ([77 FR 58112](#)). DOE announced its intention to prepare the EA to assess the potential environmental effects of conveying approximately 1,641 acres of Hanford Site land to TRIDEC. Conveyance of the land could include title transfer, lease, easement, license, or a combination of these realty actions. DOE anticipates that there may be continuing mission needs, such as security and safety buffer zones on some of the requested lands, making them less suitable for conveyance. Therefore, the lands that will be addressed in the EA analysis will include the acreage requested by TRIDEC and approximately 2,772 additional acres (1,123 hectares) adjacent to the requested lands. The EA will evaluate the potential environmental impacts of conveying approximately 1,641 acres (665 hectares) of the total 4,413 acres (1,787 hectares) included in the analysis area.

The EA will analyze the reasonably foreseeable environmental effects associated with the probable future uses of lands in the analysis area, based on industry targets described in the TRIDEC proposal, including warehousing and distribution; research and development; technology manufacturing; food processing and agriculture; and back office (i.e., business services). The proposed action may affect floodplains and wetlands, so the notice of intent also serves as a notice of proposed floodplain or wetland action in accordance with DOE floodplain and wetland environmental review requirements.

2.1.5.2.5 Draft Environmental Assessment for Expansion of Borrow Areas on the Hanford Site (DOE/EA-1934)

The CLUP-EIS ([DOE/EIS-0222-F](#)), which became final after the ROD was signed by RL in November 1999 ([64 FR 61615](#)), required a mineral resources management plan be prepared as part of implementing the CLUP-EIS. The *Draft Industrial Mineral Resources Management Plan* ([DOE/RL-2000-61](#)) was transmitted to RL in June 2001. This plan provided a framework for the operation of existing borrow pits, recommended closure of others that are not being used or may be incompatible with the current Hanford Site mission, provided direction for borrow pits and quarries that might be developed in the near future, and supported the NEPA requirements with respect to borrow pits and quarries. However, the *Draft Industrial Mineral Resources Management Plan* was never issued as a final document.

In October 2001, the *Environmental Assessment for Use of Existing Borrow Areas on the Hanford Site* ([DOE/EA-1403](#)) was issued. DOE proposed to obtain borrow materials from existing active borrow pits and quarries on the Hanford Site. The total volume of materials to be recovered over a 10-year period was estimated to be approximately 10,000,000 cubic yards (7,600,000 cubic meters). For analysis, it was assumed that of the total disturbed surface area for active borrow sites (i.e., 1.2 square miles [3 square kilometers]); expansion could result in an additional surface area disturbance of 10 percent (approximately 0.12 square miles [0.3 square kilometer]).

In March 2003, the *Environmental Assessment for Reactivation and Use of Three Former Borrow Sites in the 100-F, 100-H, and 100-N Areas* ([DOE/EA-1454](#)) was issued. The DOE proposed to obtain borrow materials from formerly used borrow pits in the 100-F, 100-H, and 100-N Areas on the Hanford Site that were not included in [DOE-RL-2000-61](#) or [DOE/EA-1403](#). Under the proposed action in [DOE/EA-1454](#) and associated FONSI, the DOE reopened and reactivated the three former borrow sites in the 100-F, 100-H, and 100-N Areas.

An addendum to [DOE/EA-1454](#) was proposed during CY2011 to clarify ambiguity regarding application of the 10 percent expansion allowance and impose a limitation on the depth to which the borrow pits could be excavated. The existing EA lacked sufficient data to adequately determine the surface area of the borrow pits at the time the EA was prepared; therefore, it was difficult to ascertain just how much each pit could be expanded. Furthermore, there was a need to define the high groundwater level and add some distance above that level to ensure groundwater would not seep into the borrow pits. The addendum was proposed to develop some level of analysis to further explain or justify the broader interpretation of expansion. The addendum was placed on hold pending the resolution of potentially broader borrow pit considerations at the Hanford Site.

For the 100-F, 100-H, and 100-N Areas' borrow pits, it was decided that because the borrow pits were to be reopened and reactivated pursuant to [DOE/EA-1454](#) and associated FONSI, a survey would be conducted to establish the existing boundaries as a basis for the 10 percent expansion allowed. Best management practices and other protective measures (i.e., review of groundwater monitoring and level data from nearby wells) would be applied to ensure that excavation activities would not reach the groundwater.

In May of 2012, the DOE NEPA Compliance Officer approved two addendums to [DOE/EA-1403](#). The proposed expansions of the two borrow pits is within the 10 percent expansion analyzed and allowed in [DOE/EA-1403](#) and no further NEPA documentation is necessary. The first addendum allowed expansion of Pit 6 to continue to supply sand and gravel fill material for remediation sites in the 300 and 600 Areas of the Hanford Site. The expansion would excavate approximately 6.0 acres (2.4 hectares) of previously disturbed land along the western boundary of the pit. Pit 6 is located approximately 0.5 mile (0.8 kilometer) west of the 300 Area on the west side of Route 4 South. Because of its close proximity to the 300 Area, Pit 6 has been the primary, source of fill material for ongoing remediation activities in the 300 Area.

The second addendum allowed expansion of Pit 9 by 4.5 acres to supply sand and gravel fill material for remediation sites in the 300 and 600 Areas of the Hanford Site. Pit 9, which has been in operation since the late 1980's to support the construction of the Columbia Generating Station, is located approximately 3.0 miles (4.8 kilometers) north of the 300 Area on the east side of Highway 4S.

The *Draft Environmental Assessment for Expansion of Borrow Areas on the Hanford Site* ([DOE/EA-1934](#)) was issued for a public comment period (December 10, 2012 to January 14, 2013). The final EA and FONSI or decision to prepare an EIS and ROD is expected in the spring of 2013. Cleanup activities could result in large excavated areas needing to be backfilled and revegetated. The purpose of the proposed action in the EA is to meet DOE's need to secure raw aggregate sand and gravel material [(approximately 3,783,613,393 tons (10,714,000 bank cubic meters)] to support ongoing environmental cleanup and restoration projects (e.g., backfill of remediated waste sites), as well as construction and maintenance activities across the Hanford Site. While final remedial action decisions have yet to be made for some cleanup work, the proposed action would support the projected needs for sand and gravel for a period of approximately 10 years. The EA does not address borrow sources for Warden Silt Loam needed for the construction of modified RCRA Subtitle C barriers (and possibly other evapotranspiration barriers) proposed for use on the Hanford Site in support of closure activities.

DOE is considering a reassessment of the use of all borrow sources on the Hanford Site in light of concerns the Native American Tribes have expressed over the use of Borrow Area C and the anticipated need for mineral resources in support of site remediation and closure. Borrow Area C is a primary source of Warden Silt Loam that is important to proper design, construction, and functioning of evapotranspiration barriers proposed for use at the Hanford Site; however, Borrow Area C is located on a traditional cultural property of significance to Native American Tribes. The other major source of Warden Silt Loam on the Hanford Site, McGee Ranch, is located on land designated for the Hanford Reach National Monument. While other deposits of Warden Silt Loam exist on the Hanford Site, they tend to be thin veneers and removal would result in the disturbance of large acreages. Deposits of Warden Silt Loam at Borrow Area C and McGee Ranch are much deeper and would result in less surface disturbance. DOE is considering preparing a new EA to analyze mineral resource needs and sources on the Hanford Site.

2.1.5.2.6 Midway-Benton No. 1 Rebuild Project near the Town of Desert Aire, Benton County, Washington (DOE/EA-1912)

The Bonneville Power Administration (BPA) released the *Midway-Benton No. 1 Transmission Line Rebuild Project Preliminary Environmental Assessment* in June 2012 for public review and comment ([DOE/EA-1912](#)). BPA responded to comments in an [Environmental Assessment Revision Sheet](#) issued on December 6, 2012. The EA Revision Sheet documents the changes incorporated into the EA based on comments received during the public review process. The Preliminary EA, with the addition of changes documented on the [Environmental Assessment Revision Sheet](#), constitutes the Final assessment that was not reprinted.

The Midway-Benton No. 1 transmission line is located between BPA's Midway and Benton substations and the Benton-Othello No. 1 transmission line is located between BPA's Benton Substation and Avista's Othello Substation. BPA owns, operates, and maintains the first 11 miles of the Benton-Othello No. 1 transmission line after it leaves the Benton Substation. The Midway-Benton No. 1 and the BPA-owned portion of the Benton-Othello No. 1 transmission lines are located in Benton County, Washington, on the DOE's Hanford Site.

Both transmission lines are old, physically worn, and structurally unsound in places. Midway-Benton No. 1 transmission line serves Franklin County Public Utility District and the Benton-Othello No. 1 transmission line serves Avista Utilities. The poor condition of the existing transmission lines creates risks to public and worker safety and may lead to outages that would adversely affect power deliveries to BPA's customers in eastern Washington. Further, the existing conductors on Midway-Benton No. 1 and Benton-Othello No. 1 transmission lines are made from copper and the hardware for this type of conductor is no longer available.

2.1.5.2.7 Draft Programmatic Environmental Assessment for Recycle of Scrap Metals Originating from Radiological Areas (DOE/EA-1919)

In December of 2012, the DOE issued the *Draft Programmatic Environmental Assessment for the Recycle of Scrap Metals Originating from Radiological Areas (DOE/EA-1919)*. Metals with volumetric radiological contamination, and scrap metals resulting from RCRA and CERCLA clean-up activities, are not included in the scope of the Preliminary EA. In addition, sites managed by the Office of Legacy Management are not included since these facilities do not generate potentially radiologically contaminated scrap metal that could be recycled.

DOE plans to complete the Preliminary EA, and as appropriate, issue a FONSI or prepare a Preliminary EIS prior to deciding whether to implement a change to the policy established by the Secretary of Energy in a July 13, 2000, memorandum that imposed an agency-wide suspension on the unrestricted release of scrap metal originating from radiological areas at DOE facilities for the purpose of recycling. The suspension was imposed in response to public concerns about the potential effects of radioactivity in or on metal recycled from the Department's facilities.

2.1.5.3 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 EA nor an EIS 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 segmented into smaller parts to avoid significance and are 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; 4) does not adversely affect environmentally sensitive resources; and 5) does not involve genetically engineered organisms, synthetic biology, government designated noxious weeds or invasive species unless contained/confined in a manner to prevent unauthorized release into the environment.

On October 13, 2011, DOE-HQ published modifications to its NEPA implementing procedures (i.e., [10 CFR 1021](#)) in the FR ([76 FR 63764](#)). Among other changes, procedure modifications stipulate that *Proposed recurring activities to be undertaken during a specified time period, such as routine maintenance activities for a year, may be addressed in a single categorical exclusion determination after considering the*

potential aggregated impacts. Prior to this modification to the NEPA implementing procedures, the Hanford Site was using Sitewide categorical exclusions that were preapproved by the DOE NEPA Compliance Officer and served a similar purpose.

On August 9, 2012, the DOE NEPA Compliance Officer directed the elimination of 16 Sitewide categorical exclusions, effective December 31, 2012, and requested Hanford Site Contractors to submit for approval annual categorical exclusions for routine and recurring work activities in accordance with the provisions of the newly modified NEPA implementing procedures. Activity specific categorical exclusions continue to be submitted to the DOE NEPA Compliance Officer for non-routine, non-recurring, project-specific work activities. A standard format was developed for use by the DOE NEPA Compliance Officer to perform and document the results of NEPA review screening activities.

Copies of Annual and Activity Specific categorical exclusions approved by the DOE NEPA Compliance Officer are posted on the DOE NEPA web page found at: <http://www.hanford.gov/page.cfm/CategoricalExclusions>.

2.1.6 Toxic Substances Control Act

JK Perry

Toxic Substances Control Act (TSCA) requirements that apply to the Hanford Site primarily involve regulation of 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*. Background information regarding Hanford Site PCB management activities are as follows:

- PCB wastes on the Hanford Site are stored and/or disposed in accordance with 40 CFR 761
- Some radioactive PCB waste remains in extended storage onsite pending the development of adequate treatment and disposal technologies and capacities
- Electrical equipment that might contain PCBs is maintained and serviced in accordance with 40 CFR 761
- The *Framework Agreement for Management of Polychlorinated Biphenyls (PBCs) in Hanford Tank Waste (EPA et al. 2000)*, signed on August 31, 2000, resulted in the Tri-Party Agencies and DOE contractors working together to resolve the regulatory issues associated with managing PCB waste at 1) the WTP (currently under construction); 2) the waste tank farms; and 3) affected waste management units adjacent to the waste tank farms.

RL submitted the *2011 Hanford Site Polychlorinated Biphenyl Annual Document Log (DOE/RL-2012-23)* and the *2011 Hanford Site Polychlorinated Biphenyl Annual Report (DOE/RL-2012-22)* to EPA on July 13, 2012, as required by 40 CFR 761.180, *Records and Monitoring*. These documents describe the PCB waste management and disposal activities occurring on the Hanford Site.

Risk-based disposal approvals were implemented on the Hanford Site in 2012, including but not limited to single-shell tank waste retrieval activities in accordance with EPA Phase I and II risk-based disposal approvals for the use of DST PCB remediation waste in accordance with [40 CFR 761.61\(c\)](#). **Note:** Phase I identifies general conditions that apply to the overall strategy and retrieval process and Phase II identifies tank-specific conditions.

2.1.7 Institutional Controls Plan

DR Ranade

The *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions, (DOE/RL-2001-41)*, describes the institutional controls for the Hanford Site and how they are implemented and maintained in accordance with CERCLA and/or RCRA decision documents. The CERCLA 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 and the CERCLA decision documents identify specific requirements for these controls.

Institutional controls are primarily administrative in nature and typically are used to augment the engineered components of a selected remedy to minimize the potential for human exposure to contaminants. Active institutional controls, such as controlling access to the Hanford Site or activities that may affect remedial action, generally are employed during remediation. After remediation is completed, passive institutional controls are employed 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 area, also may be employed after remediation is completed.

Hanford Site institutional controls assessments are most appropriately conducted in conjunction with the Hanford Site CERCLA Five-year review. DOE will continue to conduct institutional controls assessments as required by the CERCLA and/or RCRA decision documents. The ongoing review of the institutional controls by individual projects also will continue. The Hanford Site institutional controls assessment, in conjunction with the CERCLA Five-year review, will be a 'roll up' of these reviews and will serve as a means to evaluate effectiveness of the institutional controls. Based on the ongoing review, contractors will provide an annual update on the effectiveness of the institutional controls to EPA and Ecology at the Area Unit Managers Meetings conducted every September. Minutes from the unit manager's meeting are available in the TPA Administrative Record and can be accessed online at <http://www5.hanford.gov/arpir>.

The River Corridor Project, managed by WCH, has a number of institutional controls in both interim action and final ROD documents. Access controls were in place and active for WCH managed projects and no public trespass events at waste sites were reported during 2012. In addition, approved excavation permits were in place for all active remediation activities. Warning signs were in place at access road entrances to active remediation areas in the 100 and 300 Areas. Required shoreline signage checked during the 2012 institutional controls assessment was present at the 300 Area and at the reactor areas in the 100 Areas.

The Central Plateau Project, managed by CHPRC, also has a number of institutional controls in both interim and final ROD documents. Assessment of institutional controls at 200-UP-1 Operable Unit, 221-U Facility, and 200-ZP-1 Operable Unit did not identify deficiencies with land-use management, entry restrictions, groundwater management, or warning signs.

2.1.8 Federal Insecticide, Fungicide, and Rodenticide Act

JM Rodriguez

The *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA) 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* ([RCW 15.58](#)), the *Washington Pesticide Application Act* ([RCW 17.21](#)), and rules relating to general pesticide use codified in [WAC 16-228](#), *General Pesticide Rules*. Commercial pesticides are applied on the Hanford Site by commercial pesticide operators that are listed on one of two commercial pesticide applicator licenses, and by a licensed private commercial applicator.

2.1.9 Reportable Releases

TH Pysto

Federal regulations establish reporting requirements for certain environmental releases; these 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](#), *Spills and Discharges into the Environment*) 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 (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.

Two reports were made to the National Response Center in 2012. The first report was in January 2012, when a WCH transportation truck accident resulted in the spilling the contents of a container, and small amounts of hydraulic fluid, diesel fuel, and coolant. The vehicle was transporting 38,220 pounds (17,336 kilograms) of lead-contaminated soils with lead concentrations of up to 968 parts per million (ppm), resulting in a potential release of approximately 37 pounds (16 kilograms) of lead, which exceeded the Reportable Quantity for lead of 10 pounds (4 kilograms). The second report to the National Response Center was in June 2012, regarding a release of low concentration radioactive material within the boundaries of the Hanford Site National Priority List. No known reportable quantity was exceeded; this was a conservative notification.

During 2012, hazardous substance releases were conservatively assessed under [WAC 173-303-145](#), and notifications were provided to Ecology for various minor spills. These spills were cleaned up, and materials were disposed of in accordance with applicable requirements.

2.2 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.

2.2.1 Atomic Energy Act of 1954

JW DeMers and FM Roddy

The [AEA](#) was promulgated to ensure 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 TSD 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](#), *Procedural Rules for DOE Nuclear Activities*; [10 CFR 830](#), *Nuclear Safety Management*; and [10 CFR 835](#), *Occupational Radiation Protection*) and directives (e.g., [DOE O 435.1, Chg. 1](#) [Section 5.2.3] and [DOE O 458.1](#) [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.

DOE Directives may be accessed via the Departmental Directives Program website at: <https://www.directives.doe.gov/>.

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

2.2.2 DOE O 458.1, Radiation Protection of the Public and the Environment

JW DeMers and FM Roddy

The purpose of *Radiation Protection of the Public and the Environment* ([DOE O 458.1](#)) 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 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 [ICRP]); 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 ICRP 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 O 458.1](#) 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 [AEA](#) 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 O 458.1](#), are to ensure 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 O 458.1](#) is to provide radiological protection of the environment to the extent practical.

[DOE O 458.1](#) also provides derived concentration guide values as reference values for conducting radiological environmental protection programs at operational DOE facilities and sites. Table 2.1 provides the radiation standards (dose limits) for protection of the public from all routine DOE Concentrations. 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; ingestion of water, inhalation of air, and 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.

2.2.3 DOE O 435.1, Radioactive Waste Management

MS Collins

The purpose of [DOE O 435.1, Chg. 1, Radioactive Waste Management](#), is to establish requirements to manage of all high-level waste (HLW), transuranic waste, and low-level waste, including the radioactive component of mixed waste (i.e., HLW, transuranic waste, and low-level waste containing chemically hazardous constituents) in a safe manner that is protective of the worker, public health, 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](#)
- [DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees](#)
- [DOE O 458.1, Radiation Protection of the Public and the Environment](#).

**Table 2.1 Radiation Standards for Protection of the Public from all Routine DOE Concentrations
(Dose Limits)¹****All Pathways (DOE O 458.1)**

Effective dose equivalent for any member of the public from all routine DOE operations² shall not exceed the values below.

	Effective Dose Equivalent ³	
	mrem/year	mSv/year
Routine public dose	100	1
Potential authorized temporary public dose ⁴	500	5

Dose to Native Aquatic Animal Organisms from Liquid Discharges (DOE O 458.1)

Radioactive material in liquid waste discharged to natural waterways shall not cause an absorbed dose⁵ to native aquatic animal organisms that exceed 1 rad (10 milligray) per day.

Drinking Water Pathway Only (40 CFR Parts 9, 141, and 142 (65 FR 76708); WAC 246-290, Group A Public Water Supplies; and DOE O 458.1)

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, OMB Approvals Under the Paperwork Reduction Act; 141, National Primary Drinking Water Regulations; and 142, National Primary Drinking Water Regulations Implementation.

Air Pathways Only (40 CFR 61, National Emission Standards for Hazardous Air Pollutants)

	Effective Dose Equivalent ³	
	mrem/year	mSv/year
Public dose limit at location of maximum annual air concentration as a consequence of routine DOE operations ²	10	0.1

¹ 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.

² Routine DOE operations imply normal, planned activities and do not include actual or potential accidental or unplanned releases.

³ Effective dose equivalent is expressed in rem (or millirem) and Sv (or millisievert).

⁴ 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 HQ for an increase from the routine public dose limit to a temporary annual dose limit.

⁵ Absorbed dose is expressed in rad (or millirad) with the corresponding value in gray (or milligray) in parentheses.

mrem = millirem

rem = roentgen equivalent in man

Sv = Sievert

2.3 Air Quality

TG Beam

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

2.3.1 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 \(RCW 70.94\)](#), 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.

Ecology regulates criteria and toxic air pollutant emissions at the Hanford Site by enforcing applicable federal requirements in [40 CFR 52](#), *Approval and Promulgation of Implementation Plans*; [40 CFR 60](#), *Standards of Performance for New Stationary Sources*; [40 CFR 61](#), [40 CFR 63](#), *National Emission Standards for Hazardous Air Pollutants for Source Categories*; [40 CFR 68](#), *Chemical Accident Prevention Provisions*; and [40 CFR 82](#), *Protection of Stratospheric Zone*; as well as the state requirements in [WAC 173-400](#), *General Regulations for Air Pollution Sources*; [WAC 173-460](#), *Controls for New Sources of Toxic Air Pollutants*; [WAC 173-480](#); and [WAC 173-491](#), *Emission Standards and Controls for Sources Emitting Gasoline Vapors*. Criteria and toxic air pollutant emissions are often referred to as 'nonradioactive' 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, *National Emission Standard for Asbestos*. The Benton Clean Air Agency also regulates outdoor burning activities at the Hanford Site in accordance with state requirements in [WAC 173-425](#), *Outdoor Burning*.

2.3.2 Air 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](#)), and criteria and toxic air pollutants ([WAC 173-400-110](#), *New Source Review (NSR) for Sources and Portable Sources*; and [WAC 173-460-040](#), *New Source Review*) to determine whether a notice of construction application must be submitted to the Washington State Department of Health and/or 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 *Radioactive Air Emissions License for the Department of Energy Richland Operations Office Hanford Site, License Number FF-01 (DOH 2012)* issued by the Washington State Department of Health in February 2012. 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 microSv) per year standard specified in [40 CFR 61.92](#), *Standard*. Hanford Site radioactive air emissions data are published annually in the radionuclide air emissions report for the Hanford Site ([DOE/RL-2013-12](#), *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2012*).

As a major source of air pollutants, the Hanford Site is subject to the air operating permit requirements in [40 CFR 70](#), *State Operating Permit Programs*; and [WAC 173-401](#), *Operating Permit Regulation*. In coordination with the Washington State Department of Health and the Benton Clean Air Agency, Ecology issued Renewal 1 of the 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 radioactive air emissions license FF-01 ([DOH 2012](#)) issued by the Washington State Department of Health and notice of construction approval orders issued by Ecology. The [Air Operating Permit](#) requires the submittal of semiannual reports to the regulatory agencies documenting the status of required monitoring and permit deviations. In addition, an annual report documenting the compliance status of Hanford Site emission sources against applicable *Clean Air Act* requirements, and an annual report that documents total emissions of criteria and toxic pollutants is also required. The [Air Operating Permit](#) was not revised in 2012 to incorporate new Washington State Department of Health and Ecology air emission licenses, approval orders, and updated regulatory requirements. Renewal 1 of the Air Operating Permit was scheduled to expire on December 31, 2011; however, the Hanford Site submitted a renewal application to ensure the permit would continue in effect until Ecology issues Renewal 2 of the [Air Operating Permit](#). Ecology issued a draft Renewal 2 of the [Air Operating Permit](#) for public comment on December 3, 2012; Ecology is scheduled to issue Renewal 2 in the spring of 2013.

2.3.2.1 Air Inspections

The Washington State Department of Health, 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 2012, the regulatory agencies conducted over 30 *Clean Air Act* inspections at the Hanford Site; those inspections did not result in any violations being issued by regulatory agencies.

2.4 Water Quality

CJ Clement

This section provides information on federal, state, and local requirements, including permits, related to protection of water quality.

2.4.1 Federal Permit – Discharges to Columbia River

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* (NPDES, [40 CFR 122](#)). The DOE does not currently have any discharges to the Columbia River requiring permits.

2.4.2 State Waste Discharge Permits – Discharges to the Soil Column/Groundwater

Ecology has a State Wastewater Discharge Permit Program that regulates discharges to waters of the state, including groundwater. Five individual Ecology state waste discharge permits were in effect during 2012 ([ST-4500](#), [ST-4502](#), [ST-4507](#), [ST-4511](#), and [ST-0045514](#)). DOE is the holder of all the state waste discharge permits. Ecology's Waste Water Discharge Permits webpage is located at <http://www.ecy.wa.gov/programs/nwp/permitting/wwd/index.html>.

Two general Ecology permits were in effect during 2012, [WAG-50-5180](#) and [WAG-50-5181](#). These are Washington State Sand and Gravel General Permits that were issued to BNI.

Most onsite sewage systems (e.g., septic systems) operate under permits issued by the Washington State Department of Health. The Washington State Department of Health issues annual permits to DOE for the operation of Hanford Site onsite sewage systems, which include some holding-tank sewage systems.

2.4.3 Local Discharge Permit – Discharges to the City of Richland Sewer

The city of Richland regulates industrial wastewater discharges to its sewer collection system in accordance with city of Richland Code, Richland Pretreatment Act – [Chapter 17.30](#). DOE is the holder of Permit No. CR-IU010, which allow discharges from the 300 Area facilities.

2.4.4 Safe Drinking Water Act of 1974

LM Kelly

The *Safe Drinking Water Act of 1974* (SDWA) 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 SDWA. 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 SDWA 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 DWSs. 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 2012, affected Hanford Site water systems demonstrated compliance with the filtration and disinfection treatment technique requirements and limits for disinfectant residuals and disinfection byproducts.

To protect the health of workers using public water supplies on the Hanford Site, water systems were monitored during 2012 for microbiological, chemical, physical, and radiological constituents. There were no microbiological detections during the 2012 monitoring cycle, and all chemical concentrations in drinking water were well below the maximum contaminant levels established by EPA. Table 2.2 provides selected DWSs; and system-specific information and analytical results for 2012 radiological monitoring are summarized in Section 7.1.3. Table 2.3 provides the selected surface freshwater quality criteria for toxic pollutants and Table 2.4 provides the Washington State water quality criteria for the Hanford Reach of the Columbia River.

Table 2.2. Selected Drinking Water Standards

Constituent	DWS ¹		Agency ²
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 trihalomethanes ³	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 pCi/L ⁴	11.1 Bq/L	EPA
Beta particle and photon activity	4 mrem/yr ⁵	40 µSv/yr	EPA, DOH
Carbon-14	2,000 pCi/L ⁴	74.1 Bq/L	EPA
Cesium-137	200 pCi/L ⁴	7.4 Bq/L	EPA
Cobalt-60	100 pCi/L ⁴	3.7 Bq/L	EPA
Iodine-129	1 pCi/L ⁴	0.037 Bq/L	EPA
Ruthenium-106	30 pCi/L ⁴	1.11 Bq/L	EPA
Strontium-90	8 pCi/L ⁴	0.296 Bq/L	EPA, DOH
Technetium-99	900 pCi/L ⁴	33.3 Bq/L	EPA
Total alpha (excluding uranium)	15 pCi/L ⁴	0.56 Bq/L	EPA, DOH
Tritium	20,000 pCi/L ⁴	740 Bq/L	EPA, DOH
Uranium	30 µg/L	0.03 ppm	EPA, DOH

¹ Maximum contaminant level for drinking water supplies.

² DOH = Washington State Department of Health at [WAC 246-290](#).

EPA at [40 CFR 141](#), *National Primary Drinking Water Regulations*; [40 CFR 143](#), *National Secondary Drinking Water Regulations*; and [EPA 822-R-96-001](#), *Drinking Water Regulations Health Advisories*.

³ Standard is for total trihalomethanes.

⁴ EPA DWSs 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).

⁵ 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.

Bq = Becquerel

L = liter

yr = year

pCi/L = picocuries per liter

ppm = parts per million

µg/L = micrograms per liter

Table 2.3. Selected Surface Freshwater Quality Criteria for Toxic Pollutants

Compound	Level that Yields Acute Toxicity ¹		Level that Yields Chronic Toxicity ¹		Protective Level for Human Health Consumption of Water and Organisms ²	
	µg/L	ppm	µg/L	ppm	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 ⁽³⁾	0.59	0.00059 ⁽⁴⁾	–	–
Chromium (VI)	15	0.015	10	0.01	–	–
Copper	8.4	0.0084 ⁽⁵⁾	6.0	0.006 ⁽⁶⁾	–	–
Lead	28	0.028 ⁽⁷⁾	1.1	0.0011 ⁽⁸⁾	–	–
Mercury	2.1	0.0021	–	–	0.14	0.00014
Nickel	750	0.75 ⁽⁹⁾	83	0.083 ⁽¹⁰⁾	610	0.61
Silver	0.94	0.00094 ¹¹	–	–	–	–
Thallium	–	–	–	–	1.7	0.0017
Zinc	60	0.060 ⁽¹²⁾	55	0.055 ⁽¹³⁾	–	–
Total Recoverable Metals						
Chromium(III) ¹⁴	300	0.30 ⁽¹⁵⁾	96	0.096 ⁽¹⁶⁾	–	–
Mercury	–	–	0.012	0.000012	–	–
Selenium	20	0.02	5.0	0.005	–	–
Anions						
Cyanide ¹⁷	22.0	0.022	5.2	0.0052	700	0.70
Chloride ¹⁸	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

¹ [WAC 173-201A-240, Toxic Substances](#). For hardness-dependent criteria, the minimum value of 47 mg CaCO₃/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.

² [40 CFR 131.36, Toxics Criteria for those States not Complying with Clean Water Act Section 303\(c\)\(2\)\(B\)](#).

³ $(1.1367 - [\ln(\text{hardness})]) 0.04184$
 $\exp(1.128[\ln(\text{hardness})] - 3.828)$. Hardness expressed as mg CaCO₃/L.

⁴ $(1.1017 - [\ln(\text{hardness})]) 0.04184$
 $\exp(0.7852[\ln(\text{hardness})] - 3.490)$.

⁵ $(0.960) \exp(0.9422[\ln(\text{hardness})] - 1.464)$.

⁶ $(0.960) \exp(0.8545[\ln(\text{hardness})] - 1.465)$.

⁷ $(1.4620 - [\ln(\text{hardness})]) 0.1457$
 $\exp(1.273[\ln(\text{hardness})] - 1.460)$.

⁸ $(1.4620 - [\ln(\text{hardness})]) 0.1457$
 $\exp(1.273[\ln(\text{hardness})] - 4.705)$.

⁹ $(0.998) \exp(0.8460[\ln(\text{hardness})] + 3.3612)$.

¹⁰ $(0.997) \exp(0.8460[\ln(\text{hardness})] + 1.1645)$.

¹¹ $(0.85) \exp(1.72[\ln(\text{hardness})] - 6.52)$.

¹² $(0.978) \exp(0.8473[\ln(\text{hardness})] + 0.8604)$.

¹³ $(0.986) \exp(0.8473[\ln(\text{hardness})] + 0.7614)$.

¹⁴ Where methods to measure trivalent chromium are unavailable, these criteria are to be represented by total recoverable chromium.

¹⁵ $(0.316) \exp(0.8190[\ln(\text{hardness})] + 3.688)$.

¹⁶ $(0.860) \exp(0.8190[\ln(\text{hardness})] + 1.561)$.

¹⁷ Criteria based on weak and dissociable method.

¹⁸ Dissolved in association with sodium.

Table 2.4. Washington State Water Quality Criteria for the Columbia River, Hanford Reach¹

Parameter	Permissible Levels
Fecal coliform	<ul style="list-style-type: none"> Geometric mean value less than or equal to 100 colonies/100 milliliters (0.026 gallon) Not more than or equal to 10 percent 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	<ul style="list-style-type: none"> Less than or equal to 18°C (64°F) as a result of human activities 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) 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	<ul style="list-style-type: none"> 6.5 to 8.5 range 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 percent 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 (Table 2.1)
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 (Table 2.8)

¹ [WAC 173-201A](#), *Water Quality Standards for Surface Waters of the State of Washington*.

2.4.5 Permit Deviations

CJ Clement

Five permit deviations on the Hanford Site were reported in 2012:

- Permit ST 4502: January 2, 2012, decommissioning and demolition wastewater with elevated pH from PFP was accidentally discharged to the TEDF.
- Permit ST-4502: February 1, 2012, an unauthorized discharge of micronutrient solution from the 200 West Pump and Treat Project was transferred to TEDF.
- Permit ST 4502: February 5, 2012, a minor leak on a vacuum relief valve on the TEDF transfer line was reported.
- Permit CR-IU010: November 12, 2012, an accidental discharge of propylene glycol to the City of Richland sewer was discovered.
- Permit ST 4502: December 13, 2012, a nitrate level at TEDF greater than the permit daily maximum limit was discovered and reported.

2.5 Natural and Cultural Resources

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

2.5.1 Ecological Compliance

MR Sackschewsky

DOE policies require that all Hanford Site projects with the potential to adversely affect biological resources conduct an ecological compliance review before the project starts. DOE uses the review to determine if the project will comply with the *Endangered Species Act of 1973* ([16 USC 1531](#)), the *Migratory Bird Treaty Act of 1918* (16 USC 703), and the *Bald and Golden Eagle Protection Act*, as well as Executive Order [11988](#), *Floodplain Management* (42 FR 26951) and Executive Order [11990](#), *Protection of Wetlands* (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.

There were 275 reviews performed during 2012, including 118 ecological compliance reviews to support general Hanford Site activities, and 157 reviews for River Corridor environmental restoration activities.

2.5.1.1 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. Upper Columbia River Steelhead trout (*Oncorhynchus mykiss*) and spring-run Chinook salmon (*Oncorhynchus tshawytscha*) are listed under the *Endangered Species Act of 1973* ([16 USC 1531](#)) as either threatened or endangered ([50 CFR 17](#), Subpart B, *Lists*) and occur onsite, and Critical Habitat for these species has been designated within the Hanford Reach. The *Threatened and Endangered Species Management Plan: Salmon and Steelhead* ([DOE/RL-2000-27](#)) is in place for these species. The bull trout (*Salvelinus confluentus*) is also listed under the *Endangered Species Act of 1973* ([16 USC 1531](#)) 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 2010a](#)). Two plant species, the Umtanum desert buckwheat (*Eriogonum codium*) and White Bluffs bladderpod (*Physaria douglasii* ssp. *tupleshensis*) have been proposed for listing under the *Endangered Species Act of 1973* ([16 USC 1531](#)). Other species on the Hanford Site are listed by the Washington Department of Fish and Wildlife as endangered, threatened, or sensitive (refer to Section 11.2).

2.5.1.2 Migratory Bird Treaty Act

The *Migratory Bird Treaty Act* prohibits taking or disturbing listed 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 [DOE/RL-96-32](#). 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. MSA maintains a migratory bird permit issued by the USFWS (MB14155A-2) that allows for certain *Migratory Bird Treaty Act*-related actions. A report of all activities conducted under this permit is provided to USFWS annually.

2.5.1.3 Bald and Golden Eagle Protection Act

The *Bald and Golden Eagle Protection Act* ([16 USC 668](#)) 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 Management Plan for the Hanford Site, South Central Washington* ([DOE/RL-94-150](#)) was published in 2009 to direct Hanford Site activities in accordance with current federal and state regulations and guidelines. 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.

DOE continued to maintain a bald eagle take permit from the USFWS (MB30480-A-1) to cover potential disturbance to eagles using the 100-K Area night roost and the night roosts in the vicinity of the 100 HX pump-and-treat system between 100-H and 100-D Areas.

2.5.1.4 Executive Orders 11990 and 11988 and 11990

Executive Orders 11990 and 11988 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. Compliance with these executive orders, as well as the wetland provisions of the *Clean Water Act of 1977*, are implemented at the Hanford Site 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.

2.5.2 Cultural Resource Compliance

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DOE's policy is to comply with all cultural resource-related laws and regulations ([DOE P 141.1](#), *Department of Energy Management of Cultural Resources*). Cultural resources on the Hanford Site are subject to the provisions of laws, regulations, executive orders, and proclamations. Laws include the *Antiquities Act of 1906*, *Historic Sites Act of 1935*, *National Historic Preservation Act of 1966*, NEPA, *Archaeological and Historic Preservation Act of 1974*, *American Indian Religious Freedom Act of 1978*, *Archaeological Resources Protection Act of 1979*, and *Native American Graves Protection and Repatriation Act*.

Regulations applicable to cultural resources include the *National Register of Historic Places* ([36 CFR 60](#)); *Determinations of Eligibility for Inclusion in the National Register of Historic Places* ([36 CFR 63](#)); *National Historic Landmarks Program* ([36 CFR 65](#)); *Curation of Federally-Owned and Administered Archaeological Collections* ([36 CFR 79](#)); *Protection of Historic Properties* ([36 CFR 800](#)); *Protection of Archaeological Resources* ([43 CFR 7](#)); and *Native American Graves Protection and Repatriation and Regulations* ([43 CFR 10](#)).

Executive orders applicable to cultural resources 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 13175](#), *Consultation and Coordination with Indian Tribal Governments* (65 FR 67249); [Executive Order 13287](#), *Preserve America* (68 FR 10635); and [Presidential Proclamation 7319](#), *Establishment of the Hanford Reach National Monument* (65 FR 37253). Refer to Section 11.3 for details regarding Hanford Site Cultural Resource Programs.

2.6 Other Environmental Statutes

Information regarding additional statutes is presented in the following sections.

2.6.1 Emergency Planning and Community Right-to-Know Act of 1986

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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 2.5 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) 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) Toxic Chemical Release Inventory, which contains information about total annual releases of certain toxic chemicals and associated waste management activities.

The *2012 Hanford Site Tier Two Emergency and Hazardous Chemical Inventory* (DOE/RL-2013-15), was submitted to Ecology's Community Right-To-Know Unit; local emergency planning committees for Benton, Franklin, and Grant Counties; and the city of Richland and Hanford Site fire departments on February 28, 2013. Fifty-six 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 Federal Building). Table 2.6 lists the average quantities of the 10 hazardous chemicals stored in greatest quantity on the Hanford Site in 2012.

The *2012 Hanford Site Toxic Chemical Release Inventory* report ([DOE/RL-2013-16](#)), was submitted to EPA and Ecology on June 25, 2013. During CY 2012, the Hanford Site exceeded activity thresholds for five chemicals and one chemical category; lead, naphthalene, nitrate compounds, propylene, toluene, and xylene. Information concerning these chemicals is described in Table 2.7.

Table 2.8 provides an overview of reporting under the [*Emergency Planning and Community Right-to-Know Act of 1986*](#) during 2012 and early 2013.

Table 2.5. Emergency Planning and Community Right-to-Know Act of 1986 Sections and Requirements Summary

Section	CFR 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 Occupational Safety and Health Administration (OSHA) hazardous chemical in quantity equal to or greater than 10,000 pounds (4,500 kilograms), or an extremely hazardous substance in quantity equal to or greater than threshold planning quantity or 500 pounds (230 kilograms), 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 10,000 pounds (4,500 kilograms), or an extremely hazardous substance in quantity equal to or greater than threshold planning quantity or 500 pounds (230 kilograms), 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 CY. Thresholds are 25,000 pounds (11,300 kilograms) for manufactured or processed or 10,000 pounds (4,500 kilograms) for otherwise used except for persistent, bio-accumulative, toxic chemicals, which have thresholds of 100 pounds (45 kilograms) or less.	Annually by July 1	EPA; State Emergency Response Commission

Table 2.6. Average Quantity of the 10 Hazardous Chemicals¹ Stored in Greatest Quantities

Hazardous Chemical	Average Quantity, lbs	Average Quantity, kg
Sodium	4,620,000	2,100,000
Sodium Chloride	3,340,000	1,510,000
Mineral oil	2,010,000	910,000
Portland Cement	1,460,000	661,000
Diesel Fuel (Grades 1 and 2)	1,120,000	507,000
Iron(II) Sulfate Heptahydrate	972,000	441,000
Petroleum Distillates	685,000	311,000
Lead Acid Batteries	518,000	235,000
Ready Mix Concrete	516,000	234,000
Fly Ash (Class F)	310,000	141,000

¹ Includes chemicals defined as hazardous under [29 CFR 1910.1200\(c\)](#), Hazard Communication

kg = kilograms

lbs = pounds

Table 2.7. Toxic Chemicals Exceeding Reporting Thresholds

Chemical	CAS No.	Non-exempt Use Description
Lead	7439-92-1	Ammunition fired during range practice by Hanford Safeguards and Security
Naphthalene	91-20-3	Diesel used for stationary equipment
Nitrate Compounds	group category code N511	Sodium nitrate solution used for startup testing of 200 West Pump and Treat
Propylene	115-07-1	Propane gas used for construction-related heating equipment at WTP
Toluene	108-88-3	Gasoline used for stationary equipment
Xylene	1330-20-7	Gasoline used for stationary equipment

Table 2.8. Emergency Planning and Community Right-to-Know Compliance Reporting

Section	Description of Reporting	Status	Notes
302	Emergency planning notifications	Yes	
304	Extremely hazardous substance release notification	Not required	No releases occurred.
311	Material safety data sheet	Yes	
312	Chemical inventory	Yes	
313	Toxic release inventory	Yes	

2.6.1.1 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.

2.6.2 Pollution Prevention Program

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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.

RL 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 in Environmental, Energy, and Economic Performance* (74 FR 52117), and [DOE O 436.1](#), *Departmental Sustainability*, establish pollution prevention and environmental stewardship requirements. In accordance with these requirements, pollution prevention and waste minimization activities are documented, tracked, and reported. Table 2.10 summarizes Hanford Site pollution prevention and waste minimization quantities recycled in FY2012.

Table 2.10. Recycle Quantities

FY2012 Recycled Material	Quantity (Metric Tons)
Non-Hazardous Material	
Cardboard	44.12
CI Shredded Paper	825.28
Furniture	189.08
Plastic Bottles	15.9
Tires	13.61
Wood Pallets	91.51
Plastic Hard Hats	0.181
CHPRC Zero Waste Picnic	0.306
Subtotal	1180
Hazardous Material	
Aerosol Cans	0.82
Antifreeze	31.42
Antifreeze - Fleet	0.22
Ballasts	1.70
Batteries	4.83
Fluorescent Bulbs	5.81
Lamps	1.32
Lead Acid Batteries	14.80
Lead Acid Batteries (Fleet)	13.24
PCB Waste Oil <50 ppm	64.00
Lead	9.98
Toner Cartridges	15.10
Used Engine Oils (Fleet)	32.72
Used Oil	33.99
Fire Extinguishers	2.75
Exit Signs	0.002
Circuit Boards	0.004
Keyboards/Mice/Power strips	0.726
Subtotal	233.43
Total	1413.38

2.6.2.1 Pollution Prevention and Waste Minimization Accomplishments and Awards

In 2012, the Hanford Site was awarded three DOE Office of Environmental Management (EM) Best in Class awards and eight Honorable Mention awards for pollution prevention and waste minimization accomplishments performed in FY2011. In 2012, the Hanford Site also was awarded the Federal Electronic Challenge Gold Award for outstanding achievements in electronic stewardship.

2.6.2.2 Contractor-Specific Accomplishments

The MSA recycle/reuse and waste minimization activities included the following:

- In FY2012, over 633 computers, monitors, printers, televisions, and servers were recycled through a certified recycler. In addition, Hanford transferred/donated 4,571 computers, monitors, televisions, printers, and servers through the PC Nationalization Program.
- Initiated the reduction of standalone printers and copiers to reduce the generation of solid waste. This goal is being addressed in two phases, resulting in a 30% reduction by FY2013.
- Launched an aluminum can recycling program for the Hanford Site in April 2012.
- A change to the requirements for the TPA Administrative Record was approved in February 2012, allowing data packages, technical literature, engineering designs, maps, computer models and technical databases to be submitted in electronic format only. Since the “Go Electronic” change was implemented, the TPA Administrative Record has processed 676 Analytical Data Packages as electronic records versus hard copy. The data packages contained 299,733 pages that have been reduced to only 23,625 hard copy pages by going to electronic storage, for a savings of 92 feet of paper.
- Developed a “Green Buy” catalog to clearly identify environmentally preferred products. In addition, mechanisms and controls were implemented into the procurement process to ensure that noncompliant products would be blocked from being purchased.

CHPRC recycle/reuse and waste minimization activities included the following:

- Employees diverted 1,260 pounds (572 kilograms) of waste from ending up in a landfill at their 4th Annual All-Employee Family Picnic. More than 2,800 participants attended the afternoon event of family-friendly fun celebrating success on the project and improved safety. In keeping with the company’s recent ISO 14001:2004 Certification, the picnic was planned as an environmentally friendly, ZERO WASTE picnic. The objective was to reduce consumption, maximize recycling, and minimize waste. At the end of the day, 95% of the waste generated at the picnic was diverted from the local landfill. Scrap food was donated to a local pig farmer and glass, cardboard, plastic, aluminum and bottle caps were separated and distributed to the appropriate recycling facilities. Compostable plates, cups, utensils, paper towels and napkins were separated and were sent to commercial compost facility, leaving only 68 pounds (31 kilograms) of garbage to be sent to the local landfill.
- Established an FY2012 Environmental Management System (EMS) objective and target to evaluate available in-situ biological spill treatment/cleanup products for petroleum based spills, and to identify opportunities for use onsite. CHPRC was specifically looking for products that could either be disposed as non-regulated waste or left in place without detrimental effects to the environment. Five potential products were identified for further evaluation.
- Evaluated and tested a 100 percent re-refined motor oil in equipment, after testing the product was found to be a viable substitute for new motor oil.
- Recycled 600 gallons (2,280 liters) of used soybean oil through the Hanford Site Centralized Consolidation/Recycling Center.

- CHPRC had been using an aging Linux computer cluster for vadose zone and groundwater fate and transport modeling since 2008. With this system reaching the end of its useful life, CHPRC sought to replace the system with a new cluster to meet current and future groundwater simulation requirements. The functional requirements for a new platform were developed and MSA/Lockheed Martin Services, Inc., (LMSI) were enlisted to refine the hardware specification and construct the system. The new system, named "Tellus", was constructed and brought into service in time to take over the simulation load as the old cluster was retired from service. A key recycling opportunity occurred when it was recognized that LMSI was upgrading key computer systems in the Hanford Local Area Network (HLAN), freeing 2-year old blade systems. Incorporating these components in the Tellus platform, rather than purchasing new equivalent components, achieved a very significant costs savings on hardware (60%) while utilizing highly serviceable hardware with a substantial remaining service life.
- After the loss of American Recovery and Reinvestment Act (ARRA) funding, CHPRC established an FY2012 EMS objective and target to collect, consolidate, and reintroduce office furniture, equipment and supplies back into the supply chain. Through this reutilization effort CHPRC avoided >\$4M in unnecessary acquisitions for the DOE and its' Contractors during FY2012:
 - ‡ 210 Items of Accountable Property valued at \$3,884,813.92 were redeployed to Other Hanford Contractors and DOE Field Offices for beneficial reuse
 - ‡ 2,673 items of excess property including equipment and consumables were redeployed to the CHPRC and other Hanford Contractors from the Energy Northwest Warehouse
 - ‡ 344 Items including boxes of bulk supplies were captured and redistributed in 2420 Stevens Center Place in conjunction with personnel moves and office cleanout campaigns.

WRPS sustainability performance activities included the following:

- Recycling approximately 10.8 tons (9.98 metric tons) of radiologically contaminated lead bricks.
- Implementation of video conferencing for meetings, conserving petroleum use and greenhouse gasses.
- Safety and Health, Work Control, Engineering, Environmental and Regulatory Affairs are testing iPads in an effort to get rid of paper by doing away with clipboards and notebooks in the field, which demonstrates significant productivity and performance improvements along with the paper/printer/toner cartridge savings.
- Many organizations, such as Procurement, Information Resources, Human Resources, Project Integration, Training, are providing more and more electronic options for workers, saving paper, toner, cost and energy.
- The focus of the 2012 EMS objectives and targets was centered on sustainability. These objectives aimed to increase energy efficiency, reduce greenhouse gases, conserve water, increase use of sustainable products and prevent pollution. The following are examples of sustainable practices that occurred within the Tank Farm Facility:
 - ‡ The Facilities Maintenance organization purchased and put into use two low-speed electric vehicles with plans to replace gas-powered vehicles in their fleet as appropriate. This effort will help reduce petroleum usage and greenhouse gas emissions.
 - ‡ A team of One System engineers looked at six options for upgrading the ventilation and cooling of double-shell waste-staging tanks in the AY/AZ tank farms. The preferred option was estimated to cost well above the target cost. Rather than design-building more than was needed, Engineering chose to upgrade the existing AY/AZ ventilation system to meet safety requirements. This option resulted in a cost of approximately \$27 million, while the other three options would have exceeded the target cost of \$40-to-\$47 million. Ultimately, this project will result in reduced waste, worker exposure and overall construction costs.
 - ‡ Procurement implemented an electronic procurement filing system, which eliminated a significant amount of paper, binders, and tabs. Measurement of FY2012 totals will be compared to FY2013 totals, which are an EMS objective.

- In FY 2012/FY 2013, Procurement and Environmental Protection are conducting a study on recycled printer cartridges with performance results to be published and utilized for future sustainable acquisitions.
- Supporting the Hanford Site initiation of composting efforts for tumbleweeds with the MSA Biological Controls organization.
- Supporting the incorporation of #2 plastics for recycling.
- Re-using waste boxes that are sent to PermaFix North West are unloaded, decontaminated, inspected by WRPS Quality Assurance and if acceptable returned to WRPS for re-use. For FY2012, Waste Service's re-used 65 waste boxes. The average cost of a new waste box is about \$8,000 and by reusing 65 boxes, Waste Services saved \$520,000. The average waste box sent to PermaFix is about 100 cubic feet (2.8 cubic meters). By reusing 65 boxes WPRS kept 6,500 cubic feet (182 cubic meters) out of the land fill.
- Facilities and Property Management and Construction organizations replaced the roofs of nine mobile offices totaling approximately 21,000 square feet (1,953 square meters) with a white polyurethane foam roofing system. The foam roofing system meets the DOE directive for "cool roofs" providing a highly reflective surface that does not absorb as much heat and has a high albedo.
- Facilities and Property Management and Construction organizations renovated seven mobile office facilities incorporating the following sustainable practices:
 - ‡ Replaced the HVAC units with new more energy-efficient units, replacing the old refrigerant with more environmentally friendly refrigerant.
 - ‡ Replaced the windows with new more energy-efficient windows with a low-E coating and replaced older appliances with Energy Star approved appliances.
 - ‡ Installed low flow faucets.
 - ‡ Used low volatile organic carbon products.
- WRPS installed approximately 170 total modular workstations in 2750E D wing 1 north, D wing 1 south and D wing 2 north. The approximate cost of all furniture if procured new would have been about \$935,000, however, WRPS reutilized furniture from other DOE sites and from 1200 Jadwin, saving approximately \$893,000.

WCH recycle/reuse and waste minimization activities included the following:

- Used biodegradable or bio-based hydraulic oils and greases in equipment working adjacent to sensitive habitats (e.g., Columbia River) adverse environmental impact from leaks and spills.
- Reused 36 roll-on/roll-off containers, which were no longer certified for waste shipments, to macroencapsulate waste at ERDF in lieu of procuring new containers.
- Recycled approximately 328 tons (297 metric tons) of scrap steel from 100-N Area
- To avoid excavating soil from new or existing borrow pits:
 - ‡ Re-used 1,125 tons (1,020 metric tons) of building excavation spoils and utilized 2,815 bank cubic meters of clean overburden as backfill at 100-F Area.
 - ‡ Used 770 tons (698 metric tons) of building slabs and basements as clean concrete fill in 300 Area.
 - ‡ Provided 600 tons (544 metric tons) of soil removed during the excavations of the new cells at ERDF as fill to remediated waste sites.

2.6.3 Environmental Orders

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Three DOE orders and two Presidential Executive Orders addressing environmental protection are complied with at the Hanford Site.

[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 biobased, environmentally preferable, energy-efficient, water-efficient, and recycled products; 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 EMS 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 establishing environmental management training, environmental compliance review and auditing, and leadership awards to recognize outstanding environmental, energy, or transportation management performance.

[Executive Order 13514](#) (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. In addition, [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 be established. [Executive Order 13514](#) also sets goals for 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](#) requires continued implementation of a formal sustainable EMS.

[DOE O 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 Order 13423](#) and [Executive Order 13514](#) including the establishment of an EMS that includes environmental, energy, and transportation objectives and targets.

[DOE O 450.1A](#), *Environmental Protection Program*, requires implementation of an EMS that is integrated into the Integrated Safety Management System and reflects the elements and framework found in the International Organization for Standardization (ISO) 14001:2004(E) standard, *Environmental Management Systems – Requirements with Guidance for Use*. [DOE O 450.1A](#) states that each EMS 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 EMS must address sustainable practices for enhancing environmental, energy, and transportation performance required by Executive Order 13423 and [DOE O 430.2B](#) to include 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 nanomaterial's hazards, and identifying opportunities to implement sustainable practices.

[DOE O 436.1](#), *Departmental Sustainability*, requires developing a Site Sustainability Plan that is integrated with the Hanford Site operational plans. In addition, the order requires developing an EMS that is certified to or conforms with the ISO 14001:2004 standard, submittal of sustainability goal data and reports, as well as *Emergency Planning and Community Right-to-Know Act of 1986* reporting. [DOE O 436.1](#) also cancels [DOE O 450.1A](#) and [DOE O 430.2B](#). Implementation of DOE orders and executive orders by Hanford Site contractors is addressed in Section 3.0.

MSA, as the Hanford Site services and infrastructure contractor, updated the sustainability plan for the Hanford Site in 2012 with input from DOE and Hanford 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 component, as required by [DOE O 436.1](#) and [Executive Order 13423](#). Environmental objectives developed in 2010 were maintained in 2012, as were plans for recycling; ozone-depleting substance management, environmentally preferred procurement management, and electronic asset stewardship (refer to Section 3.0).

2.7 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 during 2012. All Hanford Site occurrences are reported to the Occurrence Notification Center and subsequently recorded in the Occurrence Reporting and Processing System. This system is a DOE electronic database that tracks occurrence reports across the DOE complex ([DOE M 231.1-2, Occurrence Reporting and Processing of Operations Information](#)). The following sections summarize occurrences 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).

2.7.1 Operational Emergency; Recurring; or Category 1

There were no Hanford Site environmental occurrences ranked as Operational Emergency, Recurring, or Category 1, Significant Impacts.

2.7.2 Operational Emergency; Recurring; or Category 2

There were no Hanford Site environmental occurrences ranked as Operational Emergency, Recurring, or Category 2, Moderate Impacts.

2.7.3 Operational Emergency; Recurring; or Category 3

There were no Hanford Site environmental occurrences ranked as Operational Emergency, Recurring, or Category 3, Minor Impacts.

2.7.4 Operational Emergency; Recurring; or Category 4

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. Summarized below, is one Category 4 occurrence with potential environmental implications that occurred on the Hanford Site in 2012, and the discoveries of legacy contamination.

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 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 2012, there were 27 documented occurrences of legacy contamination.

2.8 Standards and Permits

JK Perry, TG Beam, CJ Clement, and JW Wilde

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 are listed in Table 2.11.

Table 2.11. Environmental Permits

Dangerous Waste Permit (RCRA)
<p><i>Hanford Facility Dangerous Waste Permit (WA7890008967) was issued on September 27, 1994, and has undergone several revisions. The permit expired on September 27, 2004; however, Permit WA7890008967, Rev. 8C, remains in effect until a new permit is issued. Ecology issued a draft permit for public review and comment, from May 1, 2012 through October 22, 2012 (WA7890008967, Rev. 9). Ecology received more than 4,000 comments on the draft permit, including approximately 1,800 comments from the public and 3,000 comments from the DOE. Because information and arguments brought up during the comment period raised substantial new questions, Ecology plans to revise the draft Permit and reopen the comment period (see Section 2.1.1.1).</i></p>
Air Permits
<ul style="list-style-type: none"> • 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 expired January 1, 2012. Because the Hanford Site submitted a complete AOP renewal application, the permit remains in effect until a new one is issued, which is expected in the spring of 2013. The permit is intended to provide a compilation of applicable <i>Clean Air Act</i> requirements for both radioactive and non-radioactive emissions at the Hanford Site. It will be implemented through federal and state programs (see Section 2.3.2). • <i>Radioactive Air Emissions License for the Department of Energy Richland Operations Office Hanford Site, License Number FF-01 (DOH 2012), is issued to RL by the Washington State Department of Health. This permit was effective February 23, 2012, and expires December 31, 2017. The FF-01 license is a compilation of all applicable radioactive air emission requirements.</i>
Drinking Water Permits
<ul style="list-style-type: none"> • ID# 00177 J is a permit to operate the 100-K Area drinking water system. The permit is issued by the State of Washington Department of Health. • ID# 001004 is a permit to operate the 200-West Area drinking water system. The permit is issued by the State of Washington Department of Health. • ID# 418408 is a permit to operate the 300 area drinking water system. The permit is issued by the State of Washington Department of Health. • ID# 419470 is a permit to operate the 400 area drinking water system. The permit is issued by the State of Washington Department of Health.

Table 2.11. Environmental Permits**Waste Water Permits**

- Permit [CR-IU010](#), 300 Area combined Sewer Industrial Wastewater Permit, is issued to RL by the city of Richland. Permit CR-IU010 governs the discharges from the 300 Area facilities into the city of Richland sewer collection system.
- HAN002 through HAN073 permits on-site sewage systems to operate on the Hanford site. These permits are issued by the State of Washington Department of Health.
- Permit [ST 4500](#), *State Waste Discharge Permit* allows treated wastewater from the Effluent Treatment Facility to be discharged to the State-Approved Land Disposal Site. This permit expired August 1, 2005; old permit will remain in effect until the new permit is issued. On February 3, 2005, Ecology received the DOE's application for renewal of the Permit ([05-AMCP-0153](#)); however, Ecology has not reissued the Permit.
- Permit [ST 4502](#), *State Waste Discharge Permit* allowed treated effluent from the 200-East and 200-West Areas to be discharged to the 200 Area Treated Effluent Disposal Facility. This permit was superseded by Permit No. ST 4502, on July 1, 2012.
- Permit [ST 4507](#), *State Waste Discharge Permit* 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 expired permit remains in effect. The lagoon ceased operations in November of 2012. DOE submitted a request to Ecology to cancel this permit on December 19, 2012 (13-EMD-0016). Ecology responded to this request on February 7, 2013 and canceled Permit ST-4507.
- Permit [ST 4511](#) is a Categorical State Waste Discharge Permit that authorizes the discharge of wastewater from maintenance, construction, and hydro testing activities and allows for cooling water, condensate, and industrial storm water discharges at the Hanford Site. This permit was issued February 16, 2005, and expired February 16, 2010. A permit renewal application for [ST 4511](#) was filed with the Ecology in August 2009. The expired permit will remain in effect until a new permit is issued.
- Permit [ST-0045514](#), *State Waste Discharge Permit* for the 200-West Area Evaporative Sewage Lagoon, and replaces the 100-N Sewage Lagoon (Permit ST 4507). The 200-West Area Evaporative Sewage Lagoon is a new domestic wastewater treatment facility located northeast of the 200-West Area of the Hanford Site. The facility consists of double-lined evaporative lagoons and is designed to have no liquid discharge to the ground. The system will provide domestic wastewater treatment for the 200 West and 600 Areas, as well as provide treatment for domestic wastewater hauled from the 200-East Area and other locations within the Hanford Site.
- Permit [WAG-50-5180](#), Washington State Sand and Gravel General Permit for the Concrete Batch Plant in the 200-East Area. The Concrete Batch Plant supports the construction of the WTP, and the primary function is making concrete. The permit provides coverage for discharges of process water, storm water, and mine dewatering activities associated with Sand and Gravel operations and rock quarries. Bechtel National is the owner of the permit and the operator is Ready Mix Concrete. This permit was effective October 1, 2010, and expires on October 1, 2015.
- Permit [WAG-50-5181](#), Washington State Sand, and Gravel General Permit for Gravel Pit 30 Quarry in the 200-East Area. Ecology issued the permit to BNI as the owner and to Ready Mix Concrete as the operator. This permit was effective October 1, 2010, and expires on October 1, 2015. The Pit 30 Quarry supports the construction of the WTP, and the primary function is making gravel.

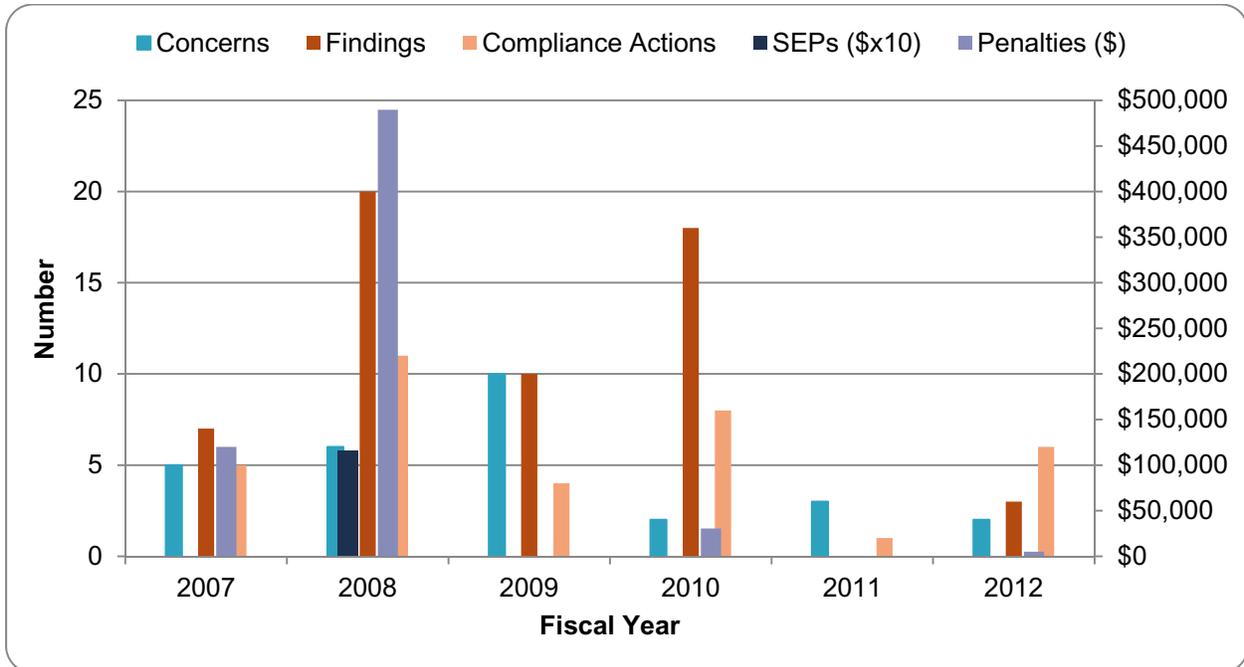
Table 2.11. Environmental Permits

Wildlife Permits		
<ul style="list-style-type: none"> Permit MB14155A-2, Federal Fish and Wildlife Permit, issued by the U.S. Fish and Wildlife Service to MSA; authorizes the collection of migratory birds from transformers and conductors when imminent threat of fire and power outages. This permit expires March 31, 2013. 		
<ul style="list-style-type: none"> Permit MB30480A-1, Federal Fish and Wildlife Permit, issued by the U.S. Fish and Wildlife Service to CHPRC; authorizes incidental take of bald eagles associated with operations at 100-K Area and the 100-HX Pump and Treat System. This permit expires March 31, 2014. 		
<ul style="list-style-type: none"> Permit MB14155A-2, Federal Fish and Wildlife Permit, issued by the U.S. Fish and Wildlife Service to MSA; authorizes the collection of migratory birds for determination and control of radiological and chemical contamination. This permit expires March 31, 2015. 		
<ul style="list-style-type: none"> Review Reference Number 13260-2009-I-0121, Federal Fish and Wildlife Section 7 Review, issued to Environmental Assessment Services in July of 2009 for the potential of incidental take of salmonids during fishing activities in the Columbia River. This review has no expiration listed. 		
<ul style="list-style-type: none"> Review Reference Number 13260-2011-I-0080, Federal Fish and Wildlife Section 7 Review, issued to DOE in July of 2011 for the potential of incidental take of bull trout during fishing activities in the Columbia River. This review has no expiration listed. 		
<ul style="list-style-type: none"> Permit 11-295c, Scientific Collection Permit issued by the Washington Department of Fish and Wildlife to Environmental Assessment Services for August 2011 through August 2012; authorizes the collection of food fish, shellfish, game fish, and wildlife for research purposes. This permit is renewed annually. 		
<ul style="list-style-type: none"> Permit 12-304a, Scientific Collection Permit issued by the Washington Department of Fish and Wildlife to Environmental Assessment Services for September 2012 through September 2013; authorizes the collection of food fish, shellfish, game fish, and wildlife for research purposes. This permit is renewed annually. 		
Agency Contact Information		
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
U.S. Fish and Wildlife Service Migratory Bird Permit Office 911 N.E. 11th Avenue Portland, OR 97232-4181	Washington State Department of Health P.O. Box 47890 Olympia, WA 98504-7890	

2.9 Environmental Noncompliance's

During CY2012 there were three findings, and one fine. The findings included (1) Notice of Noncompliance for violation of the 184-H Post-Closure Monitoring Plan, where the groundwater concentration limits for nitrate and other waste indicators was exceeded; (2) Notice of Violation for missed TPA Milestone M-047-06; and (3) Notice of Penalty for missed TPA Milestone M-047-06 that resulted in a fine of \$5,000 for failure to comply with the requirements of M-047-06.

Figure 2.1. Environmental Noncompliance's



SEP = Supplemental Environmental Project (performed to benefit the local community in lieu of a penalty payment).

3.0 Environmental Management Systems

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DOE requires that Hanford Site contractors develop and operate under an Integrated Safety Management System (ISMS). In accordance with contract obligations, contractors maintain an Environmental Management System (EMS) that is consistent with the ISO standard—*Environmental Management Systems – Requirements with Guidance for Use* ([ISO 14001:2004\[E\]](#)). All but one Hanford Site contractor has established ISMS 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 Hanford Site entities under the authority of [DOE M 450.4-1](#), *Integrated Safety Management System Manual*, had incorporated appropriate environmental program elements within their ISMS. The dates that DOE approved the Hanford Site contractor’s ISMS are provided in Table 3.1.

[DOE O 450.1A](#) requires implementation of an EMS that is integrated into each DOE site ISMS and reflects the elements and framework in the [ISO 14001:2004\(E\)](#) standard. 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 O 450.1A](#) further states that each EMS 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 ensure continual environmental improvement. In addition, the EMS must address sustainable practices for enhancing environmental, energy, and transportation performance required by [Executive Order 13423](#) (72 FR 3919) and [DOE O 430.2B](#); 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 nanomaterial hazards; and identification of opportunities to implement additional sustainable practices. Implementing an EMS 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](#) builds upon the requirements of [Executive Order 13423](#) (72 FR 3919), including the requirement to implement an EMS 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. The dates that DOE directed Hanford Site contractors to implement [DOE O 450.1A](#), [DOE O 430.2B](#), [Executive Order 13423](#), and [Executive Order 13514](#) are provided in Table 3.1. The date these orders were issued are provided in Table 3.2.

[DOE O 436.1](#), approved in May 2011, requires development of a Site Sustainability Plan that is integrated into operational plans, and development of an EMS that is certified to, or conforms with the [ISO 14001:2004\(E\)](#) standard. The order also requires submitting sustainability goal data and reports as well as [Emergency Planning and Community Right-to-Know Act](#) reporting. [DOE O 436.1](#) cancels [DOE O 430.2B](#) and [DOE O 450.1A](#). The dates that DOE directed Hanford Site contractors to implement [DOE O 436.1](#) and cancel implementation of [DOE O 430.2B](#) and [DOE O 450.1A](#), are provided in Table 3.1, in addition to the dates that Hanford Site contractors became certified to or declared conformance with the [ISO 14001:2004\(E\)](#) standard.

Performance related to EMS must be reported annually to DOE HQ. Each contractor is given an overall ranking of Red, Yellow or Green based on the previous FY’s performance. Rankings for Hanford Site contractors are provided in Table 3.1 along with rankings for both Hanford DOE Offices.

MSA—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 was revised in 2012 and describes the energy management program; identifies planned energy efficiency, water conservation, transportation fleet management, and sustainable buildings activities; and includes an emergency conservation component, as required by [DOE O 436.1](#) and [Executive Order 13423](#) (72 FR 3919). Environmental objectives, developed in 2010, were maintained, as were plans for recycling, ozone-depleting substance management, environmentally preferred procurement management, and electronic asset stewardship. The *Hanford Site Ozone-Depleting Substance Program Plan* ([DOE/RL-2010-86](#)) 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 when disposing ozone-depleting substances that are removed from refrigerant systems being decommissioned or taken out of service.

Several contractors have made their environmental policy and environmental aspects available to the public through company Internet websites (Table 3.3). Benefits of implementing the systematic approach of an EMS, 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 usage; efficient environmental sampling; increased recycling; more efficient waste disposal; and enhanced awareness of environmental performance.

3.1 Environmental Performance Measures

MSA, in consultation with the DOE and other Hanford Site prime contractors, developed and maintains environmental performance measures for the Hanford Site. Performance measures address the goals of [DOE O 436.1](#), [Executive Order 13423](#) (72 FR 3919), and [Executive Order 13514](#) (74 FR 52117).

The measures developed in response to these executive 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 ensure environmental goals within the DOE orders are appropriately managed. Performance related to EMS must be reported annually to DOE HQ.

Fleet Management. The acquisition target for alternative fuel vehicles was surpassed in FY2012 (Figure 3.1). DOE requires that a minimum of 75 percent of all non-mission critical light-duty vehicles purchased through the end of FY2014 be alternative fuel vehicles ([DOE O 436.1](#)). This percentage increases to 100 percent beginning in FY2015. The vehicle fleet reduction target also was met in FY2012 (Figure 3.2). A requirement was set for Hanford to reduce its January 2011 fleet inventory of 1567 non-mission critical vehicles by 369 vehicles (35 percent of the FY2005 inventory of 1053 vehicles) to reach 1198 non-mission critical vehicles by the end of FY2014 ([DOE O 436.1](#)).

Table 3.1 DOE Contract Actions and Contractor Implementation

DOE Contract Actions & Contractor Implementation	Richland Operations Office (RL)				Office of River Protection (ORP)		
	HPMC Occupational Medical Services (HPMC)	CH2M HILL Plateau Remediation Company (CHPRC)	Mission Support Alliance, LLC (MSA)	Washington Closure Hanford, LLC (WCH)	Advanced Technologies and Laboratories, Inc. (ATL)	Bechtel National, Inc. (BNI)	Washington River Protection Solutions LLC (WRPS)
Contract Implementation	October 1, 2012	October 1, 2008	August 24, 2009	August 27, 2005	May 5, 2005	December 11, 2000	October 1, 2008
Contractor ISMS Established	NA	November 2009	January 2011	November 2007	March 2006	February 2003	September 2009
Direction to Implement DOE EO 13423	NA	October 2008	August 2009	June 2009	NA	NA	October 2008
Direction to Implement DOE O 430.2B	NA	June 2009	August 2009	June 2009	NA	NA	October 2008
Direction to Cancel DOE O 430.2B	NA	July 2012	July 2012	October 2012	NA	NA	NA
Direction to Implement DOE O 450.1A	NA	June 2009	August 2009	June 2009	November 2009	NA	October 2009
Direction to Cancel DOE O 450.1A	NA	July 2012	December 2012	October 2012	NA	NA	NA
Direction to Implement DOE EO 13514	NA	NA	May 2011	NA	NA	NA	March 2011
Direction to Implement DOE O 436.1	NA	July 2012	July 2012	October 2012	NA	NA	NA
Contractor EMS Established	NA	November 2009	December 2009	September 2009	NA	NA	September 2009
DOE Declared DOE O 450.1A Conformance	NA	December 2009	December 2009	November 2009	NA	NA	September 2009
Most Recent Declaration of Conformance	NA	NA	NA	November 2012	NA	NA	September 2012
ISO 14001 Certification	NA	July 2012	September 2011	NA	NA	NA	NA
Contractor EMS Scorecard Rating	Red	Green	Green	Green	Red	Red	Green
EMS Scorecard for 2012	Green				Yellow		

RL: DOE-Richland Operations Office

HPMC: HPMC Occupational Medical Services
 CHPRC: CH2M HILL Plateau Remediation Company
 MSA: Mission Support Alliance, LLC
 WCH: Washington Closure Hanford, LLC

ORP: DOE-Office of River Protection

ATL: Advanced Technologies and Laboratories, Inc.
 BNI: Bechtel National, Inc.
 WRPS: Washington River Protection Solutions, LLC

Table 3.2 DOE Order and Executive Order Issuance

Order	Approval Date
DOE Order 450.1	January 15, 2003
Executive Order 13423	January 26, 2007
DOE Order 430.2B	February 27, 2008
DOE Order 450.1A	June 4, 2008
Executive Order 13514	October 8, 2009
DOE Order 436.1	May 2, 2011

Table 3.3 Hanford Site Environmental Management System Internet Links

Contractor	Website	Category
CHPRC	http://www.platauremediation.hanford.gov/index.php/page/154/	Policy
MSA	http://msa.hanford.gov/msa/filedisplay.cfm?fileid=Env%2E%20Management%20System	Policy, Aspects
WCH	http://www.washingtonclosure.com/about_us/environmental_stewardship	Policy, Aspects
WRPS	http://www.wrpstoc.com/what_we_do/environmental_management	Policy, Aspects

Alternative Fuel Use. The alternative fuel use target was surpassed for FY2012 as was the target for petroleum-based fuel use (Figure 3.3). 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 used by 2 percent annually through FY2020, relative to a FY2005 baseline and to increase the amount of alternative fuels used by 10 percent annually through to FY2015, relative to a FY2005 baseline ([Executive Order 13514](#) [74 FR 52117]).

Potable and Non-Potable Water. The target objectives for potable and non-potable water were met in FY2012 (Figure 3.4). Water use requirements, as specified by Executive Order 13514 (74 FR 52117), stipulate the reduction of potable water consumption intensity by 2 percent annually through FY2020, or 26 percent by the end of FY2020, relative to a baseline of water consumption in FY2007. Correspondingly, there is a requirement to reduce non-potable water use by 2 percent annually through the end of FY2020, or 20 percent by the end of FY2020, relative to a FY2010 baseline.

Green Electricity. The target objective for green electricity was met; however, the target objective for standard electricity was not met in FY2012 (Figure 3.5). 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 percent annually, or 45 percent through the end of FY2020, relative to the FY2003 baseline, and an increase in renewable energy consumption (green electricity) equivalent to 7.5 percent of the annual electricity and thermal consumption total by FY2010.

Facility Fuel. The target objectives for facility fuel use were met in FY2012 (Figure 3.6). Objectives were established to demonstrate improvements in energy efficiency and effective management of energy use. The target requirements include reducing energy use by 3 percent annually (or 45 percent through the end of FY2020) relative to the FY2003 baseline.

Facility Energy Use. The target objective for facility energy use was met in FY2012 (Figure 3.7). Requirements call for the reduction of energy use, a combination of electricity, fuel oil and natural gas use, by 3 percent annually, or 45 percent through the end of FY2020, relative to the FY2003 baseline,

Electronic Product Environmental Assessment Tool. The target objectives for Electronic Product Environmental Assessment Tool were exceeded, with 98 percent of the purchases meeting the requirements (Figure 3.8). [Executive Order 13514](#) (74 FR 52117) specifies 95 percent 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.

Sanitary Waste Reduction. The target objective for sanitary waste reduction requires the diversion of post-consumer materials suitable for reuse and recycling from landfills by 10 percent per year, based on a FY2010 baseline (Figure 3.9). More Hanford Site sanitary waste was recycled than was sent to landfills in FY2012.

Regulated Waste Reduction. The target objective for regulated waste reduction was met in FY2012 (Figure 3.10). Objectives for regulated waste reduction on the Hanford Site include eliminating or minimizing waste generation 5 percent annually (based on FY2009 generation) through source reduction including segregation, substitution, and reuse that would otherwise require storage, treatment, and long-term monitoring and surveillance. Regulated waste includes waste such as hazardous, universal, special, state-regulated industrial and radioactive waste not suitable for disposal in sanitary or construction and demolition landfills. Regulated waste from Hanford's ERDF is not included in Figure 3.9. Waste to this facility decreased in FY2012 (Figure 3.11).

In addition to these metrics, each contractor has established company-specific performance measures within their EMS.

3.2 Awards and Recognition

JF Ollero

3.2.1 Hanford Site

The Hanford Site did not receive any other DOE, federal agency, state agency, or industry-sponsored environmental awards or recognition in 2012. As part of their EMS, several Hanford Site contractors developed internal environmental awards programs to recognize leadership in environmental, energy, and transportation stewardship.

3.2.2 Advanced Technologies and Laboratories

Advanced Technologies and Laboratories received notification from DOE-HQ in March 2011 that it was successfully recertified at the Voluntary Protection Program Star level.

3.2.3 CH2M Hill Plateau Remediation Company

In July 2011, CHPRC received the Voluntary Protection Program Merit Status. CHPRC was awarded five DOE-EM Environmental Star Awards in 2012 for activities performed in FY2011, including two EM Best-in-Class awards and three Honorable Mention awards. The projects awarded the EM Best-in-Class, *Preparation of the U-Canyon for Demolition and Barrier Construction*, a co-project with WCH, and *Next Generation Retrieval*, focused on pollution prevention measures to divert waste from being disposed in landfills. The projects awarded Honorable Mentions included *Stockpiled Material Used as Backfill, Pump & Treat Process Improvements*, and *Rail Cars Preserved for Public Display*. In addition, CHPRC was awarded the ORP Manager's Award for Exemplary Service for developing a method to remove radioactive sodium metal from the scrap metal of a sodium-cooled nuclear reactor and received an Academy of Certified Hazardous Materials Management (ACHMM) Special Achievement award from the Eastern Washington Chapter for organizing and implementing a Zero-Waste Picnic. CHPRC also attained [ISO 14001:2004](#) certification in July 2012.

3.2.4 Mission Support Alliance, LLC

MSA maintained certification to the [ISO 14001:2004\(E\)](#) standard in FY2012 by successfully passing an external surveillance of its EMS. Certification was initially achieved in September 2011. Also in September 2011, DOE awarded the HAMMER training facility, operated by MSA, the Voluntary Protection Program Star Status. DOE awarded MSA with Voluntary Protection Program Star Status in January 2011 for its Mission Support Services and Merit Status for its Safeguards and Security group. Star status is DOE's highest level of excellence in employee safety and health. MSA also was awarded several DOE EM Environmental Star Awards in 2012 for activities performed in FY2011, including one EM Best-in-Class award and four Honorable Mention awards. The project awarded Best-in-Class, *Data Center and Infrastructure Consolidation*, focused on operational efficiencies within datacenters that allowed consolidation of 13 datacenters into two and yielded a 50 percent power and 18 percent energy load reduction. Activities awarded an Honorable Mention included *Voice over Internet Protocol (VoIP)*, *Sustainable Fleet Management*, *Thin Client*, and a co-project with WCH *Solar Powered Lighting at the 618-11 Burial Ground Remediation Site*.

3.2.5 Washington Closure Hanford, LLC

WCH was awarded three DOE EM Environmental Star Awards in 2012 for activities performed in FY2011, which included one DOE EM Best-in-Class award and two Honorable Mention awards. The project awarded Best-in-Class, *Preparation of the U-Canyon for Demolition and Barrier Construction*, a co-project with CHPRC, focused on pollution prevention measures to divert waste from being disposed in landfills. The Honorable Mention awards included *Removal and Reuse of 30 Miles of Rail Line* and a co-project with MSA *Solar Powered Lighting at the 618-11 Burial Ground Remediation Site*.

3.2.6 Washington River Protection Services

WRPS maintains its Voluntary Protection Program Merit Status. The WRPS employees have amassed an unprecedented safety record; surpassing 5 million hours without a lost-workday injury resulting in two Presidents Awards from URS for safety performance in 2012.

The WRPS President and Project Manager declared the EMS conformance to the ISO 14001 standard, consistent with the requirement of [DOE O 450.1A](#) following the required triennial audit. The DOE-ORP Manager documented the EMS for WRPS conformance to the [ISO 14001:2004](#) standard in a memo to DOE-HQ dated September 26, 2012.

Figure 3.1. Fleet Management – Acquisitions
 (FY2005 through FY2020)
 AFV = alternative fuel vehicles

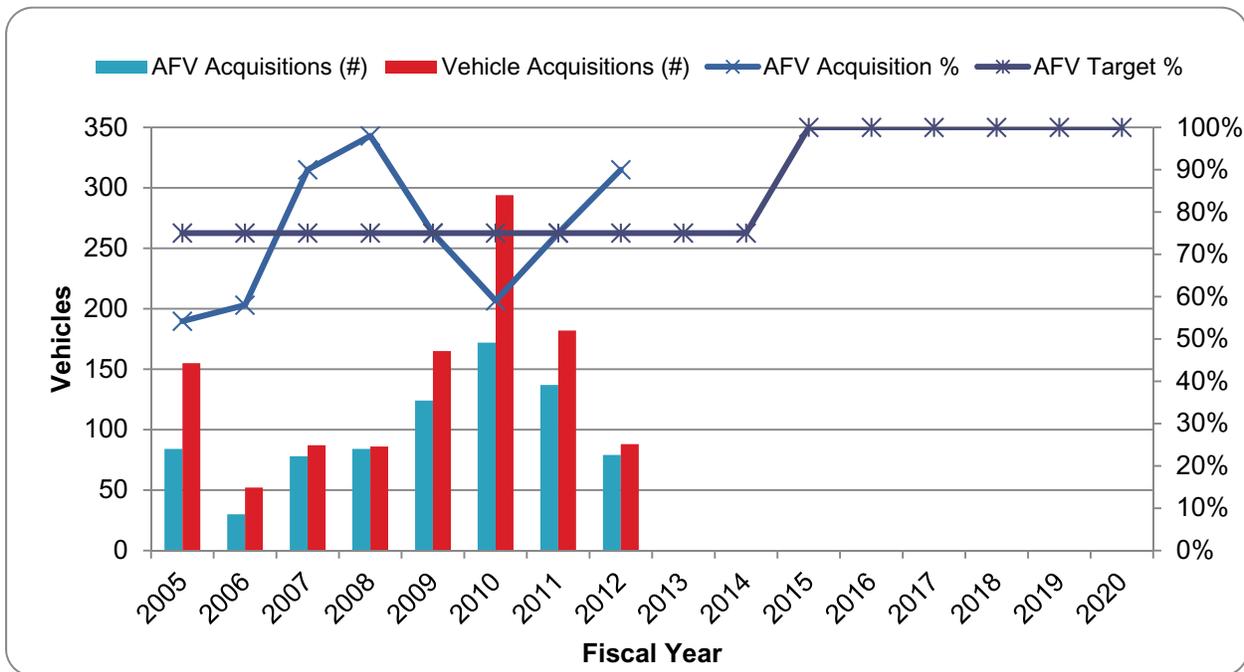


Figure 3.2. Fleet Management – Reduction
(FY2005 through FY2012, Target Objectives through 2015)

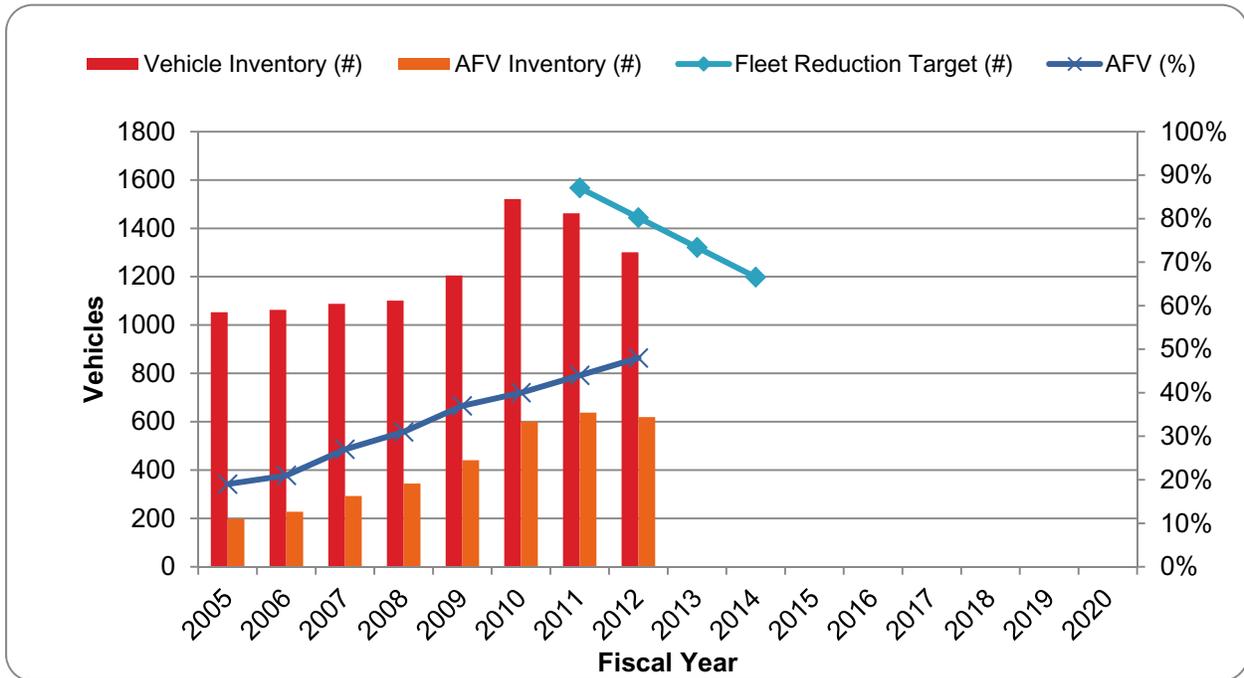


Figure 3.3. Vehicle Fuel Use
(FY2005 through FY2012, Target Objectives through 2020)

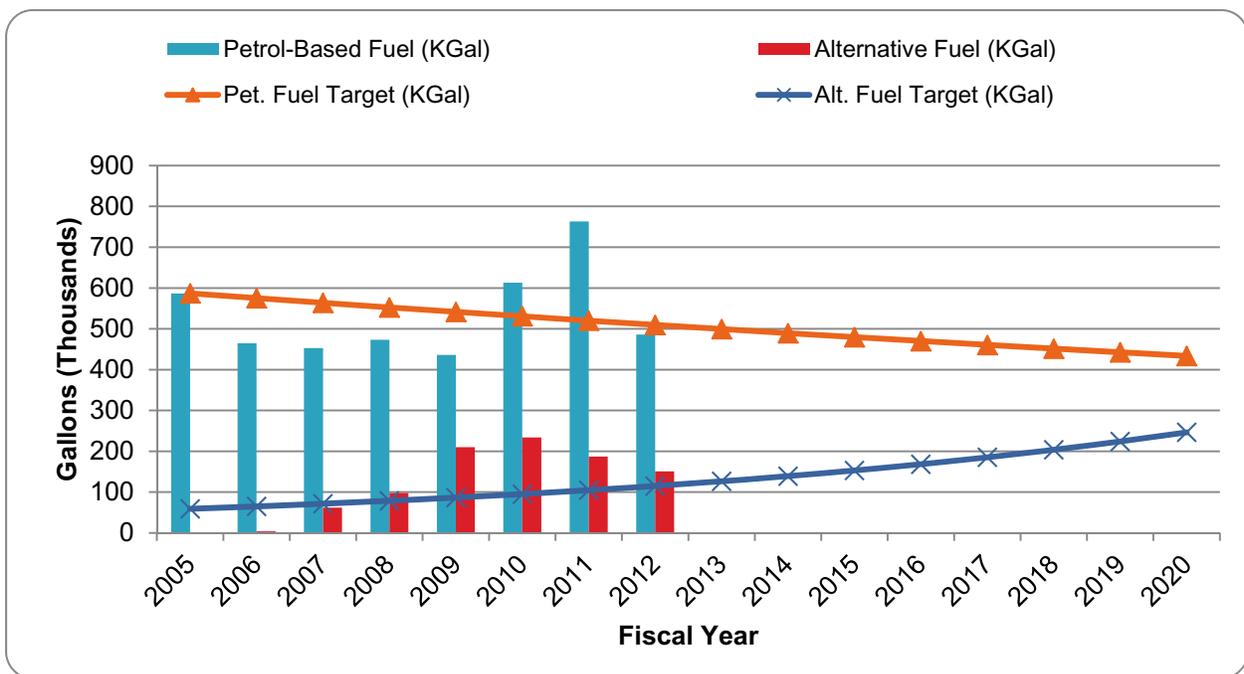


Figure 3.4. Water Use
 (FY2007 through FY2012, Target Objectives through 2015)

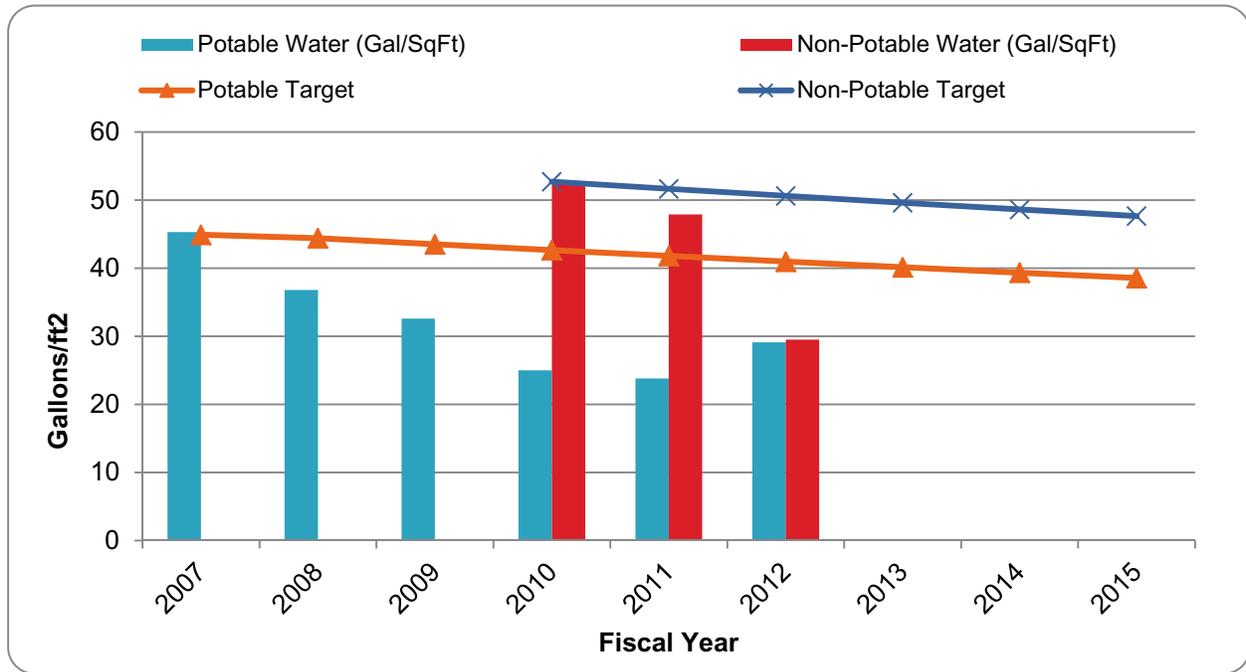


Figure 3.5. Electricity Use
 (FY2003 through FY2012, Target Objectives through 2015)

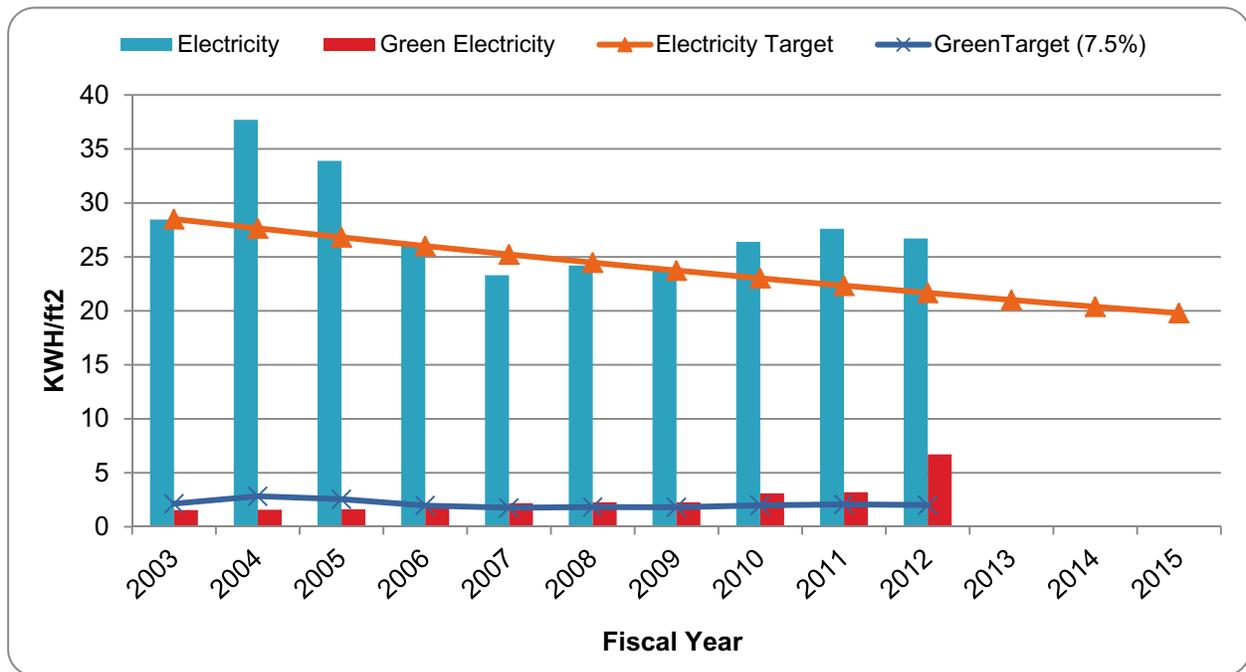


Figure 3.6. Facility Fuel Use
 (FY2003 through FY2012, Target Objectives through 2015)
 KBTU = one thousand British thermal units

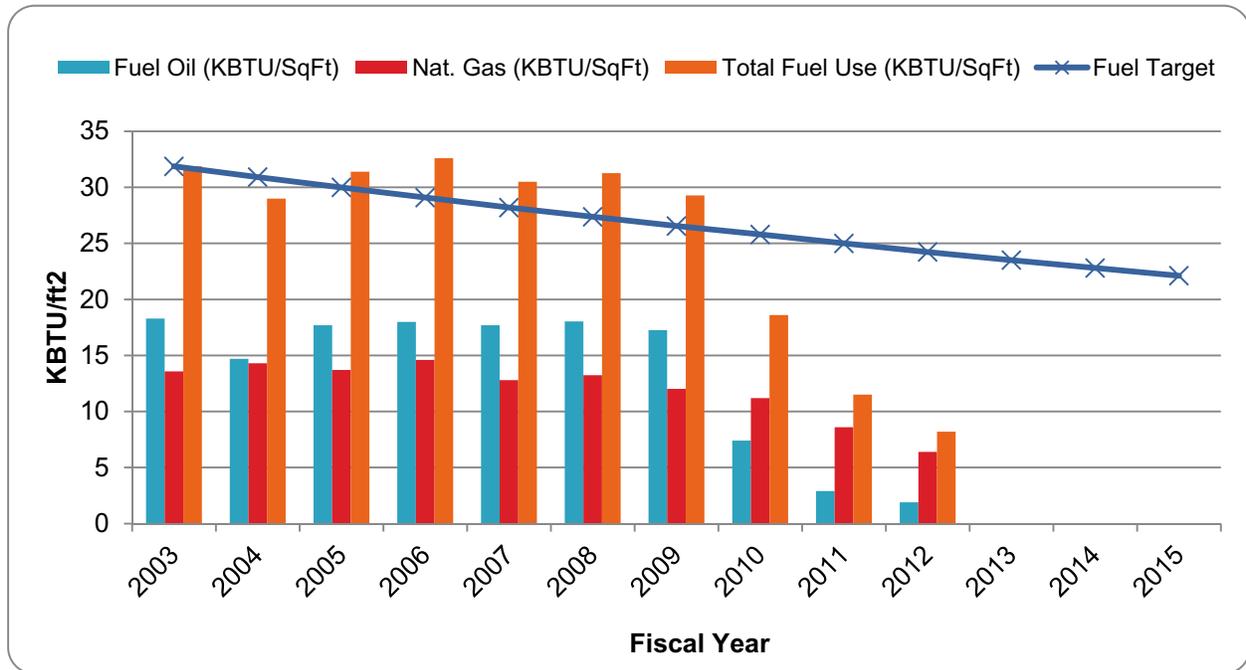


Figure 3.7. Facility Energy Use
 (FY2003 through FY2012, Target Objectives through 2015)
 KBTU = one thousand British thermal units

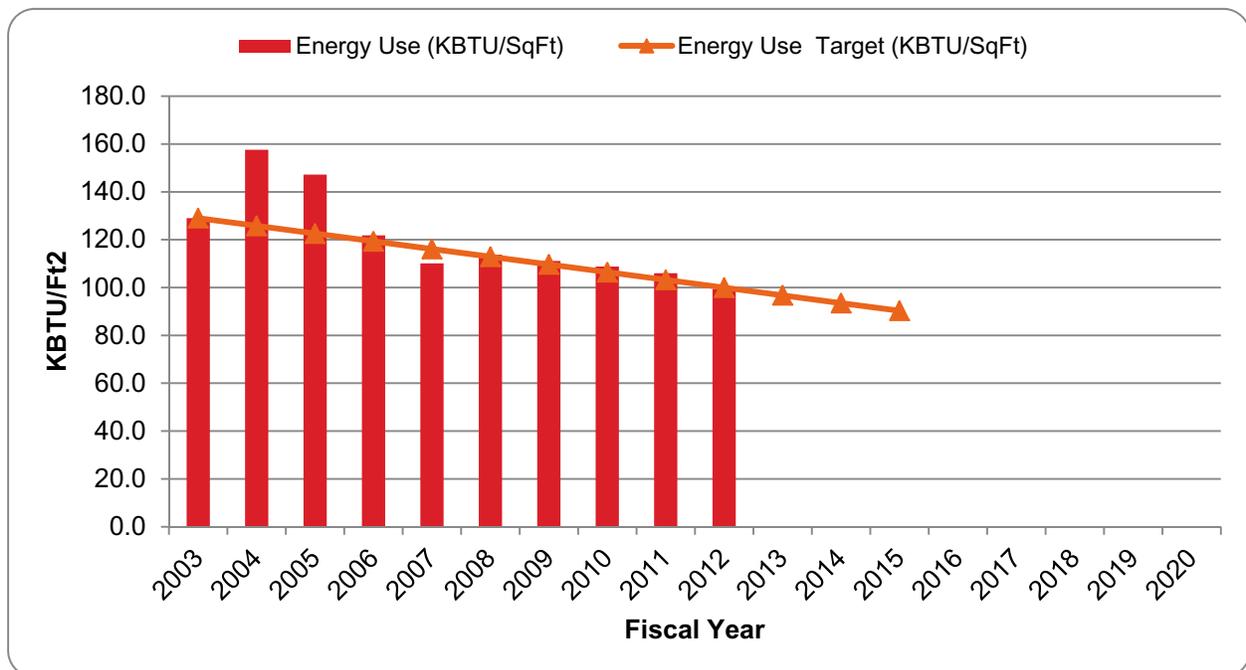


Figure 3.8. Electronic Product Environmental Assessment Tool Standards Compliance
(FY2009 through FY2012, with Target Objectives through 2015)

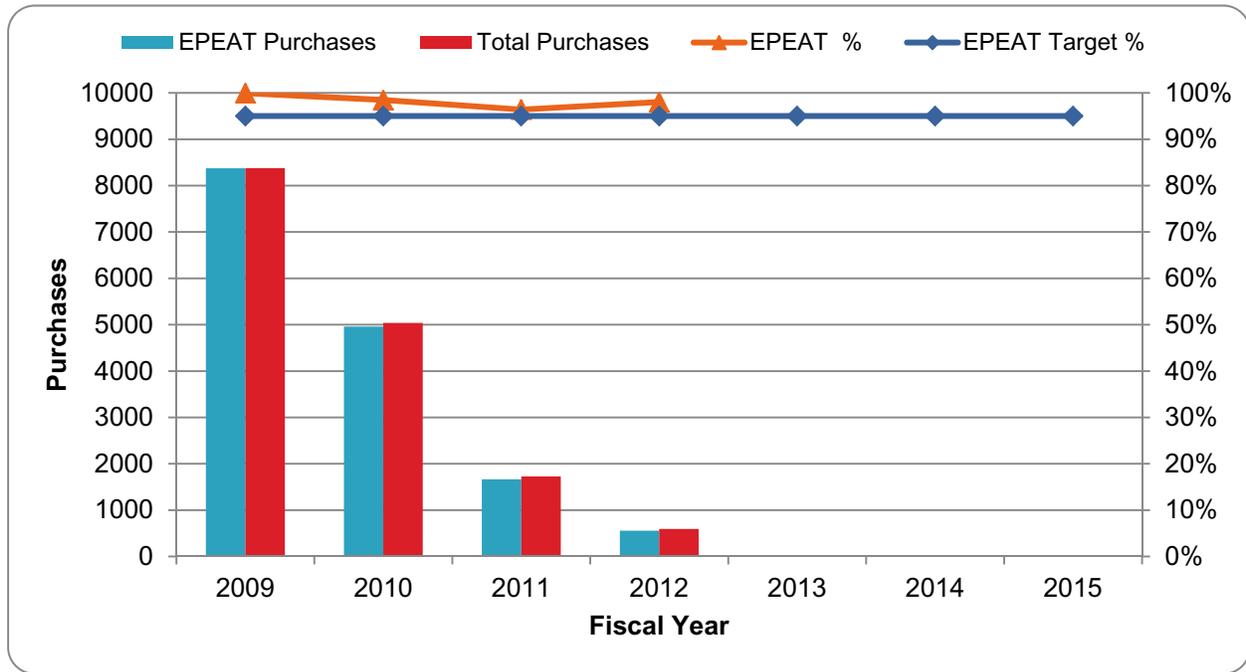


Figure 3.9. Sanitary Waste Reduction
(FY2008 through FY2012, Target Objectives through 2015)

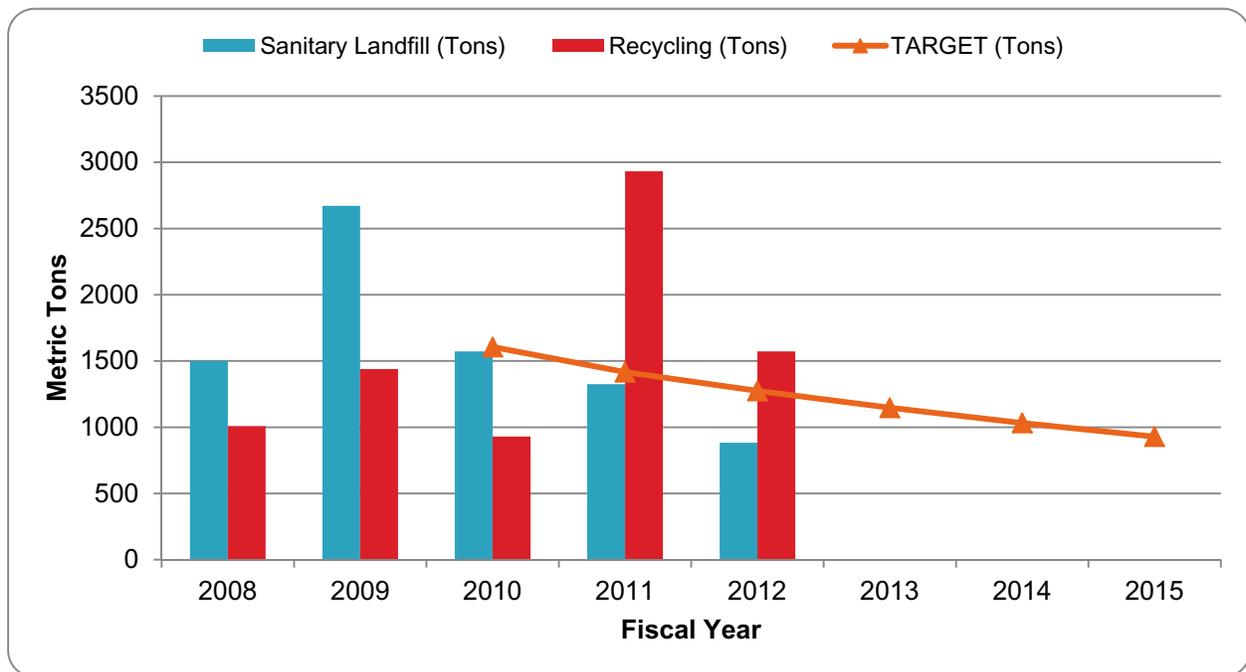


Figure 3.10. Regulated Waste Reduction

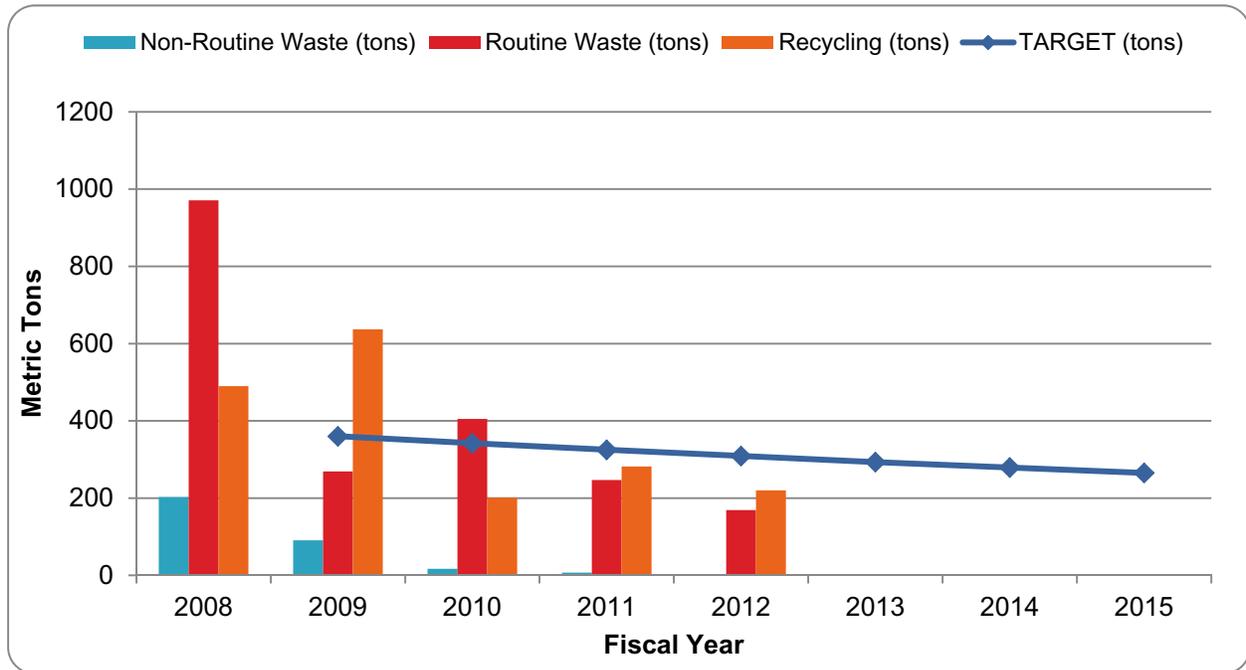
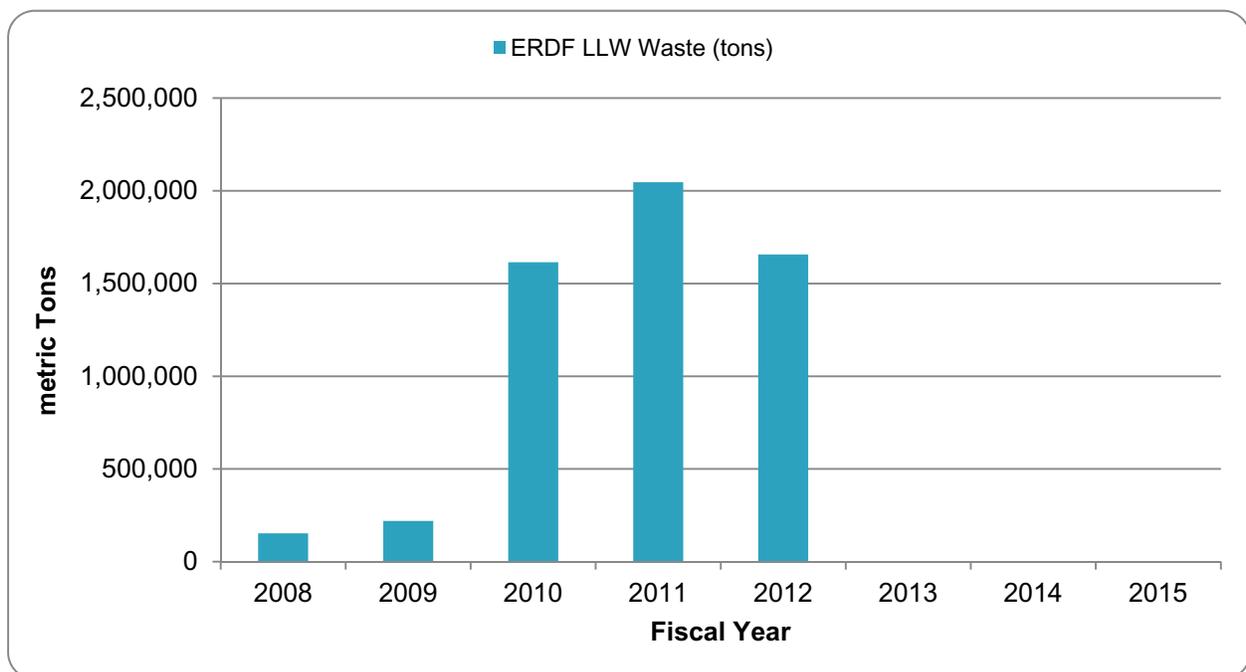


Figure 3.11. Onsite Waste Disposal
(FY2008 to FY2012, at the Environmental Restoration Disposal Facility)



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4.0 Radiological Protection and Doses

This section provides information on Hanford Site radiological program and doses, and cleanup activities as DOE progresses toward site closure and the likely transfer of property to other entities during 2012.

4.1 External Radiation Monitoring

CJ Perkins

External radiation is defined as radiation originating from a source external to the human body. External radiation was monitored at the Hanford Site 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 percent to 25 percent at any location because of changes in soil moisture and snow cover (National Council on Radiation Protection and Measurements 1975).

The Harshaw^{TM1} 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. 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 3.3 feet (1 meter) aboveground 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 included underground radioactive material areas, contamination areas, soil contamination areas, high-contamination areas, roads, and fence lines.

External radiation fields were monitored in 2012 at 118 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 4.1 compares 2011 and 2012 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. Data obtained from on-site thermoluminescent dosimeters is used as a qualitative indicator and verification of ambient air sampling results per the [FF-01](#), *Hanford Site Radioactive Air Emissions License*.

Additional information on radiation, dose rates, and dose terminology can be found in Appendix A, Helpful Information; and Appendix B, Glossary.

4.1.1 External Radiation Measurements

100-K Area. Cleanup activities for the K Basins Closure Project during 2012 resulted in continued decreases in the average dose rates at most TLD locations in the 100-K Area compared to 2011 (Figure 4.1). Dose-rate levels measured in 2012 at monitoring stations in the K-East Area were 27 percent lower than 2011 levels. Dose-rate levels measured in 2012 at monitoring stations at the CVDF and in the 100-K West Area were unchanged compared to 2011.

¹ Harshaw is a trademark of Thermo Fisher Scientific, Inc., Waltham, Massachusetts.

100-N Area. Average dose-rate levels observed in the 100-N Area during 2012 showed an overall increase (approximately 10 percent) compared to 2011 levels. This was primarily due to elevated first quarter measurements at the monitoring station located along/near the transportation route for disposal of radioactive waste. Due to overall decreases in dose rate levels at the individual TLD locations, during the fourth quarter of 2012, monitoring concluded at all monitoring stations except the shoreline location.

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 4.1). The 2012 average dose rate was unchanged compared to 2011, and was less than 100 millirem (1 millisievert) per year.

200-East and 200-West Areas. Dose rate levels measured during 2012 in the 200-East and 200-West Areas were slightly increased compared to 2011 (Figure 4.1). Average dose rates measured in 2012 at ERDF (located near the 200-West Area) were slightly higher than 2011 levels (approximately 9 percent).

200-North Area. One TLD monitoring site, located in the 200-North Area at the contaminated 212-R Railroad Car Disposition Area, continued to show a significant annual average dose rate decrease (approximately 65 percent) in 2012 compared to 2011 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 began to fall as the radiologically contaminated railroad cars were dispositioned.

300 and 400 Areas. The average dose rates in 2012 in the 300 and 400 Areas and at the 300 Area Treated Effluent Disposal Facility were comparable to 2011 levels (Figure 4.1).

618-10 Burial Ground. TLD monitoring was initiated during late-February 2010 at four locations at this project. The average dose rates in 2012 were comparable to 2011 levels.

Integrate Disposal Facility. The average dose rates in 2012 were slightly higher (7 percent) than 2011 levels.

Table 4.1. Thermoluminescent Dosimeter Results
(mrem/year)^a

Location	No. of Dosimeters	2011		2012		Percentage Change ^e
		Maximum ^b	Average ^{c,d}	Maximum ^b	Average ^{c,d}	
100-K	14	207 ± 203	102 ± 74	107 ± 16	82 ± 16	-19
100-N	5	203 ± 185	116 ± 115	311 ± 535	140 ± 228	10
200-East	42	385 ± 407	100 ± 98	176 ± 87	102 ± 48	1
200-West	24	178 ± 63	96 ± 52	151 ± 12	100 ± 40	4
200-North (212-R) ^f	1	570 ± 86	251 ± 456	88 ± 13	83 ± 9	-66
300 Area	8	114 ± 12	86 ± 29	111 ± 20	86 ± 23	<1
300 TEDF	6	81 ± 6	79 ± 4	86 ± 16	83 ± 6	5
400 Area	7	89 ± 8	79 ± 9	91 ± 8	82 ± 8	4
618-10	4	75 ± 34	74 ± 4	80 ± 20	77 ± 6	4
CVDF	4	78 ± 13	74 ± 5	76 ± 12	75 ± 2	<1
ERDF	3	89 ± 5	81 ± 13	101 ± 26	89 ± 20	9
IDF ^f	1	88 ± 13	83 ± 7	98 ± 15	89 ± 12	7

^a To convert to international metric system units, multiply mrem/year by 0.01 to obtain millisievert/year

^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 2011 mean

^f Maximum value represents highest quarterly value ± analytical uncertainty.

TEDF = 300 Area Treated Effluent Disposal Facility

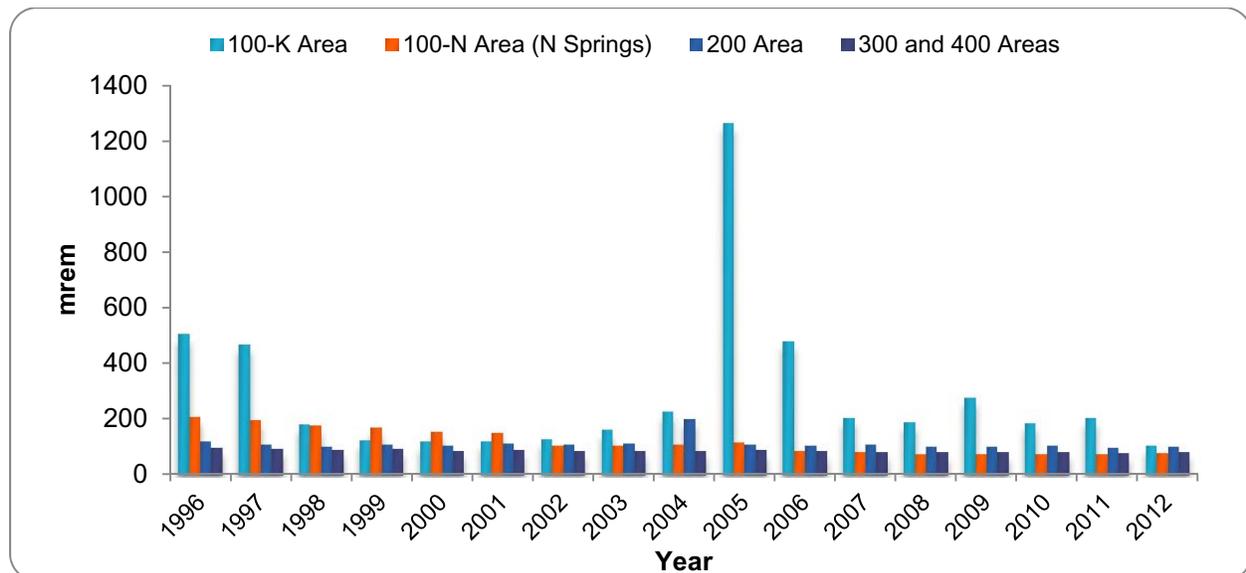
4.1.2 Waste Disposal Sites Radiological Surveys

MC Dorsey

During 2012, a total of 744 environmental radiological surveys were conducted at active and inactive waste disposal sites and the surrounding terrain to detect and characterize radioactive surface contamination. Data obtained from on-site thermoluminescent dosimeters is used as a qualitative indicator and verification of ambient air sampling results per the [FF-01](#), *Hanford Site Radioactive Air Emissions License*. Vehicles equipped with radiation detection devices and global positioning systems were used to measure accurately the extent of contamination. Area measurements were entered into the Hanford Geographical Information System, a computer database maintained by MSA. 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 Hanford Site operational areas. These sites were posted as underground radioactive material areas, contamination areas, and soil contamination areas. The external dose rate at 80 percent 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.

Figure 4.1. Average Thermoluminescent Dosimeter Results



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 0.25 inch [0.6 centimeter]). 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. In addition, onsite paved roadways on which radioactive materials are transported to ERDF are surveyed annually. Table 4.2 shows the outdoor contamination areas, underground radioactive material areas, and interim-closed areas.

Table 4.2. Outdoor Contamination Area Status

Areas	Change in Status of Outdoor Contamination Areas During CY2012	Area	
		acres	ha
100 Area	Contamination/soil contamination area/underground radioactive material area to interim closed ^a	17.3	7.0
200-East Area	Contamination/soil contamination area/underground radioactive material area to interim closed ¹	0.0	0.0
200-North Area	Contamination/soil contamination area/underground radioactive material area to interim closed ¹	0.0	0.0
200-West Area	Contamination/soil contamination area/underground radioactive material area to interim closed ¹	0.0	0.0
300 Area	Contamination/soil contamination area/underground radioactive material area to interim closed ¹	2.5	1.0
400 Area	None to report	0.0	0.0
600 Area	Contamination/soil contamination area/underground radioactive material area to interim closed ¹	0.0	0.0
Totals		19.8	8.0

^a Change due to remediation activities.

Ha = hectare acres

4.2 Potential Radiological Doses

R Perona, RT Ryti

Potential radiological doses to the public and biota from Hanford Site operations in 2012 were evaluated 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 areas of contaminated soil and operating facilities. A summary of the methods and results of the public and biota dose assessments is provided here. Details of the methods used to calculate radiological doses are provided in Appendix D.

The radiological impacts of 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 O 458.1](#), Chg. 2; Section 4.1.1)
- Collective dose to the population residing within 50 miles (80 kilometers) of Hanford Site operation areas (Section 4.2.2)
- Doses for air pathways calculated using regulation-specified 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 4.2.3)
- Doses from recreational activities including hunting and fishing (Section 4.2.4.1)
- Dose to a worker consuming drinking water on the Hanford Site (Section 4.2.4.2)
- Doses from non-DOE industrial sources on and near the Hanford Site (Section 4.2.5)
- Absorbed dose received by biota exposed to radionuclide releases to the Columbia River and to radionuclides in onsite surface water bodies (Section 4.2.6).

Radiological dose assessments related to environmental releases are ideally based on direct measurements of radionuclide concentrations in specific exposure media; however, amounts of many radioactive materials released to the Columbia River or the atmosphere in 2012 from Hanford Site sources were too small to be measured in environmental media after they were dispersed in the offsite environment. For the radionuclides present in measurable amounts, it is difficult to distinguish the small contribution of Hanford Site sources from

contributions caused by fallout from historical nuclear weapons testing and naturally occurring radionuclides such as uranium and its decay products. As a result, computer models are employed to calculate offsite radionuclide concentrations based on measured and estimated releases.

Calculations of radiation dose require the use of biological and radiological models of the behavior of radioactive material in the human body. Scientific understanding of these processes has improved over time. In the 1960s, the annual environmental reporting at the Hanford Site used the recommendations and methodologies of the ICRP Report 2 ([ICRP 1959](#), *Permissible Dose for Internal Radiation*). In the 1970s the annual reports began to follow the newer recommendations in ICRP Reports 26 and 30 ([ICRP 1977](#), *Recommendations of the ICRP*; and ICRP [1979](#), *Limits for Intakes of Radionuclides by Workers*), incorporated in the dose factors from the EPA in Federal Guidance Reports 11 and 12 ([EPA 520/1-88-020](#), *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*; [EPA 402-R-93-081](#), *External Exposure to Radionuclides in Air, Water, and Soil*). The GENII Version 1 computer code, used at the Hanford Site beginning in 1988, used ICRP 26/30 methods ([ICRP 1977](#), [1979](#)) and EPA dose factors. The GENII Version 2 computer code, used for the annual report dose calculations beginning in 2009, uses ICRP Report 60 methods ([ICRP 1991](#), *1990 Recommendations of the International Commission on Radiological Protection*) and updated EPA dose factors ([EPA 402-R-99-001](#), *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*).

Offsite dose for a maximally exposed individual (Section 4.2.1) and collective dose for the population residing within 50 miles (80 kilometers) of Hanford Site operation areas (Section 4.2.2) are calculated separately for liquid releases to the Columbia River and stack air emissions. Radiological doses from the water pathways are calculated based on differences in radionuclide concentrations between upstream and downstream sampling points on the Columbia River. Although the downstream minus upstream radionuclide concentrations potentially include contributions from all operating areas, they have been assigned to the 200 Area for tabulation of radiological dose. No direct discharge of radioactive materials from the 100 or 300 Areas to the Columbia River was reported during 2012. Radiological doses from the air pathways are calculated based on stack emissions measurements from approximately 60 emission points in Hanford Site operation areas.

Columbia River shoreline spring water containing radionuclides is known to enter the river along the portion of the Hanford Site shoreline extending from the 100-BC Area downstream to the 300 Area. Cesium-137, tritium, and uranium isotopes were found in the Columbia River downstream of the Hanford Site in 2012 at concentrations elevated relative to upstream levels (Appendix C). Radioactive air emissions are discussed in Section 6.1 and summarized in Table 6.1. For the GENII Version 2.10 ([PNNL-14583, Rev 3a](#)) calculations supporting this dose assessment, ingrowth of radioactive progeny during environmental transport was calculated to develop a complete set of radionuclide release estimates. Details on the development of air pathway and water pathway radioactive release estimates is provided in Appendix D.

4.2.1 Maximally Exposed Individual Dose (Offsite Resident)

The maximally exposed individual is a hypothetical person whose location and lifestyle is such that it is unlikely any actual member of the public would have received a higher radiological dose from Hanford Site releases during 2012. This individual's exposure pathways were chosen to maximize the combined doses from all reasonable environmental routes of exposure to radionuclides in Hanford Site liquid effluents and air emissions using a multimedia pathway assessment ([DOE O 458.1, Chg. 2](#); Section 4.e). In reality, such a combination of maximized exposures to radioactive materials is highly unlikely to apply to any single individual. The individual pathway dose calculations themselves also incorporate conservative assumptions intended to ensure that modeled concentrations of radionuclides in exposure media and resulting doses are protective. For these reasons, the dose assessment results for the maximally exposed individual represent a reasonable upper bound of potential individual dose rather than an anticipated dose to an actual individual.

The location of the hypothetical, maximally exposed individual varies, depending on the relative contributions of radioactive air emissions and liquid effluent releases from Hanford Site operational areas. Four offsite locations were evaluated to determine the location of the maximally exposed individual (Figure 4.2). The Ringold locations receive maximal air pathway impacts from the 200 Area. Depending on prevailing wind

direction, either the Sagemoor or Horn Rapids Road location may receive maximal air pathway impacts from the 300 Area. A small population of West Pasco residents obtains their drinking water from the Riverview location via a community water system, and the domestic drinking water pathway is applied to that location. Residences in the vicinity of Horn Rapids Road receive drinking water from the City of Richland, which has an intake downstream of the Hanford Site. Both Riverview and Horn Rapids Road are locations where Columbia River water is withdrawn for irrigation.

Dose calculations for 2012 releases indicate that the maximally exposed individual is located at the PNNL Physical Sciences Facility, an offsite business just to the south of the Hanford Site 300 Area at 638 Horn Rapids Road. For the Horn Rapids Road receptor dose calculations, the following exposure routes were evaluated:

- Inhalation and external radiation exposure related to airborne radionuclides
- External radiation exposure and inadvertent soil ingestion for radionuclides deposited on the ground
- Ingestion of domestic drinking water from the Columbia River
- Ingestion of locally grown food products irrigated with Columbia River water and/or containing radionuclides deposited from the air
- External radiation exposure to radionuclides in Columbia River water and sediments near the Hanford Site during recreational activities, and inadvertent ingestion of water while swimming
- Consumption of locally caught Columbia River fish.

A graphical depiction of the conceptual site model showing all potentially complete exposure pathways for the Horn Rapids Road maximally exposed individual evaluated using GENII Version 2.10 ([PNNL-14583, Rev 3a](#)) is provided in Figure 4.3. Additional information related to the selection of the maximally exposed individual location for releases is provided in Appendix D. Exposure variable input values related to residency and recreational exposure times, intake rates for water, foods, other media, and agricultural pathway assumptions for the maximally exposed individual are provided in Appendix D.

The total dose to the maximally exposed individual at Horn Rapids Road in 2012 was calculated to be 0.19 millirem (1.9 microsievert) per year (Table 4.4; Figure 4.4). This dose is 0.19 percent of the 100-millirem (1,000-microsievert) per year public dose limit specified in DOE O 458.1, Chg. 2 and 0.76 percent of the 25-millirem (250-microsievert) per year threshold where a supplemental assessment of dose to the lens of the eye, skin, and extremities is required. Water pathway contributions assigned to the 200 Areas contributed approximately 75 percent of the total dose of 0.19 mrem/year, with the remaining 25 percent related to air pathway exposures.

The primary radionuclides and exposure pathways contributing to the maximally exposed individual dose are as follows:

- Air Releases: Inhalation of radioactive progeny of radon-220 from the 300 Area contributed approximately 55 percent of the total air pathways dose of 0.046 mrem/year. Consumption of food products grown downwind from the Hanford Site contributed most of the remaining 45 percent of the of the total air pathways dose. Virtually all of these food-related doses are due to airborne releases of tritium from the 300 Area.
- Water Releases: Consumption of fish from the Columbia River contributed approximately 70 percent of the total water pathways dose of 0.14 mrem/year. Consumption of food grown using Columbia River water withdrawn downstream from the Hanford Site contributed most of the remaining 20 percent of the 0.14 mrem/year total. Potassium-40 contributed approximately 70 percent of the water pathways dose, with uranium isotopes contributing most of the remaining 30 percent.

The total annual dose in 2012 is approximately twice as large as that in the 2011 dose calculations ([DOE/RL-2011-119, Hanford Site Environmental Report for Calendar Year 2011](#)), but approximately equivalent to the total dose in the 2010 dose calculations ([PNNL-20548, Hanford Site Environmental Report for Calendar Year 2010](#)). The difference between 2011 and 2012 dose estimates is attributable to the inclusion of naturally-occurring potassium-40 in the 2012 water pathways dose calculations. Although annual average

potassium-40 concentrations in the Columbia River near Richland were nearly identical in 2011 and 2012, the 2012 concentrations were statistically elevated relative to upstream concentrations and potassium-40 was therefore included in the 2012 dose calculations for water releases. Details related to the contribution of individual radionuclides and exposure pathways for air and water releases from Hanford Site operational areas are provided in Appendix D.

Figure 4.2. Locations Important to Hanford Site Dose Calculations

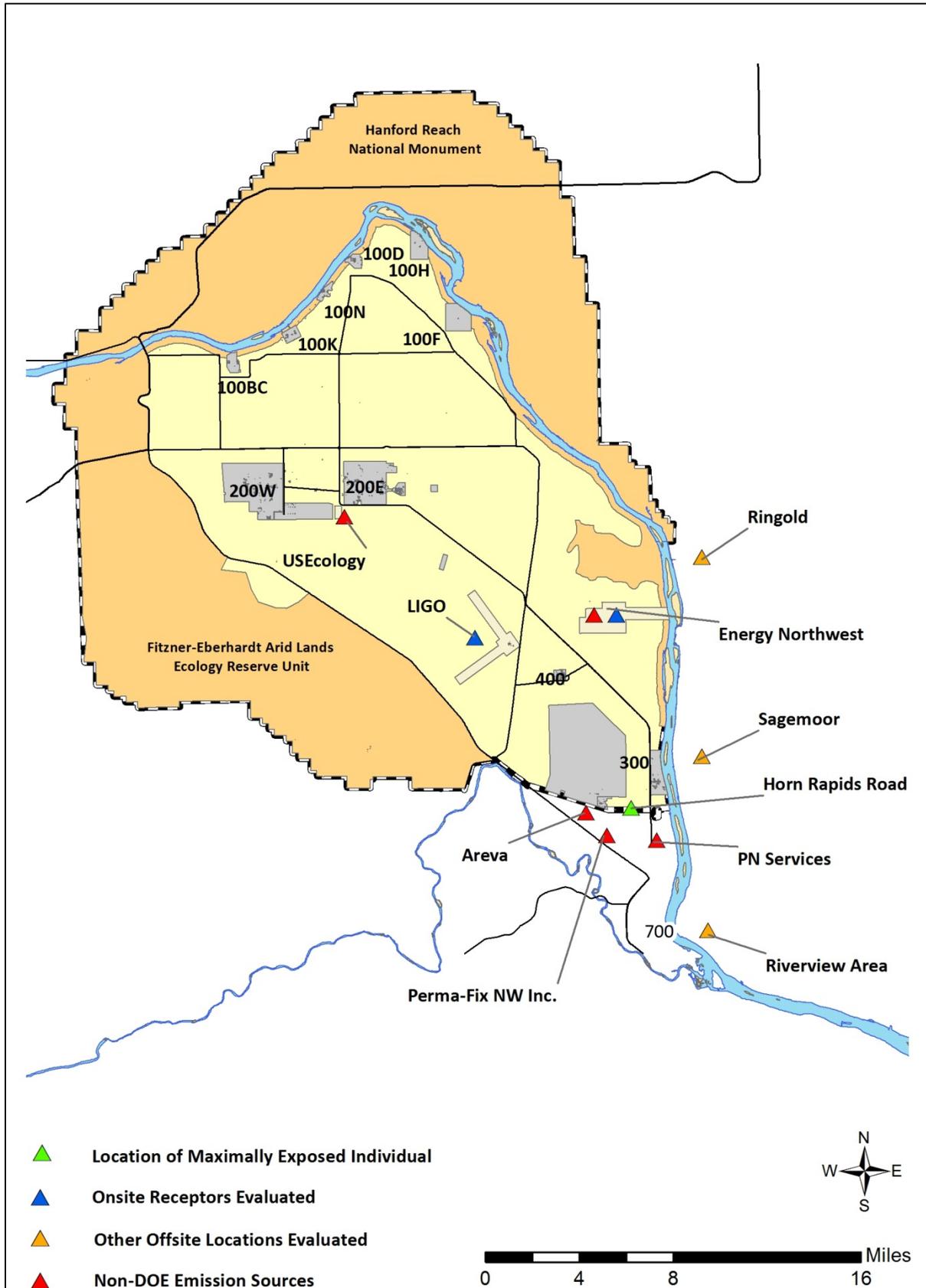


Figure 4.3 Conceptual Site Model of Exposure Pathways Evaluated in Dose Calculations
(Horn Rapids Road MEI)

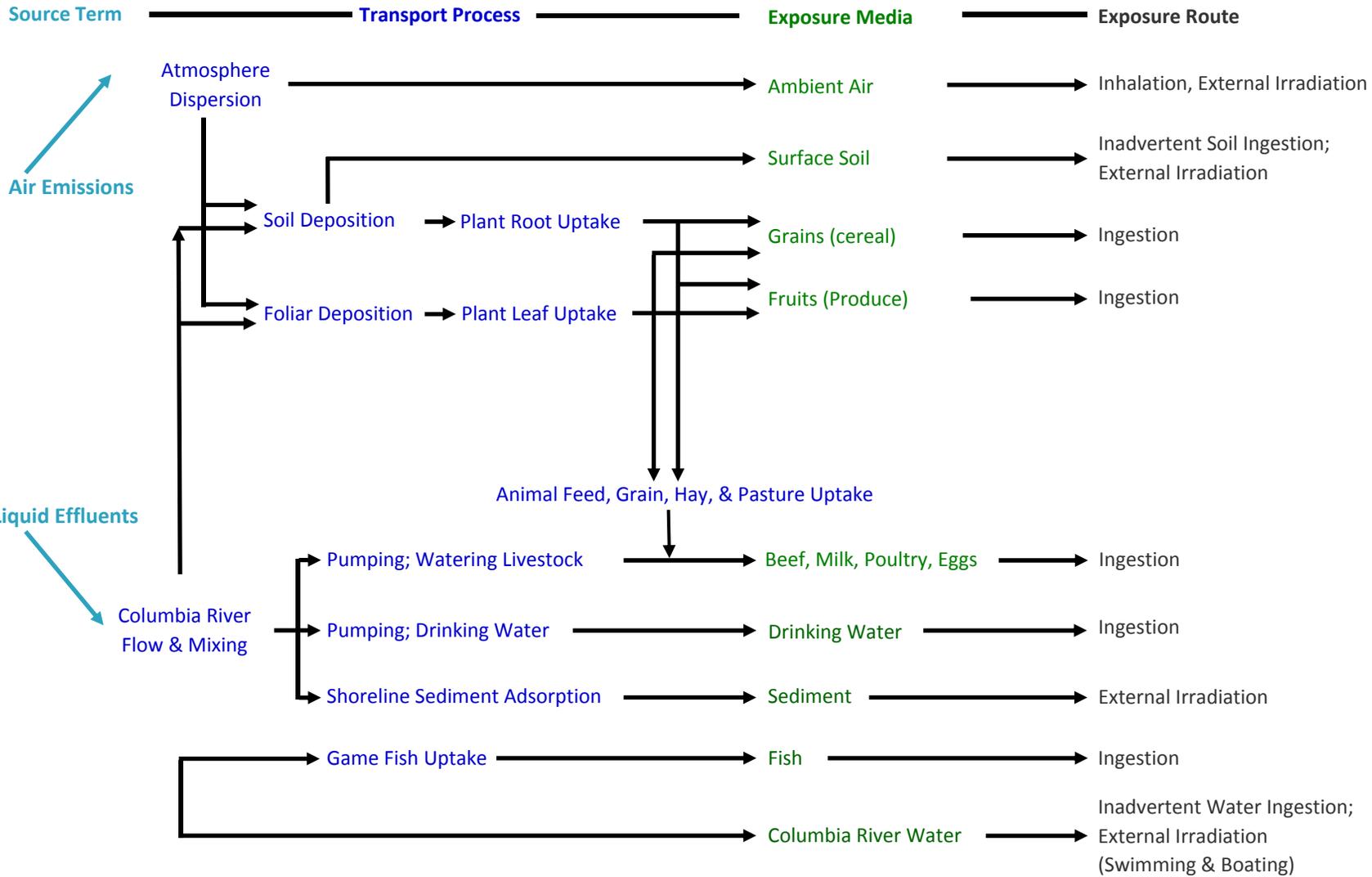


Table 4.3. Pathway Doses for the Hypothetical, Maximally Exposed Individual Residing at Horn Rapids Road

Release Type	Exposure Pathway	Dose Contributions from Operational Areas, mrem ^a				
		100 Area	200 Area ^c	300 Area	400 Area	Pathway Total
Air	Food Ingestion	4.3E-07	0.00016	0.018	1.3E-07	0.018
	Inhalation	4.3E-06	0.00012	0.027	2.5E-07	0.027
	External, Soil Ingestion	1.7E-09	2.5E-07	0.00052	3.7E-09	5.2E-04
	Subtotal Air	4.7E-06	0.00028	0.046	3.8E-07	0.046
Water	Irrigation (food and soil ingestion; external)	NA ^b	0.024 ^c	NA	NA	0.024
	Drinking Water Ingestion	NA ^b	0.0074 ^c	NA	NA	0.0074
	Recreation (river water and sediments; external and ingestion)	NA ^b	0.00081 ³	NA	NA	0.00081
	Fish Ingestion	NA ^b	0.11 ^c	NA	NA	0.11
Subtotal Water		NA	0.14 ^d	NA	NA	0.14 ^d
Air + Water Total		4.7E-06	0.14	0.046	3.8E-07	0.19^e

^a To convert millirem (mrem) to International System dose units (microsievert; μSv), multiply by 10.

^b No measured releases; the last 100 Areas NPDES-permitted outfall (1908-K Outfall) ceased releases in March 2011.

^c Integrates releases from all operational areas, based on the difference between downstream and upstream Columbia River radionuclide concentrations.

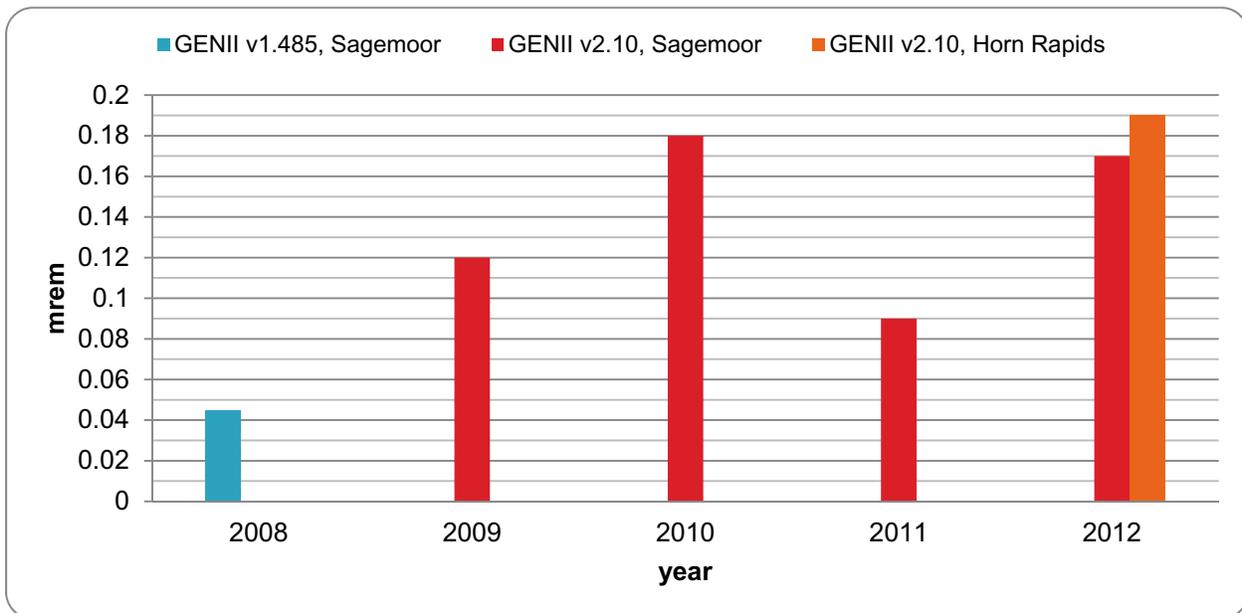
^d Water pathways dose without potassium-40, a naturally-occurring radionuclide not of Hanford origin, is 0.040 mrem.

^e Air + Water pathways dose without potassium-40, a naturally-occurring radionuclide not of Hanford origin, is 0.086 mrem.

NA: Not applicable. All liquid discharges reflected in the difference between upstream and downstream radionuclide concentrations are assigned to the 200 Area.

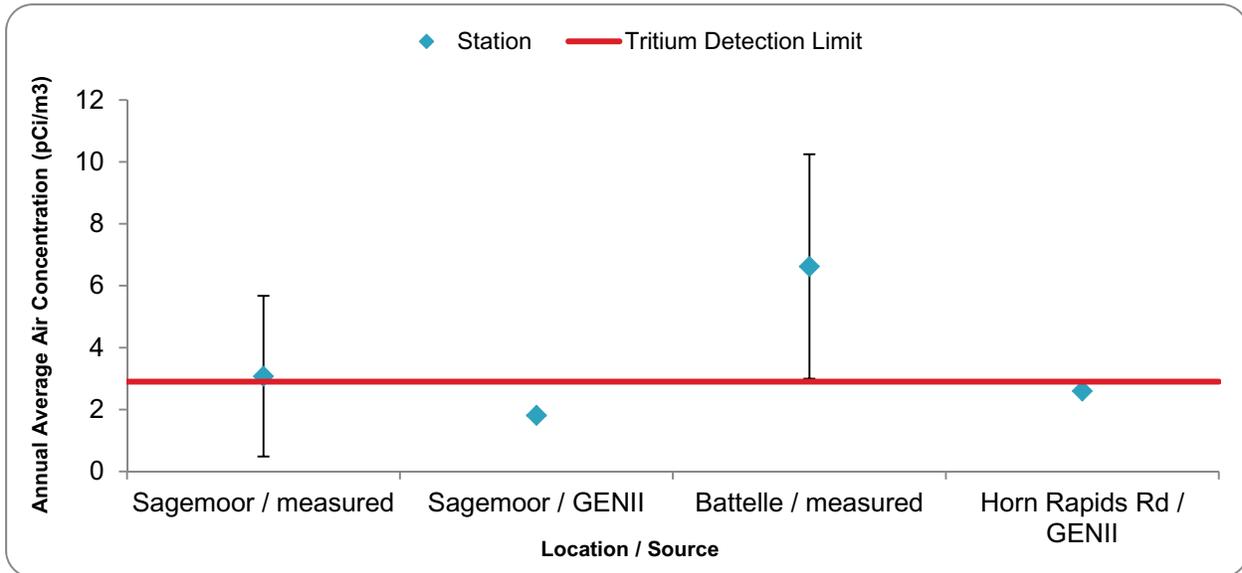
Although the calculated annual dose for the maximally exposed individual is only a very small fraction of the 100-millirem (1,000-microsievert) per year public dose limit, this dose estimate incorporates a number of conservative assumptions to ensure that pathway doses are protective. In the air pathways calculations, measurements of gross alpha and gross beta radiation in stack emissions were protectively added to the measured emissions of plutonium-239/240 and strontium-90, respectively. Although gross alpha and gross beta levels in stack emissions are similar to ambient air background, this was done to ensure that contributions from any unmeasured operations-related radionuclides are incorporated in the estimated doses.

In the irrigation pathways calculations, all produce eaten by the maximally exposed individual was assumed to originate from areas irrigated with Columbia River water. For the fish consumption pathway, near-shore water samples were protectively used to represent Columbia River water generally and it was assumed that all fish consumed by the maximally exposed individual are resident species rather than salmon or steelhead returning to spawn. Because returning species have not been living and feeding in the Hanford Reach of the Columbia River they would not be expected to harbor contaminants associated with this area.

Figure 4.4. Total Dose for the Hypothetical, Maximally Exposed Individual

Because releases of tritium from the 300 Area are a major source of calculated Hanford-related air pathways doses for the hypothetical maximally exposed individual, modeled annual-average tritium concentrations at locations near the 300 Area were compared to concentrations based on air monitoring station samples. Figure 4.5 shows the measured and modeled annual-average air concentrations of tritiated water vapor (HTO) at the Sagemoor location and at perimeter locations south of the 300 Area. Figure 4.5 also displays the approximate detection limit for this measurement, and only the measured Battelle station average concentration is substantially greater than the detection limit. Measured monthly tritium concentrations vary substantially at each monitoring location. The bars on the measured values show the 95% confidence interval for the annual average value based on the monthly measurements and the dashed line is the approximate detection limit of tritium in the monthly air samples. The modeled and measured tritium concentrations at Sagemoor are approximately equivalent and the measured value may largely reflect background levels of atmospheric tritium. The higher value for the measured concentrations of tritium at the Battelle monitoring station may reflect non-DOE 2012 tritium releases from the Battelle-operated PNNL facility.

Figure 4.5 Comparison of Measured and Modeled Tritium Air Concentrations Near the 300 Area
(error bars are 95% confidence intervals of the mean)



4.2.2 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 release location. The regional collective dose from 2012 Hanford Site operations was estimated by calculating the radiological dose to the population residing within a 50-mile (80-kilometer) radius of onsite operating areas ([DOE O 458.1](#), Chg. 2; Section 4.e(d)). The collective doses reported are based on regional population data from the 2010 census, as described in Appendix D.

The conceptual site model of potentially complete exposure pathways for the Sagemoor maximally exposed individual shown in Figure 4.3 is also applicable to the collective dose calculations. The collective dose calculation also incorporates the drinking water exposure pathway because the cities of Richland and Pasco obtain all or part of their municipal water directly from the Columbia River downstream from the Hanford Site and the city of Kennewick obtains its municipal water indirectly from the river from nearby wells. In addition to the drinking water pathway, a primary distinction between the maximally exposed individual and collective dose calculations is the use of population-average values for certain exposure variables in place of reasonable upper bound values. Exposure variable input values related to residency and recreational exposure times, intake rates for foods and other media, and agricultural pathway assumptions for the collective dose calculations are provided in Appendix D. The collective dose calculation employs population data from the 2010 census broken out according to direction and distance in order to coincide with air dispersion and deposition modeling conducted within the GENII Version 2.10 computer code ([PNNL-14583, Rev 3a](#)).

The annual collective dose is reported in units of person-rem (person-sievert), which is the sum of doses to members of the exposed population. The total collective dose calculated for this population in 2012 was 1.2 person-rem (0.012 person-sievert) per year (Table 4.5; Figure 4.6), which is above the 2011 collective dose of 0.86 person-rem (0.0086 person-sievert) ([DOE/RL-2011-119](#)) but slightly less than the 2010 collective dose of 1.1 person-rem (0.011 person-sievert) ([PNNL-20548](#)). Water pathway contributions assigned to the 200 Area contributed approximately 90 percent of the total collective dose of 1.0 person-rem, with the remaining collective dose attributable to air pathways.

The primary radionuclides and exposure pathways contributing to the collective dose are as follows:

- **Air Releases:** Consumption of food products grown downwind from the Hanford Site contributed approximately 75 percent of the of the total air pathways collective dose of 0.32 person-rem. The remaining air pathways collective dose is related to inhalation. Virtually all of the 300 Area food and inhalation air pathways doses, which combined account for 75 percent of the air pathways collective dose, are due to releases of tritium. Inhalation of plutonium-239¹ was responsible for slightly more than one-half of the air pathways collective dose from the 200 Areas, with iodine-129 exposure via consumption of food products contributing most of the remaining dose. Air releases from the 100 and 400 Areas had negligible contributions to the air pathways collective dose.
- **Water Releases:** Consumption of drinking water withdrawn from the Columbia River downstream of the Hanford Site contributed approximately 90 percent of the total water pathways collective dose of 0.89 person-rem. Consumption of food products grown with Columbia River irrigation water and consumption of Columbia River fish each contributed approximately another 3 to 5 percent. Naturally occurring isotopes of uranium (uranium-234, uranium-235, and uranium-238) from releases assigned to the 200 Area were the largest contributors (approaching 70 percent) to the drinking water collective dose.

Table 4.4. Collective Pathway Doses
(Within a 50-mile (80-Kilometer) Radius)

Release Type	Exposure Pathway	Dose Contributions from Operational Areas, mrem ^a				
		100 Area	200 Area	300 Area	400 Area	Pathway Total
Air	Food Ingestion	6.8E-05	0.014	0.12	4.7E-06	0.13
	Inhalation	0.0013	0.019	0.17	1.2E-05	0.19
	External, Soil Ingestion	3.6E-07	2.0E-05	0.0011	1.2E-07	1.1E-03
	Subtotal Air	0.0014	0.033	0.29	1.7E-05	0.32
Water	Irrigation (food and soil ingestion; external)	NA ^b	0.031 ^c	NA	NA	0.031
	Recreation (river water and sediments; external and ingestion)	NA ^b	0.0054 ^c	NA	NA	0.0054
	Fish Ingestion	NA ^b	0.04 ^c	NA	NA	0.04
	Drinking Water	NA ^b	0.81 ^c	NA	NA	0.81
Subtotal Water		NA	0.89 ^d	NA	NA	0.89
Air + Water Total		0.0014	0.92	0.29	1.7E-05	1.2^e

^a To convert person-rem to International System dose units (person-Sievert), divide by 100.

^b No measured releases; the last 100 Areas NPDES-permitted outfall (1908-K Outfall) ceased releases in March 2011.

^c Integrates releases from all operational areas, based on the difference between downstream and upstream Columbia River radionuclide concentrations.

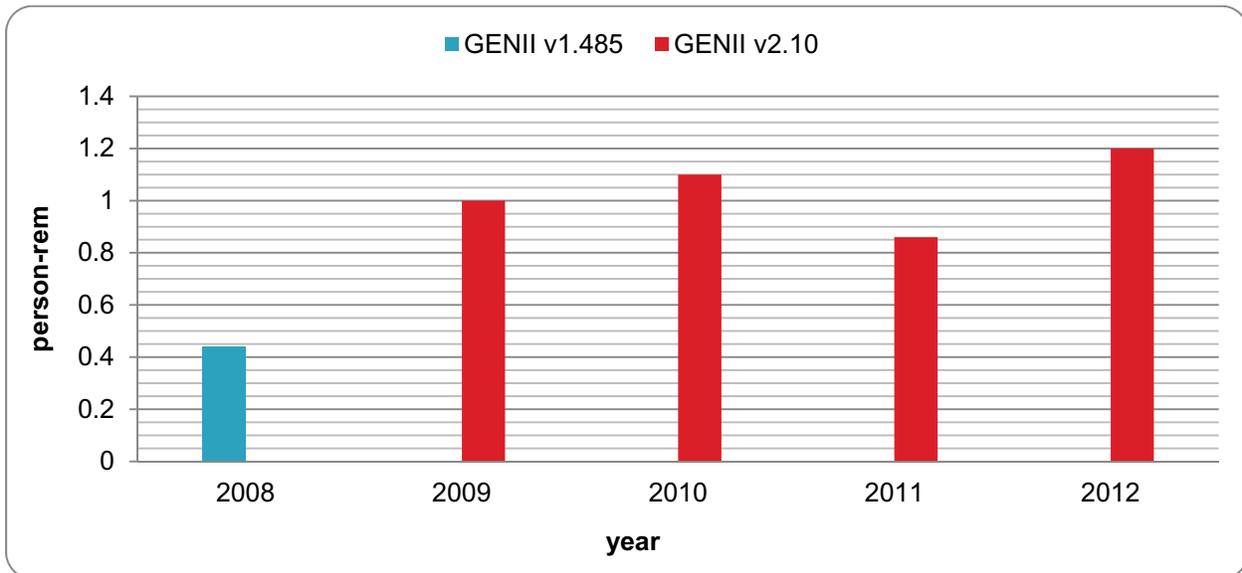
^d Water pathways dose without potassium-40, a naturally-occurring radionuclide not of Hanford origin, is 0.66 person-rem.

^e Air + Water pathways dose without potassium-40, a naturally-occurring radionuclide not of Hanford origin, is 0.79 person-rem.

NA: Not applicable. All liquid discharges reflected in the difference between upstream and downstream radionuclide concentrations are assigned to the 200 Area.

¹ Approximately two-thirds of this dose is related to gross alpha activity assigned to plutonium-239.

Figure 4.6 **Collective Total Dose**
(Within 50-Mile (80-Kilometer) Radius)



The dose for the maximally exposed individual in 2012 was 0.19 millirem (1.9 microsievert) per year (Section 4.2.1). The average individual dose from Hanford Site operations in 2012, based on the 50-mile (80-kilometer) radius population exposed to air emissions and the Tri-Cities populations exposed to water pathways releases to the Columbia River, was approximately 0.0056 millirem (0.056 microsievert). To place the maximally exposed and average individual estimated doses into perspective, the estimated doses may be compared with doses received from other routinely encountered sources of radiation. The National Council on Radiation Protection issued Report 160 in March 2009 that estimated the overall average exposure to ionizing radiation for the average American to be 620 millirem (6,200 microsievert) per year (National Council on Radiation Protection and Measurements 2009 [NCRP 2009]). Approximately 50 percent of the 620 millirem (6,200 microsievert) per year average annual dose is related to natural sources, with the remaining 50 percent attributable primarily to medical procedures.

The most relevant radiation sources for comparison to doses received from environmental media include natural terrestrial and cosmic background radiation, and inhalation of naturally occurring radon (Figure 4.7). Average annual individual background dose related to terrestrial radiation (19 mrem [190 microsievert]), cosmic background radiation (30 mrem [300 microsievert]), and radon (radon-222) and thoron (radon-220) gases (230 mrem [2,300 microsievert]) are shown relative to Hanford Site operational doses in Figure 4.8. The calculated radiological doses from Hanford Site operations in 2012 were a small percentage of national average annual doses from these natural background sources. Note that annual dose is shown on a logarithmic scale in Figure 4.8, where each increment represents a factor of 10. For example, the national average terrestrial radiation dose is about 100 times larger than the 2012 Hanford Operations dose to the maximally exposed individual.

Figure 4.7 United States Annual Average Radiological Doses from Various Sources (National Council on Radiation Protection and Measurement, 2009)

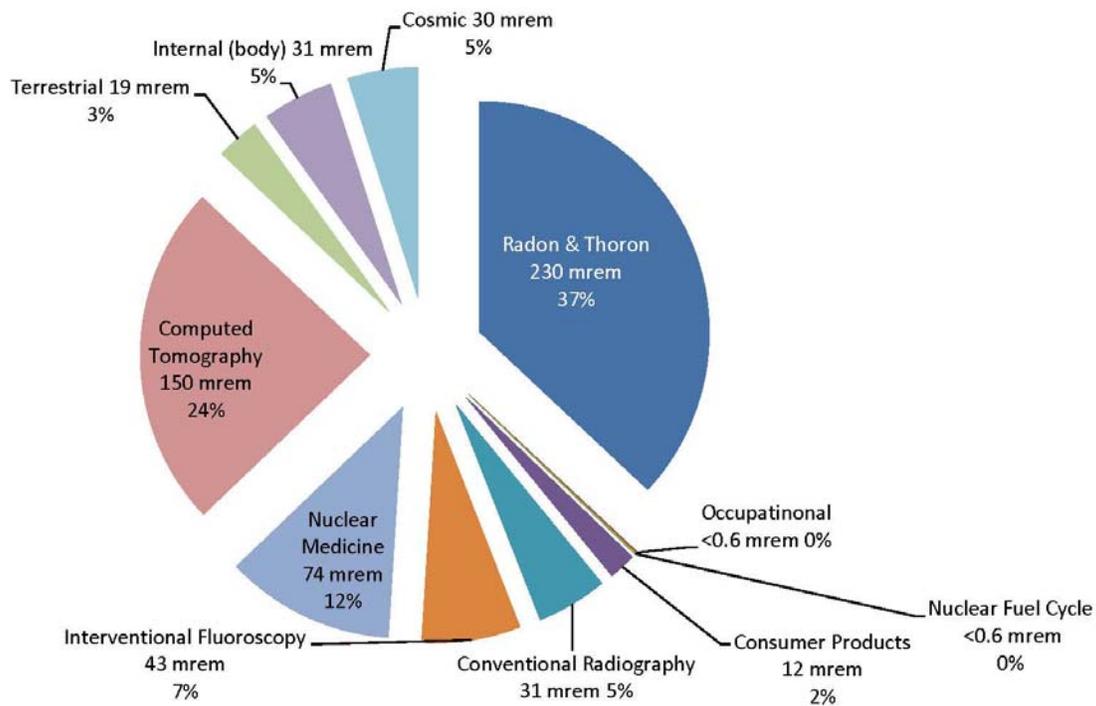
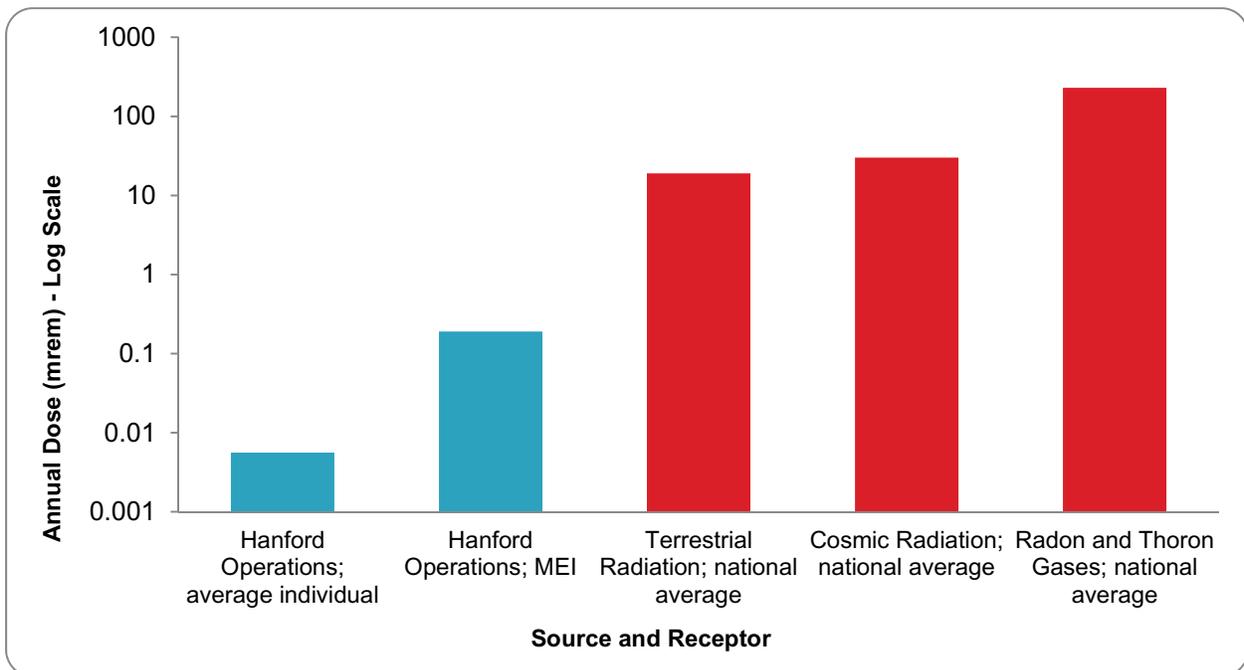


Figure 4.8 Radiological Doses from Hanford Site Operations Compared with Annual Average from Natural Sources



4.2.3 Compliance with *Clean Air Act* Standards

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 O 458.1](#), Chg. 2 and is calculated using the GENII computer code as described in Section 4.2.1. This calculation considers all reasonable environmental pathways (e.g., from releases to both air and water) that maximize a hypothetical individual's offsite exposure to the Hanford Site's radiological liquid effluents and air emissions. A second estimate of maximally exposed individual dose is required by the *Clean Air Act* and must be calculated using an EPA dose modeling computer code (CAP-88) or other methods accepted by the EPA under the *Clean Air Act* for estimating offsite exposure. The Hanford Site stack emissions and emissions from diffuse and unmonitored sources (e.g., windblown dust) are considered in the offsite dose for the *Clean Air Act*, and are based solely on an airborne radionuclide emissions pathway.

In addition to complying with the all-pathways dose limits established by [DOE O 458.1](#), Chg. 2 (100-millirem (1,000-microsievert) per year), 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](#), *Updated User's Guide for CAP88-PC*) 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 air pathways assumptions used with the GENII computer code; therefore, air-pathway doses calculated by the two codes may differ somewhat. In principle, the maximally exposed individual for air pathways assessed under [40 CFR 61](#), Subpart H, may be evaluated at a different location from the all-pathways maximally exposed individual if dose from the water pathways exceeds that from air pathways (Appendix D).

The *Clean Air Act* 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 2011 air emissions at the Hanford Site, refer to DOE's report to EPA ([DOE/RL-2013-12](#)).

4.2.3.1 Dose from Stack Emissions to an Offsite Maximally Exposed Individual

Using CAP-88, the maximally exposed offsite individual for air pathways in 2012 was at PNNL's Physical Sciences Facility, an offsite business located at 638 Horn Rapids Road in north Richland, Benton County, Washington, directly south of the Hanford Site 300 Area (Figure 4.2). The potential air pathway dose from stack emissions to a maximally exposed individual at that location calculated using the CAP-88 computer code was determined to be 0.025 millirem (0.25 microsievert) per year, which is less than 1 percent of the EPA standard of 10 mrem (100-microsievert) per year. The CAP-88 result is approximately one-half of the air pathway dose for stack emissions calculated with GENII (Table 4.4).

Dose related to radon-220 and radon-222 is not included in the dose calculated for compliance with the EPA standard in [40 CFR 61](#), Subpart H, but is regulated by the 10-millirem (100-microsievert) per year standard established by Ecology in [WAC 246-247](#). Radon-222 was not emitted as a result of Hanford Site activities in 2012, but a release of 233 Ci of radon-220 was calculated from engineering estimates for stack emissions from Building 325 in the 300 Area. A dose of 0.065 mrem (0.65 microsievert) per year was calculated for the maximally exposed offsite individual at Horn Rapids Road, far below the [WAC 246-247](#) standard.

4.2.3.2 Dose from Diffuse and Fugitive Radionuclide Emissions to an Offsite Maximally Exposed Individual

The December 15, 1989, revisions to [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) described in Section 4.2.3.1. EPA has not specified or approved standardized methods to estimate diffuse airborne 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-2013-12](#)).

The Horn Rapids Road location immediately south of the 300 Area was chosen for purposes of demonstrating compliance with the maximally exposed individual dose standard for diffuse and fugitive emissions ([DOE/RL-2013-12](#)). The estimated dose from diffuse emissions to a maximally exposed individual at Horn Rapids Road in 2012 was calculated using the CAP-88 computer code to be 0.0086 millirem (0.086 microsievert) per year. Therefore, the potential combined dose from stack emissions and diffuse emissions (excluding radon) during 2012 at the Horn Rapids Road location was 0.0336 millirem (0.336 microsievert) per year, well below the 10 millirem (100-microsievert) per year standard in [40 CFR 61](#), Subpart H.

4.2.3.3 Maximum Dose to Non-U.S. Department of Energy Workers at the Hanford Site

DOE has recently allowed private businesses to locate their activities and personnel on some regions of the Hanford Site. The EPA Region 10 Office and the Washington State Department of Health provided guidance to RL 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. 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.

Doses to members of the public employed at non-DOE facilities at locations outside access-controlled areas on the Hanford Site (those requiring DOE-access authorization for entry) were evaluated in the 2012 EPA air emissions report ([DOE/RL-2013-12](#)) as possible maximally exposed individuals. 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 4.2). The non-DOE worker dose due to stack emissions from these facilities was calculated using the CAP-88 computer code assuming full-time occupancy because EPA guidance does not currently allow for adjustment of such doses to account for less than full-time occupancy. Even assuming an employee is continuously present, the estimated doses to non-DOE onsite workers in 2012 were lower than the 0.025 millirem (0.25 microsievert) per year dose calculated with CAP-88 to an offsite maximally exposed individual at Horn Rapids Road. Combined stack emissions and diffuse/fugitive emissions dose for the Columbia Generating Station was 0.0038 millirem (0.038 microsievert) per year, and for the Laser Interferometer Gravitational Wave Observatory was 0.0048 millirem (0.048 microsievert) per year ([DOE/RL-2013-12](#)).

4.2.4 Special Case Dose Estimates

The exposure assumptions used to calculate the dose to the maximally exposed individual were selected to provide a scenario yielding a reasonable upper bound dose estimate. The maximally exposed individual dose calculations are based on measurements of radionuclide releases from stack emissions and differences between downstream and upstream radionuclide concentrations in the Columbia River, followed by modeling of environmental transport to an offsite receptor. Other exposure scenarios exist that could have resulted in significant individual doses. Two such scenarios include 1) an outdoor recreationalist who consumed meat from contaminated wildlife that migrated from the Hanford Site, and 2) an individual who drank water from a groundwater supply well at the FFTF in the 400 Area. The potential doses resulting from these scenarios are examined in the following sections.

4.2.4.1 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 offsite. Wildlife sampling was conducted at the Hanford Site to estimate radionuclide tissue concentrations in animals from the site that could potentially have been hunted offsite.

Radionuclide samples were collected in 2012 from quail, elk, and mule deer. Various tissues were sampled, including bone, liver, and muscle tissue. For the purpose of estimating dose from ingestion of game meat, only radionuclide concentrations in muscle tissue are employed. Seven muscle tissue samples were available in 2012 for quail and elk, and three from mule deer. The only radionuclide detected in the muscle tissue of quail, elk, and mule deer was potassium-40, a primordial radioisotope not of Hanford Site origin. Other than potassium-40, there was only a single positive detection; a value of 0.0246 pCi/g (0.00091 Bq/g) for the gamma radiation-emitting radionuclide cesium-137 measured in the muscle tissue of an elk from North Bend, Washington. This radionuclide is produced in the process of nuclear fission and is present in the environment due to worldwide fallout from historic nuclear weapons tests. Although cesium-137 is also associated with Hanford Site operations, an elk from the vicinity of North Bend, WA would not harbor Hanford-related contamination.

Regardless of the origin of the cesium-137 measured in the elk from North Bend, WA, the radiation dose received from consumption of this meat would be negligible. The dose related to consumption of 2.2 pounds (1 kilogram) of elk meat that contains 0.0246 pCi/g [0.00091 Bq/g] of cesium-137 is estimated to be 0.0012 millirem (0.012 microsievert) per year.

This dose estimate was derived using a cesium-137 ingestion dose factor of 5.0×10^{-5} mrem/pCi (1.4×10^{-2} microsievert/Bq) from ICRP Report 72 ([ICRP 1996](#), *Age-dependent Doses to the Members of the Public from Intake of Radionuclides – Part 5 Compilation of Ingestion and Inhalation Coefficients*) in the following manner:

$$0.0246 \text{ pCi cesium-137/g} \times 1 \text{ kg} \times 1,000 \text{ g/kg} \times 4.8 \times 10^{-5} \text{ mrem/pCi} = 0.0012 \text{ millirem} \\ (0.012 \text{ microsievert}) \text{ per year.}$$

4.2.4.2 Onsite Drinking Water Dose

Drinking water was sampled and analyzed for tritium, strontium-90, gross alpha radiation, and gross beta radiation during 2012 in accordance with applicable regulations ([40 CFR 141](#)); water samples were collected from the 100-K Area, 200-West Area, and two sources in the 400 Area. The annual average gross alpha radiation concentrations measured during 2012 were below applicable DWSs. Gross beta radiation standards are published as dose-based levels (millirem or microsievert per year). Tritium and strontium-90 are both man-made soluble beta radiation emitters; there are also naturally-occurring beta emitters in the uranium, actinium, and thorium decay series. Potential onsite drinking water dose from Hanford-related beta-emitting radionuclides is addressed by evaluating the drinking water data for tritium and strontium-90.

Strontium-90 was not identified above detection limits in any drinking water samples. Based on four samples, the annual average 400 Area drinking water tritium concentration was 1,730 pCi/L (64 Bq/L). Assuming a consumption rate of 0.26 gallon (1 liter) per day for 250 working days at the FFTF, the potential annual worker dose in 2012 would be approximately 0.03 millirem (0.3 microsievert). A single tritium sample was also collected from Well P-14 in the 400 Area, where a value of 9,000 pCi/L was reported. Based on this single measurement, an annual worker drinking water dose for this well would be 0.15 millirem (1.5 microsievert). These estimates are well below EPA's drinking water dose limit of 4 millirem (40 microsievert) per year for beta-emitting radionuclides in public drinking water supplies. The dose estimate was derived using a tritium ingestion dose factor of 6.7×10^{-8} mrem/pCi (1.8×10^{-5} microsievert/Bq) from ICRP Report 72 ([ICRP 1996](#)) in the following manner:

$$1,730 \text{ pCi tritium/L} \times 1 \text{ L/day} \times 250 \text{ d/year} \times 6.7 \times 10^{-8} \text{ mrem/pCi} = 0.03 \text{ millirem/year.}$$

4.2.5 Doses from Non-U.S. Department of Energy Sources

Doses from non-DOE sources was not quantified in 2012 because the maximally exposed individual dose of 0.19 millirem (1.9 microsievert) per year from DOE-related sources (Section 4.2.1) was far below the threshold of 25 millirem (250 microsievert) per year at which the contribution of non-DOE sources must be included. [DOE O 458.1](#) paragraph 4.e.(1)(c) states that dose evaluations to demonstrate compliance with the public dose limit must include:

- The dose to members of the public from DOE-related exposure sources only, if the projected DOE-related dose to the representative person or maximally exposed individual is 25 millirem (0.25 millisievert) in a year or less. If the DOE-related dose is greater than 25 millirem in a year, the dose to members of the public must include major non-DOE sources of exposure and dose from DOE-related sources.
- Before it was superseded by the release of [DOE O 458.1](#) in 2011, DOE O 5400.5, Chg 2, provided the applicable requirements for radiation protection of members of the public. Chapter II, Paragraph 7, of DOE O 5400.5, Chg 2, has a reporting requirement for a combined dose due to DOE and other manmade sources. Therefore, earlier Hanford Site environmental reports have routinely evaluated dose contributions from various non-DOE industrial sources of radiation exposure on or near the Hanford Site. In 2010, 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 4.2). The total individual dose from non-DOE source activities in 2010 was conservatively estimated at about 0.004 millirem (0.04 microsievert) per year. The *Hanford Site Environmental Report for Calendar Year 2010* is online at <http://msa.hanford.gov/msa/filedisplay.cfm?fileid=1467&confirm=true>.

4.2.6 Dose to Non-Human Biota

Dose assessments for non-human biota evaluate the potential for exposures from Columbia River sediment and water and exposures associated with West Lake. Upper estimates of the radiological dose to aquatic organisms were made in accordance with the [DOE O 458.1](#), Chg. 2, interim requirement for management and control of liquid discharges. The current dose limit for aquatic animal organisms is 1 rad (10 milligray) per day. Rad is a unit of absorbed dose of ionizing radiation equal to an energy of 100 ergs per gram of irradiated material. In addition to the dose limit for aquatic organisms there is a proposed dose limit for riparian or terrestrial wildlife is 0.1 rad (1 milligray) per day.

Concentration guides for assessing doses to biota are very different from the DOE-derived concentration standards used to assess radiological doses to humans. A tiered approach is used to estimate radiological doses to aquatic and terrestrial biota. This method uses the RESidual RADioactive (RESRAD)-BIOTA computer code ([DOE/EH-0676](#), *User's Guide, Version 1. RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation*; [DOE/STD-1153-2002](#), *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*) to compare radionuclide concentrations measured by routine monitoring programs to a set of biota concentration guides.

Biota concentration guides are the water or sediment concentrations of a radionuclide that would produce 1 rad (10 milligray) per day for aquatic biota or 0.1 rad (1 milligray) per day for riparian or terrestrial wildlife. 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 limit. If the sum of fractions exceeds 1.0, then the dose limit has been exceeded. If the initial estimated screening value (Tier 1) exceeds the guideline (sum of fractions more than 1.0), additional screening calculations are performed (Tier 2 or Tier 3) to evaluate more accurately 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 2012 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 Columbia River sediment and water as tabulated in Appendix C. The detected radionuclides evaluated across all locations in the Columbia River sediment and water biota dose assessment are carbon-14, cesium-137, plutonium-239/240, strontium-90, tritium, uranium-234, uranium-235, and uranium-238. Most of the locations located on the Columbia River had samples collected from riverbank springs or seeps that carry groundwater contaminants into the Columbia River. Concentrations in springs or seeps are greater than those observed in the river water, and therefore the dose assessment results for these discrete areas of elevated concentrations are protective relative to the potential for impacts on populations of biota in the Columbia River. The results of the screening calculations listed in Table 4.6 show the concentrations in all Columbia River sediment and water samples passed the Tier 1 screen, indicating that the calculated doses were below dose limits (sum of fractions less than one). Most of the estimated dose is associated with uranium isotopes, which are the key radionuclides for the biota dose assessment. The sum of fractions tends to be greater at locations where uranium water concentrations were estimated from sediment (and not measured). Further documentation of the Columbia River biota dose calculations is provided in Appendix D.

Table 4.5. Estimated Doses to Biota associated with Columbia River Sediment and Water
(Using RESRAD-BIOTA^a Computer Code)

Location	Media Evaluated for Key Radionuclides	Tier 1 Screen	
		Sum of Fractions ^b	Pass or Fail
Priest Rapids Dam	Sediment, Water ^c	0.26	Pass
100-B Area	Sediment ^c , Water	<0.01	Pass
100-K Area	Sediment, Water ^c	0.09	Pass
100-N Area	Sediment ^c , Water	0.02	Pass
100-D Area	Sediment, Water ^c	0.02	Pass
100-H Area	Sediment, Water	<0.01	Pass
White Bluffs Slough	Sediment, Water ^c	0.21	Pass
100-F Area	Sediment, Water ^c	0.10	Pass
Hanford Town Site	Sediment, Water	0.20	Pass
300 Area Spring	Sediment ^c , Water	0.23	Pass
McNary Dam	Sediment, Water ^c	0.26	Pass

^a A screening method to estimate radiological doses to aquatic and riparian 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 or Tier 3) is required. The sum of fractions has been rounded to two figures with a maximum of two decimal points. Maximum concentrations and the Biota Concentration Guides are presented in Appendix D.

^c The biota dose assessment requires concentration data for both sediment and water. If one of these media is not measured then it is estimated by using the default water to sediment partition coefficient. The footnote next to sediment means that sediment was estimated from water (water was measured) and footnote next to water means that water was estimated from sediment (sediment was measured).

Biota dose calculations also were completed for West Lake, which is located on the Central Plateau of the Hanford Site. West Lake is a vernal pool or ephemeral wetland that fills with water during the winter and generally becomes smaller or dries up entirely in other seasons. West Lake is part of the 200 Area Unplanned Release Waste Group Operable Unit (200-UR-1 Operable Unit), and is planned for supplemental characterization ([DOE/RL-2009-121](#), *Sampling and Analysis Plan for the West Lake Site*). The results of these planned investigations will be presented in the appropriate CERCLA remedial action document for the 216-N-8 waste site. In parallel with these planned CERCLA studies, this program has been collecting sediment data annually. In addition, other media (water and biota) have been collected from West Lake on a less regular schedule. Both sediment and water samples were collected in 2012 and data tabulated (Appendix C, Tables C.2 and C.3).

The RESRAD-BIOTA results of the screening calculations listed in Table 4.7 show the West Lake sediment and water concentrations failed the Tier 1 and Tier 2 screens. The Tier 1 screen was based on the maximum concentration and the Tier 2 screen was based on the average concentrations of two water samples. The estimated biota dose for Tiers 1 and 2 was almost entirely due to the measured concentration of uranium in water and the assumed potential for uptake from water to aquatic biota.

The default bioaccumulation factor for uranium isotopes from water to aquatic biota is 1000. This means that the concentration in tissues would be 1000 times that measured in water. Site-specific data from West Lake support a much lower uranium bioaccumulation factor. Aquatic biota (only brine flies have been sampled and are also relevant organisms) and water were sampled concurrently in 2000 and 2007 ([PNNL-13487](#), *Hanford Site Environmental Report for Calendar Year 2000*; [DOE/RL-2007-50](#), *Central Plateau Ecological Risk Assessment Data Package Report*). The maximum concentration of any of the uranium isotopes in brine flies was 0.77 pCi/g in 2007. The maximum uranium-238 water concentration was 1400 pCi/L in 2007. The bioaccumulation factor is calculated by dividing the biota concentration (in pCi/g) by the water concentration (in pCi/ml). Therefore, the maximum bioaccumulation factor for uranium would be less than one. A bioaccumulation factor of one was used for the Tier 3 biota dose calculation as a somewhat protective measure of site-specific uranium uptake into the food chain. The Tier 3 biota dose calculations resulted in sum of fractions less than one, indicating that the calculated doses were below dose limits. Further documentation of the West Lake biota dose calculations, including the Tier 3 Biota Concentration Guides, is provided in Appendix D.

Table 4.6. Estimated Doses to Biota associated with West Lake
(Using RESRAD-BIOTA^a Computer Code)

Tier	Exposure Assumptions	Sum of Fractions ^b	Pass or Fail
1	Maximum Sediment, Water Concentration and Default Bioaccumulation	36	Fail
2	Average Sediment, Water Concentration and Default Bioaccumulation	19	Fail
3	Average Sediment, Water Concentration and Site-specific Bioaccumulation	0.33	Pass

^a A screening method to estimate radiological doses to aquatic and riparian 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 or Tier 3) is required.

4.2.7 Radiological Dose in Perspective

Scientific studies (National Research Council 1980; National Research Council [1990](#), *Health Effects of Exposure to Low Levels of Ionizing Radiation*; United Nations Science Committee on the Effects of Atomic Radiation, [[UNSCEAR](#)] [1988](#)) have been performed to estimate the possible risk from exposure to low levels of radiation. These studies provide information to government and scientific organizations for use in recommending radiological dose limits and standards for public and occupational safety.

Although no increase in the incidence of health effects from low doses of radiation actually has 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, historically, painters of radium dials). This concept is known as the “linear no-threshold” hypothesis. Under these assumptions, public exposure to radiation from current Hanford Site releases, exposure to natural background radiation (which is hundreds of times greater), and exposure to very high levels of radiation each increases an individual’s probability or chance of developing a detrimental health effect (primarily cancer) proportional to the dose received.

Scientists do not fully agree on how to translate the available epidemiological data on health effects from high radiological doses into the numerical probability (risk) of detrimental effects from low radiological doses ([UNSCEAR 2012](#)). Some scientific studies have indicated that low radiological doses may result in beneficial rather than adverse effects ([Calabrese 2009](#), *The road to linearity: why linearity at low doses became the basis for carcinogen risk assessment*). Because cancer is a common disease in the general population and may be attributable to many other causes besides radiation (e.g., genetic defects, natural and man-made chemicals, and natural biochemical reactions in the body), 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 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 (*A Method for Estimating Radiation Risk from TEDE*, [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).

One approach for providing perspective on calculated risks related to low-dose radiation exposures is to compare them to risks involved in other typical activities. Table 4.8 compares the estimated risks from various radiological doses to the risks of some activities encountered in everyday life.

Table 4.7. Estimated Risk from Various Activities and Exposures

Activity or Exposure Per Year	Risk of Fatality
Home accidents	100×10^{-6} ^(a)
Firearms (sporting accidents)	10×10^{-6} ^(a)
Flying as an airline passenger (cross-country roundtrip – accidents)	8×10^{-6} ^(a)
Recreational boating (accidents)	6×10^{-6} ^(a)
Riding or driving 300 miles (483 kilometers) in a passenger vehicle	2×10^{-6} ^(a)
Natural background radiological dose (310 mrem [3,100 μ Sv]) for 70 year	0 to $13,000 \times 10^{-6}$ ^(a)
Dose of 1 mrem (10 μ Sv) for 70 year	0 to 40×10^{-6} ^(a)
Flying as an airline passenger (cross-country roundtrip – radiation)	0 to 6×10^{-6} ^(b)
Dose to the hypothetical, maximally exposed individual (2012 dose rate) living near the Hanford Site for 70 year	0 to 7×10^{-6} ^(b)

^a Real actuarial values

^b Upper bound calculated using 6×10^{-7} risk of developing a fatal cancer after receiving a dose of 1 millirem (10 microsievert) (ISCORS, 2002).

4.3 Radiological Release of Hanford Site Property

JW DeMers and FM Roddy

Principle requirements for the control and release of DOE property containing residual radioactivity are in [DOE O 458.1](#). These requirements are designed to ensure the following:

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

The site contractors transitioned from DOE O 5400.5, Chg. 2, to the new order, [DOE O 458.1](#).

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

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 CERCLA requirements. Radiologically contaminated property is disposed at ERDF if subject to CERCLA requirements, and if not, at the CWC in the 200-West Area. Personal property that has contamination levels below approved DOE control and release guidelines ([DOE O 458.1](#)) 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 O 458.1](#)) 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 O 458.1](#).

Accordingly, in May 2006, a request to DOE was submitted by WCH (DOE 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 4.9) were reviewed by RL and DOE HQ personnel and approved for use by WCH in May 2007. RL provided conditional approval in 2008 to CHPRC and Fluor Hanford, Inc. to use the hard-to-detect authorized limits.

WRPS submitted a request to ORP in June 2009 for approval to use these hard-to-detect authorized limits. ORP provided conditional approval for this request in June 2009. MSA submitted a request to RL in October 2009 for approval to use these hard-to-detect authorized limits. RL provided conditional approval for this request in November 2009.

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 in 2012 using these hard-to-detect authorized limits. The estimated total residual radioactivity for these items was less than 5 curies.

Table 4.8. Approved Release Criteria (Authorized Limits) for Select Hard-to-Detect Radionuclides^a for Residual Beta-Gamma Surface Contamination

Average	Maximum	Removable
50,000 dpm/100 cm ²	150,000 dpm/100 cm ²	10,000 dpm/100 cm ²

^a Carbon-14, iron-55, nickel-59, nickel-63, selenium-79, technetium-99, palladium-107, and europium-155
DPM = disintegrations per minute

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

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 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 also were used to determine specific radionuclides of concern for this residual radioactivity. For any potential residual radioactivity, [DOE O 458.1](#) 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. Fluor Hanford, Inc., the Hanford Site contractor responsible for these remedial actions, submitted a request to RL in January 2007 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 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.

RL 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 RL and DOE HQ personnel, these authorized limits (Table 4.10) were approved in August 2007 for use by Fluor Hanford, Inc. CHPRC assumed responsibility from Fluor Hanford, Inc., in October 2008 for all Hanford Site groundwater remedial actions. In

anticipation of this transfer of responsibility in September 2008, CHPRC submitted a request to RL for approval to use the authorized limits for resin previously approved for Fluor Hanford, Inc. RL approved this request in October 2008.

Approximately 72,000 pounds (33,700 kilograms) of resin was shipped offsite in 2012 for regeneration under these approved authorized limits. CHPRC has changed to non-regenerative resins, which will be disposed in ERDF, eliminating off-site resin regeneration shipments.

Table 4.9. 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

4.3.3 Granular Activated Carbon for Offsite Shipment and Regeneration Radiological Clearance

Carbon tetrachloride was found in the unconfined aquifer beneath the 200-West Area 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.

Workers installed a groundwater pump-and-treat system in 1996 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 used to determine specific radionuclides of concern for this residual radioactivity. For any potential residual radioactivity, ([DOE O 458.1](#)) 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. Following review by RL and HQ personnel in October 2010, approved authorized limits for offsite shipment and regeneration of granular activated carbon (Table 4.11) was approved for use by CHPRC.

Approximately 18,000 pounds (8,200 kilograms) of granular activated carbon was shipped offsite in 2012 for regeneration under these approved modified authorized limits.

Table 4.10. Approved Modified Authorized Limits for Offsite Shipment and Regeneration of Granular Activated Carbon

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

5.0 Environmental Restoration and Waste Management

Environmental restoration and waste management activities continued on the Hanford Site during 2012. The following sections describe ongoing Hanford Site River Corridor closure, cleanup and remediation, facility decommissioning, waste management operations, underground waste storage tank status, construction of the WTP and its associated facilities, and research activities related to waste cleanup.

5.1 River Corridor Closure

JA Lerch

The River Corridor includes the Hanford Site 100 and 300 Areas, which border the Columbia River. The River Corridor includes nine deactivated plutonium-production reactors, numerous support facilities, and liquid- and solid-waste disposal sites. DOE's award of the River Corridor Closure Contract to WCH in 2005 established a focus to complete cleanup actions in the 100 and 300 Areas with the following principle goals:

- 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 long-term stewardship (surveillance and maintenance).

The Mission Completion Project is addressing the last two items under the River Corridor Closure Contract. Key project scope includes assessment and integration activities, and long-term stewardship transition support.

5.1.1 Assessment and Integration

The Tri-Party Agencies agreed in 1991 that interim remedial actions in the 100 and 300 Areas could be implemented by relying on streamlined qualitative risk assessments to establish interim action cleanup levels. Waste site cleanup under interim action RODs was initiated during the mid-1990s, and continue under the River Corridor Closure Contract. In parallel, WCH is responsible for conducting risk assessment activities and providing technical support for the development of integrated source and groundwater RI/FS reports and proposed plans to establish final action cleanup decisions for the River Corridor.

River Corridor Baseline Risk Assessment. Human health and ecological risk assessments have been completed to evaluate the impacts from Hanford Site releases to the upland, riparian, and near shore areas of the River Corridor. The *River Corridor Baseline Risk Assessment, Volume II: Human Health Risk Assessment* (DOE/RL-2007-21, Vol. II, [Part 1](#) and [Part 2](#), Rev. 0) was issued in August 2011. The *River Corridor Baseline Risk Assessment, Volume I: Ecological Risk Assessment* (DOE/RL-2007-21, Vol. I, [Part 1](#) and [Part 2](#), Rev. 0) was issued in March 2012. 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. Preliminary remediation goals that are protective of human health and the environment are proposed to support development of final action cleanup decisions through the RI/FS process for the River Corridor. The risk assessment results are reflected in the River Corridor RI/FS reports.

Remedial Investigation of Hanford Site Releases to the Columbia River. Human health and ecological risk assessments have been completed to evaluate potential impacts to the Columbia River from Hanford Site releases. The *Columbia River Component Risk Assessment, Volume I, Screening-Level Ecological Risk Assessment* (DOE/RL-2010-117, Vol. I, Rev. 0) was issued in June 2012; and *Columbia River Component Risk Assessment, Volume II, Baseline Human Health Risk Assessment* (DOE/RL-2010-117, Vol. II, Rev. 0) was issued in September 2012. The risk assessment results are being reflected in the River Corridor RI/FS reports.

River Corridor RI/FS Process. Field investigation activities and development of draft integrated source and groundwater RI/FS reports and proposed plan documents for the six River Corridor decision areas (100-B/C, 100-K, 100-N, 100-D/H, 100-F/IU-2/IU-6, and 300 Area) continued. Draft RI/FS reports for the 100-K Area ([DOE/RL-2010-97](#)) and 300 Area ([DOE/RL-2010-99](#)) decision areas were submitted for regulatory review in September and December 2011, respectively. Draft RI/FS reports for the 100-F ([DOE/RL-2010-98](#)) and 100-D/H ([DOE/RL-2010-95](#)) decision areas were submitted for regulatory review in December 2012. The draft RI/FS report for 100-N Area was submitted to the regulators for review in June 2013. Delivery of a draft RI/FS report for the 100-B/C Area has been deferred to 2016 to allow for additional characterization groundwater before making recommendations on final cleanup actions. Public review of proposed actions and development of final action RODs for the six decision areas are anticipated to range from 2013 to 2017.

5.1.2 Long-Term Stewardship

The long-term stewardship task is focused on achieving interim closure and transition of surveillance and maintenance responsibilities within the River Corridor from the cleanup contractor to the site services contractor, which administers the long-term stewardship program for DOE. Within the River Corridor Closure Contract, key elements of the long-term stewardship work include preparing interim remedial action reports for each CERCLA-decision area and developing long-term stewardship transition and turnover package documents.

Transition and turnover packages were completed in 2012 for Segment 3 of the 100-F/IU-2/IU-6 Area. The package describes the completion of site assessment activities, removal of facilities, removal of miscellaneous debris, and site remediation to interim action RODs for a specific parcel of land. An interim remedial action report also was prepared and issued for Segment 3 of the 100-F/IU-2/IU-6 Area ([DOE/RL-2012-14](#)).

5.1.3 Cleanup and Remediation Activities

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

5.1.4 100 Area

5.1.4.1 100-B/C, 100-D, 100-F, 100-K, 100-H, and 100-N Areas Waste Sites

DG Saueressig

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

The 100 Area 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. Full-scale remediation of waste sites in the 100 Areas began in 1996. 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. The 100 Area remediation activities were performed during 2012 in the 100-B/C, 100-D, 100-F, 100-K, 100-H, 100-N and IU-2/6 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.

Remediation activities focused on waste burial grounds and miscellaneous waste sites. The 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. Characterization of unknown material is critical to ensure worker safety and 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 complies with post-cleanup goals can vary significantly from one waste site to another. The interim action RODs for 100 Area waste sites authorizes remediation activities. Waste generated from the cleanup of waste sites is disposed at ERDF in the 200 Area. 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.

A total of 1,089,500 tons (988,400 metric tons) of contaminated soil from 100 Area remediation activities in 2012 were disposed at ERDF. Quantities and respective locations are as follows:

- 558,100 tons (506,300 metric tons) from the 100-B/C Area
- 223,000 tons (202,300 metric tons) from the 100-D Area
- 60,100 tons (54,500 metric tons) from the 100-F Area
- .1 tons (.1 metric tons) from 100-H Area
- 51,000 tons (46,300 metric tons) from the 100-K Area
- 188,800 tons (171,300 metric tons) from the 100-N Area
- 8,500 tons (7,700 metric tons) from the IU-2/6 Area.

5.1.4.2 K Basins

BM Barnes and DJ Watson

The 100-K Area remediation activities included facility demolition, waste site remediation, cleanout of the K West Basin, and groundwater pump-and-treat operations. The K West Basin and the CVDF are the only remaining operating nuclear facilities. The K West Basin is undergoing cleanout that involves removing radioactive contaminated sludge and debris as a precursor to facility deactivation and demolition. For nearly 30 years, the basins stored 2,300 tons (2,100 metric tons) of N Reactor spent fuel and a small quantity of slightly irradiated single-pass reactor fuel (from other Hanford Site reactors). In October 2004, the major cleanup effort to remove the fuel from the K East and K West Basins was completed.

This fuel corroded during storage and the fuel washing and packaging process left behind approximately 989 cubic feet (28 cubic meters) of sludge. The 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, generated during the fuel washing and packaging process, are 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; PCBs; and fission products. Sludge has been defined as any material that is less than or equal to 0.25 inch (0.64 centimeter) in size. The project's CERCLA remedial design documentation will describe the means of sludge treatment and location of the national repository for sludge disposal. 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 0.02 inch (500 microns) 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 0.02 inch (500 microns) to settle and not be recirculated.

5.1.4.2.1 100-K Area Remediation Progress and Accomplishments

- 105-KE Reactor Building interim safe storage activities continued in FY2013. Engineering for reactor penetration sealing and the Safe Storage Enclosure continued.
- Demolished and disposed of the following:
 - ‡ 183.2-KE Sedimentation Basins (continued decontamination and decommissioning, continuing thru FY2013)
 - ‡ 183.3-KE Filter Basins (continued decontamination and decommissioning, continuing thru FY2013)
- Completed processing of pretreated knock-out-pot sludge including the removal from the K West Basin in Multi-Canister Overpacks to be managed as spent nuclear fuel and transferred to the CSB for interim storage. Completed design for an annex to the K West Basin that will be used for removal of sludge currently stored in underwater-engineered containers for transfer to T Plant for interim storage pending treatment and packaging for disposal at a national repository. Completed partial demolition of an existing annex to the K West Basin used for removal of spent nuclear fuel and commenced construction of the annex to be used for sludge removal.
- Continued groundwater pump-and-treat operations
- Continued preparing the 105-KE Reactor Building into interim safe storage configuration
- Continued testing of systems and components to be used for removing K Basins sludge at the Maintenance and Storage Facility located in the 400 Area prior to deployment to the K West Basin and its radiological environment.

5.1.4.2.2 K Basins Progress on Defense Nuclear Facilities Safety Board Recommendations*RA Quintero*

No changes occurred in 2012 to the K Basins Sludge Treatment Project commitment dates contained in the DOE Implementation Plan ([DOE 2002](#)) and its revision ([DOE 2005](#)) for stabilizing the nuclear materials identified in Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2000-1 ([DNFSB 2000-1](#)). Revisions to the implementation plan commitment dates for completing K Basins sludge treatment and packaging are in development.

In its periodic report to Congress dated June 25, 2012, the DNFSB closed two Sludge Treatment Project issues, regarding integration of safety into design and safety basis development, that had been identified in 2011 ([DNFSB 2012a](#), *Report to Congress on the Status of Significant Unresolved Technical Differences between the Board and the Department of Energy on Issues Concerning the Design and Construction of DOE's Defense Nuclear Facilities*). In its next periodic report to Congress dated December 24, 2012, the DNFSB identified two new issues concerning spray leak consequence analyses and safety instrumented systems ([DNFSB 2012b](#), *Report to Congress on the Status of Significant Unresolved Technical Differences between the Board and the Department of Energy on Issues Concerning the Design and Construction of DOE's Defense Nuclear Facilities*). DOE is working with DNFSB staff to resolve these issues.

5.1.5 200 Area – Central Plateau*PA Burke*

The Central Plateau is a 75-square-mile (194-square-kilometer) region near the center of the Hanford Site, which includes the area designated in [DOE/EIS-0222-F](#) and ROD ([64 FR 61615](#)) as the Industrial-Exclusive Area, a rectangular area of about 20 square miles (52 square kilometers) in the center of the Central Plateau. The Industrial-Exclusive Area contains the 200-East and 200-West Areas, used primarily for the Hanford Site nuclear fuel processing and waste management and disposal activities. The Central Plateau also encompasses the CERCLA 200 Area NPL 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.

The *Hanford Site Cleanup Completion Framework* ([DOE/RL-2009-10](#)) defines the path forward for cleanup at the Hanford Site. The 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](#), the Tri-Party Agencies developed changes to the TPA that reflect the path forward for Central Plateau cleanup.

The Central Plateau includes two principal cleanup areas (see Figure 8.1):

- **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 10 square miles (26 square kilometers) 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. Completing cleanup for the approximately 65-square-mile (168-square-kilometer) Outer Area will reduce the active footprint of cleanup for the Central Plateau to the Inner Area.

5.1.5.1 Inner Area

The Inner Area (anticipated to encompass approximately 10 square miles [26 square kilometers]) 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 subsections.

5.1.5.1.1 200-PW-1, 200-PW-3, 200-PW-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 PFP and PUREX. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). At EPA's request, the Tri-Party Agencies agreed to retain the 200-PW-1, 200-PW-3, 200-PW-6, Operable Unit group and the 200-CW-5 Operable Unit and consolidate them into a single decision (Table 5.1).

The *Record of Decision Hanford 200 Area Superfund Site 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* ([DOE et al. 2011](#)) was issued in December 2011. The selected remedy in the ROD addresses soils and subsurface disposal structures contaminated primarily with plutonium and cesium, two settling tanks, and associated pipelines. The remove, treat, and dispose approach for contaminated soil and debris will be used to address plutonium contaminated soils and subsurface structures, and consists of the following: 1) Remove a portion of contaminated soil, structures, and associated debris; 2) treat these removed wastes as required to meet disposal requirements at ERDF (Section 5.4.3.7) or waste acceptance criteria for offsite disposal at the Waste Isolation Pilot Plant in Carlsbad, New Mexico; and 3) dispose at ERDF or Waste Isolation Pilot Plant. The 200-CW-5 Operable Unit, also known as the Z-Ditches, will use the remove, treat, and dispose approach to excavate contaminated soils and dispose at ERDF or the Waste Isolation Pilot Plant, as appropriate.

Table 5.1. Central Plateau Operable Unit Structure

New Operable Unit Group	Description	Predecessor Operable Units		Lead Regulatory Agency
Inner Area				
200-PW-1/3/6, 200-CW-5	Plutonium-contaminated soil sites located near the PFP 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, 200-PW-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	Ecology
200-IS-11	Pipelines, diversion boxes, etc., in the 200-IS-1 Operable Unit			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	Ecology
200-DV-1	Selected soil waste sites in the Inner Area with deep vadose zone contamination	200-TW-1/2	200-PW-5	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	Ecology
200-CP-1	PUREX Canyon; Associated waste sites	200-IS-1 200-MG-1/2	200-MW-1 200-UR-1	Ecology
200-CR-1	REDOX Canyon; associated waste sites	200-IS-1 200-MG-1/2	200-UR-1	EPA
Outer Area				
200-OA-1, 200-CW-1, 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

Three of the six 200-PW-1 waste sites, also known as the High-Salt Waste Group, will use the remove, treat, and dispose approach to excavate the highest concentrations of contaminated soils, located up to 2 feet (.6 meters) below the bottom of the disposal structure, and dispose at Waste Isolation Pilot Plant. An evapotranspiration barrier will be constructed over the remaining waste in these waste sites.

200-PW-3 Operable Unit: This operable unit, also known as the Cesium-137 Waste Group, will require that three of the five waste sites receive additional backfill to achieve coverage of at least 15.0 feet (4.57 meters) depth. Contamination at the other two waste sites is deeper than 15.0 feet (4.57 meters) from the ground surface and will not require additional backfill.

200-PW-6 Operable Unit: This operable unit and three of the six 200-PW-1 waste sites, also known as the Low-Salt Waste Group, will use the remove, treat, and dispose approach to excavate a significant portion, approximately 90 percent, of the contaminated soils to a depth of 33 feet (10 meters) below ground surface, and dispose at ERDF or Waste Isolation Pilot Plant, as appropriate. An evapotranspiration barrier will be constructed over the remaining waste in these waste sites. A soil vapor extraction system is being used to remove and treat carbon tetrachloride contamination at waste sites in the High-Salt Waste Group and will continue to be used until vadose zone cleanup levels are met. Soil covers will be used to provide coverage to a depth of at least 15.0 feet (4.57 meters) over cesium-contaminated soils. This consists of maintaining or enhancing the existing soil cover with additional backfill.

Institutional controls and long-term monitoring will be required for waste sites in the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units where waste is left in place and precludes unrestricted land use.

5.1.5.1.2 200-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-CR-1, 200-CW-5, 200-IS-1, 200-PW-1, 200-PW-6, and 200-SW-2 Operable Units. Specific sites are listed in the *Tri-Party Agreement Action Plan, Appendix C*. 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 *Remedial Investigation/Feasibility Study Work Plan 200-WA-1 and 200-BC-1 Operable Units (DOE/RL-2010-49)* was issued in December 2011. 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.

5.1.5.1.3 200-EA-1 Operable Unit (200-East Inner Area)

This operable unit consolidates the remaining Inner Area sites in the 200-East Area except for the environmental media underlying tank farm waste management areas (WMA), landfills in the 200-SW-2 Operable Unit, PUREX, B Plant Canyon, and several waste sites with deep vadose zone contamination that are adjacent to WMA environmental media sites. Specific sites are listed in the *Tri-Party Agreement Action Plan, Appendix C*. 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 make use of a comprehensive application of the technical cleanup principles for the Inner Area developed for the 200-WA-1 Operable Unit.

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. The 200-EA-1 Work Plan has not been initiated.

5.1.5.1.4 200-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 in the tank farm WMAs. Specific sites are listed in the *Tri-Party Agreement Action Plan, Appendix C*.

The Tri-Party 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 issued in September 2011.

5.1.5.1.5 200-SW-2 Operable Unit (Burial Grounds)

This operable unit 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 added to the 200-SW-2 Operable Unit during restructuring. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). Portions of the burial grounds listed in the *Hanford Facility Dangerous Waste Permit* (WA7890008967) include TSD facilities. DOE is working with Ecology to remove unused areas from the permit scope.

The Tri-Party Agencies agreed to use a coordinated CERCLA remedial action and RCRA corrective action process for cleanup decisions in the 200-SW-2 Operable Unit. The *200-SW-2 Radioactive Landfills Group Operable Unit RCRA RFI/CMS and RI/FS Work Plan* ([DOE/RL-2004-60](#)) was issued in October 2011.

5.1.5.1.6 200-DV-1 Operable Unit (Deep Vadose Zone)

This operable unit includes 44 soil waste sites located in the 200-East and 200-West Areas. The sites in this operable unit were previously located in the 200-TW-1/2 and 200-PW-5 Operable Units. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). 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 200-DV-1 Operable Unit Work Plan.

Work on the 200-DV-1 Operable Unit is being closely coordinated with the ongoing RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) process for tank farm WMA 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 on 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](#)), 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.

5.1.5.1.7 200-CB-1 Operable Unit (B Plant Canyon)

This operable unit includes the B Plant Canyon Building (221-B) and the WESF, 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 the *Tri-Party Agreement Action Plan*, [Appendix C](#). 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 Agencies. Cesium and strontium capsules located in the WESF are not included in the scope of the 200-CB-1 Operable Unit.

5.1.5.1.8 200-CU-1 Operable Unit (U Plant Canyon)

This operable unit includes the U Plant Canyon Building (221-U) and other structures included in the 2005 ROD 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) took place in 2011.

5.1.5.1.9 200-CP-1 Operable Unit (PUREX Canyon)

This operable unit includes the PUREX Canyon Building (202-A), PUREX Storage Tunnels (218-E-15 and 218-E-16), exterior components of the ventilation system for each structure (e.g., deep bed filters), and 20 soil waste sites in the vicinity. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). 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 Agencies.

5.1.5.1.10 200-CR-1 Operable Unit (REDOX Canyon)

This operable unit includes the REDOX Canyon Building (202-S), exterior components of the ventilation system (e.g., filters), and 12 soil waste sites located in the vicinity. Specific sites are listed in the *Tri-Party Agreement Action Plan*, [Appendix C](#). 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 Building 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 Agencies.

5.1.5.2 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 65 square miles (168 square kilometers) and contains more than 90 waste sites and structures scattered throughout the 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 implementing 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.

5.1.5.2.1 200-OA-1, 200-CW-1, and 200-CW-3 Operable Units (Outer Area)

Soil waste sites in the Outer Area requiring cleanup are assigned to one of the following three operable units:

- **200-CW-1 Operable Unit.** Contains ponds that were used for discharging 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 eight ponds and associated sewer lines, control structures, and unplanned releases.
- **200-CW-3 Operable Unit.** Contains 16 sites that were associated with operating the 200-North Area, a small complex initially used for temporary storage of spent nuclear fuel and later for storing 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 could 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 Units RI/FS work plan and continued in 2011. The *200-CW-3 Operable Unit Interim Remedial Action Report* ([DOE/RL-2011-58](#)) was issued in September 2011. The summary of waste site remediation activities, cleanup verification processes, and cost information will support developing a final remedial action for the Outer Area of the Hanford 200 Area NPL site.

5.1.5.2.2 Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill

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

Because the NRDWL is a RCRA-permitted TSD 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 being conducted in accordance with the NEPA.

5.1.6 300 Area

DE Faulk

Remediation efforts in 2012 focused on the 300-FF-2 Operable Unit waste sites. The 300-FF-2 Operable Unit ROD ([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.



Figure 5.1. 300 Area North of Apple Street

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 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 at ERDF (Section 5.4.3.7) located on the Central Plateau and other EPA-approved disposal facilities. Approximately 299,600 tons (296,600 metric tons) of contaminated soil from the 300-FF-2 Operable Unit were disposed in 2012 at ERDF. Remediation of all waste sites north of Apple Street, including backfill and revegetation was completed in 2012 (Figure 5.1). The 340 building remediation and vault removal continues with completion scheduled for 2013. Remedial designs have been initiated on all remaining waste sites south of Apple Street.

The 618-10 Burial Ground, located just west of Route 4 South, operated from 1954 to 1963 and is approximately 5.2 acres (2.1 hectares) 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 8.6 acres (3.5 hectares) in size. Both burial grounds (Figure 5.2) received waste including transuranic material from the 300 Area laboratory facilities. The burial grounds consist of multiple trenches, vertical pipe units, and caissons. The 618-11 Burial Ground contains trenches, vertical pipe units and four caissons. Remediation of the 618-11 Burial Ground will commence after the 618-10 Burial Ground.



Figure 5.2 618-10 and 618-11 Burial Grounds

Remediation of the 618-10 Burial Ground trenches began in April 2011 and continued through 2012. The 2012 activities focused on burial ground trenches. Future activities will include remediation of vertical pipe units that consist of the following four configurations:

- 15-feet (4.6-meter) long 14-inch (35.6-centimeter) diameter soil pipe
- 10-feet (3-meter) long 12-inch (30.5-centimeter) diameter pipe
- Culvert pipes
- 15-feet (4.6-meter) long, 22-inch (56-centimeter) diameter vertical pipe units constructed from 55-gallon (209-liter) drums.

These vertical pipe units were constructed by welding five 55-gallon (209-liter) bottomless drums together end-to-end and burying them vertically. The vertical pipe units are generally open to the soil at the bottom and closed at the top with a concrete cover. The currently planned remediation method will involve installation of a 48-inch (122-centimeter) steel over-casing around each vertical pipe unit. Each vertical pipe unit then will be augered to size-reduce the vertical pipe unit, its contents, and the soil within the over-casing. The material will be stabilized grout or other stabilization media. Following stabilization, the material will be removed for disposal.

5.2 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, the deactivation and decommissioning of facilities in the 100, 200, 300, and 400 Areas, and ancillary reactor facilities.

5.2.1 100 Area

DJ Warren

Deactivation, decontamination, decommissioning, and demolition activities in the 100 Area included demolition (see Figure 5.3), as well as

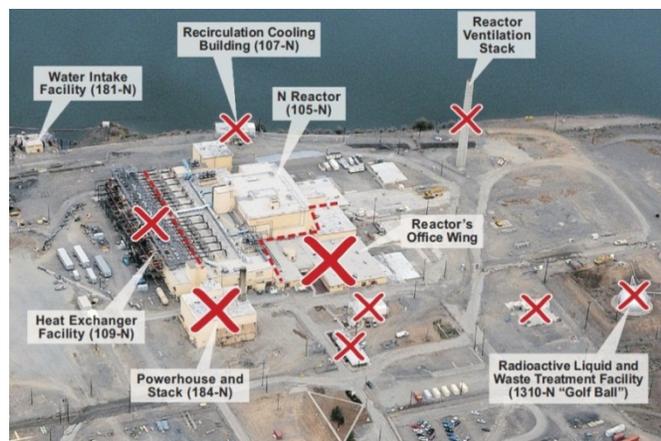


Figure 5.3. 100-N Facilities Demolished

construction actions at the 100-N and 100-D Areas, and 100-H Area, which were conducted as non-time-critical removal actions under CERCLA. These actions are summarized below.

100 Area facilities demolished in 2012:

- 105-N Fuel Storage Basin and Lift Station
- 105-ND Remote Air Intake
- 105-NE Fission Products Trap
- 107-N Basin Recirculation Facility (Below Grade)
- 181-N River Pumphouse
- 181-NA Pump House Guard Tower
- 181-NB #3 Diesel Enclosure
- 181-NE Hanford Generating Plant River Pumphouse
- 182-N High Lift Pumphouse
- 184-NA Stack Base (below grade)
- 1112-N Guard Station (below grade)
- 1112-NA Microwave Tower Annex (below grade)
- 1120-N Equipment Warehouse
- 1143-N Carpenter/Paint Shop
- 1303-N Spacer Silos
- 1607-N3 100-N Sanitary Sewer System No. 3
- 1607-N9 100-N Sanitary Sewer System No. 9
- 1900-N Water Supply Tanks Foundation Rings (below grade)
- 1902-D Water Tank Pedestals (100-D Area, below grade)
- 1904-NB Sewage Lift Station #2
- 1904-NC Sewage Lift Station #3
- 1908-N Reactor Outfall Structure
- 1908-NE Hanford Generating Plant Outfall
- HS0007 and HS0008 Hazardous Materials Material Storage Containers
- MO-100 Mobile Office
- MO-403 Change House and Lunchroom Trailer
- MO-415 Administration Mobile Office
- MO-425 Mobile Office
- MO-426 Mobile Office
- MO-427 Change Room Trailer
- MO-765 Mobile Office
- MO-889 Water Trailer (100-D Area)
- MO-929 Water Trailer (100-D Area)
- MO-980 Water Trailer (100-D Area).

100 Area construction activities completed in 2012, in support of future decommissioning, deactivating, decontaminating, and demolishing activities:

- Completion of the 105-N/109-N safe storage enclosure.

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

- 1904-N 100-N Sanitary Sewer Lagoon
- 1904-NA Sewage Lift Station #1
- 1724-N Nitrogen Electrical Vault
- 183-D Water Treatment Plant (100-D Area).

5.2.1.1 100-K Area Waste Sites

LM Dittmer

Extensive remediation activities were performed throughout the 100-K Area during 2012. These activities included waste site remediation, verification sampling to confirm that cleanup objectives were met, backfill, re-contour, and interim re-vegetation of waste site excavations, as well as waste sorting, segregation, treatment and disposal. The 100-K Area waste sites are authorized for remedial action through interim action RODs approved by the Tri-Party Agencies.

The waste sites varied considerably in size and complexity, as well as in the nature and extent of contamination. Historically, the waste sites included liquid effluent waste sites, reactor cooling water treatment systems, septic systems, piping, and miscellaneous waste sites. Complex sampling and analysis is performed to determine whether a waste site remediation requires additional cleanup, or if the excavation complies with cleanup goals to meet site closure requirements. Twenty waste sites were interim closed in 2012 following remediation (100-K-3, 100-K-6, 100-K-18, 100-K-19, 100-K-34, 100-K-36, 100-K-46, 100-K-53, 100-K-62, 100-K-63, 100-K-68, 100-K-69, 100-K-70, 100-K-71, 100-K-97, 100-K-102, 120-KW-5, 120-KW-7, 132-KE-1 and 1607-K3).

Waste generated from the cleanup of waste sites is disposed at ERDF. This centralized disposal facility is the primary disposal pathway; however, other disposal options are available if the material does not meet the waste acceptance criteria for ERDF. A total of 15,169 tons (13,761 metric tons) of contaminated soil from 100-K Area remediation activities in 2012 were disposed at ERDF.

5.2.2 200 Area – Central Plateau

Central Plateau facilities include 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.

5.2.2.1 Plutonium Finishing Plant Decommissioning Progress

WG Cox

PFP began processing plutonium nitrate solutions into metallic plutonium during 1949 for shipment to nuclear weapons-production facilities. Operation of this plant continued into the late 1980s (Figure 5.4). DOE issued a shutdown order for the PFP in 1990 and, in 1996, authorized the deactivation and transition of plutonium-processing portions of the facility in preparation for decommissioning.

Workers at the PFP complex completed a large and multi-faceted effort in 2004 to stabilize,



Figure 5.4 Plutonium Finishing Plant Prior to Demolition

immobilize, repackage, and/or properly dispose of nearly 19.8 tons (18 metric 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.

All special nuclear materials and stored fuel elements were removed from the plant and security was downgraded by the end of 2009. The removal and disposal of process equipment, chemicals, glove boxes, and hoods from the buildings began in 2009 and continued through 2012. Significant accomplishments at PFP during 2012 include the following:

5.2.2.1.1 234-5Z, Plutonium Finishing Plant

- Removed 77 percent of all PFP glove boxes and hoods
- Removed 72 percent of all asbestos
- Removed 67 percent of process transfer lines
- Removed 36 percent of process vacuum piping
- Completed removal and stabilization of the PFP Vault complex (2736-Z, 2736-ZA, 2736-ZB, 2736-ZC, 2721-Z, 2731-ZA and nitrogen generator system)

5.2.2.1.2 236-Z, Plutonium Reclamation Facility

Removed 56 percent of pencil tanks.

5.2.2.2 Canyon Disposition Initiative

BJ Dixon

The Canyon Disposition Initiative was created to investigate the potential for using the five former chemical separations facilities (B Plant, T Plant, U Plant, PUREX Plant, and REDOX 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) ROD ([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 ROD, process equipment already in the plant will be consolidated into the belowground plant process cells. In addition, the cells, 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 began in 2009 for the 221-U Facility. Beginning in 2009 and continuing through 2011, process equipment on the canyon deck was moved to specific belowground cells within the canyon structure, Cell 30 Tank D-10 was removed from the canyon (canyon void space grouted) and transferred to the CWC for interim storage pending final treatment, packaging, and shipment to the Waste Isolation Pilot Plant. The hot pipe trench, piping and electrical galleries, drain header, process sewer, and ventilation tunnel and ducts were filled with grout in accordance with the *Remedial Design/Remedial Action Work Plan for the 221-U Facility* ([DOE/RL-2006-21](#)). These activities completed three of the five major remedy components: 1) Equipment size reduction and placement; 2) Cell 30 Tank D-10 contents disposition; and 3) canyon void space grouting. The 221-U Plant facility actions were limited to surveillance and maintenance during 2012.

5.2.3 300 Area

CP Strand

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 *Action Memorandum for General Hanford Site Decommissioning Activities* (DOE/RL-2010-22) 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/hour were observed at the failure location, indicating a possible release occurred during past operations from the 324 Building. Casings containing closed-end push probes were installed in November 2010 under B-Cell at the northern corner of the 324 Building. Dose measurements taken from these probes showed peak radiation readings of 8,900 rad/hour, confirming a significant source term from within B-Cell had been released to the soil column beneath the 324 Building. Additional probes to greater depths, and reviews of downgradient monitoring wells, confirmed that contamination had not come into contact with the groundwater. Characterization sampling of the contaminated soils has been performed and ongoing engineering evaluations are being used to develop a retrieval methodology that is protective of both workers and the environment.

Work started in February 2012 to demolish Hanford's 308 Building, which was completed in April 2012 (Figure 5.5). The 71,000-square-foot (6,603-square-meter) structure was one of the largest remaining at the 300 Area located just north of the city of Richland and once contained 52 glove boxes for development and testing reactor fuel. The building was known for the high-bay, called the 308A Building, added in 1971 that would cover one of the six small test reactors housed at different times in the 300 Area. Those reactors were in addition to the nine larger reactors along the Columbia River previously used to produce weapons plutonium.

The 300 Area buildings and structures demolished in 2012 are as follows:

- 305-A Craft Shop (slab)
- 307 Retention Basins
- 308 Plutonium Fuels Building
- 308-A TRIGA Reactor
- 335 Sodium Test Facility (slab)
- 336 High-Bay Test Facility (slab)
- 338 Maintenance Facility (slab)
- 342-C Generator
- 3329 Storage Building (slab)
- 3232 Storage Building (slab)
- 3506-C Telecommunication Building
- 3701-U Security Building (slab)
- 3704-D Storage Facility (slab)
- 3705 Photography Building (slab)
- 3705-BA Boiler Annex (slab)

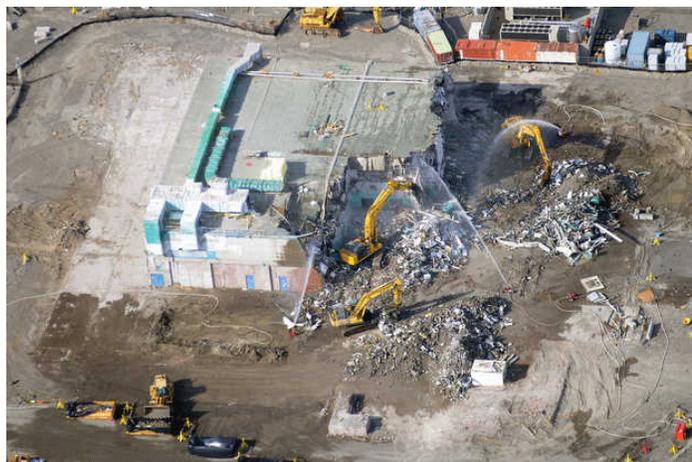


Figure 5.5. Demolished 308 Plutonium Fuels Building

- 3706-BA Boiler Annex (slab)
- 3703-E Storage Facility (slab)
- 3707-F Radiation Monitoring Building
- 3709 Paint Shop (slab)
- 3713 Carpenter Shop (slab)
- 3719 Computer Facility (slab)
- 3722 Fabrication Shop (slab)
- 3745 Radiological Calibration Lab (slab)
- 3745-A Van Degraff Lab (slab)
- 3745-B Ion Accelerator Lab (slab)
- 3746 Irradiation Physics Building (slab)
- 3746A Radiological Physics Lab (slab)
- 3763 Office Building (slab)
- 3766 Office Building
- MO-443 Mobile Office.

Facility deactivation, characterization, and demolition planning is ongoing for the balance of surplus buildings located in the 300 Area.

5.2.4 400 Area

DJ Warren

Demolition activities were conducted on the 4702 Office Building located in the 400 Area. These activities were conducted as non-time-critical removal actions under CERCLA in accordance with the *Removal Action Work Plan for River Corridor General Decommissioning Activities* ([DOE/RL-2010-34](#)). The demolition of the 4702 Office Building began in 2011 and was completed in 2012.

5.2.4.1 Fast Flux Test Facility

B M Barnes

FFTF is a DOE-owned, formerly operating 400-megawatt (thermal) liquid-metal cooled (sodium) research and test reactor located in the 400 Area (Figure 5.6). 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 also pursued. FFTF 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, the facility deactivation was completed in June 2009.

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



Figure 5.6. Fast Flux Test Facility

decommissioning was included in [DOE/EIS-0391](#), which was issued on November 12, 2012. The preferred action for the FFTF is entombment, which would remove all above-grade structures, including the reactor building. The below-grade structures, the reactor vessel, piping, and other components would remain in place and be filled with grout to immobilize the remaining radioactive and hazardous constituents. Waste generated from these activities would be disposed of in an IDF, and an engineered modified RCRA Subtitle C barrier would be constructed over the filled area. Remote-handled special components would be processed at Idaho National Laboratory and returned to Hanford. Bulk sodium inventories would be processed at Hanford for use in the WTP.

5.3 Waste Management Operations

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

5.3.1 Waste Classifications

WE Toebe

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\(3\)](#), *Designation of Dangerous Waste*, 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, HLW, or low-level waste (LLW) under the [AEA](#). Wastes that contain constituents regulated under both [WAC 173-303](#) and the [AEA](#) are classified as mixed wastes.

Radioactive and/or mixed wastes are managed in several ways. HLW is stored in large underground single-shell tanks (SST) and DST or in capsules. LLW typically is stored in tanks or containers. The method used to store LLW depends on the source, composition, and waste concentration. Transuranic waste is stored in vaults or on aboveground 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 onsite or shipped offsite ([DOE/RL-2011-16](#), *Hanford Site Annual Dangerous Waste Report Calendar Year 2010*). Dangerous and mixed wastes are treated, stored, and prepared for disposal at several Hanford Site facilities. Dangerous waste generated at the site is 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 nonhazardous waste) has been disposed 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 (i.e., oxalates).

Non-regulated demolition waste from 100 Area decommissioning projects was buried in situ (in place) or in designated disposal locations on the Hanford Site.

5.3.2 Solid Waste Inventories

JF Berger and DE Nester

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 CHPRC, MSA, and WRPS. The database does not include all waste from WCH, ERDF, or any PNNL 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 at the Hanford Site, as tracked by the Solid Waste Information and Tracking System database, are

shown in Tables 5.2 and 5.3. Quantities of dangerous waste shipped offsite, as tracked by the database, are shown in Table 5.4. Hanford Site solid waste management is discussed in [Section 5.4.3](#).

Table 5.2. Solid Waste¹ Quantities Generated on the Hanford Site

Waste Category		2007	2008	2009	2010	2011	2012
Mixed	tons	259	346	281	286	522	305
	kilograms	235,000	314,000	255,000	260,000	474,000	277,000
Radioactive	tons	330	398	696	725	4022	343
	kilograms	300,000	361,000	632,000	658,000	3,649,000	311,000

¹Solid waste includes containerized liquid waste.

Table 5.3. Solid Waste¹ Quantities Received on the Hanford Site from Offsite Sources

Waste Category		2007	2008	2009	2010	2011	2012
Mixed ²	tons	195	459	257	152	320	66
	kilograms	177,000	416,000	233,000	138,000	291,000	60,000
Radioactive ²	tons	185	445	196	388	257	82
	kilograms	168,000	404,000	178,000	352,000	233,000	74,000

¹Solid waste includes containerized liquid waste. Solid waste quantities do not include U.S. Navy reactor compartments.

²Total 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 5.4. Dangerous Waste¹ Quantities Shipped Off the Hanford Site

Waste Category		2007	2008	2009	2010	2011	2012
Containerized (DW Only)	tons	53	128	47	55	53	18
	kilograms	48,000 ²	116,000 ²	42,800 ²	49,700 ²	47,800 ²	16,600 ²
Containerized (MW Only)	tons	39	56	79	37	43	91
	kilograms	35,100 ³	50,900 ³	71,300 ³	33,900 ³	38,700 ³	82,800 ³
Bulk Solids (DW Only)	tons	—	—	3.8	20	26	3
	kilograms	—	—	3,430	18,000	23,600	2,500
Bulk Solids (Non-Rad/Non-DW)	tons	—	—	79	210	120	17
	kilograms	—	—	71,400	190,600	108,900	14,200
Bulk Liquids (DW Only)	tons	16	57	2	0	0	0
	kilograms	14,300	51,900	2,050	0	0	0
Bulk Liquids (Non-Rad/Non-DW)	tons	91	164	0	0	0	0
	kilograms	82,400	149,000	0	0	0	0
Totals	tons	198	405	211	322	242	129
	kilograms	180,000	367,000	191,000	292,000	219,000	116,100

¹ Does not include Toxic Substances Control Act waste.

² Dangerous waste (DW) only.

³ Mixed waste (radioactive and dangerous).

5.3.3 Solid Waste Management

Solid waste management includes TSD of solid waste produced as a result of Hanford Site operations or received from offsite sources authorized by DOE to ship waste to the Hanford Site. These facilities are operated and maintained in accordance with state and federal regulations and facility permits. The following sections describe specific waste TSD locations at the Hanford Site.

5.3.3.1 Central Waste Complex

LR Strickling

The CWC, a solid waste storage facility located in the 200-West Area, receives waste from sources on the Hanford Site and from offsite sources that are authorized by DOE to ship waste to the Hanford Site for TSD. The majority of waste received at the CWC is generated from ongoing cleanup, research, and development activities at the Hanford Site. Waste types include low-level, mixed low-level, transuranic, and PCB radioactive. The current volume of waste stored totals approximately 378,714 cubic feet (10,724 cubic meters).

The CWC can store as much as 735,000 cubic feet (20,800 cubic meters) 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.

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 CWC West Outside Storage area is 201,965 cubic feet (5,719 cubic meters).

The CWC is operating under interim status standards specified in the *Hanford Facility Dangerous Waste Permit* (WA7890008967), CWC Part A Form. Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

5.3.3.2 Waste Receiving and Processing Facility

LC Tuott

The WRAP 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 52,000-square-foot (4,800-square-meters) facility, along with two 21,500-square-foot (2,000-square-meters) storage buildings, is located north of the CWC in the 200-West Area.

Waste destined for the WRAP 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 WRAP Facility for onsite burial or prepared for future treatment at other onsite or offsite TSD facilities. Waste determined to be transuranic is certified and packaged for shipment to the Waste Isolation Pilot Plant for disposal.

In response to budget constraints, actions were taken in late 2011 and 2012 to place the WRAP Facility into a lay-up status until future funding is available to restart the facility. The layup actions during the interim period maintain facility safety, environmental compliance, and operational viability to enhance the transition to operational status at the end of the layup period.

The WRAP Facility is operating under interim status standards specified in the *Hanford Facility Dangerous Waste Permit* (WA7890008967), WRAP Facility Part A Form. Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

5.3.3.3 T Plant Complex

LR Strickling

The T Plant Complex (Figure 5.7) is located in the 200-West Area and provides solid waste treatment, storage, and decontamination services for the Hanford Site, as well as for offsite facilities.

The T-Plant Complex is operating under interim status standards specified in the *Hanford Facility Dangerous Waste Permit* (WA7890008967), T-Plant Complex Part A Form.

Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

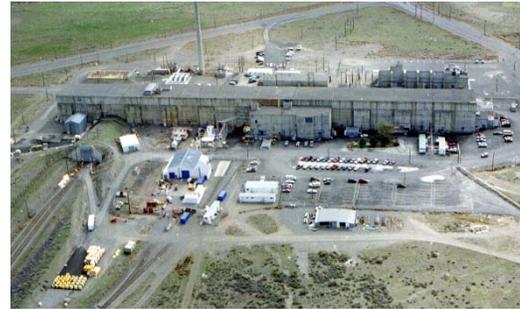


Figure 5.7. T Plant Complex

5.3.3.4 Canister Storage Building

LC Petersen

The CSB (Figure 5.8) is a large, 42,000-square-foot (3,906-square-meter) facility located in the 200-East Area that stores about 2,300 tons (2,086 metric tons) of spent nuclear fuel packaged in approximately 400 multi-canister overpacks that came from the 100-K Basins, 100-N Reactor, and T Plant. The multi-canister overpacks are stored in 220 carbon steel tubes within a below grade concrete vault. The irradiated fuel was cleaned, packaged, dried, and relocated to the CSB beginning in 2004 to provide safe interim storage in a consolidated location, allowing for cleanup of older facilities to support reducing the cleanup footprint of the Hanford Site and reducing risk. The CSB has a design life of 40 years, and will safely store the multi-canister overpacks until they are permanently placed in a National Repository.



Figure 5.8. Canister Storage Building and Interim Storage Area

Adjacent to the CSB is the Interim Storage Area, which also contains spent nuclear fuel packaged in various containers. This spent nuclear fuel will be subsequently repackaged and sent to a National Repository.

5.3.3.5 Low-Level Burial Grounds

LR Strickling

The low-level burial grounds consist of eight separate burial grounds. Two burial grounds are located in the 200-East Area and six are located in the 200-West Area. These burial grounds are regulated under the [AEA](#). Two of the burial grounds are being used for the disposal of LLW and mixed waste (i.e., low-level radioactive waste with a dangerous waste component regulated by [WAC 173-303](#)). The 218-W-5 Burial Ground is designated as LLW, located in the 200-West Area, and contains Trenches 31 and 34. The 218-E-12B Burial Ground is designated as low-level, located in the 200-East Area, and contains Trench 94. Trench 94 is dedicated for the disposal of defueled U.S. Navy reactor compartments. Trenches that contain mixed LLW are regulated under RCRA. Five of the burial grounds in the 200-West Area were used for disposing LLW 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 are operating under interim status standards specified in the *Hanford Facility Dangerous Waste Permit* (WA7890008967), Low-Level Burial Grounds Part A Form. Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967). In addition, the low-level burial grounds are included in [DOE/RL-2004-60](#). The plan outlines proposed characterization and remediation activities for specified burial grounds in the 200-East and 200-West Areas.

DOE issued a ROD ([69 FR 39449-39455](#), *Record of Decision for the Solid Waste Program, Hanford Site, Richland, WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant*) on June 23, 2004, for the Solid Waste Program on the Hanford Site. Part of the ROD stated that DOE would dispose LLW in lined disposal facilities. Disposal of U.S. Navy reactor compartments in Trench 94 was not affected by this ROD.

While some of the low-level burial grounds contain only LLW and mixed LLW, suspect transuranic waste previously had been placed in retrievable storage. Retrieval of suspect transuranic retrievably stored waste occurred in the following burial grounds:

- 218-W-4C Burial Ground was initiated in October 2003 in accordance with the TPA Change Number [M-91-03-01](#), and removal of waste from trenches in this burial ground was completed in May 2008
- 218-W-4B Burial Ground was initiated in January 2007
- 218-W-3A Burial Ground was initiated in August 2007
- 218-E-12B Burial Ground was initiated in February 2011.

Retrieval of suspect transuranic retrievably stored waste in the 218-W-4B, 218-W-3A, and 218-E-12B Burial Grounds continued through September 2011 at which time retrieval activities were suspended due to reprioritization of work at the Hanford Site. Retrieval activities in these burial grounds are planned to resume in FY2015.

The Next Generation Retrieval Project also received an EM Best in Class Sustainability Award in 2012 for enhancing methods and equipment to remove retrievably stored transuranic waste from the burial grounds.

5.3.3.5.1 Low-Level Waste Burial Ground 218-W-5, Trenches 31 and 34

Trenches 31 and 34 are rectangular landfills with approximate base dimensions of 250 x 100 feet (76 x 30 meters). The floor of the excavation slopes slightly (nominally 1:3), giving a variable depth of 30 to 40 feet (9 to 12 meters). These trenches comply with WAC 173-303 requirements for double liners and leachate removal/collection systems. The floor and sides of the trenches are covered with a layer of soil 3.3 feet (1 meter) 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 originally designated for mixed LLW. Disposal of LLW in the unlined trenches ceased June 23, 2004. Since that date, Trenches 31 and 34 have accepted LLW and mixed LLW for disposal. Disposal in Trench 31 began in May 2005, and disposal in Trench 34 began in September 1999.

In 2012, a total of 9,817 cubic feet (278 cubic meters) of waste were disposed in Trenches 31 and 34 as follows:

- Trench 34 has approximately 182,340 cubic feet (5,164 cubic meters) of waste in 5,288 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. No waste was disposed of in Trench 34 in 2012. At the end of 2012, Trench 34 was filled to approximately 82 percent of waste capacity.

- Trench 31 has approximately 189,428 cubic feet (5,364 cubic meters) of waste in 3,348 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 50 percent of waste capacity.

5.3.3.5.2 Low-Level Waste Burial Ground, Trench 94

LR Strickling and JA Conley

Two defueled U.S. Navy reactor compartment were received in 2012 and placed in LLW burial ground, Trench 94 (218-E-12B Burial Ground), bringing the total number of reactor compartments received to 125. 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 33 feet (10 meters) in diameter, 47 feet (14.3 meters) long, and weigh between 1,000 and 1,500 tons (900 and 1,400 metric tons). Decommissioned cruiser reactor compartments are approximately 33 feet (10 meters) in diameter, 42 feet (12.8 meters) high, and weigh approximately 1,500 tons (1,362 metric tons).

5.3.3.6 Waste Encapsulation and Storage Facility

LC Petersen

The WESF (Figure 5.9), 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 WESF 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, 20,000-square-foot (1,860-square-meters) building, 157 feet (48 meters) long and 40 feet (12 meters) 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 are 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.



Figure 5.9. Waste Encapsulation and Storage Facility

The WESF is operating under interim status standards specified in the *Hanford Facility Dangerous Waste Permit* (WA7890008967), WESF Part A Form. The WESF is a storage only unit for strontium and cesium encapsulated salts in double-containment stainless-steel capsules in underwater pool cells; and does not generate regulated waste. The water provides cooling and shielding for the capsules that are considered sealed sources. Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

In 2012, the cesium capsules stored in WESF pool cells were redistributed to reduce heat loading in certain pool cells and to alleviate beyond-design basis concerns associated with events during which all pool cell water is lost. This redistribution project received recognition in November 2012 from the Eastern Washington Chapter of the Academy of Certified Hazardous Materials Managers. This recognition came in the form of an Excellence in Hazardous Materials Management Award.

5.3.3.7 Integrated Disposal Facility

L C Tuott

The IDF (Figure 5.10) is located in the south-central part of the 200-East Area, and is a new unused landfill that is not actively operating. 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 IDF has a process design disposal capacity of 2.89 million cubic feet (82,000 cubic meters). The IDF is referenced in [DOE/EIS-0391](#) as a future disposal option for Hanford Site wastes.



Figure 5.10. Integrated Disposal Facility

The IDF operates in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967, Rev. 8C). Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

5.3.3.8 Environmental Restoration Disposal Facility

MA Casbon

ERDF is located near the 200-West Area, and is a massive landfill regulated by the EPA. 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. The total available expansion area of the ERDF site was authorized in a 1995 ROD ([EPA/ROD/R10-95/100](#)) to cover as much as 1.6 square miles (4.1 square kilometers). To provide a barrier to prevent contaminant migration from the in-ground facility, ERDF is constructed to RCRA Subtitle C minimum technology requirements, which includes a double liner and leachate collection system (40 CFR 264.301). Remediation waste disposed in the facility includes soil, rubble, or other solid waste materials contaminated with hazardous, low-level radioactive, or mixed (combined hazardous and radioactive) LLW.

Designed to be expanded as needed, ERDF comprises a series of cells or disposal areas. Each pair of cells (Cells 1 through 8) is large enough to hold approximately 1.4 million tons (1.27 million metric tons) of material. Two 'super cells', each the equivalent of a pair of existing cells, were constructed using *American Recovery and Reinvestment Act* funds and completed in January 2011. The total constructed trench capacity of ERDF is approximately 18 million tons (16.3 million metric tons); Cells 1 through 4 are full with an interim cover, Cells 5 and 6 are being filled and near operational capacity, Cells 7 and 8 are over half-full, and disposal in Super Cells 9 and 10 continues. The interim cover over Cells 1 and 2 was extended an additional 500 feet (152 meters) to cover Cells 3 and 4 at the end of 2012.

5.3.4 Liquid Waste Management

LC Petersen

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.

5.3.4.1 200 Area Effluent Treatment Facility

The 200 Area ETF (Figure 5.11) is located in the 200-East Area. The 200 Area ETF stores and 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 150 gallons (570 liters) per minute.

The 200 Area ETF operates in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967, Rev. 8C). Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

The effluent discharges are managed in accordance with limitations set forth in the State Waste Discharge Permit ST-4500 ([ST 4500](#)) and the 200 Area ETF Delisting Permit. 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 ETF cannot be practically removed. 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 in 2012 was approximately 9.4 million gallons (35.8 million liters). This wastewater was primarily CERCLA-regulated wastewater (groundwater from the 200-UP-1 and 200-ZP-1 Operable Units in the 200-West Area and some wastewater from the K Basins).

5.3.4.2 Liquid Effluent Retention Facility

The LERF (Figure 5.11) is located in the 200-East Area and consists of three RCRA-compliant surface impoundments used to store process condensate from the 242-A Evaporator, groundwater from various operable unit pump-and-treat systems, leachate from ERDF and from LLW burial Trenches 31 and 34, and other aqueous waste. The LERF provides a steady flow and consistent pH for the 200 Area ETF feed. Each basin has a maximum capacity of 7.8 million gallons (29.5 million liters) and each basin is constructed of two flexible, high-density polyethylene membrane liners. A system is provided to detect, collect, and remove leachate from between the primary and secondary liners. Beneath the secondary liner is a soil and bentonite clay barrier, should both the primary and secondary liners fail. Each basin has a floating membrane cover constructed of very low-density polyethylene to keep out windblown soil and weeds and to minimize evaporation of small amounts of organic compounds and tritium that may be present in the basin contents. The facility began operating in April 1994 and receives liquid waste resulting from cleanup activities regulated by both RCRA and CERCLA. Historically, RCRA and CERCLA wastewaters were segregated in the surface basins and processed with different disposal destinations; however, the ROD for ERDF was amended in 2007 to allow receipt of all RCRA and CERCLA waste ([DOE et al. 2007](#)). Therefore, segregation of RCRA and CERCLA wastewater is no longer required.



Figure 5.11. 200 Area Effluent Treatment Facility and Liquid Effluent Retention Facility

LERF operates in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967, Rev. 8C). Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

The volume of wastewater received for LERF basin storage in 2012 was approximately 7.5 million gallons (28.4 million liters). The majority of wastewater received at the LERF was pipeline-transported contaminated groundwater from operable unit pump-and-treat systems, totaling approximately 4.2 million gallons (15.9 million liters). Another major contributor to wastewater received into LERF during 2012 was the CERCLA-regulated leachate from ERDF, totaling approximately 2.9 million gallons (11.0 million liters). Approximately 0.34 million gallons (1.3 million liters) of wastewater were received from various facilities by tanker trucks that included approximately 147,000 gallons (0.56 million liters) of leachate from LLW burial Trenches 31 and 34. No process condensate was received from the 242-A Evaporator in 2012.

The volume of wastewater being stored in the LERF at the end of 2012 was approximately 15.2 million gallons (57.5 million liters).

5.3.4.3 200 Area Treated Effluent Disposal Facility

The 200 Area TEDF, located east of the 200-East Area, is a collection and disposal system for non-RCRA 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 ([ST 4502](#)).

The 200 Area TEDF consists of approximately 11 miles (18 kilometers) of buried pipelines connecting three pumping stations, the 6653 Building (known as the disposal sample station), and two 5-acre (2-hectare) disposal ponds. The facility began operating in April 1995 and has a capacity of 3,400 gallons (12,900 liters) per minute. The volume of unregulated effluent disposed to this facility in 2012 was approximately 21.8 million gallons (82.4 million liters).

5.3.4.4 242-A Evaporator

AL Hummer

The 242-A Evaporator (Figure 5.12), 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 LERF for further treatment. This process reduces the volume of liquid waste sent to the DSTs for storage and reduces the potential need for additional DSTs.

The *American Recovery and Reinvestment Act of 2009* funded the majority of the upgrade activities in 2011 to extend the 242-A Evaporator service life through 2032.



Figure 5.12. 242-A Evaporator

The 242-A Evaporator operates in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967, Rev. 8C). Waste volume reduction activities at the 242-A Evaporator are managed in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967); however, in 2012 the 242-A Evaporator did not perform waste volume reduction activities. Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

5.4 Underground Waste Storage Tanks

AL Hummer

Most Hanford Site waste is stored in 149 large underground single-shell (single-walled) tanks 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. This section provides information about the SSTs and DSTs on the Hanford Site, and activities that occurred in 2012 related to their operation and closure.

5.4.1 Single-Shell Tank System

The SST system includes 149 tanks that were constructed between the years 1943 and 1964 to store mixed waste generated on the Hanford Site; 67 of the tanks are assumed to have leaked in the past. Pumpable liquids in the SSTs were transferred to the newer and safer DSTs several years ago under the Interim Stabilization Program to help prevent additional environmental releases. Approximately 237,700 gallons (899,700 liters) of radioactive and hazardous waste were removed from SSTs C-101, C-104, C-107, C-108, C-109 (Figure 5.14) and C-112 in 2012 and transferred to safer DST storage, leaving approximately 29.3 million gallons (111 million liters) of waste in the SSTs.

Figure 5.13. C-Farm, Tank C-109 Waste Removal



The SST system is undergoing closure and operates in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967), *Single-Shell Tank System Part A Form*. Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

5.4.2 Double-Shell Tank System

The DST system contains 28 DSTs constructed between the years 1968 and 1986. The tanks contain liquids and settled solids from past nuclear operations, including waste transfers from older SSTs. The DST system storage capacity is approximately 33 million gallons (126 million liters), and stores radioactive and chemical waste. Storage space within the DST system is being managed to store waste pending treatment by the WTP, or a supplemental treatment process, and includes emergency pumping space available at all times for 1 million gallons (3.8 million liters).

The DST system is operating under interim status standards specified in the *Hanford Facility Dangerous Waste Permit* (WA7890008967), *Double-Shell Tank System Part A Form*. Refer to Section 2.1.1.1 for additional information on the *Hanford Facility Dangerous Waste Permit* (WA7890008967).

At the end of 2012, there were 26.7 million gallons (98 million liters) of waste in the DSTs. Quantities of liquid waste generated in 2012 and stored in underground storage tanks are provided in the *Hanford Site Annual Dangerous Waste Report Calendar Year 2012* (DOE/RL-2013-10). Table 5.5 summarizes the liquid waste generated and stored from 2008 through 2012 in underground storage tanks.

Table 5.5 Tank Farm System Quantities of Liquid Waste ¹ Generated and Stored ²

Type of Waste	Units	2008	2009	2010	2011	2012
DSTs waste added	Gallons	85	325	412	113	632
	Liters	322	1,230	1,560	428	2,392
DSTs year-end volume	Gallons	26,778	25,971	25,835	25,948	26,700
	Liters	101,366	98,311	97,796	98,224	98,000
242-A Evaporator volume evaporated	Gallons	0	960	548	0	0
	Liters	0	3,634	2,074	0	0
Single-Shell Tanks volume pumped	Gallons	69 ³	102 ³	240 ³	560 ³	238 ³
	Liters	262 ³	386 ³	909 ³	2120 ³	900 ³

¹ 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; and does not include containerized (e.g., barreled) waste included in the solid waste category.

² Multiply volumes shown by 1,000.

³ Volume does include dilution or flush water.

5.4.3 Underground Waste Storage Tanks and Associated Facilities Progress on Defense Nuclear Facilities Safety Board

JM Garcia

Throughout 2012, ORP and its contractors met with and provided information to the DNFSB and its technical staff to resolve concerns regarding Hanford Site underground storage tank farm projects. The following issues were addressed in 2012:

- Conduct of Operations
- Supplemental Treatment Project
- Waste Feed Delivery and Tank Waste Strategies
- Tank Farms DST Ventilation System Safety Classification/Flammable Gas Control Strategy
- Safety Basis.

During FY2012, WRPS implemented procedure and program changes to comply with the URS work control standard. WRPS successfully completed the URS Corporate Phase 1 assessment of the work control program and has remained engaged with the Energy Facility Contractors Group (EFCOG) work planning team and associated standard. WRPS developed a field observation checklist to improve the consistency of management

oversight and developed a data collection method and metric to evaluate causes of work package changes following approval. WRPS implemented an electronic work order review and approval application for documenting subject matter expert review and approval, consolidated the work control template library to promote standardization and developed a Joint Review Group screening criteria to broaden the effectiveness of the evaluation. ORP oversight has identified periodic weaknesses in work planning rigor and work instruction compliance; however, the improvements in waste transfer instructions and recognition of the need to stop and revise work instructions when necessary, indicate maturation of the WRPS work planning process implementation. The overall WRPS work control culture has exhibited improvement through FY2012 and completion of the EFCOG improvements and scheduled URS Phase II work control standard assessment are expected to drive additional improvement.

5.4.3.1 Defense Nuclear Facilities Safety Board Recommendation 2012-2

On September 28, 2012, the DNFSB issued Recommendation [DNFSB 2012-2](#), *Hanford Tank Farms Flammable Gas Safety Strategy*, for which DOE is currently preparing a response. The DNFSB Recommendation documented their position that DOE needs to upgrade the DST ventilation systems and other instrumentation systems used for safety-related functions at the Hanford Tank Farms. The DNFSB Recommendation is broken into five sub-recommendations. The sub-recommendations are:

1. Take near-term action to restore the classification of the DST ventilation systems to safety-significant. In the process, determine the necessary attributes of an adequate active ventilation system that can deliver the required flow rates within the time frame necessary to prevent and mitigate the site-specific flammable gas hazards at the Hanford Tank Farms.
2. Take near-term action to install safety-significant instrumentation for real-time monitoring of the ventilation exhaust flow from each DST.
3. Take near-term action to upgrade the existing installed non-safety-related equipment that is being used to fulfill safety functions at the Hanford Tank Farms to an appropriate safety classification. This includes instrumentation and control equipment whose indications are necessary for operators to take action to accomplish necessary safety functions.
4. Identify compensatory measures in case any existing DST ventilation systems become unavailable at the Hanford Tank Farms.
5. Evaluate means to reduce the existing inventory of retained flammable gases in a controlled manner. Because these gases will continue to be generated until the tank contents are processed, evaluate methods to reduce the future retention of flammable gases in these tanks or periodically mix them to prevent the future accumulation of flammable gas inventories that could cause the tank headspace to exceed the lower flammability limit if rapidly released.

ORP is working closely with DOE HQ to respond to the DNFSB's Recommendation [2012-2](#).

5.4.4 Vadose Zone Program

SJ Eberlein

Vadose zone program personnel are 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](#)).

In FY2012, most Tank Farm Vadose Zone activities were suspended due to funding constraints. Monitoring was conducted at the two interim surface barriers (one that covers a portion of the 241-T Tank and one that covers all of the 241-TY Tank Farm). These two surface barriers cover areas where soil has been

contaminated due to past leaks from tanks or tank associated equipment, and reduce water infiltration through the contaminated soil.

5.4.4.1 Direct-Push Boreholes and Sampling

Direct-push technology, using a hydraulic hammer unit to evaluate subsurface contamination in the vadose zone, was deployed in C Tank Farm during 2012. One direct-push borehole was made in the C Tank Farm as part of the Phase II RCRA investigation of that WMA.

5.4.4.2 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). 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. In FY2012, deep electrodes were placed in C Tank Farm as part of the direct push activity, to support future electrical resistivity work.

5.4.4.3 Interim Surface Barriers

The effectiveness of the T Tank Farm interim surface barrier at reducing infiltration is assessed through a barrier-monitoring program ([PNNL-16538, T Tank Farm Interim Surface Barrier Demonstration – Vadose Zone Monitoring Plan](#)). Pre-barrier data were collected and a monitoring report for FY2007 was issued in January 2008 ([PNNL-17306, T Tank Farm Interim Surface Barrier Demonstration – Vadose Zone Monitoring FY07 Report](#)). Additional post-barrier data were compiled into a FY2010 monitoring report issued in January 2011 ([PNNL-20144, T-TY Tank Farm Interim Surface Barrier Demonstration – Vadose Zone Monitoring FY10 Report](#)). The barrier monitoring continued during 2012. The barrier is resulting in slow drying of the vadose zone as water, which would normally recharge the surface, is diverted. Monitoring is underway at a second interim barrier, the TY Tank Farm. Based on monitoring results to date, *Technical Basis for Soil Moisture and Soil Pore Pressure Head Measurement Frequency Reduction at T and TY Farm Interim Surface Barriers*([RPP-RPT-53570](#)) was developed.

Two interim barriers were designed to be placed over most of the tanks in the SX Tank Farm. Modified asphalt was selected as the impermeable surface, and an evapotranspiration basin will be located south of the SY Tank Farm to redirect any runoff back to the atmosphere. The design and monitoring plan was approved by Ecology for future construction. Construction has been delayed until 2015, pending results of interim measures testing planned for FY2013.

5.5 Waste Treatment and Immobilization Plant

HM Groce

The WTP is being built on 65 acres (26 hectares) located on the Central Plateau in the 200-East Area (Figure 5.14) to treat radioactive and hazardous waste stored in 177 underground tanks. The WTP comprises four major facilities (Pretreatment Facility, High-Level Waste Vitrification Facility, Low-Activity Waste Vitrification Facility, and Analytical Laboratory), along with 20 support buildings and the associated infrastructure (balance of facilities). Construction of the WTP is managed in accordance with the *Hanford Facility Dangerous Waste Permit* (WA7890008967). Refer to Section 2.1.1.1 for additional information on the Hanford Facility Dangerous Waste Permit (WA7890008967).

In early 2012, DOE curtailed construction on the Pretreatment Facility and portions of the High-Level Waste Vitrification Facility pending resolution of open technical questions affecting the completion of design for the facilities. In mid-2012, the Secretary of Energy assembled a team of independent technical experts to resolve the outstanding technical questions. Construction continued in the Analytical Laboratory, Low-Activity Waste Vitrification Facility, Balance of Facilities and portions of High-Level Waste Vitrification Facility not impacted by technical questions.

Pretreatment Facility. Before construction was suspended in pretreatment in early 2012 pending resolution of open technical questions, workers completed miscellaneous steel erection activities at the 77-foot elevation and annex foundation preparations.

High-Level Waste Vitrification Facility. Construction on the portions of the facility impacted by open technical questions was suspended, but other work continued. Workers installed 3,100 cubic yards of concrete and 370 tons of structural steel completing the civil build through the 37-foot elevation and began selective concrete wall installations to the 58-foot elevation. Critical path filter cave internals (high-efficiency particulate air filters, heating and ventilation ductwork and piping, steel plating) were installed, and the first cell-top concrete was placed.

Low-Activity Waste Vitrification Facility. Construction emphasis continued on interior partition wall and bulk commodity installations. By year end, facility partition walls were 80 percent complete and piping installations were 90 percent complete. Throughout the year, workers installed more than 14,000 linear feet of electrical conduit and completed preparations to support the start of melter refractory installation in early 2014. Facility progress is positioned to support the TPA construction substantially complete milestone in July 2014.

Analytical Laboratory. Construction was completed to meet the TPA milestone for construction substantially complete in December 2012. Over the year, workers completed installation of 20,000 linear feet of electrical conduit, 2,200 linear feet of process piping, the radiological/chemistry laboratory casework, administration area architectural finishes and the high-purity gas system. By the end of the year, workers had started bulk electrical cable pulling activities.

Balance of Facilities. Emphasis in 2012 continued on facility completion efforts to support upcoming turnovers for startup testing. More than 44,000 linear feet of cable was pulled and 3,900 terminations completed during the year. In October 2012, the Switchgear Building 87 was released to the startup group, and workers continued completion activities for turning over the Balance of Facilities Switchgear Building 91 in early 2014. Startup activities included initiation of medium- and low-voltage system checkouts in Building 87 and initiation of meter and relay calibrations of those systems.



Figure 5.14. Waste Treatment and Immobilization Plant

The WTP construction site was awarded the DOE Voluntary Protection Program Superior Star status in September 2012 for the second year in a row for outstanding safety and health programs. Superior Star status is awarded to sites that previously earned Voluntary Protection Program Star status and continue to maintain safety performance and active employee engagement in safety initiatives. Also in September 2012, WTP employees surpassed 13 million hours without a day-away-from-work injury.

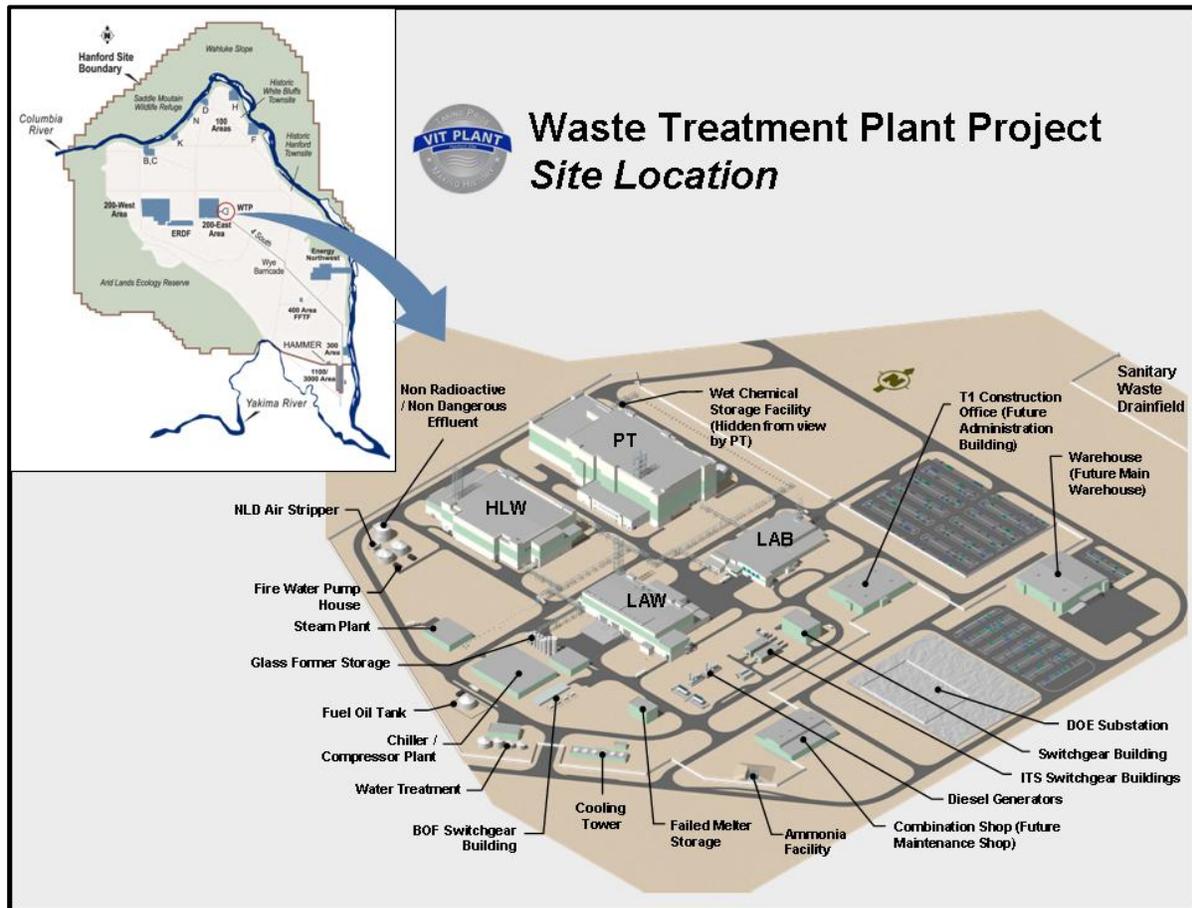


Figure 5.15. Waste Treatment and Immobilization Plant Site Location

From project inception through December 2012, the WTP crew placed 225,000 cubic yards (172,025 cubic meters) of concrete; erected 20,000 tons (18,144 metric tons) of structural steel; installed 329,000 linear feet (100,279 meters) of pipe; and 356,000 linear feet (108,509 meters) of cable and wire.

5.5.1 Waste Treatment and Immobilization Plant Progress on Defense Nuclear Facilities Safety Board Recommendations

JM Garcia

Throughout 2012, ORP and its contractors met with and provided information to the DNFSB and its technical staff to resolve commitments and review the following technical topics regarding the WTP Project. The following issues were addressed in 2012:

- WTP Spray Leak
- HLW high-efficiency particle absorber (HEPA) Loading and Aerosol Entrainment Coefficient Testing
- Low-Activity Waste Hazard Analysis

- Instrumentation and Control Design for Low-Activity Waste
- WTP Emergency Power System and supporting Emergency and Turbine Design Progress.

5.5.1.1 Defense Nuclear Facility Safety Board Recommendation 2010-2

The DNFSB issued [Recommendation 2010-2](#), Pulse Jet Mixing at the WTP on December 17, 2010, which DOE accepted on February 10, 2011.

The DNFSB Recommendation documented their position that testing and analysis completed to date have been insufficient to establish, with confidence, that the pulse jet mixing and transfer systems at the WTP will perform adequately at full scale, and that safety implications exist from incomplete mixing. The DNFSB identified five unresolved technical concerns as well as seven sub-recommendations, which are being addressed by the DOE Plan to address WTP Vessel Mixing Issues, [DOE Transmittal of Board Recommendation 2010-2 Implementation Plan](#) (IP), which was submitted November 10, 2011, to the DNFSB by the Secretary of Energy.

Since submittal of the IP, routine quarterly updates have been provided to the DNFSB on deliverables and efforts to resolve technical issues. On [August 27, 2012](#), the Secretary of Energy indicated that based on initial test results and the need to align the Pretreatment Facility safety authorization basis with test activities, a revision to the IP would be required. Recent activities by the Secretary of Energy on WTP to assist in the resolution of technical issues have resulted in additional adjustments to the IP. The outcome of the Secretary of Energy efforts will establish a more comprehensive approach for resolution of mixing issues at WTP, which will provide the basis for development of a revised IP. In a letter dated [November 8, 2012](#), from the Secretary of Energy to DNFSB Chairman Winokur, the Department informed the DNFSB that a revised IP will not be completed by the end of the CY as initially planned.

5.5.1.2 Defense Nuclear Facilities Safety Board Recommendation 2011-1

The DNFSB issued [Recommendation 2011-1](#), Safety Culture at the WTP on June 9, 2011, which DOE accepted on June 30, 2011. The Recommendation stated the DNFSB position that both DOE and contractor project management behaviors reinforce a subculture at WTP that deters the timely reporting, acknowledgement, and ultimate resolution of technical safety concerns.

The DOE Deputy Secretary chartered a Headquarters 2011-1 Response Team in September 2011, and DOE revised the Integrated Safety Management (ISM) System Guide ([DOE G 450.4-1C](#)) to include a definition for safety culture, and to identify safety culture focus areas and associated attributes, also in September 2011.

DOE issued the [IP for DNFSB Recommendation 2011-1](#) in December 2011, along with the Secretary of Energy memorandum, "Nuclear Safety at the Department of Energy," establishing the department's expectations for a robust safety culture.

In January 2012, the DOE Office of Health, Safety, and Security released the Health, Safety, and Security Independent Oversight Assessment of Nuclear Safety Culture and Management of Nuclear Safety Concerns at the Hanford Site WTP. The ORP Manager directed BNI to amend their Nuclear Safety and Quality Culture Plan to include the Health, Safety, and Security recommendations (completed in May 2012), and ORP developed its own Safety Culture IP in April 2012.

On March 22, 2012, ORP and its contractors participated in a DNFSB public meeting in Richland, WA concerning the status of actions related to unresolved technical issues in the design of the WTP, including DOE's IP for the DNFSB Recommendation 2010-2, as well as the status of actions related to DOE's [IP for DNFSB Recommendation 2011-1](#). A supplemental session was held in Washington, D.C. on May 22, 2012, to allow the DNFSB to receive testimony from DOE HQ management.

In June 2012, RL and ORP, along with their contractors, conducted an organizational climate and safety conscious work environment (SCWE) survey, with approximately 6,500 of 10,500 personnel responding (62%). Results from the independent survey firm were provided in October 2012, and each organization is evaluating the results and will be planning further improvement actions. This survey also will constitute part

of the SCWE self-assessments that Hanford federal and contractor organizations will perform, with results to be provided to the DNFSB by March 2013.

On September 14, 2012, DOE provided to the DNFSB an [Addendum to DOE IP for DNFSB Recommendation 2011-1](#), specifying a series of BNI to ORP, and ORP to DOE EM briefings to track progress on the safety culture improvement actions. The first briefings were conducted in October, and DOE EM provided the results during a safety culture briefing to the DNFSB on November 20, 2012.

In accordance with the implementation plan, ORP and BNI will complete their near-term safety culture improvement activities by April 2013, with an effectiveness review to be provided to the DNFSB by May 2013. DOE Health, Safety, and Security will conduct a follow-on safety culture review of ORP and BNI in April 2013, and issue a report by May 2013.

5.5.1.3 Pretreatment Facility – Hydrogen in Piping and Ancillary Vessels

At the recommendation of the DNFSB, a 12-member Hydrogen in Pipes and Ancillary Vessels Independent Review Team was assembled and chartered to review the proposed approach to use a quantitative risk analysis for analyzing and designing piping that has the potential to accumulate hydrogen and be exposed to detonations during the life of the plant. The IRT concluded that the design approach for hydrogen in pipes and ancillary vessels piping, ancillary vessels and components (e.g., pumps, valves, jumpers, etc., made of high strain rate materials like austenitic stainless steel and Hastelloy®⁴) are acceptable provided BNI resolves the findings and recommendations. The team identified 37 findings and 38 recommendations that were resolved by the project. The project formally issued all the calculations, reports and Summary Response Sheets, that provided details of how each finding and recommendation was resolved, in early August 2011 to support the IRT's final review. Following review of the responses and updated calculations and project reports, additional questions by the IRT and Quantitative Risk Analysis Peer Review Team were identified. The final updates to calculations, reports and Summary Response Sheets were completed in late December 2011. The IRT and Quantitative Risk Analysis Peer Review Team issued its final report in early January 2012 accepting all project responses and revised calculations and reports. In February 2012, DOE's detonation consultant, Dr. Shepherd of the California Institute of Technology, identified additional questions and concerns regarding the final calculations and reports. Dr. Shepherd accepted the project responses in June 2012 after the project provided additional analyses, including clarifying sensitivity analyses, and following several reviews. Project reports were revised in October 2012 documenting the results of the additional analyses requested by Dr. Shepherd.

The project has been executing the new processes and procedures for conducting piping analyses in accordance with the qualitative risk assessment processes. This work is being conducted on an example WTP route to demonstrate the quality and configuration management processes for evaluating a piping system and deal with design system changes if required as a result of the analyses. The processes and qualitative risk assessment results are being reviewed with the DOE and DNFSB local representatives in advance of using them in support of routine production design work tentatively scheduled to resume in mid-2013, and provide additional operations and design information to support the environmental and nuclear safety hazards analyses of the respective WTP piping systems necessary to complete the authorization bases for the impacted facilities.

5.5.1.4 Structural Issues

Successful completion of this effort and the ORP Peer Review Team Quarterly Reviews, the DNFSB staff, in December 2010, concluded that all the issues relating to composite steel behavior/structural steel design issues on WTP are closed. Additionally, through ORP Peer Review Team Quarterly Review discussions on System for Analysis of Soil-Structure Interaction (SASSI) Computer Code on the application of SASSI - Subtraction and Direct Methods on WTP's HLW foundation, ORP, and BNI documented a comparative and reliable technical justification between the stated methods. This justification document was reviewed by DOE Peer Review Team and results were reported in 2012. The final versions of the safety system requirements will be issued during 2012/2013 at the completion of WTP structural design, while incorporating required interim

⁴ A registered trademark of Haynes International, Inc., Humble, Texas.

updates requested by DNFSB staff. ORP has been actively providing quarterly updates on the ORP Peer Review Team input. The last Peer Review Team Quarterly Review for 2012 findings was provided to the DNFSB staff.

5.6 Scientific and Technical Contributions to Hanford Site Cleanup

MD Freshley and RA Peterson

PNNL scientific and technical contributions to cleanup at the Hanford Site were focused on applied science, technology development, and basic science contributions. These contributions were funded through the RL, ORP, DOE EM Office of Tank Waste Management, the DOE EM Office of Soil and Groundwater Remediation, and the DOE Office of Science Subsurface Biogeochemical Research Program. The contributions included performing evaluations, analyzing data, providing reviews, preparing and operating special facilities, and creating new technologies to address site cleanup challenges. The 2012 contributions to Hanford Site cleanup are provided in the paragraphs below.

Waste Processing. Conducted fundamental engineering development to support resolution of the mixing issues associated with WTP, including working with BNI to identify necessary and sufficient testing to demonstrate large-scale mixing. An effort also was conducted to develop fundamental models of the mixing process to facilitate a broader understanding of the processing of mixed metal oxide-hydroxide slurries. In addition, the understanding of mixed metal oxide-hydroxide slurries is being transferred to evaluate the potential for spray releases in the WTP. The team developed the first new data on spray releases in several decades which will significantly improve the safety basis technical underpinning for the WTP.

Improve the immobilization of both Low Activity Waste and High Activity Waste. In collaboration with WRPS and the Savannah River Site, cast stone and fluidized bed steam reforming were evaluated as technologies to treat Low-Activity Waste at the Hanford Site. In addition, researchers have teamed with Savannah River National Laboratory, Catholic University, and the Missouri University of Science and Technology to develop new glass formulations capable of significantly reducing the volume of both Low-Activity Waste glass and high-activity waste glass.

Evaluated New Material for Cutting the Tops of HLW Tanks. During 2012, researchers at collaborated with staff from WRPS to perform a proof of concept demonstration of the technology.

K Basin Sludge. Work also continued on characterizing 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.

Deep Vadose Zone Applied Field Research Initiative. In the area of subsurface science and remediation, a major area of emphasis is the Deep Vadose Zone Applied Field Research Initiative (AFRI). The Deep Vadose Zone AFRI is developing effective, science-based solutions for remediating, characterizing, monitoring, and predicting the behavior and fate of contamination in in vadose zone environments to protect water resources. To that end, the Deep Vadose Zone AFRI is developing the technical basis to quantify, predict, and monitor post-remediation contaminant discharge from the vadose zone and facilitating development of in-situ solutions that limit discharge. During 2012, the AFRI focused on developing flux-based methods and process-level understanding of waste disposal practices for evaluating, vadose zone characterization and remediation technologies, endpoints for vadose zone and groundwater contaminants, and monitoring.

The Deep Vadose Zone AFRI led a multi-agency and multi-disciplinary collaboration between DOE, the EPA, and the U.S. Army Corps of Engineers to develop an approach and guidance for defining endpoints for volatile contaminants in the vadose zone and decision support for termination of soil vapor extraction. The approach and framework are documented in [PNNL-21843, SVE System Optimization, Transition, and Closure Guidance](#), and [PNNL-21326, Treatability Test Report: Characterization of Vadose Zone Carbon Tetrachloride Source Strength Using tomographic Methods at the 216-Z-9 Site](#). This framework for flux-based measurement and assessment was extended to metals and radionuclides. Methods for collecting and assessing information from the vadose zone and integration of flux-related measurements and predictive

analyses to support remediation assessments were developed and documented in [PNNL-21815](#), *Remedy Evaluation Framework for Inorganic, Non-Volatile Contaminants in the Deep Vadose Zone*. The Deep Vadose Zone AFRI evaluated and documented the range of important waste disposal chemistries at the Hanford Site and quantified their impact on attenuation mechanisms and the fate and transport of uranium. This information can be used to optimize characterization of subsurface contamination, screen and develop remedial options, and provide technical support for remedial decisions.

Investments in subsurface geophysical imaging software were integrated to develop an advanced high-performance geophysical imaging code that reconstructs subsurface images using electrical resistivity tomography. This technology makes use of high-performance computing to process data and characterize contaminant plumes in three dimensions with unprecedented resolution. The code was applied to the Hanford Site B Complex to delineate previously unresolved detail concerning contaminant distributions beneath former waste sites and real-time monitoring of subsurface remedial activities.

Several different vadose zone remediation technologies were evaluated as part of the Deep Vadose Zone AFRI. The project continued evaluating the performance of the Hanford Site prototype barrier, continuing monitoring that has been ongoing for more than 20 years. The knowledge obtained from this study provides critical understanding and technical validation for the use of engineered natural barriers for vadose zone remediation and closure. The AFRI also evaluated pore-water extraction as a vadose zone treatment technology, summarized in [PNNL-21882](#), *Pore-Water Extraction Scale-Up Study for the SX Tank Farm*.

Systems-based approaches are being used to develop an endpoint framework for evaluation of difficult contaminants in the vadose zone and subsurface. The current efforts to define endpoints include evaluation of iodine-129 biogeochemistry, scientific and technical understanding of plutonium and americium mobility, and biogeochemical and hydrogeologic controls on technetium-mobility. These are summarized in a series of reports ([SRNL-STI-2012-0045](#), *Biogeochemical Considerations Related to the Remediation of ¹²⁹I Plumes*; [SRNL-STI-2012-00592](#), *Laboratory Report on Iodine (¹²⁹I and ¹²⁷I) Speciation, Transformation, and Mobility in Hanford Groundwater, Suspended Particles and Sediments*; and [PNNL-21651](#), *Plutonium and Americium Geochemistry at Hanford: A Site-Wide Review*).

DOE assembled a team of multidisciplinary technical experts from DOE EM and the Office of Legacy Management (LM), national laboratories, academia, and consulting firms to work collaboratively to identify Scientific Opportunities for Monitoring at Environmental Remediation Sites. Although the document is focused on complex-wide issues for monitoring relying on conceptual site models, lines-of-evidence, flux-based approaches, and innovative monitoring tools, a number of examples and case studies in the document ([PNNL-21379](#), *Scientific Opportunities for Monitoring at Environmental Remediation Sites (SOMERS): Integrated Systems-Based Approaches to Monitoring*) were from the Hanford Site. This document will provide the basis for development of long-term monitoring frameworks at DOE sites.

Through the Deep Vadose Zone AFRI, direct support was also provided to several remediation activities in the 200-West Area as well as along the 100-Area river corridor. Biological communities present in fluidized bed reactors in the 200-West Area Pump-and-Treat to remove carbon tetrachloride and nitrate from pumped groundwater. Molecular tools (e.g., microbial fingerprinting and sequencing) to determine the spatiotemporal identity, composition, and function of the microbial community within the fluidized bed reactor to support performance optimization. A real-time sensor is being applied to provide real-time analysis of aqueous technetium-99 in effluent streams from the 200-West Area Pump-and-Treat facility. Previously, this was accomplished through sampling and analysis. Staff provided a scientific and technical peer review of 100-KR-4 Operable Unit pump-and-treat operations, resulting in cessation of pH adjustment of effluent streams prior to reinjection. An evaluation of the nature and extent of chromate impact associated with the 100-C-7 Operable unit ([PNNL-21845](#), *Investigation of Hexavalent Chromium Flux to Groundwater at the 100-C-7:1 Excavation Site*). The study quantified the potential long-term risk to groundwater. The Deep Vadose Zone AFRI also conducted a remedial investigation of pre-Hanford orchard lands. The major contaminant for this operable unit is residual lead arsenate, used as a pesticide on fruit orchards that occupied much of the land near the Columbia River during the pre-Hanford era. The investigation is continuing to determine whether there is risk to human health and the environment from contamination within the operable unit.

Advanced Scientific Computing for Environmental Management. Advanced Scientific Computing for Environmental Management is a scientific tool and approach for understanding and predicting contaminant fate and transport in natural and engineered systems being developed for DOE EM. Advanced Scientific Computing for EM's modular and open source toolsets will facilitate integrated approaches to modeling and site characterization that facilitate integrated approaches to modeling and site characterization that enable robust and standardized assessments of performance and risk for DOE EM cleanup and closure activities. Specifically, the Advanced Simulation Capability for Environmental management (ASCEM) initiative is aimed at addressing these critical DOE EM program needs to better understand and quantify the subsurface flow and contaminant transport behavior in complex geological systems and the long-term performance of engineered components including cementitious materials in nuclear waste disposal facilities, in order to reduce uncertainties and risks associated with DOE EM's environmental cleanup and closure programs. The project completed a Phase II Demonstration ([ASCEM-SITE-2012-01](#)) that highlights an end-to-end demonstration of ASCEM capabilities with emphasis on integration and linkage between components at the 100-BC Cribs waste site near the 200-East Area.

300 Area Integrated Field Research Challenge Project. Research continued in the 300 Area to characterize the uranium-contaminated subsurface, examine fundamental science issues important to contaminant transport and groundwater remediation, and support future cleanup decisions at DOE sites. A large-scale sorption experiment involving injection of groundwater with higher uranium concentration was conducted in 2012. Results of experiments at the field site and implications for the site conceptual model are summarized in [PNNL-22048, Updated Conceptual Model for the 300 Area Uranium Groundwater Plume](#). Additionally, studies were performed on sediment samples from the 300 Area that were uncharacterized ([PNNL-22032, Uranium in Hanford Site 300 Area: Extraction Data on Borehole Sediments](#)) and laboratory studies were completed on the use of polyphosphate for treating uranium ([PNNL-21733, Use of Polyphosphate to Decrease Uranium Leaching in Hanford 300 Area Smear Zone Sediment](#)). These results will be used to update the conceptual model for uranium contamination in the 300 Area and support remedial design for the 300-FF-5 Operable Unit.

6.0 Air Monitoring

CJ Perkins, CR Ramos, and DJ Rokkan

[DOE O 458.1](#), Chg. 2, requires 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 *Safety Management System Policy* ([DOE P 450.4](#)) and its component EMS (Section 3). Component systems are tools for achieving site and contractor compliance with environmental, public health, and resource protection laws, regulations, and DOE orders.

[DOE/RL-91-50](#) 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 O 458.1 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 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.

6.1 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. Nonradioactive constituents and parameters are monitored directly, sampled and analyzed, or estimated based on inventory usage.

Emission data are documented in this and other reports, all of which are available to the public. For example, DOE annually submits to EPA and the Washington State Department of Health a report of Hanford Site radionuclide air emissions (e.g., [DOE/RL-2013-12](#)) in compliance with [40 CFR 61](#), Subpart H and with [WAC 246-247](#).

6.1.1 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 one percent of the standard for public dose, which is 10 millirem (100 microsievert) per year.

Distinguishing Hanford Site-produced radionuclides in the environment is challenging because concentrations of emissions from site stacks are comparable to widespread background concentrations of radionuclides that originated from historical atmospheric nuclear weapons testing. Gross alpha and gross beta concentrations in stack emissions are on average equivalent to concentrations in the environment, including concentrations at distant locations upwind of the Hanford Site. Radioactive emissions decreased on the Hanford Site largely because the production and processing of nuclear materials 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) sampling criteria provided in contractor environmental compliance manuals; and 3) potential of each radionuclide to contribute to the public dose. Continuous air monitoring systems with alarms also are 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 on the Hanford Site in the 100, 200, 300, 400, and 600 Areas. The prime sources of emissions and the number of emission points by operating area in 2012 are as follows:

- In the 100 Areas, three radioactive emission points were active. Emissions originated from cleanup activities at the 100-K West Fuel Storage Basin, which in previous years contained irradiated nuclear fuel, and from the CVDF.
- In the 200 Areas, 41 radioactive emission points were active. The primary locations of these emission points were the PFP, T Plant, U Plant, B Plant, WESF, underground tanks storing high-level radioactive waste, waste evaporators, the WRAP Facility, and the PUREX Plant.

- In the 300 Area, five 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, and 331 Life Sciences Laboratory.
- In the 400 Area, three radioactive emission points were active. The sources of these emissions are three facilities that have been shut down: FFTF, 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 (WSCF) where low-level radiological and chemical analyses are performed on various types of samples (e.g., particulate air filters, liquids, soil, and vegetation).

Air emission data collected in 2012 were comparable to those collected in 2011. Table 6.1 summarizes Hanford Site radioactive airborne emissions in 2012.

6.1.2 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 6.2 summarizes the Hanford Site emissions of nonradioactive pollutants discharged to the atmosphere. (Note: the 100 and 400 Areas have no criteria and toxic air pollutants of regulatory concern.)

In previous years, gaseous ammonia has been emitted from the PUREX Plant, 242-A Evaporator, AP Tank Farm, and AW Tank Farm, all located in the 200-East Area. Ammonia emissions are tracked only when activities at these facilities are capable of generating them. Table 6.2 also summarizes the reportable ammonia emissions during 2012, which were produced only 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 WAC 173-400, *General Regulations for Air Pollution Sources*. Based on the quantities of fossil fuel consumed at Hanford Site power plants, the resulting emissions were calculated using EPA-approved formulas ([AP-42](#), *Compilation of Air Pollutant Emission Factors*, Volume I: *Stationary Point and Area Sources*).

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, the emissions may be reported annually with EPA approval.

Table 6.1 Hanford Site Radioactive Airborne Emissions

Radionuclide	Half-Life	2012 Releases, Ci ^a				
		100 Area	200-East Area	200-West Area	300 Area	400 Area
Tritium (as HT)	12.3 years	NA	NA	NA	2.9 x 10 ⁺¹	NA
Tritium (as HTO)	12.3 years	NA	NA	NA	6.8 x 10 ⁺¹	1.8 x 10 ⁻³
Na-22	2.6 years	NA	NA	NA	NA	1.4 x 10 ^{-9(b)}
Krypton-85	10.7 years	NA	NA	NA	1.8 x 10 ⁻⁶	NA
Strontium-90	29.1 years	4.9 x 10 ⁻⁶	1.6 x 10 ⁻⁴	4.0 x 10 ⁻⁷	8.7 x 10 ⁻⁸	NA
Yttrium-90	1.5 seconds	NA	1.6 x 10 ⁻⁴	NA	NA	NA
Technetium-99	211,100 years	NA	NA	NA	4.0 x 10 ⁻⁶	NA
Iodine-129	16,000,000 years	NA	9.8 x 10 ⁻⁴	NA	NA	NA
Cesium-134	2.1 years	NM	NM	NM	NM	NM
Cesium-137	30 years	4.0 x 10 ⁻⁶	3.6 x 10 ⁻⁵	2.7 x 10 ⁻⁷	7.6 x 10 ⁻⁸	8.4 x 10 ^{-7(c)}
Europium-152	13.5 years	NM	NM	NM	3.4 x 10 ⁻⁹	NA
Europium-154	8.6 years	NM	NM	NM	1.3 x 10 ⁻⁷	NA
Gadolinium-153	240.4 days	NA	NA	NA	2.3 x 10 ⁻⁹	NA
Radon-219	4.0 seconds	NA	NA	NA	2.8	NA
Radon-220	55.6 seconds	NA	NA	NA	6.6 x 10 ⁻¹	NA
Radium-226	1,600 years	NA	NA	NA	4.4 x 10 ⁻¹⁰	NA
Actinium-227	21.6 years	NA	NA	NA	5.6 x 10 ⁻¹⁰	NA
Protactinium-231	32,760 years	NA	NM	NA	NA	NA
Uranium-232	68.9 years	NA	NA	NA	5.1 x 10 ⁻⁹	NA
Uranium-233	159,200 years	NA	NA	NA	2.2 x 10 ⁻⁸	NA
Neptunium-237	2,144,000 years	NA	NA	NA	1.3 x 10 ⁻⁷	NA
Plutonium-238	87.7 years	7.9 x 10 ⁻⁷	ND	6.5 x 10 ⁻⁷	1.9 x 10 ⁻¹¹	NA
Plutonium-239/240	24,110 years	4.6 x 10 ⁻⁶	6.8 x 10 ⁻⁸	3.3 x 10 ⁻⁵	1.8 x 10 ⁻⁸	7.5 x 10 ^{-8(d)}
Plutonium-241	14.4 years	3.8 x 10 ⁻⁵	3.4 x 10 ⁻⁸	1.5 x 10 ⁻⁵	4.3 x 10 ⁻⁷	NA
Americium-241	432.2 years	3.9 x 10 ⁻⁶	6.7 x 10 ⁻⁸	6.7 x 10 ⁻⁶	1.9 x 10 ⁻¹¹	NA
Americium-243	7,380 years	NA	NA	NA	8.1 x 10 ⁻⁸	NA
Gross alpha	NA	8.3 x 10 ⁻⁶	6.8 x 10 ⁻⁷	6.2 x 10 ⁻⁵	4.9 x 10 ⁻⁸	NA
Gross beta	NA	1.3 x 10 ⁻⁵	3.3 x 10 ⁻⁴	1.0 x 10 ⁻⁵	3.3 x 10 ⁻⁶	NA

^a To convert to the International System of Units, multiply pCi/g by 0.037 to obtain Bq/g.

^b Calculated from estimated residual sodium inventory remaining in FFTF primary coolant piping.

^c This release value derives from data on gross beta emissions from 400 Area stacks.

^d 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.

Table 6.2 Hanford Site Criteria and Toxic Air Pollutant Emissions

Constituent	2012 Releases	
	lb	kg
Particulate matter-total	0	0
Particulate matter-10	0	0
Particulate matter-2.5	0	0
Nitrogen oxides	14,000	6,400
Sulfur oxides	0	0
Carbon monoxide	18,000	8,200
Volatile organic compounds	10,000	4,500

6.2 Ambient Air Monitoring

CJ Perkins and CR Ramos

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 Hanford Site 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 RL's environmental monitoring plan ([DOE/RL-91-50](#)).

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.

6.2.1 Hanford Site Ambient Air Monitoring

CJ Perkins

A network of continuously operating samplers at 74 locations across the Hanford Site was used during 2012 to monitor radioactive airborne materials in air near site facilities and operations (Table 6.3). Most air samplers were located at or within approximately 1,640 feet (500 meters) 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 2012 monitoring year. Airborne particle samples were collected at each location by drawing air through a cellulose filter. The filters were collected biweekly, field-surveyed for gross radioactivity, held for at least 5 days, and then analyzed for gross alpha and beta activity. A 5-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 (Table 6.3) 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.

Figure 6.1 shows the annual average air concentrations of selected radionuclides in the 100, 200, and 600 Areas compared to EPA concentration values and air concentrations measured in distant communities. The EPA concentration values for environmental compliance ([40 CFR 61](#), Appendix E, Table 2) are dose-based reference values used as 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 2012

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, shows the annual average and maximum concentrations of radionuclides in air samples collected near facilities and operations during 2012.

Table 6.3. Hanford Site Monitoring Locations and Analyses for Ambient-Air Monitoring Samples

Site	No. of Samplers	EDP Code	Analyses	
			Bi-weekly	Composite
100-D Area Field Remediation Project ¹	4	N467, N468, N514, N515	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium-239/240, Uranium-234, Uranium-235, Uranium-238, Americium-241
100-H Area Field Remediation Project ¹	3	N509, N510, N574	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium-239/240, Uranium-234, Uranium-235, Uranium-238
100-K Basins Closure ¹ (100-K Area)	6	N403 ⁽²⁾ , N476, N575, N576, N577, N578	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium-239/240, Uranium-234, Uranium-235, Uranium-238, Americium-241, Pu-241
118-K-1 Field Remediation Project ¹ (100-K Area)	3	N403, N534, N535	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium-239/240, Uranium-234, Uranium-235, Uranium-238
100-N Area D4 Project	3	N102, N103, N106	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium-239/240, Uranium-234, Uranium-235, Uranium-238, Americium-241
200-East Area	17	N019, N158, N498, N499, N957, N967, N968, N969, N970, N972, N973, N976, N977, N978, N984 ⁽²⁾ , N985, N999	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium-239/240, Uranium-234, Uranium-235, Uranium-238
CSB (200-East Area)	2	N480, N481	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium-239/240, Uranium-234, Uranium-235, Uranium-238, Pu-241, Americium-241
IDF (200-East Area)	2	N532, N559	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium-239/240, Uranium-234, Uranium-235, Uranium-238

Table 6.3. Hanford Site Monitoring Locations and Analyses for Ambient-Air Monitoring Samples

Site	No. of Samplers	EDP Code	Analyses	
			Bi-weekly	Composite
200-West Area	25	N155, N161, N165 ⁽²⁾ , N168, N200, N304, N433, N441, N442, N449, N456, N457, N550, N551, N554, N555, N956, N963, N964, N965, N966, N974, N975, N987, N994	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium- 239/240, Uranium-234, Uranium-235, Uranium-238
300 Area Decontamination & Demolition and 300-FF-2 Field Remediation projects (300 Area) ¹	2	N557, N130	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium- 239/240, Uranium-234, Uranium-235, Uranium-238
ERDF	7	N482 ⁽²⁾ , N168, N517, N518, N550, N551, N963	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium- 239/240, Uranium-234, Uranium-235, Uranium-238
600 Area (WYE Barricade)	1	N981 ⁽²⁾	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium- 239/240, Uranium-234, Uranium-235, Uranium-238
618-10 Burial Ground	4	N548, N549, N579, N580	Gross Alpha/Beta	GEA, Strontium-90, Plutonium-238, Plutonium- 239/240, Uranium-234, Uranium-235, Uranium-238

¹ Far-field air sampling station(s) provide supplemental air monitoring data. See Table 6.4 for a listing of locations.

² Collocated sampling location with Washington State Department of Health.

D4 = deactivation, decommission, decontamination and demolition.

EDP = Environmental data point (EDP) code = sampler location code.

GEA = Gamma energy analysis

Figure 6.1. Hanford Site Average Radionuclide Concentrations in Ambient-Air Samples Compared to Distant Communities Samples

*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.
 KBC = K Basins Closure Project.*

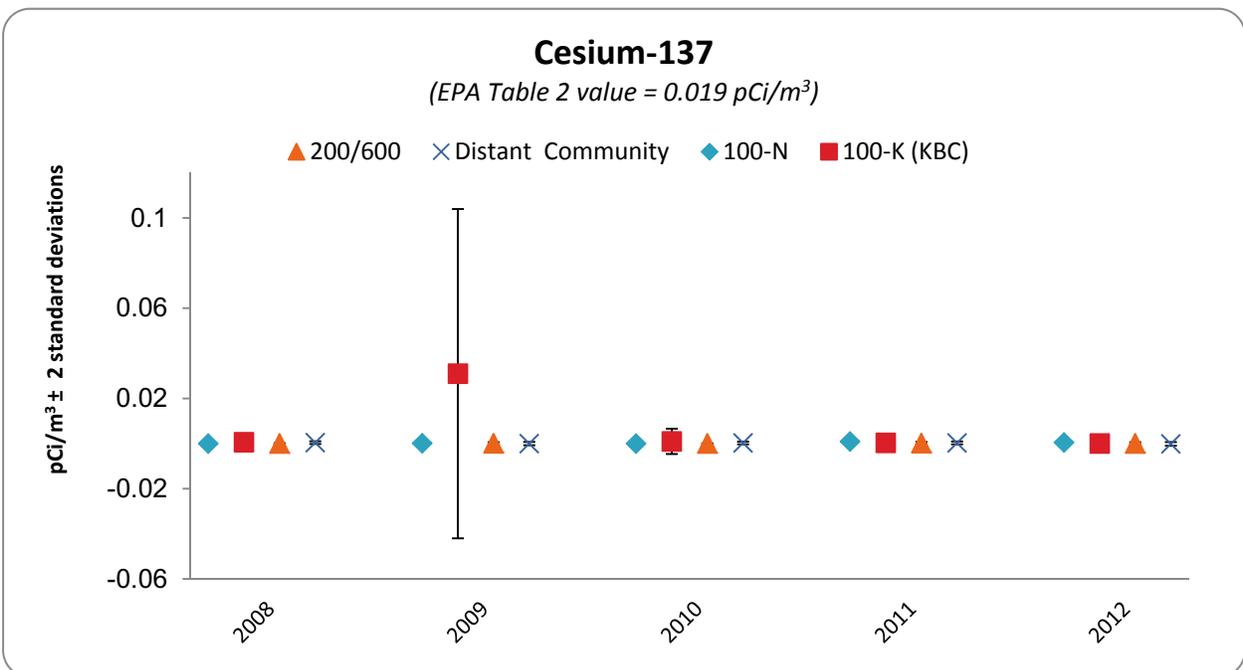
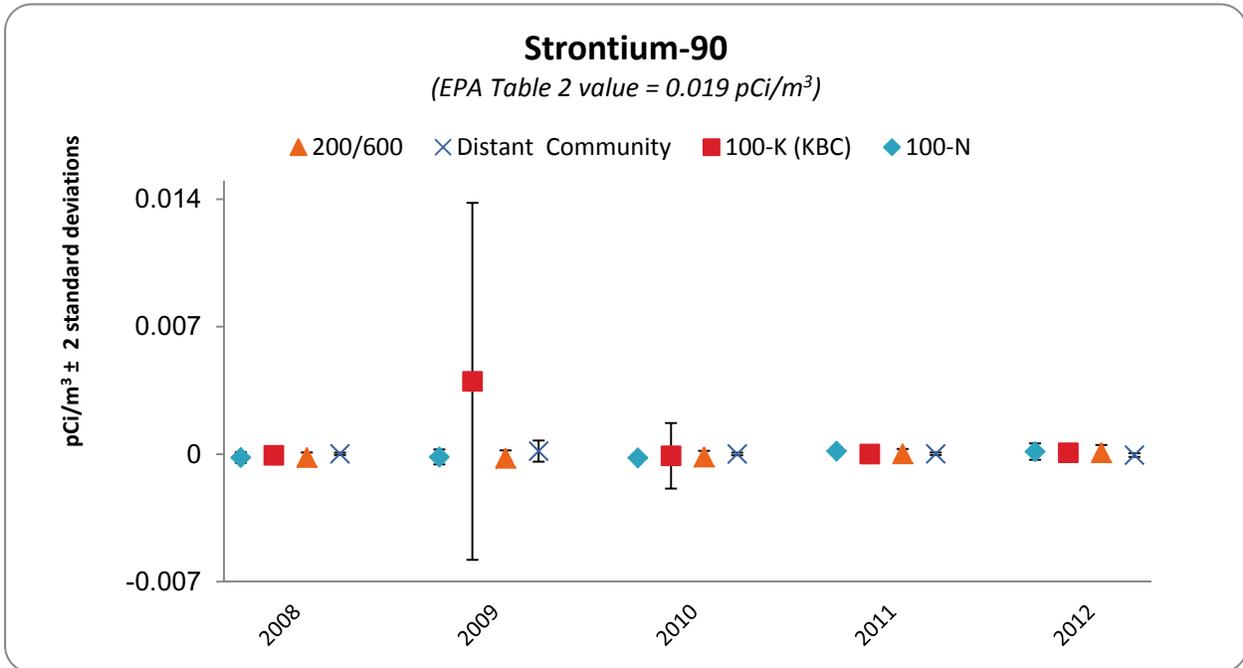


Figure 6.1 Hanford Site Average Radionuclide Concentrations in Ambient-Air Samples Compared to Distant Communities Samples (Cont.)

*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.
 KBC = K Basins Closure Project.*

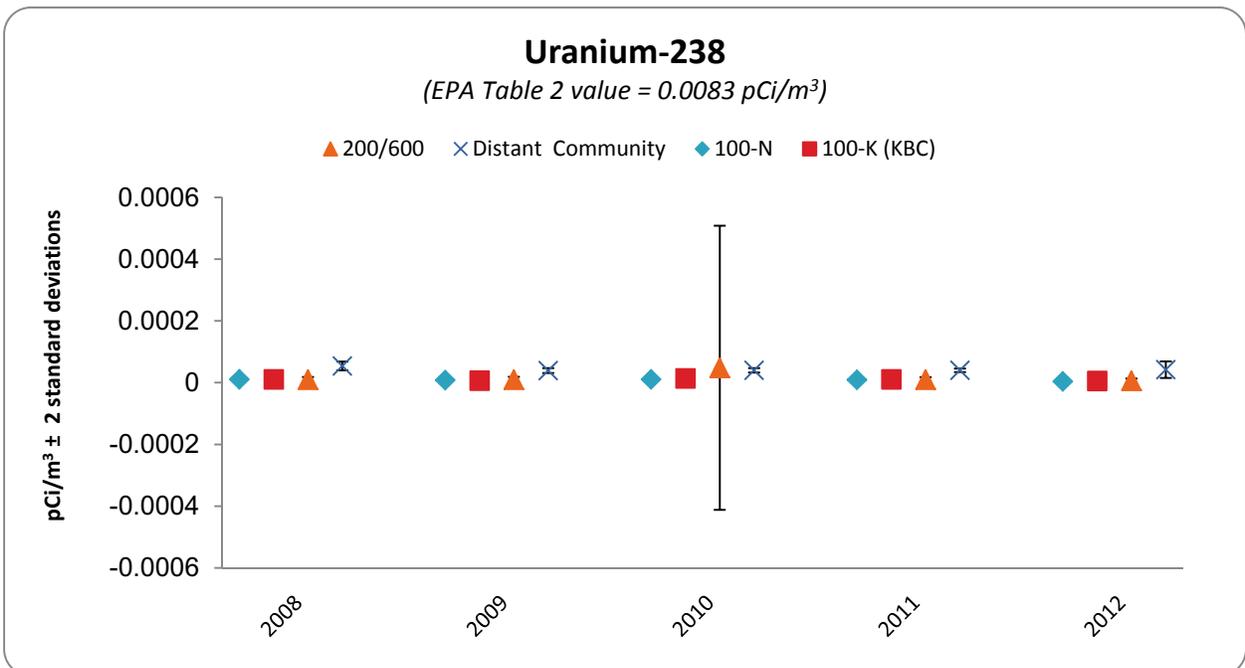
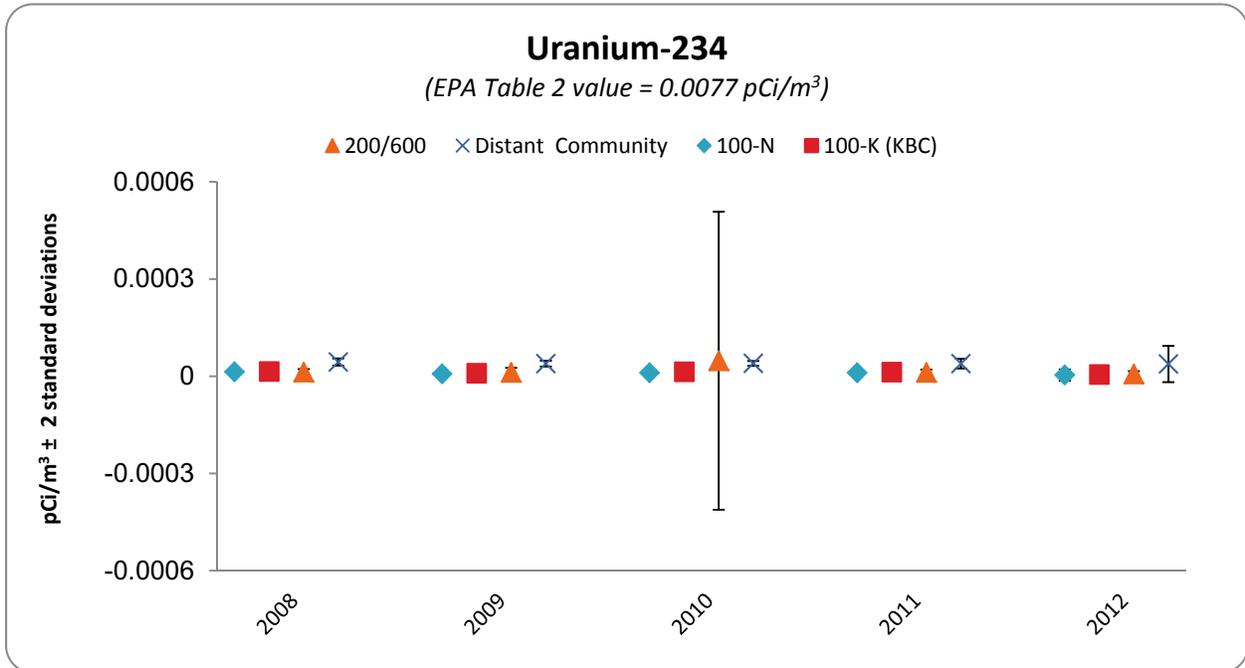
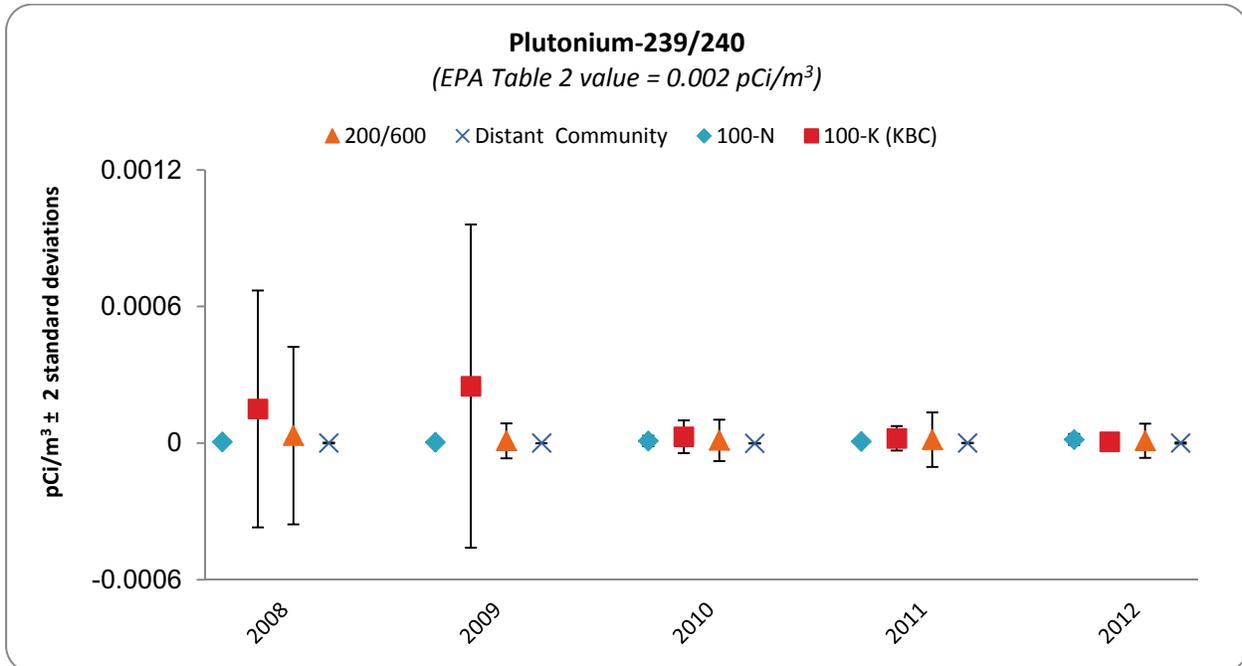


Figure 6.1 Hanford Site Average Radionuclide Concentrations in Ambient-Air Samples Compared to Distant Communities Samples (Cont.)

*As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.
KBC = K Basins Closure Project.*



Air monitoring results from the stations in the 100-D, and 100-H Areas, and the 118-K-1 Field Remediation and 100-N deactivation, decommission, decontamination and demolition projects were at or below typical Hanford Site levels in 2012. Uranium-234 and uranium-238 were consistently detected while plutonium-239/240 was detected in approximately 35 percent of the samples and strontium-90 in approximately 20 percent. The presence of americium-241 was analyzed in samples taken at the 100-D, 100-H, 118-K-1, and 100-N Area stations and was detected in approximately 60 percent of those samples.

Ambient air was monitored in 2012 at six locations in the 100-K Area. Uranium-234, uranium-238, and americium-241 were detected in approximately 25 percent of the samples while plutonium-239/240, plutonium-241, and cesium-137 were detected in approximately 16 percent of the samples.

Air sampling was conducted at 21 locations in the 200-East Area during 2012. Radionuclide levels measured in the 200-East Area ambient-air composite samples in 2012 were similar to those measured in previous years. Uranium-234, uranium-238, and strontium-90 were detected in approximately 40 percent of the samples while all other radionuclides were either detected in less than 15 percent of the samples or not at all.

Air sampling was conducted at 25 locations in the 200-West Area during 2012. 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 42 percent of the samples. Plutonium-239/240 was detected in approximately 33 percent of the samples. The plutonium-239/240 concentration at air-sampling location N165 (near the 216-Z-9 Trench) was greater than 10 percent of the EPA concentration value ([40 CFR 61](#), Appendix E, Table 2) for the composite sample collected during the first-half of 2012. This elevated plutonium value is believed to originate from the nearby retired 216-ZP-9 Trench that received liquid waste from PFP until 1995. Required notifications were made to the Washington State Department of Health.

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 deactivation, decommission, decontamination

and demolition project continued in 2012. Uranium-238 was detected consistently and at levels similar to those measured in previous years.

Air sampling was conducted at six locations in 2012 at the ERDF (200-West Area). Radionuclide levels measured at this site were similar to typical Hanford Site levels. Uranium-234 and uranium-238 were detected in 75 percent of the samples while plutonium-239/240 was detected in approximately 50 percent of the samples.

Air monitoring was conducted at four locations at the 618-10 Burial Ground Project (north of the 300 Area). The analytical results showed that uranium-234, uranium-238, plutonium-239/240, and americium-241 were detected consistently. During the first-half of 2012, one air monitoring result from one station located at the 618-10 Field Remediation project was greater than 10 percent of EPA's concentration values ([40 CFR 61](#), Appendix E, Table 2) and was reported to EPA and Washington State Department of Health. Plutonium-239/240 at station N548 was elevated and no contributing cause was specifically identified for the elevated concentration.

6.2.2 Hanford Site and Offsite Ambient Air Monitoring

CR Ramos

Airborne radionuclide samples were collected in 2012 by 40 continuously operating samplers at or in the vicinity of the Hanford Site. The sampling stations were grouped into four location classifications: 1) onsite (21 stations), 2) perimeter (11 stations), 3) nearby communities (7 stations), and 4) distant community (1 station) (see Figure 6.2 and Table 6.4). Onsite air samplers 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.

6.2.2.1 Sampling and Analysis

Samples were collected and analyzed according [DOE/RL-2012-01](#), *Hanford Site Environmental Surveillance Far Field Sampling Schedule Calendar Year 2012*. Airborne particulates were sampled at each location by drawing ambient air through a glass-fiber filter continuously and collecting the filter every two weeks. The filter samples were then transported to an analytical laboratory and stored for at least 72 hours. The storage time allows 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 and selected filters were 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. These 2-week 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. Table 6.4 shows the analysis for the 2-week and quarterly composite samples.

Atmospheric water vapor was collected for tritium analysis at 20 locations in 2012 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](#), *Ambient Air Sampling for Tritium – Determination of Breakthrough Volumes and Collection Efficiencies for Silica-Gel Absorbent*. The collected water was distilled from the silica gel and analyzed for its tritium content.

6.2.2.2 Monitoring Results

All sample results in 2012 showed very low radiological concentrations in air. All radionuclide concentrations (Table 6.5) were less than their respective DOE-derived concentration guide (Appendix D, Table D.2). The derived concentration guides are concentrations that would result in a dose of 100 millirem (1 millisievert) per year under conditions of continuous exposure. A more conservative dose standard is the EPA concentration value ([40 CFR 61, Appendix E, Table 2](#)) of 10 millirem (100 microsievert) per year from airborne radiological material. All radionuclide concentrations in air samples collected in 2012 were below the EPA standard.

Gross alpha concentrations were slightly higher in the air samples collected in 2012 from onsite, perimeter, and nearby communities location classes than from the distant community (Table 6.5). However, the average gross alpha concentration ($6.5\text{E-}04$ pCi/m³) from onsite, perimeter, and nearby communities location classes is less than 4 percent of the DOE-derived value. In addition, the maximum gross alpha concentration ($2.7\text{E-}03$ pCi/m³) from all locations is less than 14 percent of the DOE-derived value ($2.0\text{E-}02$ pCi/m³). There is no EPA concentration value for gross alpha. The average gross alpha concentrations in the air samples collected in 2012 were comparable to the last 5 years.

Gross beta concentrations were comparable in the air samples collected in 2012 from onsite, perimeter, and nearby communities location classes compared to air samples from the distant community (Table 6.5). Gross beta concentrations were lower in the air samples collected from all location classes in 2012 compared to air samples collected in the last 5 years.

Gross beta and gross alpha concentrations in air peaked during the fall and winter months in 2012 (Figure 6.4), repeating a pattern of natural radioactivity fluctuations (Eisenbud 1987). Figure 6.4 shows that this fluctuation is seen in both the onsite and distant locations.

Plutonium-239/240 was detected in 5 out of 68 air samples collected from onsite and perimeter location classes in 2012 (Table 6.5). There were no detects in the 14 air samples collected from the nearby and distant communities. The maximum reported plutonium-239/240 concentration was less than 1 percent of the DOE-derived concentration guide and the EPA concentration value. Figure 6.4 shows that plutonium-239/240 concentrations in the air samples collected in 2012 are at levels similar to those measured in previous years. There were no plutonium-238 detects in 2012.

Uranium-234 and uranium-238 were both detected in almost all of the air samples collected in 2012 from all four-location classes (Table 6.5). Figure 6.4 shows that uranium-234 and uranium-238 concentrations were at levels similar to those measured in previous years. The maximum concentrations measured in all locations were less than 1 percent of DOE-derived concentration guides and EPA concentration values for both radionuclides.

Uranium-235 was detected in 2 out of 64-air samples collected from onsite, perimeter, and nearby communities location classes in 2012 (Table 6.5). There was one detect in the four air samples collected from the distant community location group. The maximum reported uranium-235 concentration was less than 1 percent of the DOE-derived concentration guide the EPA concentration value.

Cesium-137 was detected in one out of at least 80 air samples collected from onsite, perimeter, and nearby communities location classes in 2012 (Table 6.5). There were no detects in the four air samples collected from the distant community location group. The maximum reported cesium-137 concentration was 10 percent of the EPA concentration value but less than 1 percent of the DOE-derived concentration guide.

Cobalt-60 and strontium-90 were not detected in any of the samples collected during 2012 (Table 6.5).

Figure 6.2. Ambient-Air Sampling Locations

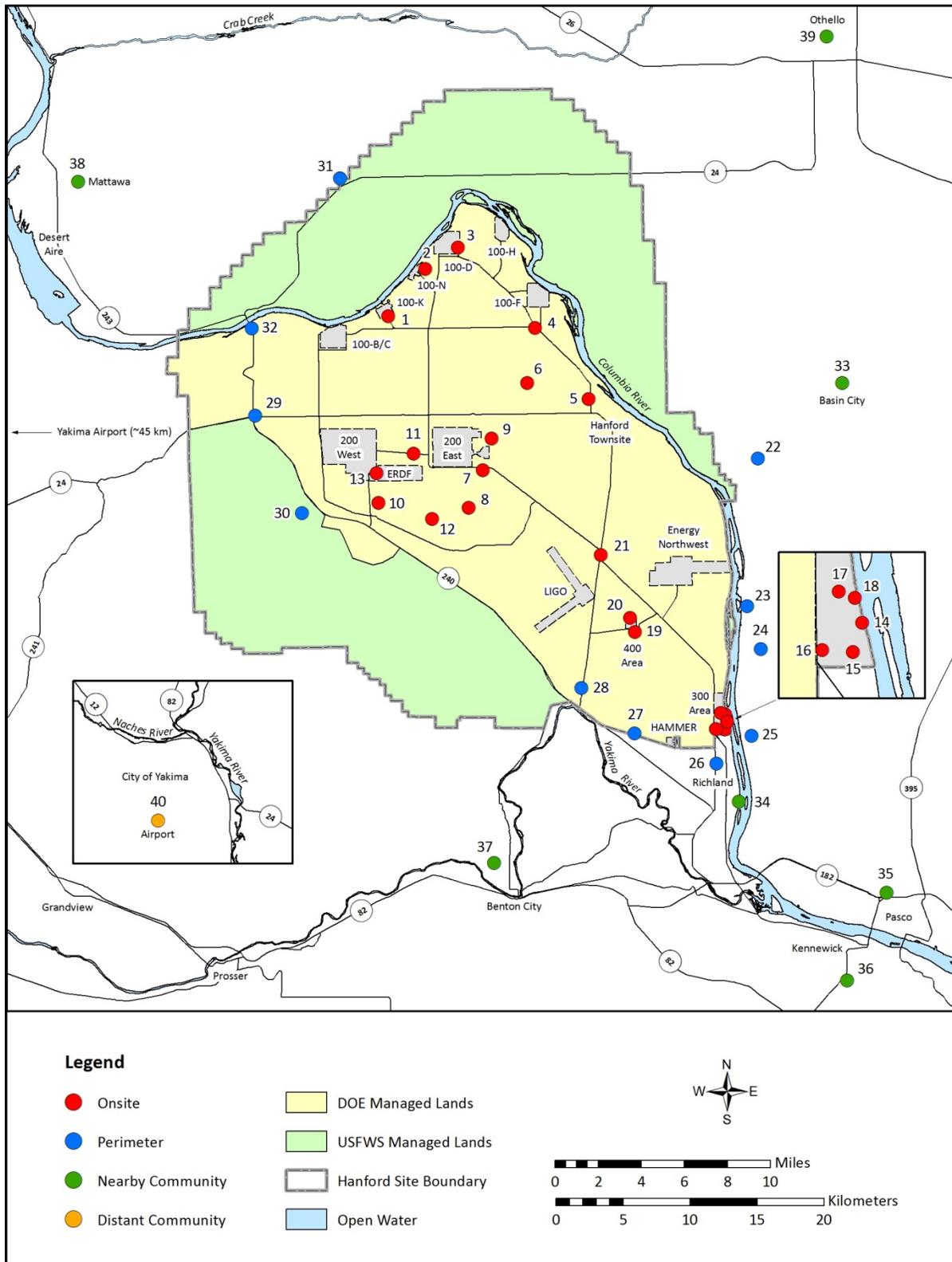


Table 6.4. Hanford Site and Offsite Ambient-Air Sampling Locations, Composite Groups, and Analytes

Sampling Location ^{1,2}	Analytes ³	Composite Group	Analytes ⁴	
Onsite				
1	100-K Area	Alpha, beta, tritium	100 Area	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 Mountain	Alpha, beta	Gable Mountain	Gamma, plutonium, uranium
7	200 ESE	Alpha, beta, tritium	200 E Area	Gamma, strontium, plutonium, uranium
8	S of 200-E	Alpha, beta		
9	B Pond	Alpha, beta	B Pond	Gamma, 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 100-B/C Crib	Alpha, beta		
13	200 W SE	Alpha, beta	200 West	Gamma, 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		
17	300 Trench	Alpha, beta, tritium	300 NE	Gamma, strontium, plutonium, uranium
18	300 NE	Alpha, beta, tritium		
19	400 S ⁵	Alpha, beta, tritium	400 Area	Gamma, strontium, plutonium
20	400 N	Alpha, beta		
21	Wye Barricade	Alpha, beta	Wye Barricade	Gamma, plutonium, uranium
Perimeter				
22	Ringold Met Tower	Alpha, beta, tritium	Ringold Met Tower	Gamma, plutonium
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, uranium
25	Byers Landing	Alpha, beta, tritium	Byers Landing	Gamma, strontium, plutonium, uranium
26	Battelle Complex	Alpha, beta, tritium	Battelle Complex	Gamma, uranium
27	Horn Rapids Substation	Alpha, beta	Prosser Barricade	Gamma, strontium, plutonium
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, plutonium, uranium
34	Leslie Groves-Richland	Alpha, beta, tritium	Leslie Groves-Richland	Gamma, strontium, plutonium, uranium
35	Pasco	Beta	Tri-Cities	Gamma, strontium, plutonium, uranium
36	Kennewick	Alpha, beta		
37	Benton City	Beta	Benton City	Gamma
38	Mattawa	Beta	Mattawa	Gamma
39	Othello	Beta	Othello	Gamma, uranium
Distant Communities				
40	Yakima	Alpha, beta, tritium	Yakima	Gamma, strontium, plutonium, uranium

Table 6.4. Hanford Site and Offsite Ambient-Air Sampling Locations, Composite Groups, and Analytes

¹ Refer to Figure 6.2.

² Sampling location names are derived from the Hanford Environmental Information System database.

³ Alpha (gross) and beta (gross) samples were collected and analyzed every 2 weeks; tritium samples were collected and analyzed every 4 weeks.

⁴ Gamma spectroscopy, strontium-90, Plutonium-238, Plutonium-239/240 (plutonium-238 and plutonium-239/240), and isotopic uranium (uranium-234, uranium-235, and uranium-238) analyses were performed on quarterly composite samples.

⁵ Air sampler at 400 E was relocated to south of 400 Area and renamed as 400 S.

Table 6.5. Hanford Site Airborne Radionuclide Concentrations
(2012 Compared to Previous Years)

Radionuclide (approximate detection limit)	Location Group ^a	2012				2007 - 2011				Derived Concentration Guide ^e (pCi/m ³)
		No. of Samples	No. of Detects ^b	Average ^c (pCi/m ³)	Maximum ^d (pCi/m ³)	No. of Samples	No. of Detects ^b	Average ^c (pCi/m ³)	Maximum ^c (pCi/m ³)	
Cesium-137 (1.1E-03 pCi/m ³)	Onsite	44	1	8.6E-05 ± 5.6E-04	7.1E-04 ± 7.7E-04 ^f	217	1	6.4E-05 ± 5.8E-04	1.2E-03 ± 1.0E-03 ^f	4.0E+02
	Perimeter	32	0	2.0E-05 ± 6.4E-04	1.1E-03 ± 7.8E-04 ^f	158	3	1.1E-04 ± 1.4E-03	6.9E-03 ± 2.0E-03	
	Nearby communities	24	0	6.3E-05 ± 7.3E-04	1.0E-03 ± 9.2E-04 ^f	116	1	1.0E-04 ± 1.0E-03	2.7E-03 ± 2.5E-03 ^f	
	Distant communities	4	0	-1.6E-04 ± 7.8E-04	2.1E-04 ± 7.0E-04 ^f	20	0	3.0E-04 ± 8.3E-04	1.3E-03 ± 1.3E-03 ^f	
Cobalt-60 (1.1E-03 pCi/m ³)	Onsite	44	0	-8.8E-08 ± 7.8E-04	8.7E-04 ± 9.0E-04 ^f	214	2	2.1E-05 ± 6.0E-04	1.2E-03 ± 1.6E-03 ^f	8.0E+01
	Perimeter	32	0	-2.9E-05 ± 7.2E-04	7.1E-04 ± 7.4E-04 ^f	156	0	3.9E-05 ± 8.2E-04	1.7E-03 ± 2.2E-03 ^f	
	Nearby communities	24	0	-2.0E-04 ± 1.6E-03	9.6E-04 ± 6.0E-04 ^f	114	0	6.8E-05 ± 1.0E-03	2.2E-03 ± 1.7E-03 ^f	
	Distant communities	4	0	7.9E-05 ± 4.0E-04	2.9E-04 ± 8.0E-04 ^f	20	0	1.7E-04 ± 6.5E-04	6.6E-04 ± 1.0E-03 ^f	
Gross Beta (1.0E-03 pCi/m ³)	Onsite	535	535	1.6E-02 ± 1.3E-02	3.8E-02 ± 2.3E-03	2710	2709	1.9E-02 ± 3.1E-02	5.9E-01 ± 6.5E-02	9.0E+00
	Perimeter	279	279	1.6E-02 ± 1.3E-02	3.6E-02 ± 4.4E-03	1398	1398	1.8E-02 ± 2.1E-02	9.4E-02 ± 1.1E-02	
	Nearby communities	181	181	1.6E-02 ± 1.3E-02	3.4E-02 ± 4.0E-03	856	856	1.8E-02 ± 2.1E-02	8.7E-02 ± 9.7E-03	
	Distant communities	26	26	1.4E-02 ± 1.1E-02	3.1E-02 ± 2.9E-03	126	126	1.6E-02 ± 1.7E-02	5.6E-02 ± 6.5E-03	
Gross Alpha (3.5E-04 pCi/m ³)	Onsite	535	489	6.4E-04 ± 6.3E-04	2.3E-03 ± 5.4E-04	2704	2353	7.8E-04 ± 1.2E-03	2.0E-02 ± 7.4E-03	2.0E-02
	Perimeter	279	249	6.5E-04 ± 7.2E-04	2.7E-03 ± 6.1E-04	1397	1215	7.7E-04 ± 1.0E-03	8.2E-03 ± 1.6E-03	
	Nearby communities	78	73	6.8E-04 ± 6.4E-04	1.6E-03 ± 4.2E-04	388	342	7.7E-04 ± 1.2E-03	4.8E-03 ± 1.3E-03	
	Distant communities	26	23	6.2E-04 ± 7.9E-04	2.0E-03 ± 6.2E-04	126	100	6.7E-04 ± 7.7E-04	2.0E-03 ± 7.1E-04	
Plutonium-238 (3.0E-06 pCi/m ³)	Onsite	44	0	4.1E-07 ± 4.8E-06	8.1E-06 ± 8.6E-06 ^f	184	11	5.2E-07 ± 4.9E-06	3.0E-05 ± 6.9E-06	3.0E-02
	Perimeter	24	0	-3.7E-07 ± 2.6E-06	1.4E-06 ± 6.6E-06 ^f	100	8	6.7E-07 ± 3.8E-06	1.3E-05 ± 4.2E-06	
	Nearby communities	12	0	-7.2E-07 ± 3.6E-06	1.9E-06 ± 3.8E-06 ^f	55	7	7.4E-07 ± 3.0E-06	5.7E-06 ± 3.2E-06	
	Distant communities	4	0	-1.1E-06 ± 6.0E-06	2.6E-06 ± 1.7E-05 ^f	15	3	1.1E-06 ± 3.7E-06	7.5E-06 ± 4.8E-06	

6.16

Table 6.5. Hanford Site Airborne Radionuclide Concentrations
(2012 Compared to Previous Years)

Radionuclide (approximate detection limit)	Location Group ^a	2012				2007 - 2011				Derived Concentration Guide ^e (pCi/m ³)
		No. of Samples	No. of Detects ^b	Average ^c (pCi/m ³)	Maximum ^d (pCi/m ³)	No. of Samples	No. of Detects ^b	Average ^c (pCi/m ³)	Maximum ^c (pCi/m ³)	
Plutonium-239/240 (3.0E-06 pCi/m ³)	Onsite	44	4	7.7E-07 ± 7.3E-06	1.3E-05 ± 5.3E-06	185	28	1.1E-06 ± 5.0E-06	2.1E-05 ± 7.0E-06	2.0E-02
	Perimeter	24	1	4.6E-08 ± 2.8E-06	2.4E-06 ± 5.7E-06 ^f	107	9	1.2E-06 ± 1.1E-05	5.5E-05 ± 1.3E-05	
	Nearby communities	12	0	-3.4E-07 ± 2.3E-06	1.2E-06 ± 5.4E-06 ^f	53	7	8.4E-07 ± 5.4E-06	1.6E-05 ± 4.6E-06	
	Distant communities	4	0	2.8E-07 ± 2.8E-06	2.6E-06 ± 1.3E-05 ^f	18	0	2.1E-07 ± 1.6E-06	1.8E-06 ± 2.0E-06 ^f	
Strontium-90 (1.0E-04 pCi/m ³)	Onsite	28	0	1.3E-05 ± 9.3E-05	1.4E-04 ± 1.4E-04 ^f	144	2	1.1E-05 ± 6.2E-05	1.6E-04 ± 5.2E-05	9.0E+00
	Perimeter	24	0	1.1E-05 ± 2.3E-04	4.2E-04 ± 3.3E-04 ^f	125	4	1.1E-05 ± 9.3E-05	3.1E-04 ± 1.0E-04	
	Nearby communities	8	0	5.7E-06 ± 9.8E-05	6.2E-05 ± 1.8E-04 ^f	48	1	3.0E-05 ± 2.9E-04	7.2E-04 ± 1.9E-04	
	Distant communities	4	0	-4.6E-05 ± 1.0E-04	3.0E-05 ± 4.8E-05 ^f	19	0	5.5E-05 ± 3.0E-04	6.7E-04 ± 8.0E-04 ^f	
Tritium (1.0 pCi/m ³)	300 Area	77	57	8.6E+00 ± 2.7E+01	6.9E+01 ± 6.6E+00	377	324	9.7E+00 ± 2.4E+01	8.4E+01 ± 1.2E+01	1.0E+05
	Onsite	77	41	4.0E+00 ± 9.8E+00	3.5E+01 ± 3.8E+00	314	193	4.4E+00 ± 1.5E+01	7.7E+01 ± 1.1E+01	
	Perimeter	89	39	4.1E+00 ± 1.4E+01	5.8E+01 ± 5.6E+00	442	296	6.9E+00 ± 2.1E+01	7.6E+01 ± 1.1E+01	
	Nearby communities	24	12	4.5E+00 ± 9.1E+00	1.4E+01 ± 2.2E+00	128	89	8.1E+00 ± 2.1E+01	6.2E+01 ± 1.0E+01	
	Distant communities	13	5	2.8E+00 ± 7.1E+00	1.1E+01 ± 2.4E+00	66	36	2.4E+00 ± 4.8E+01	7.1E+01 ± 1.2E+01	
Uranium-234 (1.0E-05 pCi/m ³)	Onsite	32	22	3.2E-05 ± 2.6E-05	5.8E-05 ± 4.2E-05	145	117	3.7E-05 ± 4.1E-05	8.8E-05 ± 2.1E-05	9.0E-02
	Perimeter	16	9	3.2E-05 ± 4.9E-05	6.8E-05 ± 2.8E-05	79	65	4.5E-05 ± 5.3E-05	9.4E-05 ± 3.1E-05	
	Nearby communities	16	10	3.5E-05 ± 3.5E-05	6.2E-05 ± 2.3E-05	68	57	4.5E-05 ± 4.2E-05	1.0E-04 ± 3.0E-05	
	Distant communities	4	2	3.8E-05 ± 5.6E-05	7.2E-05 ± 3.5E-05	19	15	3.4E-05 ± 2.8E-05	5.1E-05 ± 2.9E-05	
Uranium-235 (1.0E-05 pCi/m ³)	Onsite	32	1	1.8E-06 ± 5.9E-06	1.0E-05 ± 1.1E-05 ^f	139	27	2.7E-06 ± 9.7E-06	3.6E-05 ± 4.0E-05 ^f	1.0E-01
	Perimeter	16	0	7.6E-07 ± 9.1E-06	1.0E-05 ± 2.3E-05 ^f	75	15	3.1E-06 ± 6.9E-06	1.9E-05 ± 1.3E-05	
	Nearby communities	16	1	6.4E-06 ± 1.5E-05	2.5E-05 ± 4.0E-05 ^f	62	21	3.8E-06 ± 8.9E-06	2.2E-05 ± 3.4E-05 ^f	
	Distant communities	4	1	1.2E-05 ± 2.2E-05	3.0E-05 ± 1.8E-05	16	2	3.3E-06 ± 5.4E-06	1.0E-05 ± 8.2E-06 ^f	

6.17

Table 6.5. Hanford Site Airborne Radionuclide Concentrations
(2012 Compared to Previous Years)

Radionuclide (approximate detection limit)	Location Group ^a	2012				2007 - 2011				Derived Concentration Guide ^e (pCi/m ³)
		No. of Samples	No. of Detects ^b	Average ^c (pCi/m ³)	Maximum ^d (pCi/m ³)	No. of Samples	No. of Detects ^b	Average ^c (pCi/m ³)	Maximum ^c (pCi/m ³)	
Uranium-238 (1.0E-05 pCi/m ³)	Onsite	32	30	4.1E-05 ± 2.7E-05	7.8E-05 ± 5.0E-05	145	137	3.9E-05 ± 3.2E-05	8.7E-05 ± 5.8E-05	1.0E-01
	Perimeter	16	12	4.7E-05 ± 5.0E-05	1.2E-04 ± 6.4E-05	79	79	4.8E-05 ± 4.0E-05	9.6E-05 ± 5.6E-05	
	Nearby communities	16	14	4.7E-05 ± 2.4E-05	8.0E-05 ± 6.9E-05 ^f	68	67	5.0E-05 ± 3.4E-05	9.5E-05 ± 3.2E-05	
	Distant communities	4	3	4.2E-05 ± 2.7E-05	6.0E-05 ± 2.5E-05	19	17	3.7E-05 ± 2.9E-05	5.8E-05 ± 1.9E-05	

^a Location groups are identified in Table 6.4.

^b Detection is defined as a value reported above the minimum detectable activity and above the total propagated analytical uncertainty.

^c Average of all samples ±2 times the standard deviation.

^d Maximum single sample result ± total analytical uncertainty. Negative concentration values are explained in Appendix A.

^e DOE-derived concentration guide (Appendix D, Table D.2).

^f Maximum value reported is a non-detect.

1 pCi = 0.037 Bq

Figure 6.3. Gross Alpha and Beta Concentrations in Airborne Particulate Samples
 (1 pCi = 0.037 Bq)

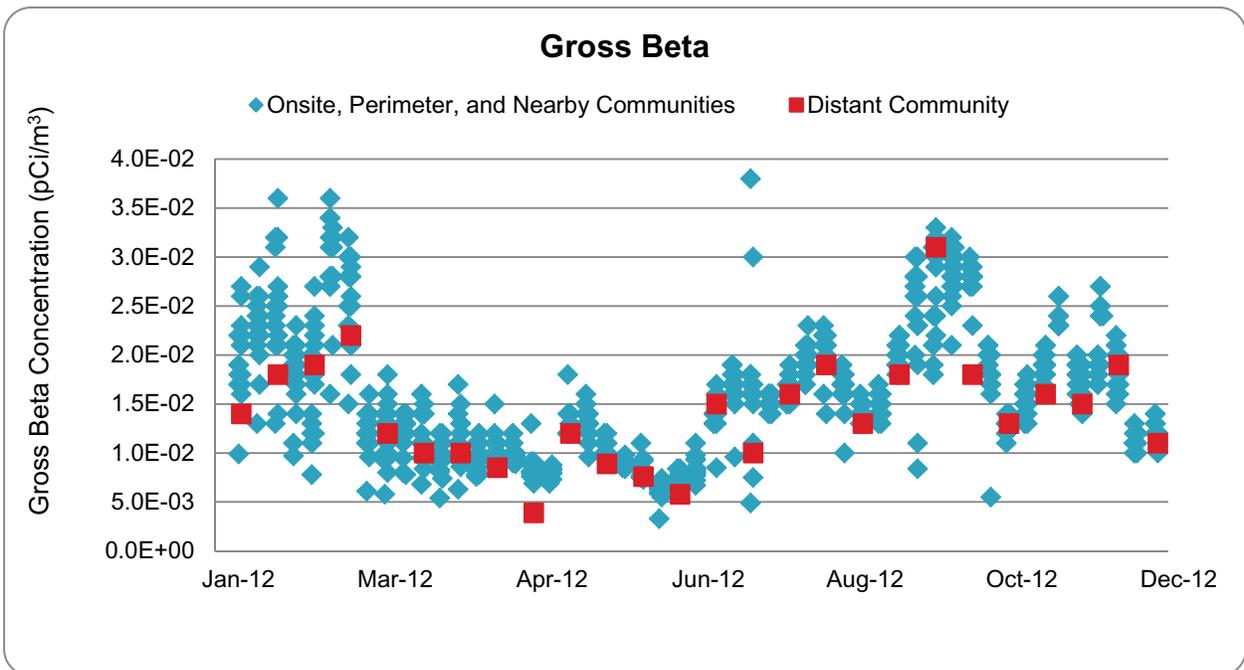
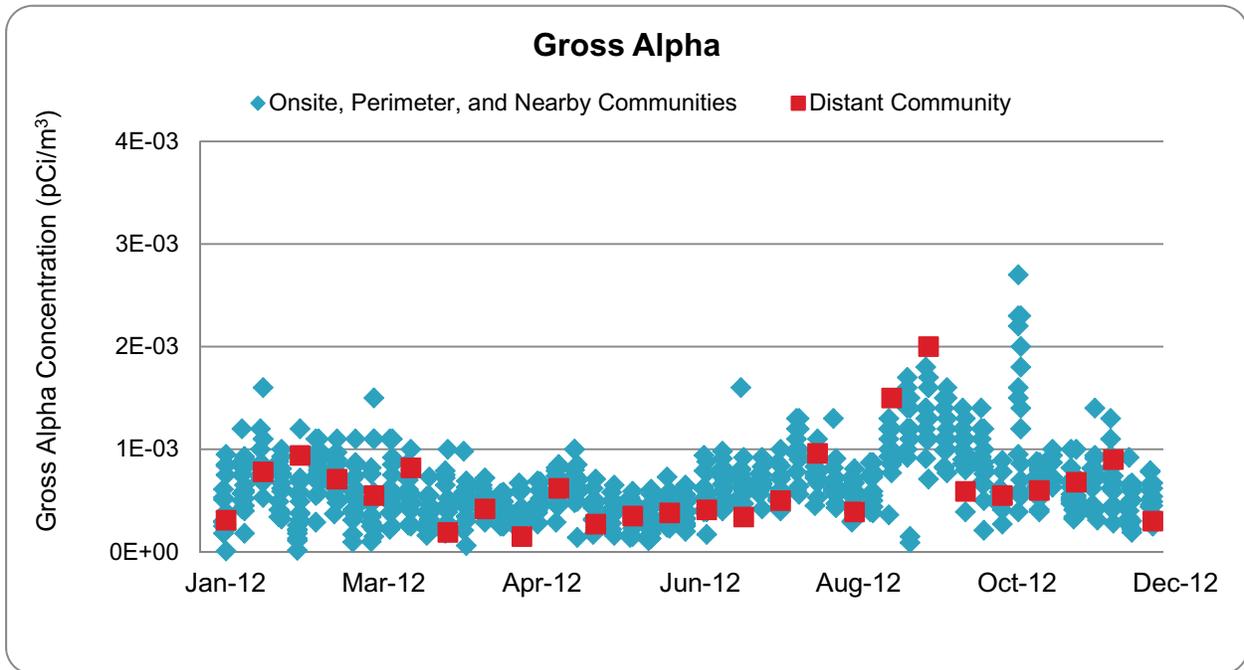


Figure 6.4. Radionuclide Concentrations in Ambient-Air Samples
 (1 pCi = 0.037 Bq)

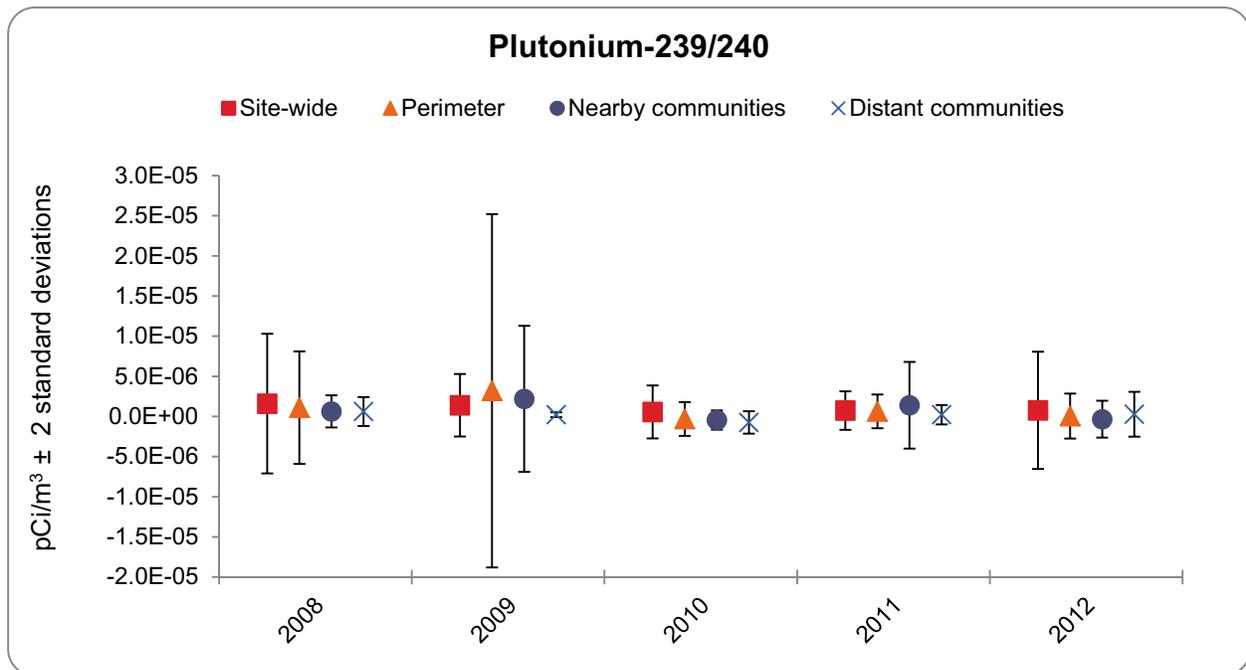
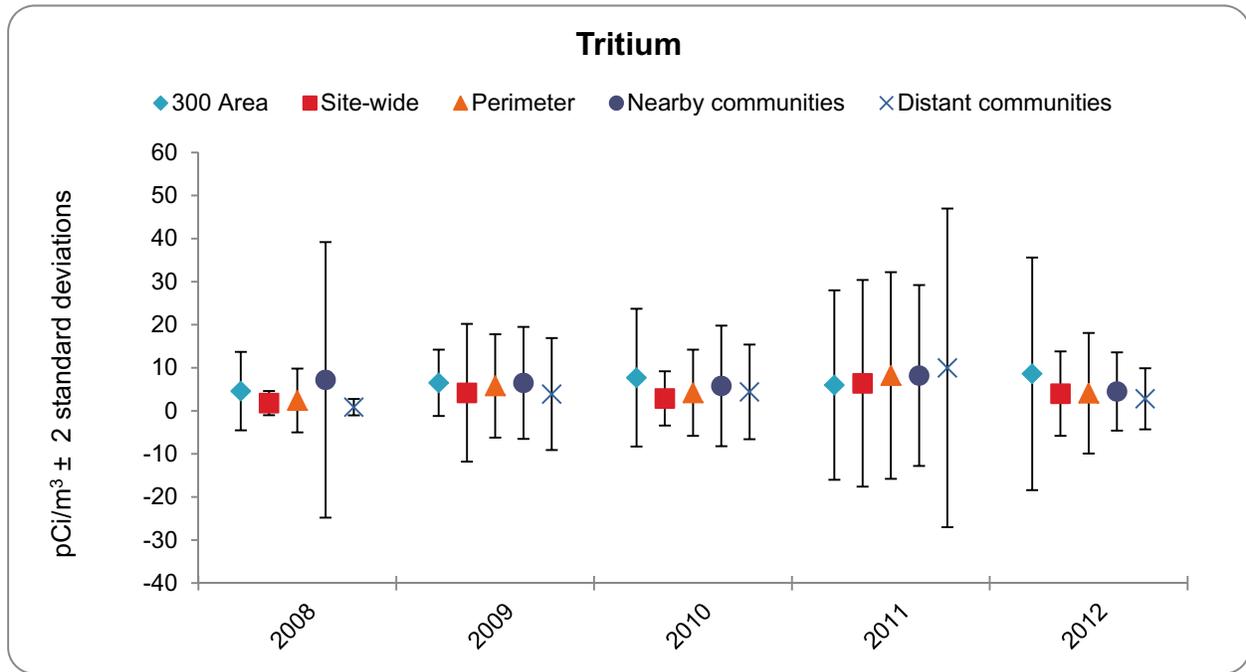


Figure 6.4. Radionuclide Concentrations in Ambient-Air Samples (cont.)
 (1 pCi = 0.037 Bq)

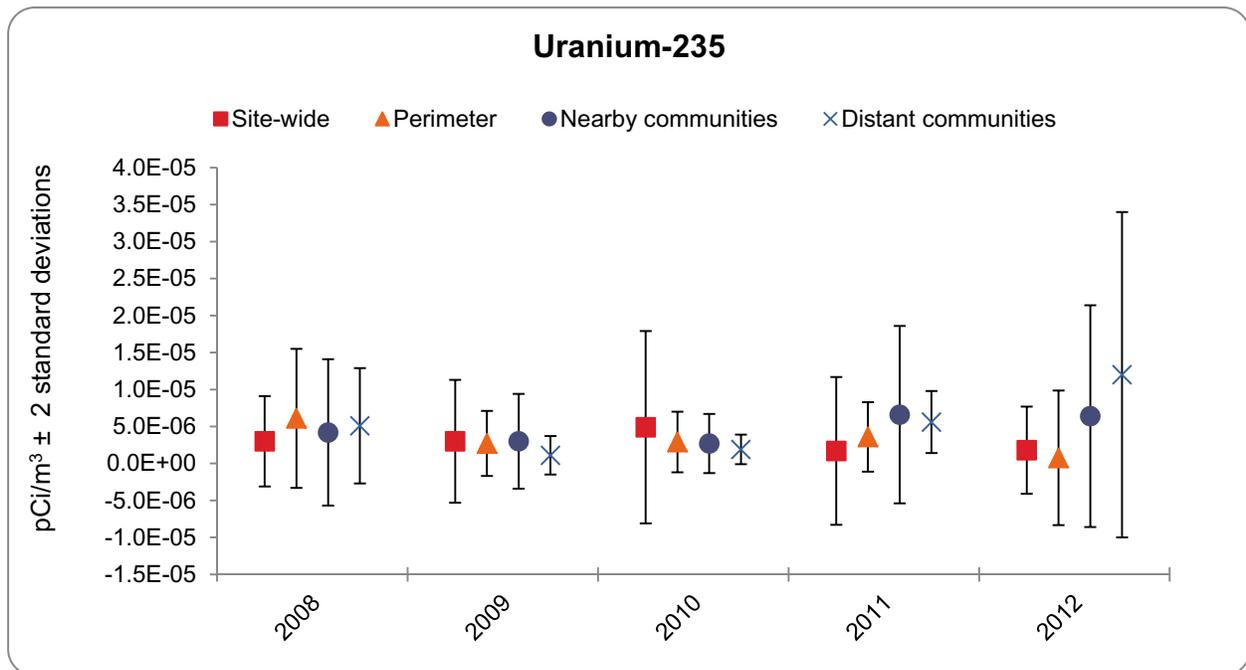
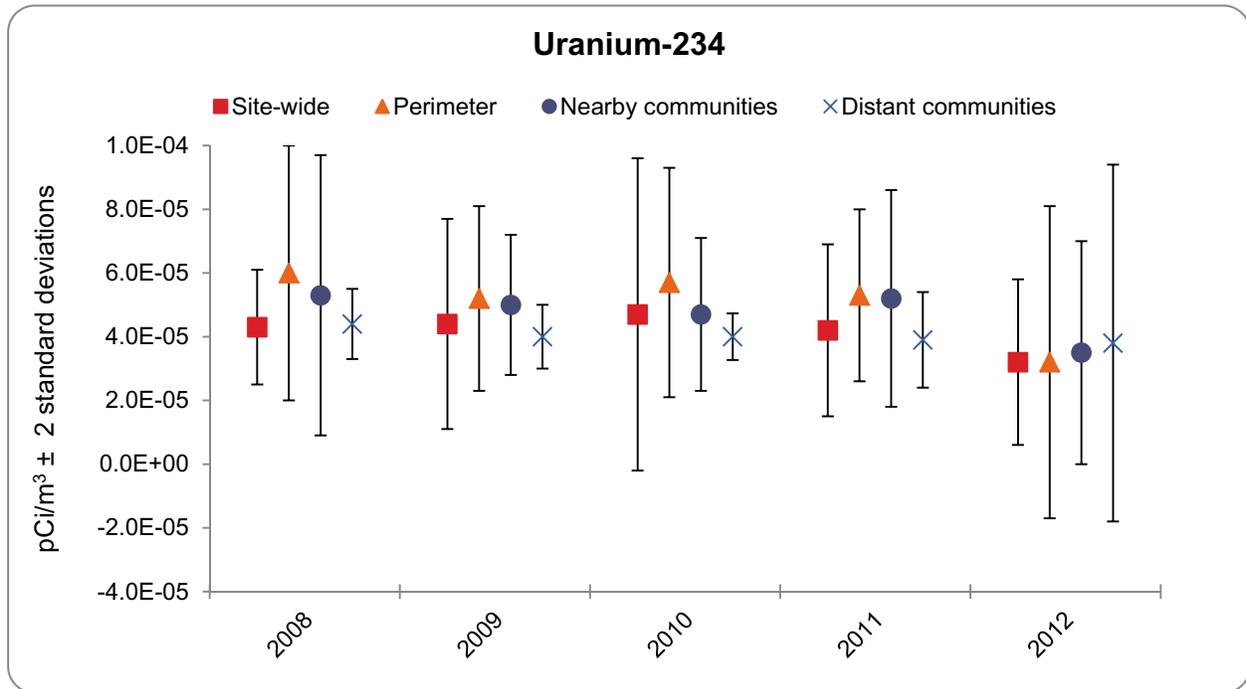
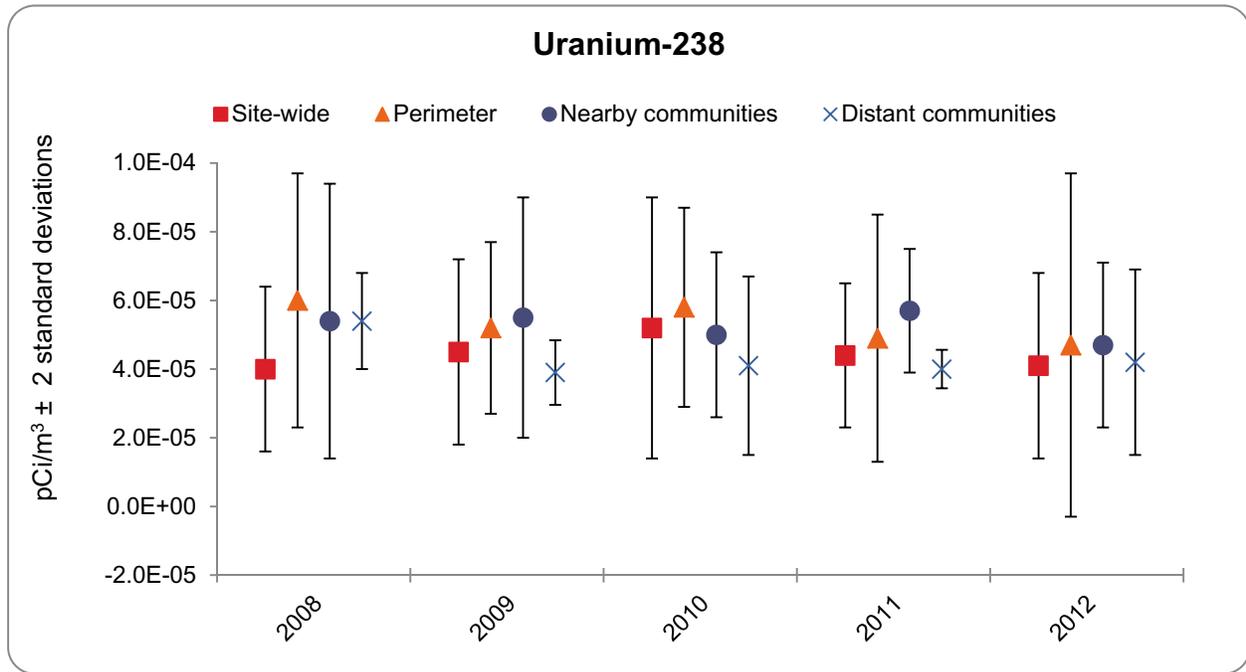


Figure 6.4. Radionuclide Concentrations in Ambient-Air Samples (cont.)
 (1 pCi = 0.037 Bq)



7.0 Water Monitoring

7.1 Drinking Water Systems

LE Bisping and LM Kelly

Eight DOE-owned, contractor-operated, public water systems supplied drinking water during 2012 to DOE facilities on the Hanford Site (Table 7.1). Effective March 31, 2012, the Washington State Department of Health consolidated the 200-East Area water system with the 200-West Area water system. All drinking water for the 200 Areas was supplied from the 200-West Area water treatment plant. The source of supply for the 100-K and 200-W Area systems was the Columbia River via the Export Line. The source of supply for the 400 Area system was groundwater from the unconfined aquifer beneath the site. MSA operated five of the public water systems; WCH operated one system; and CHPRC operated two systems. The city of Richland supplied water to the 300 Area booster pumping station (385 Building) where sodium hypochlorite was added as necessary prior to distribution to 300 Area consumers. In addition to the 300 Area, the city of Richland provided drinking water to the Richland North Area and HAMMER.

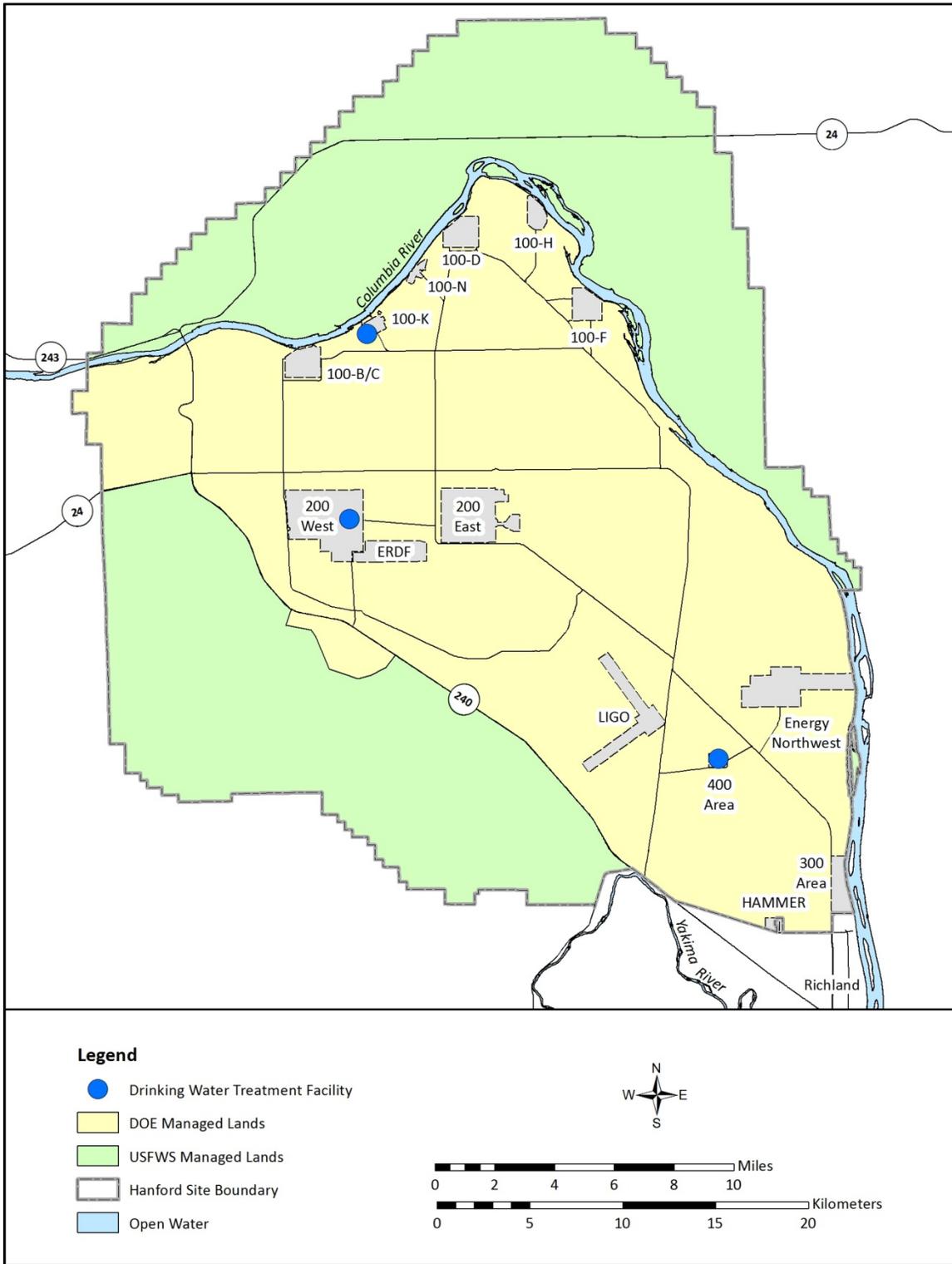
Table 7.1. Drinking Water Systems

Public Water Systems	Water Source	Operator
100-K Area	Columbia River	CHPRC
200-West Area	Columbia River	MSA
251 Substation	Trucked Water from 283-W Water Treatment Plant	MSA
Wye Barricade	Trucked Water from 283-W Water Treatment Plant	MSA
Yakima Barricade	Trucked Water from 283-W Water Treatment Plant	MSA
300 Area	City of Richland (Columbia River and Wells)	WCH
400 Area	400 Area Groundwater Wells	CHPRC
609 Fire Station	Trucked Water from Water Treatment Plant 283-W Water Treatment Plant	MSA

7.1.1 Drinking Water Treatment Facilities

Raw water was treated at three DOE-owned water treatment facilities in the 100-K, 200-West, and 400 Areas (Figure 7.1). Water for the 100-K Area and 200-West Area facilities was obtained from the Columbia River. In support of deactivation, decommission, decontamination, and demolition activities in 100-K East Area, the existing 100-K Area water treatment plant was shut down permanently in February 2011 and replaced with a new membrane alternative filtration technology plant located near the western portion of the 100-K Area. The plant and modified distribution system was placed in operation in April 2011. The 400 Area source of supply was groundwater provided from one of three wells. The 400 Area primary supply well 499-S1-8J (P-16) was the source of drinking water for all of 2012. Emergency backup wells 499-S0-8 (P-14) and 499-S0-7 (P-15) did not supply water to 400 Area consumers during 2012.

Figure 7.1. Drinking Water Treatment Facilities and Sampling Locations



7.1.2 Monitoring

Samples at all three drinking water treatment facilities were collected monthly and analyzed 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 HAMMER was not routinely monitored for radiological contaminants by DOE contractor personnel. However, personnel from MSA, Public Safety, and Resource Protection 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 this section and tabulated in Appendix D. 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/documentcenter/view/6754>.

7.1.3 Radiological Results

PNNL scientists conducted radiological monitoring of drinking water at one DOE-owned pump and three water treatment facilities during 2012. MSA, the site water-compliance organization, conducted routine chemical, physical, and microbiological monitoring of onsite drinking water. Individual water systems operated by MSA, CHPRC, and WCH performed process monitoring (including chemical and physical sampling) at the water treatment plants and distribution systems to determine compliance with applicable regulations.

[WAC 246-290](#) requires that all drinking water analytical results be reported routinely to the Washington State Department of Health. Radiological results for Hanford Site drinking water samples are reported to the state through this annual environmental report. 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 MSA, but are not published.

All DOE-owned Hanford Site drinking water systems were in compliance with DWSs for radiological, chemical, and microbiological contaminant levels during 2012. Contaminant concentrations measured during the year were similar to those observed in recent years as described in environmental reports [DOE/RL-2011-119](#) and [PNNL-20548](#).

Drinking water samples collected by PNNL for radiological analysis in 2012 were analyzed for gross alpha, gross beta, tritium, and strontium-90 (Table 7.2). 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 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) are 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](#) and [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 in 2012 were below state and federal maximum allowable contaminant levels. The gross alpha, tritium, and strontium-90 results from the two 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), as was gross beta results for seven of the eight river water samples. The 400 Area source of drinking water for 2012 was well 499-S1-8J (P-16). Gross beta and tritium were found in all 400 Area water samples, but still below the maximum allowable contaminant level. Gross alpha and strontium-90 were not detected in 400 Area water samples (Table 7.2).

Table 7.2. Drinking Water Annual Average Concentrations of Selected Radiological Constituents

Constituent	Systems	Samples Analyzed from Each Location	Annual Average ^a (pCi/L) ^b	Standard
Gross alpha ^{c,d}	100-K Area	4	0.239 ± 1.473	15 ^{e,f}
	200-West Area	4	0.708 ± 1.107	
	400 Area	4	0.285 ± 0.588	
Gross beta ^c	100-K Area	4	1.646 ± 2.395 ^d	50 ^f
	200-West Area	4	1.843 ± 5.167	
	400 Area	4	10.418 ± 8.510	
Tritium ^g	100-K Area	1	-171 ± 326 ^d	20,000 ^f
	200-West Area	1	-140 ± 326 ^d	
	400 Area	7	1613 ± 418.84	
Strontium-90 ^{d,g}	100-K Area	1	0.385 ± 1.09	8 ^{e,f}
	200-West Area	1	0.442 ± 1.08	
	400 Area	1	-0.808 ± 0.986	

^a For locations with more than one sample analyzed, the annual average is ±2 times the standard deviation.

^b Multiply pCi/L by 0.037 to convert to Bq/L.

^c Gross alpha samples were collected and analyzed quarterly. Gross beta samples were collected monthly, composited, and analyzed quarterly.

^d Analytical results for all samples were below the detection limit.

^e WAC 246-290.

^f 40 CFR 141.

^g Samples were collected quarterly, composited, and analyzed annually, with the exception of the 400 Area tritium analyses. In the 400 Area, tritium samples were collected and analyzed quarterly; plus three additional tritium samples were collected February 2012, March 2012, and August 2012 and analyzed.

Soil and Groundwater Remediation Project personnel collected and analyze 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 of the 400 Area drinking water wells (Table 7.3; Figure 7.2). PNNL staff collected raw (untreated) water samples in 2012 from backup well 499-S0-8 (P1-14). Samples were collected quarterly, composited for a single annual tritium analysis (9000 ± 1780 pCi/L), and fell below the 20,000-pCi/L (740-Bq/L) state and federal annual average DWS.

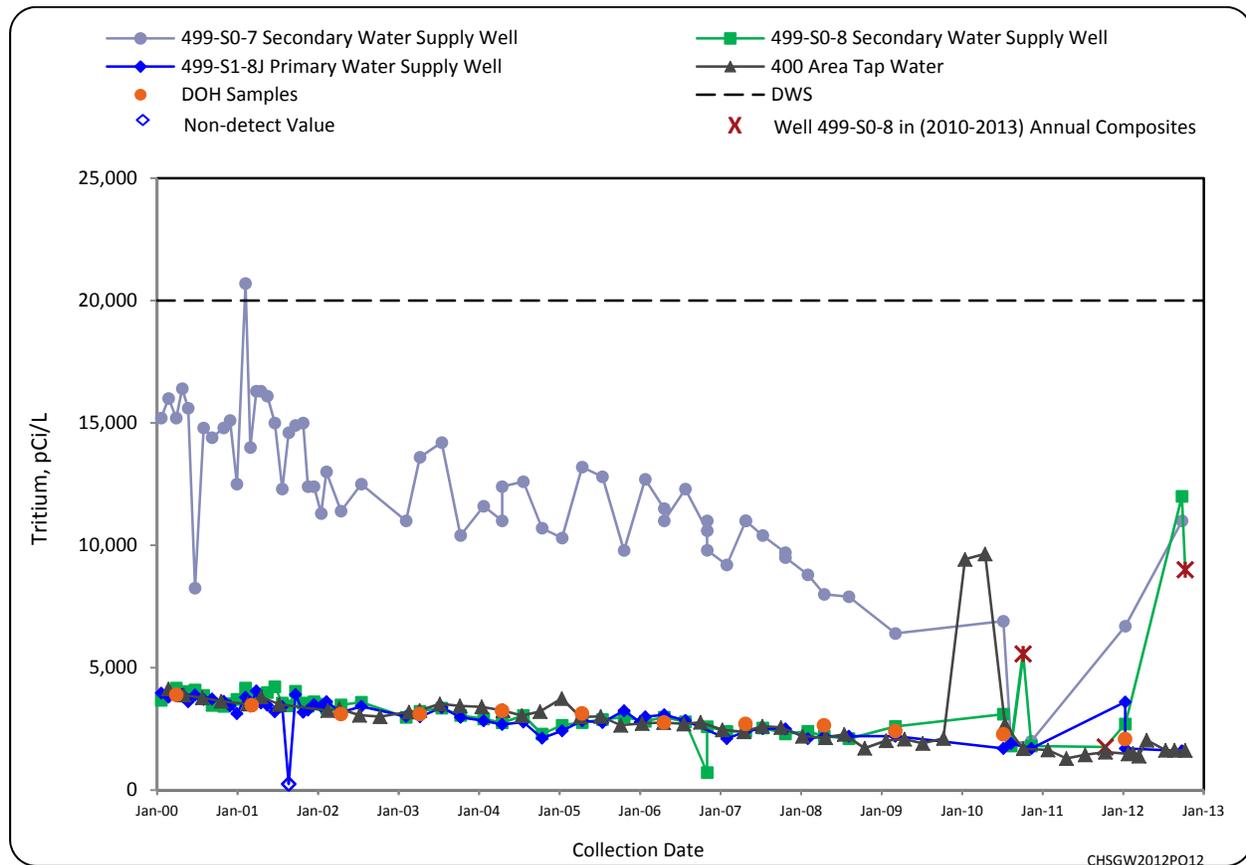
Table 7.3. Tritium Concentrations in Hanford Site 400 Area Drinking Water Wells

Sampling Date	Primary Drinking Water Well 499-S1-8J (P-16) (pCi/L) ^a	Backup Drinking Water Well 499-S0-8 (P-14) (pCi/L) ^a	Backup Drinking Water Well 499-S0-7 (P-15) (pCi/L) ^a
1/11/2012	2,650 ± 2,687 ^b	2,700 ± 600 ^c	6,700 ± 1,400 ^c
9/24/2012	1,600 ± 398 ^c	12,000 ± 2,530 ^c	11,000 ± 2,240 ^c

^a Multiply pCi/L by 0.037 to convert to Bq/L.

^b Two samples collected 1/11/2012, annual average ±2 times the standard deviation.

^c Reported concentration ± 2 total propagated analytical error

Figure 7.2. 400 Area Tritium Concentrations in Drinking Water*(Multiply pCi/L by 0.037 to convert to Bq/L)*

7.2 Columbia River Surface Water

ME Hoefer and ZL Simmons

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 7.3). Aquatic sediment monitoring was conducted for the Columbia River and one onsite pond. Tables 7.4 and 7.5 summarize the sampling locations, types, and frequencies, as well as sample analyses included in surface-water and sediment monitoring during 2012. This section describes the monitoring efforts and summarizes the results for these aquatic environments.

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 Hanford 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 Hanford Site also is 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 260,000 square miles (670,000 square kilometers) before discharging to the Pacific Ocean. Three dams in Canada and 11 dams in the United States regulate the flow of the river; four 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 Hanford 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 un-impounded. River flow through the Hanford Reach fluctuates significantly throughout the year and is controlled primarily by operations at upstream dams. Figure 7.4 shows the maximum, average, and minimum flow rates of the Columbia River at Priest Rapids Dam for 2012. The annual average flow of the Columbia River downstream of Priest Rapids Dam in 2012 was approximately 148,100 cubic feet (4,200 cubic meters) per second which was above the 10-year average annual flow rate of 110,500 cubic feet (3,100 cubic meters) per second ([USGS 2012](#), *USGS Water-Data Report for 2012, 12472800 Columbia River Below Priest Rapids Dam, WA*). The Columbia River had above normal flows in 2012; the average daily flow rate downstream of Priest Rapids Dam was 152,000 cubic feet (4,308 cubic meters) per second. The highest monthly average flow rate occurred during July (276,000 cubic feet [7,813 cubic meters] per second) (Figure 7.4). The lowest monthly average flow rate occurred during October (70,000 cubic feet [1,982 cubic meters] per second), based on mean daily flows. Daily average flow rates varied from 41,090 to 353,990 cubic feet (1,163 to 10,021 cubic meters) per second. Because of fluctuation in discharges, the depth of the river varies significantly. The river stage (river water surface elevation) may change along the Hanford Reach by up to 10 feet (3 meters) within a few hours. 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, the relative distance of each area from Priest Rapids Dam, and the width of the river varies from approximately 980 to 3,300 feet (300 to 1,000 meters) as it passes through the Hanford Site.

Figure 7.3. Surface-Water and Sediment Sampling Locations

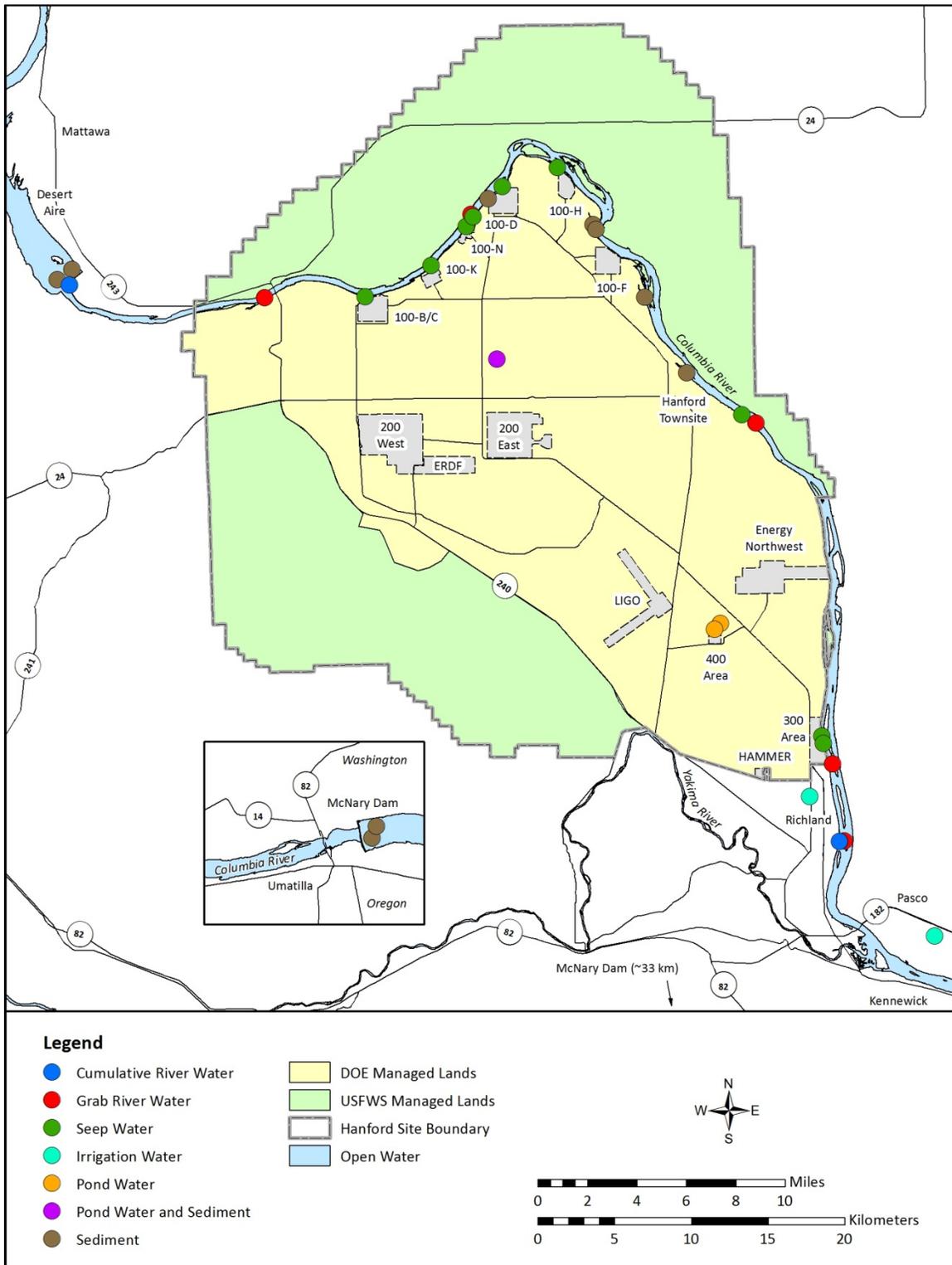


Table 7.4. Surface-Water Surveillance

Location	Sample Type	Frequency	Analyses
Columbia River - Radiological			
Priest Rapids Dam, and Richland Pump House	Cumulative	Monthly Composite ^a	Alpha, beta, low tritium ^b , strontium-90, technetium-99, isotopic uranium ^c
	Particulate (filter)	Monthly	Gamma energy analysis
		Continuous ^d	
		Quarterly	Isotopic plutonium ^f
	Soluble (resin)	Continuous ^e	
		Monthly	Gamma energy analysis
		Quarterly	Isotopic plutonium
		Continuous ^e	
Vernita Bridge and Richland	Grab (transects)	Quarterly	Low tritium ^b , strontium-90, technetium-99, isotopic uranium ^c
100-N Area, 300 Area, and Hanford town site	Grab (transects)	Annually	Low tritium ^b , strontium-90, technetium-99, isotopic uranium ^c
Columbia River - Chemical			
Vernita Bridge and Richland	Grab (transects)	2/year	Temperature, pH, anions, specific conductance, chromium, nitrate + nitrite
	Grab (transects)	Annually	Metals (filtered and unfiltered), volatile organic compounds
100-N Area, 300 Area, and Hanford town site	Grab (transects)	Annually	Metals (filtered and unfiltered), anions, mercury
Onsite Ponds			
West Lake	Grab (water)	Annually ^g	Isotopic uranium ^c
West Lake	Grab (seep)	Annually ^h	Low tritium ^b , strontium-90, technetium-99, isotopic uranium ^c
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 Monthly Composite indicates river water was collected at set intervals 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 Monthly Continuous = 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 Quarterly Continuous = 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 West Lake standing water sampled during first quarter.

^h West lake seep water collected during second quarter.

Table 7.5. Columbia River Sediment Surveillance

Location ^a	Sample Type	Frequency	Analyses
Priest Rapids Dam ^b	Grab	Annually	Gamma energy analysis, anions, hexavalent chromium, strontium-90, isotopic uranium ^c , isotopic plutonium ^d , metals, mercury, and total organic carbon
McNary Dam ^b			
Hanford Reach ^e			

^a Refer to Figure 7.3.

^b Two locations near the Dam.

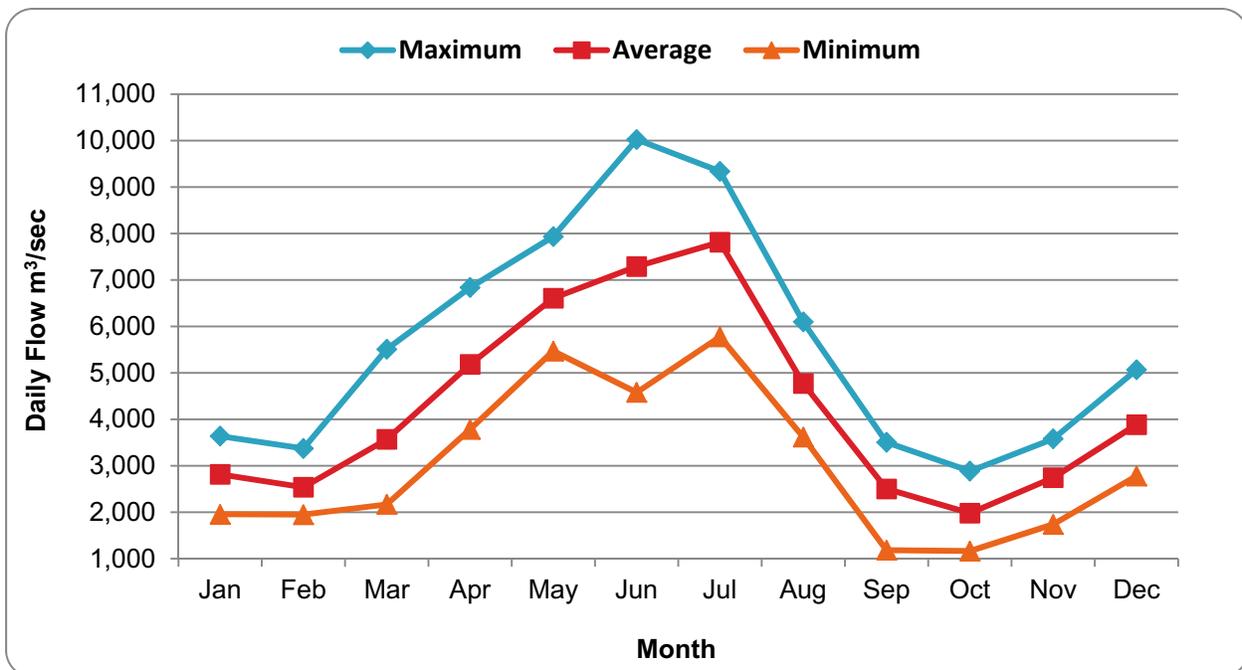
^c Isotopic uranium (uranium-234, uranium-235, and uranium-238).

^d Isotopic plutonium (plutonium-238 and plutonium-239/240).

^e 100-F Slough, Hanford Slough, and White Bluffs Slough (two samples).

Figure 7.4. Columbia River Flow Rates at Priest Rapids Dam

(multiply m³/sec by 35.31 to obtain ft³/sec)



7.2.1 Monitoring

Columbia River water samples were collected from fixed-location monitoring stations at Priest Rapids Dam and at the city of Richland in 2012 and analyzed for radionuclides. Cross-river transects and near-shore locations near Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland were analyzed for both radionuclides and chemicals (Figure 7.3). Samples were collected upstream from the Hanford Site at Priest Rapids Dam and Vernita Bridge to provide data from locations unaffected by Hanford 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 7.6.

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 samplers were used to obtain unfiltered samples of Columbia River water (cumulative samples), which were composited for a period of 7 days. The samplers collect water at set intervals of time and set incremental volumes. These weekly samples were combined into monthly and quarterly composite samples for radiological analyses (Table 7.4). 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](#).

Radionuclides of interest were selected for analysis based on the following criteria:

- Their presence in historical effluent discharges from Hanford Site facilities or in near-river groundwater underlying the Hanford Site
- Their importance in determining water quality, and in 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. 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. Analytical detection levels (defined as the laboratory-reported minimum detectable concentration) for all radionuclides were less than or equal to 10 percent of their respective Washington State water quality criteria levels (Appendix C). 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 percent significance level.

Transect sampling (i.e., a series of 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. That study concluded that, under certain flow conditions, contaminants entering the Columbia 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 16 feet [5 meters] from shore). This sampling pattern was used during 2012 and allowed the cross-river concentration profile to be determined and provided information over a larger portion of the Hanford Site shoreline where the highest contaminant concentrations would be expected. The city of Richland transects and near-shore locations were sampled quarterly during 2012. Vernita Bridge transects and near-shore locations were sampled during the first, third, and fourth quarters of 2012. Vernita Bridge transects and near-shore locations were not sampled during the second quarter due to safety concerns with extremely high river flows. Annual transect and near-shore sampling were conducted at the 100-N Area, 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.

Columbia River transect water samples collected during 2012 were analyzed for both radiological and chemical contaminants (Table 7.4). Specific metals and anions were selected for analysis following reviews of existing surface-water and groundwater data, various RI/FS work plans, and preliminary Hanford Site risk assessments ([DOE/RL-92-67](#), *Final Remedial Investigation/Feasibility Study-Environmental Assessment Report for the 1100-EM-1 Operable Unit, Hanford*; [WCH-380](#), *Field Summary Report for Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington*). Grab samples of water collected along transects were radiologically and chemically analyzed. Metals analyses included both unfiltered and filtered samples.

7.2.2 Radiological Results

Fixed-Location Samples. Results of radiological analyses of Columbia River water samples collected at Priest Rapids Dam and the city of Richland in 2012 and for the previous 5 years are summarized in Appendix C, Table C.5. All individual radiological contaminant concentrations measured in Columbia River water during 2012 were less than 1/25 of the DOE-derived concentration guides (Appendix D). 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 DWS and Washington State ambient surface-water quality criteria ([40 CFR 141](#); [WAC 173-201A](#); Appendix D).

Radionuclide concentrations monitored in Columbia River water were low throughout 2012. Tritium, uranium-234, uranium-238, and naturally occurring beryllium-7 and potassium-40 were consistently measured in river water at levels greater than their reported minimum detectable concentrations. Strontium-90, technetium-99, 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.

The 2012 average gross alpha and gross beta concentrations measured upstream and downstream of the Hanford Site were similar to those observed during recent years (Figures 7.5 and 7.6). 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 2012 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 2012 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 7.7). Average tritium concentrations in Columbia River water collected at the city of Richland were only 0.16 percent of the Washington State ambient surface-water quality criterion of 20,000 Ci/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 city of Richland shoreline tend to be elevated when compared to average tritium concentrations across the river at this location. 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 2012 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.

Figure 7.5. Gross Alpha Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site
 (± 2 standard deviations, AWQS = ambient water quality standard)

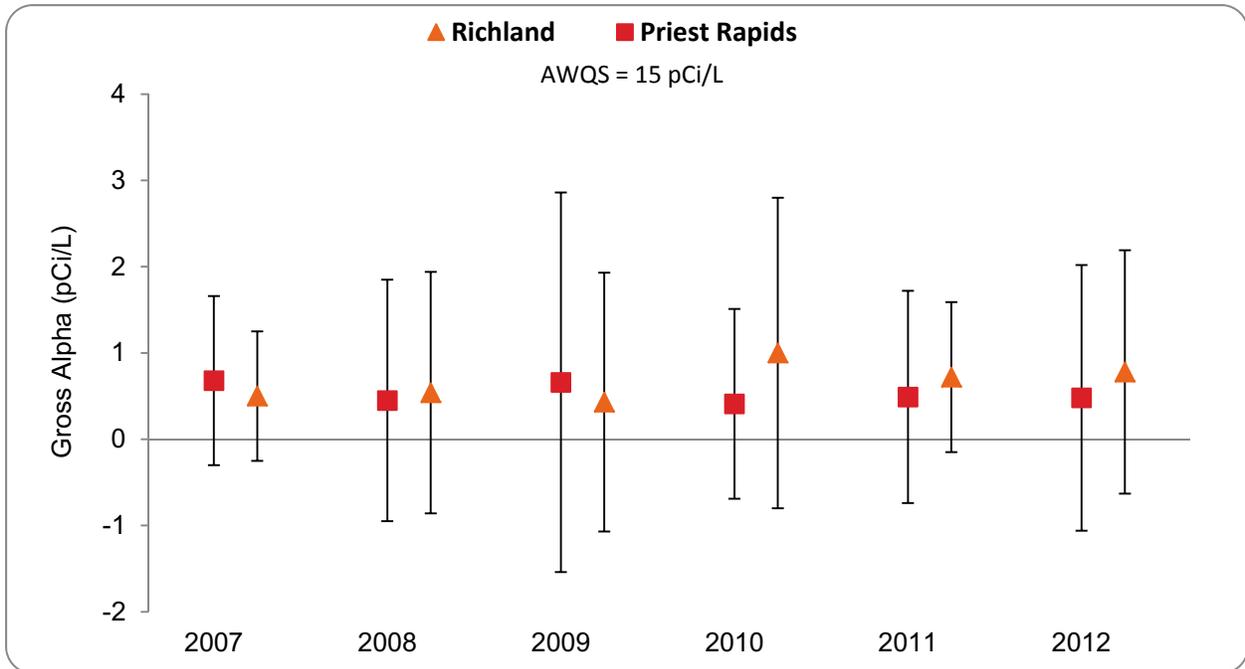


Figure 7.6. Gross Beta Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site
 (± 2 standard deviations, AWQS = ambient water quality standard)

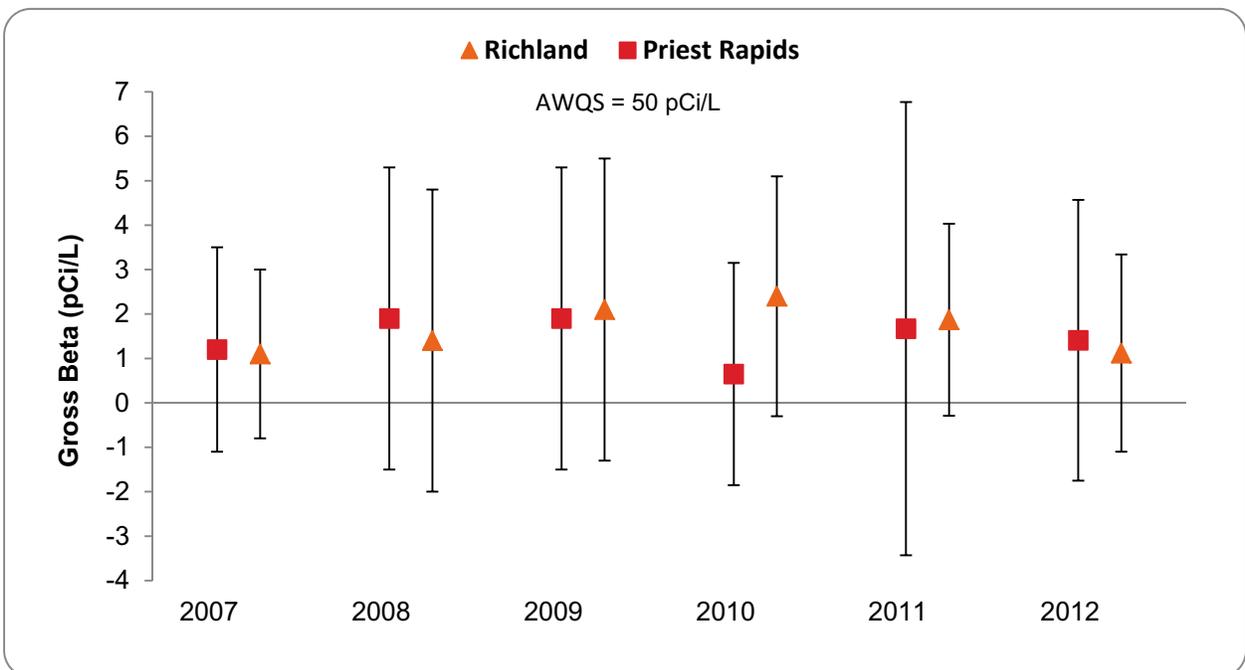
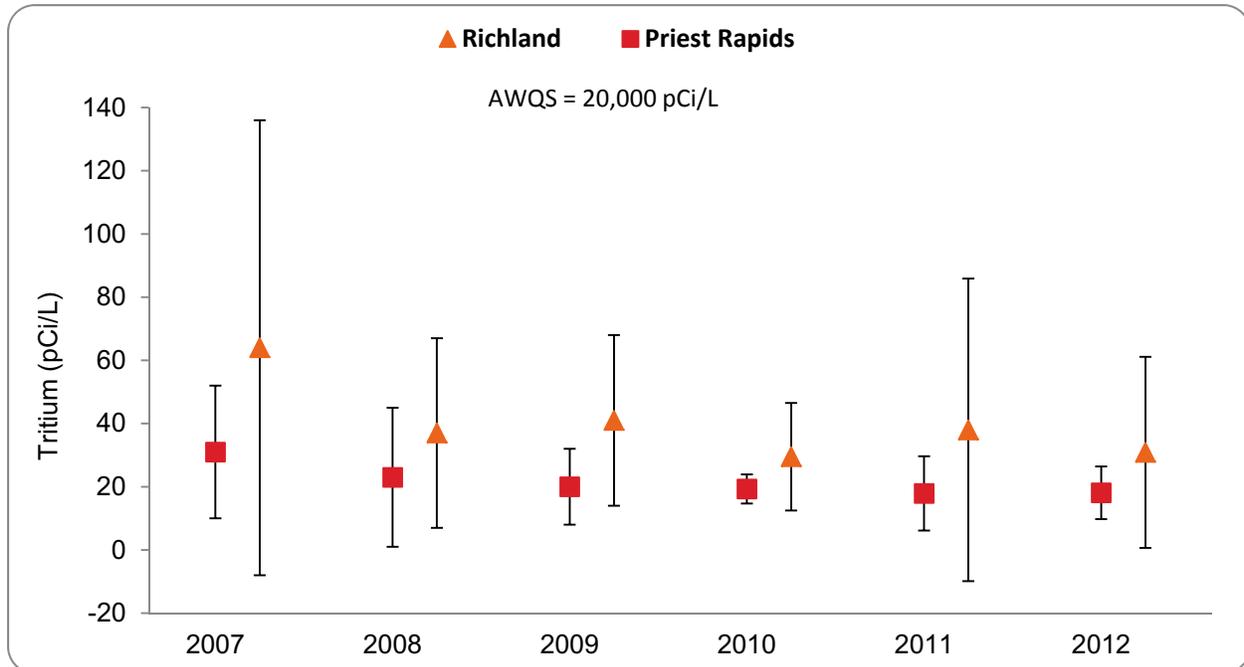


Figure 7.7. Tritium Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site
(± 2 standard deviations, AWQS = ambient water quality standard)



Average strontium-90 levels measured in Columbia River water collected upstream and downstream of the Hanford Site during 2012 were similar to those reported in previous years (Figure 7.8). Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Area. 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 upstream concentrations were less than the minimum detectable concentration. Average strontium-90 concentrations in Columbia River water at the city of Richland were less than 0.15 percent of the Washington State ambient surface-water quality criterion (8 pCi/L [0.30 Bq/L]).

Annual average uranium-234 and uranium-238 concentrations measured in water samples collected upstream and downstream of the Hanford Site in 2012 were similar to those observed during recent years (Figure 7.9). Monthly uranium concentrations measured at the city of Richland in 2012 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 and has been detected at elevated levels in shoreline springs at the 300 Area in the past ([Section 7.4; PNNL-13692, Survey of Radiological and Chemical Contaminants in the Near-Shore Environment at the Hanford Site 300 Area](#); [PNNL-16805, Investigation of the Hyporheic Zone at the 300 Area, Hanford Site](#)). Elevated uranium concentrations were measured in the effluent discharged into the Columbia River from the aquaculture lab at the Battelle complex in the 300 Area. Uranium from non-Hanford Site sources, such as fertilizer use, also is 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. 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 2012 were well below the EPA DWS of 30 $\mu\text{g/L}$ (approximately 20 pCi/L [0.74 Bq/L], Appendix D).

Columbia River water samples were not collected for iodine-129 analysis in 2012 because the unique instrument for this assay was not operational, and an alternative for this ultra-trace measurement capability was not available before a sampling schedule was set. The onsite source of iodine-129 to the Columbia River is the discharge of contaminated groundwater along the portion of shoreline downstream of the Hanford town site (Section 8.0, Groundwater Monitoring). 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).

Plutonium-239/240 concentrations for river water samples at the city of Richland in 2012 were extremely low. 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). 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 upstream concentrations were less than the reported minimum detectable concentrations.

Figure 7.8. Strontium-90 Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site

(± 2 standard deviations, AWQS = ambient water quality standard)

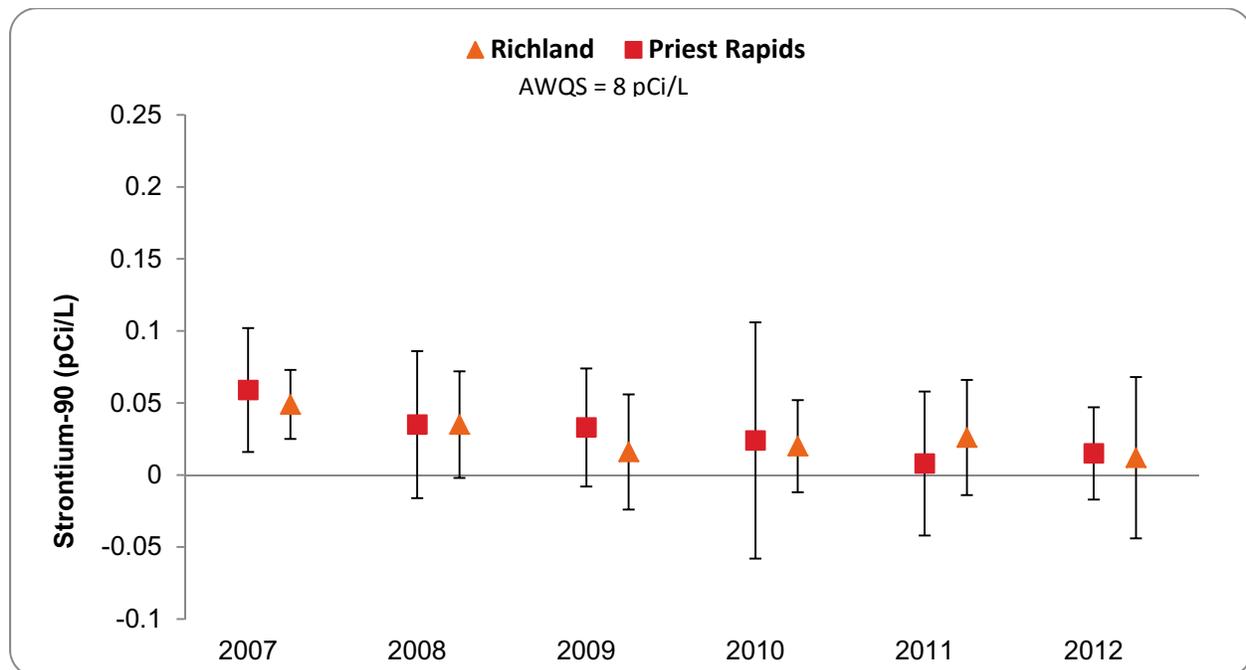
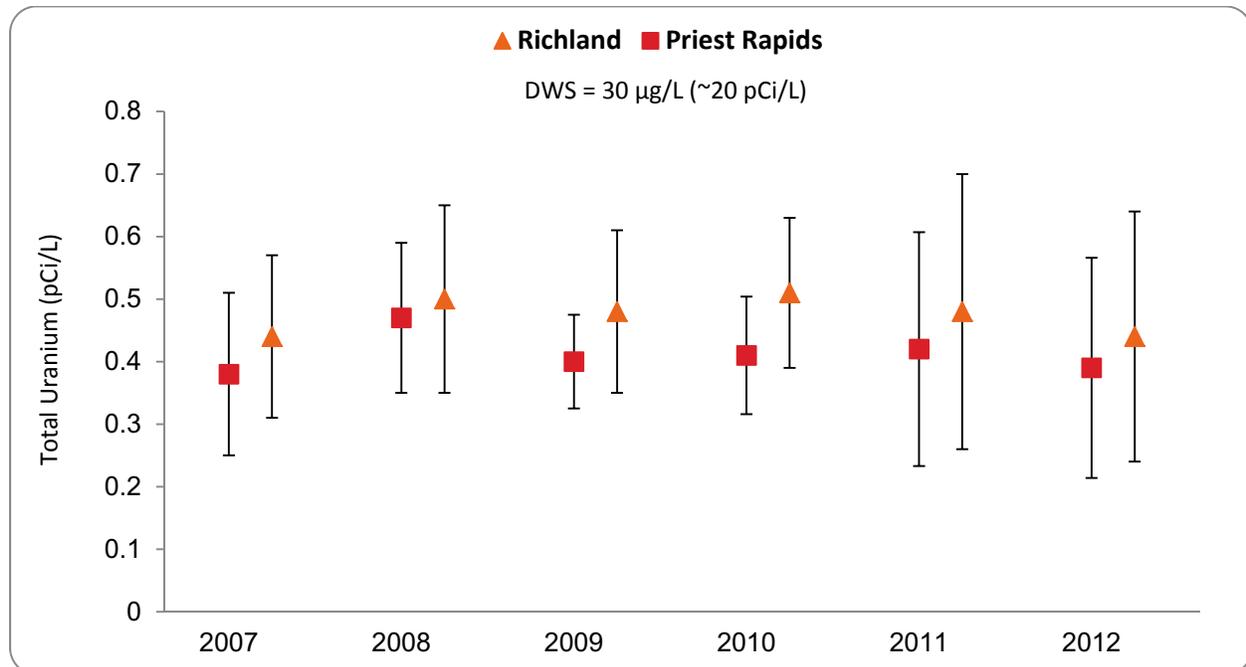


Figure 7.9. Uranium Annual Average Concentrations in Columbia River Water Upstream and Downstream of the Hanford Site
(± 2 standard deviations)



Columbia River Transect Samples. Radiological results from samples collected along Columbia River transects and at near-shore locations near Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland are presented in Appendix C. 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, and most 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 and the EPA DWSs.

Tritium concentrations measured along Columbia River transects at Vernita Bridge, 100-N Area, Hanford town site, 300 Area, and the city of Richland during September 2012 are depicted in Figure 7.10. The transect at Vernita Bridge is the most upstream location. Stations 1 and 4 are located along the Benton County and Grant-Franklin County shorelines, respectively. The 100-N Area, Hanford town site, 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. The gradient is most pronounced during periods of relatively low river flow. Since transect sampling began in 1987, 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 2012, the highest tritium concentration measured in cross-river transect water was 118 ± 10 pCi/L (4.37 ± 0.37 Bq/L) at the 300 Area. Specific conductivity results for the 2012 transect water samples collected at the 300 Area indicate there was only limited mixing of groundwater into the river at the time of sample collection.

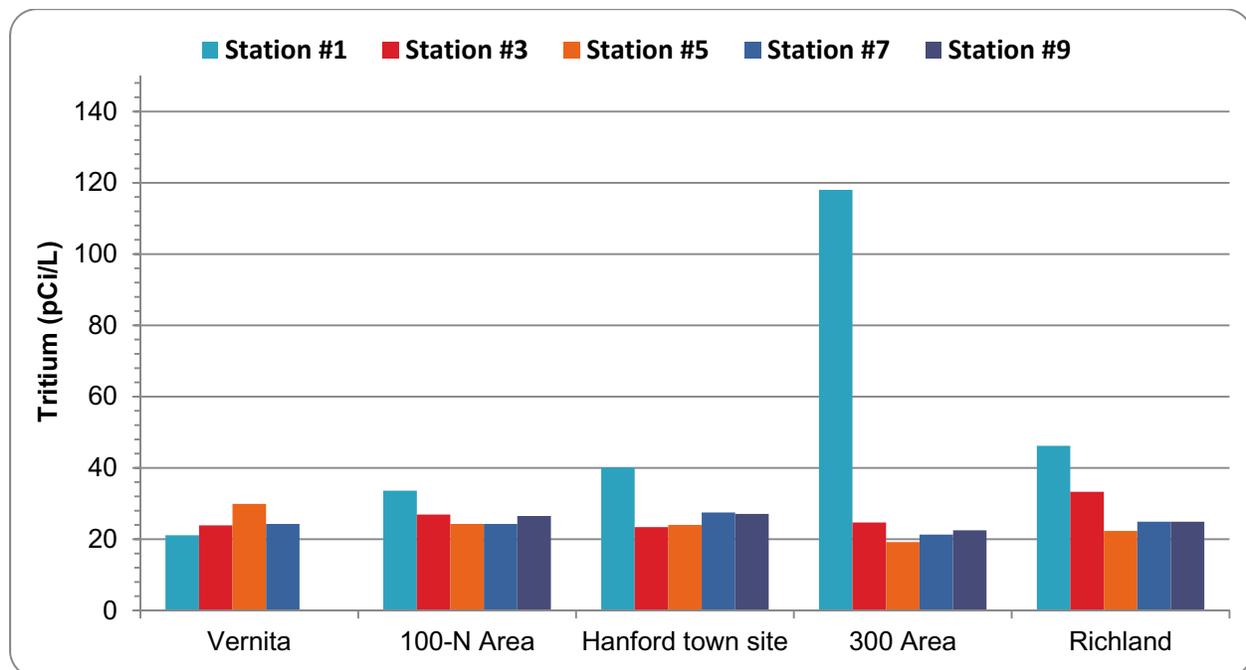
Strontium-90 concentrations in Hanford Reach river water for transect samples collected in 2012 were similar to reference concentrations for most locations. The maximum strontium-90 concentration was 0.054 ± 0.037 pCi/L (0.0020 ± 0.0014 Bq/L) for a water sample collected along the city of Richland transect. The average 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.

Uranium isotopes were monitored in transect water samples collected in 2012 from near the Vernita Bridge, 100-N Area, Hanford Town Site, 300 Area, and city of Richland (Figure 7.3). Uranium concentrations were highest in the water sample collected near the 300 Area shoreline (300 Area-1 HRM 43.1). Uranium isotopes measured in the 300 Area riverbank seep water samples collected in 2012 parallel the 300 Area-1 HRM 43.1 concentrations and are likely associated with its presence.

The total uranium concentrations in all transect samples collected during 2012 were below the EPA DWS of $30 \mu\text{g/L}$ (approximately 20 pCi/L [0.74 Bq/L]). 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.

Figure 7.10. Tritium Concentrations in Cross-River Transect Water Samples (Hanford Reach, Columbia River)

Washington State ambient water quality standard for tritium is 20,000 pCi/L (740 Bq/L)



7.2.3 Chemical and Physical Results

Chemical and physical water quality data was compiled in 2012 for the Columbia River. 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; and industrial, agricultural, and mining effluent introduced upstream of the Hanford Site.

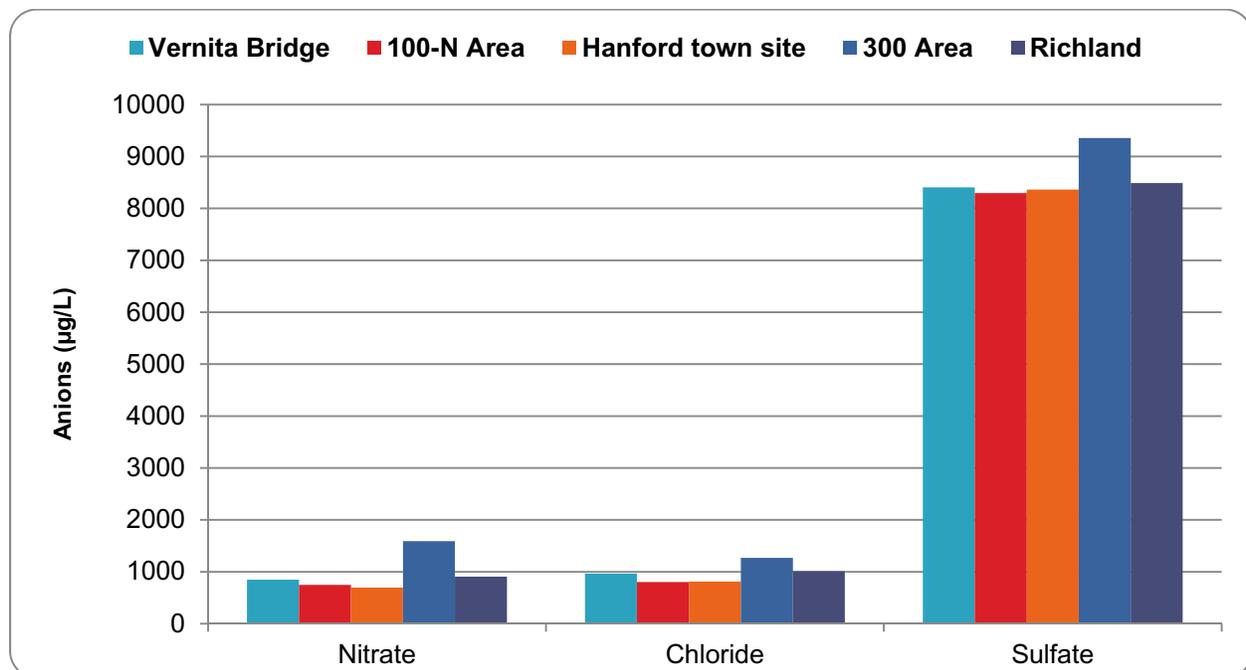
The concentrations of metals and anions observed in river water during 2012 were similar to those observed in the past and remain below regulatory limits. Metals and anions were detected in Columbia River transect samples both upstream and downstream of the Hanford Site. Copper, nickel, and uranium were detected in

most samples. Zinc was detected in several samples collected from near the Vernita Bridge and Hanford town site. Antimony, arsenic, beryllium, cadmium, chromium, lead, selenium, silver, and thallium were not detected in any Columbia River transect water samples. Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent ([WAC 173-201A](#)). 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. All dissolved 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.8).

For samples collected on the cross-river transects, concentrations of nitrate, chloride, and sulfate were slightly elevated along the Benton County shoreline near the 300 Area (see Figure 7.11). 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 [1995 U.S. Geological Survey, Nitrate Concentrations in Ground Water of the Central Columbia Plateau](#), 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, Water Quality in the Central Columbia Plateau, Washington and Idaho, 1992-95](#)). Average quarterly concentrations of chloride, nitrate, and sulfate were higher at the city of Richland transect than in the Vernita Bridge transect. The highest concentrations of nitrates were measured at the 300 Area 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 hexavalent chromium (reported as chromium in Appendix C) 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. All river transect filtered water samples for 2012 had chromium concentrations below the minimum detectable concentration.

Figure 7.11. Selected Chemical Concentrations in Columbia River Transect Samples



7.3 Columbia River Sediment

ZL Simmons

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 behind the dams located downstream of the Hanford Site. 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 re-deposition of sediment. 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 world-wide atmospheric fallout, as well as metals and other nonradioactive contaminants from mining and agricultural activities ([PNNL-13417](#), *Simultaneously Extracted Metals/Acid-Volatile Sulfide and Total Metals in Surface Sediment from the Hanford Reach of the Columbia River and the Lower Snake River*; [PNNL-16990](#), *Summary of Radiological Monitoring of Columbia and Snake River Sediment, 1988 Through 2004*). 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](#), *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*).

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. However, discharges of some pollutants from the Hanford Site to the Columbia River occurred through March 2011 at a permit-regulated liquid effluent discharge at the 100-K Area and through contaminated groundwater.

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 ([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 the reservoir behind Priest Rapids dam upstream of the site and from the White Bluffs Slough on the Hanford Reach.

7.3.1 Monitoring

Samples of the surface layer of Columbia River sediment were collected in 2012 at depths of 0 to 6.3 inches (0 to 16 centimeters) from nine river locations that were permanently submerged (some Hanford Reach sampling locations may not be submerged during an extremely low-river stage). 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. Estimated average sediment deposition rates of 0.28 inch (0.723 centimeter) per year for Priest Rapids Dam and 0.89 inch (2.25 centimeters) per year for McNary Dam ([Gibbons 2000](#), *An Investigation of the Origin of ^{152}Eu in Columbia River Sediments*). Assuming a maximum sediment sampling depth of 6.3 inches (16 centimeters) with the dredge, the samples would integrate up to approximately 22 years at Priest Rapids Dam and 7 years at McNary Dam. Sediment deposition rates have not been estimated for the slough areas along the Hanford Reach. 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 nuclear fallout, also may contribute to the contaminant load found in McNary Dam sediment. Thus, sediment samples are taken periodically in the reservoir above Ice Harbor Dam (the first dam on the Snake River upstream of the river mouth) to assess Snake River input. Sediment samples also were collected at 100-F Slough, White Bluffs Slough, and Hanford Slough along the Hanford Reach of the Columbia River, from slack-water areas where fine-grained material is known to deposit.

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. One location was sampled at 100-F Slough. The White Bluffs Slough monitoring site consisted of two sampling locations. One sample was collected at a location in Hanford Slough. Samples were collected using a clamshell style sediment dredge; this sampling method is discussed in PSRP-DI-001, Environmental Surveillance Sampling. All sediment samples were analyzed for gamma-emitting radionuclides, anions, hexavalent chromium, strontium-90, uranium-234, uranium-235, plutonium-238, uranium-238, plutonium-239/240, metals, mercury, and total organic carbon ([DOE/RL-91-50](#)). The specific analytes selected for sediment samples were based on findings of previous Columbia River sediment investigations, reviews of past effluent contaminants discharged from site facilities, and reviews of contaminant concentrations observed in Hanford Site groundwater monitoring wells near the Columbia River.

7.3.2 Radiological Results

Radionuclides consistently detected in river sediment adjacent to and downstream of the Hanford Site during 2012 included 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 past Hanford Site operations. Potassium-40, and uranium isotopes occur naturally in the environment, and uranium isotopes have been present in past releases of 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](#)). Uranium concentrations were slightly elevated at the White Bluffs Slough and McNary Dam locations as compared to values measured in 2007 through 2011. Other radionuclide concentrations reported in river sediment were similar to those reported for previous years, with the exception of cesium-137 (see Appendix D), and there were no obvious differences between locations. The values for cesium-137 at the White Bluffs Slough were not elevated compared to Priest Rapids Dam, and were lower than elevated values measured in 2004 through 2007, and 2011. Previous studies of soils from the White Bluffs Slough detected elevated concentrations of cesium-137. The average, maximum, and minimum concentrations of selected radionuclides measured in Columbia River sediment (2007 through 2012) are presented in Figures 7.12, 7.13, and 7.14.

7.3.3 Chemical Results

Detectable amounts of most metals were found in all river sediment samples (Figure 7.15). 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, copper, nickel, and zinc differed the most between locations, which may be associated with upstream mining activities. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured values.

Figure 7.12. Cesium-137 Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment

(Upper and lower bars represent maximum and minimum values; these values may be similar to the average and may not be visible in the Figure.)

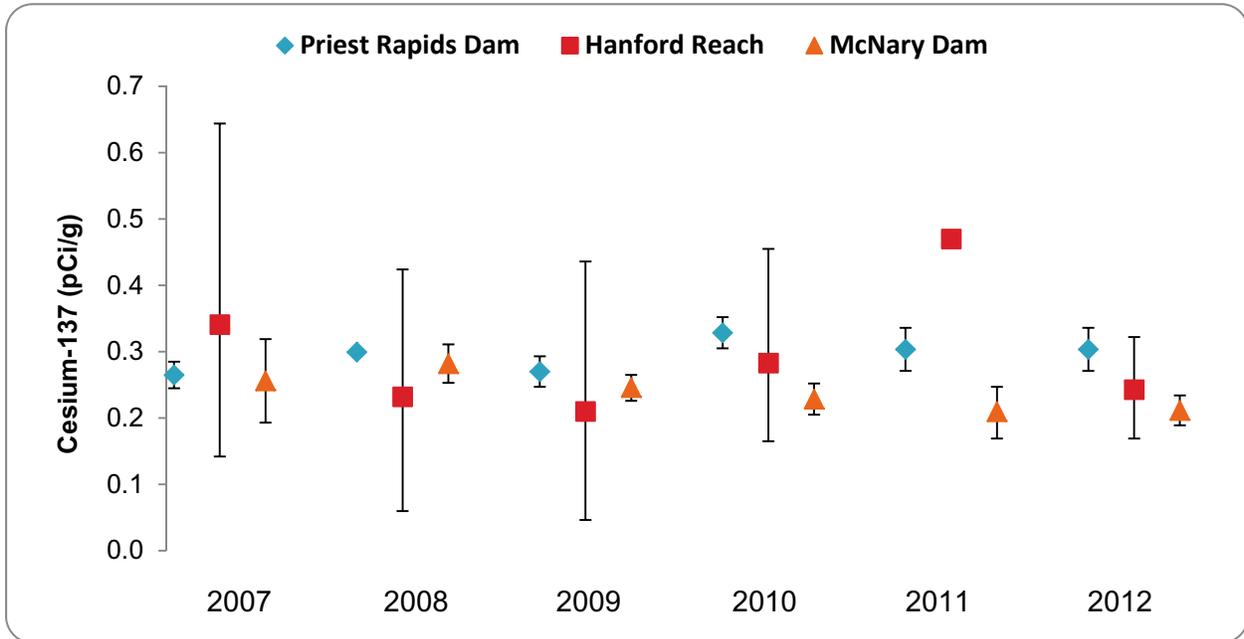


Figure 7.13. Plutonium 239/240 Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment

(Upper and lower bars represent maximum and minimum values; these values may be similar to the average and may not be visible in the Figure.)

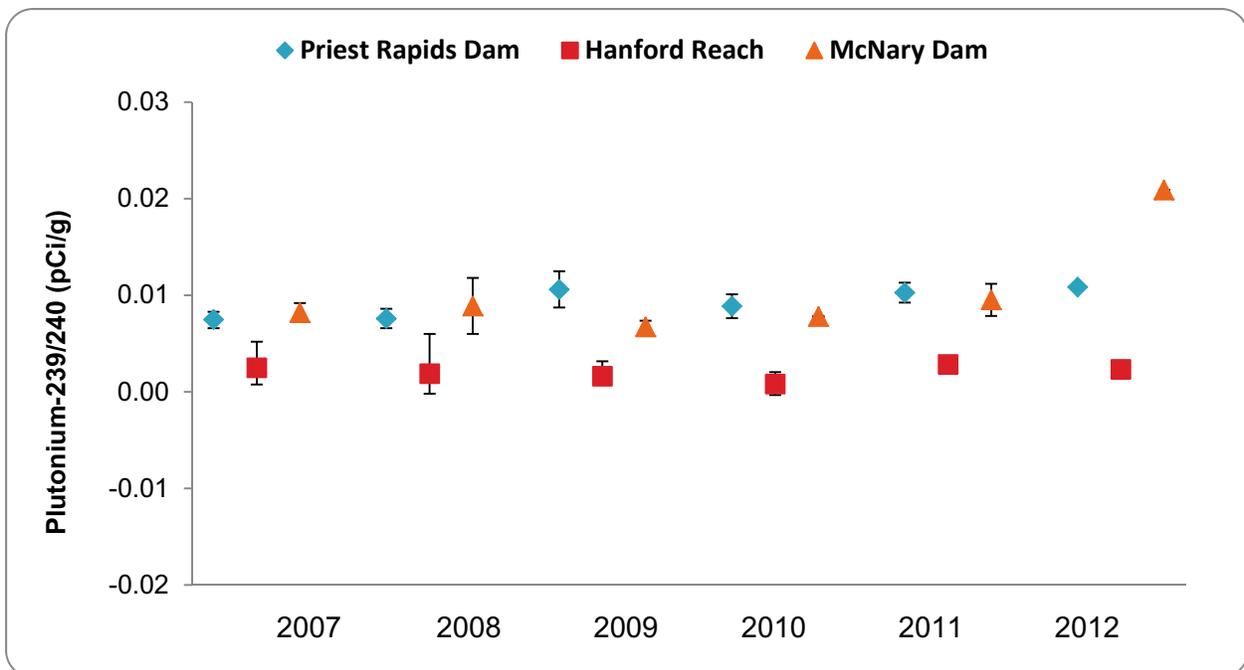


Figure 7.14. Uranium Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment

(Upper and lower bars represent maximum and minimum values; these values may be similar to the average and may not be visible in the Figure.)

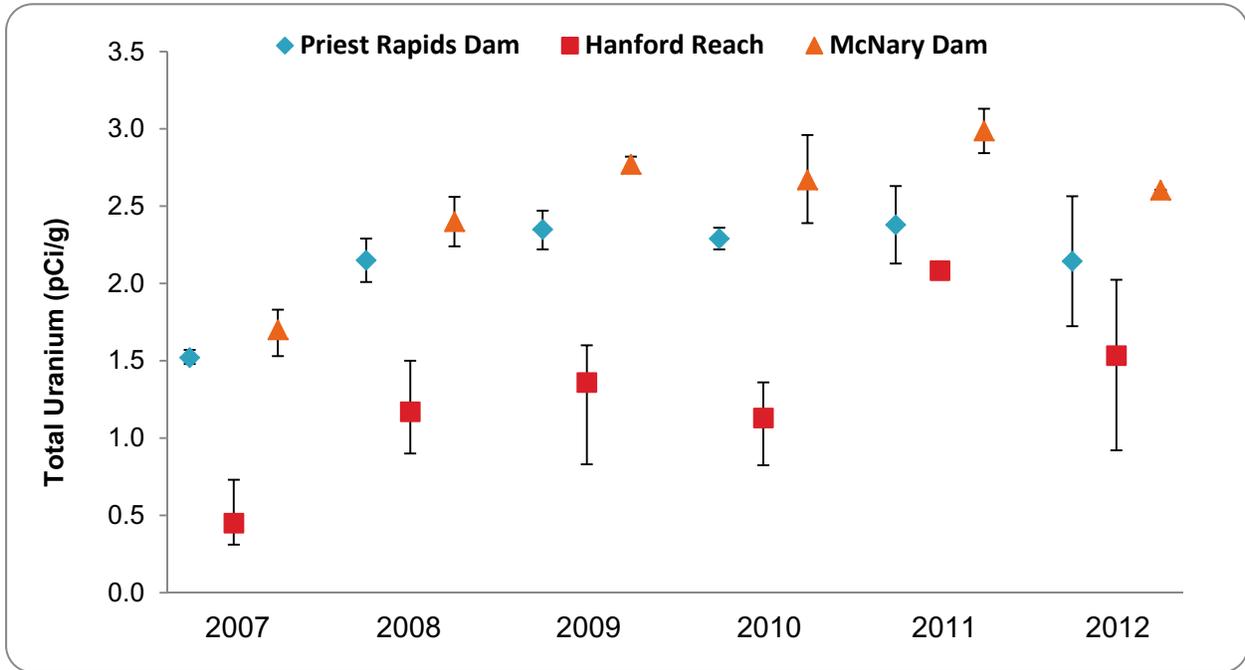
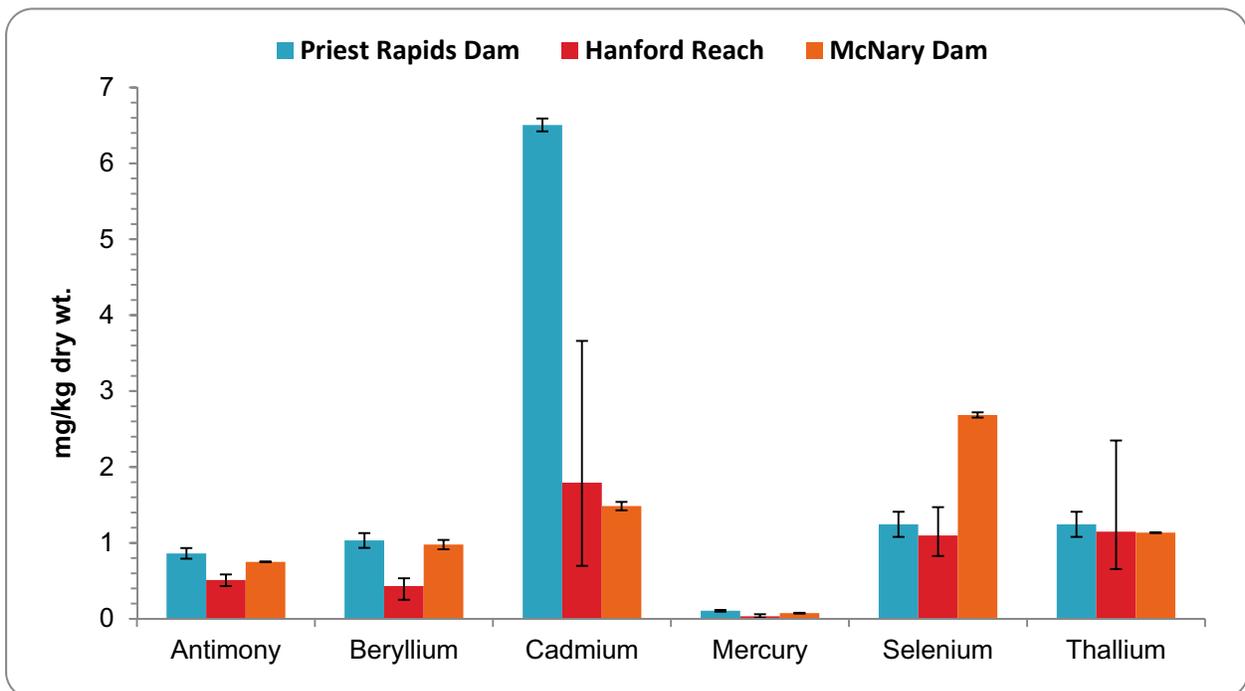
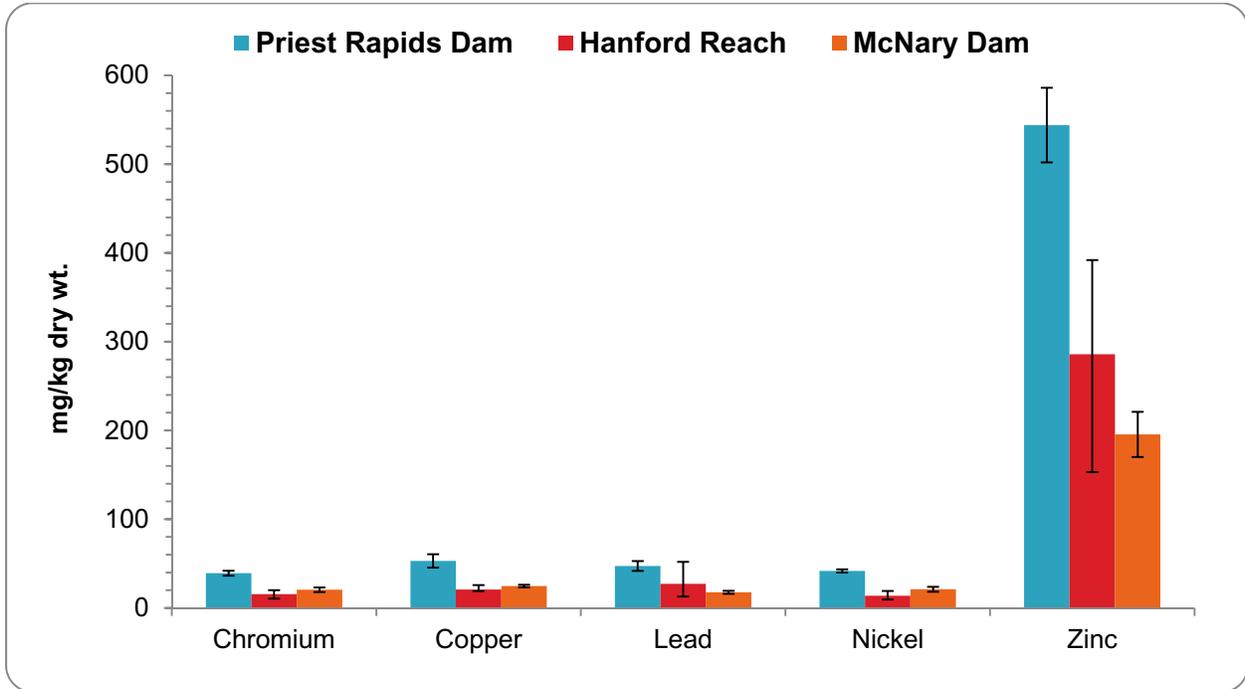


Figure 7.15. Selected Metals Average, Maximum, and Minimum Concentrations Measured in Columbia River Sediment (Washington and Oregon)

(Upper and lower bars represent maximum and minimum values; these values may be similar to the average and may not be visible in the Figure.)



7.4 Columbia River Riverbank Seep Water

ZL Simmons

Samples of Columbia River riverbank seep water and one associated sediment sample were collected along the Hanford Reach (Figure 7.3) and analyzed to determine the potential impact of radiological and chemical contaminants from the Hanford Site on the public and the aquatic environment. Various radiological analyses were performed on selected seeps following reviews of existing surface-water and groundwater data, multiple RI/FS work plans, and preliminary Hanford Site risk assessments ([DOE/RL-92-67](#), [WCH-380](#)). Specific analyses performed on samples collected from each location are listed in Tables 7.6 and 7.7.

7.4.1 Seep Water Monitoring

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](#), *Sampling and Analysis of 100 Area Springs*, Rev. 1; [PNL-5289](#), *Investigation of Groundwater Seepage from the Hanford Shoreline of the Columbia River*; [PNL-7500](#), *1988 Hanford Riverbank Springs Characterization Report*; [WHC-SD-EN-TI-006](#), *Hydrologic and Geologic Data Available for the Region North of Gable Mountain, Hanford Site, Washington*). 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 riverbank seeps. Routine monitoring of riverbank seeps 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 seep water. In addition, contaminants in groundwater near the Columbia River are monitored using shoreline groundwater-sampling tubes (aquifer tubes) (Section 7.5; [BHI-01153](#), *Aquifer Sampling Tube Completion Report: 100 Area and Hanford Townsite Shorelines*; [PNNL 14444](#), *Aquifer Sampling Tube Results for Fiscal Year 2003*; [PNNL-16805](#); [PNNL-16894](#), *Investigation of the Stornium-90 Contaminant Plume along the Shoreline of the Columbia River at the 100-N Area of the Hanford Site*; [SGW-41497](#), *Aquifer Tube Optimization Evaluation*).

Riverbank Seeps were documented along the Hanford Reach long before Hanford Site operations began during World War II ([Jenkins 1922](#), *Underground Water Supply of the Region about White Bluffs and Hanford*). During the early 1980s, researchers walked a 41-mile (66-kilometer) 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 riverbank seeps 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 riverbank seeps also varies with river stage (river-water surface 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 riverbank seeps in the Hanford Reach to vary. At the 300 Area, the river stage also is 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 riverbank seeps 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 seeps. Riverbank seep 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 seep 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 estimate accurately the volume of contaminated groundwater discharging via springs to the Columbia River within the Hanford Reach. Studies of riverbank seeps conducted during 1983 ([PNL-5289](#)); 1988 ([PNL-7500](#)); and 1991 ([DOE/RL-92-12; WHC-EP-0609, Riverbank Seepage of Groundwater Along the 100 Areas Shoreline, Hanford Site](#)); and results of near-shore studies in 1997 ([PNNL-11933, Survey of Radiological Contaminants in the Near-Shore Environment at the Hanford Site 100-N Reactor Area](#)) and 2001 ([PNNL-13692](#)) noted that discharges from the springs had only localized effects on Columbia River contaminant concentrations.

7.4.1.1 Monitoring Results

Routine monitoring of selected riverbank seeps was initiated in 1988. Currently, riverbank seep water samples are collected for contaminant monitoring and to support groundwater operable unit investigations ([DOE/RL-91-50](#)). Tables 7.6 and 7.7 summarize the sampling locations and frequencies, as well as sample types and analyses included in riverbank seeps monitoring during 2012. This section describes the monitoring efforts and summarizes the results for these aquatic environments. Analytes of interest for samples from riverbank seeps 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.

All samples collected during 2012 were analyzed for tritium. Water samples from selected seeps were analyzed for anions, carbon-14, metals, strontium-90, technetium-99, uranium-234, uranium-235, uranium-238, and volatile organic compounds. Only unfiltered samples were analyzed, except for metals analyses, in which case both filtered and unfiltered samples were analyzed (Table 7.6).

Table 7.6. Columbia River Riverbank Seep Water Monitoring

Spring Location ^a	Sample Type	Sampling Frequency	Analyses
100-B Area	Grab	Annually	Tritium, strontium-90, metals (filtered and unfiltered), anions, mercury
100-K Area	Grab	Annually	Carbon-14, tritium, metals (filtered and unfiltered), anions, mercury, volatile organic compounds analyses
100-N Area	Grab	Annually	Alpha, beta, tritium, strontium-90, metals (filtered and unfiltered), anions, mercury
100-D Area	Grab	Annually	Alpha, beta, technetium-99, tritium, isotopic uranium ^b , metals (filtered and unfiltered), anions, mercury
100-H Area	Grab	Annually	Tritium, strontium-90, technetium-99, metals (filtered and unfiltered), anions, mercury
Hanford town site	Grab	Annually	Alpha, beta, tritium, anions
300 Area	Grab	Annually	Alpha, beta, tritium, isotopic uranium ^b , anions, volatile organic compounds analyses

^a Refer to Figure 7.3.

^b Isotopic uranium (uranium-234, uranium-235, and uranium-238).

Table 7.7. Hanford Reach Riverbank Seeps Sediment Monitoring

Spring Location ^a	Sampling Frequency	Analyses
100-D Area	Annually	Gamma energy analysis, strontium-90, isotopic uranium ^b , isotopic plutonium ^c , hexavalent chromium anions, metals, mercury, and total organic carbon

^a Refer to Figure 7.8.

^b Isotopic uranium (uranium-234, uranium-235, and uranium-238).

^c Isotopic plutonium (plutonium-235, and plutonium-238/239).

7.4.1.2 Radiological Results

Contaminants of Hanford Site origin continued to be detected in 2012 in water from riverbank seeps entering the Columbia River along the Hanford Site. Gross alpha, gross beta, carbon-14, strontium-90, tritium, and total uranium (uranium-234, uranium-235, and uranium-238) were detected in seep water samples. All radiological contaminant concentrations measured in riverbank seeps were less than applicable DOE-derived concentration guides, but exceeded the Washington State ambient water quality criteria for gross alpha, and for tritium at some locations ([DOE O 458.1](#), Admin Chg. 3).

Gross beta concentrations in riverbank seep water at locations in the 100 Areas were elevated compared to gross beta concentrations in Columbia River water at Priest Rapids Dam, but were below the Washington State ambient water quality criterion. The highest gross beta concentration measured in riverbank seeps was near the Hanford town site (20 ± 3.9 pCi/L [0.74 ± 0.14 Bq/L]), which was 40 percent of the Washington State ambient surface water quality criterion of 50 pCi/L (1.85 Bq/L) ([WAC 173-201A](#); [40 CFR 141](#)).

Tritium concentrations varied widely with location. The highest tritium concentration measured in riverbank seeps was near the Hanford town site ($32,600 \pm 6,340$ pCi/L [$1,207 \pm 235$ Bq/L]), which exceeded the Washington State ambient surface water quality criterion of 20,000 pCi/L (740 Bq/L) ([WAC 173-201A](#); [40 CFR 141](#)). Tritium concentrations in most riverbank seep water samples were elevated compared to the 2012 Columbia River water concentrations at Priest Rapids Dam.

All water samples from riverbank seeps were analyzed for strontium-90. The highest strontium-90 concentration detected in shoreline spring water was at the 100-N Area (4.6 ± 0.75 pCi/L [0.17 ± 0.028 Bq/L]), which was approximately 50 percent 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.

Water samples from riverbank seeps 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 a practical alternative for this ultra-trace measurement capability is not available. The highest concentrations were measured in water samples from the Hanford town site seeps in 2005, with all values below the Washington State surface water quality criterion of 1 pCi/L (0.037 Bq/L) (Appendix D). Riverbank seep water samples were analyzed for iodine-129 in 2007 to 2010 with traditional gamma spectrometry, which has a higher detection limit than the ultra-trace method. All samples analyzed for iodine-129 in 2007 to 2010 were below the detection limit of 1 pCi/L (0.037 Bq/L).

Uranium isotopes were monitored in riverbank seep water samples from the 100-D Area and the 300 Area. The highest concentrations of uranium were found in the 300 Area seep water collected at 300 Area Spring DR 42-2 downgradient from the retired 300 Area Process Trenches. The total uranium concentration in this seep exceeded the EPA DWS of 30 µg/L (approximately 20 pCi/L [0.74 Bq/L]). Maximum and average concentrations of uranium-234, uranium-235, and uranium-238 were lower in 2012 than they were during 2007-2010. Lower concentrations of uranium isotopes at Spring DR 42-2 in 2012 may be attributed to changes in riverbank storage. Spring DR 42-2 in the 300 Area had an elevated gross alpha concentration

(42 ± 7.8 pCi/L [1.6 ± 0.29 Bq/L]), which exceeded the Washington State ambient surface water quality criterion of 15 pCi/L (0.56 Bq/L). 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 seep water from 2007 through 2012 parallel uranium concentrations and are likely associated with the presence of the uranium.

7.4.1.3 Chemical Results

Chemical contaminants originating from the Hanford Site continued to be detected in water from riverbank seeps entering the Columbia River. Metals and anions of interest (chloride, nitrate, and sulfate) were detected in seep 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 38-3 in the 100-B 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](#), *Limited Field Investigation Report for Uranium Contamination in the 300-FF-5 Operable Unit at the 300 Area, Hanford Site, Washington*), were not observed in the riverbank seeps.

Table 7.8 presents concentration ranges of selected chemicals measured in riverbank seep water during 2007 through 2012. For most locations, the 2012 chemical sample results were similar to those previously reported ([PNNL-14687](#), *Hanford Site Environmental Report for Calendar Year 2003*). Nitrate concentrations for 2007 through 2012 were highest in seep water samples from the 100-F Area. Dissolved chromium concentrations in riverbank seeps for 2006 through 2012 were highest in the 100-K Area. Hanford Site groundwater monitoring results for 2012 indicated similar contaminant concentrations at shoreline areas near the discharge locations for the springs (Section 8.0, Groundwater Monitoring).

The Washington State ambient surface water quality criteria for copper, lead, nickel, and zinc are total-hardness dependent ([WAC 173-201A](#); Appendix D). For comparison purposes, the minimum value of 47-mg/L calcium carbonate for 1992 through 2000 water samples collected near the Vernita Bridge by the U.S. Geological Survey were used. Concentrations of most metals measured in water collected from seeps along the Hanford Site shoreline during 2007 through 2012, were below the Washington State ambient surface water chronic toxicity levels ([WAC 173-201A](#)). However, for 2007 through 2012, the maximum concentrations of dissolved chromium in riverbank seep water from the 100-K, 100-D, 100-H and 100-F Areas were above the Washington State ambient surface water chronic and acute toxicity levels ([WAC 173-201A](#)); concentrations from the 100-B Area was only above the Washington State ambient surface water chronic toxicity levels. All dissolved chromium results for 2012 were below the Washington State ambient surface water chronic toxicity levels. Arsenic concentrations in riverbank seep 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](#)). Nitrate concentrations at all riverbank seep locations were below the EPA DWS of 45 mg/L.

7.4.2 Sediment Monitoring

Beginning in the 1990s, periodic studies were conducted to collect and analyze sediment from riverbank seeps in the 100 Areas and the 300 Area ([DOE/RL-92-12](#); [WHC-EP-0609](#); [WHC-SD-EN-TI-125](#), *Sampling and Analysis of the 300-FF-5 Operable Unit Springs and Near Shore Sediments and River Water*; [WHC SD-EN-TI-198](#), *100 Area Columbia River Sediment Sampling*). Routine sampling of sediment from riverbank seeps began during 1993 at the Hanford town site and the 300 Area. Sampling of riverbank seeps sediment in the 100-B, 100-K, and 100-F Areas began during 1995 and in 2004 in the 100-H Area. One sediment sample was collected in 2012 from a riverbank seep in the 100-D Area (100-D Spring 102-1).

Table 7.8. Columbia River Riverbank Seeps Concentration Ranges for Selected Chemicals in Water Monitoring Samples, Hanford Site

2007 – 2012 Analyte	Ambient-Water Quality Criterion Level ^a	Sample Location							
		100-B Area	100-D Area	100-F Area	100-H Area	100-K Area	100-N Area	Hanford town site	300 Area
Dissolved Metals (µg/L)									
Antimony	NA	0.118 – 0.23	0.136 – 2.32	0.0988 – 0.128	0.165 – 0.243	0.0938 – 0.238	0.157 – 0.201	0.152 – 0.341	0.139 – 0.447
Arsenic	190	0.424 – 1.24	0.486 – 7.44	0.378 – 2.11	0.342 – 3.15	0.385 – 7.11	1.92 – 26.9	1.89 – 4.01	0.871 – 6.27
Cadmium	0.59	0.00396 – 0.109	0.0105 – 0.0535	0.0074 – 0.0275	0.00201 – 0.0375	0.00827 – 0.0254	0.009 – 0.0246	0.00726 – 0.0248	0.0137 – 0.0376
Chromium	10 ^b	2.23 – 14.9	1.51 – 35.4	0.826 – 15.5	3.2 – 37.2	0.787 – 71.9	4.89 – 8.26	0.524 – 2.55	1.27 – 3.3
Copper	6	0.203 – 1.57	0.344 – 1.07	0.23 – 0.583	0.396 – 0.887	0.247 – 0.73	0.178 – 1.61	0.244 – 0.701	0.309 – 0.678
Lead	1.1	0.154 – 1.41	0.00869 – 0.447	0.0508 – 0.224	0.118 – 1.02	0.118 – 0.386	0.0896 – 0.269	0.00598 – 0.217	0.0271 – 0.376
Nickel	83	0.342 – 2.1	0.295 – 4.36	0.118 – 2.61	0.0989 – 2.66	0.124 – 2.61	0.318 – 2.01	0.255 – 0.915	0.169 – 3.03
Thallium	NA	0.00283 – 0.024	0.00983 – 0.0305	0.00626 – 0.00985	0.00419 – 0.0121	0.00379 – 0.0158	0.00276 – 0.00699	0.00316 – 0.0157	0.00613 – 0.0185
Zinc	55	0.433 – 16.7	1.46 – 5.33	1.02 – 2.47	0.68 – 4.82	1.09 – 3.65	1.16 – 54.9	0.734 – 2.71	1.3 – 4.14
Number of Samples		9	9	4	10	8	6	12	12
Total Recoverable Metals (µg/L)									
Chromium	96 ^c	2.22 – 253	1.53 – 272	2.28 – 58.8	3.22 – 57.6	1.01 – 74.1	2.16 – 9.9	1.02 – 6.83	2.06 – 9.14
Mercury	0.012	0.00022 – 0.113	0.000748 – 0.296	0.00155 – 0.0601	0.000524 – 0.064	0.000436 – 0.0499	0.000766 – 0.00528	0.000571 – 0.0093	0.000535 – 0.0119
Selenium	5	0.305 – 1.26	0.208 – 2.04	0.155 – 1.96	0.339 – 1.31	0.795 – 2.14	0.754 – 0.918	0.383 – 1.72	2.09 – 3.91
Number of Samples		11	9	4	10	8	8	12	12
Anions (mg/L)									
Nitrate	45 ^d	1.64 – 8.85	0.73 – 15.1	23.9 – 46.0	2.47 – 20.8	0.775 – 31.4	1.81 – 18.6	4.83 – 23.0	13.5 – 27.4
Number of Samples		10	9	3	8	8	6	10	16

^a Ambient water quality criteria values ([WAC 173-201A-240](#)) for chronic toxicity unless otherwise noted.

^b Value for hexavalent chromium.

^c Value for trivalent chromium.

^d DWS ([WAC 246-290](#)).

NA = Not available.

7.4.2.1 Radiological Results

Results for 2012 shoreline seep sediment samples were similar to those observed in Columbia River Sediment. Potassium-40, cesium-137, and uranium isotopes were the only radionuclides reported above the minimum detectable concentrations. Appendix C, Table C.9 compares radionuclide and total organic carbon concentrations in Columbia River sediment near Hanford Site collected during 2007 through 2012.

7.4.2.2 Chemical Results

Concentrations of metals in shoreline seep sediment samples collected in 2012 were similar to concentrations in Columbia River sediment samples. Appendix C, Table C.10 compares metal concentrations in sediment samples collected in 2012. Currently, there are no Washington State freshwater sediment quality criteria to compare with the measured values.

7.5 Pond Water and Sediment

ZL Simmons

Two onsite ponds, FFTF Pond and the West Lake Pond (Figure 7.3), located near facilities in various stages of remediation, were sampled periodically during 2012. The ponds are accessible to migratory waterfowl, deer, and other wildlife, creating a potential biological pathway for the dispersion of contaminants. The FFTF 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](#), *Geohydrologic Study of the West Lake Basin*). West Lake has not received direct effluent discharges from Hanford Site facilities, but it is influenced by precipitation and changing water table elevations that are related to the discharge of water to the ground in the 200 Areas. The water level in West Lake fluctuates, and the lake changes from standing water in winter and spring to dry or nearly dry in summer and fall. 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.

7.5.1 Fast Flux Test Facility Pond Water

Grab samples were collected quarterly in 2012 from the FFTF Pond water. All water samples collected from the FFTF Pond were analyzed for gross alpha, gross beta, and gamma-emitting radionuclides. Water samples collected from the FFTF Pond during the third quarter of 2012 were analyzed for uranium-234, uranium-235, and uranium-238. Volatile organic compounds analysis was conducted on water samples collected from the FFTF Pond during the fourth quarter of 2012.

Figure 7.16 shows the annual average gross beta and tritium concentrations in FFTF Pond water from 2007 through 2012. Average gross beta levels increased slightly during 2012 as compared to 2011. Tritium concentrations in FFTF Pond water were slightly lower in 2012 than they were in 2011. 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. Radionuclide concentrations in FFTF Pond water samples collected during 2012 and in the previous 5-years are shown in Appendix C, Table C.1.

7.5.2 West Lake Water

Water monitoring continued at West Lake in 2012 with biannual sampling conducted during the first and second quarters. The groundwater table in the 200-East Area has dropped in recent years (Section 8, Groundwater Monitoring), decreasing the size of West Lake, and causing the suspended sediment loading to increase. West Lake water samples collected from 2002 through 2010 were not analyzed for gross alpha, gross beta, strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238 because of the high sediment load. A special study conducted in 2000 ([PNNL-13487](#), *Summary of the Hanford Site Environmental Report for Calendar Year 2000*) indicated that uranium is present in a soluble form in West Lake water. As a result, analysis of West Lake water samples for uranium-234, uranium-235, and uranium-238 was resumed in 2011.

During the first quarter of 2012, a grab sample of standing lake water was collected for analysis of uranium-233, uranium-234, uranium-235, and uranium-238. The uranium-234 and uranium-238 concentrations were above applicable DOE-derived concentration guides ([DOE O 458.1](#), Admin Chg. 3).

A grab sample of seep water was collected for analysis during the second quarter of 2012 when the lake was nearly dry. The seep water collected within the footprint of West Lake was analyzed for tritium, uranium-234, uranium-235, and uranium-238. Tritium concentrations in seep water collected from West Lake in 2012 was below the laboratory-reported detection limit. Figure 7.17 shows the annual average concentrations of uranium-234 and uranium-238 in West Lake Pond water from 1998 through 2012.

Radionuclide concentrations in the West Lake Pond water samples collected during 2012 and in the previous 5-years are shown in Appendix C, Table C.3.

7.5.3 West Lake Sediment

One sediment sample was collected from West Lake during the first quarter of 2012. The West Lake sediment sample was analyzed for gross alpha, gross beta, strontium-90, technetium-99, uranium-234, uranium-235, uranium-238, and gamma-emitting radionuclides. 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. The sediment sample was collected from upper-layer material near the pond shoreline and was collected with a hand-scoop.

Radionuclide levels in West Lake surface sediments are similar to previous measurements reported. Uranium concentrations are most likely from naturally occurring uranium in the surrounding soil ([BNWL-1979](#), *Environmental Surveillance at Hanford for CY-1975*). Radionuclide levels from samples collected during 2012 and a summary of those collected during the previous 5-years are shown in Appendix C, Table C.2.

Figure 7.16. Gross Beta and Tritium in Pond Water Samples from the Fast Flux Test Facility Pond

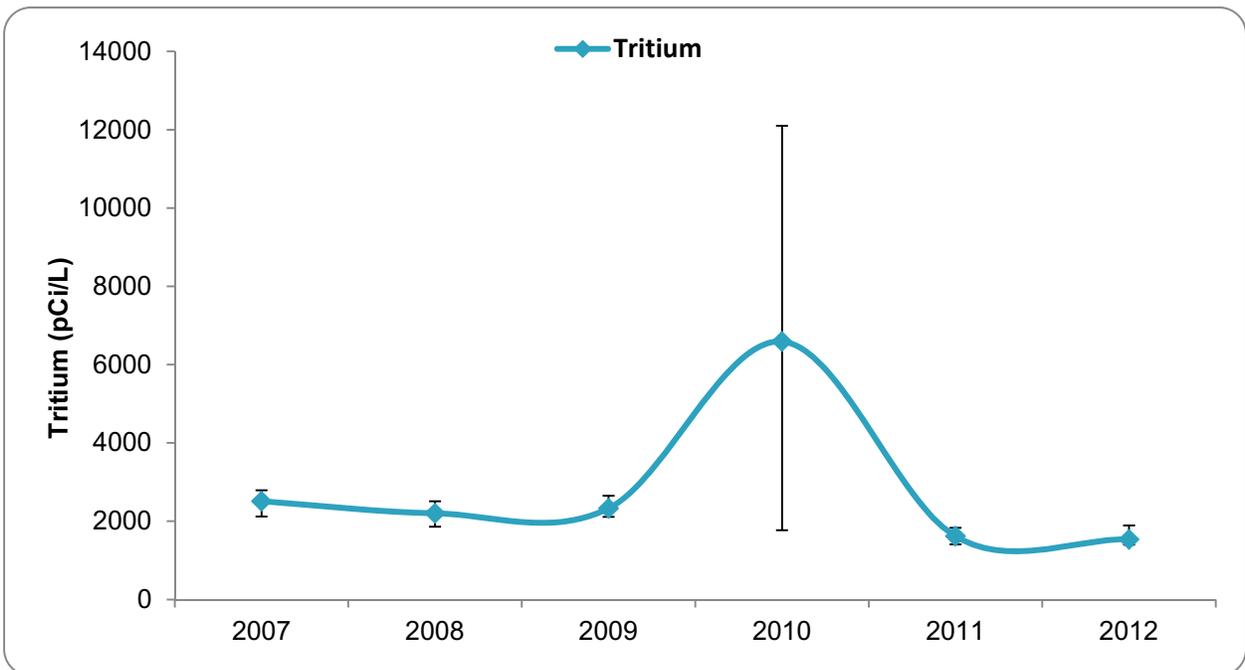
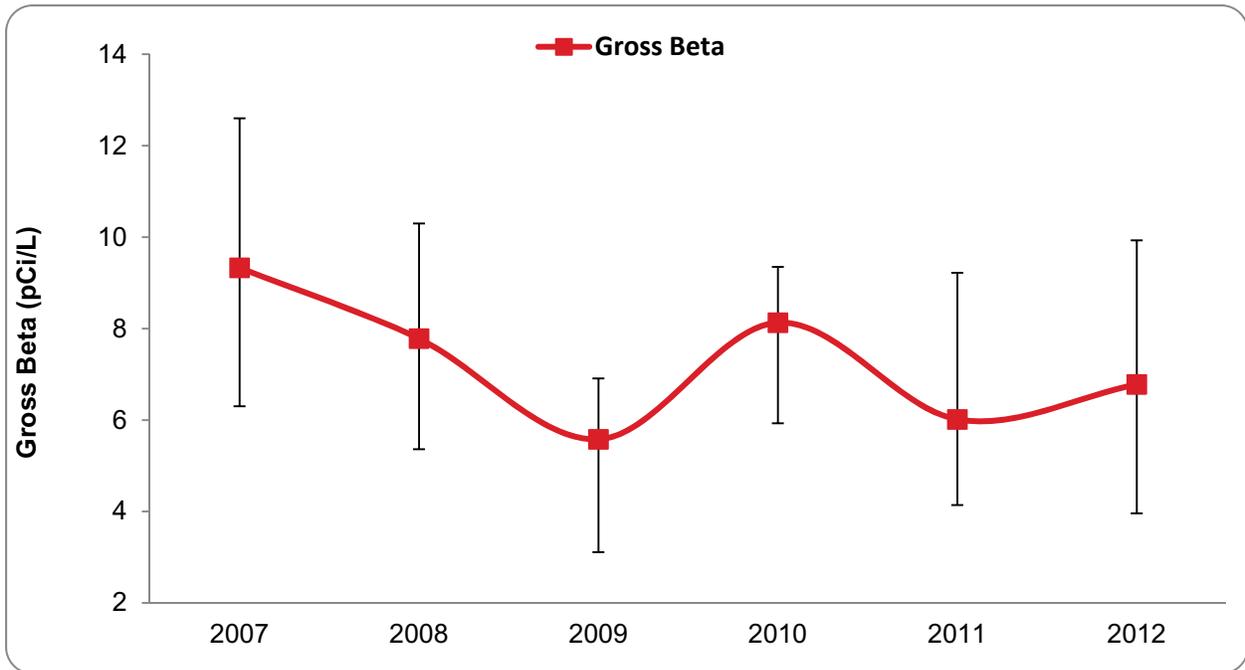
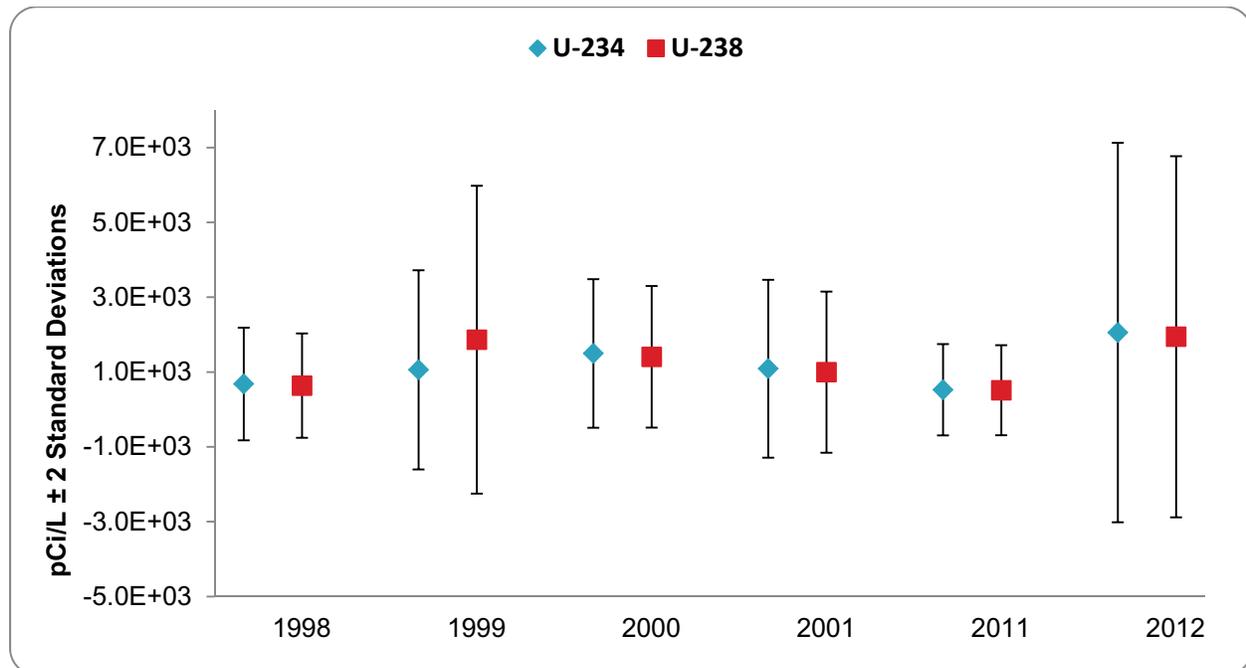


Figure 7.17. Uranium in West Lake Water Samples



7.6 Offsite Irrigation Water

M. Hoefler

As a result of public concern about the potential for Hanford Site-associated contaminants in offsite water, sampling was conducted in 2012 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 4.2.1).

Offsite Irrigation Water Monitoring. Water samples were collected in 2012 from an irrigation canal located east of the Columbia River and from a location downstream of the Hanford Site at Riverview. Samples of the water supply from the Horn Rapids irrigation pumping station (Figure 7.3) were collected from the irrigation valve at the Battelle sporting complex. Each location was sampled three times during the 2012 irrigation season. Unfiltered samples were analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, uranium-234, uranium-235, and uranium-238.

Sample Results. Most radionuclide concentrations measured in irrigation water in 2012 were at similar 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. Beta results from the Riverview area were slightly higher than levels detected in the Columbia River while strontium-90 results had a similar juxtaposition between irrigation and upstream water samples. All radionuclide concentrations were within the historical range and were less than their respective DOE-derived concentration guides and Washington State ambient surface-water quality criteria ([DOE O 458.1](#), Admin Chg. 3; [WAC 173-201A](#); [40 CFR 141](#)).

7.7 Liquid Effluent

DJ Rokkan

Liquid effluents were discharged to ground disposal units from a few facilities in 2012 at the Hanford Site. Only one of those waste streams is permitted for radioactive constituents; however, all are sampled and analyzed for select radioactive parameters and nonradioactive hazardous materials.

Contaminant data from liquid effluent sampling and analyses has been reported to DOE annually in the annual Environmental Releases report (i.e., [HNF-EP-0527-21](#)). The report includes summaries of monitoring results on liquid effluents discharged to the soil, regulated by [WAC 173-216](#), and reported to Ecology.

7.7.1 Radionuclide Results

The only active discharge point for radioactive liquid effluent to the ground in 2012 is the 616-A Crib, also known as the State-Approved Land Disposal Site. Table 7.9 summarizes the analysis results on this effluent discharge point for 2012.

Table 7.9. Radionuclides in the 200 Area Liquid Effluent Discharged to the State Approved Land Disposal Site

Radionuclide	Half-Life	Release, Ci ^a
Tritium	12.35 years	3.5

^a 1 Ci = 3.7×10^{10} Bq.

7.7.2 Nonradioactive Hazardous Materials Results

Nonradioactive hazardous materials in several liquid effluent streams discharge to ground disposal units in the 100, 200, and 400 Areas. These discharges are authorized by six State-approved discharge permits ([WAC 173-216](#)), which stipulate monitoring requirements. The effluents are monitored for select materials. The EPA is notified immediately if chemicals in the liquid effluents exceed reportable quantities under CERCLA. If chemicals in effluents remain stable at predicted levels, these levels may be reported annually if EPA has approved this practice. Section 2.4.1 provides a brief synopsis of the state waste discharge permits.

8.0 Groundwater Monitoring

MJ Hartman

The Hanford Site, part of the DOE's nuclear weapons complex, encompasses approximately 600 square miles (1,500 square kilometers) northwest of the city of Richland along the Columbia River in southeastern Washington State (see Section 1, Figure 1.1); the Hanford Site Map is shown in Figure 8.1. In 1943, as part of the top-secret Manhattan Project, the federal government took possession of the Site to build the world's first large-scale plutonium production reactor, the B Reactor. This reactor was used to make the plutonium for the Trinity Test and the bomb that was dropped on Nagasaki, Japan in 1945. During the Cold War period (1945 to 1991), the government built nine reactors along the Columbia River for the production of weapons-grade plutonium.

During reactor operations, chemical and radioactive waste was released into the environment and contaminated the soil and groundwater beneath portions of the Hanford Site. Groundwater flows to the Columbia River and is the primary exposure route for contaminants to reach human, environmental, and ecological receptors (Figure 8.2).

Since the 1990s, DOE has worked to characterize, remove, treat, and dispose of contamination from past operations. DOE developed a plan to address groundwater and vadose (unsaturated) zone contamination in consultation with EPA and Ecology. Key elements associated with managing the Hanford Site's groundwater and vadose zone contamination are to: 1) Protect the Columbia River and groundwater; 2) develop a cleanup decision process; and 3) achieve final cleanup.

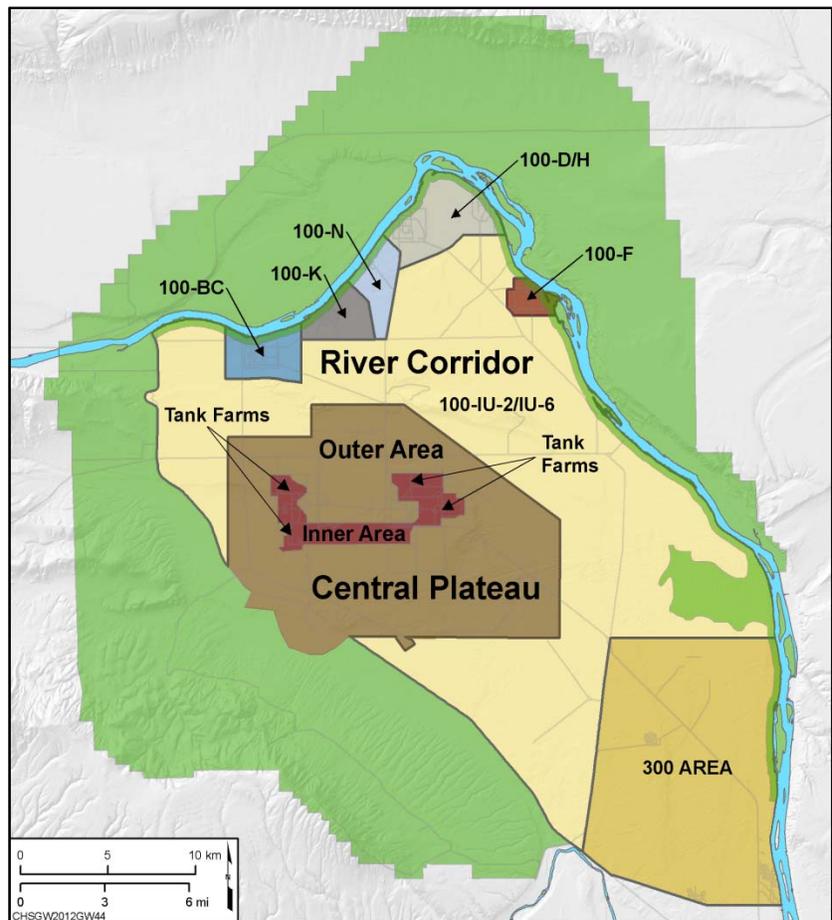
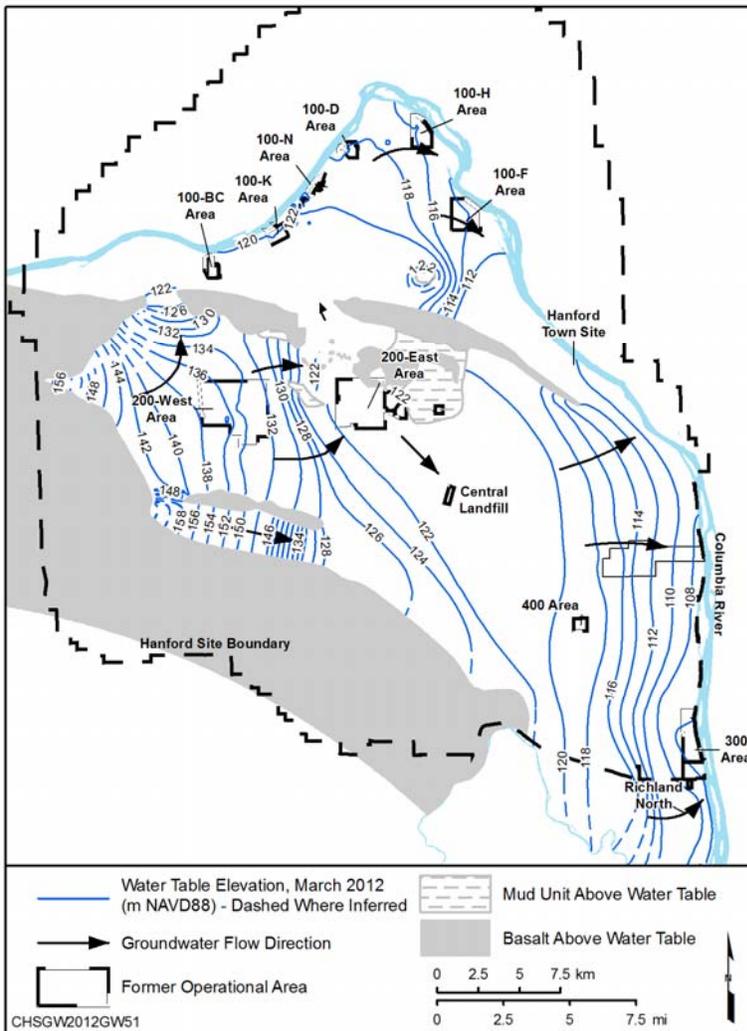


Figure 8.1. Hanford Site Map

The Hanford Site is located in southeastern Washington State on the shore of the Columbia River. The River Corridor includes the 100 Area, where nine nuclear reactors formerly operated, and the 300 Area, where nuclear fuel assemblies were made. The Central Plateau includes the 200 Area, where chemical processing of nuclear fuel occurred.

Figure 8.2. Water Table Map

Groundwater flows from areas where the water table is high to where it is lower, and eventually discharges to the Columbia River.



This chapter summarizes the results of Hanford Site groundwater monitoring for 2012. An online groundwater monitoring report for 2012 ([DOE/RL-2013-22](#)) includes additional detail and describes monitoring results for RCRA TSD units, CERCLA groundwater operable units, and the requirements of the [AEA](#). The groundwater data summarized in this chapter—and information on well locations, construction, and screened intervals—can be found through the DOE’s Environmental Dashboard Application at <http://environet.hanford.gov/EDA/>. RCRA regulates the management of solid waste, hazardous waste, and certain underground storage tanks. It applies to active or recently active TSD units. Monitoring is required at some units to determine if they are affecting groundwater quality in the uppermost aquifer. The uppermost aquifer is the unconfined aquifer beneath most of the Hanford Site. Groundwater monitoring requirements for the Site’s RCRA units fall into one of two broad categories: interim status or final status. A permitted RCRA unit requires final status monitoring, as specified in [WAC 173-303](#). The RCRA units not currently incorporated into a permit require interim status monitoring.

RCRA groundwater monitoring is conducted under one of three possible phases: 1) Contaminant indicator evaluation (or detection) monitoring; 2) groundwater quality assessment (or compliance) monitoring; or 3) corrective action monitoring. In the interim-status contaminant indicator evaluation monitoring, four indicator parameters (pH, specific conductivity, total organic carbon, and total organic halides) are monitored and evaluated against statistically derived threshold values calculated from upgradient wells. In final status detection monitoring, site-specific indicators are evaluated using statistical methods identified in the respective permit. Groundwater quality assessment (interim status) or compliance (final status) monitoring occurs when a facility appears to have impacted groundwater quality. The objective of the monitoring program shifts from detection to assessing the nature and extent of the problem. Under corrective action monitoring, Ecology has stipulated some form of groundwater remediation. The goal of a corrective action groundwater monitoring program is to determine if the corrective action is effective.

CERCLA is the federal government’s program to clean up the nation’s uncontrolled hazardous and radioactive waste sites. Cleanup decisions are based on the results of environmental investigations that include the vadose zone and groundwater. CERCLA groundwater monitoring on the Hanford Site includes monitoring of

contaminants and water levels, and monitoring the effectiveness of groundwater remedial actions, such as pump-and-treat systems.

DOE orders implement requirements of the [AEA](#) at DOE sites. These requirements include groundwater monitoring to detect, characterize, and respond to releases of radionuclides. This [AEA](#) monitoring is integrated with CERCLA and RCRA monitoring on the Hanford Site.

DOE operates an extensive groundwater monitoring program on the Hanford Site, collecting thousands of samples from hundreds of wells each year (Figure 8.3). Figure 8.4 compares maximum concentrations of the major groundwater contaminants in various parts of the Hanford Site in 2012. These contaminants are discussed further in the sections that follow.

Figure 8.3. Well Trips in 2012

DOE sampled 923 wells and 347 shoreline aquifer tubes in 2012. Many of the wells and tubes were sampled multiple times, for a total of 4,205 sampling events.

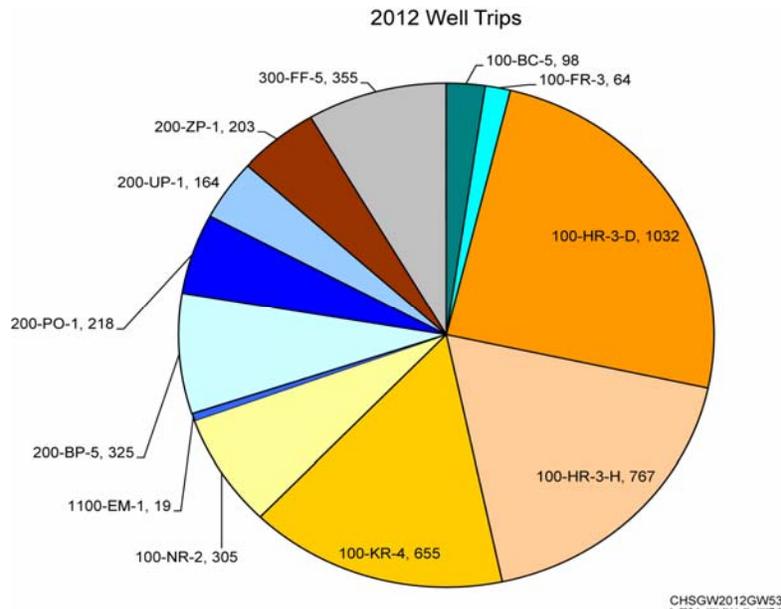
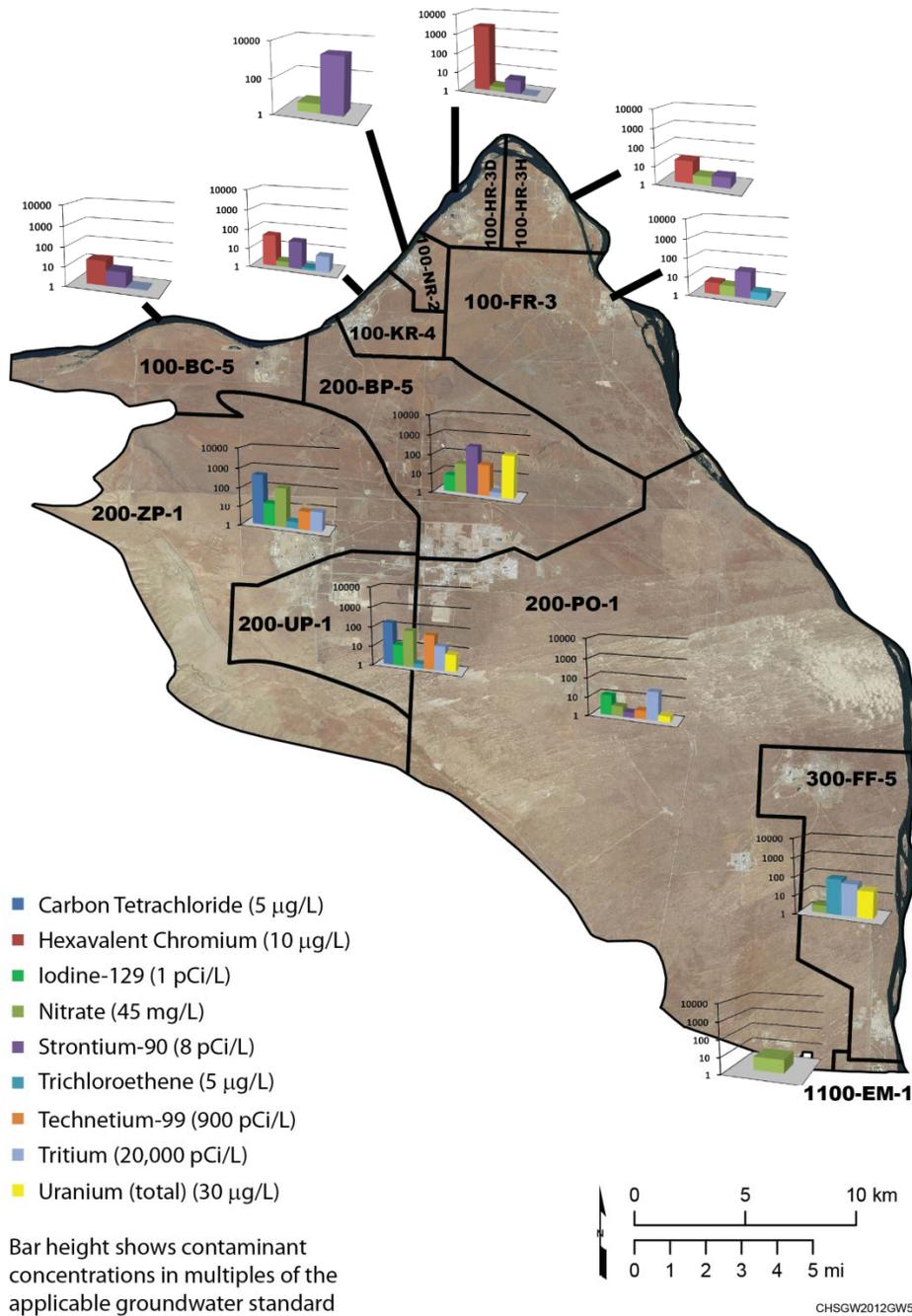


Figure 8.4. Maximum Concentrations of Groundwater Contaminants in Groundwater Interest Areas

This map shows the maximum concentrations of groundwater contaminants in each groundwater interest area in 2012. The heights of the bars represent multiples of the applicable water quality standards. For example, if the maximum strontium-90 concentration was 80 pCi/L, the bar is 10 units high because the DWS is 8 pCi/L.



8.1 River Corridor

The Columbia River flows through the northern portion of the Hanford Site before turning south toward the city of Richland. The region of the site along the shoreline is known as the River Corridor and includes the 100 and 300 Areas. Hanford Site groundwater flows toward the Columbia River, so groundwater is the primary exposure route for Hanford Site contaminants to reach human and environmental receptors (see Figure 8.2). Daily, monthly, and seasonal changes in river stage, controlled by operation of Priest Rapids Dam, affect the flow of nearby groundwater. During periods of high river stage, the river temporarily recharges the adjacent aquifer, whereas during periods of low or moderate river stage, groundwater discharges from the aquifer to the river. River stage changes cause a mixing zone to occur in the aquifer near the shore.

Table 8.1 summarizes information about the River Corridor. In the 100 Area, groundwater contamination is related to past disposal of waste associated with water-cooled nuclear reactors and the primary groundwater contaminants are hexavalent chromium, strontium-90, nitrate, and tritium (Figure 8.5). Other contaminants of concern in the 100 Area include carbon-14, total petroleum hydrocarbons, and trichloroethene. The primary sources of hexavalent chromium contamination were the routine disposal of reactor cooling water, which contained the corrosion inhibitor sodium dichromate, and unplanned spills and leaks of the high-concentration sodium dichromate stock solution. Uranium is the primary groundwater contaminant in the 300 Area, and tritium forms a small, high-concentration plume in an outlying region of the 300-FF-5 Groundwater Operable Unit.

By the end of 2012, more than 74 percent of the waste sites near the river had been remediated or classified as not requiring remediation under interim RODs. Cleanup of the remaining sites is underway. Removal of contaminated soil reduces the potential for future groundwater contamination. Groundwater remediation systems in the 100 Area are limiting the amount of contamination reaching the Columbia River and reducing the mass of contaminants in the groundwater.

DOE released a series of draft Remedial Investigation/Feasibility Study (RI/FS) Reports and Proposed Plans for portions of the River Corridor in 2012. These documents present the results of extensive field studies and related evaluations, and make recommendations for completing remediation of former waste sites and groundwater.

Interim cleanup of the River Corridor has achieved a great deal, but final decisions are yet to be made. CERCLA provides a process for making cleanup decisions. This process is known as RI/FS, and the decision will be published in a ROD. DOE submitted documents for 100-K and 300-FF-5 to regulatory agencies for review in 2011 and for 100-D/H areas and 100-F/IU areas in 2012.

8.1.1 100-BC-5 Operable Unit

Groundwater contamination in the 100-BC-5 Operable Unit is related to disposal of solid and liquid waste associated with the operation of two water-cooled reactors. Contaminants include hexavalent chromium, which forms a large plume at relatively low concentrations (generally less than 50 µg/L). Concentrations appear to be declining very slowly in most wells. However, concentrations increased sharply in 2012 in a well downgradient of a large excavation at a contaminated waste site. The contamination appears to be moving toward the northeast through the uppermost, highly permeable portion of the unconfined aquifer. Concentrations are expected to decline quickly now that waste site remediation is complete.

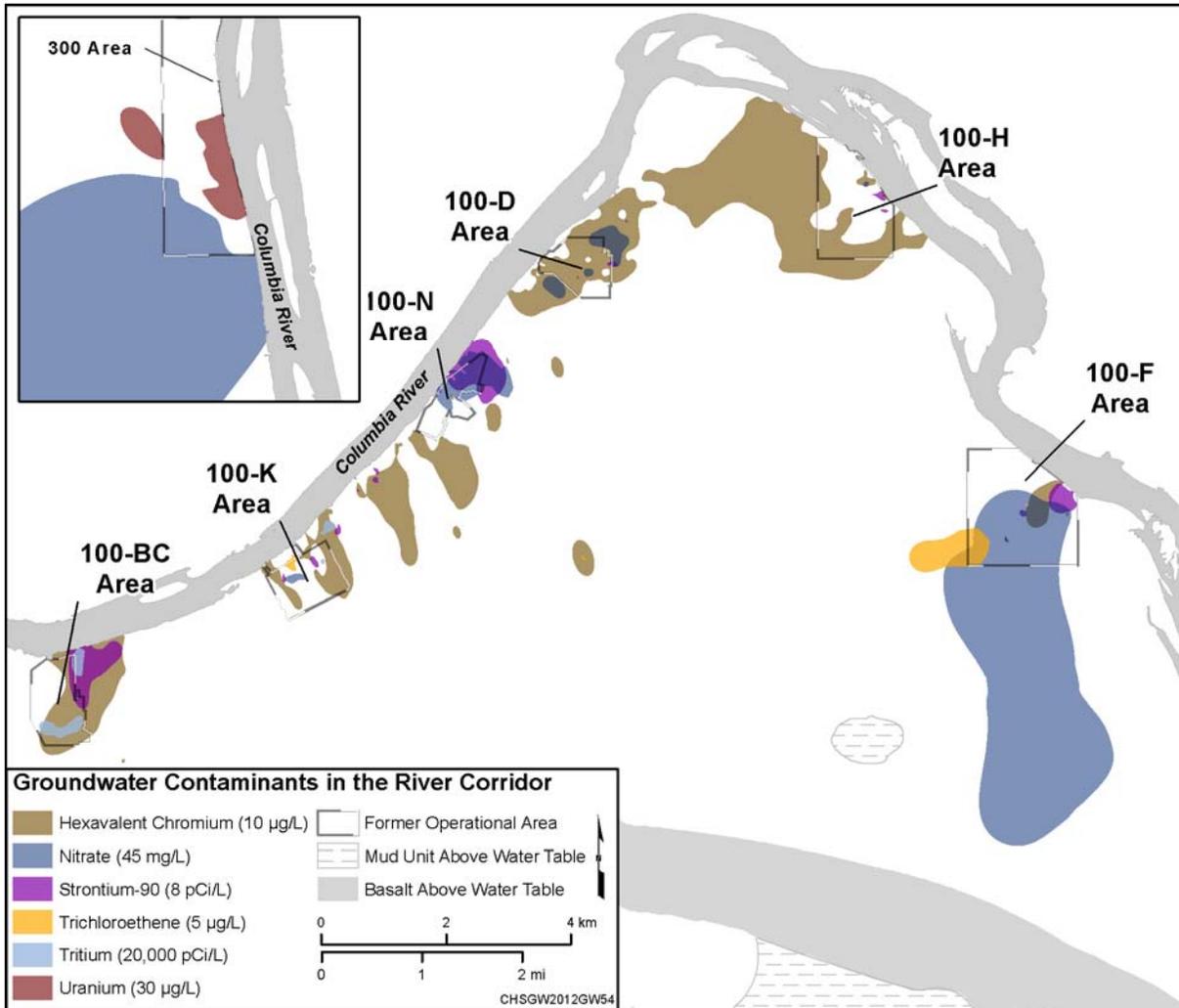
Tritium and strontium-90 concentrations exceed the DWSs in several wells, and are declining overall. Nearly all of the former waste sites have been excavated and backfilled under an interim ROD. No groundwater interim action was required.

Table 8.1. River Corridor Overview

River Corridor Overview									
Area	Primary Operations	Status of Waste Site Remediation under interim ROD ^(a)	Groundwater Contamination: Maximum Concentration and Plume Area						
			Carbon-14	Hexavalent Chromium	Nitrate	Strontium-90	Trichloroethene	Tritium	Uranium
100-BC	Reactor operations -- B Reactor 1944-69; C Reactor 1952-69	92% complete	N	Yellow	Green	Green	<DWS	Green	N
100-K	Reactor operations -- KE Reactor 1955-71; KW Reactor 1955-70	>40% complete	Green	Yellow	Green	Yellow	Green	Green	<DWS
100-N	Reactor operations -- N Reactor 1963-87	>40% complete	<DWS	Yellow	Green	Red	N	Green	N
100-D & 100-H	Reactor operations -- D Reactor 1944-67; DR Reactor 1950-64; H Reactor 1949-65	>70% complete	N	Red	Green	Green	N	<DWS	Green
100-F	Reactor operations -- F Reactor 1945-65; Biological experiments until 1976	98% complete	N	Green	Green	Yellow	Green	<DWS	<DWS
300	Nuclear fuel fabrication and research -- 1940s-1960s	>85% complete	N	N	(b)	<DWS	Yellow	Yellow	Orange
1100	Vehicle maintenance, 1954-85; solid waste landfill --1950s-1970	100% (final ROD)	N	N	(b)	N	<DWS	<DWS	(b)
Standards			2000 pCi/L	10 µg/L	45 mg/L	8 pCi/L	5 µg/L	20,000 pCi/L	30 µg/L
Mobility in subsurface			High	High to Moderate	High	Slight	Moderate	High	Moderate
Legend									
Colors indicate maximum concentration in 2012					Height of bar indicates plume area above standard (km ²)				
N Not detected or not analyzed									
NOTES									
(a) Approximate percentage by number of waste sites classified as closed, interim closed, no action, rejected, or not accepted (end of 2012).									
(b) Nitrate in 300-FF-5, and nitrate and uranium in 1100-EM-1, originates from offsite sources, so plume areas and maximum concentrations are not shown									
ABBREVIATIONS									
DWS Drinking water standard					ROD Record of decision				

Figure 8.5. River Corridor Groundwater Contaminant Plumes

Nitrate and Hexavalent Chromium are the Most Widespread Contaminants in River Corridor Groundwater. Strontium-90 is present in the Reactor Areas and Uranium in the 300 Area.



8.1.2 100-KR-4 Operable Unit

The principal groundwater issues for the 100-KR-4 Operable Unit are cleaning up hexavalent chromium in the groundwater, tracking contaminant plumes, and monitoring groundwater near the former 100-K East and 100-K West Fuel Storage Basins. Remediation of waste sites continued in 2012. Groundwater contaminant plumes are decreasing in size due to remediation and natural processes including dispersion, discharge to the Columbia River, degradation, and radioactive decay.

Hexavalent chromium is the primary contaminant of concern for groundwater (Figure 8.6). Three pump-and-treat systems operate as interim actions to remove hexavalent chromium from the groundwater. Between 1997 and 2012, 1,515 pounds (687 kilograms) of hexavalent chromium have been removed, and the size of the plume (at the 20 µg/L contour) has shrunk by 32 percent.

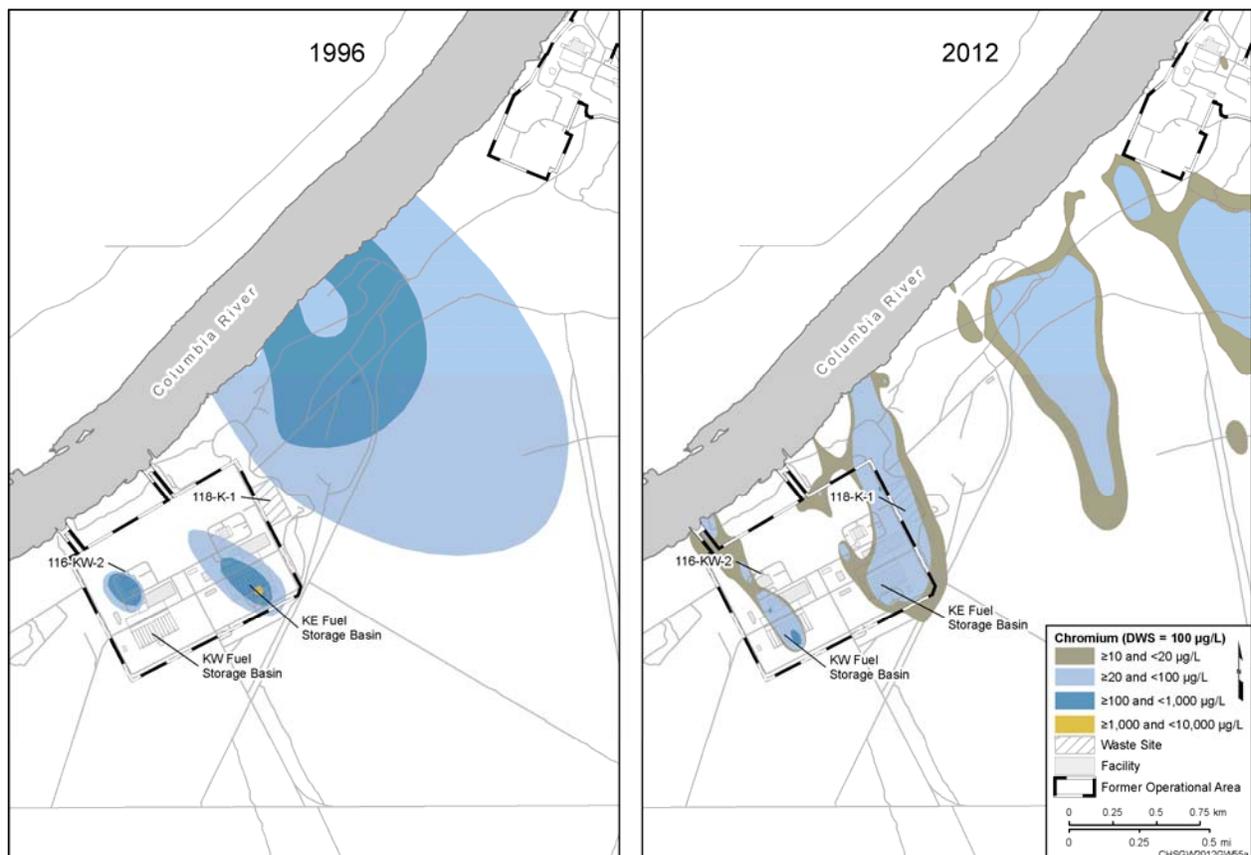
Sources near K West and K East contributed carbon-14 contamination to groundwater. Concentrations above the DWS are limited to a few wells, but the plumes are migrating downgradient toward the Columbia River.

Although a portion of the plume with the highest concentrations lies within the capture zone of groundwater extraction wells of one of the pump-and-treat systems, some plume segments may lie beyond the capture zone.

Tritium is present in 100-KR-4 groundwater, with primary sources near K East basin and possibly the 118-K-1 Burial Ground. Tritium contamination in this region is intercepted by extraction wells near the Columbia River.

Figure 8.6. 100-K Hexavalent Chromium Plumes

Three pump-and-treat systems reduce the amount of hexavalent chromium entering the Columbia River from 100-KR-4. The systems have removed 1,515 pounds (687 kilograms) of chromium from groundwater since 1997, and the concentrations and size of the main plume have declined as a result.



As in previous years, few wells in the 100-KR-4 Operable Unit had strontium-90 concentrations above the 8 pCi/L DWS in 2012. In the K West region, strontium-90 was detected for the first time in two upgradient extraction wells and one monitoring well, all located inland of the currently-defined plume. These detections likely reflect the migration of strontium-90 contained in treated groundwater injected into three upgradient injection wells. The treatment system removes hexavalent chromium but not strontium-90. Strontium-90 concentrations in the treated water in 2012 were well below the DWS.

Nitrate and trichloroethene also continued to exceed their DWSs in a few wells in the 100-KR-4 Operable Unit in 2012.

The CERCLA process is underway to make final cleanup decisions for the 100-KR-4 Operable Unit. DOE has proposed pump-and-treat for hexavalent chromium as part of a preferred alternative for groundwater remediation. The draft RI/FS report and proposed plan underwent review in 2012 and are awaiting final resolution of comments.

The concrete 100-K East and 100-K West Basins were integral parts of each reactor building. Until 2004, the water-filled basins were used to store irradiated fuel from the last run of N Reactor, as well as miscellaneous fuel fragments recovered during remedial actions at other reactor areas. Leaks at and around the basins have contaminated groundwater in the past. 100-K East Basin was demolished, but some contaminated soil remains. The 100-K West Basin has been emptied of fuel rods but remains a depository for contaminated sludge from the 100-K East and 100-K West basins. The 100-K West Basin and the 116-KW-2 Crib are scheduled for removal after 2015. Groundwater monitoring in 2012 did not show new groundwater impacts from the basins.

8.1.3 100-NR-2 Operable Unit

Principal groundwater issues for the 100-NR-2 Operable Unit include remediation of strontium-90 and total petroleum hydrocarbons, and RCRA monitoring. The major liquid waste sites have been remediated, and excavation is continuing at remaining waste sites. Other groundwater contaminants include nitrate and tritium.

The primary groundwater contaminant is strontium-90, which originated at the 116-N-1 and 116-N-3 waste sites. Strontium-90 tends to bind to sediment grains, and the shape and size of the plume does not change significantly from year to year. Pump-and-treat technology was found to be ineffective in cleaning up strontium-90 so DOE is applying an in situ technology, apatite sequestration (Figure 8.7). The goal is to create a reactive zone in the aquifer that captures strontium-90 as groundwater flows through it to the Columbia River. Apatite-forming chemicals were injected into a line of wells along the river shoreline several times since 2006. As the injected chemicals reacted with the aquifer and sediments, strontium-90 levels temporarily increased in downgradient wells and aquifer tubes. Subsequently, strontium-90 and gross beta concentrations declined.

In 2012, RCRA monitoring continued under detection programs at the decommissioned 1301-N, 1324-N/NA, and 1325-N facilities (waste sites 116-N-1, 120-N-1, 120-N-2, and 116-N-3). Results indicated no releases of dangerous waste constituents from the RCRA units.

DOE completed CERCLA RI/FS field studies in 2012. Results will be described in an upcoming RI/FS report and this information will be used to make decisions for remediation of waste sites and groundwater.

8.1.4 100-HR-3 Operable Unit

The 100-D and 100-H Areas, and the 600 Area between them, are combined into the 100-HR-3 Operable Unit. Remediation of waste sites continued in 2012. Hexavalent chromium is the primary contaminant of concern for groundwater, and a large plume extends from 100-D to 100-H Area (Figure 8.8). The highest concentrations are found near former waste sites in 100-D. Concentrations declined sharply in 2012 as a result of interim groundwater remediation. Hexavalent chromium also was detected at relatively high levels within the Ringold upper mud unit beneath a portion of 100-H, unlike elsewhere in the 100 Areas. Additional groundwater contaminants in 100-HR-3 include strontium-90 and nitrate.

Pump-and-treat systems remove hexavalent chromium contamination from the groundwater as part of an interim action. Between 1997 and 2012, these systems removed 3,786 pounds (1,717 kilograms) of hexavalent chromium. Average concentrations in groundwater declined 25 to 60 percent between 2011 and 2012.

Figure 8.7. Apatite Barrier and Strontium-90 Conceptual Model, 100-N Area

DOE injected chemicals into a line of wells along the river shore in 100-NR-2, creating a treatment zone in the aquifer. As contaminated groundwater flows through this zone, strontium-90 binds to the sediment grains before it can reach the river.

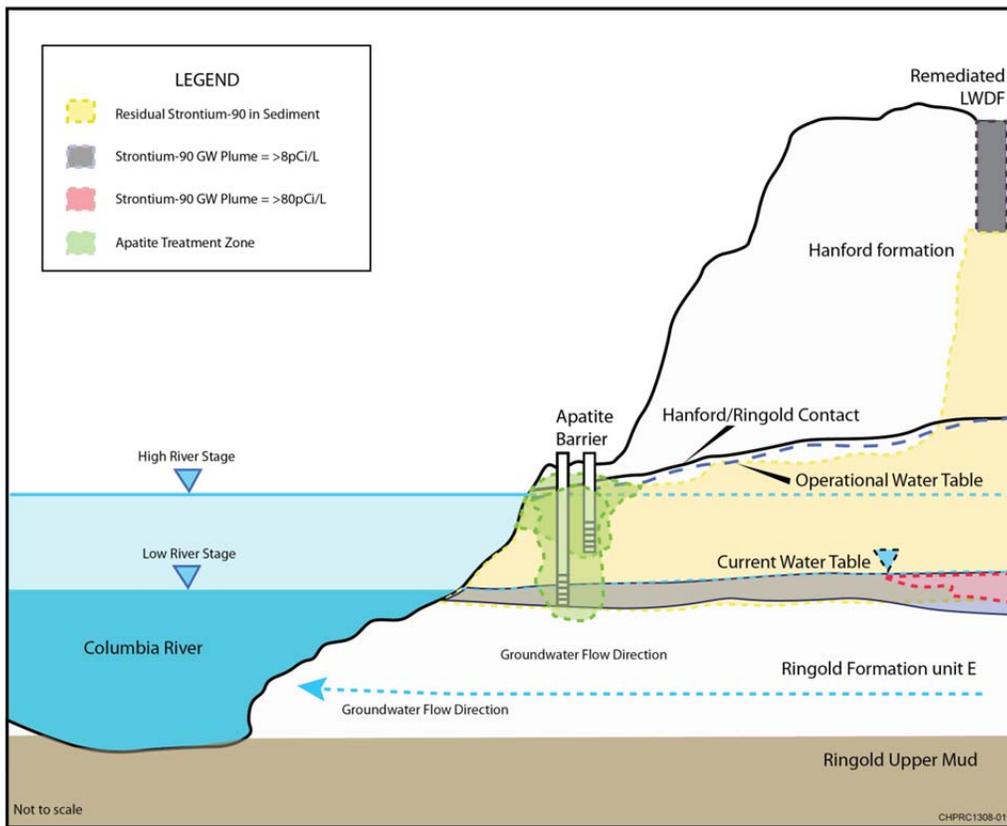
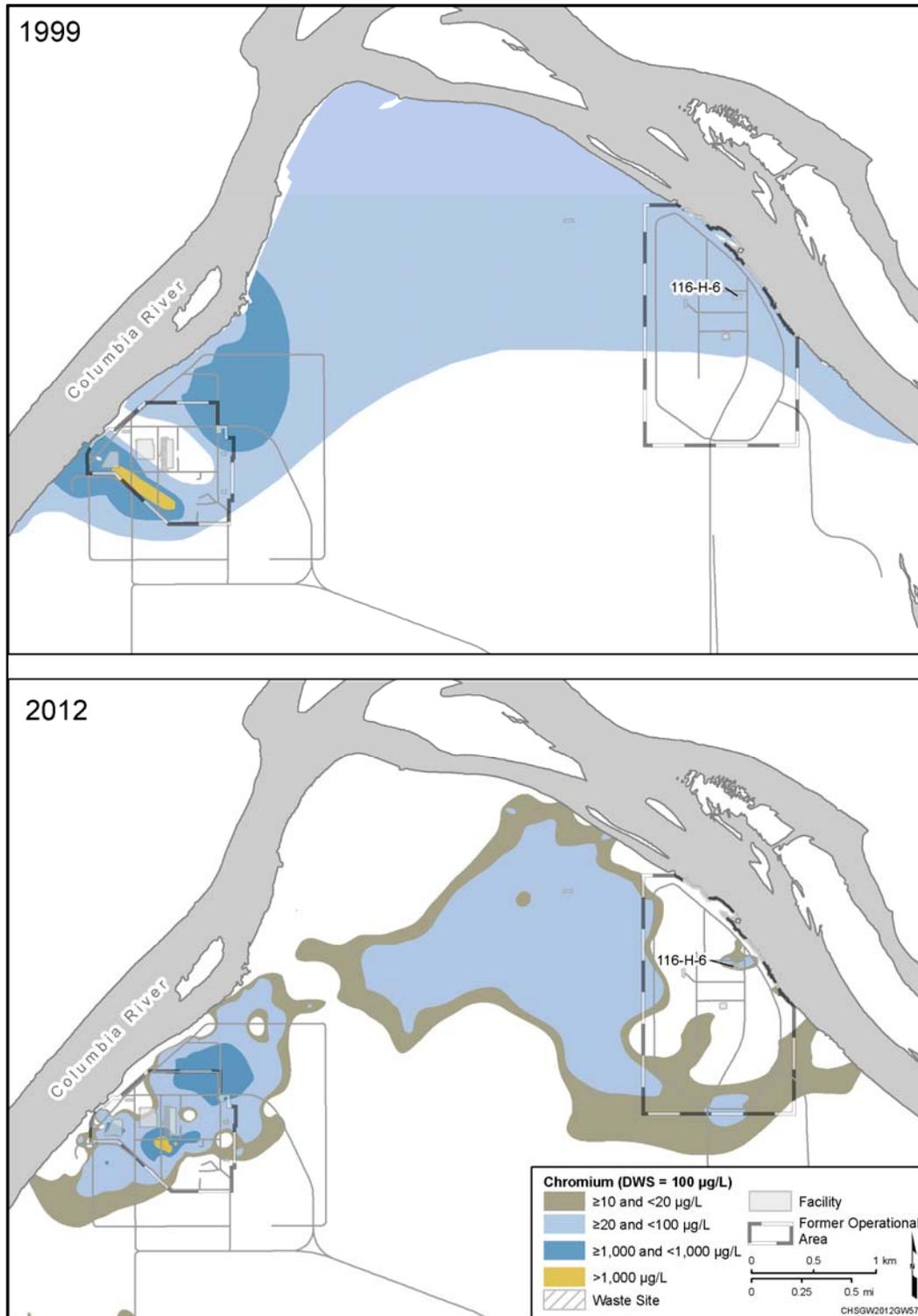


Figure 8.8. 100-HR-3 Hexavalent Chromium Plumes

A large hexavalent chromium plume is present in 100-HR-3. The size of the plume has decreased since 1999 due to groundwater remediation, discharge to the Columbia River, and dispersion. Operation of expanded pump-and-treat systems in 2011 and 2012 have decreased concentrations sharply.



The CERCLA process is underway to make final cleanup decisions for the 100-D and 100-H areas. The results of the RI field studies were evaluated, and in 2012 DOE submitted Draft A of an RI/FS report and proposed plan. The results of the RI/FS will support selection of final remedies under CERCLA, using an approach that integrates the data needs for waste sites and groundwater. DOE has proposed ongoing pump-and-treat as the preferred alternative for remediating hexavalent chromium in groundwater.

DOE expanded pump-and-treat systems in 100-HR-3 in recent years. Since 1997, the systems have removed 3,786 pounds (1,717 kilograms) of chromium from groundwater.

The former 183-H solar evaporation basins (waste site 116-H-6) is monitored in accordance with RCRA corrective action requirements during the post-closure period to track contaminant trends during operation of the CERCLA interim action for chromium. Concentrations of waste indicators increased in 2012, most likely as a result of unusually high river stage.

8.1.5 100-FR-3 Operable Unit

Groundwater contamination in the 100-FR-3 Operable Unit originated from disposal of solid and liquid waste associated with operation of the water-cooled F Reactor and biological experiments. Nitrate concentrations in groundwater exceed the DWS beneath much of the 100-F Area and a large region downgradient. Smaller plumes of hexavalent chromium, strontium-90, and trichloroethene are present. Strontium-90, hexavalent chromium, and trichloroethene concentrations are declining; and nitrate concentrations are stable.

Nearly all of the former waste sites have been excavated and backfilled under a ROD for interim action. No groundwater interim action was required. DOE released a draft RI/FS report and proposed plan in December 2012. DOE has proposed monitored natural attenuation as the preferred alternative for groundwater remediation.

8.1.6 300-FF-5 Operable Unit

Three geographic regions comprise the 300-FF-5 Operable Unit: the 300 Area Industrial Complex, the 618-11 Burial Ground region, and a region including the 618-10 Burial Ground and 316-4 Cribs. Most of the former waste sites have been remediated or are classified as not requiring remediation under an interim ROD. Contaminants of concern in 300 Area groundwater are uranium, trichloroethene, and *cis*-1,2-dichloroethene.

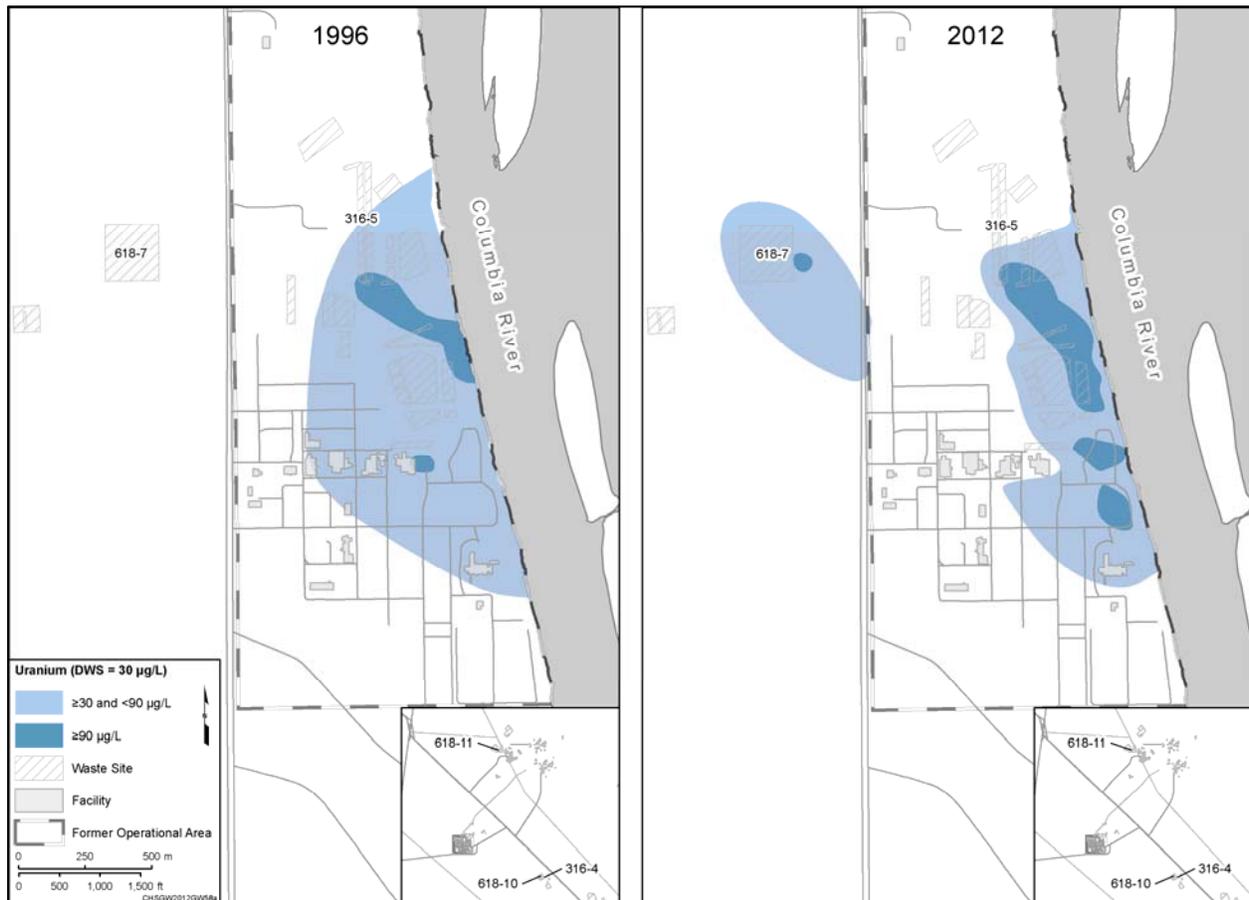
Concentrations of uranium, trichloroethene, and cis-1,2-dichloroethene are relatively constant or gradually decreasing in 300-FF-5.

Uranium has persisted longer than expected, and concentrations remain above the DWS (30 µg/L) in groundwater in the 300 Area Industrial Complex (Figure 8.9). Concentrations vary with changes in water table elevation, which relate to the stage of the Columbia River. When the water table is high, uranium concentrations decline in wells near the river and increase in inland wells.

Another area of uranium contamination developed downgradient of the 618-7 Burial Ground when it was remediated in 2007 and 2008. The contaminant plume resulted from the infiltration of dust control water and soil fixatives used during remediation activities. Uranium concentrations have generally declined in downgradient wells in recent years as the contamination migrates downgradient and merges with the uranium plume in the 300 Area Industrial Complex.

Figure 8.9. Uranium Plume in 300-FF-5

The plume in 300-FF is attenuating slowly. DOE is investigating alternatives for more rapid remediation.



Trichloroethene concentrations exceeded the DWS in one well screened in the upper part of the unconfined aquifer in 2012. Higher concentrations were detected in groundwater samples collected from a deeper, finer-grained sedimentary unit during the RI, but only in a limited area. This unit produces little water, so none of the monitoring wells are screened in it. However, at aquifer tube sites along the Columbia River, at least one aquifer tube is screened in this finer-grained sediment, and sampling reveals trichloroethene contamination.

Groundwater downgradient of the 618-11 Burial Ground contains 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, and the plume has maintained its basic shape since its discovery in 1999. Relatively constant tritium concentrations immediately downgradient of the site suggest that buried materials are providing an ongoing source of tritium to groundwater. At wells farther downgradient from the burial ground, concentration trends reflect the plume's migration. The conceptual model for the plume, including a simulation of plume evolution over time, indicates that tritium concentrations will be below the DWS when the plume reaches the Columbia River.

Nitrate concentrations exceed the DWS in 300-FF-5 groundwater, with sources including the 618-11 Burial Ground, 200-East Area waste sites, and non-Hanford Site activities.

RI activities to support selection of final remedial actions for 300-FF-5 groundwater were completed in 2011. A draft RI/FS report and proposed plan were submitted to EPA for review in December 2011 and a ROD is expected in 2013.

RCRA groundwater monitoring continued at the decommissioned 300 Area Process Trenches (waste site 316-5). The unit is monitored in accordance with post-closure corrective action requirements. Uranium and *cis*-1,2-dichloroethene continued to exceed permit limits in 2012. Site remediation will be coordinated under the 300-FF-5 Groundwater Operable Unit.

8.1.7 1100-EM-1 Operable Unit

The only portion of the River Corridor for which final cleanup decisions have been made is the former 1100-EM-1 Groundwater Operable Unit. This operable unit was removed from the NPL in 1996. The selected remedy was monitored natural attenuation of volatile organic compounds, with institutional controls on drilling of new water supply wells. Trichloroethene was the primary contaminant of concern, but concentrations have remained below the cleanup level since 2001.

Wells in the North Richland Well Field are monitored frequently to detect any changes in potential Hanford Site contaminants near these wells. Tritium associated with the plume originating from sources in the 200-East Area has not been detected in these wells.

Uranium concentrations in Hanford Site wells downgradient of DOE's inactive Horn Rapids Landfill have increased gradually since 1996 and exceeded the DWS for the first time in 2012. The presence of uranium at these locations is likely associated with the plume moving northeast from an offsite facility.

8.2 Central Plateau

When the Hanford Site was operating, irradiated fuel reprocessing, isotope recovery, and associated waste management activities occurred in the 200-East and 200-West Areas in the central portion of the Hanford Site. For the purpose of site cleanup, this region is defined as the Central Plateau and is divided into Inner and Outer Areas (Figure 8.1). The Inner Area is the final footprint area of the Hanford Site that will be dedicated to waste management and containment of residual contamination, while the Outer Area is the remainder of the Central Plateau. Contaminant sources included unlined cribs, trenches, and ponds, leakage from underground storage tanks, and other unplanned releases. There are seven SST waste management areas in the 200 Area. Some of these tanks have leaked, contaminating the vadose zone and groundwater beneath the tanks. Table 8.2 summarizes information about the Central Plateau.

Groundwater in the unconfined aquifer beneath the Central Plateau generally flows from upland areas in the west toward the regional discharge areas along the Columbia River (Figure 8.2). The flow of water divides beneath the 200-East Area, with some water flowing toward the north through Gable Gap and some flowing southeast. Previous effluent discharges caused groundwater mounds to form beneath the 200 Area that significantly affected regional flow patterns in the past. These discharges largely ceased in the mid-1990s and water levels declined, but remnants of groundwater mounds remain. Waste sites in the Central Plateau currently are a lower priority for cleanup than waste sites in the River Corridor because they are farther from the Columbia River and pose less risk to human and ecological receptors. Remediation of the Central Plateau waste sites is expected to accelerate after River Corridor remediation is complete. Until then, cleanup activities on the Central Plateau focus on completing decision documents, remediating groundwater plumes, and decontaminating and decommissioning facilities.

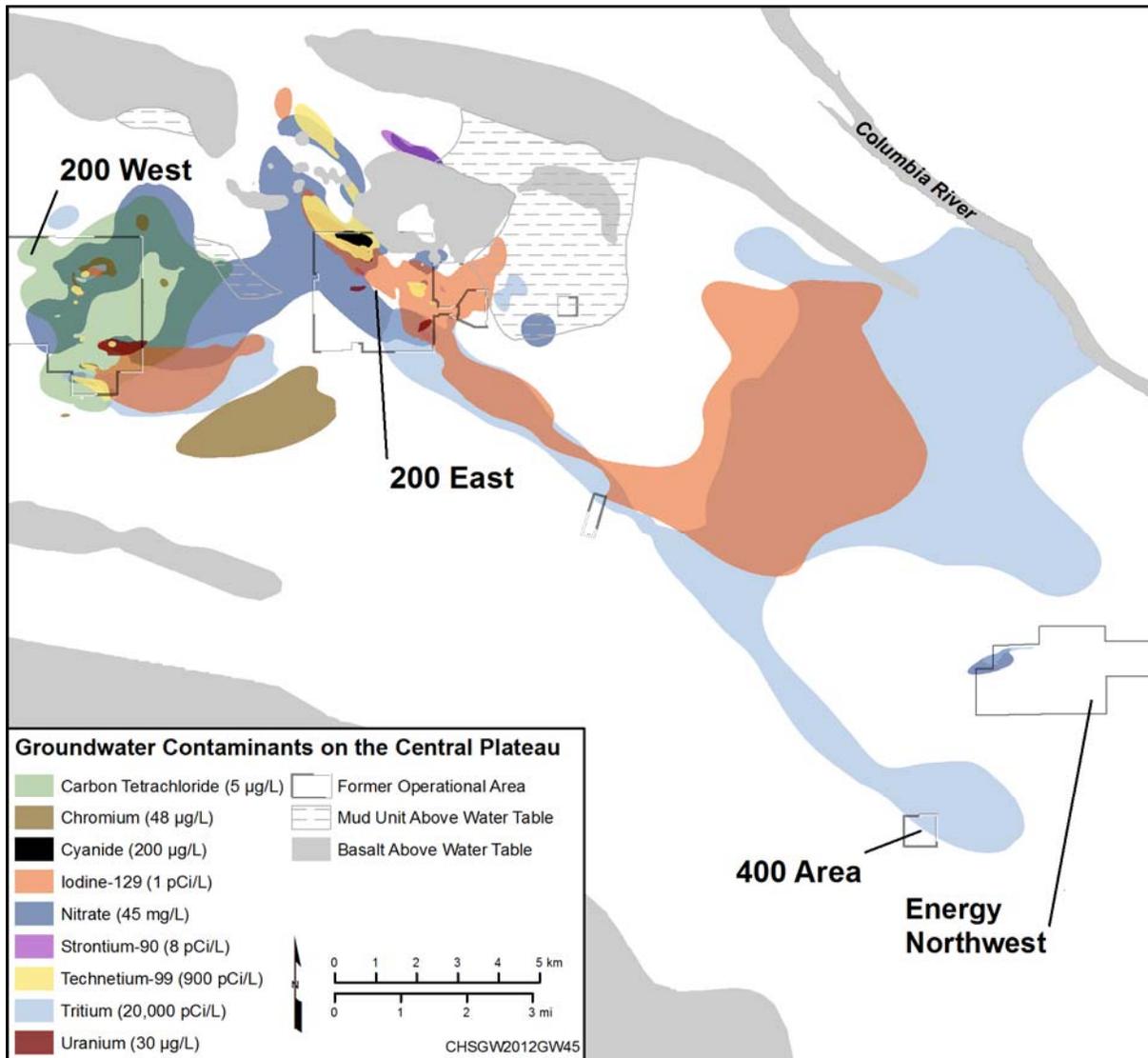
Groundwater contaminant plumes of tritium and iodine-129 formed when the waste discharged to ponds and cribs reached the aquifer. These contaminants form regional plumes originating on the Central Plateau (Figure 8.10). The tritium and nitrate plumes have shrunk over the years as a result of dispersion and radioactive decay. A large carbon tetrachloride plume originated in 200-West Area. This plume is expanding at the edges, but the high-concentration core is contained by a pump-and-treat system. Other groundwater contaminants in the Central Plateau include technetium-99, uranium, strontium-90, trichloroethene, and cyanide.

Table 8.2. Central Plateau Overview

Central Plateau Overview				Groundwater Contamination: Maximum Concentration and Plume Area									
Area	Primary Operations	Status of Groundwater ROD	Groundwater Remedial Action	Carbon Tetrachloride	Chromium	Cyanide	Iodine-129	Nitrate	Strontium-90	Trichloroethene	Technetium-99	Tritium	Uranium
200-ZP-1	T Plant (Pu separation) 1944-1956; Pu Finishing Plant: 1949-1989	Signed 2008 (final)	Interim action carbon tet. P&T: 1995-present; Soil vapor extraction 1991-present. Final remedy P&T began in 2012	Orange	Green	<DWS	Yellow	Yellow	<DWS	Green	Green	Yellow	<DWS
200-UP-1	REDOX Plant (Pu separation) 1952-1967; U Plant (U recovery) 1952-1957	Signed 2012 (interim)	Interim action U plant Tc-99 & U: 1994-2011; Interim action S-SX P&T began in 2012	See 200-ZP-1	Yellow	N	Yellow	Green	<DWS	Green	Yellow	Yellow	Green
200-BP-5	B Plant Pu separation: 1945-1952; B Plant Sr and Cs recovery: 1967-1985	Expected 2016	Perched aquifer P&T test: 2011-2012	<DWS	Green	Green	Green	Yellow	Orange	<DWS	Yellow	Green	Yellow
200-PO-1	PUREX Plant Pu separation: 1956-1972 and 1983-1989	Expected 2016	Vadose zone desiccation test: 2011	<DWS	<DWS	N	Yellow	Green	Green	<DWS	Green	Yellow	Green
Standards				5 µg/L	48 µg/L	200 µg/L	1 pCi/L	45 mg/L	8 pCi/L	5 µg/L	900 pCi/L	20,000 pCi/L	30 µg/L
Mobility in subsurface				Multi-phase	High to Moderate	Moderate	High	High	Slight	Moderate	High	High	Moderate
Legend													
Colors indicate maximum concentration in 2012													
Height of bar indicates plume area above standard (km ²)													
ABBREVIATIONS													
DWS Drinking water standard				P&T Pump and treat system				ROD Record of decision					

Figure 8.10. Central Plateau Groundwater Contaminant Plumes

Large plumes of tritium and iodine-129 originated on the Central Plateau and moved to the east and southeast. Carbon tetrachloride and nitrate also form large plumes. Other contaminants are present in smaller areas.



8.2.1 200-ZP-1 Operable Unit

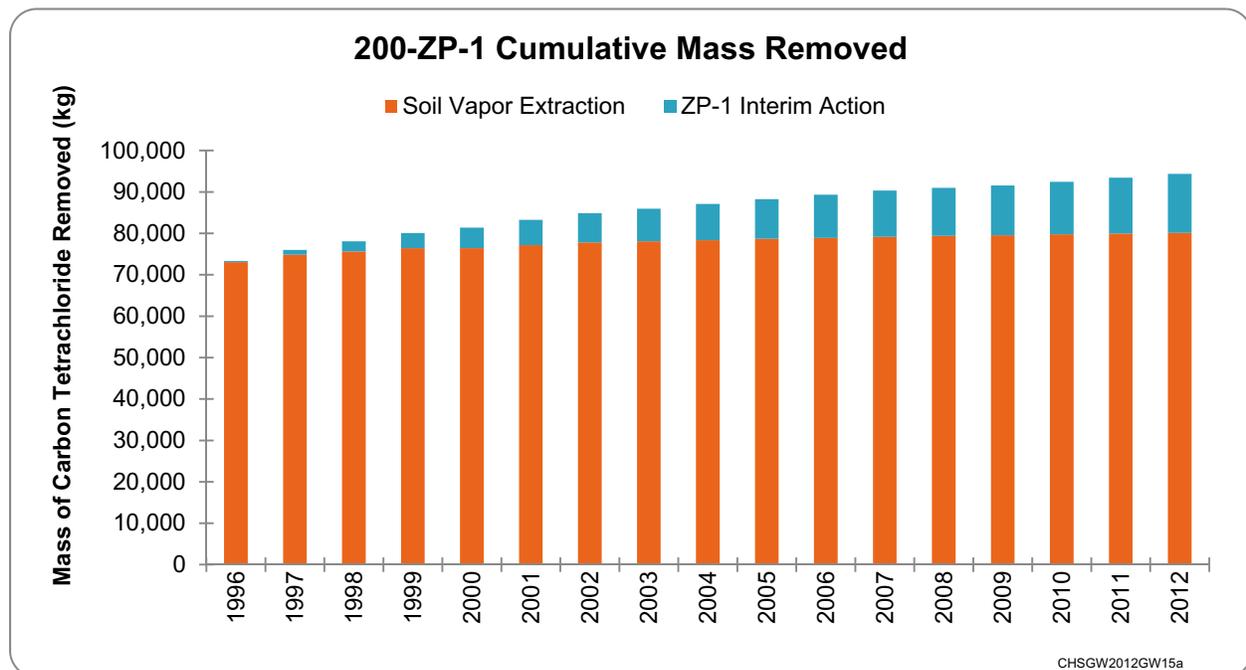
Contaminant sources in the 200-ZP-1 Operable Unit, located in 200-West Area, included cribs, ponds, and single-shell storage tanks. A final ROD for 200-ZP-1 groundwater identified carbon tetrachloride as the primary contaminant of concern. Other contaminants of concern are trichloroethene, iodine-129, technetium-99, nitrate, chromium, and tritium.

In July 2012, DOE began to operate a final action pump-and-treat system. This system is designed to remediate the entire thickness of the unconfined aquifer. Between July and December 2012, the system processed 152 million gallons (577 million liters) of groundwater and removed 1,171 pounds (531 kilograms) of carbon tetrachloride and over 24,000 pounds (11,000 kilograms) of nitrate from groundwater. Additional

extraction and injection wells will be hooked into the system in coming years. Since the early 1990s, DOE has operated soil vapor extraction systems and an interim action pump-and-treat system to remove carbon tetrachloride from the vadose zone and upper part of the unconfined aquifer. These systems have removed 207,000 pounds (94,000 kilograms) of carbon tetrachloride (Figure 8.11). Maximum concentrations in the 200-ZP-1 extraction wells in 2012 averaged 72 percent less than the maximum concentrations recorded prior to the interim action.

Figure 8.10. 200-West Area Carbon Tetrachloride Remediation

DOE began to operate a new pump-and-treat system in 200 West in 2012 as part of a final action for groundwater cleanup. This system and previous interim-action remediation systems have removed 207,000 pounds (94,000 kilograms) of carbon tetrachloride from groundwater and the vadose zone.



An interim action pump-and-treat test system has operated since 2007 to remove technetium-99 contamination near WMAs T and TX-TY. Since 2007, the system has extracted 3 ounces (82 grams) of technetium-99, 425 pounds (193 kilograms) of carbon tetrachloride, 32 pounds (14.5 kilograms) of chromium, 26 ounces (732 grams) of trichloroethene, and 187,000 pounds (85,000 kilograms) of nitrate from the aquifer.

In 2012, DOE published results of a 2011 a treatability test using one of the soil vapor extraction systems and associated vadose zone wells. The purpose of the test was to evaluate the flux of carbon tetrachloride from the vadose zone to the groundwater to assess the soil vapor concentrations to ensure that they are protective of groundwater. Results indicated that the primary remaining source of carbon tetrachloride in the vadose zone at 216-Z-9 is an area within the Cold Creek unit that is approximately 340 feet by 340 feet (90 meters by 90 meters).

Two Low-Level Waste Management Areas (LLWMA) in 200-ZP-1 are monitored under RCRA interim-status, contaminant indicator parameter programs. At LLWMA-3, a new upgradient well was installed in 2011, and in 2012, total organic carbon concentrations were higher than expected in some samples from this well. Additional sampling and analysis were conducted, and no dangerous waste contamination was found. The elevated total organic carbon could be attributed to vegetable grease used during well construction to lubricate casing connections, or could indicate the presence of natural organic material such as humic acid. No significant changes occurred at LLWMA-4 in 2012. Monitoring results showed no indication that either of these LLWMAs is contaminating groundwater.

RCRA assessment monitoring continued at WMA T and WMA TX-TY. Due to remediation activities at WMA T, chromium concentrations are declining and the plume extents at both WMAs are shrinking.

The State-Approved Land Disposal Site (SALDS) receives treated water from the ETF. It is regulated under a state waste discharge permit. The declining water table in 200-West Area has caused several of the SALDS monitoring wells to go dry over the years. All groundwater sampling results from the SALDS proximal wells were within permit compliance limits during 2012.

8.2.2 200-UP-1 Operable Unit

The southern portion of the 200-West Area and adjacent areas to the east and south comprise 200-UP-1 Operable Unit. Contaminant sources included cribs, ponds, and SSTs. Carbon tetrachloride, technetium-99, uranium, tritium, iodine-129, nitrate, and chromium plumes are present in groundwater. Carbon tetrachloride originated from sources in the 200-ZP-1 Operable Unit.

Wells near WMA S-SX continued to show the highest technetium-99 concentrations on the Hanford Site in 2012 (Figure 8.12). A new pump-and-treat system began operating during 2012. Between July and December 2012, the system removed 0.25 Curie of technetium-99 from groundwater. The system also remediates nitrate and chromium.

Near WMA U, technetium-99 concentrations increased in 2011 and 2012 in some wells, indicating that more contamination is entering the aquifer from the vadose zone. This groundwater contamination will be remediated by the 200-ZP-1 pump-and-treat system because the groundwater beneath the tank farm is within the capture zone of a nearby extraction well.

The eastward extent of the iodine-129 plume within 200-UP-1 was revised based on 2012 sample results. It is now interpreted to extend 2.8 miles (4.5 kilometers) from the source cribs instead of the previously interpreted 1.8 miles (3.0 kilometers). The tritium plume originating from the southern 200-West Area is attenuating naturally through dispersion and radiological decay.

The highest nitrate concentration in 200-UP-1 increased sharply in 2012. The contamination is believed to have originated at a local source. A planned pump-and-treat system to remediate this plume will be constructed in the coming years.

DOE released an RI/FS report and proposed plan for the 200-UP-1 Operable Unit in 2012. The preferred alternative is a combination of 1) groundwater extraction and treatment for technetium-99, uranium, and chromium, 2) a combination of pump-and-treat and monitored natural attenuation for nitrate and carbon tetrachloride, 3) monitored natural attenuation for tritium, 4) hydraulic containment for iodine-129 while treatment technologies are investigated, and 5) institutional controls.

A new interim-action ROD for the 200-UP-1 Operable Unit was released in 2012. The remedy includes groundwater pump-and-treat, natural attenuation, hydraulic containment, and institutional controls.

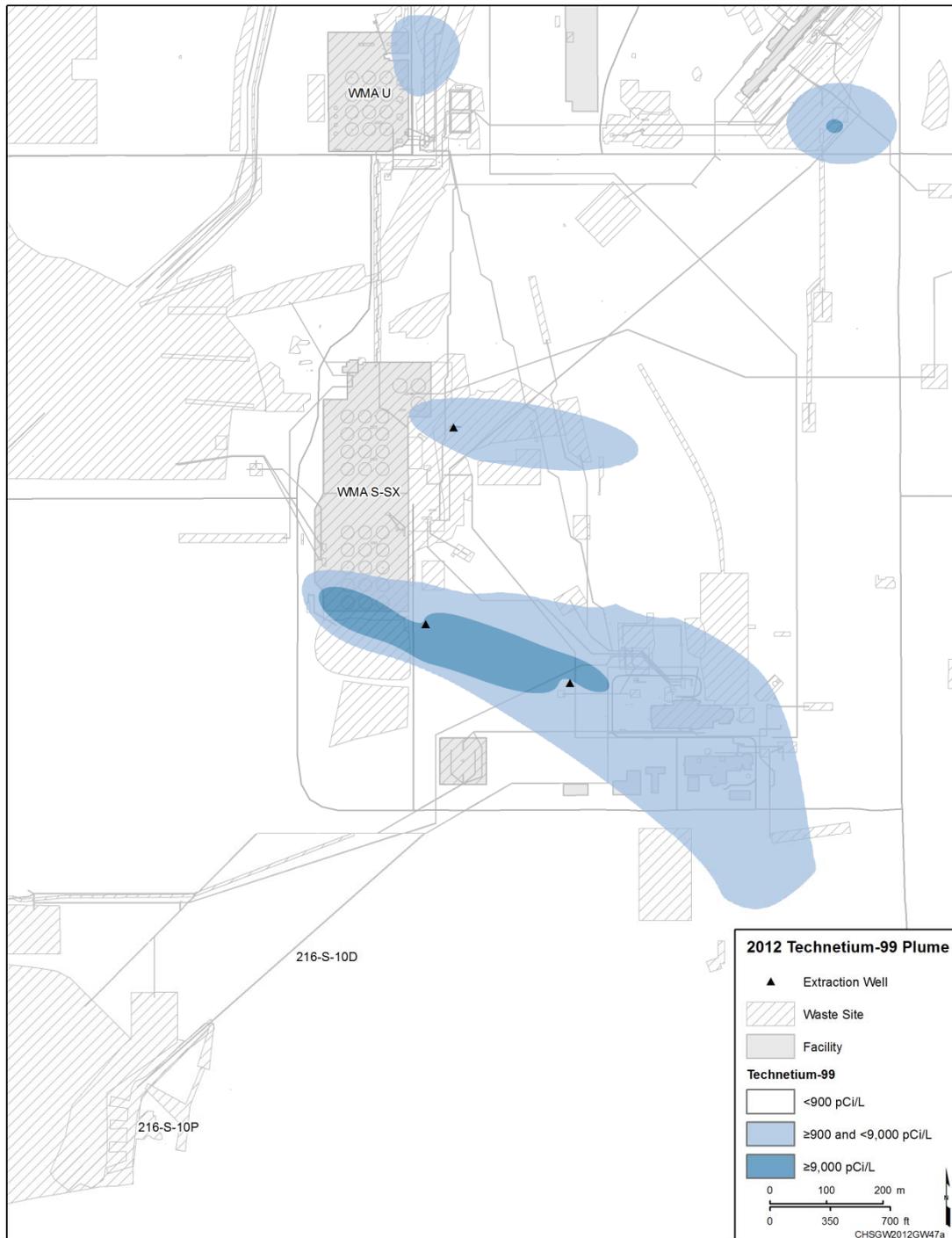
The preferred alternative specified in the proposed plan was adopted as the selected remedy in a new interim-action ROD, which was approved in September 2012. This ROD superseded both the 1997 interim-action ROD and the associated explanation of significant differences.

RCRA monitoring in 200-UP-1 included interim status groundwater quality assessment monitoring at WMA S-SX and WMA U, and interim status indicator parameter evaluation monitoring at the 216-S-10 Pond and Ditch. A revised RCRA monitoring plan was released in 2012 for WMA U. Monitoring results did not show major changes in the extent of contamination. Indicator parameters did not exceed statistical comparison values at the 216-S-10 Pond and Ditch during 2012.

ERDF is a low-level radioactive mixed waste landfill used for disposal of waste from surface remedial actions on the Hanford Site. The results of groundwater monitoring in 2012 continued to indicate that the facility has not adversely affected groundwater quality.

Figure 8.11. Technetium-99 Plumes at WMA S-SX

DOE began to operate a pump-and-treat system downgradient of S-SX Tank Farms in 2012. The system removes technetium-99, chromium, nitrate, and other contaminants from the groundwater.



8.2.3 200-BP-5 Operable Unit

The 200-BP-5 Operable Unit includes groundwater beneath the northern 200-East Area and the region to the northwest where mobile contaminants have migrated between Gable Mountain and Gable Butte. Most of the groundwater contamination is concentrated beneath WMA B-BX-BY and adjacent waste sites in the northwestern portion of the 200-East Area. Cleanup decisions for the 200-BP-5 Operable Unit are yet to be made.

Wells in 200-BP-5 have the highest uranium concentrations in groundwater on the Hanford Site. DOE has planned tests to determine the best ways to remove this contamination from the vadose zone and groundwater.

Nitrate, iodine-129, and technetium-99 form the largest contaminant plumes in the 200-BP-5 Operable Unit. These mobile contaminants have migrated to the northwest as a result of past groundwater flow. These plumes have grown in size since 2007 due to continued drainage of contaminated water from the vadose zone into the aquifer. Smaller plumes of uranium, cyanide, strontium-90, and tritium also exceed their respective DWSs. Cesium-137 and plutonium-239/240 contamination is limited to one or two wells.

Groundwater in northwestern 200-East Area flowed toward the southeast in 2012. Contaminant plumes that had been migrating toward the northwest under the previous flow direction will gradually change configuration under the new flow regime.

A planned treatability test to evaluate pumping and treating groundwater to remediate uranium and technetium-99 has been postponed. Two new wells were drilled for this test in 2011 and early 2012. These wells and an existing well were connected to piping to convey pumped water to a treatment facility.

A fine-grained geologic unit beneath the B Plant region has created an area of saturated sediments (a “perched” aquifer) in the deep vadose zone above the regional water table. This perched water is contaminated with uranium and other contaminants at concentrations higher than in the underlying aquifer. Beginning in 2011 and continuing throughout 2012, DOE operated a pumping operation to remove this perched water before it reaches groundwater. Approximately 31 pounds (14 kilograms) of uranium has been removed through pumping perched well 299-E33-344 through the end of 2012.

The 200-BP-5 Operable Unit contains six RCRA sites with groundwater monitoring requirements: WMA B-BX-BY, WMA C, 216-B-63 Trench, LERF, LLWMA-1, and LLWMA-2.

RCRA groundwater quality assessment monitoring at WMA B-BX-BY and WMA C indicates that the dangerous waste constituent cyanide in groundwater originated in the WMAs. Changing directions of groundwater flow may necessitate changes to the groundwater monitoring networks for these facilities.

RCRA contamination indicator parameter monitoring continued at the 216-B-63 Trench and LLWMA-2 in 2012. Results continued to show that these units have not adversely affected groundwater quality. The 216-B-63 Trench monitoring plan was revised in response to changing flow directions.

At LLWMA-1, total organic carbon concentrations in a downgradient well exceeded the critical mean value in 2012. DOE submitted a draft assessment plan to Ecology, as required. Assessment results indicated no dangerous waste or dangerous waste constituents in the groundwater and the site returned to indicator parameter monitoring in 2013. The elevated total organic carbon is believed to reflect natural organic material.

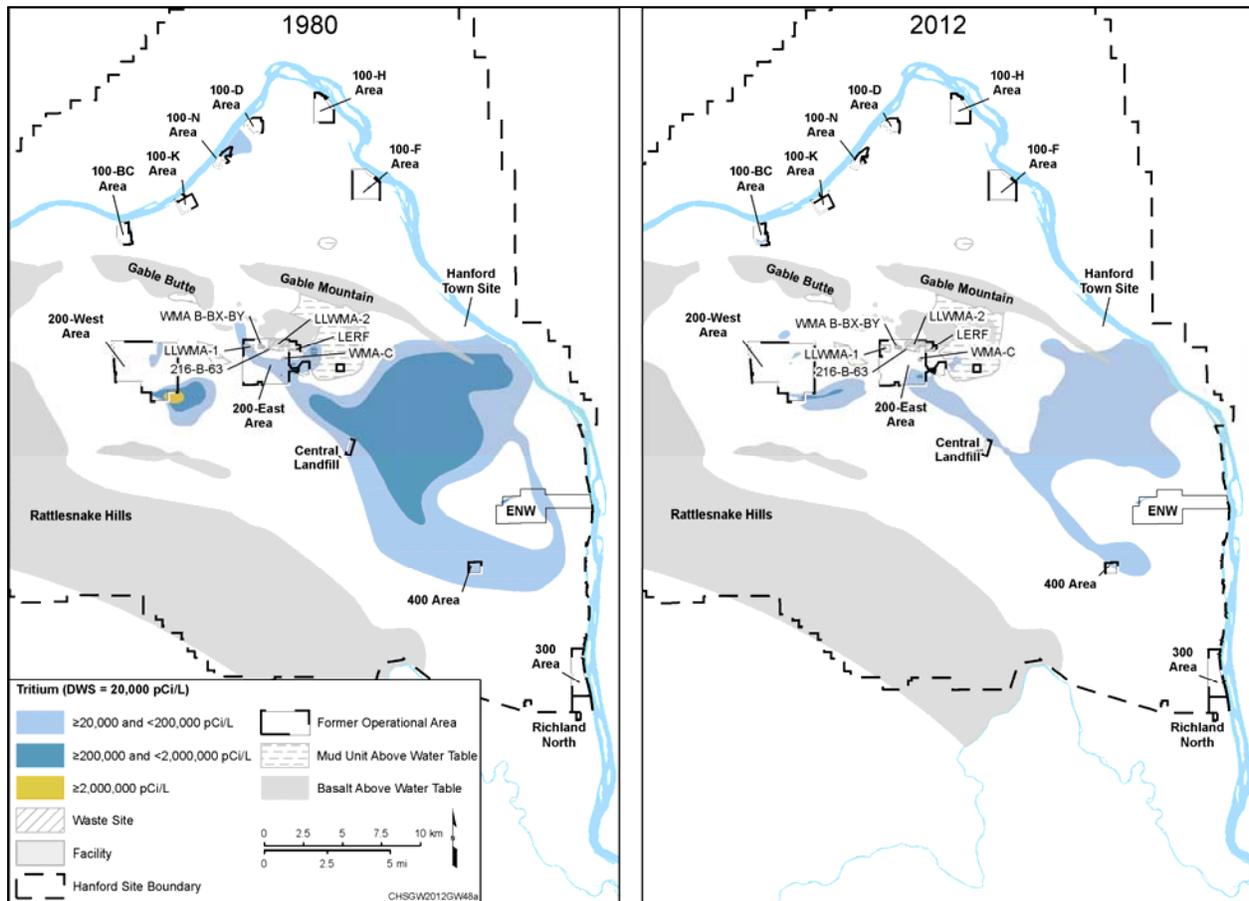
DOE monitors the LERF under a RCRA final-status detection program. Results showed no indication that the site has affected groundwater.

8.2.4 200-PO-1 Operable Unit

The southern portion of the 200-East Area and a large region of the Hanford Site to the east and southeast comprise the 200-PO-1 Groundwater Operable Unit. Disposal of large volumes of liquid waste created regional groundwater plumes of tritium, iodine-129, and nitrate. Concentrations of tritium are declining as the groundwater plume attenuates naturally as a result of radioactive decay and dispersion. The size of the tritium plume has decreased by one-third since 1980 (Figure 8.13). The area of the iodine-129 plume above the 1 pCi/L contour has decreased slightly over the past decade, and maximum concentrations have declined significantly as a result of dispersion. Radioactive decay has not decreased the level of iodine-129 contamination noticeably because this isotope has a half-life of 15.7 million years. The nitrate plume covers a large area, with concentrations above background, but mostly below the DWS. Other contaminants in 200-PO-1 include strontium-90, technetium-99, and uranium in smaller areas near their sources.

Figure 8.12. Tritium Plumes

Hanford Site tritium plumes are gradually shrinking as concentrations decline as a result of radioactive decay, dispersion, and discharge to the Columbia River. Since 1980, the area of the plume has decreased by approximately 35%, and the maximum concentration has declined 90 percent.



DOE conducted a CERCLA RI in 200-PO-1 in 2008 and 2009 and submitted an RI report to Ecology in 2012. The report recommended that the next step in the CERCLA process should be a feasibility study to develop remedies to address the groundwater contamination associated with the operable unit.

In 2012, DOE released a report on monitoring associated with a 2011 soil desiccation test. The test was conducted in an interval containing high moisture and associated technetium-99 contamination near the

BC Cribs and Trenches. This technology is being considered as a remedy for contamination in the deep vadose zone. For approximately 6 months, nitrogen was injected into a well; and soil gas was extracted from another well. A combination of in situ sensors and geophysical measurements provided data to monitor performance. As anticipated, desiccation occurred more rapidly from higher-permeability sediment. The results of the treatability test demonstrated the field-scale effectiveness of the soil desiccation method by reducing subsurface soil moisture content to levels that would significantly decrease future vertical water and contaminant movement. DOE plans to conduct longer-term monitoring of moisture conditions at the test site to assess the rewetting behavior of the desiccated zone.

The 200-PO-1 Groundwater Operable Unit includes seven RCRA units, one state permitted landfill, and one state permitted discharge facility.

RCRA assessment monitoring continued in 2012 at WMA A-AX. An assessment of the water quality was completed in December 2012. The analytical results revealed the only elevated potential elevated dangerous waste/dangerous waste constituents were chromium and nickel. However, these constituents were considered to be associated with well casing corrosion observed in a television survey, and do not indicate a waste release.

RCRA monitoring at the 216-A-36B Crib, 216-A-37-1 Crib, 216-A-29 Ditch, 216-B-3 Pond, and the NRDWL continued under interim-status, indicator parameter programs in 2012. Monitoring results provided no indication of releases from these facilities to groundwater.

The IDF is an expandable, double-lined landfill that is regulated under RCRA and the [AEA](#). It is not yet in use, and current groundwater monitoring is directed at obtaining baseline data.

The TEDF is a state-permitted liquid waste site. The uppermost aquifer beneath this facility is confined beneath the Ringold Formation lower mud unit. Under the original permit, groundwater monitoring was performed to demonstrate that the mud unit continued to protect the confined aquifer from potential impacts associated with discharges. This monitoring approach was not ideal because the wells were not monitoring the actual discharges. To address this situation, the permit was revised; it does not require groundwater monitoring. Instead, the effluent discharged to the facility is monitored to ensure that groundwater quality standards are met. Thus, groundwater monitoring was discontinued after the new permit went into effect on July 1, 2012.

The SWL 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 2012 included specific conductance, nitrite, sulfate, and total organic carbon.

Three water supply wells provide drinking water and serve as an emergency water supply for the 400 Area, which is in the footprint of 200-PO-1. Because the 400 Area is in the path of the Hanford Site-wide tritium plume, DOE routinely monitors the wells for tritium. These wells are screened deep in the unconfined aquifer, just above the Ringold lower mud unit.

8.3 Confined Aquifers

Although most Hanford Site groundwater contamination is found in the unconfined aquifer, DOE monitors wells in deeper aquifers because of potential downward movement of contamination and potential migration of that contamination offsite through the confined aquifers. There is no evidence of offsite migration via the confined aquifers.

One confined aquifer occurs within sand and gravel at the base of the Ringold Formation. Carbon tetrachloride, nitrate, and technetium-99 have contaminated this unit in a portion of 200-West Area where the upper confining unit is absent. New wells have been installed in recent years to monitor and remediate this contamination. The Ringold confined aquifer is the uppermost aquifer in a region east of 200-East Area (within portions of 200-BP-5 and 200-PO-1). Iodine-129 and tritium are detected in wells at this location, but the contamination has not migrated to wells farther downgradient.

In the northern Hanford Site, fine-grained sedimentary units informally called the Ringold upper mud confine deeper sediments in the Ringold Formation. This unit is contaminated with hexavalent chromium in some parts of 100-H Area.

Groundwater within basalt fractures and joints, interflow contacts, and sedimentary interbeds make up the upper basalt-confined aquifer system. No significant contamination is detected in the basalt-confined aquifer, except in the northwestern 200-East Area, where poor well construction and temporary drilling effects allowed local migration of groundwater from the overlying unconfined aquifer.

8.4 Wells

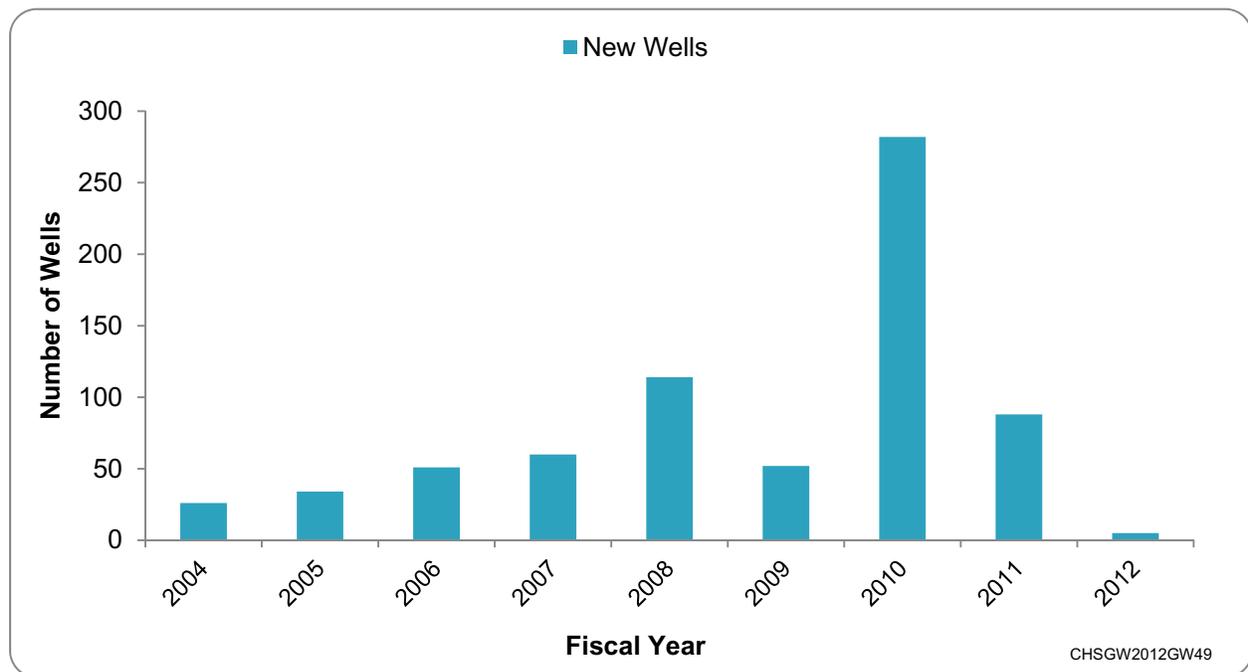
Over the lifetime of the Hanford Site, DOE has installed thousands of wells to monitor and remediate groundwater and provide geologic data. During 2012, DOE installed five new wells (Figure 8.14 and Table 8.3). Three of these will be injection wells for the new 200 West pump-and-treat system, and two were installed for a treatability test in 200-East Area.

DOE identifies wells, boreholes, or other subsurface installations for decommissioning when they are no longer needed. In 2012, 28 borings and wells were physically decommissioned. This involved sealing the wells in compliance with Washington State groundwater protection laws.

Table 8.3. Wells Installed in 2012

Groundwater OU	No. of New Wells
100-BC-5	0
100-KR-4	0
100-NR-2	0
100-HR-D/H	0
100-FR	0
200-ZP-1	2
200-UP-1	1
200-BP-5	2
200-PO-1	0
300-FF-5	0
Total	5

Figure 8.13. Groundwater Monitoring Wells Installed from 2004-2012



8.5 Conclusions

The items below highlight the primary conclusions based on Hanford Site groundwater monitoring in 2012.

- Decades of waste disposal have contaminated a large area of the Hanford Site's groundwater (Table 8.4). The largest contaminant plume—tritium from waste sites on the Central Plateau—is decreasing in size due to radioactive decay and dispersion (Figure 8.15). Hexavalent chromium is the primary concern in the River Corridor, where groundwater remediation is shrinking plumes, and reducing concentrations.
- Groundwater flows toward the Columbia River and is the primary exposure route for contaminants to reach human, environmental, and ecological receptors.
- More than 74% of the former waste sites in the River Corridor have been remediated or are classified as not needing remediation under interim RODs. The rest of the waste sites will be remediated in the next few years. Thus, potential sources of additional groundwater contamination are being removed from the region that poses the greatest threat to the Columbia River. Remedial investigations have collected data to determine appropriate remedies for remaining vadose zone and groundwater contamination. The Tri-Party Agencies (Ecology, EPA, and DOE) will develop final RODs for the River Corridor units in coming years.
- Interim remediation of hexavalent chromium contamination in the 100-KR-4 and 100-HR-3 operable units continued in 2012. DOE has expanded pump-and-treat systems in these regions to control larger portions of the plumes. Chromium concentrations in compliance wells remained above cleanup goals, so remediation will continue.
- An in situ remediation method being applied in 100-NR-2 is reducing the amount of strontium-90 discharging to the Columbia River.
- On the Central Plateau, contamination is still present in many parts of the thick vadose zone, and may continue to drain into the groundwater. Remediation of the Central Plateau waste sites and vadose zone will accelerate after River Corridor remediation is complete. Meanwhile, DOE has been remediating groundwater and testing methods to remediate the deep vadose zone.
- The final remedy for the 200-ZP-1 Operable Unit includes an expanded pump-and-treat system that began operating in 2012. This system will remediate carbon tetrachloride and other groundwater contaminants from the entire thickness of the unconfined aquifer.
- A new interim action ROD for the 200-UP-1 Operable Unit was approved in 2012 for remediation of technetium-99, uranium, nitrate, and other contaminants. The remedy includes pump-and-treat, hydraulic control, monitored natural attenuation, and institutional controls.
- Final cleanup decisions for the 200-BP-5 and 200-PO-1 operable units are yet to be made. Remedial investigation studies have gathered information to support cleanup decisions in coming years.
- Groundwater discharges to the Columbia River via springs and areas of upwelling. Contaminant concentrations in some springs are above applicable water quality standards. Concentrations are below these standards in river water samples.

Figure 8.14. Change in Size of Major Groundwater Plumes

The Hanford Site’s largest contaminant plumes are tritium, iodine-129, and nitrate. The sizes of the Sitewide tritium and iodine-129 plumes have declined since 2000. Tritium has a half-life of approximately 12 years, so radioactive decay causes concentrations to decline. Iodine-129 has a half-life of 17 million years, so the decline in plume size was mainly caused by advection and dispersion. Nitrate plumes are present in all of the groundwater operable units. The total size of the nitrate plumes has changed very little since 2000.

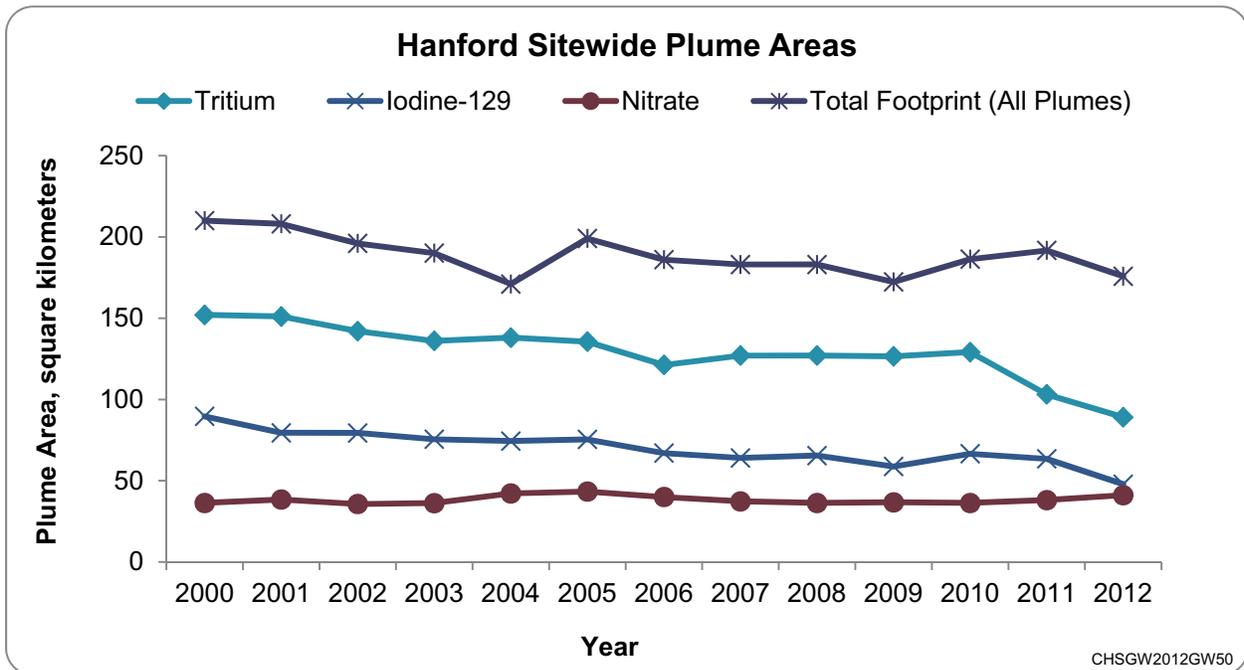


Table 8.4. Groundwater Contaminants on the Hanford Site

Contaminant	Primary Locations	Plume Area Above Standard (kilometers²)	DWS	Remediation in Place?	Mobility^a and Half-Life
Carbon Tetrachloride	200 West	13.4	5 µg/L	Yes	Mobile and denser than water
Chromium (hexavalent)	100-K, 100-D, 100-H	1.2	48 µg/L ^b	Yes	Mobile to moderate
Cyanide	200 East	0.2	200 µg/L	No	Mobile
Iodine-129	200 Area	47.8	1 pCi/L	Yes, 200 West	Mobile; 17 million years
Nitrate (as NO ₃ ⁻)	200 Area, 100-F, 100-D, 100-H, 100-N	38.2	45 mg/L	Yes, 200 West	Mobile
Strontium-90	100 Areas, 200 East	2.0	8 pCi/L	Yes, 100-N	Slightly mobile; 28.9 years
Technetium-99	200 Area	2.7	900 pCi/L	Yes, 200 West	Mobile; 213,000 years
Trichloroethene	100-F, 200 West	0.9	5 µg/L	Yes, 200 West	Mobile to moderate
Tritium	200 Area, 300 Area, 100-BC, 100-K	88.8	20,000 pCi/L	No	Mobile; 12.3 years
Uranium	200 West, 200 East, 300 Area	1.7	30 µg/L	No	Moderate; 240,000 years (U-234), 4.5 billion years (U-238)
Area of combined plumes^c		152			

^a “Mobile” means a contaminant moves readily in groundwater. “Moderate” means a contaminant undergoes geochemical reactions in the aquifer and moves slower than the groundwater. “Slight” means a contaminant binds to sediment grains and moves much slower than the groundwater.

^b Washington State “Model Toxics Control Act—Cleanup” ([WAC 173-340](#)) groundwater cleanup level.

^c Many plumes overlap so the area of combined plumes is less than the sum of the individual plume areas

9.0 Soil Monitoring

MC Dorsey and ME Hoefer

Radiological monitoring of soil is conducted at a variety of locations: onsite near facilities and operations, onsite away from facilities and operations (Hanford Site), 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.

Data obtained from on-site soil samples is used as a qualitative indicator and verification of ambient air sampling results per the [FF-01](#), *Hanford Site Radioactive Air Emissions License*.

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 which unplanned releases can be compared to. The Hanford Site Environmental Surveillance Master Sampling Schedule is available online at <http://www.hanford.gov/page.cfm/environmentalsurveillance>.

The number and location of Hanford Site soil samples collected during 2012 are summarized in Table 10.4. Only those radionuclides with concentrations consistently above analytical detection limits are discussed in this section. Soil samples from offsite locations were last collected in 2008 ([PNNL-18427](#), *Hanford Site Environmental Surveillance Data Report for Calendar Year 2008*).

9.1 Monitoring Results

ME Hoefer

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](#)).

9.2 Sampling Results

ME Hoefer

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, re-suspension and movement of contaminants from radiologically contaminated surface areas, uptake of contaminants into plants whose roots contact belowground waste, or translocation of buried waste by intruding animals.

Soil samples were collected on or adjacent to waste disposal sites and from locations downwind and near or in the boundaries of operating facilities and remedial action sites. The number and locations of soil samples collected during 2012 are summarized in Table 9.1. Only radionuclides with concentrations consistently above analytical detection limits are discussed in this section.

Table 9.1. Soil Sample Locations

Number of Samples Analyzed	Operational Area (discrete samples analyzed)						Composites ²
	200-East ^{1,2}	200-West ^{1,2}	600 ^{1,2}	300 ¹	400	ERDF	
53	6	11	5	16	1	1	13

¹ Number of samples includes one or more replicate samples.

² 40 individual soil samples from the 200 and 600 Areas were combined into 13 composite samples using a multi-incremental approach

Individual soil samples are 2.2 pounds (1.0 kilogram), which represent a parent sample consisting of five plugs of soil; each sample is approximately 1.0 inch (2.5 centimeters) deep and 4 inches (10 centimeters) in diameter. Soil samples are sieved in the field to remove potential sample intrusions such as rocks and plant debris, and then dried in the laboratory prior to analysis to remove residual moisture. Some soil samples were analyzed as single parent samples (discrete EDP codes) while others were composited with the following approach:

A multi-incremental sampling technique is used when collecting samples from a large given area (i.e., a decision unit). Individual samples are processed using a gridded pattern approach and combined with other samples from the decision unit to create a composite sample that represents the decision unit as a whole. This compositing limits the variability of selected environmental contaminant concentrations in a given area and reduces the amount of sampling error due to heterogeneity while allowing for a reproducible mean concentration for the decision unit.

Soil samples were analyzed for radionuclides expected to occur in the areas sampled (i.e., gamma-emitting radionuclides, strontium-90, uranium isotopes, and/or plutonium isotopes). The analytical results from Hanford Site soil 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](#), *Soil Concentration Limits for Accessible and Inaccessible Areas*) developed specifically for use at the Hanford Site. These concentration values for radionuclides were established to ensure that effective dose equivalents to the public do not exceed the established limits for any reasonable scenario, such as direct exposure, inadvertent ingestion, inhalation, and consumption of foods, including animal products. The accessible soil concentration values are based on a radiation-dose estimate scenario ([WHC-SD-EN-TI-070](#)) in which an individual would have to spend 100 hours per year in direct contact with the contaminated soil. The conservatism inherent in pathway modeling 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, and decontamination, and decommissioning activities. A partial list of these values is provided in Table 9.2.

Table 9.2. Accessible Soil Concentration Limits for Selected Radionuclides
pCi/g¹ dry weight

	Cobalt- 60	Strontium- 90	Cesium- 137	Uranium- 234	Uranium- 235	Uranium- 238	Plutonium- 239/240
Accessible soil ² concentration limits (WHC-SD-EN-TI-070)	7.1	2,800	30	630	170	370	190

¹ To convert to international metric system units, multiply pCi/g by 0.037 to obtain Bq/g.

² Hanford Site soil that is not behind security fences.

[WHC-SD-EN-TI-070](#), *Soil Concentration Limits for Accessible and Inaccessible Areas*

Some degree of variability is always associated with collecting and analyzing environmental samples; therefore, variations in sample concentrations from year to year are expected. In general, radionuclide concentrations in soil samples collected from or adjacent to waste disposal facilities in 2012 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 2012 were higher in different operational areas when compared to concentrations measured in distant communities in previous years. Historically, 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-137, strontium-90, plutonium-238, plutonium-239/240, and uranium were detected consistently in the 2012 soil samples. Concentrations of these radionuclides were elevated near and within facility boundaries when compared to historical concentrations measured offsite at distant communities. Figure 9.1 shows the average concentrations of selected radionuclides in soil samples collected during 2012 and the preceding 4 years. Some individual levels demonstrate a high degree of variability, although overall trends are stable.

Table 9.3 provides a summary of selected analytical results for near-facility soil samples collected and analyzed. The average and maximum results were reported for six operational areas, along with comparative data for the preceding 5 years. Complete lists of radionuclide concentrations for all soil samples collected during 2012, as well as sampling location maps, are available upon request.

Soil samples collected in 2012 at locations in the 200-East Area, 200-West Area, 300 Area, and 600 Area 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; however, remained higher than those measured in the 200 Area. The higher uranium levels in the 300 Area were expected because of uranium releases to the environment during past fuel-fabrication operations. Plutonium-239/240 was found at higher levels in a number of soil samples in the 200 and 600 Areas. Uranium isotopes were also elevated in a small number of samples from the 200 and 600 Areas; the 200 and 600 Areas also had elevated levels of europium-155 in six samples, while the 300 and 400 Areas had slightly elevated levels of europium-155 in two samples. Cesium-137 levels were above historical levels in both the 200 and 600 Areas in 2011 and 2012, and are likely attributable to the radiological releases associated with the Fukushima nuclear plant incident in March of 2011.

Non-routine soil samples were collected from the 100 Areas in 2012 in support of environmental restoration contractor projects. One soil sample collected was from ERDF in the 200-West Area, and showed slightly elevated concentrations of cesium-137, plutonium-239/240, and uranium; however, were comparable to concentrations observed in previous years at other near-facility sampling locations on the Hanford Site. Four additional samples were collected in the 600 Area in support of the WCH 618-10 Remediation Project, and were comparable to previous years and similar to those listed for the ERDF samples. Table 9.4 provides a summary of selected analytical results for samples from these sites.

9.3 Radiological Contamination Investigations

MC Dorsey

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 Area and 200 Area 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.

Ten instances of radiological contamination in soil samples were collected in 2012 during the investigations. Of the 10, 6 were identified as speck contamination, and all were cleaned up and disposed onsite in licensed burial grounds. None of the soil samples were submitted for radioisotopic analysis. The number of soil investigation contamination incidents and range of radiation dose levels in 2012 were generally within historical values ([WHC-MR-0418](#), *Historical Records of Radioactive Contamination in Biota at the 200 Areas of the Hanford Site*). Table 9.5 summarizes the number and general locations of soil contamination incidents investigated during 2012. Table 9.6 provides the number of contamination incidents investigated from 1999 through 2012.

Figure 9.1. Hanford Site Soil Samples Average Concentrations of Selected Radionuclides
(2008 through 2012) 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.

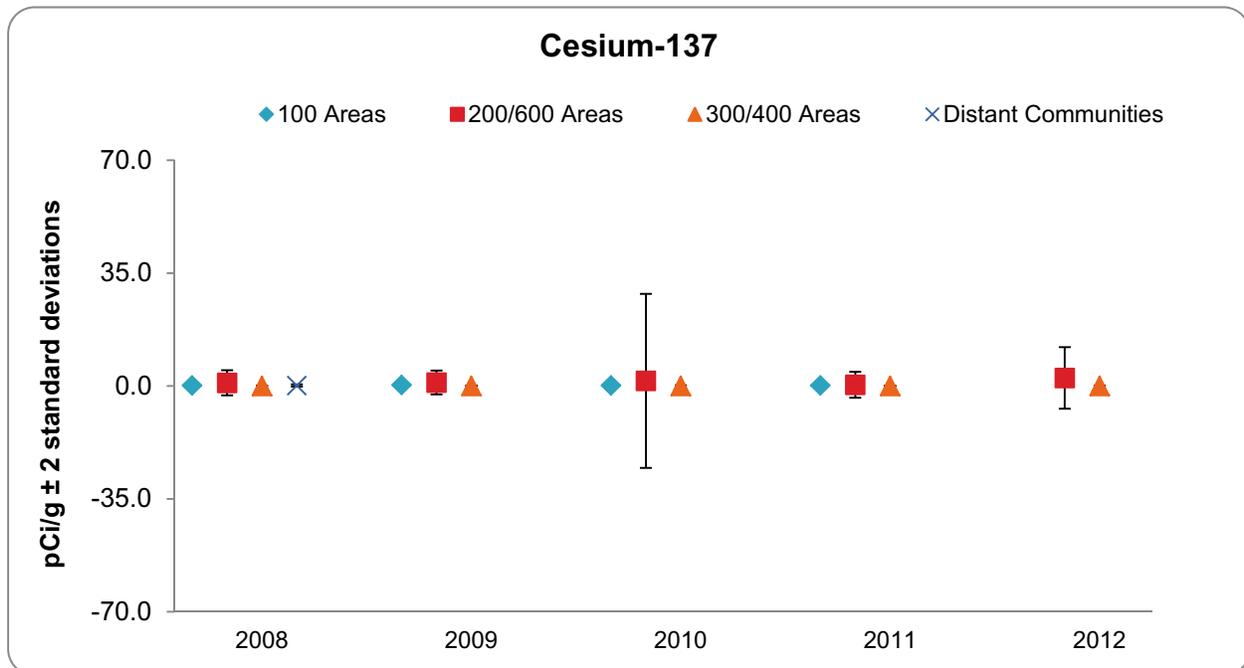


Figure 9.1. Hanford Site Soil Samples Average Concentrations of Selected Radionuclides (Cont.)

(2008 through 2012) 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.

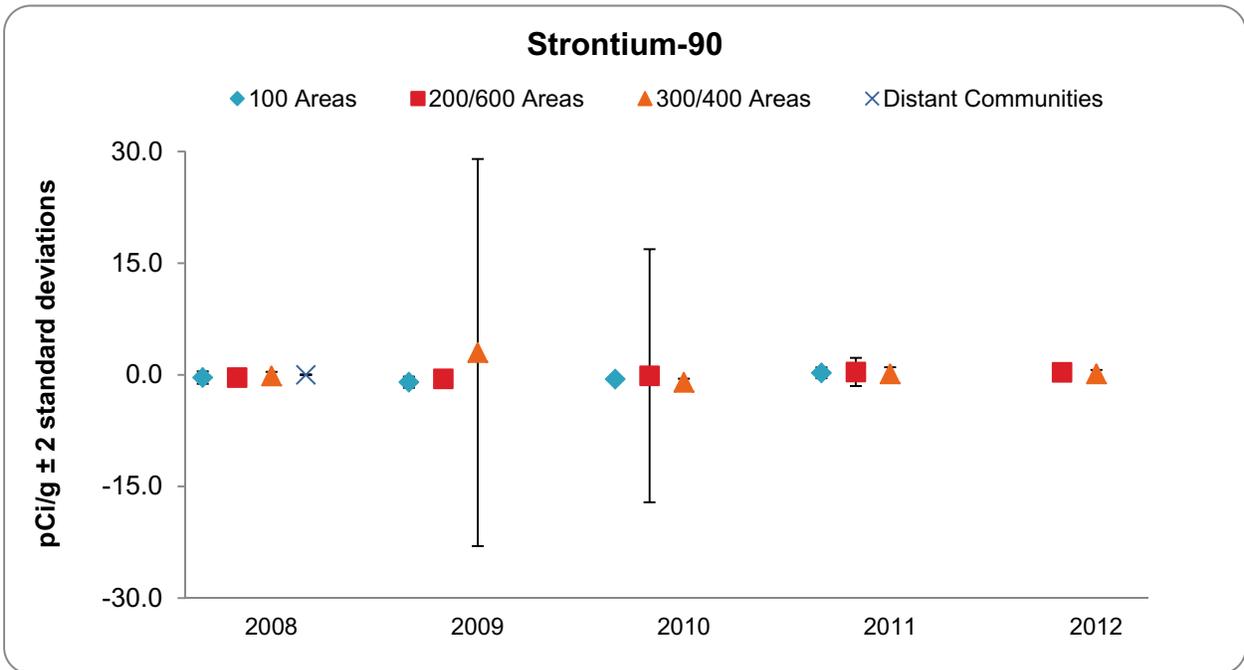
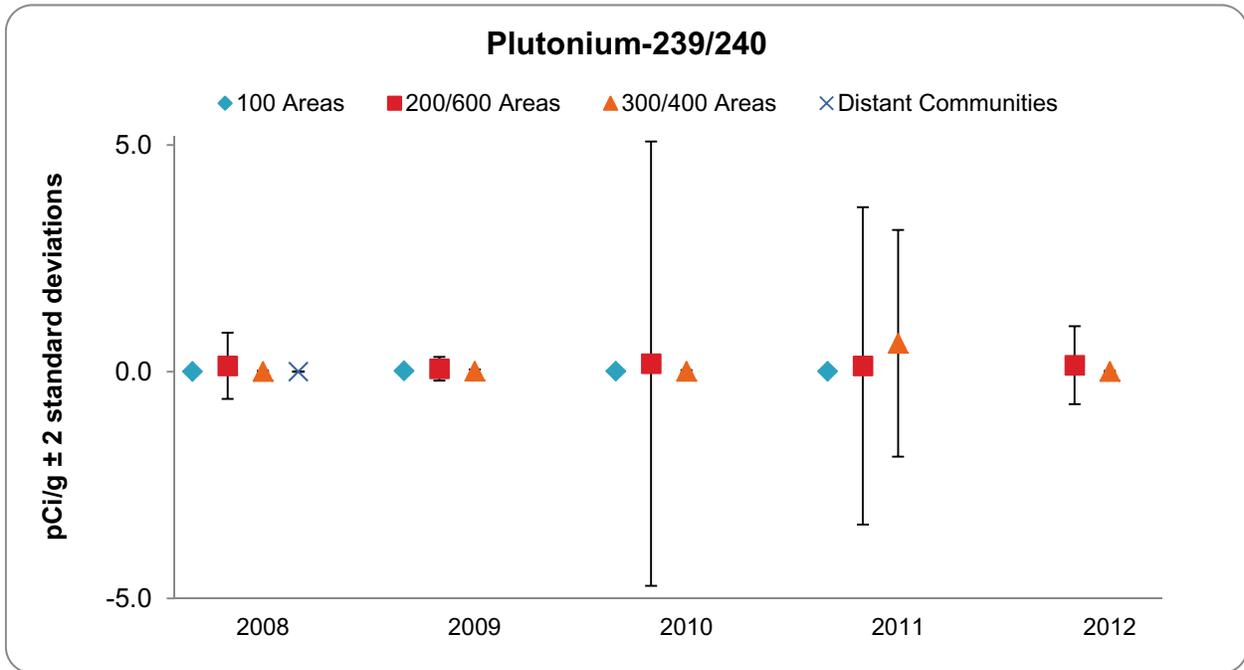


Figure 9.1. Hanford Site Soil Samples Average Concentrations of Selected Radionuclides (Cont.)

(2008 through 2012) 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.

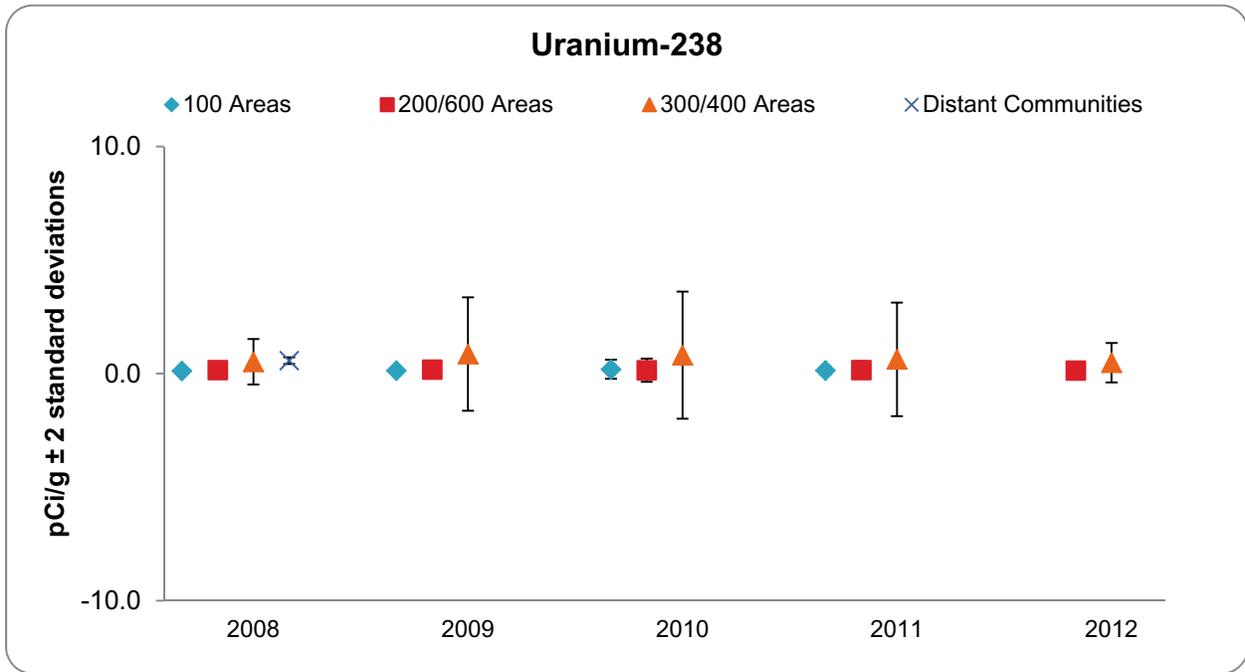


Table 9.3. Concentrations of Selected Radionuclides in Near-Field Soil Samples(pCi/g)
(2012 compared to previous years)

Radionuclide	Area	2012				2007 - 2011			
		Number of		Average ^a	Maximum ^b	Number of		Average ^a	Maximum ^b
		Samples	Detections			Samples	Detections		
Americium-241	300	4	3	5.3E-02 ± 1.0E-01	1.4E-01 ± 4.6E-02	4	2	1.5E-02 ± 2.3E-02	3.3E-02 ± 1.7E-02
Cobalt-60	200-East	6	0	-8.9E-04 ± 1.0E-02	9.1E-03 ± 1.1E-02 ^c	75	0	-7.8E-04 ± 8.9E-03	1.0E-02 ± 7.8E-03 ^c
	200-West	11	0	2.2E-05 ± 8.6E-03	8.4E-03 ± 9.2E-03 ^c	137	1	-9.9E-05 ± 9.0E-03	1.3E-02 ± 1.3E-02 ^c
	300	16	0	4.2E-05 ± 9.8E-03	1.2E-02 ± 1.4E-02 ^c	81	0	-1.5E-04 ± 7.6E-03	9.7E-03 ± 8.5E-03 ^c
	400	1	0	2.7E-03 ^d	2.7E-03 ± 5.9E-03 ^c	5	0	-1.5E-03 ± 8.5E-03	2.4E-03 ± 5.7E-03 ^c
	600	6	0	1.9E-03 ± 6.6E-03	6.4E-03 ± 6.4E-03 ^c	87	0	-1.5E-02 ± 2.8E-01	1.4E-02 ± 1.3E-02 ^c
Cesium-137	200-East	6	6	6.7E+00 ± 1.6E+01	2.0E+01 ± 2.7E+00	75	75	1.7E+00 ± 5.8E+00	1.4E+01 ± 2.2E+00
	200-West	11	11	1.2E+00 ± 2.2E+00	3.7E+00 ± 4.4E-01	137	135	1.3E+00 ± 3.5E+00	1.4E+01 ± 2.3E+00
	300	16	11	4.2E-02 ± 1.0E-01	2.1E-01 ± 3.6E-02	81	68	6.2E-02 ± 1.3E-01	3.6E-01 ± 6.4E-02
	400	1	1	1.3E-01 ^d	1.3E-01 ± 2.1E-02	5	5	2.9E-02 ± 1.3E-02	3.9E-02 ± 2.5E-02
	600	6	6	4.4E-01 ± 6.9E-01	9.0E-01 ± 1.2E-01	87	83	1.8E+00 ± 2.1E+01	9.4E+01 ± 1.7E+01
Plutonium-238	200-East	6	0	-1.0E-02 ± 9.3E-03	-5.8E-03 ± 1.5E-02 ^c	75	3	2.6E-03 ± 4.4E-02	1.2E-01 ± 5.5E-02
	200-West	11	0	6.6E-03 ± 2.2E-02	3.6E-02 ± 2.8E-02 ^c	137	10	9.9E-03 ± 5.9E-02	2.1E-01 ± 5.9E-02
	300	16	0	1.0E-03 ± 1.5E-02	1.3E-02 ± 1.5E-02 ^c	81	2	6.4E-04 ± 2.6E-02	4.1E-02 ± 3.8E-02 ^c
	400	1	0	6.9E-03 ^d	6.9E-03 ± 1.1E-02 ^c	5	0	-1.3E-02 ± 4.3E-02	1.0E-02 ± 1.3E-02 ^c
	600	6	0	-5.9E-04 ± 1.7E-02	8.7E-03 ± 1.6E-02 ^c	87	4	7.7E-03 ± 8.1E-02	3.7E-01 ± 1.1E-01
Plutonium-239/240	200-East	6	5	3.9E-02 ± 5.7E-02	8.3E-02 ± 3.5E-02	75	23	5.8E-02 ± 8.0E-01	3.5E+00 ± 7.7E-01
	200-West	11	10	2.6E-01 ± 1.2E+00	2.1E+00 ± 5.4E-01	137	105	1.9E-01 ± 1.4E+00	7.3E+00 ± 1.9E+00
	300	16	4	2.3E-02 ± 1.0E-01	2.0E-01 ± 6.8E-02	81	25	1.2E-02 ± 3.2E-02	7.6E-02 ± 2.8E-02
	400	1	1	2.8E-02 ^d	2.8E-02 ± 1.6E-02	5	0	2.6E-03 ± 5.7E-03	6.7E-03 ± 1.0E-02 ^c
	600	6	3	2.1E-02 ± 3.5E-02	5.4E-02 ± 2.6E-02	87	44	1.0E-01 ± 1.1E+00	4.9E+00 ± 1.3E+00
Strontium-90	200-East	6	4	6.7E-01 ± 9.1E-01	1.4E+00 ± 3.4E-01	75	7	-4.3E-02 ± 4.1E+00	1.7E+01 ± 2.2E+00
	200-West	11	2	2.1E-01 ± 4.1E-01	5.8E-01 ± 2.9E-01 ^c	137	21	-1.4E-01 ± 2.4E+00	1.1E+01 ± 1.4E+00
	300	16	0	6.8E-02 ± 4.0E-01	3.9E-01 ± 3.2E-01 ^c	81	5	4.6E-01 ± 1.2E+01	5.5E+01 ± 7.1E+00
	400	1	0	6.5E-01 ^d	6.5E-01 ± 4.6E-01 ^c	5	0	-3.7E-01 ± 1.1E+00	2.8E-01 ± 2.6E-01 ^c
	600	6	2	2.1E-01 ± 2.7E-01	3.5E-01 ± 2.8E-01 ^c	87	8	-2.1E-01 ± 1.0E+00	1.2E+00 ± 4.6E-01

Table 9.3. Concentrations of Selected Radionuclides in Near-Field Soil Samples*(pCi/g)
(2012 compared to previous years)*

Radionuclide	Area	2012				2007 - 2011			
		Number of		Average ^a	Maximum ^b	Number of		Average ^a	Maximum ^b
		Samples	Detections			Samples	Detections		
Uranium-234	200-East	6	5	1.3E-01 ± 7.1E-02	1.9E-01 ± 5.9E-02	75	75	1.5E-01 ± 8.4E-02	2.5E-01 ± 8.2E-02
	200-West	11	6	1.2E-01 ± 6.7E-02	1.9E-01 ± 6.1E-02	137	137	1.6E-01 ± 1.2E-01	4.3E-01 ± 1.2E-01
	300	16	16	3.5E-01 ± 8.1E-01	1.4E+00 ± 3.8E-01	81	81	7.2E-01 ± 1.9E+00	5.0E+00 ± 1.3E+00
	400	1	1	7.4E-01 ^d	7.4E-01 ± 2.1E-01	5	5	1.6E-01 ± 1.1E-01	2.4E-01 ± 7.4E-02
	600	6	5	1.4E-01 ± 7.2E-02	2.0E-01 ± 6.7E-02	87	87	1.7E-01 ± 1.4E-01	6.4E-01 ± 1.8E-01
Uranium -235	200-East	6	2	1.2E-02 ± 1.8E-02	2.6E-02 ± 1.6E-02	75	40	1.3E-02 ± 1.3E-02	3.3E-02 ± 1.9E-02
	200-West	11	5	8.2E-03 ± 1.6E-02	2.2E-02 ± 1.5E-02	130	69	1.5E-02 ± 2.1E-02	5.2E-02 ± 2.8E-02
	300	16	8	2.0E-02 ± 5.0E-02	8.9E-02 ± 3.6E-02	81	58	4.8E-02 ± 1.1E-01	2.7E-01 ± 8.6E-02
	400	1	1	5.8E-02 ^d	5.8E-02 ± 2.7E-02	5	3	1.5E-02 ± 1.6E-02	2.9E-02 ± 1.8E-02
	600	6	2	1.0E-02 ± 1.3E-02	2.3E-02 ± 1.6E-02	77	38	1.4E-02 ± 1.9E-02	6.1E-02 ± 2.7E-02
Uranium-238	200-East	6	5	1.4E-01 ± 5.9E-02	1.8E-01 ± 6.3E-02	75	75	1.6E-01 ± 8.1E-02	2.5E-01 ± 8.0E-02
	200-West	11	6	1.3E-01 ± 5.5E-02	2.0E-01 ± 6.3E-02	137	137	1.6E-01 ± 1.3E-01	4.5E-01 ± 1.3E-01
	300	16	16	3.6E-01 ± 8.0E-01	1.4E+00 ± 3.8E-01	81	80	7.2E-01 ± 1.9E+00	4.9E+00 ± 1.3E+00
	400	1	1	9.3E-01 ^d	9.3E-01 ± 2.5E-01	5	5	1.6E-01 ± 7.2E-02	2.1E-01 ± 6.9E-02
	600	6	5	1.5E-01 ± 7.9E-02	2.2E-01 ± 6.9E-02	87	87	1.7E-01 ± 1.2E-01	5.1E-01 ± 1.5E-01

^a Average ± two standard deviations^b Maximum ± analytical uncertainty^c Maximum value reported is a non-detect^d Standard deviation cannot be calculated for one sample.

Table 9.4. Radionuclide Concentrations in River Corridor Cleanup Contractor Projects' Soil Samples
pCi/g^(a) dry wt.^(b)

Project/Facility	Location ^c	Date	Cobalt-60	Strontium-90	Cesium-137	Uranium-234	Uranium-238	Plutonium-239/240
618-10 Field Remediation	D179	3/30/12	1.7E-03±9.5E-03	-3.2E-02±2.4E-01	2.1E-01±3.6E-02	1.0E-01±3.9E-02	9.7E-02±3.7E-02	1.0E-02±1.1E-02
	D180	3/30/12	1.2E-02±1.4E-02	1.2E-02±1.2E-01	4.3E-02±1.7E-02	1.2E-01±4.6E-02	1.4E-01±4.8E-02	2.0E-02±1.4E-02
	D181	3/30/12	3.8E-03±1.2E-02	8.3E-02±2.8E-01	5.2E-02±2.2E-02	1.0E-01±3.8E-02	9.9E-02±3.8E-02	2.0E-01±6.8E-02
	D182	3/30/12	-3.1E-03±5.2E-03	-9.2E-03±9.2E-02	7.2E-02±1.4E-02	1.2E-01±4.4E-02	1.2E-01±4.3E-02	9.3E-02±3.7E-02
ERDF	D146	8/15/12	-2.8E-03±4.9E-03	2.8E-03±2.8E-02	1.8E-02±7.7E-03	1.5E-01±5.4E-02	1.3E-01±4.5E-02	2.1E-03±7.2E-03
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 soils that are not behind security fences.

Table 9.5. Soil Contamination Incidents Investigated

Location	2012 Incidents
100 Area	0
200-East Area	
Tank farms	5
Burial grounds	2
Cribs, ponds, and ditches	0
Fence lines	0
Roads and railroads	0
Unplanned release sites	0
Underground pipelines	0
Miscellaneous	2
200-West Area	
Tank farms	1
Burial grounds	0
Cribs, ponds, and ditches	0
Fence lines	0
Roads and railroads	0
Unplanned release sites	0
Underground pipelines	0
Miscellaneous	0
Cross-site transfer line	0
200-BC cribs and trenches	0
200-North Area	0
300 Area	0
400 Area	0
600 Area	0
TOTAL	10

Table 9.6. Soil Contamination Incidents Investigated

Year	Incidents	Year	Incidents
1999	42	2006	25
2000	25	2007	17
2001	20	2008	16
2002	22	2009	28
2003	30	2010	22
2004	19	2011	10
2005	20	2012	10

10.0 Biota Monitoring

10.1 Agricultural Monitoring

ME Hoefler

Food and farm products (alfalfa, cherries, leafy vegetables, milk, potatoes, tomatoes, and wine) were collected in 2012 at locations near the Hanford Site (Figure 10.1). Samples analyzed to determine radiological contaminant concentrations were obtained from the following locations:

- Generally downwind (east and southeast) of the Hanford Site where airborne emissions or contaminated dust from the site potentially would be deposited
- 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 comparing:

- Analytical results obtained from similar samples collected from the same regions over long periods of time
- Analytical results from samples collected at downwind locations to results from samples obtained from generally upwind or distant locations
- 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 2012 were below levels that could be detected by analytical laboratories; however, some contaminants that potentially could have originated from the Hanford Site (e.g., tritium and uranium) were found at low levels in some samples. These findings are 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 4.0. 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](#)).

Agricultural products sampled in 2012 are listed in Table 10.1, and described in the following sections.

Figure 10.1. Agricultural Monitoring Locations

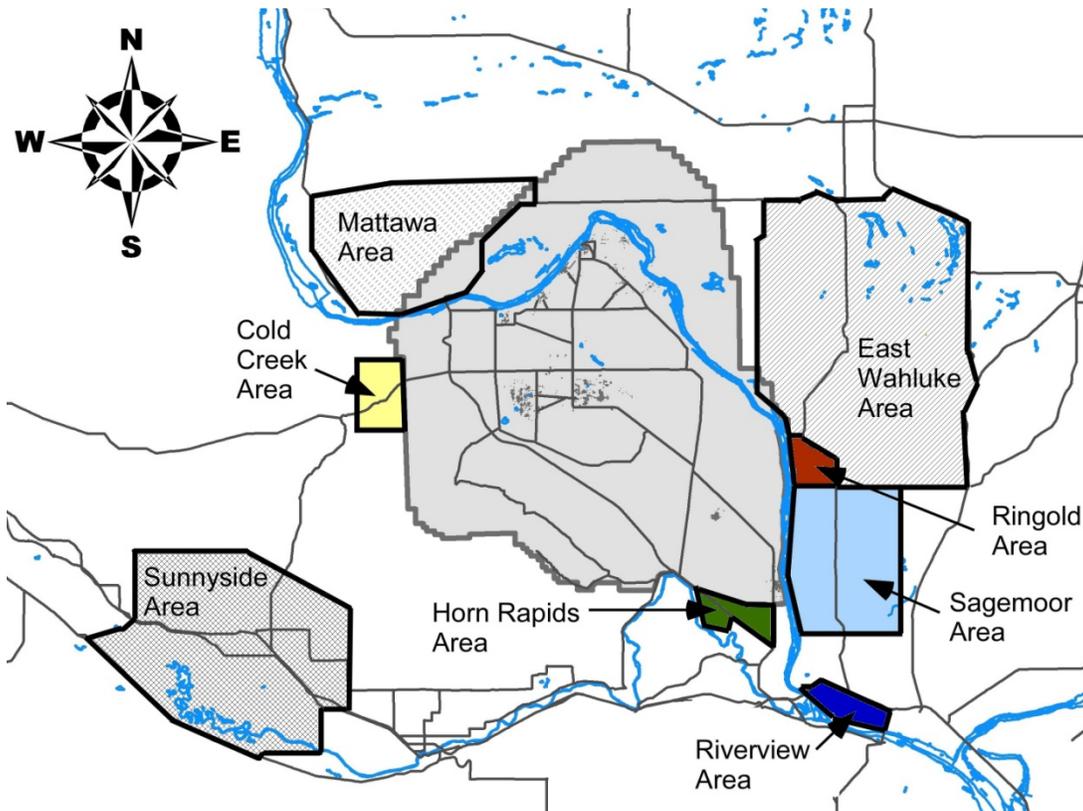


Table 10.1. Agricultural Monitoring

Product	Sampling Locations	Analytes
Milk	East Wahluke, Sagemoor, and Sunnyside	Gamma, Strontium-90, Tritium
Apples	Mattawa, Sagemoor, and Sunnyside	Gamma, Strontium-90
Leafy Vegetables	Riverview, Sagemoor, and Sunnyside	Gamma, Strontium-90
Potatoes	East Wahluke, Riverview, Sagemoor, and Sunnyside	Gamma, Strontium-90
Tomatoes	Riverview and Sunnyside	Gamma, Strontium-90, Tritium

10.1.1 Milk

Milk samples were obtained quarterly in 2012 from several dairies in the East Wahluke sampling area, 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 Hanford Site are now similar to levels measured in samples obtained from the dairy generally upwind of the Hanford Site.

Tritium – Tritium was detected in all milk samples collected in 2012. Concentrations ranged from a maximum of 55 pCi/L (2.0 Bq/L) in a Sagemoor area sample to 19 pCi/L (0.70 Bq/L) in a Sunnyside area sample. Annual average concentrations for the three sampling areas were 43 pCi/L (1.6 Bq/L) for Sagemoor (n = 5); 29 pCi/L (1.1 Bq/L) for East Wahluke (n = 4); and 29 pCi/L (1.1 Bq/L) for Sunnyside (n = 4). These are lower concentrations than historically measured in these areas.

Strontium-90 – Strontium-90 was not measured at detectable concentrations in any milk samples collected in 2012.

Cesium-137 – No manmade gamma emitters were detected in milk samples collected and analyzed in 2012.

10.1.2 Fruit and Vegetables

Apples, leafy vegetable (e.g., lettuce), potato, and tomato samples were collected from upwind and downwind sampling areas during the 2012 growing season (Figure 10.1). All samples were analyzed for gamma-emitting radionuclides and strontium-90. Tomato samples were also monitored for tritium (Table 10.1). All fruit and vegetable concentrations of gamma-emitting radionuclides, strontium-90 and tritium were reported as non-detects and were well within historical range.

10.2 Animal Monitoring

JW Wilde and CT Lindsey

In 2012, the fish and wildlife species sampled and analyzed for Hanford Site operations-produced contaminants included Smallmouth bass (*Micropterus dolomieu*), Mule Deer (*Odocoileus hemionus*), Elk (*Cervus elaphus*), and California quail (*Callipepla californica*). Monitoring fish and wildlife for uptake and exposure to Hanford Site operations-produced contaminants ensures that consumption of fish and wildlife obtained from Hanford Site environs does not pose a threat to human health, while providing long-term contamination trends. These species were selected and monitored because the species provide a potential pathway for offsite human consumption. Figure 10.2 shows the locations on and around the Hanford Site where fish and wildlife were collected. Samples from the fish and wildlife were analyzed for selected (suspected or known to be present at the Hanford Site) radionuclides and metals (Table 10.2). In addition, samples were collected from locations distant from the Hanford Site to obtain reference (background) contaminant measurements. All fish and wildlife samples were monitored for strontium-90 contamination and analyzed by gamma spectrometry to detect a number of gamma emitters, including cesium-137 (refer to Appendix D). Since the 1990s, strontium-90 and cesium-137 have been the most frequently measured radionuclides in fish and wildlife samples.

Most fish and wildlife samples are collected on and around the Hanford Site and analyzed for human-pathway exposure every 2 to 3 years, with samples obtained at locations determined not to be affected by Hanford Site effluents and emissions approximately every 5 years.

Table 10.2. Animal Monitoring Sample Analysis

Biota	Offsite Locations	Onsite Locations	Gamma	Strontium-90	Trace Metals
Fish (Smallmouth bass)	1	3	10	9	2
Large game (deer and elk)	1	7	20	10	9
Upland game birds (quail)	1	2	7	7	0

Strontium-90 is present in Hanford Site environments because of past Hanford Site operations and waste disposal practices. Contaminated groundwater entering the Columbia River through shoreline springs in the 100-N and 100-H Areas, is the primary source of measurable Hanford Site-produced strontium-90 in the Columbia River. 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, *Ecotoxicity Literature Review of Selected Hanford Site Contaminants*).

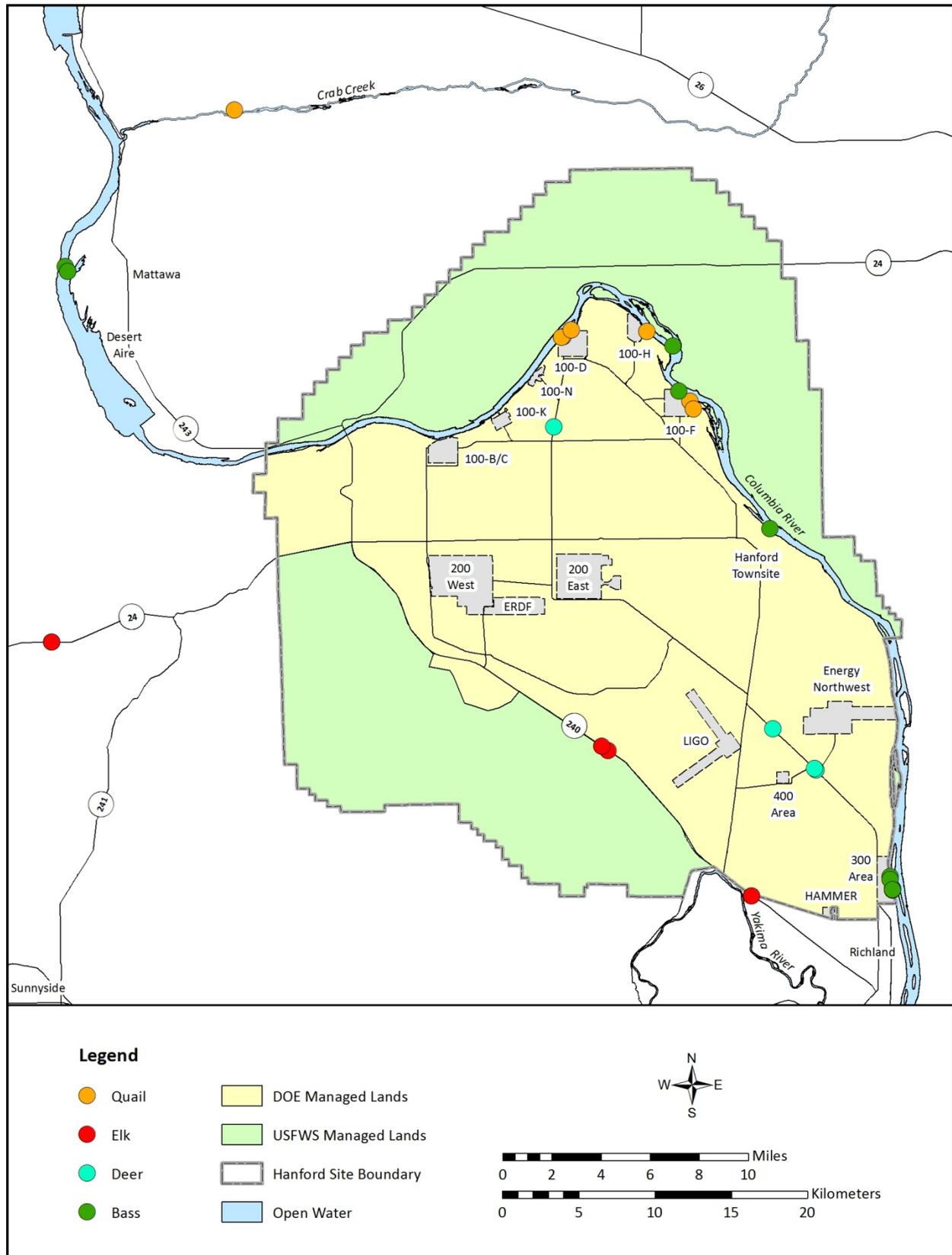
Hard-tissue concentrations may profile an organism's lifetime exposure to strontium-90; however, since strontium-90 does not accumulate in the edible portions of fish and wildlife, strontium-90 generally does not contribute much to the human dose (National Council on Radiation Protection and Measurements, 1991).

Cesium-137 is present in Hanford Site environments because of past Hanford Site operations, waste disposal practices, and from historical worldwide fallout resulting from nuclear weapons testing. Cesium-137 is particularly important to the human food chain because cesium-137 is chemically similar to potassium, and is found in the muscle tissues of fish and wildlife. Cesium-137 is an indicator of recent exposure to radioactive materials, because cesium-137 has a relatively short biological half-life (less than 200 days in muscle, and less than 20 days in the gastrointestinal tract (PNL-9394).

Gamma spectrometry results for most radionuclides generally are 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 analytical laboratory detection levels.

A number of trace metals associated with Hanford Site operations have a potential to accumulate in certain fish and wildlife tissues. These metals are contaminants of potential concern (e.g., copper, lead, and mercury), particularly along the Hanford Site Columbia River shoreline where contaminated groundwater flows into the river. Hanford Site historical operations have resulted in the production of both radiological and non-radiological wastes, including trace-metal emissions in a variety of forms. Including liquid and solid wastes that were placed in disposal sites (trenches, cribs, ditches, ponds, and underground storage tanks), and fly ash (produced from burning coal in coal-fired steam/power plants associated with some Hanford Site reactors) released to the atmosphere. The fly ash contains trace metals and natural radionuclides that may have deposited on soil surfaces around the 100 Area reactors.

Figure 10.2. Animal Monitoring Locations



10.2.1 Smallmouth Bass

In 2012, smallmouth bass were sampled and analyzed for radiological contaminants, since smallmouth bass are sometimes harvested for food along the Hanford Reach of the Columbia River, which could potentially contribute to human exposure through digestion. Smallmouth bass are a predatory fish that feed on invertebrates and smaller fish that may be exposed to trace metals and persistent radionuclides in the Columbia River environment through food sources.

Ten smallmouth bass samples were collected from three locations along the Hanford Reach, including a reference location (two from the region known as the Hanford Slough, four from the areas around the 300 Area, and one from the 100 Areas). The following are the radiological results for the 10 smallmouth bass:

Cesium-137. Manmade gamma-emitting radionuclides, including cesium-137, were not detected above the reporting limit (0.03 pCi/g [0.001 Bq/g] wet weight) in any of the muscle samples analyzed. These results are consistent with those reported historically 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 smallmouth bass samples collected from the reference area and the three Hanford Reach locations.

Trace Metals. Two bass samples were analyzed for 17 different trace metal concentrations. Only mercury, selenium, thorium, and zinc were detected above the analytical detection limit at any location. Table 10.3 provides a summary of the 2012 metal analyses for the smallmouth bass samples.

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.

Table 10.3. Metals Analyses for the Smallmouth Bass Samples

Isotope	Samples	Detects
Aluminum	2	0
Antimony	2	0
Arsenic	2	0
Beryllium	2	0
Cadmium	2	0
Chromium	2	0
Copper	2	0
Lead	2	0
Manganese	2	0
Mercury	2	2
Nickel	2	0
Selenium	2	2
Silver	2	0
Thallium	2	0
Thorium	2	2
Uranium	2	0
Zinc	2	2

10.2.2 Deer and Elk

Deer and elk can be exposed to metals and persistent radionuclides when they forage on plants where roots have access to contaminated groundwater or soil, drink contaminated water, or incidentally ingest contaminated soil. Deer and elk 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 large mammal movements. In 2012 the Hanford Environmental Surveillance Program collected deer and elk by opportunistic means, road strikes, rather than hunting site animals. Deer and elk have been captured and tagged at the Hanford Site that were 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.

A total of four elk and four deer were collected from vehicle collisions with animals. All samples were collected when the location led investigators to believe the herd could contact Hanford Environs. Radionuclide levels in the eight animals collected at the Hanford Site in 2012 were compared to levels found in one elk collected by the Washington Department of Fish and Wildlife near North Bend, Washington. Results from deer collected in 2012 were compared to samples collected in previous years from background locations distant from the site and to results reported for deer and elk collected from the Hanford Site over the past 12 years.

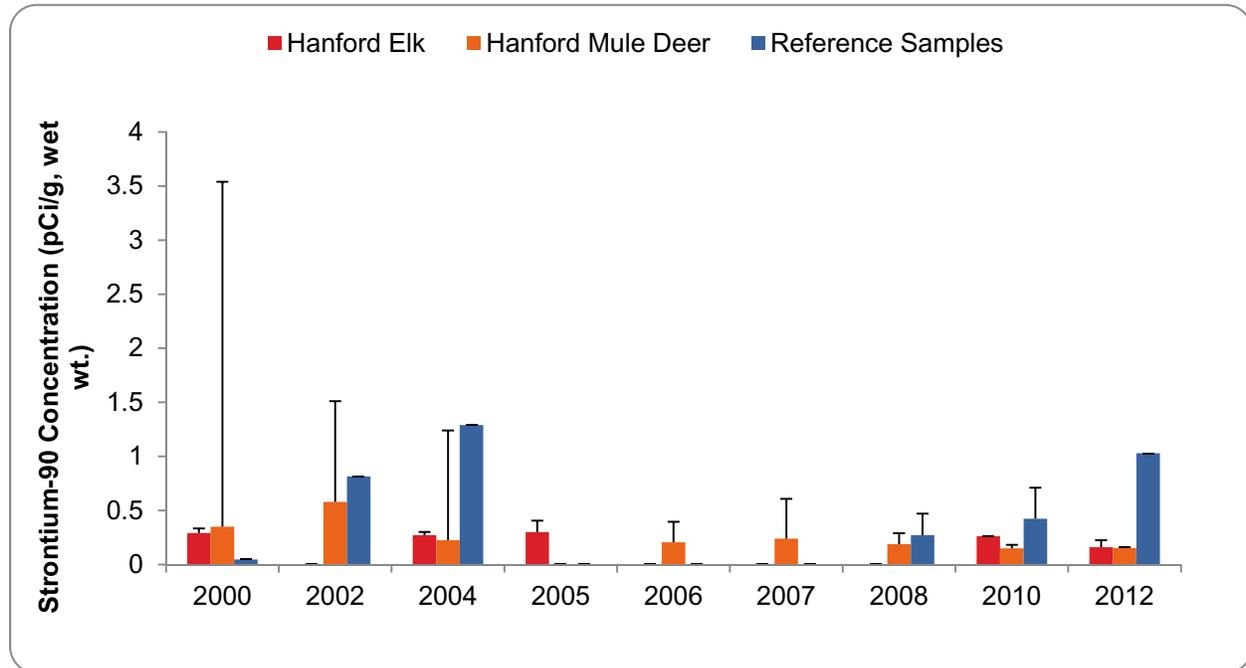
Cesium-137. Cesium-137 was detected in the muscle tissue collected at the background location near Deer Park (0.147 pCi/g [0.0054 Bq/g] wet weight). Cesium-137 was not found above detection limits (0.03 pCi/g [0.001 Bq/g] wet weight) in the other deer muscle samples submitted for analysis in 2012. These results are consistent with a decline in cesium-137 levels in wildlife examined from the preceding 10 years.

Strontium-90. Concentrations of strontium-90 detected in deer bone samples collected at the Hanford Site in 2012 ranged from 0.12 pCi/g (0.0044 Bq/g) wet weight to 0.219 pCi/g (0.0081 Bq/g) wet weight. Strontium-90 concentrations measured in bone samples from the reference location was 1.03 pCi/g (0.038 Bq/g) wet weight; the highest strontium value of samples measured in 2012 (both on and off site) was found in the elk bone collected near North Bend, Washington (Figure 10.3).

Trace Metals. Trace metals were analyzed in mule deer and elk liver samples collected from Hanford Site samples and the reference location. Concentrations measured in deer and elk liver samples were compared to historical concentrations reported for the Hanford Site.

Seven metals (aluminum, cadmium, chromium, copper, manganese, selenium and thorium) were found above analytical detection limits in 2012. With the exception of aluminum and thorium, all other trace-metal concentrations in 2012 were similar to, or less than, the levels previously reported for deer and elk collected on the Hanford Site and at reference locations. Thorium levels in 2012 were elevated above those previously reported for both the reference and Hanford Site sampling locations. Aluminum was elevated compared to historical aluminum levels reported for the Hanford Site data but only slightly above reference locations collected in 2012.

Figure 10.3 shows the historical median and maximum strontium-90 concentrations (pCi/g wet weight) in deer and elk bone samples collected near the Hanford Site and from reference locations since 2000.

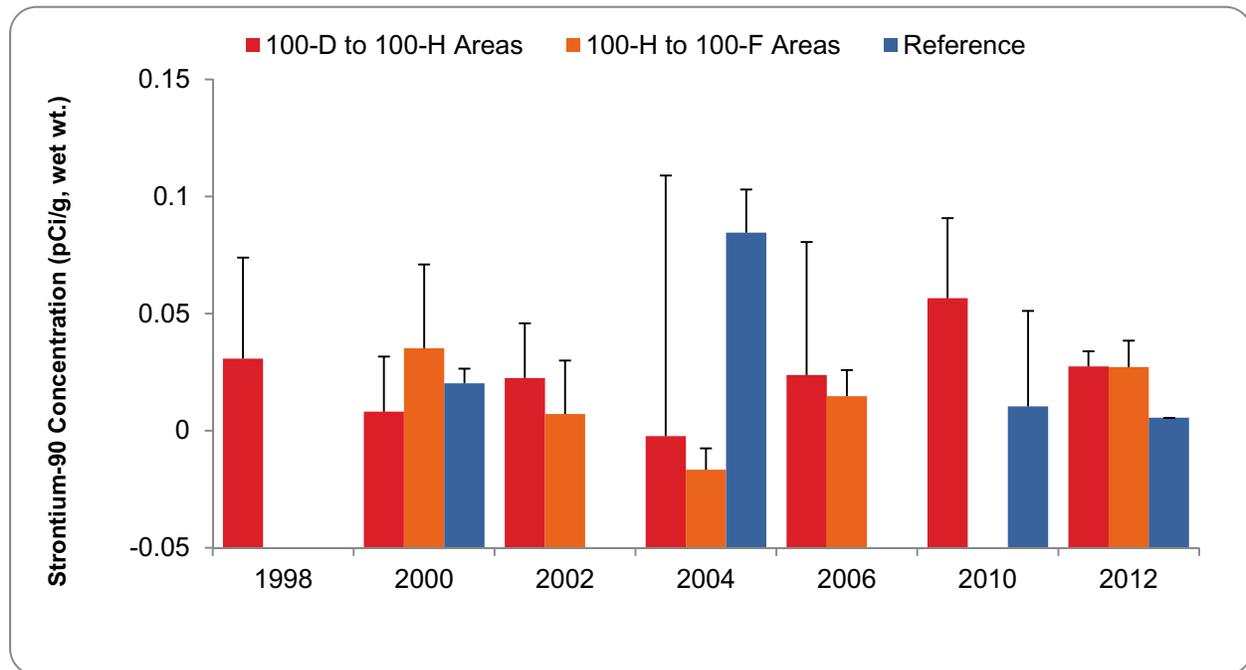
Figure 10.3. Strontium-90 Concentrations in Deer and Elk Bone Samples*Maximum concentrations are represented by the upper bar.*

10.2.3 Upland Game Bird Analytical Results

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 and three more in the region between 100-H and 100-F Areas in 2012. One additional reference sample was collected from a background location near the Crab Creek Wildlife Area in Grant County. All quail were monitored for cesium-137 in muscle and strontium-90 in bone. Radionuclide levels found in muscle and bone samples analyzed during 2012 were compared to levels measured in upland game bird samples collected at the Hanford Site during the past 10 years, and to samples collected from reference locations in 2000, 2004, 2010 and 2012.

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 2012. 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 2012. Comparisons of the maximum and median strontium-90 concentrations reported for game bird bone samples collected at the Hanford Site since 1998 and reference locations are consistent with these results which do not indicate elevated levels of strontium-90. Figure 10.4, shows the median and maximum strontium-90 concentrations (pCi/g wet weight) and reference quail bone samples for 2012 compared to previous years.

Figure 10.4. Strontium-90 Concentrations in Quail Bone Samples*Maximum concentrations are represented by the upper bar.*

10.2.4 Porcupine Impact Assessment

Woody vegetation occurring along the shorelines of the Columbia River has long been identified as a potential pathway for transport of Hanford Site contaminants from the groundwater into the surface environment ([PNNL-13692](#); [PNL-10711](#), *Location Analysis and Strontium-90 Concentrations in Deer Antlers on the Hanford Site*; [Tiller and Poston 2000](#), *Mule Deer Antlers as Biomonitors of Strontium-90 on the Hanford Site*). Porcupines are relatively common residents along the Columbia River and feed on the bark, leaves, and cambium of woody plants ([Fitzner and Gray 1991](#), *Status, Distribution, and Ecology of Wildlife on the U.S. DOE Hanford Site: A Historical Overview of Research Activities*; [Tenneson and Oring 1985](#), *Winter Food Preferences of Porcupines*). As such, porcupines may be good sentinel indicators of localized contamination from Hanford Site releases because of their relatively limited home range (5-25 hectares [12-62 acres]) and long lifespan (15 years). However, little to no contaminant data exists for porcupines residing on or near the Hanford Site. A small-scale sampling effort was initiated during 2012 to obtain co-located samples of tree bark/cambium tissue and porcupine tissue concentrations of strontium-90 and trace metals from the riparian zone of the Columbia River near the 100-Areas of the Hanford Site.

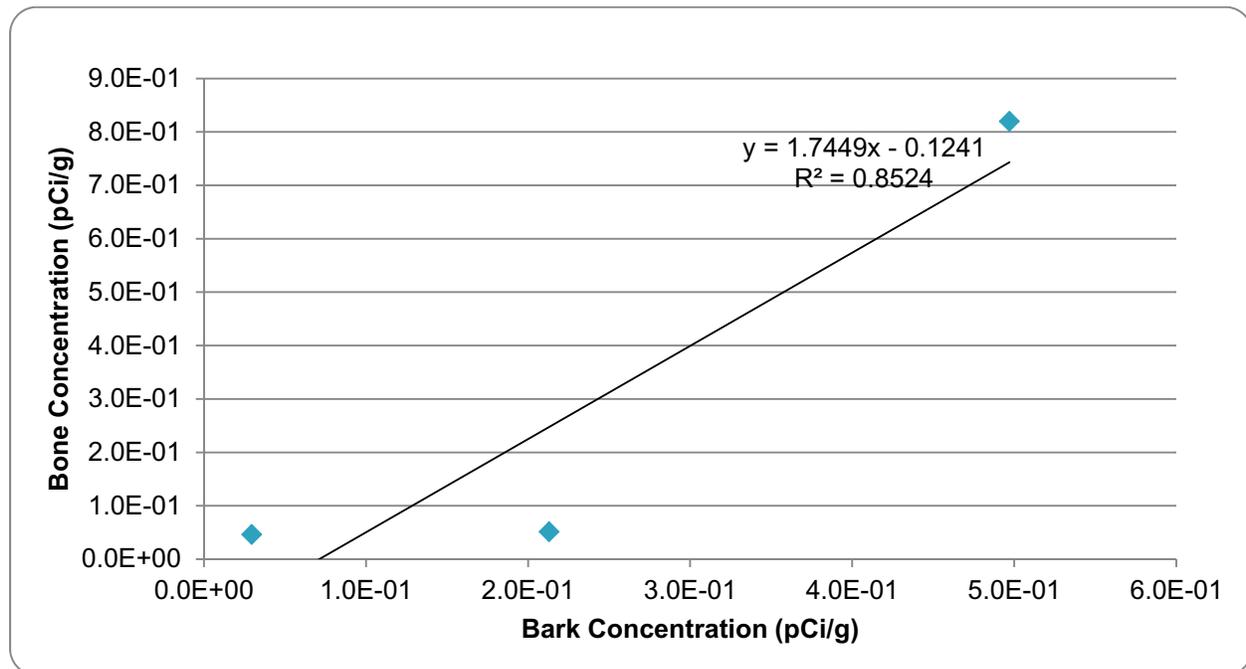
The primary goal of this effort was to determine strontium-90 and trace metal levels in woody vegetation and a mammalian consumer (such as porcupines) of the woody vegetation, and to examine whether porcupines would be a good indicators of regional environmental contamination within the riparian zone of the Columbia River near the 100 Areas of the Hanford Site. Another goal was to determine whether porcupine quills (modified hairs) could be used as a suitable non-lethal indicator of strontium-90 and/or trace metal levels in porcupines. This effort also provided results that may be useful for ongoing Hanford Site environmental monitoring, remedial investigations, risk assessments, and/or injury assessments that need to consider 'onsite measures' of biological uptake or vegetation-to-mammal strontium-90 biological concentration factors.

Sampling areas were selected based on the presence of contaminated groundwater plumes along the shorelines of the Columbia River, and sample results reported during prior sampling events that showed uptake and/or accumulation of strontium-90 and trace metals in vegetation and mammals ([DOE/RL-2006-26](#), *Aquatic and Riparian Receptor Impact Information for the 100-NR-2 Groundwater Operable Unit*; [DOE/RL-2007-21](#),

River Corridor Baseline Risk Assessment). A multiple increment sampling design was used to help obtain sample results that were representative of each general area.

Three porcupines were located and sampled for strontium-90 and trace metals during the 2012 sampling effort. These samples were designated Porcupine 1, Porcupine 2, and Porcupine 4. Porcupine 3 was a duplicate sample taken from Porcupine 2. Strontium-90 was detected in both tree bark and porcupine bone collected from 2 of the 3 samples collected. Strontium-90 concentrations in samples of porcupine bone tissues ranged from below the analytical detection limit (0.05 pCi/g fresh weight) up to 0.8 pCi/g (fresh weight). Concentrations of strontium-90 were also detected in two of the three tree bark samples and results ranged from below the analytical detection limit (0.05 pCi/g fresh weight) up to (0.5 pCi/g fresh weight). A positive relationship for strontium-90 was observed between co-located samples of bark and bone (Figure 10.5).

Figure 10.5. Strontium-90 Levels Observed in Co-located Porcupine Bone and Tree Bark Samples



One porcupine was collected in an area with strontium-90 contaminated groundwater. Strontium-90 was detected in both the tree bark and porcupine bone collected from this location, showing a likely pathway for this contaminant from the groundwater through the trees and to the porcupines. The corresponding levels reported in the bone and bark from this area were 0.82 pCi/g (bone) and 0.50 pCi/g (bark) but were not detectable in the quills (less than 0.05pCi/g.). Strontium-90 levels in the quills were expected to be a small percentage of the level in the bone. The data from this effort suggested that there may be a correlation between some metal levels observed in the quills and liver of porcupines. When metals such as copper, manganese, selenium and zinc were detected in the liver of an individual, they were also detected in the quills. The quill samples often contained higher levels than the liver samples for aluminum, chromium, selenium, manganese and zinc. This indicates that non-lethal quill collections could be used to assess accumulation of some trace metals in porcupines. Due to the low mass requirement for metals analysis (around .035 ounce [1 gram]) it is reasonable that the required number of quills (about 40) could be retrieved from a porcupine without difficulty.

Although uptake of strontium-90 by porcupines was demonstrated in this assessment, all concentrations reported for bark, quills, and liver were below the values listed in (DOE/RL-2007-21, Table 8-9, *Summary of Lowest Observable Adverse Effect Level (LOEL) Based Tier 1 Refined Ecological Preliminary Remediation Goals for Wildlife*). Based on this limited sampling effort, it does not appear that porcupines feeding on woody vegetation within the 100 Area shorelines of the Columbia River were experiencing greater exposure

than was estimated for their guild (riparian herbivorous mammal) in the River Corridor Baseline Risk Assessment ([DOE/RL-2007-21](#)). Additional sampling of bark in areas with the highest known groundwater contaminant concentrations could show whether porcupines consume materials with higher contaminant loads than were observed during this study. Additional information detailing this monitoring effort is available in the *Calendar Year 2012 Assessment of Porcupines and Woody Vegetation in the 100 Areas of the Hanford Site* ([HNF-54680](#)).

10.3 Plant Monitoring

Plant monitoring conducted on and around the Hanford Site in 2012 is summarized in this section. Included are discussions of surveys and monitoring of Hanford Site plant populations, monitoring contaminants in perennial vegetation growing near facilities and operations, and control of contaminated or unwanted vegetation.

Plant populations and habitats that occur on the Hanford Site are surveyed and monitored to assess the abundance, vigor or condition, and distribution of populations and species. These data can be integrated with contaminant monitoring results and used to help characterize potential risks or impacts to biota. Vegetation near onsite facilities and operations is monitored for radiation to determine the effectiveness of effluent monitoring and controls within facilities, assess the adequacy of containment at waste disposal sites, and detect and monitor unusual conditions. Hanford Site 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, refer to Section 10.4 or [DOE/RL-91-50](#).

10.4 Vegetation Monitoring

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Monitoring of rabbitbrush and sagebrush leaves and stems provides information about atmospheric deposition of radioactive materials in uncultivated areas and at Hanford Site locations that potentially could 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 releases from the Hanford Site can be compared.

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 through the roots of vegetation growing on or near former waste disposal sites.

The number and location of Hanford Site vegetation samples collected during 2012 are summarized in Table 10.4. Only those radionuclides with concentrations consistently above analytical detection limits are discussed in this section. Data obtained from on-site vegetation samples is used as a qualitative indicator and verification of ambient air sampling results per the [FF-01, Hanford Site Radioactive Air Emissions License](#). Vegetation samples from offsite locations were last collected in 2008 ([PNNL-18427, Hanford Site Environmental Surveillance Data Report for Calendar Year 2008](#)).

Individual vegetation samples (approximately 17.6 ounces [500 grams]) consisted of new-growth leaf cuttings taken from the available brushy, deep-rooted species (e.g., sagebrush and/or rabbitbrush). To avoid decimation of any individual plant through overharvesting, often a sample consisted of mixed biota representing several

like members of the sampling-site plant community. Vegetation samples were dried prior to analyses, and analytical results were reported on a dry weight basis.

Some vegetation samples were analyzed as single parent samples (discrete electronic data points) while others were composited with the following approach: A multi-incremental sampling technique is used when collecting samples from a large given area (i.e., a decision unit). Individual samples are processed using a gridded pattern approach and combined with other samples from the decision unit to create a composite sample that represents the decision unit as a whole. This compositing limits the variability of selected environmental contaminant concentrations in a given area and reduces the amount of sampling error due to heterogeneity while allowing for a reproducible mean concentration for the decision unit.

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 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.

Table 10.4. Vegetation Monitoring Locations

Number of Samples Analyzed	Operational Area (discrete samples analyzed)						Composites ^b
	100-N	200-East	200-West ^a	300 ^a	400	600 ^a	
34	2	2	3	12	1	4	10

^a Number of samples includes one or more Replicate Samples.

^b 24-individual vegetation samples from the 200 and 600 Areas were combined into 10 composite samples using a multi-incremental approach.

10.4.1.1 Vegetation Monitoring Results

Some degree of variability is always associated with collecting and analyzing environmental samples; therefore, variations in sample concentrations from year to year are expected. In general, radionuclide concentrations in vegetation samples collected from, or adjacent to, waste disposal facilities in 2012 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 Area and 600 Area, and uranium in the 300 Area and 400 Area.

Uranium-234 and uranium-238 were detected consistently in the 2012 samples. Individual samples where concentrations of cesium-134, plutonium-238, and ruthenium-106 were detected, but remained within historical range. Five soil samples showed detectable concentrations of cesium-137 and an additional seven samples showed detectable levels of strontium-90. All Concentrations of detected radionuclides were elevated near and within facility boundaries compared to historic concentrations measured at distant communities. These concentrations did remain within the historical range of those collected within facility boundaries. Figure 10.6 shows the Hanford Site and distant community's average concentration of selected radionuclides for vegetation samples (Note: Distant Community vegetation samples were not collected in 2012.)

Table 10.5 provides a summary of selected radionuclides detected in vegetation samples collected and analyzed in 2012 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. Vegetation samples collected in 2012 at locations in the 100-N Area, 200-East Area, 200-West Area, 400 Area, and 600 Area were comparable to those collected in previous years. Vegetation samples collected in the 300 Area and 600 Area showed concentrations of uranium-234, uranium-235 and uranium-238 that were comparable to historical data, and higher than in vegetation samples measured in the 100 and 200 Areas. The higher uranium levels in the 300 Area were normal in comparison to historical data. The uranium levels are due to uranium

releases to the environment during past fuel-fabrication operations in that area. Plutonium-239/240 was found at higher levels in an individual vegetation sample in the 200-West Area. Seven vegetation samples from the 200 Area and 600 Area had slightly elevated concentrations of Strontium-90 in comparison to other areas sampled. This range of strontium-90 concentrations was comparable to historical levels.

Figure 10.6. Average Concentration of Selected Radionuclides in Vegetation Samples from the Hanford Site

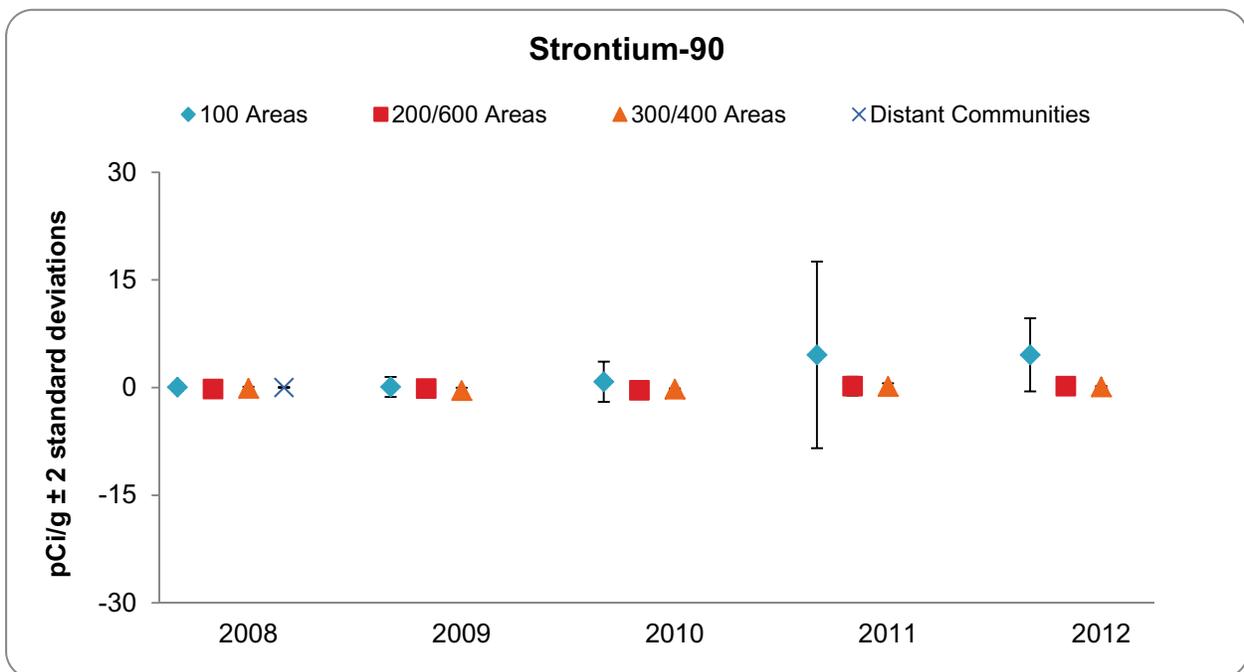
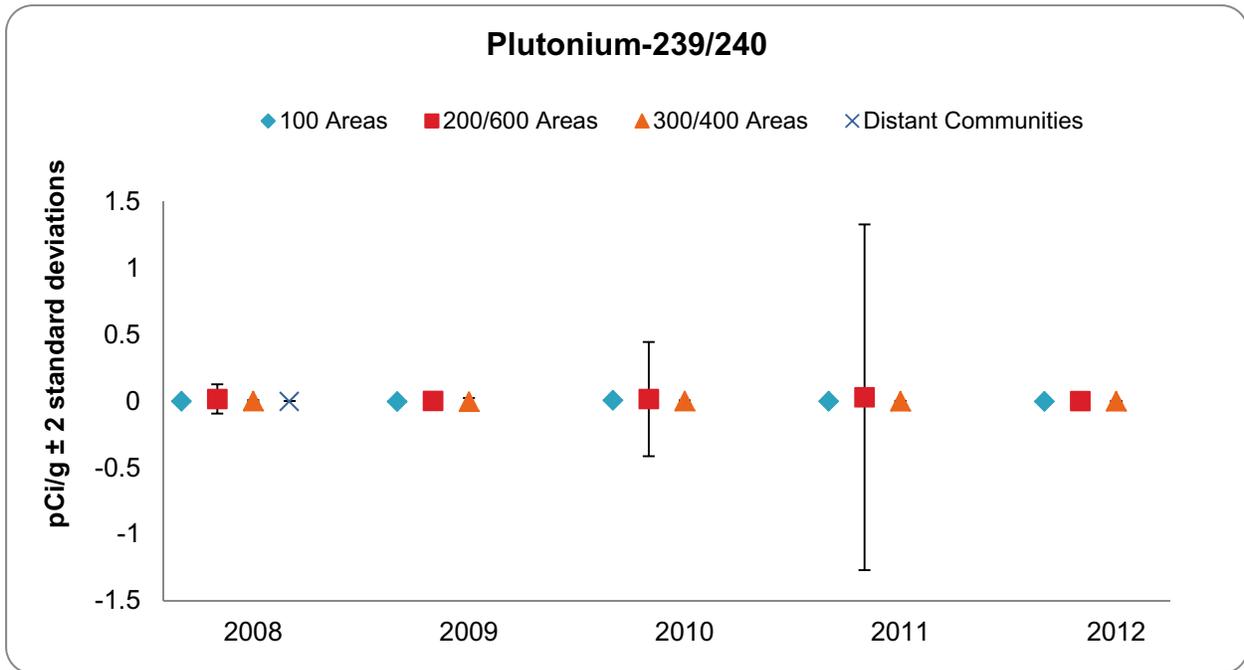


Figure 10.6. Average Concentration of Selected Radionuclides in Vegetation Samples from the Hanford Site (cont.)

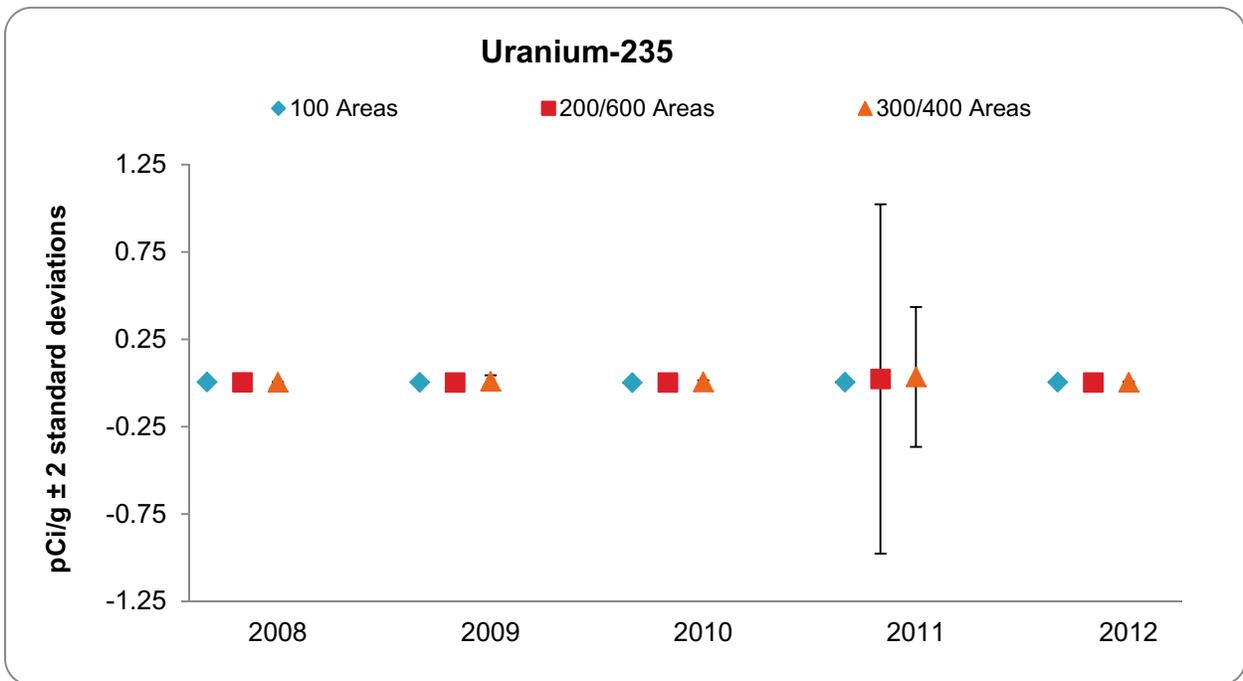
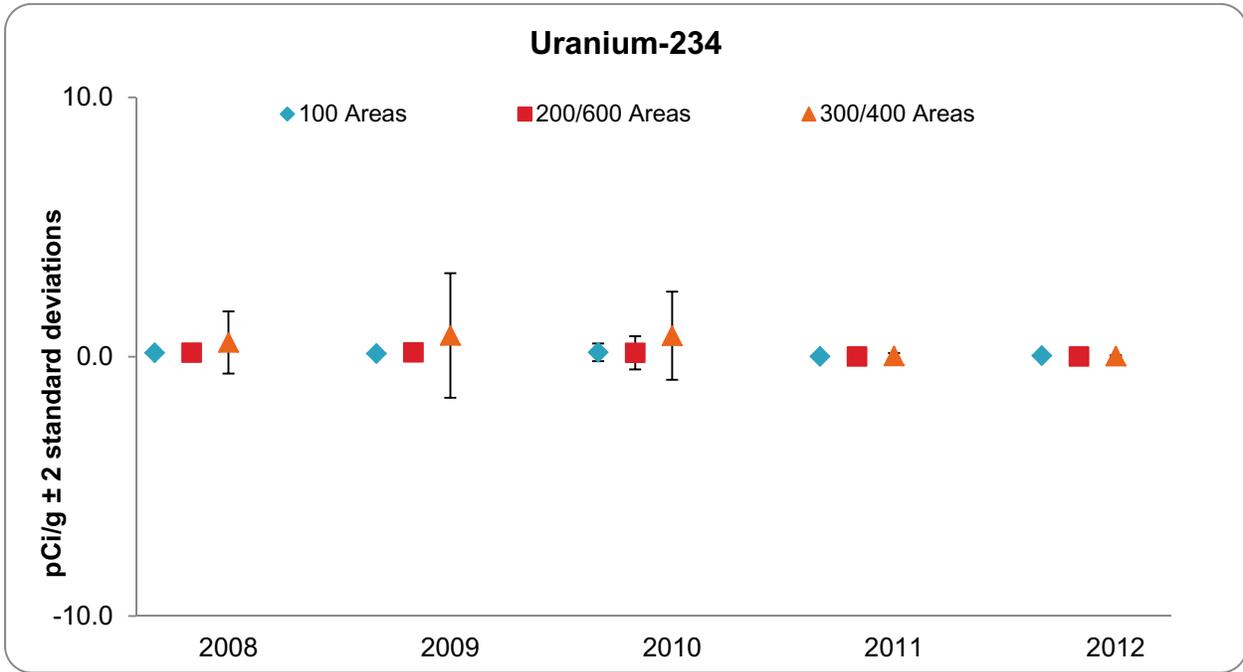


Figure 10.6. Average Concentration of Selected Radionuclides in Vegetation Samples from the Hanford Site (cont.)

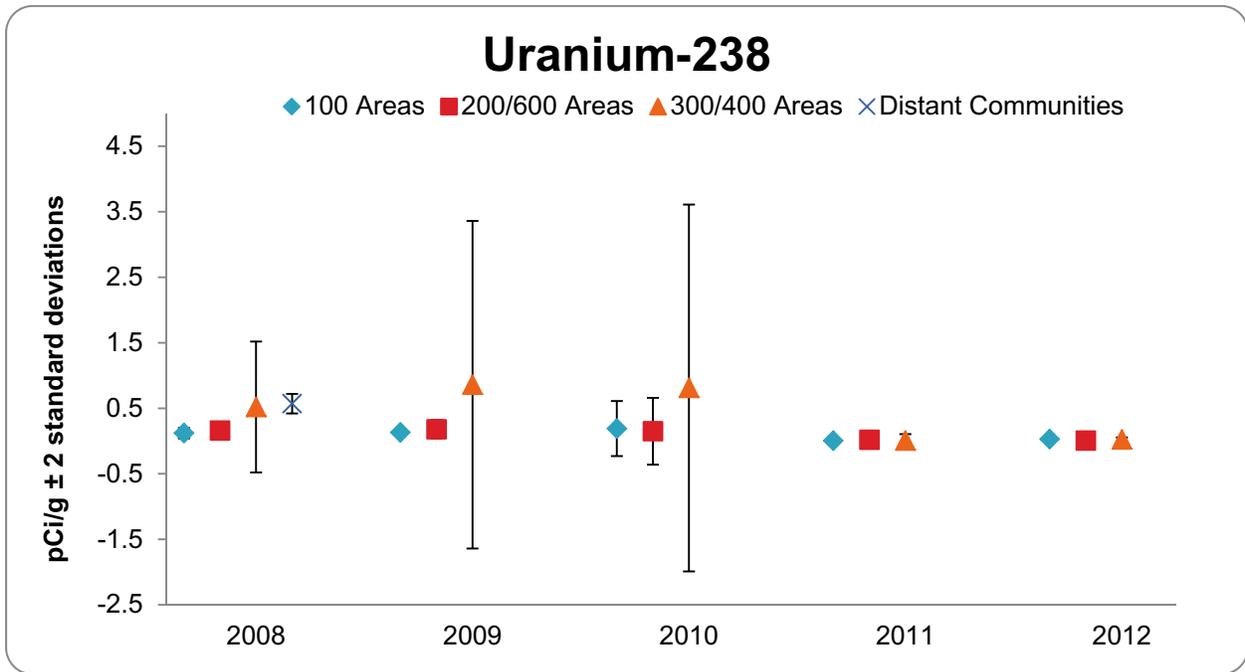


Table 10.5. Vegetation Concentrations of Selected Radionuclides
(pCi/g)

Isotope	Area	2012				2007 to 2011			
		Number of Samples	Detects	Average ^a	Maximum ^b	Number of Samples	Detects	Average ^a	Maximum ^b
Cobalt-60	100	2	0	-7.9E-03 ± 3.1E-02	7.8E-03 ± 6.2E-02 ^c	15	0	1.0E-02 ± 4.4E-02	3.6E-02 ± 8.8E-02 ^c
	200-E	5	0	-3.3E-03 ± 2.1E-02	1.3E-02 ± 2.6E-02 ^c	48	0	-5.3E-03 ± 6.2E-02	5.4E-02 ± 1.1E-01 ^c
	200-W	10	0	-1.4E-02 ± 2.7E-02	2.5E-03 ± 2.5E-02 ^c	109	0	-8.9E-03 ± 6.9E-02	1.1E-01 ± 9.5E-02 ^c
	300	12	0	-5.8E-04 ± 4.5E-02	3.9E-02 ± 3.5E-02 ^c	69	0	-9.6E-03 ± 7.6E-02	7.5E-02 ± 5.8E-02 ^c
	400	1	0	-2.3E-02 ^d	-2.3E-02 ± 3.5E-02 ^c	4	0	2.4E-03 ± 5.2E-02	2.5E-02 ± 3.8E-02 ^c
	600	4	0	-8.9E-03 ± 1.7E-02	1.7E-03 ± 1.7E-02 ^c	79	1	4.0E-03 ± 8.6E-02	2.6E-01 ± 1.3E-01
Cesium-137	100	2	0	2.5E-02 ± 5.2E-02	5.1E-02 ± 6.9E-02 ^c	15	1	9.6E-04 ± 7.7E-02	8.7E-02 ± 8.5E-02 ^c
	200-E	5	2	5.5E-02 ± 7.9E-02	1.1E-01 ± 4.6E-02	48	7	5.0E-02 ± 1.6E-01	3.3E-01 ± 1.4E-01
	200-W	10	2	1.6E-02 ± 5.3E-02	5.2E-02 ± 4.3E-02	109	23	7.2E-02 ± 2.6E-01	1.2E+00 ± 2.1E+00 ^c
	300	12	0	3.4E-03 ± 4.2E-02	4.7E-02 ± 4.4E-02 ^c	69	8	2.7E-02 ± 1.5E-01	3.6E-01 ± 9.7E-02
	400	1	0	2.8E-02 ^d	2.8E-02 ± 3.8E-02 ^c	4	0	-1.9E-02 ± 6.4E-02	2.3E-02 ± 9.2E-02 ^c
	600	4	1	8.1E-03 ± 6.5E-02	6.1E-02 ± 3.5E-02	79	11	3.0E-02 ± 1.3E-01	2.0E-01 ± 8.6E-02
Plutonium-238	100	2	0	-2.2E-03 ± 6.4E-03	1.0E-03 ± 9.7E-03 ^c	15	0	-3.9E-04 ± 2.2E-02	1.9E-02 ± 1.8E-02 ^c
	200-E	5	0	-2.1E-03 ± 7.3E-03	2.8E-03 ± 8.3E-03 ^c	48	3	2.1E-03 ± 1.8E-02	3.5E-02 ± 1.4E-02
	200-W	10	0	-7.6E-04 ± 3.8E-03	1.9E-03 ± 5.5E-03 ^c	109	5	7.7E-04 ± 1.5E-02	2.7E-02 ± 1.8E-02
	300	12	1	2.5E-03 ± 9.0E-03	1.5E-02 ± 9.1E-03	69	4	2.5E-03 ± 3.6E-02	8.7E-02 ± 4.7E-02
	400	1	0	8.1E-04 ^d	8.1E-04 ± 5.4E-03 ^c	4	0	2.5E-03 ± 1.7E-02	1.3E-02 ± 1.8E-02 ^c
	600	4	0	1.1E-03 ± 6.5E-03	5.4E-03 ± 5.3E-03 ^c	79	1	2.1E-03 ± 1.8E-02	3.2E-02 ± 2.3E-02 ^c
Plutonium-239/240	100	2	0	3.5E-05 ± 2.1E-03	1.1E-03 ± 3.7E-03 ^c	15	2	1.3E-03 ± 8.3E-03	9.2E-03 ± 7.3E-03
	200-E	5	0	3.4E-03 ± 5.2E-03	5.7E-03 ± 5.6E-03 ^c	48	2	2.2E-03 ± 1.7E-02	5.9E-02 ± 2.2E-02
	200-W	10	2	2.4E-03 ± 9.6E-03	1.3E-02 ± 7.7E-03	109	41	2.8E-02 ± 2.7E-01	1.3E+00 ± 2.8E-01
	300	12	0	9.3E-04 ± 2.8E-03	3.5E-03 ± 4.3E-03 ^c	69	2	2.9E-04 ± 1.5E-02	1.0E-02 ± 6.5E-03
	400	1	0	-8.1E-04 ^d	-8.1E-04 ± 1.6E-03 ^c	4	0	2.9E-03 ± 5.6E-03	7.0E-03 ± 7.6E-03 ^c
	600	4	0	7.5E-04 ± 2.1E-03	1.8E-03 ± 4.4E-03 ^c	79	11	3.2E-03 ± 1.2E-02	3.6E-02 ± 1.6E-02
Strontium-90	100	2	2	4.6E+00 ± 5.1E+00	7.1E+00 ± 1.2E+00	15	6	1.1E+00 ± 6.7E+00	1.3E+01 ± 1.7E+00
	200-E	5	2	2.8E-01 ± 4.2E-01	6.6E-01 ± 1.9E-01	48	13	-5.3E-02 ± 1.1E+00	1.0E+00 ± 2.8E-01
	200-W	10	2	2.4E-01 ± 3.8E-01	7.4E-01 ± 2.0E-01	109	6	-1.6E-01 ± 6.4E-01	6.4E-01 ± 4.3E-01
	300	12	1	1.1E-01 ± 2.5E-01	4.6E-01 ± 1.7E-01	69	7	-1.5E-01 ± 4.8E-01	4.3E-01 ± 2.2E-01
	400	1	0	-9.0E-03 ^d	-9.0E-03 ± 9.0E-02 ^c	4	0	-1.0E-01 ± 3.9E-01	1.6E-01 ± 1.8E-01 ^c
	600	4	0	5.0E-02 ± 2.7E-02	6.4E-02 ± 9.8E-02 ^c	79	4	-8.7E-02 ± 7.4E-01	1.3E+00 ± 3.4E-01
Uranium-234	100	2	2	4.0E-02 ± 4.4E-02	6.2E-02 ± 2.2E-02	15	12	1.2E-02 ± 9.0E-03	1.9E-02 ± 9.7E-03
	200-E	5	2	6.7E-03 ± 5.4E-03	1.0E-02 ± 7.5E-03	48	46	1.4E-02 ± 9.2E-03	2.6E-02 ± 1.2E-02
	200-W	10	6	1.1E-02 ± 8.3E-03	2.2E-02 ± 1.2E-02	109	104	1.7E-02 ± 2.2E-02	1.1E-01 ± 3.5E-02
	300	12	11	2.5E-02 ± 3.1E-02	5.4E-02 ± 2.0E-02	69	60	3.4E-02 ± 1.1E-01	4.4E-01 ± 1.8E-01
	400	1	1	1.9E-02 ^d	1.9E-02 ± 1.1E-02	4	3	1.4E-02 ± 9.4E-03	2.0E-02 ± 1.0E-02
	600	4	1	1.1E-02 ± 1.6E-02	2.5E-02 ± 1.3E-02	79	61	1.4E-02 ± 2.0E-02	8.4E-02 ± 2.8E-02

Table 10.5. Vegetation Concentrations of Selected Radionuclides
(pCi/g)

Isotope	Area	2012				2007 to 2011			
		Number of Samples	Detects	Average ^a	Maximum ^b	Number of Samples	Detects	Average ^a	Maximum ^b
Uranium-235	100	2	1	4.6E-03 ± 7.2E-03	8.2E-03 ± 6.8E-03	15	5	4.8E-03 ± 6.2E-03	1.0E-02 ± 7.5E-03
	200-E	5	0	2.6E-03 ± 4.6E-03	6.4E-03 ± 6.3E-03 ^c	48	5	2.4E-02 ± 2.8E-01	1.0E+00 ± 0.0E+00 ^c
	200-W	10	0	3.3E-03 ± 2.8E-03	5.7E-03 ± 5.6E-03 ^c	109	26	3.3E-03 ± 5.0E-03	1.3E-02 ± 7.9E-03
	300	12	3	3.7E-03 ± 5.0E-03	8.2E-03 ± 6.1E-03	69	16	5.5E-03 ± 1.9E-02	7.9E-02 ± 7.1E-02 ^c
	400	1	0	3.8E-03 ^d	3.8E-03 ± 3.9E-03 ^c	4	1	3.8E-03 ± 2.9E-03	6.1E-03 ± 5.2E-03
	600	4	0	3.8E-03 ± 3.6E-03	5.7E-03 ± 6.2E-03 ^c	78	16	3.2E-03 ± 4.4E-03	1.1E-02 ± 7.7E-03
Uranium-238	100	2	2	2.9E-02 ± 3.9E-02	4.9E-02 ± 1.8E-02	15	10	7.1E-03 ± 6.8E-03	1.3E-02 ± 7.3E-03
	200-E	5	1	4.6E-03 ± 7.1E-03	7.9E-03 ± 5.9E-03	48	41	9.8E-03 ± 7.8E-03	1.8E-02 ± 9.5E-03
	200-W	10	4	7.9E-03 ± 1.1E-02	2.0E-02 ± 1.0E-02	109	97	1.5E-02 ± 2.8E-02	1.4E-01 ± 4.3E-02
	300	12	11	2.6E-02 ± 3.1E-02	5.7E-02 ± 2.1E-02	69	66	3.0E-02 ± 1.3E-01	5.2E-01 ± 1.9E-01
	400	1	1	1.2E-02 ^d	1.2E-02 ± 8.1E-03	4	4	9.3E-03 ± 6.1E-03	1.4E-02 ± 9.2E-03
	600	4	2	5.5E-03 ± 4.2E-03	7.3E-03 ± 6.1E-03	79	66	1.1E-02 ± 1.5E-02	6.1E-02 ± 2.1E-02

^a Average ± two standard deviations.

^b Maximum ± analytical uncertainty.

^c Maximum value reported is a non-detect.

^d Standard deviation cannot be calculated for one sample.

10.4.1.2 Radiological Contamination*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.

Radiological contamination was found in 18 vegetation samples surveyed during the 2012 investigations. Sixteen of the samples were tumbleweeds (Russian thistle) or tumbleweed fragments, one sample was grass roots, and one sample was *Typha latifolia* (cattail reed). None of the samples was analyzed for specific radionuclides, and all samples were disposed at a licensed facility.

Section 10.3.1 provides a discussion of the vegetation control on the Hanford Site. Table 10.6 summarizes the number and general locations of vegetation contamination incidents investigated from 1999 through 2012.

Table 10.6. Vegetation Contamination Incidents Investigated

Year	Number of Incidents	Location	2012 Incidents
1999	85	200-East Area	
2000	66	Tank Farms	1
2001	31	Burial grounds	1
2002	16	Cribs, ponds, and ditches	0
2003	32	Fence lines	1
2004	60	Roads and railroads	0
2005	66	Unplanned release sites	0
2006	75	Underground pipelines	0
2007	62	Miscellaneous	7
2008	127	200-West Area	
2009	109	Tank Farms	4
2010	36	Burial grounds	1
2011	29	Cribs, ponds, and ditches	0
2012	18	Fence lines	1
		Roads and railroads	0
		Unplanned release sites	0
		Underground pipelines	0
		Miscellaneous	2
		Cross-site transfer line	0
		200-BC Cribs and trenches	0
		200-North Area	0
		100 Areas	0
		300 Area	0
		400 Area	0
		600 Area	0
		Former 1100 Area	0
		Total	18

10.4.2 Vegetation Control

JM Rodriguez and RC Roos

Vegetation control at the Hanford Site consists of cleaning up of 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 4,087 acres (1,654 hectares) were treated with herbicides in 2012 on radiological waste sites, around operations areas, and along roadways to keep these areas clean of deep-rooted noxious vegetation (e.g., Russian thistle, also known as tumbleweed). Follow-up treatments are included in the total treated acres; several areas received three or four treatments per year.

10.4.2.1 Noxious Weeds

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 weed plant communities degrade ecosystems unless control measures are taken. Control measures can be mechanical, chemical, cultural, or biological; approximately 34 acres (14 hectares) on the Hanford Site were treated in 2011 along roadways.

The environmental assessment delineating noxious weed control by herbicides that was mandated in 2008 ([DOE/EA-1728D](#), *Environmental Assessment, Integrated Vegetation Management on the Hanford Site, Richland, Washington*) was completed in 2012. The FONSI clears the way to develop an appropriate process for NEPA clearance of noxious weed control. As budget is approved, noxious weed control will be performed.

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 2012 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. Control of the yellow starthistle in 2012 consisted of hand pulling individual plants as they were identified.

Yellow starthistle seeds are known to remain viable for 10 years in the soil. The small number of seedlings found over much of the area of infestation indicates the seed bank is being exhausted. Careful control efforts over the next few years at the Hanford Site should result in the 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 lifecycle 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. In the past, areas of dense rush skeletonweed infestation north of the Wye Barricade largely have been eliminated. Nevertheless, considerable rush skeletonweed remains as scattered individual plants. Populations of rush skeletonweed have increased in some areas burned by past wildfires. Reduction in active control efforts over the past few years while NEPA requirements have been evaluated has allowed some populations of skeletonweed to increase in both aerial extent and density.

The deep and extensive root system of rush skeletonweed makes it extremely difficult to eliminate. The area north of the HAMMER facility has been treated with herbicides in the past and will continue to be monitored for sprouts emerging from roots remaining in the ground. Additional aerial applications may 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.

Babysbreath (*Gypsophila paniculata*). Babysbreath is resistant to control by herbicides; however, the aboveground portion of the plant can be killed by certain herbicides. Using these herbicides, flowering and population growth can be prevented. These plants should be eradicated by continually removing the top portions through herbicide use. Herbicides were not used to control babysbreath in 2012 while NEPA authorization was being finalized. Active control of babysbreath in 2012 at the Hanford town site consisted of hand pulling individual plants to prevent seed production.

Dalmatian Toadflax (*Linaria genistifolia* ssp. *Dalmatica*). A small population of dalmatian toadflax plants is found near Energy Northwest at the Hanford Site. Sprouts and seedlings of the long-lived perennial plant will be eliminated as they are identified. The current population consists of plants widely scattered across the area of infestation. The low-density population is not conducive to successful establishment of predatory species. Consequently, no biological controls have been released at the Hanford Site for dalmatian toadflax. Toadflaxes growing along road shoulders were controlled using herbicides.

Diffuse Knapweed (*Centaurea diffusa*). Aerial applications for control of diffuse knapweed have been effective in the past. Spot treatment of scattered individuals continued in 2012. 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.

Medusahead (*Taeniatherum asperum*). No medusahead plants were discovered in 2012. The Hanford Site will continue to be monitored to verify the seed bank has been eradicated.

Purple Loosestrife (*Lythrum salicaria*). The bank of the Columbia River and islands along the Hanford Site are monitored for purple loosestrife. Populations are found on many islands and along the banks of the river. Individual plants and small populations 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 and the control the organisms over winter on the ground in the weed populations. Winter mortality prevents an effective population of control agents from developing. No control measures were applied in 2012 for purple loosestrife.

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 were 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; however, no active control measures were performed in 2012.

Spotted Knapweed (*Centaurea maculosa*). Spotted knapweed at the Hanford Site has been controlled so that sprouts or seedlings are rare. In 2012, no sprouts or seedlings were found. The Hanford 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. *Cyphocleonus achates*, a root-feeding weevil has been released specifically for spotted knapweed. It is expected that the population of spotted knapweed at the Hanford Site is too small and scattered to sustain a biological control population. However, *Cyphocleonus* is known to use diffuse knapweed. It is hoped that a

population of *Cyphocleonus* will establish in diffuse knapweed, and control spotted knapweed. Most biological controls for diffuse knapweed also are effective for spotted knapweed.

10.5 Waste Site Remediation and Revegetation

RC Roos and JM Rodriguez

In 2012, approximately 150 acres (61 hectares) of waste sites in 200-East and 200-West Areas were seeded with perennial bunch grass seed. This was done to repair and improve existing vegetative caps on the sites. An unusually wet fall allowed good germination of the seed, and high expectations of success for the seeding efforts.

Waste Sites in 200-East and 200-West Areas were designed and constructed with a cap of perennial grass. The cap is essential to performance of the engineered waste sites. However, soil used as backfill and cover on waste sites was often sandy. The sand provides a poor medium for growth of the grass. Over the years, poor soil combined with lack of maintenance has resulted in degradation and decreased function of the vegetative caps on many waste sites. Integrated Biological Control has been actively restoring vegetative caps on waste sites.

Vegetative caps on waste sites perform three primary functions:

1. Prevent Erosion – A well designed and maintained grass cap stabilizes soil on waste sites by physically covering the soil surface and also serving as a windbreak, reducing wind velocity at the soil surface.
2. Exclude Tumbleweed Growth – Tumbleweeds are the main biological vector of contamination spread on the Hanford Site. They are deep-rooted annual plants that quickly invade and establish on disturbed soil. The deep roots readily absorb radionuclides buried in the soil, and transport them to the aboveground portions of the plant. At the end of the 1 year life cycle, dead tumbleweeds detach from the roots and blow away with the wind. In this way, radioactive contamination can be transported from posted and monitored disposal areas.

A well designed and maintained grass cap excludes tumbleweeds by direct competition for space and nutrients (primarily water). Stabilized soil forms a crypto-biotic crust composed of moss, lichen, algae, and other organisms that provide a poor surface for germination of tumbleweed seeds. The combination of competition for resources and prevention of germination effectively excludes tumbleweeds from establishing on waste sites.

3. Prevent Water Percolation Through The Soil Column – Waste sites were designed with vegetative caps to prevent natural precipitation moving through the soil column and washing radioactive or hazardous materials downward toward groundwater.

The 6- to 7-inch (15- to 18-centimeter) average precipitation received at the Hanford Site typically percolates 2 to 4 inches (5 to 10 centimeters) into the soil during the winter. Evaporation during summer months removes some moisture from the soil. However, as surface soil dries, it acts as a mulch, inhibiting further evaporation. Evaporation alone does not remove all of the natural precipitation from the soil. Water remaining in the soil from the previous year has an additive effect during the subsequent wet season, allowing water to percolate to increasing depth.

Vegetative caps on waste sites were designed so that in addition to evaporation from the soil surface, plant roots would mine water from deeper in the soil profile, transporting it to leaves where it is lost through evaporation. The process of water moving from soil into plant roots, through the plant and out the leaves to the atmosphere is transpiration.

The combination of evaporation and transpiration removes sufficient moisture from the soil so that precipitation during subsequent wet seasons falls on dry soil, yielding no net increase in depth of percolation.

Effective containment of waste in burial grounds depends on the combination of evaporation and transpiration drying the soil, preventing additive percolation and transport of contaminants to groundwater.

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11.0 Resource Protection

11.1 Ecological Protection

MR Sackschewsky, JW Wilde, CT Lindsey, and JJ Nugent

The Hanford Site is a relatively undisturbed area of shrub steppe that supports a rich diversity of plant and animal species adapted to the semiarid environment of the Columbia Plateau. The Hanford Site contains biologically diverse shrub-steppe plant communities that have been protected from most disturbances, except for fire, for more than 65 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.

Ecological monitoring personnel collect ecological data and information needed to monitor, assess, and conserve resources; ensure RL is in compliance with legal and regulatory requirements for the biological resources; and protect sensitive resources and habitats found at the Hanford Site. Project personnel survey and monitor resources and key biota to assess the abundance, health, and distribution of populations and species at the Hanford Site. Inventory and monitoring activities help protect natural resources within the DOE-operated portions of the Hanford Site including the DOE-managed portion of the Hanford Reach National Monument.

Ecological monitoring and ecological compliance support the Hanford Site's waste management and environmental restoration mission through the following activities:

- Ensure 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 orders, DOE orders, and DOE-RL resource management guidance
- 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.

Population level surveys are conducted to monitor fish, wildlife, and plants in order to develop baseline information and monitor any changes resulting from Hanford Site operations. Data collection and analysis are integrated with environmental surveillance monitoring of biotic and abiotic media and analytical results are used to characterize any potential risk or impact to the biota. Thus, the Hanford Site ecological monitoring 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.

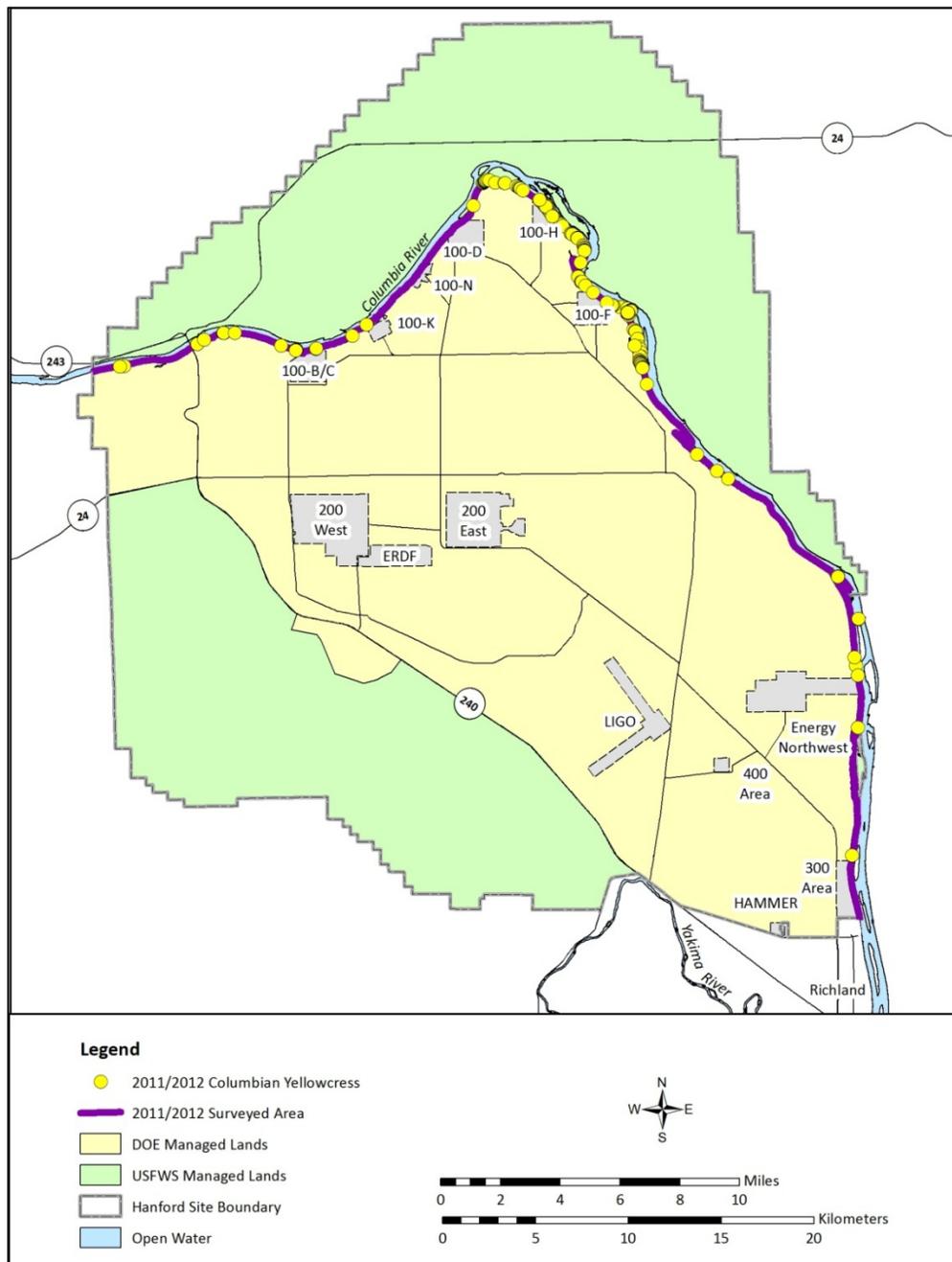
11.1.1 Rare Plants

Plant populations monitored at the Hanford Site include taxa classified by the Washington State Natural Heritage Program as endangered, threatened, or sensitive species, and those species listed as Review Group 1 (i.e., taxa in need of additional fieldwork before status can be determined). Rare plant monitoring for 2012 focused on Columbia yellowcress (*Rorippa columbiae*), also called persistentsepal yellowcress, which is a rhizomatous perennial species that occurs along the shorelines of the Columbia River on the Hanford Site. It is endemic to Washington, Oregon, and California, is a federal species of concern in eastern Washington, and is listed as endangered by the Washington Natural Heritage Program. The extensive damming of the Columbia River has reduced its habitat, and the species is currently known from only two disjunctive locations in Washington: a relatively small population below the Bonneville Dam and an extensive population along the Hanford Reach. A survey of the entire Hanford Reach on the central Hanford Site (Benton County) shoreline began in 2011 and was completed in 2012.

A graded survey approach was used, starting in areas of previously identified populations, then in areas with ideal habitat, followed by areas with less ideal habitat. The focus of the 2012 survey was to inventory the remaining sections of the Hanford shoreline that were not surveyed in 2011 in order to complete the entire

length of the shoreline along the central Hanford Site. Between the 2011 and 2012 surveys, the entire length of the Hanford Reach on the central Hanford side was surveyed for Columbian yellowcress, totaling a survey length of 63.3 miles (101.8 kilometers). The length of the Columbia River along the survey area is approximately 47 miles (75.6 kilometers), and the difference is made up by the rise and fall of the river shoreline, which includes large sloughs. Figure 11.1 shows the survey area and locations for Columbian yellowcress from the 2011 and 2012 combined surveys; 245 patches, with approximately 91,250 ramets, were recorded. This provides an up-to-date map of the current distribution of the plant within the described area, and a snapshot in time of the patch sizes and ramet abundance. These data not only inform future shoreline activities to ensure that impacts to Columbian yellowcress are avoided, but set a baseline to compare population levels and distribution in the future.

Figure 11.1. Surveyed Area and Locations for Columbian Yellowcress



Although Columbian yellowcress continues to occur regularly in the areas along the Hanford Reach where its microhabitat requirements exist, and can be relatively abundant during certain years (e.g., 2011 and 2012), its lack of recruitment and seed reproduction are causes for concern. The 2012 survey was conducted late in the growing season, and the absence of mature fruits indicates that the species is unable to reproduce via seed under the regulated flow conditions present on the Hanford Reach. Currently, the Columbian yellowcress habitat is usually inundated until late summer, and then is still periodically submerged by water released by upriver dams for power production. In addition, beginning in mid-October the habitat is inundated daily due to the Reverse Load Factoring flow regime conducted at the upstream Priest Rapids Dam. Reverse Load Factoring is used, as part of the Vernita Bar Agreement, to encourage fall Chinook salmon (*Oncorhynchus tshawytscha*) to spawn deeper in the river. Prior to flow regulation by the upstream dams, summer was characterized by sustained low river levels within the Hanford Reach; current management of the river typically inundates and exposes the species' habitat repeatedly, often daily. This management pattern has shifted the primary growing period into the fall and has limited, if not halted, reproduction by seed.

Future research considerations for Columbian yellowcress should include annual surveys for successful fruiting at several locations, including plants that occur at low and high flow levels. In addition, the relative abundance of ramets should be documented annually at several locations, and an inventory of the entire population should be conducted at least every 3 years. Although some work has been conducted on the islands and opposite shoreline (Grant/Franklin counties), these areas lack a large-scale continuous survey. An inventory of the species in these areas would contribute greatly to the overall picture of the status of this endangered species along the Hanford Reach. Additional details from this survey are available in the 2011 and 2012 monitoring reports, available online at <http://www.hanford.gov/page.cfm/ecologicalmonitoring>.

11.1.2 Fish and Wildlife Monitoring

This section provides inventory, monitoring, and survey information for species found at the Hanford Site during 2012, and presents this information in context with historical data and trend information. Historically, four fish and wildlife species on the Hanford Site have been annually monitored: 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, and all were monitored in 2012. Monitoring consisted of estimating numbers of fall Chinook salmon redds, surveying for steelhead redds, assessing bald eagle nesting and night roosting activity, and counting mule deer. All of these species have the potential to be impacted by Hanford Site operations, and yearly monitoring provides baseline data for ecological assessments. Additional monitoring efforts were aimed at nesting raptors, migratory birds, burrowing owls, bats, ground squirrels, elk, and snake hibernacula.

The sections below provide brief summaries of the 2012 monitoring results. More detailed monitoring reports are available for most of these subjects at <http://www.hanford.gov/page.cfm/ecologicalmonitoring>.

11.1.2.1 Fall Chinook Salmon

Chinook salmon (*Oncorhynchus tshawytscha*), commonly referred to as king salmon, are the largest of the Pacific salmon ([Myers et al. 1998](#), *Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California*; [Netboy 1958](#), *Salmon of the Pacific Northwest: Fish Vs. Dams*). Adult fall Chinook salmon destined for the Hanford Reach enter the Columbia River in late summer and spawn from mid-October through November. Females fan out nests or redds in suitable gravel substrate and deposit eggs in an egg pocket while males simultaneously extrude milt to fertilize the eggs. Redds are readily identifiable at this time and appear as clean swept gravel patches amidst darker undisturbed substrate that is covered by algae (periphyton). Aerial counts of Chinook salmon redds have been conducted since 1948 at Hanford to provide an index of relative abundance among spawning areas and years. The counts also have been useful to document the onset of spawning, to locate spawning areas, and to determine intervals of peak spawning activity.

The Hanford Reach historically has been divided into 11 sections, with the number of redds being totaled by section. Eight additional subsections (100-B/C, 100-K, 100-N, 100-D, 100-H, 100-F, Dunes, 300 Area) were

added in 2011 to monitor better the abundance and distribution of fall Chinook salmon redds in areas of potential upwelling of contaminated groundwater.

Three aerial surveys were completed during 2012 along the length of the Hanford Reach section of the Columbia River. Table 11.1, provides a summary of the fall Chinook salmon redd counts for the 2012 Aerial Surveys along the length of the Hanford Reach portion of the Columbia River. The first survey was performed on October 21, the second on October 30, and the third on November 18. The counts performed by survey area for each flight is shown in Table 11.1. The maximum count describes the highest number of redds documented in a survey area within any single flight. The total number of redds, comprised of the maximum count from each survey area, totaled 8,368 for the 2012 survey. The number of fall Chinook aerial redds occurring within the newly defined subsections, coinciding with areas of potential contaminated groundwater upwelling is shown in Table 11.2.

Table 11.1. Summary of Fall Chinook Salmon Redd Counts

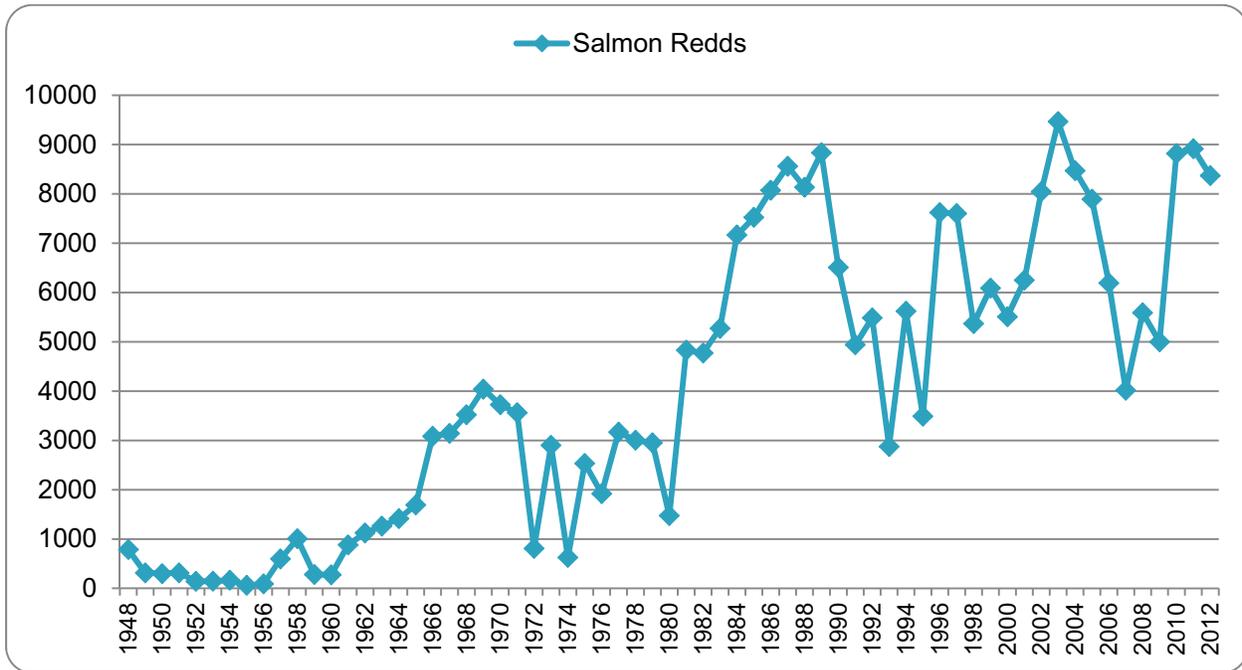
Area	Description	10/21/12	10/30/12	11/18/12	Maximum Count
0	Islands 17-21 (Richland)	0	0	0	0
1	Islands 11-16	3	147	533	533
2	Islands 8-10	4	353	807	807
3	Near Island 7	12	425	700	700
4	Island 6 (lower half)	14	553	1,375	1,375
5	Island 4, 5 and upper 6	9	947	1,195	1,195
6	Near Island 3	1	225	475	475
7	Near Island 2	6	301	528	528
8	Near Island 1	4	160	340	340
9	Near Coyote Rapids	1	19	29	29
N/A	Midway (China Bar)	0	25	68	68
10	Near Vernita Bar	28	1,180	2,315	2,315
11	Near Priest Rapids Dam	0	0	3	3
Total		82	4,335	8,368	8,368

Table 11.2. Summary of Fall Chinook Aerial Redd Counts by Potential Contaminated Groundwater Upwelling Subsections

Hanford Site Sub-Area	10/21/2012	10/30/2012	11/18/2012	Maximum Count
300 Area	0	0	0	0
Dunes	0	0	0	0
100-F Area	12	425	700	700
100-H Area	9	947	1,195	1,195
100-D Area	4	160	340	340
100-N Area	0	0	0	0
100-K Area	0	0	0	0
100-B/C Area	1	19	29	29
Total	26	1,551	2,264	2,264

The peak annual aerial fall Chinook redd count for 2012 (8,368) was slightly less than in 2011 (8,915), and was less than the all-time highest count in 2003 (9,465); but was in excess of the average for the previous 10 years (7,239) (see Figure 11.2). The historical areas where fall Chinook redds were observed in 2011 and 2012 included locations of potential contaminated groundwater upwellings. However, more work would be needed to confirm the actual presence of contaminated groundwater upwelling within these spawning areas.

Figure 11.2. Fall Chinook Salmon Redd Counts, Hanford Reach
(1948 through 2012)



11.1.2.2 Steelhead

Steelhead use the Hanford Reach for rearing as juveniles, as a migratory corridor as both juveniles and adults, and for spawning as adults. Both Mid-Columbia and Upper Columbia summer-run steelhead potentially use the Hanford Reach, both of which are currently listed as threatened under the [Endangered Species Act of 1973](#). Because of their high public value and [Endangered Species Act of 1973](#) listing status, steelhead were selected for monitoring under this program.

Steelhead build nests termed “redds,” in gravel or cobble substrate and spawn in the spring; the steelhead fry emerge from the gravel later that same spring. Adult steelhead generally utilize smaller tributary habitat and substrate but will spawn in larger mainstem rivers, such as the Columbia, where suitable habitat exists. Spawning within the Reach would likely occur between February and early June, with peak spawning in mid-May (Eldred 1970, *Steelhead Spawning in the Columbia River, Ringold to Priest Rapids Dam, September 1970 Progress Report*; [Watson 1973](#), *Estimate of Steelhead Trout Spawning in the Hanford Reach of the Columbia River*; [PNL-5371](#), *Anadromous Salmonids of the Hanford Reach, Columbia River: 1984 Status*; and [DOE/RL-2000-27](#)).

Although few redds are counted, aerial counts of steelhead redds are conducted at Hanford each spring to identify spawning areas and timing as well as to provide an annual index of relative abundance among spawning areas. The counts also are useful to document that spawning by [Endangered Species Act of 1973](#) listed wild upriver summer steelhead is minimal in the Hanford Reach, and would allow project activities to avoid redds, if identified. Similar to the methods used to document fall Chinook salmon spawning, the survey area is divided into 11 sections, with the number of redds being totaled by section. Eight additional subsections (Dunes, 100-B/C, 100-K, 100-N, 100-D, 100-H, 100-F, and 300 Areas) were added to monitor better the abundance and distribution of steelhead redds in areas of potential upwelling of contaminated groundwater.

Survey flight altitudes range from approximately 800 to 1,200 feet (244 to 366 meters) with air speeds of 75 to 100 miles (120 to 161 kilometers) per hour. Redds, when observed, are counted individually. Flights are cancelled if weather conditions are adverse (i.e., wind, fog, or low clouds) or if river flows are excessively

high. High flows resulting from spring run-off can justify survey cancelation because as river flows increase they eventually flood areas typically characterized by terrestrial vegetation and lacking steelhead spawning habitat, leaving previously usable habitat too swift for spawning and too deep to be observed from the air. Sustained flows in excess of 160,000 cubic feet/second (4,530,695 cubic liters/second) are considered too high to survey.

Two of three scheduled aerial surveys were completed along the length of the Hanford Reach during the 2012 survey season, which is consistent with historical levels of effort. The first survey was performed on March 18 and the second and final survey was completed on April 21. High river flows prevailed throughout the month of May, which hampered the survey effort. The May survey was attempted on May 12, 20, and 26 but suspended due to poor weather conditions and/or high river flows.

No steelhead redds were observed in 2012. Although no steelhead redds were documented in 2012, there were some other noteworthy observations. Surprisingly, fall Chinook salmon redds were still readily visible in some locations during the first (March 18, 2012) steelhead redd survey flight. This is well past the 6 week redd life, the period after which redds are indiscernible from the surrounding substrate, expected for fall Chinook salmon redds. Fall Chinook redds were especially noticeable in survey area 7 (Table 11.1). The large number and size of the redds, presence in historic fall Chinook salmon spawning areas, as well as the complete lack of adult fish observed in the vicinity distinguished these as fall Chinook salmon redds rather than steelhead redds. Under the conditions observed on March 18, 2012, in areas where steelhead and fall Chinook salmon spawning habitat features may overlap, steelhead spawning on top of or in close proximity to fall Chinook salmon redds would be extremely difficult to distinguish from still readily visible fall Chinook salmon redds. The presence of adult steelhead would be necessary to distinguish them. Under the conditions just described, verification of steelhead redds absent of spawning adults would require closer inspection via boat, submersible camera, or diver. Fall Chinook salmon redds were no longer visible by the second (April 21, 2012) steelhead redd count survey.

The population of natural-origin steelhead inhabiting the upper Columbia River has been reduced to the point of listing under the *Endangered Species Act of 1973*, so the number of steelhead spawning in the Hanford Reach may be low at present, but will likely increase as recovery actions are successfully implemented. Monitoring should continue, both to document this recovery, and to ensure that Hanford Site activities do not adversely affect the recovery of these fish. Additional information detailing this monitoring effort is available in the monitoring report, online at (http://www.hanford.gov/files.cfm/hnf-53665_-_rev_00.pdf).

11.1.2.3 Bald Eagle

Bald eagles were removed from the federal endangered and threatened species list in July 2007, and were down-listed from threatened to sensitive by the WDFW in January 2008. Federal laws including the *Bald and Golden Eagle Protection Act of 1940* and the *Migratory Bird Treaty Act of 1918* still provide protection for eagles, their nest trees, and communal night roosts. [DOE/RL-94-150](#) sets temporal and spatial restrictions on Hanford Site work activities to protect eagles and their habitats in accordance with current federal and state guidelines. Under the plan, communal night roosts and nest sites are protected with a 0.25 mile (400 meter) buffer zone. Night roost buffers are enforced from November 15 until March 15, and nest exclusion buffers are maintained until nest abandonment or fledging of young, whichever is later. Work-related access into roost areas is allowed between 10 AM and 2 PM after notification of Hanford Site Ecological Compliance staff.

Monitoring of the bald eagle is essential to: 1) maintain current biological information about bald eagle abundance and distribution on the Hanford Site, 2) ensure compliance with protection regulations, and 3) inform future protection and management efforts and decisions. During the 2012-2013 season, 220 surveys were conducted including 208 night roost surveys, 3 boat surveys, and 9 nest site surveys (as of March 19, 2013).

The WDFW defines a communal or night roost as “a tree or a group of trees in which at least 3 eagles roost for at least 2 nights and during more than 1 year.” Night roost surveys were conducted between half an hour before and half an hour after sunset. On 21 separate days between mid-November 2012 and mid-March 2013, 208 roost surveys were conducted at 14 locations (Figure 11.3). The number of eagles using each roost site on

days between night roost surveys was estimated using linear interpolation. The results of this analysis are shown in Table 11.3. Five of the roost sites (both the 100-H Area, both of the White Bluffs, and the upstream F-Island) have met the requirement of more than 3-eagles on at least 2 nights for each of the last 2 years. Two additional sites (100-F Slough and Wooded Island) met the requirement during the 2011-2012 season, but not during the 2012-2013 season. However, both of these sites were frequently used by one or two eagles per night (one-third of the time for the 100-F Slough, two-thirds of the time at Wooded Island) and are still considered major roost sites. The other seven monitored locations were used infrequently over the last 2 years.

The entire Hanford Reach was surveyed by boat three times during the 2012-2013 season (mid-December, late January, and late February). Boat surveys were used to determine the number, age class, and distribution of eagles present on the Hanford Reach (Figure 11.2). Boat surveys also were used to identify additional potential night roosts and nest sites, and to identify the primary foraging areas along the Hanford Reach. During the January 22 boat survey, an adult eagle was observed sitting on a nest at the Upstream of Wooded Island night roost location. This nest location was later confirmed to be occupied by a pair of adult bald eagles.

Nest site surveys were conducted in two historical locations (100-H Area downstream night roost and upstream of Wooded Island night roost). Nest sites were monitored for nesting activities (e.g., a pair defending the nest from other eagles, nest tending, pair bonding behaviors, etc.). No nesting activities were observed at the 100-H Area location; however, nesting activity was confirmed at the Wooded Island location. When the nest was initially discovered in late January, it appeared to be small and under construction on top of an existing heron nest. During the final boat survey, conducted in late February, the nest was much larger, approximately 80 inches (2.03 meters) wide and 30 inches (0.76 meters) deep, and appeared complete. The area was posted with a nest protection sign was posted to ensure that no vehicular traffic approaches the nest within 0.25 mile (400 meters), as required by [DOE/RL-94-150](#). MSA staff will continue to monitor the nest on a weekly basis to determine the outcome of the nesting attempt.

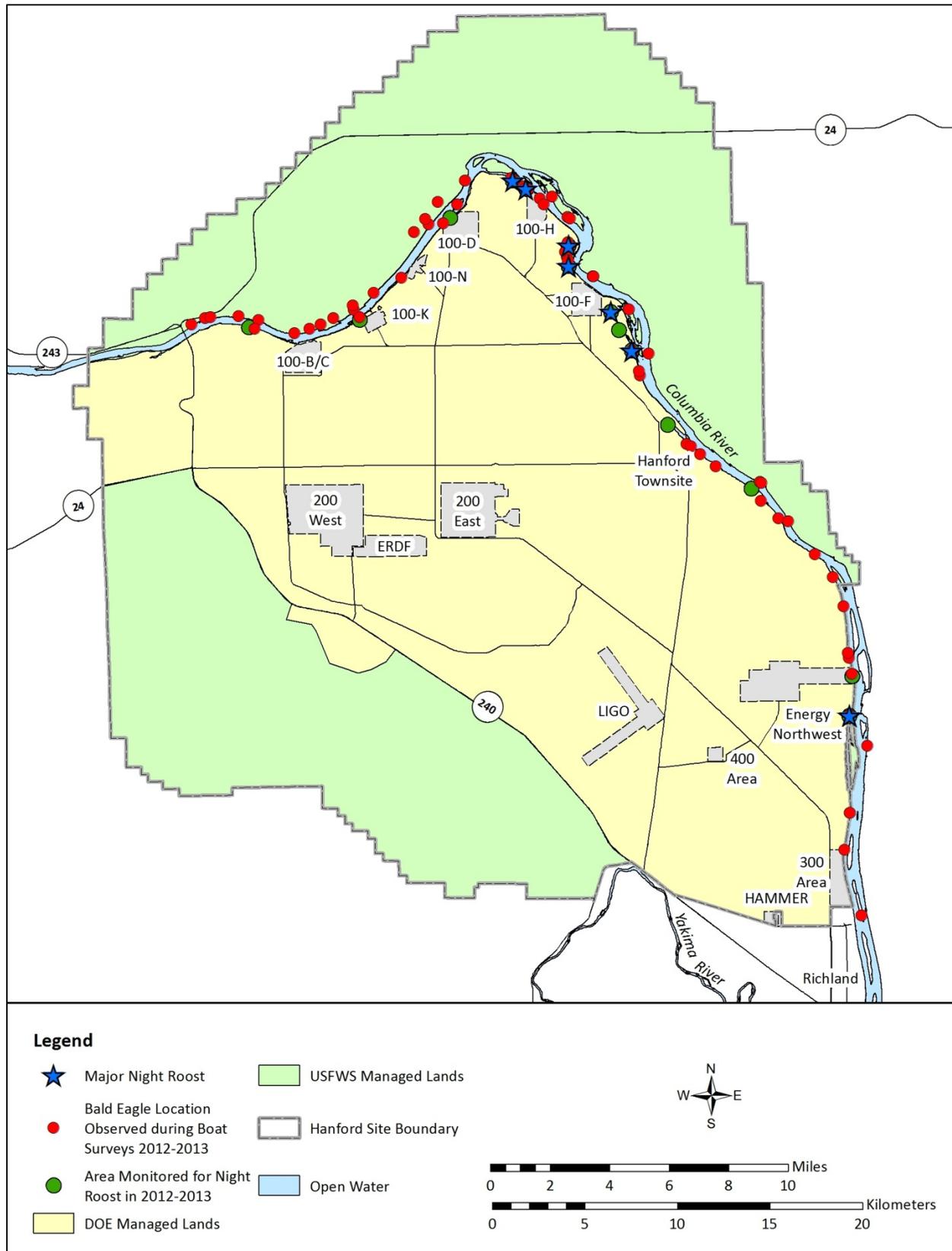
Table 11.3. Bald Eagle Night Roost Surveys Results
(2012-2013)

Night Roost Location	WDFW Qualifying Nights ¹	Nights with Eagles Present	Percent of Nights with Eagles Present
100-B/C Area ¹	0	10	9
100-K Area	0	2	2
100-D Area	0	0	0
100-H Upstream	43	72	63
100-H Downstream	8	42	37
Upstream White Bluffs	92	115	100
Downstream White Bluffs	8	54	47
100-F Island Upstream	1	37	32
100-F Island Downstream ¹	0	2	2
100-F Slough	11	42	37
Upstream Hanford Townsite	0	2	2
Downstream Hanford Townsite	0	4	3
Energy Northwest Outfall ¹	0	1	1
Upstream of Wooded Island	1	73	63

¹ Three or more eagles present at the site.

WDFW = Washington Department of Fish and Wildlife

Figure 11.3. Bald Eagle Night Roost Locations



11.1.2.4 Raptor Nest Monitoring

The Hanford Site supports a large and diverse community of raptorial birds (PNL-3212), with 26 species of raptors observed on the Hanford Site. Thirteen raptor species have been recorded nesting on the Hanford Site, including eight species of diurnal raptors and five species of owls (Table 11.4). Several of these species are on state and federal threatened and endangered species lists ([WDFW 2012a](#)). The Ferruginous Hawk (*Buteo regalis*) is a Washington State threatened species and a federal species of concern. The Bald Eagle (*Haliaeetus leucocephalus*) is a Washington State sensitive species and a federal species of concern. The Burrowing Owl (*Athene cunicularia*) is a Washington State candidate species and a federal species of concern (a separate monitoring effort on the Hanford Site was instituted 2012 for Burrowing Owls) (see Section 11.1.2.6). Swainson's Hawks (*Buteo swainsoni*), Prairie Falcons (*Falco mexicanus*), and Ospreys (*Pandion haliaetus*) are Washington State Monitored species. Because of the status of these species, it is important that nest locations be documented to avoid disturbance during the nesting season and to track populations over time to determine impacts of Hanford operations on these species. Common ravens also nest on the Hanford Site, though they are not considered raptors, they perform a similar ecological role.

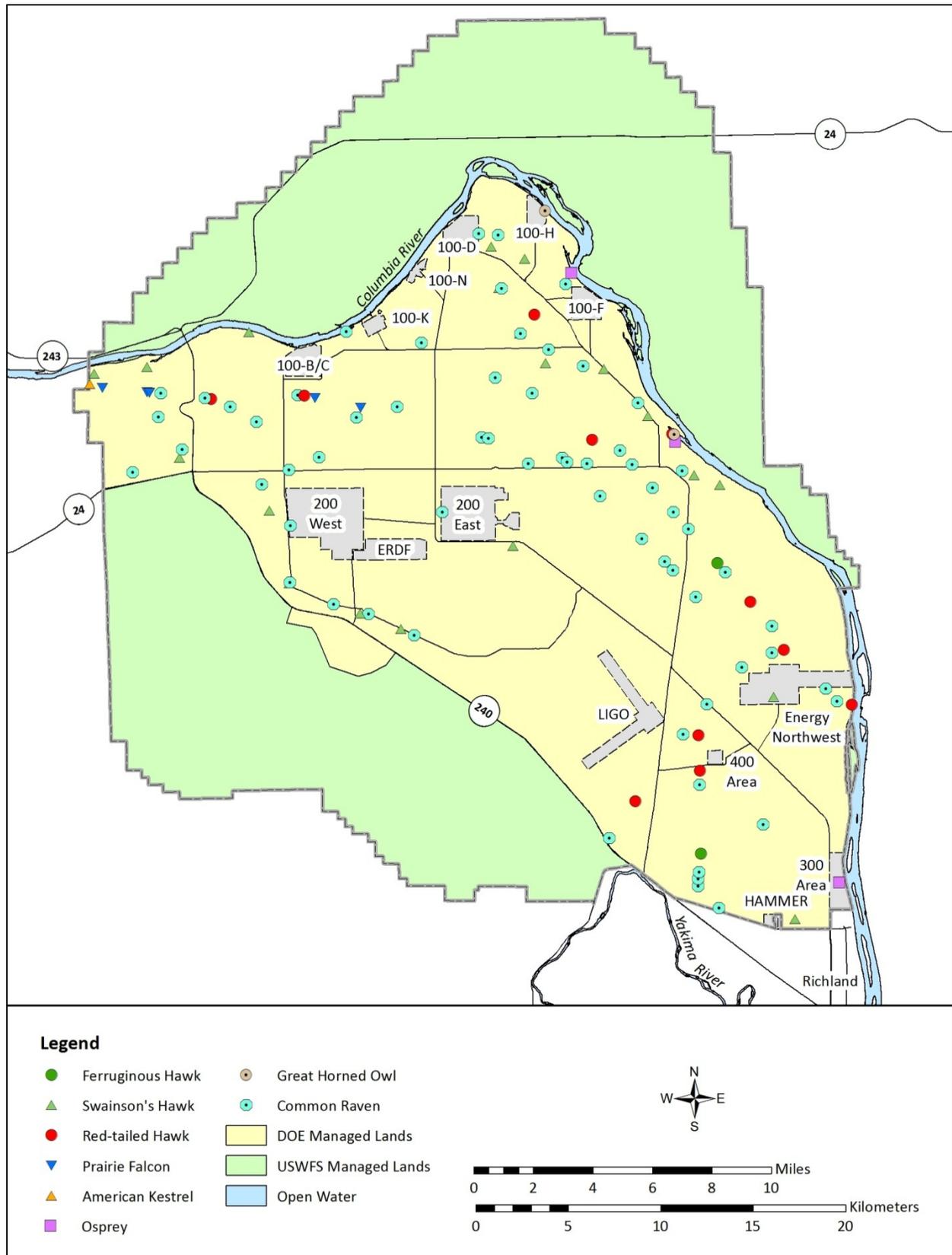
In 2012, nest surveys for raptors and common ravens were conducted on the DOE managed lands of the Hanford Site including central Hanford, McGee Ranch and Riverland areas, the dunes area, and the southern shoreline of the Columbia River. Nests were located using vehicular and foot surveys. Nest searches occurred in late May and early June when all species occupy nesting territories.

Table 11.4 shows the nest substrates used by raptors and ravens on DOE managed lands of the Hanford Site in 2012. There were 107 nest sites recorded including the nest sites of Ferruginous Hawks (2), Swainson's Hawks (20), Red-tailed Hawks (11), Prairie Falcons (5), American Kestrel (1), Ospreys (3), Great Horned Owls (2), and Common Ravens (63). Approximately 88 percent of the raptor and raven nests located in 2012 were on human introduced substrates such as transmission towers, utility poles, and planted trees. Raptor and raven nest sites located in 2012 are illustrated in Figure 11.4.

Table 11.4. Nest Substrates used by Raptors and Ravens on DOE Managed Lands of the Hanford Site

Species	Tree	Cliff	Transmission Tower	Utility Pole	Nest Platform	Instrument Tower	Electrical Substation	Building	Total
Ferruginous Hawk			2						2
Swainson's Hawk	19			1					20
Red-Tailed Hawk	3	2	6						11
Prairie Falcon		5							5
American Kestrel		1							1
Osprey					3				3
Great Horned Owl	2								2
Common Raven	10	3	40	6		1	1	2	63
TOTALS	34	11	48	7	3	1	1	2	107

Figure 11.4. Raptor and Raven Nest Sites



Nesting raptors and ravens have clearly benefited from the introduction of anthropogenic nest structures on the Hanford Site. Although some nesting pairs may have used other available nesting substrates, in the absence of current anthropogenic sources, it is certain that the total number of raptors and ravens would be significantly lower without these artificial nesting locations. It is unclear what impacts artificially high nesting populations of raptors and ravens have on prey species such as ground squirrels (*Uroditellus spp.*), jackrabbits (*Lepus spp.*), and sage grouse (*Centrocercus urophasianus*), but the prevalence of raptors on the Hanford Site and the low levels or complete lack of these prey species is compelling. Additional details from this survey are available in the monitoring report ([HNF-53073](#), *Raptor Nest Monitoring Report for Calendar Year 2012*).

11.1.2.5 Hanford Bird Surveys

The Hanford Site contains a wide expanse of bird habitats that include basalt outcrops, riparian streams and springs, shrub-steppe on slopes and on plains, sand dunes and blowouts, and abandoned fields or disturbed areas ([PNL-8942](#), *Habitat Types on the Hanford Site: Wildlife and Plant Species of Concern*). Because of its large size, the Hanford Site provides habitat for shrub-steppe birds that are entirely dependent on large expanses of sagebrush or areas with native grasses in the understory (Biodiversity Inventory and Analysis of the Hanford Site 1999). In the rest of the Columbia Basin, human activities such as farming, urbanization, and industrial development have greatly decreased the amount of natural sagebrush-grass habitat and disturbance-free riparian zones that many endemic birds require for survival. Ultimately, human activities have caused the populations of a number of shrub-steppe birds to decrease, and some, such as the greater sage grouse, *Centrocercus urophasianus*, have been locally extirpated. Several sagebrush-steppe dependent species, such as the sage sparrow (*Amphispiza belli*), sage thrasher (*Oreoscoptes montanus*), and loggerhead shrike (*Lanius ludovicianus*) are currently listed by the WDFW as “candidate species” and could be listed as threatened or endangered in the future ([WDFW 2013](#)). In addition, the Hanford Site and surrounding area provides refuge to potentially 16 other state species of concern that benefit from the large expanses of undisturbed habitat.

Road surveys are a practical way to monitor changes in species richness and relative abundance of shrub-steppe birds, as reported by PNNL in [Duberstein \(2012\)](#), with the passage of time and various kinds of land-use changes initiated by human activities. During 2012, the field team monitored and described avifauna on four routes: Horn Rapids-to-Hanford Townsite (H-1rev), Old Fields (H2), Gable Mountain (H3), and Army Loop Rd (H4) (Figure 11.5). Each survey route is 12.4 miles (20.0 kilometers) long, marked at 0.8-kilometer intervals by steel fence posts, rebar posts or flags. Birds within 0.25 miles (400 meters) on either side of each transect are identified by sight or sound during a 3-minute stop at each marker post. Surveyors drive to each marker post, observe the area for 3 minutes, write down what they saw or heard, and continue on to the next marker post ([Bysrack 1981](#), *The North American Breeding Bird Survey*; Sauer et al. 2010, *The North American Breeding Bird Survey, Results and Analysis 1966 - 2009*). Staff continues to observe longer than 3 minutes only to confirm identifications or counts for birds that were noted during the 3-minute observation period. The routes were surveyed during March-June to capture pre breeding and breeding seasons and again in November-December for wintering birds.

A combined 59 bird species totaling over 3500 individuals were documented during surveys in 2012. While the number of species observed in 2012 comprises only about 25 percent of the birds ever documented on Hanford, it is within range of the surveys conducted over the last 10 to 15 years, which ranged from 59 (2004-2009) to 69 (1999-2003) species. The number and identity of species can vary with surveyor, time of year surveys performed, and the potential for documenting strictly migrant species. Of the 59 species identified, eleven percent are federally listed species of concern, state listed species of concern, or both. The percentage of species of concern in relation to all identified species is comparable to past years where more than one survey was performed (Figure 11.6). Continued and annual use of the Hanford Site by these species of concern increases the need for continued monitoring and protection of the sites ecological resources.

Figure 11.5. Bird Roadside Survey Routes

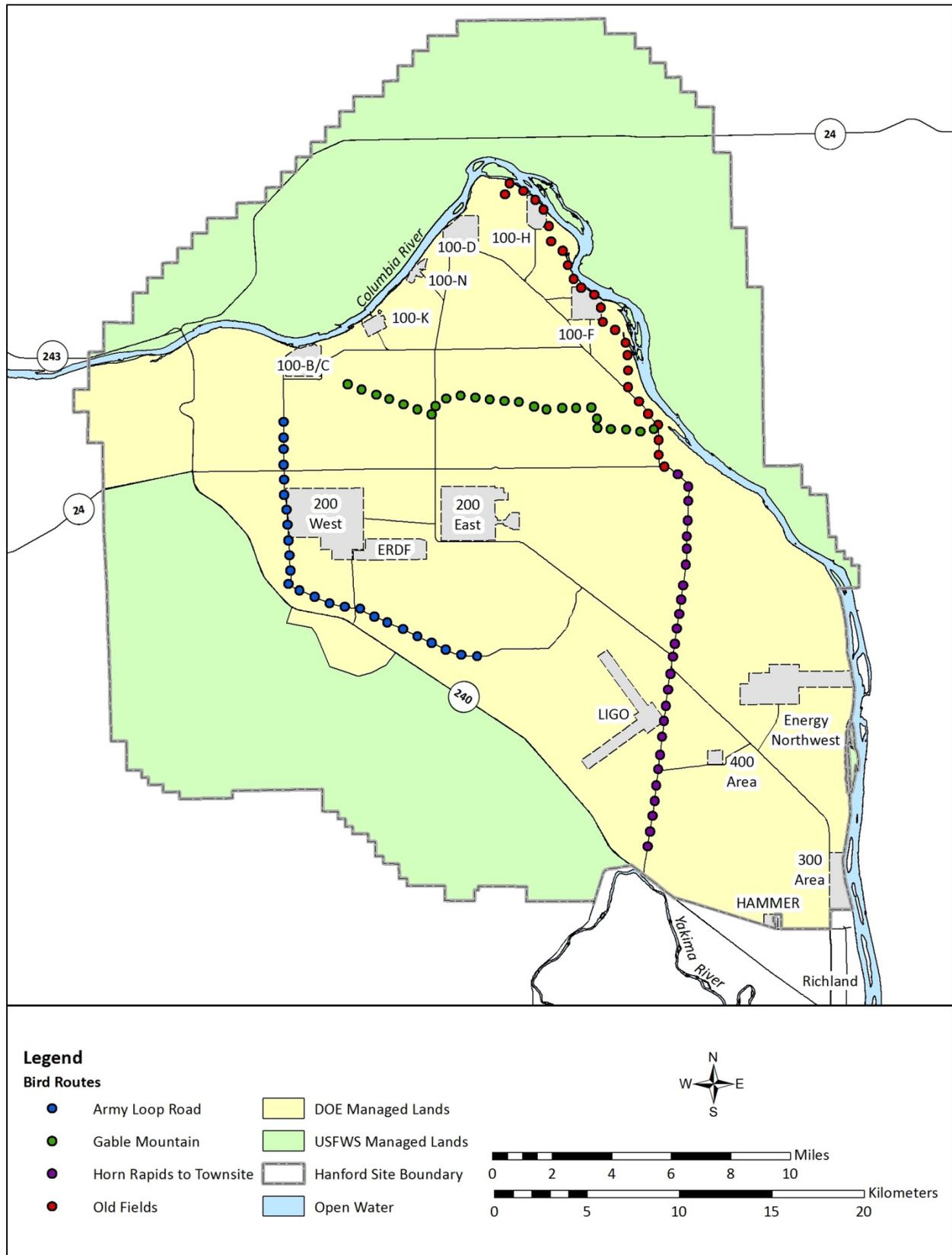
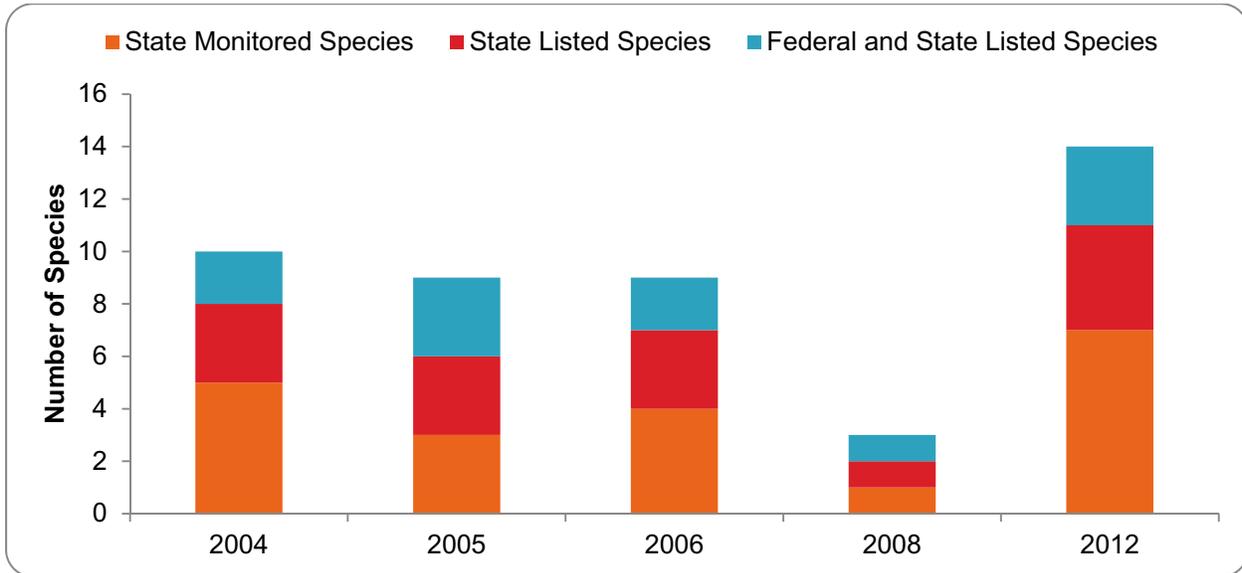


Figure 11.6. Species of Concern Documented in Multiple Surveys



11.1.2.6 Burrowing Owls

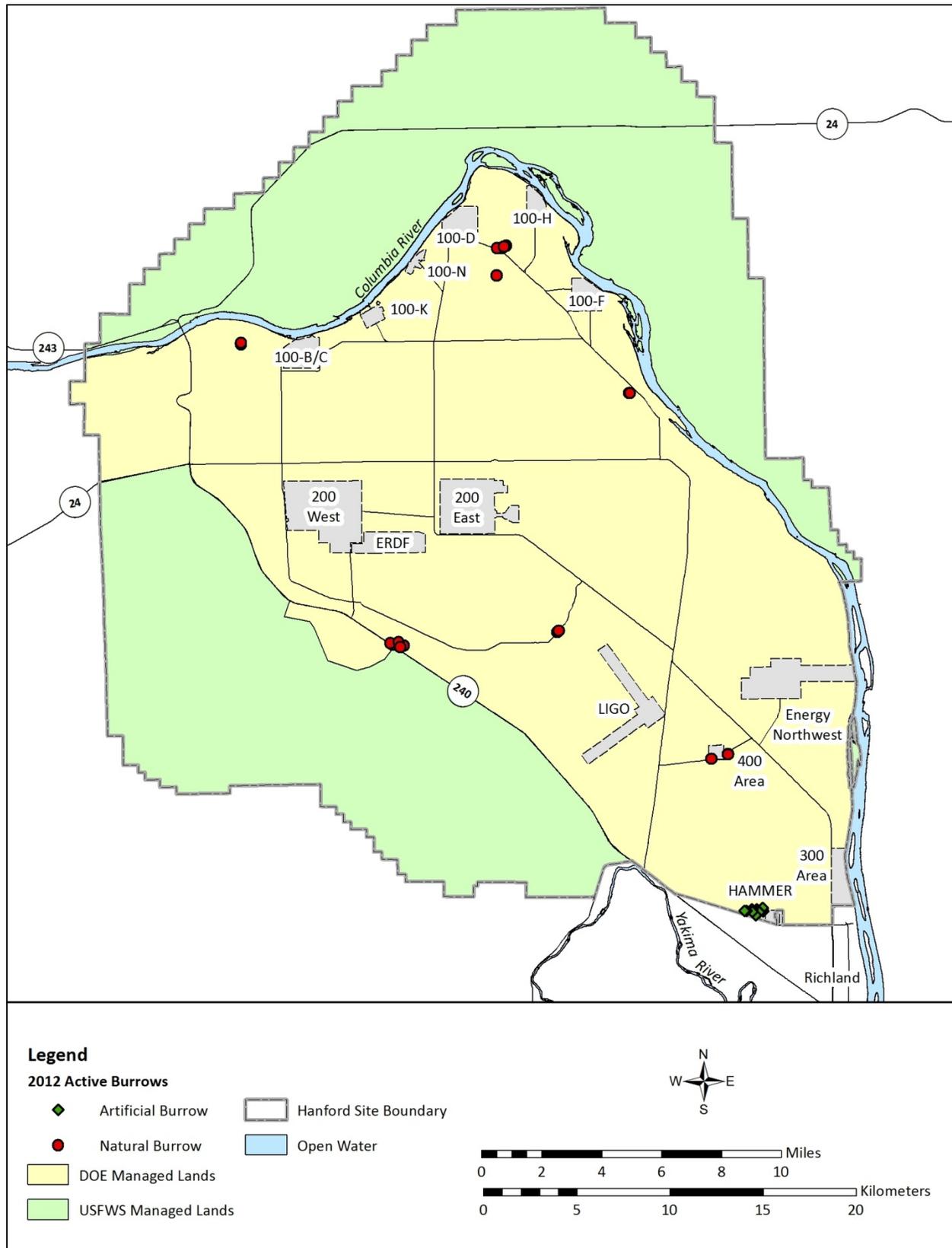
The burrowing owl (*Athene cunicularia*) is classified as a WDFW Candidate Species and is considered a species of concern in Eastern Washington by the USFWS. Burrowing owls are also protected under the *Migratory Bird Treaty Act*. Because the owl populations are declining in Washington State and throughout their historic range ([Conway and Pardieck 2006](#), *Population Trajectory of Burrowing Owls (Athene cunicularia) in Eastern Washington*; [WDFW 2012a](#)), the burrowing owl populations, and the locations of burrows are of concern locally to both the DOE and the USFWS.

Monitoring burrowing owl populations contributes to the management and protection of the species, the maintenance and management of site-wide biological diversity, and assists with proper impact assessment of Hanford Site projects. Many Hanford Site projects include impacts to the ground surface with activities such as grubbing, excavating, burning, off-road driving, compacting, and leveling. Without documentation of current owl burrow locations, it is difficult to protect them.

Over 110 historical burrow locations were visited to determine the status of burrowing owls on the Hanford Site. To avoid interfering with breeding of the owl populations, the surveys were performed in the month of May. At this point in the season most of the owlets have hatched, but have not matured enough to resemble adults. Later in the season, the young may temporarily occupy nearby burrows, which could result in an over-estimation of burrow occupation. Field team members determined if a burrow was active by looking for owls in the burrow, or the presence of castings, feces, feathers, and/or footprints at the opening of the burrow. Brief scans of the surrounding area for additional burrows were made at each location. All newly discovered burrows were documented with the GPS system and added to the Hanford Site burrow database.

Monitoring of the historic burrows during 2012 resulted in a discovery of 13 previously undocumented natural burrows, and added the location and status of 13 artificial burrows to the dataset. Figure 11.7, shows the active owl burrows documented during 2012, 39 active burrows, 23 natural and 16 artificial. Monitoring in 2013 will focus on the 39 active burrows, the artificial burrows, and natural burrows that were listed as having a continued potential for use. Radial perimeter surveys near known burrow locations will be performed in an attempt to locate new burrows on the site. All of the artificial burrows on the DOE managed lands will receive maintenance prior to the spring and potential owl use. A portion of the local burrowing owl population over winters in the area ([Conway and Pardieck 2006](#)), so care to avoid disturbance of those owls will be taken.

Figure 11.7. Active Burrowing Owl Nests



11.1.2.7 Bat Roost Monitoring

Bats belong to the order *Chiroptera*, which means “hand-wing.” Bats have a thin membrane of skin stretched between their fingers to fly. All bat species known in the state of Washington are insectivorous, and each bat can consume 600 to 1,000 insects per hour while feeding. Of the species confirmed to occur on the Hanford Site, pallid bats (*Antrozous pallidus*), small-footed myotis (*Myotis ciliolabrum*), and canyon bats (*Parastrellus hesperus*) are listed as WDFW State Monitor Species. In addition, roosting concentrations of big-brown bats (*Eptesicus fuscus*), pallid bats, and all roosts for bats in the genus *Myotis* are considered Priority Habitats by the WDFW. Roosting congregations can be maternity colonies, winter roosts, or night roosts. Identification and protection of roosting locations is becoming increasingly important with the outbreak of the fungal infection referred to as White Nose Syndrome, which is affecting bats in the eastern United States, and is rapidly expanding westward (more information available at whitenosesyndrome.org).

Monitoring during 2012 relied upon a remotely deployed acoustic detector called a Pettersson D500x (Figure 11.8). The detector was deployed at each location for a minimum of three qualifying weather nights (wind < 15 mph, minimum temperature > 50°F, no measureable precipitation), in order to minimize weather-related impacts on level of activity calculations. Acoustic recordings were analyzed, using Sonobat 3 automated analysis software and manual review, to help determine the species present and the relative level of activity (calls/bat-night).

Figure 11.8. Remotely Deployed Acoustic Detector Near Potential Bat Roosting Habitat

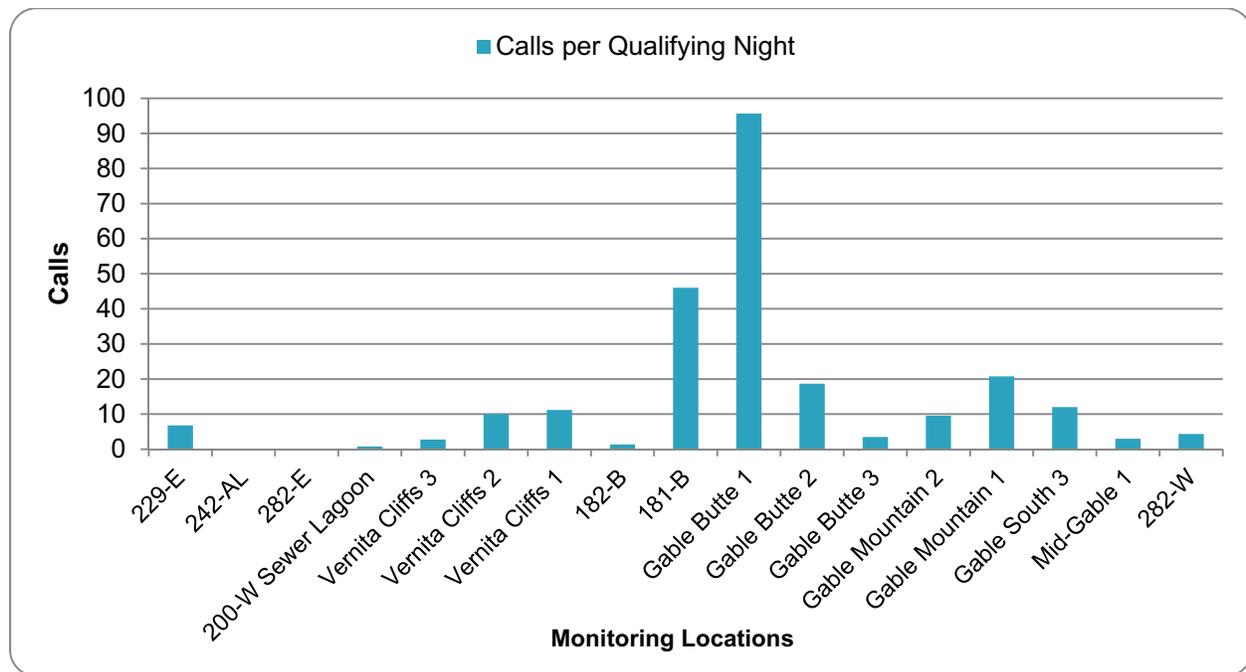


Acoustic monitoring was conducted over 119 nights at 17 locations between May 14 and September 10, 2012. Monitoring focused on natural cliff habitat between Gable Mountain and Umtanum Cliff. The Nature Conservancy of Washington *Biodiversity Inventory and Analysis of the Hanford Site* (Soll 1999), completed on the Hanford Site during 1997 and 1998, documented nine bat species using a combination of acoustics and mist netting. Our study, completed using only acoustics, documented the same nine species. Bat passes can only be used to determine relative levels of activity, but based on the information collected across all 17 monitoring locations in 2012, little brown bats appear to be the most abundant species in the natural habitats surveyed (853 bat passes) (Figure 11.9). This is in contrast to the known colony of yuma myotis at the industrialized 100-F Area, which is the largest known bat colony in the State of Washington (WCH-512, 2011 *Revegetation and Mitigation Monitoring Report*). Perhaps more surprisingly, the second and third most-recorded species were silver-haired bats (*Lasionycteris noctivagans*) (208 passes) and hoary bats (*Lasiurus*

cinereus) (102 passes). Both of these species are migratory and are termed “tree bats” because they are typically associated with trees for roosting, so the mostly treeless Hanford Site initially seems an unlikely place to detect these species at high levels ([BCI 2012](#), *BCI Species Profiles*).

Continuing bat work on the Hanford Site will include acoustic monitoring at additional locations, and may expand to include mist netting for species confirmation, and infrared video and mist netting for locating maternity colony locations, and acoustic monitoring focused on identifying winter roosting habitat.

Figure 11.9. Bat Passes Recorded for Each Species Across All Monitoring Locations



11.1.2.8 Townsend Ground Squirrels

Townsend’s ground squirrel (*Urocitellus townsendii*) is listed as a “State Candidate” by the WDFW and a species of concern in Eastern Washington by the USFWS. These animals are important to the shrub-steppe ecosystem for many reasons. They serve as an important food source for predators such as badgers, coyotes, and birds of prey such as hawks, falcons, and owls. The ground squirrel diet consists of a variety of foods including seeds, which contributes to native plant seed dispersal. The process of digging burrows helps aerate the soil and provides burrows for other species including burrowing owls ([HNF-53075](#), *Ground Squirrel Monitoring Report for Calendar Year 2012*). Their decline is due to the loss of suitable habitat and isolation of their communities through fragmentation ([WDFW 2012a](#)). Townsend’s ground squirrels can be difficult to monitor due to their concealed underground lifestyle and short season of activity.

At the onset of the 2012 monitoring season, six Townsend’s ground squirrel colonies were reported in the Public Safety and Resource Protection Database, but the status of these colonies was not known. The first monitoring goal for 2012 was to document the status of previously known colony locations. The second goal was to survey for new colonies across the approximately 316 square miles (815.8 square kilometers) central portion of the Hanford Site.

To document the status of historical colony locations identified from the 2012 surveys performed circular surveys around the colony locations, at 33 and 66-yard (30 and 60-meter) radii, looking for active burrows. Table 11.5 provides the monitoring results at historical Townsend’s ground squirrel colonies. Each colony was determined to be absent, inactive, or active.

Table 11.5. Monitoring Results at Historical Townsend's Ground Squirrel Colonies

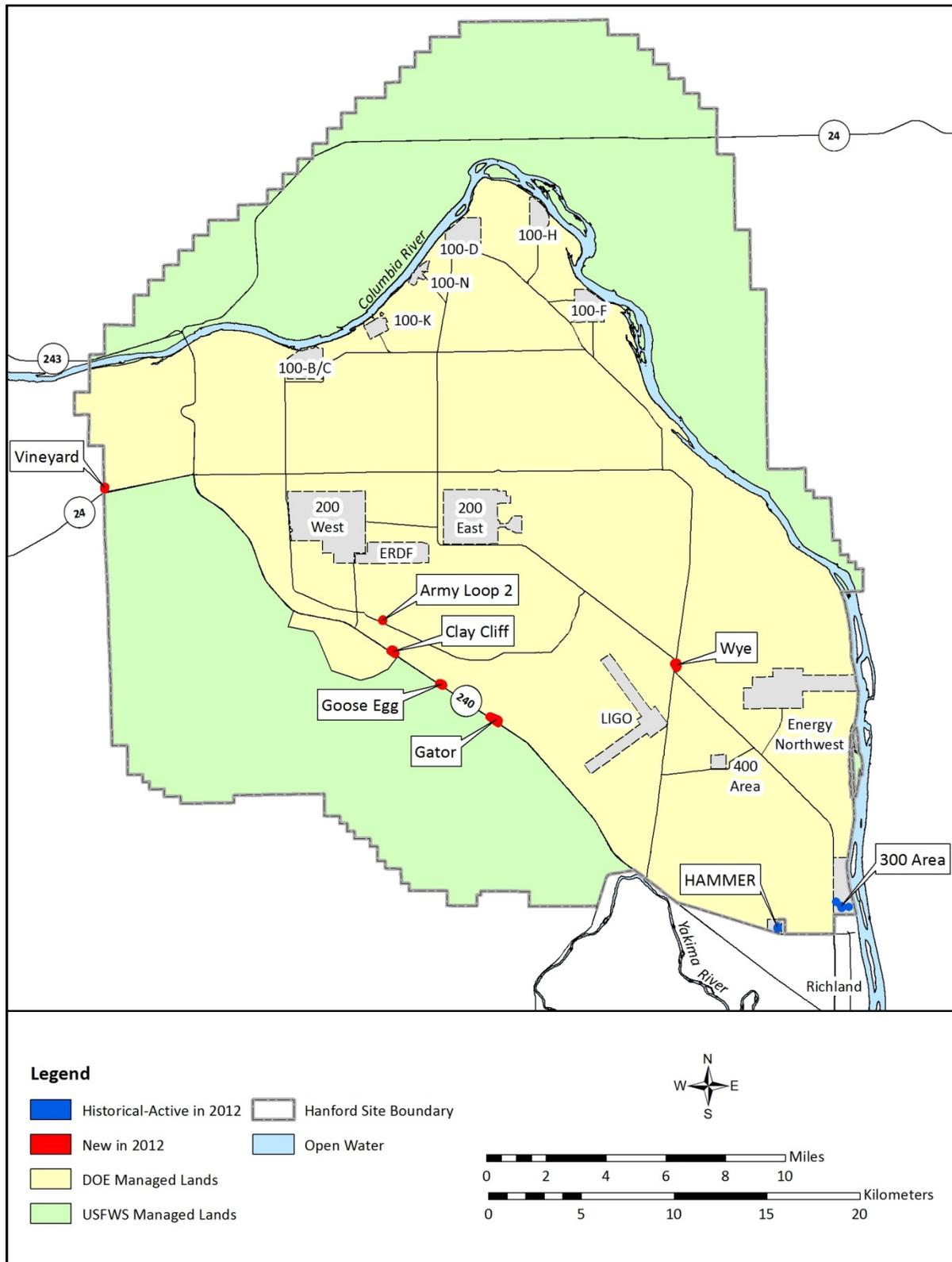
Name	2012 Status	No. Burrows
West Dunes	absent	0
East Dunes	inactive	0
South of Hanford Town Site	inactive	0
300 Area	Active	>20
HAMMER	Active	1-5
Army Loop	inactive	0

In addition to documenting the status of previously identified ground squirrel colonies, transect surveys were conducted at 30 locations to identify new colonies across the central portion of the Hanford Site. Transects were designed as squares with 1,094-yard (1,000-meter) sides and rounded corners. No ground squirrel colonies were identified along any of these transects in 2012.

Finally, field personnel conducted focused surveys at areas where other Hanford Site biologists reported seeing ground squirrels, and where squirrels were incidentally encountered during compliance reviews or other field surveys. Six previously undocumented Townsend's ground squirrel colonies were recorded through these methods during 2012. Monitoring efforts during 2012 increased the number of known active ground squirrel colonies on the central Hanford Site from two to eight (Figure 11.10).

Figure 11.10. Townsend's Ground Squirrel Colonies

Identified and Confirmed during Surveys



11.1.2.9 Mule Deer

Population characteristics of mule deer on the Hanford Site are monitored using roadside surveys to assess relative population size, and the age and sex ratios of the population. Additional data are collected to assess 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.

Four surveys were conducted in December 2012 and January 2013, the post-hunting period. There were 288 combined deer observations over four repeated surveys. It is likely that the surveys included multiple observations of the some of the same animals. 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.

Changes in mule deer population size and health can be monitored by examining trends in the ratios of fawns to does over time. In 2012, the fawn-to-doe mean estimate was 41.0 fawns per 100 does for the northern region and 37.2 for the southern region (Figure 11.11). For both regions, these ratios were higher than the last measurement in 2010, and they were slightly higher than the 10-year average. The 10-year average has remained relatively steady, ranging between 31.2 and 36.2 fawns per 100 does in the northern region and between 28.0 and 34.0 in the southern region. This relatively 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.

Testicular atrophy and sterility have been observed in some male mule deer on the Hanford Site ([PNNL-11518](#), *Investigation of Anatomical Anomalies in Hanford Site Mule Deer*). Extensive investigation during the 1990s found no relationships between the presence of testicular atrophy and numerous factors including contaminant levels, diet, disease, or natural conditions such as aging or genetics ([PNNL-11518](#)). Affected males are easily detected in the field because of their abnormal, misshapen, and velvet-covered antlers. The observed frequency of misshapen antlers in mule deer has ranged from a high of 17 percent in the southern region in 1998 to a low of 0 percent in both regions in 2003 (Figure 11.12). The 10-year averages in the northern region have been relatively steady at between 2.5 and 4 percent, while the 10-year average in the southern region has been generally declining from around 6 percent to about 3 percent. In 2012, observations of affected male deer were low; the observed frequency of antler abnormality was 0 percent in the northern region and 4.8 percent in the southern region. These frequencies should be interpreted with caution because the small sample sizes may not fully reflect population conditions. In general, the data indicate the health of the male mule deer on the Hanford Site has not changed substantially over the last decade.

Figure 11.10. Estimates for Fawns per 100 Mule Deer Does during Post-Hunting Period (Winter) on the Hanford Site
1994 through 2012 (mean \pm 1 standard error)

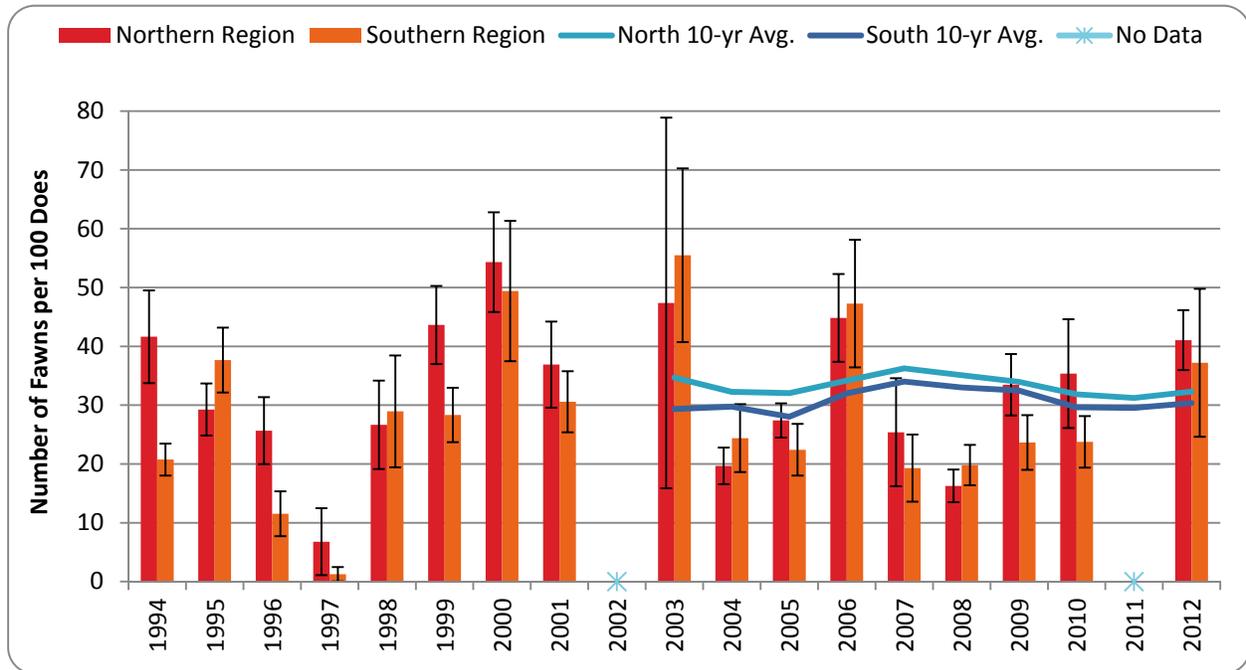
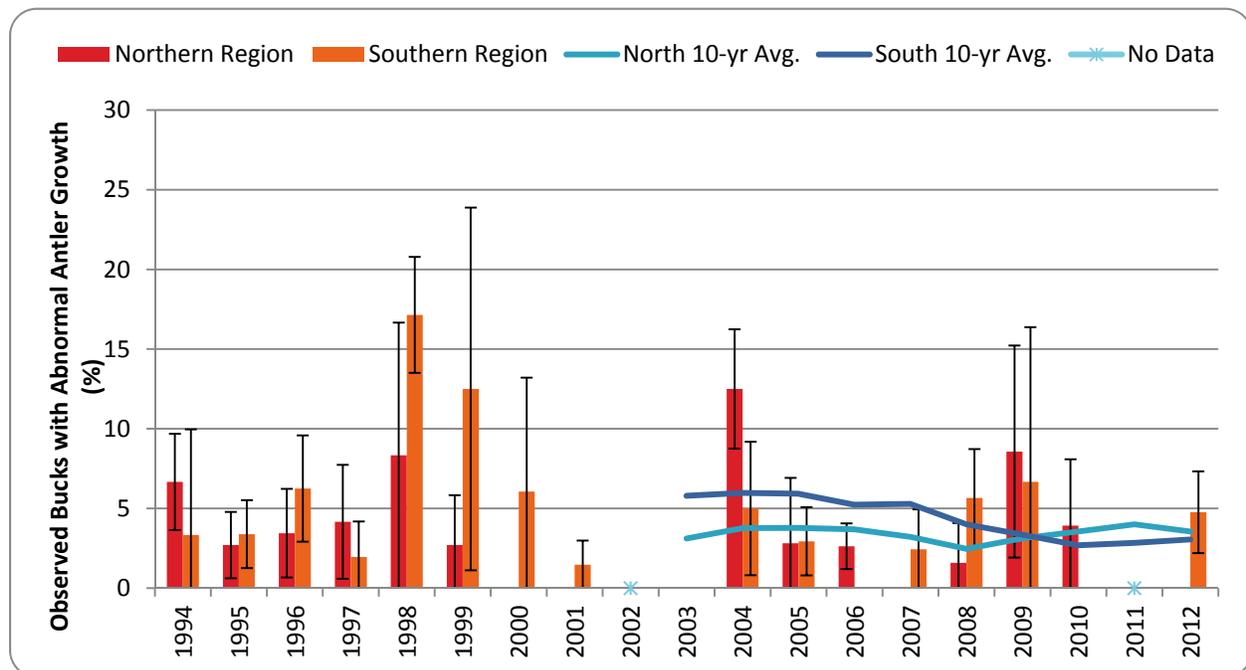


Figure 11.11. Percent of Male Mule Deer on the Hanford Site Showing Signs of Abnormal Antler Growth
1994 through 2012 (mean \pm 1 standard error)



11.1.2.10 Hanford Elk Population Status

Elk were first documented on the Hanford Site in 1972. Since then, the number of elk on site has grown to peak at over 800 individuals ([HNF-54666](#)). This elk herd is relatively isolated from other elk herds in Washington State and, as such, has been identified by state wildlife managers as the Rattlesnake Hills Elk Herd. Until recently, the central portion of the Hanford Site was used infrequently by elk. As noted in [HNF-54666](#), a single female elk was observed on central Hanford in 1997. From 1997 through 2000, only a few small herds of male (bull) elk were documented using the central Hanford Site regions. Beginning in approximately 2010, a herd of approximately 22 elk, often including cows, yearlings, and a single adult bull began regularly occupying areas along the northern portion of central Hanford, in addition to the bachelor herds of bulls.

Aerial and ground-based driving survey methods were used to monitor elk on the central portion of the Hanford Site; and did not include the Arid Lands Ecology Reserve, or other non-DOE managed portions of the Hanford Reach National Monument. The surveys were conducted in the locations where elk are known to exist. The aerial surveys were conducted using a Cessna 182 fixed-wing aircraft, flying approximately 1,200 feet (366 meters) above ground level, over a systematic grid spaced approximately 1.24 miles (2.0 kilometers) apart across the survey area. Driving surveys were performed concurrently with the aerial surveys, traveling on an established route covering most of the same area as the aerial surveys. The aerial and driving survey counts were reconciled to assess detection differences between the two survey techniques, and to avoid double counting the herds.

During 2012, four complete surveys were conducted (April 5, June 19, October 25, and December 18). On April 5, 2012, 26 elk were detected; June 19, 2012, 17 elk were detected (4 elk detected from the air, and 13-elk detected from the ground with no overlaps); October 25, 2012, two herds of elk were detected (1 herd of 6, and 1 herd of 4); December 18, 2012, 2 bull elk were detected by the ground crew.

Elk were observed incidentally, 12 times between March 27 and December 11, 2012, while personnel were working on other projects. A summary of all central Hanford elk observations in 2012 is shown in Table 11.6.

Table 11.6. Elk Observed during formal Surveys or Incidentally

Date	2012 Survey Type	Total Elk	Bulls	Cows	Calves
3/27/12	Incidental Observation	7	U/A	U/A	U/A
4/5/12	Aerial	26	1	25	0
4/26/12	Incidental Observation	2	0	2	0
5/1/12	Incidental Observation	2	2	0	0
5/14/12	Incidental Observation	8	8	0	0
5/17/12	Incidental Observation	3	0	3	0
5/24/12	Incidental Observation	1	0	1	0
5/31/12	Incidental Observation	1	0	1	0
6/19/12	Incidental Observation	13	U/A	U/A	U/A
6/19/12	Aerial	4	0	4	0
6/19/12	Ground	13	13	0	0
10/10/12	Incidental Observation	1	1	0	0
10/17/12	Incidental Observation	13	22	U/A	U/A
10/25/12	Aerial/Ground	6	2	3	1
10/25/12	Ground	4	0	4	0
11/27/12	Incidental Observation	20	2	14	4
12/11/12	Incidental Observation	37	11	U/A	U/A
12/18/12	Ground	2	2	0	0

U/A = observers were unable to distinguish between classifications

This survey was designed to provide a relative abundance estimate of the elk using the central portion of the Hanford Site. The design included a relatively low level of effort, consistent with the level of detail required to answer the study questions. The aerial survey approach was designed to allow the entire survey area to be observed during a single flight. This minimized the level of effort and costs associated with the project. However, in order to cover the survey area in a single flight (with a maximum time of approximately 2 hours), transects were spaced approximately 1.24 miles (2 kilometers) apart. This spacing results in a “blind spot” beneath the airplane that may include up to 10 percent of the survey area. In order to avoid the blind spot problem, and increase the detectability of elk from the aerial survey, the transect spacing would need to be reduced from 1.24 miles to 0.62 mile (2.0 kilometers to 1.0 kilometer); this would likely increase the level of detection because surveyors would get multiple looks at areas from varying perspectives but would double the duration of the aerial survey.

Elk numbers on the central portion of the Hanford Site appear to be slowly increasing, especially for antlerless elk. In addition to the bull herds that still frequent the central portion of the Hanford Site, herds of over 30 cows are now present regularly. The USFWS is considering allowing elk hunting on the Arid Lands Ecology (Reserve). If hunting commences on the Arid Lands Ecology (Reserve), additional elk are likely to move onto central Hanford, and the 2012 monitoring, as well as continued incidental occurrence recording, will provide a baseline population estimate. Additional elk-specific surveys, including the more robust aerial protocol described above, would likely be necessary to track more systematically and accurately any changes in elk use of central Hanford relating to hunting activities.

11.1.2.11 Snake Hibernacula

For the public, snakes are one of the least understood and most feared groups of animals, often resulting in the intentional killing of individuals and destruction of habitat. However, snakes fill an important role in the ecosystems they occupy, eating a variety of prey, and providing a source of food for many other predators.

On the Hanford Site, snakes typically seek out hibernacula in mid-October and remain there until April. Sometime during early to mid-April, western rattlesnakes (*Crotalus oreganus*) will typically spend 2 to 3 weeks moving into and out of the hibernacula locations prior to dispersing to feeding ranges. Hibernacula locations used by western rattlesnakes are readily identifiable during the emergence period, due to the presence of snakes at the openings. Personnel identified locations that appeared to be suitable for snake use, and then revisited the locations once emergence was documented at the previously known three hibernacula at the Hanford Site.

Due to the limited timeframe when snakes are present at hibernacula openings, only 1 day of surveying for new hibernacula was completed prior to snakes dispersing. During that survey day, six new snake dens were documented on the Hanford Site, increasing the number of known dens to nine. This greatly increases our understanding of snake hibernacula use across the Hanford Site, allows these locations to be considered and protected during Ecological Compliance Reviews, and provides additional opportunities for research into suitable hibernacula characteristics. This also provides opportunities for determining the presence of sensitive species, such as the striped whipsnakes (*Masticophis taeniatus*), night snakes (*Hypsiglena torquata*), and racers (*Coluber constrictor*), that may share the hibernacula with western rattlesnakes.

11.2 Endangered and Threatened Species

MR Sackschewsky

This section describes federal and state endangered and threatened species, candidate or sensitive plant and animal species, and other species of concern potentially found 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 USFWS in [50 CFR 17.11](#), *Endangered and*

Threatened Wildlife and [50 CFR 17.12](#), *Endangered and Threatened Plants*. State lists are maintained by the Washington Natural Heritage Program ([WNHP 2012](#)) and WDFW ([WDFW 2013](#)).

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 2013](#)) has the responsibility for federal listing of anadromous fish (i.e., fish that require both saltwater and freshwater to complete a lifecycle). The USFWS is responsible for all other federally listed species at the Hanford Site. Table 11.5 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 the 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 occur regularly on the Hanford Site (Table 11.5). One additional fish species (bull trout [*Salvelinus confluentus*]) was recorded at the Hanford Site but scientists believe this species is transient. Two plant species, the Umtanum desert buckwheat (*Eriogonum codium*) and the White Bluffs bladderpod (*Physaria douglasii* ssp. *tuplashensis*) were listed as threatened species under the *Endangered Species Act of 1973* in April 2013 ([78 FR 23984](#)); however, implementation of the rule has been delayed until at least November, 2013 ([78 FR 30772](#)). 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 one mammal species and one bird species are currently candidates for federal listing (Table 11.5). 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 33 state-level sensitive and candidate species of insects and animals and 15 sensitive plant species occurring or potentially occurring on the Hanford Site (Table 11.5).

Washington State officials maintain additional lower level lists of species, including a monitor list for animals ([WDFW 2013](#)) and review and watch lists for plants ([WNHP 2012](#)). 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 50 Washington State monitor list animal species occur or potentially occur on the Hanford Site (Table 11.6), as well as 26 watch or review list plant species (Table 11.7).

Table 11.5. Federal and State Endangered, Threatened, Sensitive, and Candidate Species

Common Name	Scientific Name	Federal Status ¹	State Status ¹
Plants			
Awned Halfchaff Sedge	<i>Lipocarpha (= Hemicarpha) aristulata</i>		Threatened
Beaked Spike-Rush	<i>Eleocharis rostellata</i>		Sensitive
Canadian St. John's Wort	<i>Hypericum majus</i>		Sensitive
Chaffweed	<i>Anagallis (= Centunculus) minima</i>		Threatened
Columbia Milkvetch	<i>Astragalus columbianus</i>	Species of concern	Sensitive
Columbia Yellowcress	<i>Rorippa columbiae</i>	Species of concern	Endangered
Coyote Tobacco	<i>Nicotiana attenuata</i>		Sensitive
Desert Cryptantha	<i>Cryptantha scoparia</i>		Sensitive
Desert Dodder	<i>Cuscuta denticulata</i>		Threatened
Desert Evening-Primrose	<i>Oenothera caespitosa</i>		Sensitive
Dwarf Evening Primrose	<i>Camissonia (= Oenothera) pygmaea</i>		Sensitive
Fuzzytongue Penstemon	<i>Penstemon eriantherus whitedii</i>		Sensitive
Geyer's Milkvetch	<i>Astragalus geyeri</i>		Threatened
Grand Redstem	<i>Ammannia robusta</i>		Threatened
Gray Cryptantha	<i>Cryptantha leucophaea</i>	Species of concern	Sensitive
Great Basin Gilia	<i>Aliciella (= Gilia) leptomeria</i>		Threatened
Hedgehog cactus	<i>Pediocactus nigrispinus</i> (= <i>P. simpsonii</i> var. <i>robustior</i>)		Sensitive
Hoover's Desert Parsley	<i>Lomatium tuberosum</i>	Species of concern	Sensitive
Loeflingia	<i>Loeflingia squarrosa</i> var. <i>squarrosa</i>		Threatened
Lowland Toothcup	<i>Rotala ramosior</i>		Threatened
Piper's Daisy	<i>Erigeron piperianus</i>		Sensitive
Rosy Pussypaws	<i>Cistanthe (= Calyptidium) rosea</i>		Threatened
Small-Flowered Evening-Primrose	<i>Camissonia (= Oenothera) minor</i>		Sensitive
Snake River Cryptantha	<i>Cryptantha spiculifera</i> (= <i>C. interrupta</i>)		Sensitive
Suksdorf's Monkey Flower	<i>Mimulus suksdorfii</i>		Sensitive
Umtanum Desert Buckwheat	<i>Eriogonum codium</i>	Proposed Threatened	Endangered
White Bluffs Bladderpod	<i>Physaria (= Lesquerella) tuplashensis</i>	Proposed Threatened	Threatened
White Eatonella	<i>Eatonella nivea</i>		Threatened

Table 11.5. Federal and State Endangered, Threatened, Sensitive, and Candidate Species

Common Name	Scientific Name	Federal Status ¹	State Status ¹
Mollusks			
California Floater	<i>Anodonta californiensis</i>	Species of concern	Candidate
Great Columbia River Spire Snail	<i>Fluminicola columbiana</i>	Species of concern	Candidate
Shortfaced Lanx	<i>Fisherola nuttalli</i>		Candidate
Insects			
Columbia Clubtail	<i>Gomphus lynnae</i>	Species of concern	Candidate
Columbia River Tiger Beetle ²	<i>Cicindela columbica</i>		Candidate
Silver-Bordered Fritillary	<i>Boloria selene atrocostalis</i>		Candidate
Fish			
Bull Trout ³	<i>Salvelinus confluentus</i>	Threatened	Candidate
Leopard Dace ³	<i>Rhinichthys flacatus</i>		Candidate
Mountain Sucker ³	<i>Catostomus platyrhynchus</i>		Candidate
River Lamprey ³	<i>Lampetra ayresi</i>	Species of concern	Candidate
Spring-Run Chinook Salmon	<i>Oncorhynchus tshawytscha</i>	Endangered	Candidate
Steelhead	<i>Oncorhynchus mykiss</i>	Threatened	Candidate
Birds			
American White Pelican	<i>Pelecanus erythrorhynchos</i>		Endangered
Bald Eagle	<i>Haliaeetus leucocephalus</i>	Species of concern	Sensitive
Burrowing Owl	<i>Athene cunicularia</i>	Species of concern	Candidate
Clark's Grebe	<i>Aechmophorus clarkii</i>		Candidate
Common Loon	<i>Gavia immer</i>		Sensitive
Ferruginous Hawk	<i>Buteo regalis</i>	Species of concern	Threatened
Flamulated Owl ³	<i>Otus flammeolus</i>		Candidate
Golden Eagle	<i>Aquila chrysaetos</i>		Candidate
Greater Sage Grouse	<i>Centrocercus urophasianus</i>	Candidate	Threatened
Lewis's Woodpecker ³	<i>Melanerpes lewis</i>		Candidate
Loggerhead Shrike	<i>Lanius ludovicianus</i>	Species of concern	Candidate
Northern Goshawk ³	<i>Accipiter gentilis</i>	Species of concern	Candidate
Olive-Sided Flycatcher	<i>Contopus cooperi</i>	Species of concern	
Peregrine Falcon	<i>Falco peregrinus</i>	Species of concern	Sensitive
Sage Sparrow	<i>Amphispiza belli</i>		Candidate
Sage Thrasher	<i>Oreoscoptes montanus</i>		Candidate
Sandhill Crane	<i>Grus canadensis</i>		Endangered
Western Grebe	<i>Aechmophorus occidentalis</i>		Candidate

Table 11.5. Federal and State Endangered, Threatened, Sensitive, and Candidate Species

Common Name	Scientific Name	Federal Status ¹	State Status ¹
Amphibians and Reptiles			
Sagebrush Lizard	<i>Sceloporus graciosus</i>	Species of concern	Candidate
Striped Whipsnake	<i>Masticophis taeniatus</i>		Candidate
Western Toad	<i>Bufo boreas</i>	Species of concern	Candidate
Mammals			
Black-Tailed Jackrabbit	<i>Lepus californicus</i>		Candidate
Merriam's Shrew	<i>Sorex merriami</i>		Candidate
Townsend's Ground Squirrel	<i>Urocitellus townsendii</i>	Species of concern	Candidate
Washington Ground Squirrel ³	<i>Urocitellus washingtoni</i>	Candidate	Candidate
White-Tailed Jackrabbit	<i>Lepus townsendii</i>		Candidate

¹ Endangered - Species in danger of extinction within all or a significant portion of its range.

Threatened - Species likely to become endangered in the near 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.

² Probable, but not observed, on the Hanford Site.

³ Reported, but seldom observed, on the Hanford Site.

Table 11.6. Washington State Monitored Wildlife Species

Common Name	Scientific Name	Common Name	Scientific Name
Birds		Fish	
Arctic Tern ¹	<i>Sterna paradisaea</i>	Pacific Lamprey ²	<i>Lampetra tridentata</i>
Ash-Throated Flycatcher ¹	<i>Myiarchus cinerascens</i>	Piute Sculpin	<i>Cottus beldingi</i>
Black Tern ¹	<i>Chlidonias niger</i>	Reticulate Sculpin	<i>Cottus perplexus</i>
Black-Crowned Night-Heron	<i>Nycticorax nycticorax</i>	Sand Roller	<i>Percopsis transmontana</i>
Black-Necked Stilt	<i>Himantopus mexicanus</i>	Amphibians and Reptiles	
Bobolink ¹	<i>Dolichonyx oryzivorus</i>	Night Snake	<i>Hypsiglena torquata</i>
Caspian Tern	<i>Sterna caspia</i>	Racer	<i>Coluber constrictor</i>
Forster's Tern	<i>Sterna forsteri</i>	Short-Horned Lizard	<i>Phrynosoma douglasii</i>
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	Tiger Salamander	<i>Ambystoma tigrinum</i>
Gray Flycatcher	<i>Empidonax wrightii</i>	Woodhouse's Toad	<i>Anaxyrus woodhousii</i>
Great Blue Heron	<i>Ardea herodias</i>	Mollusks	
Great Egret	<i>Ardea alba</i>	Oregon Floater	<i>Anodonta oregonensis</i>
Gyrfalcon ¹	<i>Falco rusticolus</i>	Western Floater	<i>Anodonta kennerlyi</i>
Horned Grebe	<i>Podiceps auritus</i>	Western Pearlshell	<i>Margaritifera falcata</i>
Lesser Goldfinch	<i>Spinus psaltria</i>	Winged floater	<i>Anodonta nuttalliana</i>
Long-Billed Curlew	<i>Numenius americanus</i>		
Osprey	<i>Pandion haliaetus</i>		
Prairie Falcon	<i>Falco mexicanus</i>		
Red-Necked Grebe ¹	<i>Podiceps grisegena</i>		
Snowy Owl	<i>Nyctea scandiaca</i>		
Swainson's Hawk	<i>Buteo swainsoni</i>		
Turkey Vulture ¹	<i>Cathartes aura</i>		
Western Bluebird	<i>Sialia Mexicana</i>		
Insects			
Bonneville Skipper	<i>Ochlodes sylvanoides bonnevilla</i>		
Juba Skipper	<i>Hesperia juba</i>		
Nevada Skipper	<i>Hesperia nevada</i>		
Pasco Pearl	<i>Phyciodes cocyta pascoensis</i>		
Persius' Duskywing	<i>Erynnis persius</i>		
Purplish Copper	<i>Lycaena helloides</i>		
Ruddy Copper	<i>Lycaena rubida perkinsorum</i>		
Viceroy	<i>Limenitis archippus lahontani</i>		
Mammals			
Badger	<i>Taxidea taxus</i>		
Canyon bat	<i>Parastrellus hesperus</i>		
Long-Legged Myotis ²	<i>Myotis volans</i>		
Northern Grasshopper Mouse	<i>Onychomys leucogaster</i>		
Pallid Bat	<i>Antrozous pallidus</i>		
Sagebrush Vole	<i>Lemmiscus curtatus</i>		
Small-Footed Myotis ²	<i>Myotis ciliolabrum</i>		

¹ Reported, but seldom observed on the Hanford Site.² Federal species of concern.

Table 11.7. Hanford Site Washington State Review and Watch List Plant Species

Common Name	Scientific Name	State Listing ¹
annual paintbrush	<i>Castilleja exilis</i>	Watch List
annual sandwort	<i>Minuartia pusilla</i> var. <i>pusilla</i>	Review Group 1
basalt milkvetch	<i>Astragalus conjunctus</i> var. <i>rickardii</i>	Watch List
bristly combseed	<i>Pectocarya setosa</i>	Watch List
Columbia River mugwort	<i>Artemisia lindleyana</i>	Watch List
crouching milkvetch	<i>Astragalus succumbens</i>	Watch List
false pimpernel	<i>Lindernia dubia</i> var. <i>anagallidea</i>	Watch List
giant helleborine	<i>Epipactis gigantea</i>	Watch List
Hairy bugseed	<i>Corispermum villosum</i>	Review Group 2
Kittitas larkspur	<i>Delphinium multiplex</i>	Watch List
medic milkvetch	<i>Astragalus speirocarpus</i>	Watch List
pigmy-weed	<i>Crassula aquatica</i>	Watch List
porcupine sedge	<i>Carex hystericina</i>	Watch List
Robinson's onion	<i>Allium robinsonii</i>	Watch List
rosy balsamorhiza	<i>Balsamorhiza rosea</i>	Watch List
scilla onion	<i>Allium scilloides</i>	Watch List
shining flatsedge	<i>Cyperus bipartitus</i> (= <i>C. rivularis</i>)	Watch List
Shy gilly flower	<i>Gilia inconspicua</i>	Review Group 1
small-flowered nama	<i>Nama densum</i> var. <i>parviflorum</i>	Watch List
smooth cliffbrake	<i>Pellaea glabella simplex</i>	Watch List
Smooth willowherb	<i>Epilobium pygmaeum</i>	Review Group 1
southern mudwort	<i>Limosella acaulis</i>	Watch List
stalked-pod milkvetch	<i>Astragalus sclerocarpus</i>	Watch List
Thompson's sandwort	<i>Eremogone (Arenaria) franklinii</i> var. <i>thompsonii</i>	Review Group 1
vanilla grass	<i>Anthoxanthum hirtum (Hierchloe odorata)</i>	Review Group 1
winged combseed	<i>Pectocarya penicillata</i>	Watch List

¹ Watch List: Taxa that are of conservation concern, but are more abundant and/or less threatened than previously assumed. Review Group 1: Taxa for which currently there are insufficient data available to support listing as threatened, endangered, or sensitive. Review Group 2: Taxa of potential concern but have unresolved taxonomic questions.

11.3 Cultural and Historic Resource Protection

TE Marceau, DP McFarland, and JL Mendez

Cultural and historic resources monitoring at DOE-managed portions of the Hanford Site is conducted under the auspices of DOE's Cultural Resources Program to ensure site compliance with federal cultural resources laws and regulations (Section 2.5). Program activities in 2012 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 ensure important resources are protected
- Maintained a database of cultural resources site records, project records, and regional ethno history
- Maintained archaeological and historical collections
- Identified and evaluated new cultural resources to ensure 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.

DOE's Cultural Resources Program personnel oversee all cultural resource activities at the Hanford Site. Section 106 compliance work scope in 2012 was performed for DOE by archaeologists from MSA, PNNL, and WCH.

The DOE Cultural Resources Program also schedules monthly meetings with all archaeological staff from the Hanford Site contractors to discuss and resolve issues relating to Cultural Resources Management (including survey procedures, site testing, site evaluation, consultations with external parties, etc.), with the objective of establishing and maintaining consistency among contractors.

11.3.1 Cultural Resources Reviews

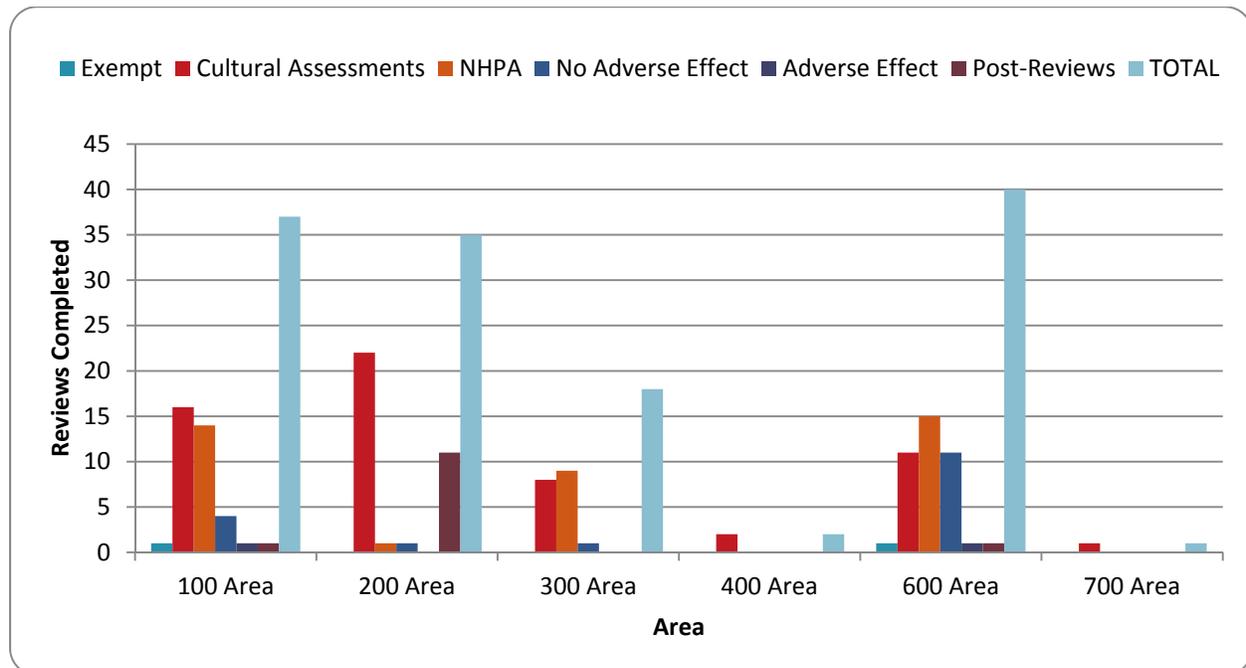
Pursuant to the *National Environmental Policy Act of 1969* and Section 106 of the *National Historic Preservation Act of 1966*, DOE conducts cultural resources reviews of federal undertakings at the Hanford Site. Section 106 reviews ensure that important cultural resources are identified and effects to those resources are evaluated so that mitigation measures can be conducted.

Hanford Site archaeologists completed 133 Section 106 reviews. Sixty-two proposed projects did not involve ground disturbance and were determined exempt by Hanford Site archaeologists after an initial review, or had satisfied the requirements of Section 106 under a prior review. Hanford Site archaeologists reviewed and completed 13 projects under an emergency declaration (i.e., post-review) in accordance with Section 5.1.1 of [DOE/RL-98-10](#) (Figure 11.12). Most projects cleared under expedited reviews occurred in the 200 Areas of the Hanford Site (Figure 11.12).

Hanford Site archaeologists reviewed 58 undertakings in 2012 that had the potential to affect cultural resources, which included efforts to identify cultural resources that might be affected by project activity, an assessment of potential impacts, and the development of mitigation, if necessary¹. Of the 58 undertakings, 39 identified as *no historic properties affected*; 17 had *no adverse effects* to historic properties; and 2 resulted in *adverse effects*. However, the *adverse effects* were avoided by taking specific actions to minimize impacts, including avoidance, following treatment plan guidelines, and archaeological monitoring. The two undertakings resulting in adverse effects to historic properties required mitigation measures as documented in a project-specific Memorandum of Agreement. Approximately 1,090 acres (441 hectares) of new ground was surveyed for cultural resources because 34 undertakings had the potential to affect physically cultural resources. In addition, some undertakings required *National Register of Historic Places* eligibility evaluations, including archaeological testing.

¹ This number does not reflect all full cultural resources reviews initiated in 2012. Additional reviews were initiated in 2012, but completed in 2013, and are not included in this report.

Figure 11.12. Section 106 Reviews by Area



11.3.2 Cultural Resources Protections

To ensure protection of the Hanford Site, cultural resources activities 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 1989 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. Activities that have been added to the monitoring tasks in 2012 include recording previously unrecorded cultural materials identified during visits, and collecting organic material from features in imminent danger of eroding from monitored sites.

In 2012, the program was refocused. MSA Cultural and Historic Resource Protection staff thoroughly researched five large existing and successful monitoring programs to refine the existing protocols, processes, forms, and data management used for the RL Site Monitoring Program. The programs researched were from the National Park Service, Department of Defense, U.S. Army Core of Engineers, Forest Service, and New Zealand's Department of Conservation. The experience, lessons learned, and accomplishments of these successful programs were used to the benefit of the RL program. The five goals for the program refocus are listed below:

- Focus on long-term stewardship (beyond DOE/Hanford Land Use and Management—Monument and increased public access)
- Build program from data up, in other words data needs to be broad spectrum, easily organized, and useful for analysis, to help with long-term management and conservation decisions
- Quantifiable as best possible, with important terms defined in the document
- Products need to be standalone documents (baseline and history included in every form)
- Baseline from both exhaustive records search and from field observations.

In 2012, 74 pre-contact archaeological sites were monitored. Site visits are conducted with the participation of tribal cultural resources personnel. Major impacts were reported at two sites on Locke Island from natural cutbank erosion. Site 45GR303 on Locke Island lost 19 feet (5.9 horizontal meters) to cutbank erosion

including at least two cultural features. Site 45GR1218 lost a minimum of 20 inches (50 centimeters) with at least three cultural features lost. Minor impacts because of project activities, natural erosion, recreational activities, and/or animal disturbance were recorded at other monitored sites. Two monitoring trips were made in 2012 to Locke Island within the Hanford Reach of the Columbia River. Water levels in 2011 were the highest in 20 years and a cause for concern. These conditions set the stage for exceptionally high levels of erosion in 2012. As noted above, one transect location lost 19 feet (5.9 horizontal meters) of island over the course of a year, with six other transect locations having lost more than 3 feet (1 meter). Examination of eroded areas on the periphery of Locke Island revealed two possible causal variables: high-water levels and water fluctuation.

One incident of project related impacts in 2012 was noted within an archaeological site. Site 45BN162, a National Register eligible site, was reportedly disturbed by vehicle activities, exposing cultural materials in the roadway on the west edge of the site. Initial field reporting recorded disturbance of shell midden feature. No in-depth impact assessment has been completed to determine whether the impacts did or did not interfere with the sites interpretive potential the integrity of the features, or the *National Register of Historic Places* eligibility.

11.3.2.1 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*. Twenty-one new archaeological sites or isolated finds were recorded (Table 11.8). *National Register of Historic Places* evaluations were completed on each of the 20 newly discovered sites; not all were determined eligible for listing in the National Register. Archaeological site forms for 24 previously recorded archaeological sites were updated, and each was re-evaluated for National Register eligibility. Of these, 10 sites were determined eligible for listing. Isolates generally are not evaluated for National Register eligibility.

Table 11.8. Sites and Isolates Recorded or Updated

	Eligible	Not Eligible	Unevaluated	TOTAL
Updates	10	14	0	24
New Sites	0	20	0	20
New Isolates	0	0	1	1
Historic Property Inventory Form	0	0	0	0
Total	10	34	1	45

11.3.2.2 Data Recovery Activities

No data recovery excavations were conducted in 2012; however, a final report documenting excavations that occurred in 2010 was completed in 2012. The Wautoma Fire Report (*Investigation, National Register Evaluation and Assessment of Adverse Effect for Archaeological Sites 45BN1514 and 45BN1506, 600 Area, Hanford Site, Benton County, Washington*) evaluated the significance and integrity of two archaeological sites, and documented impacts to them caused during reseeding activities associated with a 2007 fire on the Hanford Site.

11.3.2.3 Data and Artifact Collections Management

MSA staff maintains the Hanford Site *National Historic Preservation Act of 1966* Section 106 project/site digital database and hard copy project/site cumulative archive on behalf of RL. As part of ongoing records management, MSA staff tracks all Cultural Resource Reviews conducted on the Hanford Site. Data entry into the Section 106 database includes the tracking of important dates, actions, letters, and results of the Cultural Resource Reviews. Once a project is complete, it is closed out in the database and accessioned into the MSA CHRP paper archives for use by all Hanford Site Cultural Resource contractors and other interested researchers. In addition to a contractual obligation, management and maintenance of these files is essential to

the completion of all cultural resource compliance documentation completed on the Hanford Site. As part of ongoing records management, a total of 142 new projects were opened, with pertinent information entered into the Hanford Site *National Historic Preservation Act of 1966* Section 106 database as acquired, and 133 projects were closed out after data entry was complete, with a hard copy of the project documentation added to the CHRP archive

MSA staff also updates and maintains the Cultural Resources Geographical Information Systems (GIS) database on behalf of RL. Data entered include cultural resource information collected from Hanford Site contractors such as new archaeological surveys completed as part of *National Historic Preservation Act of 1966* Section 106 work; newly recorded and updated archaeological site locations; and contextual information describing the survey or site. The GIS database is used by all Hanford Site contractors for literature reviews, cultural resource compliance reporting and documentation, and research by RL-approved users.

As part of ongoing database management, a total of 34 polygons delineating completed archaeological surveys were added to the Hanford Site Survey Master shapefiles (map file), and 45 new archaeological sites/isolates, together with associated spatial and contextual information, were added to the GIS Archaeological Site and Isolate Database.

Finally, in order to streamline literature reviews and document retrievals, MSA staff began digitizing the hard copy files maintained in the *National Historic Preservation Act of 1966* Section 106 archives. Scanning of the extensive project files started in May 2012. By the end of September staff completed scanning 3,146 project file folders. The use of digital files provides staff, Cultural Resources contractors, and researchers approved by RL with the ability to perform key word searches within scanned documents, as well as being able to quickly retrieve documents for use in writing compliance documentation, reference compilation, and research.

The MSA staff manages the Hanford Site Manhattan Project and Cold War Era 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](#), *Programmatic Agreement Among the U.S. Department of Energy, Richland Operations Office, the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office for the Maintenance, Deactivation, Alteration, and Demolition of the Built Environment on the Hanford Site, Washington*), which directs DOE personnel to assess the contents of site historical buildings and structures prior to commencement of deactivation, decontamination, decommissioning, or demolition 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. Artifact assessments were conducted for nine buildings in 2012.

11.3.3 Cultural Resources Consultations and Public Involvement

DOE 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* (Section 2.1.4). DOE consulted with the Washington State Historic Preservation Office and Native American tribes on all 58 projects that required a full cultural resources review.

DOE Cultural Resources Program staff held 11 meetings in 2012 with tribal cultural resources staff from the [CTUIR](#), the Confederated Tribes and Bands of the Yakama Nation, the Nez Perce Tribe, and the Wanapum. Discussions focused on the cultural resources reviews completed and initiated in 2012; proposed undertakings within traditional cultural property boundaries and view sheds; and approaches to protecting threatened archaeological sites and places containing Native American human remains.

12.0 Quality Assurance

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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 2012 by the Hanford Site Environmental Monitoring and Surveillance Program staff to ensure quality and defensibility in project management, sample collection, and analytical results.

Environmental monitoring and surveillance at the Hanford Site comprehensively includes programs in groundwater, Hanford Site and offsite (far-field) environmental surveillance and monitoring, effluent monitoring, and near-facility environmental surveillance and monitoring. Due to the complexity of the Hanford Site groundwater program, quality assurance and quality control specifications for groundwater sampling and program management are reported independently in the *Hanford Site Groundwater Monitoring for 2012* ([DOE/RL-2013-22](#), Appendix D) and are not discussed further in this section. Quality assurance and quality control measures for the effluent, near-field and far-field environmental programs are described here.

The effluent, near field and far-field monitoring programs include quality assurance program plans that describe applicable quality assurance elements (e.g., [MSC-23333](#), *Environmental Quality Assurance Program Plan*). Sample analyses performed through laboratory contracts also are required to meet plan requirements. Suppliers were audited for equipment and services, which may have significantly affected project quality, before the contract awards were made.

12.1 Program Management

Site environmental monitoring and related activities are subject to an overall quality assurance program. This program implemented the requirements of [DOE G 414.1-4](#), *Safety Software Guide for Use with 10 CFR 830 Subpart A, Quality Assurance Requirements*. The Hanford Site Environmental Monitoring and Surveillance Program also was subject to the quality assurance requirements specified in the *Hanford Analytical Services Quality Assurance Requirements Documents* ([DOE/RL-96-68](#)), and project-specific quality assurance plans and documentation ([MSC-23333](#)). Quality assurance programs complied with [DOE G 414.1-4](#) using standards from the ASME ([ASME NQA-1-2008](#), *Quality Assurance Requirements for Nuclear Facility Applications*) as their basis. The program also adhered to the guidelines and objectives in *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* ([EPA QA/R-5](#)).

Record keeping is a vital part of the environmental monitoring program. Maintenance of environmental data is essential for quality assurance, regulatory compliance, trend analysis, and optimization purposes. Project documentation includes environmental sample logbooks, and as applicable, quarterly and annual occurrence reports.

12.2 Sample Collection Quality Assurance and Quality Control

Samples for the Environmental Monitoring and Surveillance Programs were collected by personnel trained in accordance with approved procedures. Established sampling locations were accurately identified and documented to ensure continuity of data. Environmental monitoring and surveillance samples, collected by project staff, were submitted to the WSCF located in the 200 Area of the Hanford Site, and the General Engineering Laboratories, LLC in Charleston, South Carolina, for chemical and radiochemical analyses (Table 12.1).

12.2.1 Field Sample Collection Quality Assurance

Personnel are trained to conduct sampling in accordance with approved schedules and procedures. Field duplicate samples were used to assess sampling and measurement precision. Continuity of all sampling location identities was maintained through careful documentation. Field duplicate samples collected and analyzed for far-field media in 2012 included four elk samples, two pond samples, 13 air samples,

14 Columbia River transect samples, and five seep samples. Field duplicate samples for near-field locations and media collected in 2012 included air, soil, and vegetation samples. Near-field air filter samples were collected and analyzed bi-weekly from two locations, then composited semiannually, by location, for isotopic analysis. Two soil and two vegetation field duplicate samples were collected in 2012 for isotopic analysis.

Analytical results for routine samples and field duplicates were reviewed against the criterion that each result must be greater than the minimum detectable activity value or the method detection limit to be evaluated. The relative percentage difference of the routine sample and duplicate must be less than 30 percent to be an acceptable result. Of the 23 detected far-field media duplicate results evaluated, 87 percent of the duplicate results analyzed by General Engineering Laboratories, LLC in 2012, for radiochemistry were acceptable (Table 12.2).

The concentration of a sample and the sample replicate were considered to be in agreement for the near-field media samples analyzed by the WSCF if one of the following criteria applied: 1) On a plot, the uncertainty error bars of the parent sample and its field duplicate overlap; 2) the lower uncertainty values for both the parent sample and its field duplicate extend below the minimum detectable concentration; or 3) the relative percentage difference was less than 30 percent or the percent significant difference was less than 15 percent. In 2012, the near-field environmental media results (air, soil, vegetation) were acceptable for 95.2 percent of the duplicate results analyzed by WSCF (Table 12.3).

12.1 Media Audits and Comparisons

The Washington State Department of Health routinely analyzed split samples of various environmental media during 2012 as part of the Hanford Environmental Radiation Oversight Program. Comparisons were conducted on several specific sample types. Media that were analyzed for radionuclides included particulate air filters from six locations, irrigation water from two locations, surface water from one location, water from five Columbia River shoreline springs, and Columbia River sediment from five locations. Wildlife and foodstuff samples analyzed for radionuclides included three elk samples from one organism, upland game birds from four locations, fruit from four locations, leafy vegetables from two locations, and vegetables from three locations. Fish samples from 10 locations were obtained for whole organ and carcass analysis.

Split samples of various environmental media were submitted for radiological analysis during 2012 as part of the Hanford Environmental Radiation Oversight Program. No comparison data were available at the time this report was written; however, Washington State Department of Health publishes data summary reports for the Hanford Environmental Radiation Oversight Program annually online at <http://www.doh.wa.gov/communityandenvironment/radiation/publications/environmentalsciences.aspx>.

12.2 Laboratory Quality Assurance Programs

Analytical laboratories are required to maintain internal quality assurance and quality control programs. Contract laboratories used to perform environmental sample analysis in 2012 included General Engineering Laboratories, LLC and WSCF (Table 12.1). The internal quality control programs for contracted laboratories 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 using factors such as the average counting efficiencies and background counts for detection instruments, length of time for background and sample counts, sample volumes, radiochemical yields, and a pre-designated uncertainty multiplier.

Radiological counting room instruments were verified to perform within calibration limits through daily checks, and the results are 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 were qualified to perform analyses through formal classroom and on-the-job training.

Periodically, inspections of services were performed, and conformance of the analytical facilities with their contractual requirements was documented. These inspections provided the framework for identifying and resolving potential performance problems. Responses to inspection findings were documented by written communication, and corrective actions were verified by follow-up audits and inspections.

12.3 Analytical Quality Assurance and Quality Control

Analytical results for the Hanford Site Environmental Monitoring and Surveillance Program samples were provided by two laboratories in 2012 (Table 12.1). Routine chemical analyses of soil, vegetation, air, water, and effluent for the Hanford Site Environmental Monitoring and Surveillance Program were performed by General Engineering Laboratories, LLC and the WSCF. These laboratories participated in managed quality assurance and quality control programs in 2012, including the Mixed Analyte Performance Evaluation Program (MAPEP), EPA-compliant performance evaluation and proficiency testing studies, and laboratory performance intercomparison studies. The General Engineering Laboratories, LLC also participated in the DOE Consolidated Audit Program (DOECAP). These managed programs use standardized audit methods, processes, and procedures to ensure, on an annual basis, to assess the validity, reliability, and defensibility of data from the contract laboratories. These quality assurance and quality control programs are briefly described below.

During 2012, General Engineering Laboratory, LLC was audited by DOECAP and participated MAPEP Studies 26 and 27 (March 2012 and August 2012), and a number of Environmental Resource Associates proficiency studies for water, soil, filter, and vegetation matrices.

WSCF maintains Ecology accreditation and was evaluated in 2012 by its participation in the following laboratory performance intercomparison studies: EPA studies (i.e., soil, water pollution, and water tritium), DOE MAPEP studies, and the National Institute of Standards and Technology Radiochemistry Intercomparison Program study.

This section presents the results of the quality assurance and quality control programs performed for media audits and comparisons, consolidated audits, and analytical result proficiency testing for environmental samples for the near-field, far-field, and effluent surveillance and monitoring programs.

12.3.1 U.S. Department of Energy Consolidated Audit Program

An audit of General Engineering Laboratories, LLC was conducted in 2012 by the DOECAP. The objective of DOECAP is to ensure the application of consistent standards between the analytical laboratories supporting the DOE complex and its compliance programs. Audit objectives included assessing the ability of the laboratory to produce data of acceptable and documented quality through analytical operations that followed approved and technically sound methods, and the handling of DOE samples and associated waste in a manner that protected human health and the environment.

The scope of the DOECAP assessment of General Engineering Laboratories, LLC included the following specific functional areas:

- Quality assurance management systems and general laboratory practices
- Data quality for organic analyses
- Data quality for inorganic and wet chemistry analyses
- Data quality for radiochemistry analysis
- Laboratory information management systems/electronic data management
- Hazardous and radioactive materials management.

In addition, DOECAP assessments include verifying corrective action implementation from previous audit findings. Eight previous Priority II findings were closed in 2012 and none remained open.

Ten new Priority II findings (requiring some corrective action by the laboratory) and 13 observations were noted during the 2012 DOECAP audit of General Engineering Laboratories, LLC.

In response to the DOECAP audit, General Engineering Laboratories, LLC prepared and submitted a Corrective Action Plan (CAP) to address findings and observations. The CAP was determined to be acceptable and was submitted with associated comments to the DOECAP Electronic Data System where findings would be tracked to closure.

12.3.2 Mixed Analyte Performance Evaluation Program

DOE's MAPEP provides critical quality assurance testing for environmental analytical services. Radiological and non-radiological (organic and inorganic) constituents were evaluated by performing semiannual proficiency testing of onsite DOE laboratories, other federal laboratories, state laboratories, commercial laboratories, and international laboratories. MAPEP proficiency tests help to ensure the accuracy of analytical results reported to DOE and other stakeholders, while also providing an efficient means for laboratories to demonstrate analytical proficiency. The validity and reliability of environmental data translates into more confident decision-making relative to environmental remediation cleanup projects, regulatory compliance, and protection of the public. Performance data for all matrices (soil, water, air filter, vegetation) from a MAPEP test session (i.e., Series) are reported to the DOE HQs' Program Offices, DOE Field Offices, Sample Management Offices or contractors, participating laboratories, and DOECAP audit personnel to support quality assurance oversight and quality improvement.

MAPEP studies were provided by the DOE Radiological and Environmental Sciences Laboratory in Idaho Falls, Idaho. Two MAPEP studies were provided: MAPEP Study 26 was performed in March 2012, and MAPEP Study 27 was performed in August 2012. MAPEP standard studies included gross alpha/beta analysis for air filters and water, radionuclides in air filters and vegetation, mixed analytes in soil and water, and semi-volatiles in soil and water. General Engineering Laboratories, LLC, WSCF, and Advanced Technologies and Laboratories International, Inc. participated in MAPEP studies in 2012.

The 2012 performance evaluation program results for General Engineering Laboratories, LLC analysis of radionuclides in water, soil, and vegetation were acceptable in 100 percent of MAPEP Study 26 and MAPEP Study 27 tests for routinely reported analytes. However, MAPEP performance evaluation results for air filters were deemed not acceptable for uranium-234 and gross alpha due to result bias exceeding threshold criteria (Table 12.4).

In 2012, WSCF received MAPEP samples containing different radionuclides and analytes for the MAPEP Study 26 and MAPEP Study 27. Of the 405 reported radionuclides and analytes, 396 results were acceptable while 9 were unacceptable, for a total acceptable rate of 98 percent as shown in Table 12.5.

12.3.3 Laboratory Performance Evaluation and Proficiency Testing

Participation of Hanford Site analytical laboratories in DOE and EPA laboratory performance evaluation programs served to ensure data quality. Hanford Site environmental monitoring contract laboratories participated in a number of EPA-sanctioned proficiency test studies including those conducted by Environmental Resource Associates and/or the National Institute of Standards of Technology. Environmental Resource Associates, accredited National Environmental Laboratory Accreditation Conference Institute EL-V3-2011, provided certified reference materials and proficiency testing for water supply, water pollution, soil, air and emissions, effluent, MRAD™, and radiochemistry for contracted laboratories.

EPA Proficiency Testing studies for the General Engineering Laboratory, LLC were provided by Environmental Resource Associates in Arvada, Colorado. Proficiency testing included three WatR™ Supply studies (WS-186, WS-192, and WS-193), two RadCheM™ studies (RAD-89, RAD-91), six WatR™ Pollution Studies (WP-202, WP-204, WP-207, WP-208, WP-12, and WP-213), and three soil studies (SOIL-77, SOIL-78, and SOIL-80). With the exception of pH results from the WS-186 WatR™ Supply Study

(March 2012) and nitrate as nitrogen in the WS-192 WatR™ Supply Study (September 2012), performance evaluation program results for inorganic compounds met performance requirements for all water and soil analytes and methods.

Results for all proficiency tests performed for the methods, analytes, and media reported by General Engineering Laboratory, LLC for the Hanford Site Environmental Monitoring and Surveillance Program were acceptable.

WSCF laboratory staff received and analyzed samples containing different analytes and compounds during participation in Environmental Resource Associates Water Pollution Studies 204 and 210, as well as Soil Studies 77 and 79. Of the 490 reported analytes, 486 results were acceptable for a total acceptable rate of 99 percent. For the Environmental Resource Associates water studies (RAD 88 and RAD 90) and a *Quik™ Response Study*, 030712B1), all 18 reported radionuclide results were acceptable for a total acceptable rate of 100 percent as shown in Table 12.5.

In the National Institute of Standards and Technology Radiochemistry Intercomparison Program (NRIP) study, WSCF received samples containing strontium-90, americium-241, isotopic plutonium, thorium-230, and isotopic uranium in filters and soils for analyses in 2012 (i.e., five spiked samples and five blank samples for each matrix). Routine radionuclide results for both filters and soils were all acceptable. The thorium-230 analysis was included in the NRIP 2012 soil samples. The thorium-230 result was biased high due to the background contribution of naturally occurring thorium-230 in the soil. After correcting for naturally occurring thorium-230, the result was within the acceptable range. Make-up soil samples are in-house for thorium-230 analysis. The NRIP performance evaluation results for WSCF are presented in Table 12.5.

Table 12.1. Laboratories and Types of Samples Analyzed for Environmental Surveillance and Monitoring

Analytical Laboratory	Effluent Monitoring Samples		Environmental Monitoring and Surveillance Samples		
	Air Filter	Water	Air Filter	Water	Other
General Engineering Laboratories, LLC			X	X	X
WSCF	X	X	X	X	

Table 12.2. Field Duplicate Sample Results for Hanford Site Far-Field Media¹

Media	Detected Analytes	Number of Detected Results Reported²	Number of Results within Control Limits³
Radionuclides			
Air	Hydrogen-3 (tritium)	8	3
Water-Pond	Hydrogen-3 (tritium)	1	1
Water-Pond	Gross beta	1	1
Water-River	Hydrogen-3 (tritium)	3	3
Water-River	Uranium-234	3	2
Water-River	Uranium-238	3	3
Water-Seep	Hydrogen-3 (tritium)	1	0
Water-Seep	Strontium-90	1	0
Water-Seep	Uranium-234	1	1
Water-Seep	Uranium-238	1	1
Anions			
Water-River	Chloride	3	3
Water-River	Fluoride	3	3
Water-River	NO ₃ -N	3	3
Water-River	Sulfate	3	3
Water-Seep	Chloride	1	1
Water-Seep	Fluoride	1	1
Water-Seep	NO ₃ -N	1	1
Water-Seep	Sulfate	1	1
Inorganics			
Water-River	Copper	4	4
Water-River	Nickel	4	4
Water-River	Uranium	4	4
Water-Seep	Chromium	2	2
Water-Seep	Copper	2	1
Water-Seep	Nickel	2	1
Water-Seep	Uranium	2	2

¹ Media analyzed by General Engineering Laboratories, LLC, Charleston, South Carolina.

² Number of reported results for radiological are those results greater than the minimum detectable activity. Number of reported results for chemistry is those results greater than or equal to the method detection limit.

³ Number of reported results within control limits for radiological analysis are those results with the relative percent difference value less than 30 percent, and the result is greater than the minimum detectable activity. Number of reported results within control limits for chemical analysis is those results with the relative percent difference value less than 30 percent, and the result is greater than or equal to the method detection limit.

Table 12.3. Field Duplicate Sample Results for Hanford Site Near-Field Media¹

Detected Analytes	Number of Results Compared	Number of Results within Control Limits²
Air Filters		
Antimony-125	2	2
Cesium-134	2	2
Cesium-137	2	2
Cobalt-60	2	2
Europium-152	2	2
Europium-154	2	2
Europium-155	2	2
Gross Alpha	26	25
Gross Beta	26	25
Plutonium-238	2	2
Plutonium-239/240	2	2
Ruthenium-106	2	2
Strontium-90	2	2
Uranium-234	2	2
Uranium-235	2	2
Uranium-238	2	2
Soil		
Antimony-125	1	1
Cesium-134	1	0
Cesium-137	1	1
Cobalt-60	1	1
Europium-152	1	1
Europium-154	1	1
Europium-155	1	1
Plutonium-238	1	1
Plutonium-239/240	1	1
Ruthenium-106	1	1
Strontium-90	1	1
Uranium-234	1	1
Uranium-235	1	1
Uranium-238	1	1
Vegetation		
Antimony-125	1	1
Cesium-134	1	1
Cesium-137	1	1
Cobalt-60	1	1
Europium-152	1	1
Europium-154	1	1
Europium-155	1	1
Plutonium-238	1	1
Plutonium-239/240	1	1
Ruthenium-106	1	1
Strontium-90	1	1
Uranium-234	1	1
Uranium-235	1	1
Uranium-238	1	1

¹ Media analyzed by WSCF laboratory.² Number of reported results within control limits for radiological analysis is those results with the relative percent difference value less than 30 percent, and the result is greater than the minimum detectable activity.

Table 12.4. DOE Mixed Analyte Performance Evaluation Program Results for Far-Field Media¹

Environmental Sample Media and Analytes		MAPEP 26 Series March 2012²	MAPEP 27 Series August 2012²
Radionuclides			
Air Filters	Gross alpha, Gross beta, Americium-241, Cesium-134, Cesium-137, Cobalt-60, Strontium-90, Uranium-234, Uranium-238, Plutonium-238, Plutonium-239/240	Uranium-234 ³	Uranium-234 ³ Gross alpha ⁴
Water	Gross alpha, Gross beta, Americium-241, Cesium-134, Cesium-137, Cobalt-60, Potassium-40, Strontium-90, Uranium-234, Uranium-238, Technetium-99, Plutonium-238, Plutonium-239/240, Tritium	100 Percent Acceptable	100 Percent Acceptable
Vegetation	Cesium-134, Cesium-137, Cobalt-60, Strontium-90	100 Percent Acceptable	100 Percent Acceptable
Inorganic Compounds			
Water	Antimony, Arsenic, Beryllium, Cadmium, Chromium, Copper, Lead, Nickel, Selenium, Thallium, Zinc, Mercury	100 Percent Acceptable	100 Percent Acceptable
Organic Compounds			
Water	1,4-Dichlorobenzene	100 Percent Acceptable	100 Percent Acceptable

¹ Far-field sample media analyzed by General Engineering Laboratories, LLC, Charleston, South Carolina.² Performance results 100 percent acceptable for all analytes unless otherwise noted.³ Result not acceptable, Bias > 30 percent.⁴ Result not acceptable, Bias > +/- 50 percent or the reported result is not statistically positive at two standard deviations.

Table 12.5. DOE Mixed Analyte Performance Evaluation Program Samples and National Institute of Standards and Technology Radiochemistry Inter-comparison Program Results for Near-Field Media¹

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, Uranium-238, Plutonium-238, Plutonium-239/240, Americium-241, Gross Alpha, Gross Beta	28	25 ²
	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	24 ³
	NRIP	Strontium-90, Thorium-230, Uranium-233/234, Plutonium-238, Uranium-238, Plutonium-240, Americium-241	7	6 ⁴
	Quik™ Response (030712B1)	Uranium-234, Uranium-238, Plutonium-238, Plutonium-239, Americium-241	5	5
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	24
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	32	32
	RAD	Hydrogen-3 (Tritium), Cobalt-60, Zinc-65, Barium-133, Cesium-134, Cesium-137, Radium-226, Radium-228, Uranium (total)	13	13

¹ Near-field samples analyzed by the WSCF.

² Failed gross beta, zinc-65, and uranium-233/234. Uranium-233/234 result was near 2 x total propagated uncertainty.

³ Failed americium-241 and uranium-233/234 in Study 26 soil sample as well as failed cesium-134 and uranium-233/234 in Study 27 soil sample 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. Americium-241, plutonium-238, plutonium-240, uranium-234, and Uranium-238 results in NRIP soil samples were acceptable.

⁴ Failed thorium-230 due to significant quantity of background thorium-230 from naturally occurring Th-230 in soil was not accounted for. Result was within the acceptable range after correcting for the naturally occurring background thorium-230. Make-up samples are in-house for thorium-230 analysis.

NRIP = National Institute of Standards and Technology Radiochemistry Intercomparison Program.

RAD = Radiochemistry Program provided by Environmental Resource Associates, Inc., a Waters Corporation.

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13.0 References

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Appendix A

Glossary

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A. 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.

A

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.

B

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.

C

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*).

D

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 limits (regulatory) – both public and occupational regulatory dose limits are set by federal [i.e., EPA, Nuclear Regulatory Commission (NRC), and DOE] and state agencies to limit cancer risk. Other radiation dose limits are applied to limit other potential biological effects with workers' skin and lens of the eye.

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.

E

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.

F

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.

field duplicate sample – Replicate sample to determine the precision of the sampling and analytical measurement process by comparing results from identical samples collected at the same time and location. Matching field duplicates are stored in separate containers and are analyzed independently by the same laboratory.

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.

G

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.

H

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.

I

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.

L

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.

M

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 $\sum x$ is the sum of all measurements.

median – Middle value in an odd-numbered set of results when the data are ranked in increasing or decreasing order or the *average* of two central values in an even number set of results.

millirem – A unit of *radiation dose equivalent* that is equal to one one-thousandth (1/1000) of a *rem*.

minimum detectable amount or concentration – Smallest amount or concentration of a chemical or radioactive material that can be reliably detected in a sample.

mitigation – Prevention or reduction of expected *risks* to workers, the public, or the environment.

mixed waste – A U.S. Environmental Protection Agency or state-designated dangerous, extremely hazardous, or acutely hazardous waste that contains both a nonradioactive hazardous component and a radioactive component.

monitoring – As defined in [DOE O 458.1, Chg 3](#), The measurement of radiation levels, discharges or environmental releases, residual radioactive levels, quantities of radioactive material, or exposure to members of the public and the use of the results of these measurements to evaluate radiological discharges or releases or potential and actual dose resulting from exposures to radioactive material or radiation.

N

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.

O

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.

P

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.

Q

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*.

R

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 EPA 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 $\text{g RPD} = \left(\frac{S - D}{S + D} \right) \times 100$ *sure* as measured in air, historically used to describe *external radiation* levels. An *exposure* of 1 R typically causes an *effective dose* of 1 *rem*.

relative percent difference (RPD) – A measure of the precision of the measurement of a sample (S) and its duplicate (D). The formula is:

S

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.

T

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.

U

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.

V

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.

W

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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B. Useful Information

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.

B.1 Public Reading Rooms

University of Washington
Government Publications Division,
Suzzallo & Allen Libraries
Box 352900
Seattle, WA 98195-2900
(206) 543-4164
www.catalog.kub.wa.edu

Portland State University
Government Information
Branford Price Millar Library
1875 SW Park Avenue
Portland, OR 97207-1151
(503) 725-4542
<http://library.pdx.edu/governmentinformationservice.html> and
http://library.pdx.edu/public_comment.html#hanf

Washington State University, Tri-Cities
US DOE Public Reading Room
Consolidated Information Center, Room 101-L
2770 University Drive
Richland, WA 99352
(509) 372-7443
<http://reading-room.labworks.org>

Gonzaga University, Foley Center
East 502 Boone
Spokane, WA 99258-0001
(509) 313-3847
<http://www.gonzaga.edu/Academics/Libraries/Foley-Library/Departments/Special-Collections/default.asp>

Hanford Health Info Archive:
<http://www.gonzaga.edu/Academics/Libraries/Foley-Library/Departments/Special-Collections/Collections/Hanford-Health-and-Information-Archives/default.asp>

B.2 Documents and Reports Web Sites

BNI: <http://www.hanfordvitplant.com/>

CHPRC: <http://prc.rl.gov/rapidweb/Environmental/index.cfm?PageNum=36>

DOE: <http://www.hanford.gov/page.cfm/OfficialDocuments>

MSA: http://msa.hanford.gov/msa/index.cfm/Environmental_Reports

PNNL: <http://www.pnnl.gov/publications/results.asp>

WCH: <http://www.washingtonclosure.com/>

WRPS: <http://www.wrpstoc.com/resources/overview/>

B.3 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.

B.4 Units of Measure

The primary units of measure used in this report follow the International System of Units and are metric. Table A.1 summarizes and defines the terms and corresponding symbols (metric and non-metric). A conversion table is provided in Table A.2.

B.5 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 B.1. Units of Measure

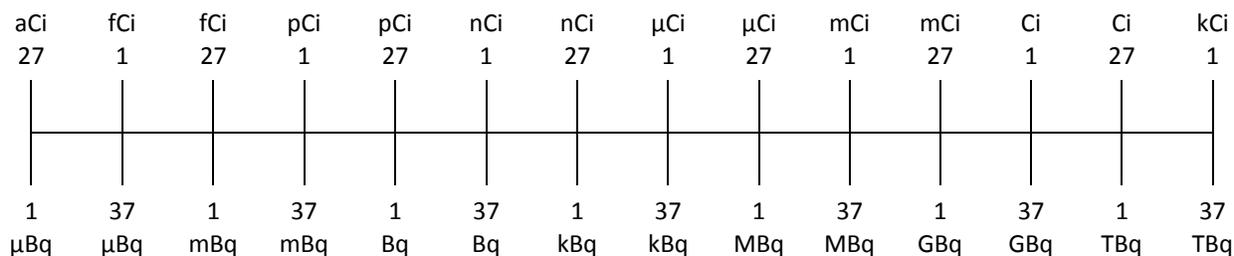
Symbol	Name	Symbol	Name
Temperature		Concentration	
°C	degree Celsius	ppb	parts per billion
°F	degree Fahrenheit	ppm	parts per million
Time		ppmv	parts per million by volume
d	day	Length	
hr	hour	cm	centimeter (1×10^{-2} m)
min	minute	ft	foot
sec	second	in.	inch
yr	year	km	kilometer (1×10^3 m)
Rate		m	meter
cfs (or ft ³ /sec)	cubic feet per second	mi	mile
cpm	counts per minute	mm	millimeter (1×10^{-3} m)
gpm	gallon per minute	μm	micrometer (1×10^{-6} m)
mph	mile per hour	Area	
mR/hr	milliroentgen per hour	ha	hectare (1×10^4 m ²)
mrem/yr	millirem per year	km ²	square kilometer
Volume		mi ²	square mile
cm ³	cubic centimeter	ft ²	square foot
ft ³	cubic foot	Mass	
gal	gallon	g	gram
L	liter	kg	kilogram (1×10^3 g)
m ³	cubic meter	mg	milligram (1×10^{-3} g)
mL	milliliter (1×10^{-3} L)	μg	microgram (1×10^{-6} g)
yd ³	cubic yard	lb	pound

Table B.2. Conversion Table

Multiply	By	To Obtain
cm	0.394	in.
m	3.28	ft
km	0.621	mi
kg	2.205	lb
L	0.2642	gal
m ²	10.76	ft ²
ha	2.47	acre
km ²	0.386	mi ²
m ³	35.31	ft ³
m ³	1.308	yd ³
pCi	1,000	nCi
μCi/mL	109	pCi/L
Ci/m ³	1012	pCi/m ³
mCi/cm ³	1015	pCi/m ³
nCi/m ²	1.0	mCi/km ²
Ci	3.7×10^{10}	Bq
pCi	0.037	Bq
rad	0.01	Gy
rem	0.01	Sv
ppm	1,000	ppb
°C	$(^{\circ}\text{C} \times 9/5) + 32$	°F
oz	28.349	g
ton	0.9078	tonne

Multiply	By	To Obtain
in.	2.54	cm
ft	0.305	m
mi	1.61	km
lb	0.454	kg
gal	3.785	L
ft ²	0.093	m ²
acre	0.405	ha
mi ²	2.59	km ²
ft ³	0.0283	m ³
yd ³	0.7646	m ³
nCi	0.001	pCi
pCi/L	10-9	μCi/mL
pCi/m ³	10-12	Ci/m ³
pCi/m ³	10-15	mCi/cm ³
mCi/km ²	1.0	nCi/m ²
Bq	2.7×10^{-11}	Ci
Bq	27	pCi
Gy	100	rad
Sv	100	rem
ppb	0.001	ppm
°F	$(^{\circ}\text{F} - 32) \div 9/5$	°C
g	0.035	oz
tonne	1.1	ton

Table B.3. Radioactivity Unit Conversions



New unit of quantity = Becquerel (Bq) (formerly curie [Ci]) (1 Ci = 3.7×10^{10} dps).
1 Becquerel = 1 disintegrations/sec (dps).

Table B.4. Radioactivity Units

Symbol	Name
Ci	curie
mCi	millicurie (1×10^{-3} Ci)
μCi	microcurie (1×10^{-6} Ci)
nCi	nanocurie (1×10^{-9} Ci)
pCi	picocurie (1×10^{-12} Ci)
fCi	femtocurie (1×10^{-15} Ci)
aCi	attocurie (1×10^{-18} Ci)

Symbol	Name
Bq	becquerel (2.7×10^{-11} Ci)
mBq	millibecquerel (1×10^{-3} Bq)
kBq	kilobecquerel (1×10^3 Bq)
MBq	megabecquerel (1×10^6 Bq)
GBq	gigabecquerel (1×10^9 Bq)
TBq	terabecquerel (1×10^{12} Bq)

B.6 Radiological Dose Limits

Regulatory dose limits both public and occupational regulatory dose limits are set by federal [i.e., EPA, Nuclear Regulatory Commission (NRC), and DOE] and state agencies to limit cancer risk. Other radiation dose limits are applied to limit other potential biological effects with workers' skin and lens of the eye.

Annual Radiation Dose Limits	Agency
Radiation Worker - 5,000 mrem	NRC, occupationally exposed
General Public - 100 mrem	NRC, member of the public
General Public - 25 mrem	NRC, D&D all pathways
General Public - 10 mrem	EPA, air pathway
General Public - 4 mrem	EPA, drinking water pathway

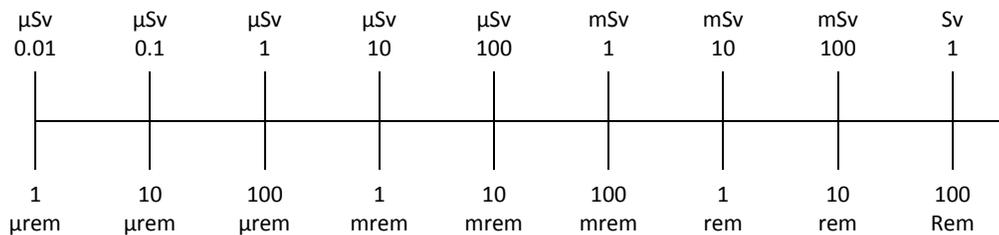
B.7 Radiological Dose Units

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 (μ Sv) 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 μ Sv] 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.

Table B.5. Radiological Dose Units Conversions



Unit of absorbed dose – Gray (Gy) (formerly rad).
 Unit of dose equivalent – Sievert (Sv) (formerly rem).
 Table also converts Gy to rad.

Roentgen (R): 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.

Table B.6. Radiation Dose or Exposure Units

Symbol	Name
mrad	millirad (1×10^{-3} rad)
mrem	millirem (1×10^{-3} rem)
μ rem	microrem (1×10^{-6} rem)
Sv	sievert (100 rem)
mSv	millisievert (1×10^{-3} Sv)
μ Sv	microsievert (1×10^{-6} Sv)
nSv	nanosievert (1×10^{-9} Sv)
R	roentgen
mR	milliroentgen (1×10^{-3} R)
μ R	microroentgen (1×10^{-6} R)
Gy	gray (100 rad)
mGy	milligray (1×10^{-3} rad)

Additional information on radiation and dose terminology can be found in Appendix B. A list of the radionuclides discussed in this report, their symbols, and their half-lives are included in Table A.7.

Table B.7. Radionuclides and Half-Lives

Cancer Risk Coefficients for Environmental Exposure to Radionuclides ([EPA 402-R-99-001](#))

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
³ H	tritium	12.35 yr	¹³⁷ mBa	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	$\sim 4.5 \times 10^9$ ^(a) yr
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 Natural uranium is a mixture dominated by uranium-238; thus, the half-life is approximately 4.5×10^9 years.

B.8 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 B.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		

B.9 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.

B.10 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.

B.11 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 the nominal detection limit.

B.12 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.

B.13 Median, Maximum, and Minimum Values

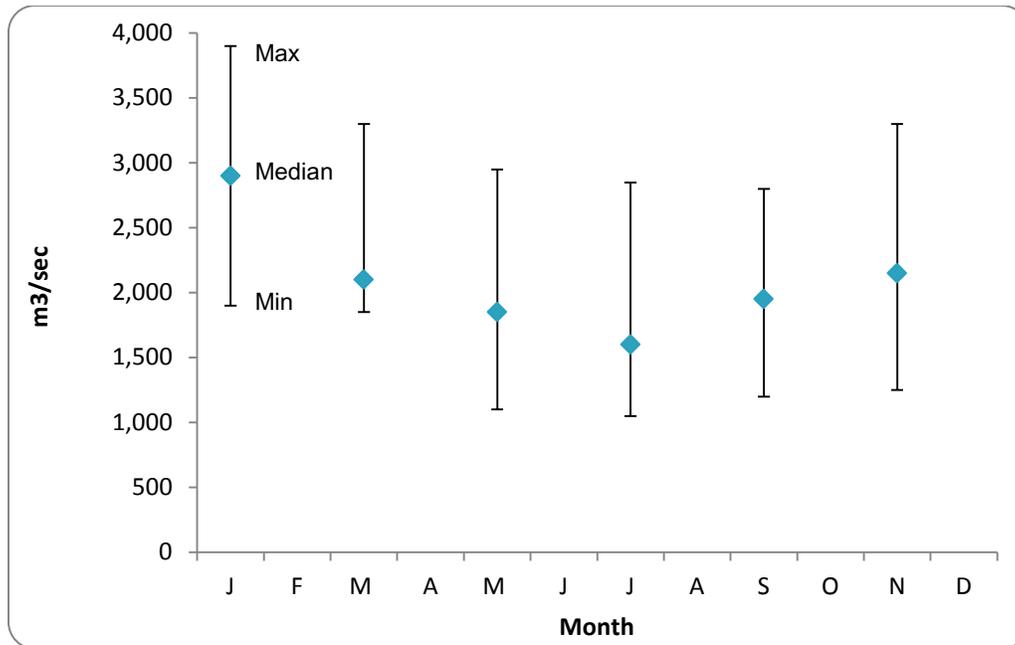
Median, maximum, and minimum values are reported in some sections of this report. A median value is the middle value of an odd numbered set and the average of the two central values in an even numbered set. For example, the median value in the odd numbered series of numbers — 1, 2, 3, 3, 4, 5, 5, 5, 6 is 4. The maximum value would be 6 and the minimum value would be 1. Median, maximum, and minimum values are reported when there are too few analytical results to accurately determine the average with a \pm statistical uncertainty or when the data do not follow a bell-shape (i.e., normal) distribution. Figure A.1 provides a graphical representation of median, maximum, and minimum values. The upper line is the maximum value, the center dot is the median value, and the lower line is the minimum value.

B.14 Negative Concentrations

Instruments used in the laboratory to measure radioactivity in Hanford Site environmental samples are sensitive enough to measure natural, or background, radiation along with any contaminant radiation in a sample. To obtain a true measure of the contaminant level in a sample, the background radiation level must be subtracted from the total amount of radioactivity measured by an instrument. Because of the randomness of radioactive emissions, the very low activities of some contaminants, or the presence of undesirable materials, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported because they are essential when conducting statistical evaluations of the data.

B.15 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.

Figure B.1 Maximum, Median, and Minimum Values Graphical Representation

B.16 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 percent chance that the value is between the upper and lower ends of the error bar and a 5 percent chance that the true value is either lower or higher than the error bar.⁽¹⁾ For example, in Figure A.4, the first plotted value is 2.0 ± 1.1 , so there is a 95 percent chance that the true value is between 0.9 and 3.1, a 2.5 percent chance that it is less than 0.9, and a 2.5 percent 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.

(1) Assuming the data are normally distributed.

Figure B.2 Data Plotted Using a Linear Scale

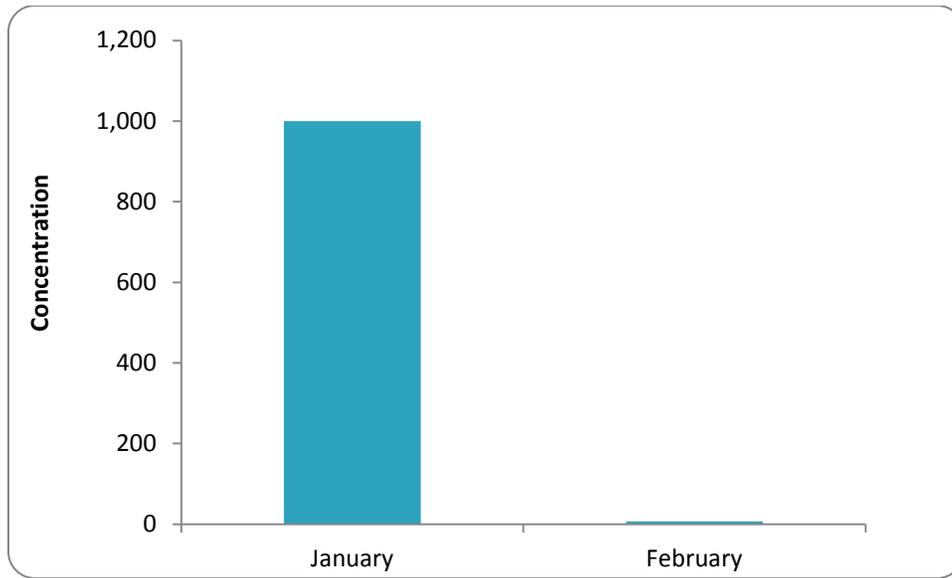


Figure B.3 Data Plotted Using a Logarithmic Scale

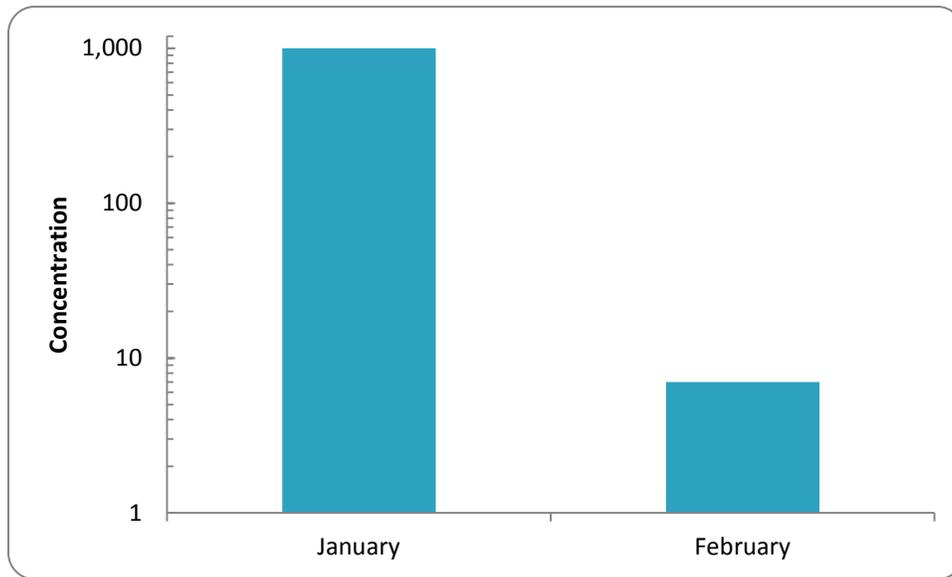
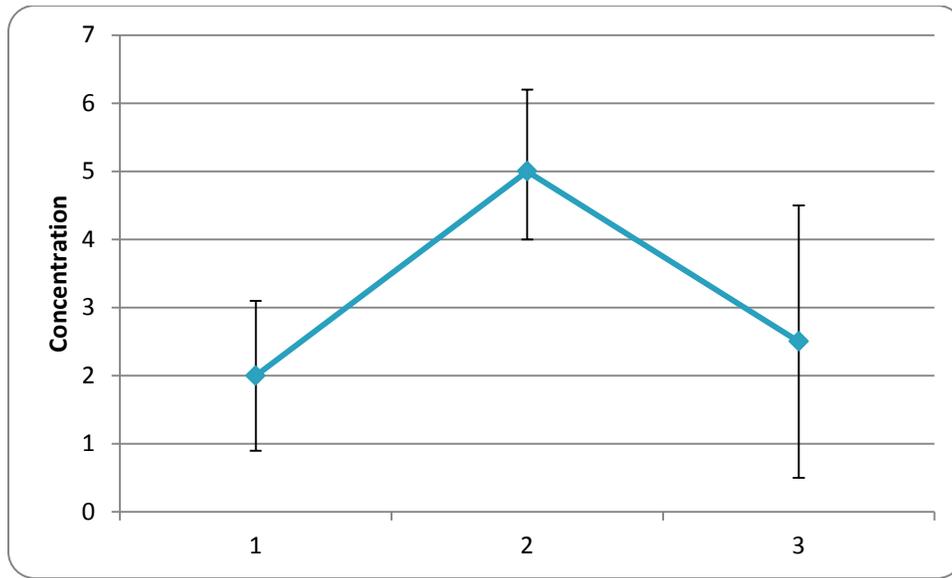


Figure B.4 Data with Error Bars Plotted Using a Linear Scale



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 B.1).

Appendix C**Additional Monitoring Results****C. ADDITIONAL MONITORING RESULTS C.1****Tables**

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Table C.3.	Radionuclide Concentrations in West Lake Water.....	C.4
Table C.4.	Radionuclide Concentrations in Near-Field Air Samples.....	C.5
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C. Additional Monitoring Results

ME Hoefer, CJ Perkins, and ZL Simmons

This appendix contains additional information on monitoring results, supplementing data summarized in the main body of the report.

Table C.1. Radionuclide Concentrations in FFTF Pond Water

Isotope	2012				2007 - 2011			
	No. of		Average ^a	Maximum ^b	No. of		Average ^a	Maximum ^b
	Samples	Detects	pCi/L	pCi/L	Samples	Detects	pCi/L	pCi/L
Antimony-125	4	0	-2.5E+00 ± 7.5E+00	2.1E+00 ± 7.0E+00	19	0	-7.3E-01 ± 5.1E+00	4.4E+00 ± 5.4E+00
Cesium-134	4	0	1.6E+00 ± 2.6E+00	3.0E+00 ± 3.0E+00	19	0	1.8E-01 ± 2.1E+00	2.2E+00 ± 3.0E+00
Cesium-137	4	0	3.1E-02 ± 6.5E-01	4.3E-01 ± 1.7E+00	19	0	1.1E-02 ± 2.1E+00	1.2E+00 ± 2.3E+00
Cobalt-60	4	0	3.3E-01 ± 1.8E+00	1.4E+00 ± 1.7E+00	19	0	-3.1E-02 ± 2.1E+00	3.0E+00 ± 2.4E+00
Europium-152	4	0	5.1E-01 ± 5.2E+00	3.8E+00 ± 7.6E+00	19	0	3.4E-01 ± 5.6E+00	4.9E+00 ± 5.5E+00
Europium -154	4	0	-1.0E+00 ± 3.2E+00	7.5E-01 ± 6.7E-01	19	0	-1.3E+00 ± 6.1E+00	4.6E+00 ± 5.6E+00
Europium -155	4	0	-2.3E+00 ± 1.2E+01	4.1E+00 ± 8.2E+00	19	0	-6.0E-01 ± 7.4E+00	8.5E+00 ± 1.0E+01
Gross Alpha	4	1	1.3E+00 ± 1.7E+00	2.6E+00 ± 2.0E+00	19	0	5.6E-01 ± 1.2E+00	1.9E+00 ± 1.6E+00
Gross Beta	4	4	7.2E+00 ± 4.7E+00	9.9E+00 ± 2.9E+00	19	18	8.5E+00 ± 7.1E+00	1.9E+01 ± 3.3E+00
Hydrogen-3	4	4	1.6E+03 ± 3.9E+02	1.9E+03 ± 4.2E+02	19	19	3.1E+03 ± 5.3E+03	1.2E+04 ± 2.4E+03
Potassium-40	4	0	1.4E+00 ± 2.3E+01	2.0E+01 ± 3.0E+01	19	0	-1.4E+00 ± 5.7E+01	5.0E+01 ± 5.0E+01
Ruhenium-106	4	0	6.5E-01 ± 1.3E+01	9.3E+00 ± 1.8E+01	19	0	1.3E+00 ± 1.2E+01	1.6E+01 ± 1.7E+01
Uranium-234	1	1	1.6E-01 ^c	1.6E-01 ± 4.7E-02	0	0	No Analysis	No Analysis
Uranium-235	1	0	2.9E-03 ^c	2.9E-03 ± 1.3E-02	0	0	No Analysis	No Analysis
Uranium-238	1	1	1.2E-01 ^c	1.2E-01 ± 3.7E-02	0	0	No Analysis	No Analysis

^a Average ± two standard deviations

^b Maximum ± analytical uncertainty

^c Standard deviation cannot be calculated for one sample.

Table C.2 Radionuclide Concentrations in West Lake Sediment

Radionuclide	2012		2007-2011		
	No. of Samples	Concentration, $\mu\text{Ci/g}^a$ Result ^b	No. of Samples	Concentration, $\mu\text{Ci/g}^a$ Average ^c	Maximum ^b
Antimony-125	1	0.0002 ± 0.046 ^d	7	0.011 ± 0.037	0.036 ± 0.0457 ^d
Beryllium-7	1	0.196 ± 0.19 ^d	7	0.03 ± 0.3	0.24 ± 0.10 ^d
Cesium-134	0	— ^e	4	0.029 ± 0.019	0.04 ± 0.023 ^d
Cesium-137	1	1.6 ± 0.16	7	1.2 ± 0.69	1.9 ± 0.16
Cobalt-60	1	-0.008 ± 0.018 ^d	7	-0.002 ± 0.01	0.009 ± 0.0168 ^d
Europium-152	1	-0.046 ± 0.058 ^d	7	-0.0002 ± 0.016	0.015 ± 0.0515 ^d
Europium-154	1	0.027 ± 0.058 ^d	7	-0.019 ± 0.086	0.047 ± 0.0597 ^d
Europium-155	1	0.028 ± 0.041 ^d	6	0.048 ± 0.051	0.094 ± 0.032 ^d
Gross Alpha	1	12 ± 3.1	7	8.4 ± 6.9	12 ± 4.8
Gross Beta	1	27 ± 3.02	7	24 ± 9	31 ± 5.4
Potassium-40	1	15 ± 1.3	7	16 ± 5.7	19 ± 2.0
Ruthenium-106	1	0.063 ± 0.16 ^d	7	0.0041 ± 0.18	0.12 ± 0.146 ^d
Strontium-90	1	0.49 ± 0.097	7	0.28 ± 0.23	0.40 ± 0.09
Technetium-99	1	-0.14 ± 0.53 ^d	7	-0.05 ± 0.49	0.14 ± 0.47 ^d
Uranium-234	1	4.4 ± 0.58	8	2.3 ± 3.6	6.4 ± 0.87
Uranium-235	1	0.21 ± 0.053	7	0.13 ± 0.22	0.36 ± 0.07
Uranium-238	1	4.1 ± 0.54	7	2.4 ± 3.5	6.1 ± 0.83

^a To convert to the International System of Units, multiply $\mu\text{Ci/g}$ by 0.037 to obtain Bq/g. All values are dry weight.

^b Result and maximum values are ± total propagated analytical uncertainty (2 Sigma).

^c Averages are ±2 standard deviations of the mean. Average values calculated using reporting limit values for all results at or below minimum detectable concentrations.

^d Result was below detection limit.

^e No result available.

Table C.3. Radionuclide Concentrations in West Lake Water
(2012, 1998 through 2001, and 2011)

Radionuclide	2012			1998 - 2001 and 2011			DOE-Derived Concentration Guides	Washington State Ambient Surface Water Quality Standard ^d
	No. of Samples	Concentration ^a		No. of Samples	Concentration ^a			
		Average ^b pCi/L	Maximum ^c pCi/L		Average ^b pCi/L	Maximum ^c pCi/L		
Tritium	1	23 ± 96 ^f	23 ± 96	18	138 ± 161	358 ± 140	2,000,000	20,000 ^{d,e}
Uranium-234	2	2,057 ± 5,073	3,850 ± 525	19	947 ± 1,812	2,650 ± 460	500	—
Uranium-235	2	80 ± 191	147 ± 47	19	35 ± 76	132 ± 23	600	—
Uranium-238	2	1,944 ± 4,827	3,650 ± 499	20	1,066 ± 2,321	4,590 ± 2,700	600	—

^a To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

^b Averages are ±2 standard deviations of the mean. Average values calculated using reporting limit values for all results at or below minimum detectable concentrations.

^c Maximum values are ± total propagated analytical uncertainty.

^d [WAC 246-290, 40 CFR 141](#). Dashes indicate no concentration guides available.

^e [WAC 173-201A-250](#) and [EPA-570/9-76-003](#).

^f Average values are not calculated when only one sample was analyzed.

Table C.4. Radionuclide Concentrations in Near-Field Air Samples

Site	Radionuclide	2012				Sampler	2007 - 2011				EPA Table 2 ^{e,f}
		No. of Samples	No. of Detection ^a	Average ^b (pCi/m ³) ^d	Maximum ^c (pCi/m ³) ^d		No. of Samples	No. of Detection ^a	Average ^b (pCi/m ³) ^d	Maximum ^c (pCi/m ³) ^d	
Gross Alpha	100-D FRP	104	100	1.0E-03 ± 9.2E-04	2.8E-03 ± 5.9E-04	N467	508	460	1.1E-03 ± 1.1E-03	4.6E-03 ± 1.2E-03	2.0E-02
	100-H FRP	73	68	9.6E-04 ± 8.6E-04	2.1E-03 ± 1.6E-03	N574	354	321	1.2E-03 ± 1.2E-03	3.6E-03 ± 8.3E-04	
	100-K KBC	156	152	1.0E-03 ± 1.1E-03	3.6E-03 ± 1.4E-03	N577	970	890	1.4E-03 ± 2.5E-03	2.0E-02 ± 2.5E-03	
	100-N	78	76	1.4E-03 ± 1.8E-03	4.3E-03 ± 1.1E-03	N103	393	370	1.2E-03 ± 1.2E-03	3.3E-03 ± 1.0E-03	
	118-K-1 FRP	78	77	1.0E-03 ± 9.3E-04	2.5E-03 ± 4.8E-04	N403	327	291	1.2E-03 ± 1.8E-03	9.4E-03 ± 4.3E-03	
	200-East	546	537	1.1E-03 ± 9.7E-04	3.3E-03 ± 6.5E-04	N481	2741	2538	1.2E-03 ± 1.3E-03	5.0E-03 ± 1.1E-03	
	200-West	627	607	1.2E-03 ± 1.2E-03	4.8E-03 ± 8.2E-04	N551	3164	2902	1.3E-03 ± 1.6E-03	1.4E-02 ± 2.0E-03	
	300 D4	52	51	1.1E-03 ± 8.0E-04	2.0E-03 ± 6.4E-04	N557	262	242	1.2E-03 ± 1.1E-03	3.3E-03 ± 9.0E-04	
	618-10 FRP	104	98	1.0E-03 ± 1.3E-03	4.5E-03 ± 1.1E-03	N548	123	102	1.2E-03 ± 3.0E-03	1.6E-02 ± 2.3E-03	
	ERDF	150	143	1.0E-03 ± 1.1E-03	3.9E-03 ± 1.3E-03	N550	790	698	1.2E-03 ± 1.6E-03	7.4E-03 ± 5.6E-03	
Gross Beta	100-D FRP	104	104	1.4E-02 ± 1.0E-02	2.9E-02 ± 2.5E-03	N514	508	508	1.7E-02 ± 1.9E-02	7.3E-02 ± 6.7E-03	9.0E+00
	100-H FRP	73	73	1.3E-02 ± 1.1E-02	3.0E-02 ± 2.5E-03	N509	354	352	1.8E-02 ± 2.1E-02	6.0E-02 ± 6.1E-03	
	100-K KBC	156	156	1.3E-02 ± 1.0E-02	3.2E-02 ± 3.2E-03	N577	970	970	2.6E-02 ± 1.2E-01	1.2E+00 ± 8.4E-02	
	100-N	78	78	1.4E-02 ± 1.4E-02	5.1E-02 ± 5.8E-03	N103	393	393	1.7E-02 ± 1.8E-02	5.4E-02 ± 5.5E-03	
	118-K-1 FRP	78	78	1.3E-02 ± 1.0E-02	3.1E-02 ± 3.3E-03	N534	327	327	2.4E-02 ± 8.8E-02	5.3E-01 ± 3.9E-02	
	200-East	546	546	1.3E-02 ± 1.1E-02	5.2E-02 ± 4.1E-03	N984	2741	2741	1.7E-02 ± 2.0E-02	9.6E-02 ± 7.8E-03	
	200-West	627	627	1.3E-02 ± 1.1E-02	3.5E-02 ± 4.4E-03	N987	3164	3161	1.7E-02 ± 2.1E-02	1.7E-01 ± 2.0E-02	
	300 D4	52	52	1.4E-02 ± 1.1E-02	3.1E-02 ± 2.6E-03	N130	262	262	1.8E-02 ± 2.0E-02	5.0E-02 ± 4.6E-03	
	618-10 FRP	104	104	1.3E-02 ± 1.1E-02	2.8E-02 ± 2.4E-03	N580	123	122	1.5E-02 ± 2.1E-02	9.0E-02 ± 9.0E-03	
	ERDF	150	150	1.3E-02 ± 1.0E-02	3.0E-02 ± 3.8E-03	N550	790	788	1.6E-02 ± 2.1E-02	9.6E-02 ± 1.6E-02	
Americium-241	100-D FRP	8	4	5.2E-06 ± 7.5E-06	1.4E-05 ± 8.8E-06	N467	32	15	6.8E-06 ± 8.4E-06	1.7E-05 ± 1.3E-05	1.9E-03
	100-H FRP	6	3	9.3E-06 ± 1.4E-05	2.5E-05 ± 1.4E-05	N574	20	7	7.9E-06 ± 8.1E-06	1.6E-05 ± 1.8E-05	
	100-K KBC	12	3	7.3E-06 ± 1.9E-05	3.1E-05 ± 1.5E-05	N403	81	65	9.5E-05 ± 4.6E-04	1.2E-03 ± 4.4E-04	
	100-N	6	6	1.9E-05 ± 1.8E-05	3.1E-05 ± 1.4E-05	N106	33	16	9.1E-06 ± 1.5E-05	3.9E-05 ± 1.7E-05	
	118-K-1 FRP	6	3	1.0E-05 ± 2.2E-05	3.1E-05 ± 1.5E-05	N403	15	13	1.6E-04 ± 6.3E-04	1.2E-03 ± 4.4E-04	
	200-East	4	0	2.4E-07 ± 4.9E-06	3.5E-06 ± 5.9E-06	N481	22	8	5.0E-06 ± 6.7E-06	1.0E-05 ± 6.1E-06	
	200-West	2	2	3.7E-05 ± 2.6E-05	5.0E-05 ± 2.3E-05	N165	8	7	7.6E-05 ± 1.8E-04	3.1E-04 ± 1.1E-04	
	618-10 FRP	8	5	4.6E-05 ± 1.2E-04	1.8E-04 ± 7.4E-05	N548	8	6	5.2E-05 ± 1.5E-04	2.4E-04 ± 9.4E-05	
Cesium-134	100-D FRP	8	0	-9.3E-05 ± 1.7E-04	4.3E-05 ± 7.8E-05	N467	40	4	5.0E-05 ± 2.0E-04	4.0E-04 ± 3.8E-04	2.7E-02
	100-H FRP	6	0	-9.8E-05 ± 1.7E-04	-2.1E-05 ± 7.6E-05	N509	28	3	2.7E-05 ± 2.4E-04	3.1E-04 ± 6.6E-04	
	100-K KBC	12	0	-5.1E-05 ± 2.5E-04	1.9E-04 ± 2.9E-04	N576	81	6	2.2E-05 ± 2.1E-04	3.2E-04 ± 3.7E-04	
	100-N	6	0	8.3E-06 ± 1.2E-04	8.9E-05 ± 8.5E-05	N102	33	3	1.6E-05 ± 2.1E-04	3.3E-04 ± 1.5E-04	
	118-K-1 FRP	6	0	-6.8E-05 ± 3.7E-04	3.3E-04 ± 1.7E-04	N534	29	2	-1.1E-05 ± 1.9E-04	2.1E-04 ± 9.8E-05	
	200-East	42	0	-2.8E-05 ± 3.4E-04	5.2E-04 ± 2.1E-04	N999	231	19	2.1E-05 ± 1.8E-04	4.1E-04 ± 4.0E-04	
	200-West	49	0	-5.9E-05 ± 2.9E-04	3.1E-04 ± 2.4E-04	N975	269	23	1.4E-05 ± 2.4E-04	5.2E-04 ± 4.0E-04	
	300 D4	6	0	8.7E-05 ± 2.6E-04	3.5E-04 ± 3.5E-04	N557	32	1	4.7E-05 ± 3.3E-04	4.8E-04 ± 1.5E-03	
	618-10 FRP	8	0	-6.7E-05 ± 2.1E-04	7.0E-05 ± 9.4E-05	N549	16	3	-6.9E-05 ± 5.9E-04	6.8E-04 ± 2.3E-04	
	ERDF	12	0	-7.2E-05 ± 3.3E-04	1.1E-04 ± 1.1E-04	N518	66	3	3.3E-05 ± 2.5E-04	5.8E-04 ± 4.5E-04	

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Table C.4. Radionuclide Concentrations in Near-Field Air Samples

Site	Radionuclide	2012				Sampler	2007 - 2011				EPA Table 2 ^{e,f}
		No. of Samples	No. of Detection ^a	Average ^b (pCi/m ³) ^d	Maximum ^c (pCi/m ³) ^d		No. of Samples	No. of Detection ^a	Average ^b (pCi/m ³) ^d	Maximum ^c (pCi/m ³) ^d	
Cesium-137	100-D FRP	8	2	9.4E-05 ± 8.4E-05	1.6E-04 ± 8.7E-05	N514	40	5	6.5E-05 ± 2.4E-04	4.5E-04 ± 1.9E-04	1.9E-02
	100-H FRP	6	0	4.9E-06 ± 1.1E-04	7.9E-05 ± 7.4E-05	N509	28	4	7.1E-05 ± 2.7E-04	5.1E-04 ± 2.5E-04	
	100-K KBC	12	2	7.5E-05 ± 2.6E-04	2.8E-04 ± 1.4E-04	N403	81	39	6.5E-03 ± 4.1E-02	1.2E-01 ± 3.9E-02	
	100-N	6	3	4.9E-04 ± 1.0E-03	1.2E-03 ± 4.2E-04	N106	33	9	1.9E-04 ± 8.0E-04	1.9E-03 ± 6.5E-04	
	118-K-1 FRP	6	3	1.9E-04 ± 2.3E-04	2.9E-04 ± 1.5E-04	N534	29	16	5.5E-03 ± 3.4E-02	7.5E-02 ± 2.4E-02	
	200-East	42	6	1.6E-04 ± 7.1E-04	1.5E-03 ± 4.9E-04	N999	231	45	9.1E-05 ± 4.4E-04	2.3E-03 ± 7.7E-04	
	200-West	49	0	-4.2E-06 ± 2.0E-04	3.1E-04 ± 3.1E-04	N987	269	42	6.2E-05 ± 2.2E-04	7.6E-04 ± 3.8E-04	
	300 D4	6	0	8.4E-05 ± 1.2E-04	2.0E-04 ± 2.9E-04	N557	32	3	4.7E-05 ± 2.5E-04	5.3E-04 ± 2.7E-04	
	618-10 FRP	8	0	-3.3E-05 ± 1.6E-04	6.5E-05 ± 8.1E-05	N548	16	4	1.9E-04 ± 6.3E-04	1.2E-03 ± 4.0E-04	
ERDF	12	0	2.7E-05 ± 1.5E-04	1.8E-04 ± 2.4E-04	N517	66	12	7.7E-05 ± 2.0E-04	4.1E-04 ± 1.7E-04		
Plutonium-238	100-D FRP	8	0	6.1E-07 ± 2.8E-06	2.6E-06 ± 6.4E-06	N514	40	0	6.3E-07 ± 1.3E-05	1.8E-05 ± 1.6E-05	2.1E-03
	100-H FRP	6	0	8.9E-07 ± 1.5E-06	1.5E-06 ± 6.6E-06	N509	28	1	-1.1E-06 ± 9.2E-06	1.1E-05 ± 1.5E-05	
	100-K KBC	12	0	2.6E-06 ± 1.2E-05	1.8E-05 ± 2.0E-05	N576	81	10	1.1E-05 ± 6.1E-05	1.5E-04 ± 7.1E-05	
	100-N	6	0	3.6E-06 ± 4.9E-06	6.2E-06 ± 8.4E-06	N102	33	0	2.2E-06 ± 1.1E-05	1.9E-05 ± 1.8E-05	
	118-K-1 FRP	6	0	3.8E-06 ± 1.0E-05	1.1E-05 ± 1.2E-05	N403	29	2	1.1E-05 ± 4.7E-05	1.1E-04 ± 5.6E-05	
	200-East	42	1	1.1E-06 ± 5.9E-06	1.0E-05 ± 1.0E-05	N970	230	4	2.0E-06 ± 2.7E-05	1.9E-04 ± 6.8E-05	
	200-West	49	1	1.5E-06 ± 1.2E-05	3.7E-05 ± 1.9E-05	N441	269	9	2.0E-06 ± 1.2E-05	3.4E-05 ± 1.7E-05	
	300 D4	6	0	-5.3E-07 ± 6.1E-06	2.3E-06 ± 5.1E-06	N130	32	3	1.3E-06 ± 1.8E-05	2.3E-05 ± 2.8E-05	
	618-10 FRP	8	2	9.1E-06 ± 2.9E-05	4.6E-05 ± 2.2E-05	N579	16	0	1.1E-06 ± 1.2E-05	1.3E-05 ± 2.6E-05	
ERDF	12	0	2.7E-06 ± 5.1E-06	7.1E-06 ± 8.1E-06	N517	66	1	1.4E-06 ± 1.1E-05	1.6E-05 ± 1.5E-05		
Plutonium-239/240	100-D FRP	8	2	2.7E-06 ± 2.1E-06	4.1E-06 ± 3.6E-06	N467	40	5	2.5E-06 ± 4.2E-06	1.0E-05 ± 6.2E-06	2.0E-03
	100-H FRP	6	1	3.4E-06 ± 3.2E-06	6.1E-06 ± 4.5E-06	N574	28	7	2.8E-06 ± 1.1E-05	2.6E-05 ± 1.3E-05	
	100-K KBC	12	2	5.9E-06 ± 1.2E-05	1.8E-05 ± 1.3E-05	N578	81	46	9.1E-05 ± 4.4E-04	1.2E-03 ± 4.7E-04	
	100-N	6	4	1.6E-05 ± 2.4E-05	3.9E-05 ± 1.8E-05	N106	33	13	5.6E-06 ± 1.2E-05	3.3E-05 ± 1.6E-05	
	118-K-1 FRP	6	2	8.9E-06 ± 1.0E-05	1.7E-05 ± 1.4E-05	N403	29	15	8.0E-05 ± 3.9E-04	9.4E-04 ± 3.6E-04	
	200-East	42	2	1.6E-06 ± 4.9E-06	9.2E-06 ± 7.0E-06	N985	231	20	9.7E-06 ± 2.4E-04	1.8E-03 ± 6.5E-04	
	200-West	49	16	1.8E-05 ± 1.0E-04	2.8E-04 ± 1.1E-04	N165	269	104	2.3E-05 ± 1.6E-04	7.1E-04 ± 2.7E-04	
	300 D4	6	0	1.4E-06 ± 7.5E-06	7.6E-06 ± 8.5E-06	N557	32	2	3.4E-06 ± 1.5E-05	3.1E-05 ± 2.0E-05	
	618-10 FRP	8	5	7.5E-05 ± 2.1E-04	3.3E-04 ± 1.3E-04	N548	16	5	6.8E-05 ± 3.3E-04	6.8E-04 ± 2.6E-04	
ERDF	12	6	7.9E-06 ± 2.3E-05	4.6E-05 ± 2.0E-05	N482	66	25	4.8E-06 ± 8.2E-06	1.9E-05 ± 1.0E-05		
Plutonium-241	100-K KBC	12	2	7.4E-04 ± 1.3E-03	2.0E-03 ± 1.1E-03	N577	81	12	6.3E-04 ± 3.4E-03	9.2E-03 ± 2.9E-03	1.9E-03
	118-K-1 FRP	6	2	1.3E-03 ± 7.4E-04	1.6E-03 ± 1.4E-03	N534	15	4	8.2E-04 ± 3.4E-03	5.8E-03 ± 1.8E-03	
	200-East	4	0	2.8E-05 ± 5.2E-04	2.1E-04 ± 6.9E-04	N481	22	0	-6.5E-05 ± 8.4E-04	7.7E-04 ± 8.4E-04	
	200-West	2	0	7.2E-04 ± 5.1E-04	9.8E-04 ± 9.8E-03	N165	8	3	6.5E-04 ± 1.4E-03	1.7E-03 ± 1.5E-03	

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Table C.4. Radionuclide Concentrations in Near-Field Air Samples

Site	Radionuclide	2012				2007 - 2011				EPA Table 2 ^{e,f}	
		No. of Samples	No. of Detection ^a	Average ^b (pCi/m ³) ^d	Maximum ^c (pCi/m ³) ^d	No. of Samples	No. of Detection ^a	Average ^b (pCi/m ³) ^d	Maximum ^c (pCi/m ³) ^d		
Strontium-90	100-D FRP	8	1	7.9E-05 ± 2.9E-04	4.5E-04 ± 2.1E-04	N468	40	3	-6.1E-05 ± 3.5E-04	3.0E-04 ± 1.5E-04	1.9E-02
	100-H FRP	6	0	-5.2E-05 ± 9.3E-05	-5.5E-08 ± 5.5E-07	N510	28	0	-9.6E-05 ± 2.9E-04	2.3E-04 ± 2.4E-04	
	100-K KBC	12	2	8.1E-05 ± 2.7E-04	3.6E-04 ± 2.2E-04	N577	81	17	7.4E-04 ± 5.5E-03	1.5E-02 ± 4.4E-03	
	100-N	6	2	1.4E-04 ± 4.5E-04	5.7E-04 ± 2.3E-04	N106	33	3	-7.9E-05 ± 3.8E-04	3.2E-04 ± 1.5E-04	
	118-K-1 FRP	6	2	1.0E-04 ± 2.8E-04	3.6E-04 ± 1.8E-04	N403	29	5	5.5E-04 ± 3.9E-03	7.7E-03 ± 2.4E-03	
	200-East	42	14	1.5E-04 ± 5.4E-04	1.7E-03 ± 5.7E-04	N984	231	10	-8.7E-05 ± 3.2E-04	4.7E-04 ± 2.3E-04	
	200-West	48	4	2.9E-05 ± 2.1E-04	3.5E-04 ± 1.6E-04	N994	269	8	-1.1E-04 ± 3.6E-04	6.2E-04 ± 2.2E-04	
	300 D4	6	0	3.2E-05 ± 1.6E-04	1.5E-04 ± 1.3E-04	N130	32	0	-2.3E-04 ± 4.8E-04	8.4E-05 ± 3.0E-04	
	618-10 FRP	8	0	6.0E-05 ± 1.1E-04	1.6E-04 ± 1.5E-04	N580	16	2	-1.2E-04 ± 7.2E-04	3.7E-04 ± 3.2E-04	
ERDF	12	1	5.0E-05 ± 1.9E-04	3.1E-04 ± 1.1E-04	N518	66	2	-9.9E-05 ± 3.5E-04	6.7E-04 ± 2.7E-04		
Uranium-234	100-D FRP	8	3	7.0E-06 ± 7.1E-06	1.4E-05 ± 9.4E-06	N515	40	35	1.1E-05 ± 7.6E-06	2.0E-05 ± 1.2E-05	7.7E-03
	100-H FRP	6	2	4.7E-06 ± 8.9E-06	1.1E-05 ± 6.7E-06	N510	28	22	1.2E-05 ± 1.6E-05	4.0E-05 ± 2.1E-05	
	100-K KBC	12	3	5.6E-06 ± 9.1E-06	1.5E-05 ± 1.0E-05	N576	81	71	1.3E-05 ± 1.3E-05	4.7E-05 ± 3.0E-05	
	100-N	6	3	4.0E-06 ± 1.7E-05	1.3E-05 ± 8.5E-06	N102	33	31	1.1E-05 ± 8.6E-06	2.0E-05 ± 1.1E-05	
	118-K-1 FRP	6	2	6.4E-06 ± 9.2E-06	1.5E-05 ± 9.3E-06	N535	29	25	1.3E-05 ± 9.8E-06	3.1E-05 ± 1.5E-05	
	200-East	42	14	7.0E-06 ± 8.4E-06	1.8E-05 ± 1.0E-05	N957	231	216	1.1E-05 ± 9.4E-06	4.4E-05 ± 2.0E-05	
	200-West	49	20	7.7E-06 ± 8.1E-06	2.0E-05 ± 1.5E-05	N965	269	249	2.5E-05 ± 2.7E-04	2.2E-03 ± 7.4E-04	
	300 D4	6	2	1.3E-05 ± 2.9E-05	4.3E-05 ± 2.1E-05	N557	32	28	1.9E-05 ± 1.6E-05	4.0E-05 ± 2.1E-05	
	618-10 FRP	8	4	8.5E-06 ± 1.1E-05	1.6E-05 ± 9.0E-06	N548	16	13	1.8E-05 ± 1.0E-05	2.7E-05 ± 1.8E-05	
ERDF	12	7	1.2E-05 ± 1.0E-05	1.9E-05 ± 1.1E-05	N518	66	65	3.6E-05 ± 1.5E-04	4.7E-04 ± 1.6E-04		
Uranium-235	100-D FRP	8	0	-5.9E-07 ± 3.7E-06	2.9E-06 ± 3.1E-06	N514	40	8	2.4E-06 ± 3.4E-06	6.8E-06 ± 5.2E-06	7.1E-03
	100-H FRP	6	1	1.1E-06 ± 7.8E-06	7.0E-06 ± 5.3E-06	N509	28	3	2.4E-06 ± 3.3E-06	6.7E-06 ± 5.1E-06	
	100-K KBC	12	0	-2.7E-07 ± 7.6E-06	8.0E-06 ± 7.5E-06	N577	80	12	2.8E-06 ± 6.8E-06	2.6E-05 ± 2.1E-05	
	100-N	6	1	-7.2E-07 ± 6.2E-06	5.3E-06 ± 4.5E-06	N106	33	7	2.4E-06 ± 3.7E-06	8.2E-06 ± 6.9E-06	
	118-K-1 FRP	6	0	-7.7E-07 ± 5.8E-06	3.0E-06 ± 3.8E-06	N534	29	2	2.2E-06 ± 2.7E-06	5.3E-06 ± 5.4E-06	
	200-East	42	2	7.9E-07 ± 4.9E-06	7.2E-06 ± 6.4E-06	N978	231	36	2.2E-06 ± 3.4E-06	8.7E-06 ± 6.1E-06	
	200-West	49	3	1.2E-06 ± 5.0E-06	7.1E-06 ± 5.4E-06	N168	268	51	4.0E-06 ± 2.9E-05	2.1E-04 ± 7.8E-05	
	300 D4	6	0	1.5E-06 ± 4.3E-06	4.4E-06 ± 6.0E-06	N557	32	5	3.9E-06 ± 5.3E-06	1.0E-05 ± 7.0E-06	
	618-10 FRP	8	0	-1.2E-06 ± 7.4E-06	3.6E-06 ± 4.0E-06	N548	16	2	3.8E-06 ± 6.6E-06	1.0E-05 ± 1.1E-05	
ERDF	12	1	1.9E-06 ± 5.5E-06	7.1E-06 ± 5.4E-06	N168	66	14	4.5E-06 ± 1.6E-05	5.3E-05 ± 2.3E-05		

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Table C.4. Radionuclide Concentrations in Near-Field Air Samples

Site	Radionuclide	2012				Sampler	2007 - 2011				EPA Table 2 ^{e,f}
		No. of Samples	No. of Detection ^a	Average ^b (pCi/m ³) ^d	Maximum ^c (pCi/m ³) ^d		No. of Samples	No. of Detection ^a	Average ^b (pCi/m ³) ^d	Maximum ^c (pCi/m ³) ^d	
Uranium- 238	100-D FRP	8	3	4.8E-06 ± 3.0E-06	6.9E-06 ± 5.2E-06	N515	40	35	8.7E-06 ± 5.7E-06	1.5E-05 ± 9.0E-06	8.3E-03
	100-H FRP	6	2	5.8E-06 ± 3.6E-06	9.3E-06 ± 7.2E-06	N509	28	22	9.9E-06 ± 9.6E-06	2.4E-05 ± 1.5E-05	
	100-K KBC	12	4	5.5E-06 ± 6.7E-06	1.3E-05 ± 7.9E-06	N576	81	69	9.4E-06 ± 1.0E-05	2.7E-05 ± 1.4E-05	
	100-N	6	2	4.1E-06 ± 1.1E-05	8.6E-06 ± 6.2E-06	N102	33	29	8.8E-06 ± 6.4E-06	1.7E-05 ± 9.2E-06	
	118-K-1 FRP	6	2	6.4E-06 ± 5.1E-06	9.5E-06 ± 6.6E-06	N534	29	24	1.1E-05 ± 1.0E-05	2.4E-05 ± 1.2E-05	
	200-East	42	19	6.2E-06 ± 8.0E-06	2.3E-05 ± 1.1E-05	N957	231	205	8.5E-06 ± 6.8E-06	2.0E-05 ± 1.1E-05	
	200-West	49	21	6.2E-06 ± 6.1E-06	1.4E-05 ± 1.2E-05	N964	269	240	2.1E-05 ± 2.4E-04	1.9E-03 ± 6.6E-04	
	300 D4	6	5	1.0E-05 ± 1.7E-05	1.8E-05 ± 1.1E-05	N557	32	25	1.3E-05 ± 1.2E-05	3.3E-05 ± 1.8E-05	
	618-10 FRP	8	5	9.9E-06 ± 1.0E-05	1.9E-05 ± 1.0E-05	N580	16	11	1.4E-05 ± 1.5E-05	2.7E-05 ± 1.6E-05	
ERDF	12	7	1.1E-05 ± 8.8E-06	2.0E-05 ± 1.1E-05	N517	66	65	3.2E-05 ± 1.3E-04	4.3E-04 ± 1.4E-04		

^a Number of samples with measurable concentrations of contaminant.

^b Average ± two standard deviations of all samples analyzed.

^c Maximum ± analytical uncertainty

^d 1 pCi = 0.037 Bq

^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, Subpart E, Table 2).

D4 = Deactivation, Decontamination, Decommissioning, and Demolition

FRP = Field Remediation project

KBC = K Basins Closure

Table C.5. Radionuclide Concentrations in Columbia River Water (Richland, Washington)

Radionuclide ^b	2012				2007-2011				WA Ambient Surface Water Quality Standard	
	Number of		Concentration ^a		Number of		Concentration ^a			
	Samples	Detects	Maximum (pCi/L) ^c	Average (pCi/L) ^c	Samples	Detects	Maximum (pCi/L) ^c	Average (pCi/L) ^c		
Tritium	12	12	7.0E+01 ± 1.1E+01	3.1E+01 ± 2.9E+01	61	59	1.4E+02 ± 3.2E+01	4.3E+01 ± 4.8E+01	20,000 ^d	
Gross Alpha	12	1	2.5E+00 ± 1.6E+00	7.8E-01 ± 1.4E+00	61	11	3.6E+00 ± 1.9E+00	6.4E-01 ± 1.3E+00	15 ^{e, f}	
Gross Beta	12	0	2.3E+00 ± 2.2E+00	1.1E+00 ± 2.2E+00	61	6	5.4E+00 ± 2.6E+00	1.8E+00 ± 2.8E+00	50	
Strontium-90	12	0	5.6E-02 ± 3.8E-02	1.2E-02 ± 5.6E-02	61	61	8.1E-02 ± 2.9E-02	3.0E-02 ± 4.2E-02	8	
Technetium-99	11	0	3.4E-01 ± 3.9E-01	-3.3E-02 ± 3.6E-01	60	17	8.1E-01 ± 3.9E-01	1.1E-01 ± 6.1E-01	900	
Uranium-234	12	12	2.8E-01 ± 5.9E-02	2.3E-01 ± 6.3E-02	61	61	3.5E-01 ± 7.3E-02	2.6E-01 ± 6.8E-02	-- ^g	
Uranium-235	12	1	3.5E-02 ± 2.8E-02	1.2E-02 ± 1.7E-02	59	4	4.5E-02 ± 4.5E-02	1.2E-02 ± 2.4E-02	-- ^g	
Uranium-238	12	12	2.4E-01 ± 5.5E-02	2.0E-01 ± 6.0E-02	61	13	2.9E-01 ± 1.2E-01	2.1E-01 ± 7.0E-02	-- ^g	
Cesium-137	P ^b	11	0	5.9E-04 ± 3.5E-03	-5.6E-04 ± 1.6E-03	57	0	9.1E-03 ± 4.8E-03	3.4E-04 ± 3.2E-03	200 ^c
	D ^b	11	0	4.4E-03 ± 7.2E-03	1.7E-03 ± 4.8E-03	57	0	7.9E-03 ± 5.6E-03	6.5E-04 ± 5.5E-03	
Plutonium-238	P ^b	4	0	6.3E-05 ± 1.2E-04	1.7E-05 ± 5.8E-05	15	0	9.5E-05 ± 9.4E-05	8.7E-06 ± 6.7E-05	600 ^c
	D ^b	3	1	3.6E-04 ± 1.6E-04	1.6E-04 ± 2.8E-04	18	2	3.3E-04 ± 9.6E-04	-6.4E-05 ± 4.8E-04	
Plutonium-239/240	P ^b	4	0	3.1E-05 ± 1.1E-04	2.0E-06 ± 4.0E-05	20	1	9.5E-05 ± 8.6E-05	-8.2E-06 ± 1.6E-04	
	D ^b	3	0	9.2E-05 ± 1.3E-04	5.8E-05 ± 6.4E-05	19	3	4.1E-04 ± 2.2E-04	6.1E-05 ± 4.8E-04	

^a Maximum values are ± total propagated analytical uncertainty (2 sigma). Averages are ±2 standard deviations of the mean.

^b Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately. Other radionuclides are based on unfiltered water samples collected by the composite system (see Section 7.2).

^c To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

^d [WAC 173-201A-250](#), and [EPA-570/9-76-003](#).

^e [WAC 246-290](#).

^f [40 CFR 141](#).

^g Dashes indicate no concentration guides available.

WA = Washington State

Table C.6. Radionuclide Concentrations in Columbia River Water (Priest Rapids Dam, Washington)

Radionuclide ^b	2012				2007-2011				WA Ambient Surface Water Quality Standard	
	Number of		Concentration ^a		Number of		Concentration ^a			
	Samples	Detects	Maximum (pCi/L) ^c	Average (pCi/L) ^c	Samples	Detects	Maximum (pCi/L) ^c	Average (pCi/L) ^c		
Composite System										
Gross Alpha	12	1	2.5E+00 ± 1.6E+00	7.8E-01 ± 1.4E+00	61	11	3.6E+00 ± 1.9E+00	6.4E-01 ± 1.3E+00	15 ^{e, f}	
Gross Beta	12	0	2.3E+00 ± 2.2E+00	1.1E+00 ± 2.2E+00	61	6	5.4E+00 ± 2.6E+00	1.8E+00 ± 2.8E+00	50 ^{e, f}	
Strontium-90	12	0	5.6E-02 ± 3.8E-02	1.2E-02 ± 5.6E-02	61	61	8.1E-02 ± 2.9E-02	3.0E-02 ± 4.2E-02	8 ^{e, f}	
Technetium-99	11	0	3.4E-01 ± 3.9E-01	-3.3E-02 ± 3.6E-01	60	17	8.1E-01 ± 3.9E-01	1.1E-01 ± 6.1E-01	900 ^d	
Tritium	12	12	7.0E+01 ± 1.1E+01	3.1E+01 ± 2.9E+01	61	59	1.4E+02 ± 3.2E+01	4.3E+01 ± 4.8E+01	20,000 ^d	
Uranium-234	12	12	2.8E-01 ± 5.9E-02	2.3E-01 ± 6.3E-02	61	61	3.5E-01 ± 7.3E-02	2.6E-01 ± 6.8E-02	-- ^g	
Uranium-235	12	1	3.5E-02 ± 2.8E-02	1.2E-02 ± 1.7E-02	59	4	4.5E-02 ± 4.5E-02	1.2E-02 ± 2.4E-02	-- ^g	
Uranium-238	12	12	2.4E-01 ± 5.5E-02	2.0E-01 ± 6.0E-02	61	13	2.9E-01 ± 1.2E-01	2.1E-01 ± 7.0E-02	-- ^g	
Continuous System										
Cesium-137	P ^b	11	0	5.9E-04 ± 3.5E-03	-5.6E-04 ± 1.6E-03	57	0	9.1E-03 ± 4.8E-03	3.4E-04 ± 3.2E-03	200 ^c
	D ^b	11	0	4.4E-03 ± 7.2E-03	1.7E-03 ± 4.8E-03	57	0	7.9E-03 ± 5.6E-03	6.5E-04 ± 5.5E-03	
Plutonium-238	P ^b	4	0	6.3E-05 ± 1.2E-04	1.7E-05 ± 5.8E-05	15	0	9.5E-05 ± 9.4E-05	8.7E-06 ± 6.7E-05	-- ^g
	D ^b	3	1	3.6E-04 ± 1.6E-04	1.6E-04 ± 2.8E-04	18	2	3.3E-04 ± 9.6E-04	-6.4E-05 ± 4.8E-04	
Plutonium-239/240	P ^b	4	0	3.1E-05 ± 1.1E-04	2.0E-06 ± 4.0E-05	20	1	9.5E-05 ± 8.6E-05	-8.2E-06 ± 1.6E-04	-- ^g
	D ^b	3	0	9.2E-05 ± 1.3E-04	5.8E-05 ± 6.4E-05	19	3	4.1E-04 ± 2.2E-04	6.1E-05 ± 4.8E-04	

^a Maximum values are ± total propagated analytical uncertainty (2 sigma). Averages are ±2 standard deviations of the mean.

^b Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately. Other radionuclides are based on unfiltered water samples collected by the composite system (see Section 7.2).

^c To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

^d [WAC 173-201A-250](#) and [EPA-570/9-76-003](#).

^e [WAC 246-290](#).

^f [40 CFR 141](#).

^g Dashes indicate no concentration guides available.

WA = Washington State

Table C.7. Radionuclide Concentrations in Columbia River Water (Hanford Reach)

Transect/Radionuclide	No. of Detections	No. of Samples	Concentration ^b					
			Maximum pCi/L ^a			Minimum pCi/L ^a		
Vernita Bridge (HRM 0.3)								
Strontium-90	0	18	0.053	±	0.034	-0.018	±	0.032
Technetium-99	0	4	-0.10	±	0.43	-0.23	±	0.41
Tritium	18	18	30	±	12	13	±	4.7
Uranium-234	18	18	0.30	±	0.070	0.165	±	0.056
Uranium-235	3	18	0.028	±	0.021	0.003	±	0.014 ^c
Uranium-238	18	18	0.22	±	0.054	0.14	±	0.04
100—N Area (HRM 9.5)								
Strontium-90	0	6	0.051	±	0.039	-0.019	±	0.031
Tritium	6	6	34	±	7	24	±	9.7
Uranium-234	6	6	0.21	±	0.061	0.115	±	0.055
Uranium-235	0	6	0.014	±	0.023	-0.012	±	0.014
Uranium-238	6	6	0.24	±	0.065	0.15	±	0.04
Hanford Town Site (HRM 28.7)								
Strontium-90	0	5	0.036	±	0.037	-0.013	±	0.032
Technetium-99	0	1	-0.07	±	0.41		±	^d
Tritium	5	5	40	±	8.0	23	±	5.2
Uranium-234	5	5	0.20	±	0.058	0.152	±	0.054
Uranium-235	0	5	0.019	±	0.020	0.007	±	0.018
Uranium-238	5	5	0.2	±	0.054	0.14	±	0.05
300 Area (HRM 43.1)								
Strontium-90	0	5	0.040	±	0.036	-0.012	±	0.032
Tritium	5	5	118	±	9.5	19	±	4.7
Uranium-234	5	5	0.733	±	0.135	0.180	±	0.054
Uranium-235	1	5	0.045	±	0.029	0.008	±	0.019
Uranium-238	5	5	0.75	±	0.13	0.14	±	0.04
Richland (HRM 46.4)								
Strontium-90	0	22	0.054	±	0.037	-0.007	±	0.033
Technetium-99	0	3	-0.27	±	0.42	-0.46	±	0.412
Tritium	22	22	48	±	7.4	0.054	±	0.037
Uranium-234	22	22	0.278	±	0.067	0.16	±	0.049
Uranium-235	3	22	0.035	±	0.020	-0.009	±	0.0161 ^c
Uranium-238	22	22	0.23	±	0.05	0.11	±	0.04

^a To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

^b Maximum and minimum values are ± total propagated analytical uncertainty (2 sigma).

^c Less than the laboratory—reported detection limit.

^d Result listed as the maximum value when only one sample is analyzed.

HRM = Hanford river marker.

Table C.8. Dissolved Metal Concentrations in Columbia River Transect Water Near Hanford Site
(2007 through 2012)

Metal	No. of Samples	No. of Detections	Maximum ($\mu\text{g/L}$) ^a	Minimum ($\mu\text{g/L}$) ^a	Average (± 2 SD) ($\mu\text{g/L}$) ^a		Minimum Detectable Concentrations	Washington State Ambient Surface Water Quality Chronic Toxicity Level ^b
Vernita Bridge								
Antimony	4	0	—	—	—	—	1.0	—
Arsenic	4	0	—	—	—	—	1.7	190
Beryllium	4	0	—	—	—	—	0.2	—
Cadmium	4	0	—	—	—	—	0.11	—
Chromium	4	0	—	—	—	—	2	10
Copper	4	4	0.879	0.76	0.83	-0.099	0.35	6
Lead	4	0	—	—	—	—	0.5	1.1
Nickel	4	4	2.3	0.63	1.07	-1.7	0.5	83
Selenium	4	0	—	—	—	—	1.5	5
Silver	4	0	—	—	—	—	0.2	—
Thallium	4	0	—	—	—	—	0.45	—
Uranium	4	4	0.47	0.44	0.46	-0.023	0.67	—
Zinc	4	1	3.58 ^c	NA	NA	NA	3.5	55
100—N Area								
Antimony	5	0	—	—	—	—	1	—
Arsenic	5	0	—	—	—	—	1.7	190
Beryllium	5	0	—	—	—	—	0.2	—
Cadmium	5	0	—	—	—	—	0.11	—
Chromium	5	0	—	—	—	—	2	10
Copper	5	5	4.02	0.87	1.6	-2.7	0.35	6
Lead	5	0	—	—	—	—	0.5	1.1
Nickel	5	5	1.3	0.87	1.04	-0.35	0.5	83
Selenium	5	0	—	—	—	—	1.5	5
Silver	5	0	—	—	—	—	0.2	—
Thallium	5	0	—	—	—	—	0.45	—
Uranium	5	5	0.57	0.56	0.56	-0.0079	0.67	—
Zinc	5	0	—	—	—	—	3.5	55
Hanford Town Site								
Antimony	5	0	—	—	—	—	1.0	—
Arsenic	5	0	—	—	—	—	1.7	190
Beryllium	5	0	—	—	—	—	0.2	—
Cadmium	5	0	—	—	—	—	0.11	—
Chromium	5	0	—	—	—	—	2	10
Copper	5	5	0.86	0.75	0.82	-0.087	0.35	6
Lead	5	0	—	—	—	—	0.5	1.1
Nickel	5	5	1.2	0.84	0.93	-0.27	0.5	83
Selenium	5	0	—	—	—	—	1.5	5
Silver	5	0	—	—	—	—	0.2	—
Thallium	5	0	—	—	—	—	0.45	—
Uranium	5	5	0.57	0.55	0.56	-0.016	0.67	—
Zinc	5	3	5.3	3.97	4.2 ^d	-1.6	3.5	55

Table C.8. Dissolved Metal Concentrations in Columbia River Transect Water Near Hanford Site
(2007 through 2012)

Metal	No. of Samples	No. of Detections	Maximum ($\mu\text{g/L}$) ^a	Minimum ($\mu\text{g/L}$) ^a	Average (± 2 SD) ($\mu\text{g/L}$) ^a		Minimum Detectable Concentrations	Washington State Ambient Surface Water Quality Chronic Toxicity Level ^b
300 Area								
Antimony	5	0	—	—	—	—	1	—
Arsenic	5	0	—	—	—	—	1.7	190
Beryllium	5	0	—	—	—	—	0.2	—
Cadmium	5	0	—	—	—	—	0.11	—
Chromium	5	0	—	—	—	—	2	10
Copper	5	5	0.92	0.81	0.85	-0.047	0.35	6
Lead	5	0	—	—	—	—	0.5	1.1
Nickel	5	5	0.79	0.69	0.73	-0.084	0.5	83
Selenium	5	0	—	—	—	—	1.5	5
Silver	5	0	—	—	—	—	0.2	—
Thallium	5	0	—	—	—	—	0.45	—
Uranium	5	5	2.2	0.54	0.90	-1.4	0.67	—
Zinc	5	0	—	—	—	—	3.5	55
Richland								
Antimony	5	0	—	—	—	—	1.0	—
Arsenic	5	0	—	—	—	—	1.7	190
Beryllium	5	0	—	—	—	—	0.2	—
Cadmium	5	0	—	—	—	—	0.11	—
Chromium	5	0	—	—	—	—	2	10
Copper	5	3	0.87	0.795	0.84	-0.075	0.35	6
Lead	5	0	—	—	—	—	0.5	1.1
Nickel	5	5	0.87	0.71	0.81	-0.13	0.5	83
Selenium	5	0	—	—	—	—	1.5	5
Silver	5	0	—	—	—	—	0.2	—
Thallium	5	0	—	—	—	—	0.45	—
Uranium	5	5	0.62	0.47	0.52	-0.1	0.67	—
Zinc	5	0	—	—	—	—	3.5	55

^a Dashes indicate results at or below minimum detectable concentrations.

^b WAC 173-201A-240, and WAC 173-201A-250. Table 240(3) Toxic Substances Criteria for the protection of aquatic life. For hardness—dependent criteria, the minimum value of 47 mg CaCo₃/L, for 1992 through 2000 water samples collected near Vernita Bridge by the U.S. Geological Survey was used. Parts per million (ppm) values are equivalent to the reported micrograms per liter ($\mu\text{g/L}$) concentrations shown.

^c Single detected value.

^d Average calculated using reporting limit values for all results at or below minimum detectable concentrations.

SD = Standard deviation.

Table C.9. Radionuclide and Total Organic Carbon Concentrations in Columbia River Sediment (Near Hanford Site)

Location / 2012 Total Organic Carbon Concentration Value	Radionuclide	2012				2007-2011			
		No. of Samples	Concentration, Ci/g ^a		No. of Samples	Concentration, Ci/g ^a			
			Average ^b	Maximum ^d		Average ^c	Maximum ^d		
Priest Rapids Dam (18,100-37,000 mg/kg)	Cobalt-60	2	-0.008 ± 0.005	-0.006 ± 0.022	10	-0.0005 ± 0.022	0.011 ± 0.016		
	Strontium-90	2	0.004 ± 0.023	0.013 ± 0.0166	10	0.009 ± 0.04	0.043 ± 0.028		
	Cesium-137	2	0.304 ± 0.092	0.34 ± 0.046	10	0.29 ± 0.063	0.35 ± 0.038		
	Europium-152	2	-0.018 ± 0.077	0.009 ± 0.0638	10	-0.007 ± 0.092	0.089 ± 0.136		
	Europium-155	2	0.061 ± 0.056	0.081 ± 0.057	10	0.07 ± 0.04	0.114 ± 0.124		
	Uranium-234	2	1.1 ± 0.65	1.4 ± 0.23	12	1.1 ± 0.33	1.4 ± 0.2		
	Uranium-235	2	0.056 ± 0.006	0.058 ± 0.039	10	0.057 ± 0.045	0.096 ± 0.026		
	Uranium-238	2	1.0 ± 0.55	1.2 ± 0.20	11	1.01 ± 0.38	1.2 ± 0.43		
	Plutonium-239/240	2	0.011 ± 0.0004	0.011 ± 0.002	10	0.009 ± 0.004	0.013 ± 0.004		
100-F Slough (1,530 mg/kg)	Cobalt-60	1		0.0187 ± 0.0194	4	0.012 ± 0.008	0.016 ± 0.012		
	Strontium-90	1		0.0133 ± 0.0279	4	0.014 ± 0.022	0.027 ± 0.025		
	Cesium-137	1		0.0228 ± 0.0209	4	0.261 ± 0.067	0.302 ± 0.043		
	Europium-152	1		-0.00284 ± 0.0481	4	0.039 ± 0.041	0.064 ± 0.033		
	Europium-155	1		0.0293 ± 0.042	4	0.037 ± 0.060	0.068 ± 0.045		
	Uranium-234	1		0.461 ± 0.106	5	0.413 ± 0.374	0.658 ± 0.074		
	Uranium-235	1		0.0541 ± 0.0354	4	0.031 ± 0.047	0.061 ± 0.021		
	Uranium-238	1		0.406 ± 0.0946	4	0.351 ± 0.251	0.433 ± 0.085		
	Plutonium-239/240	1		0.002 ± 0.00205	4	0.001 ± 0.001	0.002 ± 0.0005		
White Bluffs Slough (5,260-12,200mg/kg)	Cobalt-60	2	0.01368 ± 0.02778	0.02 ± 0.018	5	0.011 ± 0.026	0.024 ± 0.026		
	Strontium-90	2	-0.01292 ± 0.01778	-0.01 ± 0.022	5	0.010 ± 0.034	0.04 ± 0.031		
	Cesium-137	2	0.27750 ± 0.12587	0.322 ± 0.033	5	0.49 ± 0.18	0.64 ± 0.09		
	Europium-152	2	0.05325 ± 0.07029	0.078 ± 0.052	5	0.11 ± 0.15	0.20 ± 0.05		
	Europium-155	2	0.08320 ± 0.01131	0.0872 ± 0.040	5	0.065 ± 0.065	0.1 ± 0.068		
	Uranium-234	2	0.77100 ± 0.50912	1.0 ± 0.17	6	0.72 ± 0.40	1.01 ± 0.184		
	Uranium-235	2	0.03995 ± 0.00750	0.0426 ± 0.03	5	0.041 ± 0.037	0.061 ± 0.02		
	Uranium-238	2	0.82450 ± 0.58124	1.0 ± 0.18	5	0.66 ± 0.51	1.02 ± 0.184		
	Plutonium-239/240	2	0.00192 ± 0.00116	0.002 ± 0.002	5	0.004 ± 0.003	0.006 ± 0.003		
100-D Spring 102-1 (5,870 mg/kg)	Cobalt-60	1		-0.00612 ± 0.0113	e				
	Strontium-90	1		0.0148 ± 0.0272	e				
	Cesium-137	1		0.209 ± 0.0238	e				
	Europium-152	1		-0.0264 ± 0.0298	e				
	Europium-155	1		0.0487 ± 0.0351	e				
	Uranium-234	1		0.516 ± 0.11	e				
	Uranium-235	1		0.0401 ± 0.0294	e				
	Uranium-238	1		0.49 ± 0.104	e				
	Plutonium-239/240	1		0.00282 ± 0.00188	e				

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Table C.9. Radionuclide and Total Organic Carbon Concentrations in Columbia River Sediment (Near Hanford Site)

Location / 2012 Total Organic Carbon Concentration Value	Radionuclide	No. of Samples	2012				2007-2011			
			Concentration, Ci/g ^a		Concentration, Ci/g ^a		Concentration, Ci/g ^a		Concentration, Ci/g ^a	
			Average ^b	Maximum ^d	Average ^b	Maximum ^d	Average ^c	Maximum ^d	Average ^c	Maximum ^d
Hanford Slough (17,000 mg/kg)	Cobalt-60	1		0.0352 ± 0.0243			0.021 ± 0.041	0.040 ± 0.026		
	Strontium-90	1		0.000548 ± 0.0233			0.005 ± 0.016	0.015 ± 0.014		
	Cesium-137	1		0.247 ± 0.0325			0.167 ± 0.264	0.288 ± 0.036		
	Europium-152	1		0.0744 ± 0.058			0.035 ± 0.069	0.069 ± 0.028		
	Europium-155	1		0.0942 ± 0.0453			0.065 ± 0.058	0.091 ± 0.044		
	Uranium-234	1		0.925 ± 0.169			0.632 ± 0.506	0.871 ± 0.123		
	Uranium-235	1		0.0789 ± 0.0444			0.027 ± 0.027	0.041 ± 0.021		
	Uranium-238	1		0.938 ± 0.169			0.587 ± 0.512	0.782 ± 0.131		
	Plutonium-239/240	1		0.00233 ± 0.00282			0.002 ± 0.004	0.004 ± 0.0015		
McNary Dam (15,800-19,500 mg/kg)	Cobalt-60	2	0.010 ± 0.018	0.02 ± 0.03			0.008 ± 0.02	0.02 ± 0.015		
	Strontium-90	2	0.006 ± 0.041	0.021 ± 0.028			-0.0009 ± 0.027	0.0133 ± 0.024		
	Cesium-137	2	0.212 ± 0.064	0.234 ± 0.054			0.25 ± 0.082	0.319 ± 0.050		
	Europium-152	2	0.032 ± 0.078	0.059 ± 0.069			0.059 ± 0.12	0.17 ± 0.050		
	Europium-155	2	0.1 ± 0.009	0.0712 ± 0.062			0.069 ± 0.05	0.101 ± 0.104		
	Uranium-234	2	1.3 ± 0.06	1.3 ± 0.212			1.3 ± 0.49	1.7 ± 0.31		
	Uranium-235	2	0.078 ± 0.011	0.082 ± 0.043			0.068 ± 0.055	0.12 ± 0.03		
	Uranium-238	2	1.2 ± 0.04	1.2 ± 0.21			1.10 ± 0.49	1.4 ± 0.23		
	Plutonium-239/240	2	0.013 ± 0.022	0.021 ± 0.006			0.008 ± 0.004	0.012 ± 0.003		

^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 Average values calculated using reporting limit values for all results at or below minimum detectable concentrations.

^d Values are ± total propagated analytical uncertainty (2 sigma).

^e No sample data for this time period.

Table C.10. Dissolved Metal Concentrations in Columbia River Sediment (Near Hanford Site)

Metal	Priest Rapids Dam (mg/kg dry weight)	Hanford Sloughs^a (mg/kg dry weight)	McNary Dam (mg/kg dry weight)	Hanford Shoreline^b (mg/kg dry weight)
Antimony	0.79	0.56	Not Detected	Not Detected
Arsenic	9.5 – 12	4.3 – 7.4	6.9 – 7.3	5.4
Beryllium	0.94 – 1.1	0.25 – 0.53	0.92 – 1.0	0.49
Cadmium	6.4 – 6.6	0.70 – 3.7	1.4 – 1.5	1.22
Chromium	36 – 42	11 – 20	Not Detected	Not Detected
Copper	45 – 61	19 – 26	23 – 26	15
Lead	42 – 53	13 – 52	16 – 19	14.6
Mercury	0.094 – 0.12	0.014 – 0.06	0.069 – 0.08	0.0152
Nickel	40 - 44	10 – 19	18 – 24	12
Selenium	Not Detected	0.91 – 1.5	2.7 – 2.7	Not Detected
Silver	Not Detected	3.3	Not Detected	0.601
Thallium	Not Detected	Not Detected	Not Detected	Not Detected
Zinc	502 – 586	153 – 390	Not Detected	Not Detected
No. of Samples	2	4	2	1

^a 100-F Slough (n=1), Hanford Slough (n=1), White Bluffs Slough (n=2); where n = number of samples.

^b 100-D Area at 100-D Spring 102-1 (n=1)

Table C.11. Radionuclide Concentrations in Shoreline Seep Water along Hanford Site Shoreline

	2012				2007 - 2011				WA Ambient Surface Water Quality Standard (pCi/L) ^d
	No. of Samples	Concentration, pCi/L ^a		No. of Samples	Concentration, pCi/L ^a				
		Maximum ^b	Average ^{b,c}		Maximum ^b	Average ^b			
100-B Area (100-B Spring 38-3)									
Strontium-90	1	0.039 ± 0.037 ^e	NC	4	0.055 ± 0.038 ^e	0.025 ± 0.058 ^e		8	
Tritium	1	1,090 ± 275	NC	4	2,680 ± 563	1,765 ± 1,232		20,000	
100-D Area (100-D Spring 110-1)									
Gross Alpha	1	0.70 ± 1.2 ^e	NC	4	1.7 ± 1.6 ^e	0.89 ± 1.6 ^e		15	
Gross Beta	1	2.9 ± 2.2 ^e	NC	4	4.4 ± 2.4	3.2 ± 2.4		50	
Technetium-99	1	-0.016 ± 0.33 ^e	NC	0	No Analysis			900 ^f	
Tritium	1	339 ± 187	NC	4	1,840 ± 415	675 ± 1,787		20,000	
Uranium-234	1	0.23 ± 0.058	NC	0	No Analysis			— ^g	
Uranium-235	1	0.021 ± 0.020 ^e	NC	0	No Analysis			— ^g	
Uranium-238	1	0.18 ± 0.048	NC	0	No Analysis			— ^g	
100-H Area (100-H Spring 145-1)									
Tritium	1	275 ± 174	NC	5	2,110 ± 455	1,044 ± 1,574		20,000	
Strontium-90	1	0.016 ± 0.034 ^e	NC	4	0.0032 ± 0.032 ^e	0.0012 ± 0.0073 ^e		8	
Technetium-99	1	0.42 ± 0.44 ⁴	NC	4	1.7 ± 0.86	0.58 ± 1.6		900 ^f	
100-K Area (100-K Spring 68-1)									
Carbon-14	1	57 ± 27	NC	0	Not Sampled			2,000	
Tritium	1	2,890 ± 608	NC	0	Not Sampled			20,000	
100-N Area (Spring 8-13)									
Gross Alpha	1	0.9 ± 1.3 ^e	NC	4	10 ± 4.0	3.8 ± 8.9		15	
Gross Beta	1	1.2 ± 2.2 ^e	NC	4	18 ± 3.8	7.1 ± 14		50	
Strontium-90	1	0.0047 ± 0.029 ^e	NC	4	0.048 ± 0.032 ^e	0.022 ± 0.038 ^e		8	
Tritium	1	1,280 ± 381	NC	4	5,800 ± 1,160	3,488 ± 4,416		20,000	
100-N Area (Spring 89-1)									
Strontium-90	1	4.6 ± 0.75	NC	0	Not Sampled			8	
Tritium	1	886 ± 289	NC	0	Not Sampled			20,000	
Hanford Town Site (Spring 28-2)									
Gross Alpha	1	2.6 ± 2.4 ^e	NC	3	3.04 ± 2.2	1.8 ± 2.2		15	
Gross Beta	1	20 ± 3.9	NC	3	31 ± 4.4	20 ± 20		50	
Tritium	1	32,600 ± 6,340	NC	3	28,200 ± 5,520	19,267 ± 15,505		20,000	
300 Area (Springs 42-2 and 100-DR 42-2)									
Gross Alpha	2	42 ± 8	33 ± 25		86 ± 11	47 ± 48		15	
Gross Beta	2	16 ± 4	16 ± 2	6	44 ± 5	31 ± 25		50	
Tritium	2	4,300 ± 879	3,865 ± 1,230	6	7,810 ± 1,550	5,867 ± 2,790		20,000	
Uranium-234	2	24 ± 3.2	18 ± 17	6	48 ± 11	29 ± 25		— ^g	
Uranium-235	2	1.6 ± 0.26	1.3 ± 0.92	6	3.7 ± 1.07	2.4 ± 2.3		— ^g	
Uranium-238	2	23 ± 3.01	17 ± 15	6	47 ± 10	29 ± 24		— ^g	

Table C.11. Radionuclide Concentrations in Shoreline Seep Water along Hanford Site Shoreline

^a To convert to the International System of Units, multiply pCi/L by 0.037 to obtain Bq/L.

^b Maximum values are \pm total propagated analytical uncertainty, averages are ± 2 standard deviations of the mean.

^c Average values are not calculated (NC) when only one sample was analyzed. Average values calculated using reporting limit values for all results at or below minimum detectable concentrations.

^d WAC 246-290, 40 CFR 141, and Appendix D, Table D.4.

^e Value below the minimum detectable concentration.

^f WAC 173-201A-250 and EPA-570/9-76-003.

^g Dashes indicate no concentration guides available

Table C.12. Radionuclide Concentrations in Columbia River Shoreline Sediment (100-D Spring)

Radionuclide	No. of Samples	Result, pCi/g ^{a,b}
Antimony-125 ^c	1	-1.7E-02 ± 2.5E-02
Beryllium-7 ^c	1	1.4E-01 ± 9.8E-02
Cobalt-60 ^c	1	-6.1E-03 ± 1.1E-02
Cesium-134 ^c	1	4.1E-02 ± 2.7E-02
Cesium-137	1	2.1E-01 ± 2.4E-02
Europium-152 ^c	1	-2.6E-02 ± 3.0E-02
Europium-154 ^c	1	1.1E-02 ± 3.2E-02
Europium-155 ^c	1	4.9E-02 ± 3.5E-02
Potassium-40	1	1.5E+01 ± 1.4E+00
Plutonium-238 ^c	1	1.1E-03 ± 1.3E-03
Plutonium-239/240	1	2.8E-03 ± 1.9E-03
Ruthenium-106 ^c	1	2.0E-02 ± 8.1E-02
Strontium-90 ^c	1	1.5E-02 ± 2.7E-02
Uranium-234	1	5.2E-01 ± 1.1E-01
Uranium-235	1	4.0E-02 ± 2.9E-02
Uranium-238	1	4.9E-01 ± 1.0E-01

^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 Values are ± total propagated analytical uncertainty (2 sigma).

^c Results at or below minimum detectable concentrations.

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Appendix D**Dose Calculations**

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D. Dose Calculations

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Dose calculations based on measured and/or estimated releases from stack emissions, liquid effluents, and contaminated soils were conducted for the public and biota. These dose calculations are summarized in Section 4.2. Details of the methods and assumptions used for modeling individual and population dose for the public are provided in Section D.1. Methods and assumptions related to the calculation of biota dose are provided in Section D.2.

D.1 Supporting Information for Calculation of Public Doses

The radiological dose that the public could have received in 2012 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. The effective dose equivalent is the sum of doses to organs and tissues that is weighted to account for the sensitivity of the organ or tissue to the effects of radiation and for the biological effectiveness of the type of radiation causing the dose. It is expressed in units of rem (sievert), or more typically the sub-unit millirem (millisievert)¹ for individuals, and in units of person-rem (person-sievert) for the collective dose received by the total population within a 50-mile (80-kilometer) radius of the site operations areas. This appendix describes how the doses described in Section 4.2 of 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 tissue weighting factors ([ICRP 1991](#)) that represent the contribution of each organ or tissue to a person's internal radiation dose. 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 frequently too small for their concentrations to be accurately measured in many of the offsite environmental media of interest. Even when present in measurable amounts, it is difficult to distinguish the small Hanford Site contributions from levels attributable to fallout from historical nuclear weapons testing and from naturally occurring radionuclides such as uranium and its decay products. Therefore, environmental radionuclide concentrations were estimated from effluent measurements (air pathway doses) or river water measurements (water pathway doses) by using environmental transport models. The air dose calculations employ environmental transport modeling based on measurements made at the point of release (stacks and vents). The water pathway dose calculations are based on measurements of radionuclide concentrations in the Columbia River upstream and downstream of the site.

The transport of radionuclides in the environment to points of exposure is predicted using mathematical models of the physical processes underlying the various exposure pathways. These models are used to calculate radionuclide levels in air, soil, and foods at offsite locations. Long-lived radionuclides deposited on the ground become possible sources for long-term external exposure and uptake by agricultural products. Radionuclides taken into the body by inhalation or ingestion may be distributed among different organs and tissues and retained in the body for various lengths of times. Agricultural, behavioral, and dosimetric models were applied to calculate radionuclide intakes and radiological doses to the public from annual-average radionuclide concentrations in the exposure media. Computer programs were used to implement these mathematical models using Hanford Site-specific dispersion and uptake parameters. These programs are incorporated in a master code—*GENII - The Hanford Environmental Radiation Dosimetry Software System, Version 2.10* ([PNNL-14583](#), [PNNL-14584](#), [PNNL-19168](#))—which employs the internal dosimetry methodology described in International Commission on Radiological Protection Publication 60 ([ICRP 1991](#)) and external dose coefficients described in Federal Guidance Report 12 ([EPA 1993](#)). GENII Version 1.485 (PNL-6584), which incorporated internal dosimetry methods of [International Commission on Radiological Protection Publication 30](#) (1979a, 1979b, 1980, 1981a, 1981b, 1982a, 1982b, 1988) was used for dose

¹ 1 rem (0.01 sievert) = 1,000 millirem (10 millisievert).

calculations through 2008. GENII Version 2.10 is a Microsoft Windows[®]-based version that also incorporates some environmental modeling improvements (e.g., plume depletion during atmospheric transport) relative to Version 1.485. The modeling assumptions and radionuclide release data used in the GENII calculations are the primary focus of Section D.1. The ingestion and inhalation dose coefficients ([ICRP 1991](#)) and external dose coefficients ([EPA 1993](#)) used for the pathway dose calculations are described further in [PNNL-14584](#) and are not reproduced here.

The computer program, CAP88-PC (also known as CAP-88), was used to calculate an air pathway dose to a maximally exposed individual for compliance with *Clean Air Act* standards, as required by the EPA through [40 CFR 61](#), Subpart H from airborne radionuclide effluent (other than radon) released at DOE facilities. Technical details of the CAP88-PC calculations are provided in the *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2012* ([DOE/RL-2013-12](#)).

Calculations of radiological doses to the public from radionuclides released into the environment are performed to demonstrate compliance with applicable standards and regulations. [DOE O 458.1](#), Chg. 2, provides requirements for demonstrating compliance with the public dose limit of 100 mrem (1 millisievert) total effective dose in a year. Relevant requirements include:

- Compliance may be demonstrated by calculating dose to the representative person or to the maximally exposed individual
- Collective dose for members of the public should be calculated, and may be truncated by distance (e.g., 50 miles)
- The representative person or maximally exposed individual must include members of the public outside of controlled areas on DOE sites and offsite
- Analytical models used to calculate dose must be codified or approved by DOE and must consider likely exposure pathways including external radiation from air and soil, inhalation, and ingestion of water and terrestrial and/or aquatic foods
- Calculations of doses to the public from exposures resulting from both routine and unplanned activities must be performed using DOE-approved dose conversion factors
- Values of default or site-specific parameters used in the dose modeling must be included to document the calculations.

A summary of how the offsite maximally exposed individual was identified, and information on modeling assumptions and inputs to the GENII computer code used to conduct the maximally exposed individual dose calculations, is provided in Section D.1.1. Information supporting the calculation of collective offsite dose using the GENII computer code is provided in Section D.1.2.

D.1.1 Maximally Exposed Individual Dose

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. The location of the maximally exposed individual can vary from year to year, depending on the relative contributions of the different operational areas to radioactive emissions released to the air and of radionuclide releases to the Columbia River from Hanford Site facilities. The following potentially significant exposure pathways are considered for identifying the location of this hypothetical individual:

- Inhalation of airborne radionuclides
- External exposure from submersion in airborne radionuclides
- Ingestion of foodstuffs contaminated by radionuclides deposited on vegetation and the ground by airborne deposition and/or irrigation water drawn from the Columbia River
- Incidental ingestion of soil and external exposure to ground contaminated by airborne deposition and/or irrigation water

- Ingestion of drinking water drawn from the Columbia River
- 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 exposure to sediments during shoreline activities.

Determination of the Location of the Maximally Exposed Individual. Based on experience since 1990 from environmental transport modeling and environmental surveillance monitoring, several separate locations (Figure 4.2) have been used to assess the dose to the maximally exposed individual. The distinguishing characteristics of these locations are described in the following paragraphs.

Riverview Maximally Exposed Individual. The Riverview area is across the Columbia River from the city of Richland. 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 as well as some contribution from exposure to airborne emissions from the 300 Area. The Riverview location is where a small population of West Pasco residents obtain their drinking water from the river via a community water system. Therefore, the domestic drinking water pathway is applied to this location. Columbia River water from just downstream of the Hanford Site is also withdrawn for irrigation of small gardens and farms at Riverview.

Ringold Maximally Exposed Individual. The Ringold area is along the east shoreline of the Columbia River 16 miles (26 kilometers) east of separations facilities in the 200 Areas. 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. In addition, it is assumed that some individuals in the Ringold area may 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. For identifying the maximally exposed individual, Hanford Site contributions to irrigation water at Ringold are protectively evaluated using the same downstream concentrations employed for Riverview. Domestic drinking water at Ringold is not obtained from the Columbia River so this exposure pathway is incomplete.

Sagemoor Maximally Exposed Individual. An individual in the Sagemoor area, located approximately 0.87 mile (1.4 kilometers) directly across the Columbia River from the 300 Area, frequently 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, irrigation-related exposure pathways are likely incomplete at this location. However, because some individuals may obtain much of their food from local agriculture, Columbia River irrigation pathways agricultural dose has historically also been assigned to the Sagemoor area maximally exposed individual. This practice protectively, but unrealistically, sums the location-specific air deposition component of food-related dose with the irrigation component from a separate location. The added contribution of radionuclides in the Riverview area irrigation water maximizes the calculated dose from the air and water pathways combined.

Horn Rapids Road Maximally Exposed Individual. Meteorological conditions in 2012 resulted in a more southerly direction of wind dispersion than has been observed in past years. As a result, air concentrations related to 300 Area emissions were modeled to be higher at a location just to the south of the Hanford Site boundary than at the Sagemoor location across the Columbia River to the east. Buildings in this area historically have been associated with commercial and industrial activities. However, in recent years residences also have been constructed near to the southern boundary of the Hanford Site south of the 300 Area.

PNNL's Physical Sciences Facility, an offsite business located at 638 Horn Rapids Road in north Richland, Benton County, Washington, directly south of the Hanford Site 300 Area, was identified as the location of the hypothetical, maximally exposed individual ([DOE/RL-2013-12](#)) based on air dispersion exposure pathways. Residences in this area obtain drinking water from the City of Richland, which has an intake on the Columbia River downstream of the Hanford Site. Therefore, the domestic drinking water pathway is applied to this location. Additionally, some agriculture in this area occurs on leased property that receives irrigation water from the Battelle pumping station on the Columbia River just below the 300 Area.

During the period of plutonium production at the Hanford Site, Ringold was the location of the 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. For the past decade, the hypothetical, maximally exposed individual has been associated with air emissions from the 300 Area.

Because the hypothetical, maximally exposed individual at all locations is assumed to potentially receive dose from consumption of foods raised using Columbia River irrigation water, the identification of the location of the maximally exposed individual is based on the highest projected dose among the following pathways:

- Air pathways dose at Ringold (200 Area sources)
- Air pathways dose at Sagemoor (300 Area sources)
- Air pathways dose at Horn Rapids Road (300 Area sources) plus drinking water dose
- Air pathways plus drinking water pathway dose at Riverview.

For 2012, air pathways dose calculations conducted using CAP-88PC in support of *Clean Air Act* requirements identified Horn Rapids Road as the location with the highest maximally exposed individual dose (0.091 mrem, including radon) from stack emissions ([DOE/RL-2013-12](#)). At Sagemoor, Ringold and Riverview, the comparable stack emissions air pathways annual dose was 0.058 mrem, 0.0073 mrem, and 0.0084 mrem, respectively (PNNL, Personal Communication). The maximally exposed individual at Horn Rapids Road receives the highest air pathways dose, and also receives dose from the drinking water and irrigation pathways. Therefore, Horn Rapids Road was identified as the location of the hypothetical, maximally exposed individual in 2012 for the GENII calculations.

The coordinates of the maximally exposed individual location relative to each of the Hanford Site operating areas are entered in the GENII computer code to specify the location for the air pathways dose calculations. For Sagemoor, these coordinates are:

- 100 Area: 26.874 km Easting, -30.064 km Northing
- 200 Area: 24.954 km Easting, -20.814 km Northing
- 300 Area: 1.35 km Easting, 0.26 km Northing
- 400 Area: 7.909 km Easting, -6.739 km Northing.

For Horn Rapids Road, these coordinates are:

- 100 Area: 29.1 km Easting, -29.1 km Northing
- 200 Area: 22.6 km Easting, -22.6 km Northing
- 300 Area: 0 km Easting, -1.80 km Northing
- 400 Area: 7.92 km Easting, -7.92 km Northing.

Water and Air Release Inputs Used In GENII Version 2.10. As discussed in Section 4.2, the environmental data needed to perform the GENII dose calculations for the water pathways are measured upstream and downstream differences in radionuclide concentrations in the Columbia River that are assigned to the 200 Area. Measured emissions of radionuclides in stack releases are used in the GENII air pathways dose calculations. These data must be processed for input to the GENII computer code. For both water and air pathways, GENII accepts inputs for environmental releases using dimensions of activity (e.g., Curie or Becquerel) per time.

Direct liquid effluent releases from outfalls in the 100 Areas were historically used to characterize contributions from the 100 Areas. The last operating outfall, the 1908-K Outfall in the 100-K Area, ceased operations at the end of March 2011. Therefore, no annual releases were identified from the 100 Areas in 2012. Liquid effluent discharges related to historical Hanford operations are known to enter the Columbia River by groundwater discharge at certain locations along the site shoreline from the 100-B/C Area

downstream to the 300 Area. The impact of these discharges was evaluated as the difference between near-shore river water radionuclide concentrations downstream of the Hanford Site (monthly samples collected at the Richland Pumphouse, sampling location label RICH.PMPHS HRM46.4) and upstream samples collected below the Priest Rapids Dam (monthly samples collected at sampling location label PRIEST RAPIDS-RIVER). A one-tailed paired t-test was used to determine whether average downstream sample concentrations were statistically greater than upstream average concentrations, using a p-value of 0.05 as the threshold of statistical significance. Potassium-40, tritium, uranium-234, and uranium-238 were identified as potentially Hanford-related contaminants to include in the 2012 dose assessment based on this statistical test. Because uranium-235 would be expected co-occur with both uranium-234 and uranium-238, uranium-235 was also identified for inclusion in the water pathways dose assessment calculations. These liquid effluent releases were associated with the 200 Area for reporting purposes. Table D.1, summarizes the mean annual differences in downstream and upstream concentrations, and calculated annual releases for the 200 Areas GENII water pathways dose calculations.

Potassium-40 is a naturally occurring radionuclide in soil, water, and the tissues of plants and animals that is routinely detected and is not known to be of Hanford origin. Potassium-40 is also naturally present in products such as potassium-containing fertilizers. It was included in the water pathways dose assessment because in 2012 Columbia River annual-average concentrations downstream of the Hanford Site (Richland Pumphouse) were statistically elevated in comparison to upstream (Priest Rapids Dam) concentrations. A comparison of upstream and downstream potassium-40 concentrations for the past 5 years is shown in Figure D.1. Both upstream and downstream concentrations were higher in 2011 and 2012 relative to the previous 3 years, and the river location where annual-average concentrations are highest has reversed. Although the relationship may not be causal, this pattern in potassium-40 concentrations loosely reflects changes in annual-average Columbia River flow rates. During the period 2008 through 2010, the annual-average river flow rate measured below Priest Rapids Dam decreased from approximately 3,100 m³/s to 2,700 m³/s, but in 2011 and 2012 the rate increased to approximately 4,200 m³/s.

Figure D.1. Comparison of Downstream and Upstream Potassium-40 Concentrations

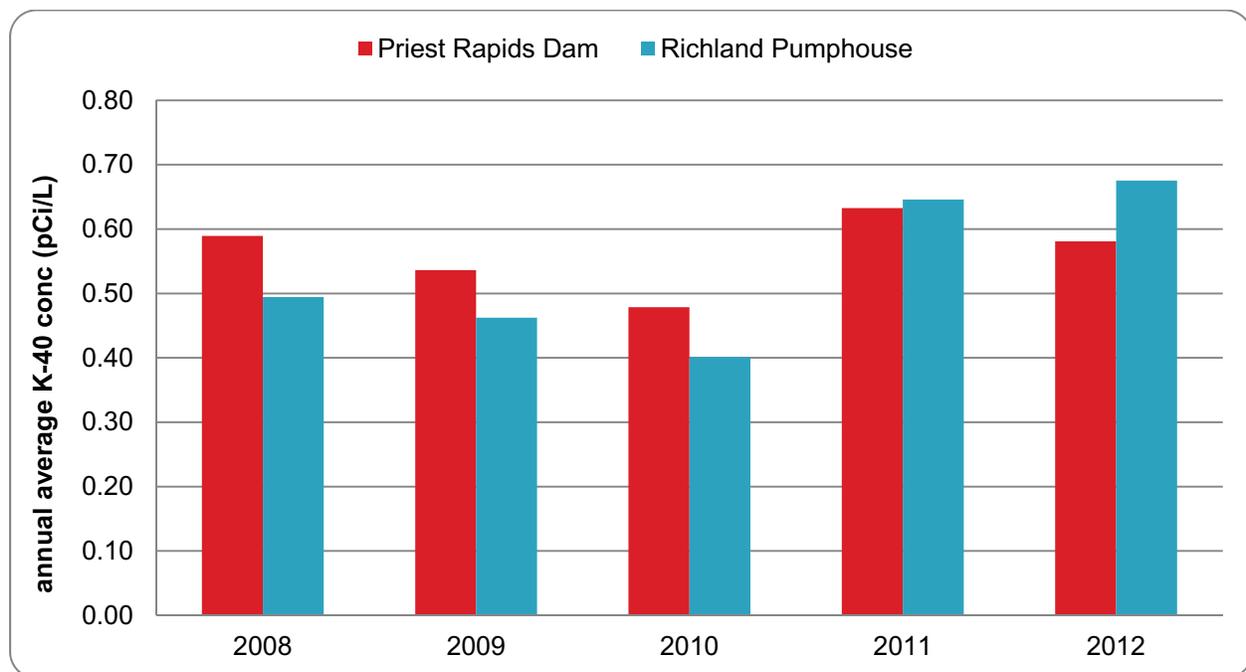


Table D.1. 200 Area Liquid Effluent Radionuclide Releases for GENII Calculations

Radionuclide	Upstream	Downstream	Difference
Columbia River Annual-Average Radionuclide Concentrations (pCi/L)			
Potassium-40	5.8E-01	6.8E-01	9.5E-02
Tritium	1.8E+01	3.1E+01	1.3E+01
Uranium-234	2.1E-01	2.3E-01	2.5E-02
Uranium-235	9.2E-03	1.2E-02	2.7E-03
Uranium-238	1.7E-01	2.0E-01	2.9E-02
Calculated Radionuclide Releases (Ci/year)¹			
Potassium-40	NA	NA	1.2E+01
Tritium	NA	NA	1.7E+03
Uranium-234	NA	NA	3.3E+00
Uranium-235	NA	NA	3.6E-01
Thorium-231 ²	NA	NA	3.6E-01
Uranium-238	NA	NA	3.8E+00
Thorium-234 ³	NA	NA	3.8E+00
Protactinium-234m ³	NA	NA	3.8E+00

¹ Calculated as the product of the difference in downstream and upstream radionuclide concentrations and the 2012 annual-average river flow rate of 4172 m³/sec at Priest Rapids Dam.

² This short-lived progeny of uranium-235 was protectively assumed to be in secular equilibrium at the time of discharge.

³ These short-lived progeny of uranium-238 were protectively assumed to be in secular equilibrium at the time of discharge.

Refer to Section 7.0 for information on Columbia River surface water sampling.

NA: Not applicable; radionuclide releases are calculated based on the difference between annual-average downstream and upstream concentrations.

Radioactive air emissions based on monitoring of stacks in the 100, 200, 300, and 400 Areas were used as the basis for the GENII air pathways dose calculations. Stack emissions are measured for specific radionuclides related to the operations at each emissions point. During the dispersion time from the stack to an offsite exposure location there is opportunity for ingrowth short-lived radioactive progeny that are included in the GENII radionuclide inventory. A protective upper-bound dispersion time of 15 hours was estimated based on the longest dispersion distance in the collective dose calculations 50 miles (80 kilometers) and an assumed (4.9 feet/second (1.5 meters/second) average wind speed. Concentrations of short-lived progeny after a 15-hr ingrowth period were included in the GENII air emissions inventory to address their potential contribution to the inhalation dose. Ingrowth of longer-lived progeny in soil and other environmental media is accounted for within GENII.

In addition to measurement of specific radionuclides, gross alpha and gross beta measurements are also made on emissions from each operating area. Following the precedent of [DOE/RL-2013-12](#), measurements of gross alpha and gross beta radiation in stack emissions were protectively added to the measured emissions of plutonium-239/240 and strontium-90, respectively, to ensure that contributions from any unmeasured operations-related radionuclides are incorporated in the estimated doses. These specific radionuclides were selected based on their historical association with releases in these operating areas and because of the relatively large values of their dose conversion factors. Air releases for the GENII air pathways dose calculations are summarized in Table D.2.

Exposure Parameter Values Used in GENII Version 2.10. GENII Version 2.10 requires input values for numerous parameters used in the environmental transport and human exposure models. Important parameters affecting the movement of radionuclides within agricultural exposure pathways such as animal dietary parameters, irrigation rates, crop yield, growing periods, and holdup periods are listed in Table D.3. The plant,

animal, and aquatic foods transfer factors used for the pathway dose calculations are documented in [PNNL-14584](#) and are not reproduced here.

The offsite radiological dose is related to the extent of external exposure to, or intake of, radionuclides released from Hanford Site operations that become incorporated in exposure media such as air, water, soil, sediment, and various foodstuffs. Tables D.4 through D.6 give the values for the diet, residency, and river recreation parameters for maximally exposed and average individuals.

Meteorological Data Used in GENII Version 2.10. GENII Version 2.10 employs an atmospheric dispersion model to calculate annual-average air concentrations and deposition rates at downwind locations based on site-specific radionuclide air emissions measurements and meteorological data ([PNNL-14583](#)). The 2012 meteorological data used in the GENII air dispersion modeling were gathered at monitoring stations in the 100 Area (station 29; 100-K), 200 Area (station 21; HMS), 300 Area (station 11; 300 Area), and 400 Area (station 9; Fast Flux Test Facility). With the exception of the 200 Area, all meteorological data were obtained at a height of 33 feet (10 meters). In the 200 Area, where some active stacks are (200 feet) (61 meters) in height, the meteorological data used were collected at 397 feet (121 meters).

Hourly meteorological data from the monitoring stations described above were formatted for use in the GENII computer code. Four meteorological files, one for each of the Hanford Site operating areas and stations described above, were created. These files were identified in the GENII Chronic Plume Air Module. A radial grid consisting of 16 directional sectors and 10 downwind distances was specified in the air module. The downwind distances were varied for each operating area to coincide with the distance to the maximally exposed individual location, as defined by the Easting and Northing coordinates described above. For example, the finest resolution was entered for the distance from the 300 Area to the maximally exposed individual location.

Table D.2. Air Pathways Radionuclide Releases for GENII Calculations

Radionuclide ^(a)	100 Area (Ci)	200 Areas (Ci)	300 Area (Ci)	400 Area (Ci)
Hydrogen-3 (as elemental tritium)	NA	NA	2.92E+01	NA
Hydrogen-3 (as tritiated water vapor)	NA	NA	6.81E+01	1.80E-03
Sodium-22	NA	NA	NA	1.40E-09
Krypton-85	NA	NA	1.76E-06	NA
Stontium-90 ^(b)	1.79E-05	5.00E-04	3.38E-06	NA
<i>Yttrium-90</i> ^(c)	2.68E-06	7.49E-05	5.06E-07	--
Technetium-99	NA	NA	4.04E-06	NA
Iodine-129	NA	9.80E-04	NA	NA
Cesium-137	4.00E-06	3.63E-05	7.57E-08	8.40E-07
<i>Barium-137m</i> ^(c)	4.00E-06	3.63E-05	7.57E-08	8.40E-07
Europium-152	NA	NA	3.41E-09	NA
Europium-154	NA	NA	1.26E-07	NA
Gadolinium-153	NA	NA	2.28E-09	NA
Radon-219	NA	NA	2.80E+00	NA
<i>Lead-211</i> ^(c)	--	--	5.05E-03	--
Radon-220	NA	NA	2.33E+02	NA
<i>Lead-212</i> ^(c)	--	--	3.28E-01	--
<i>Bismuth-212</i> ^(c)	--	--	3.11E-01	--
Radium-226	NA	NA	4.38E-10	NA
<i>Lead-214</i> ^(c)	--	--	4.48E-11	--
<i>Bismuth-214</i> ^(c)	--	--	4.33E-11	--
Actinium-227	NA	NA	5.61E-10	NA
Uranium-232	NA	NA	5.10E-09	NA
Uranium-233	NA	NA	2.19E-08	NA
Neptunium-237	NA	NA	1.25E-07	NA
Plutonium-238	7.90E-07	6.50E-07	1.88E-11	NA
Plutonium-239/240 ^(d)	1.29E-05	9.57E-05	6.67E-08	7.50E-08
Plutonium-241	3.80E-05	1.50E-05	4.31E-07	NA
Americium-241	3.90E-06	6.77E-06	1.88E-11	NA
Americium-243	NA	NA	8.06E-08	NA
<i>Neptunium-239</i> ^(c)	--	--	1.35E-08	--

^a Radionuclides in italic font are short-lived progeny of the parent listed above that may ingrow during air dispersion and for which inhalation dose coefficients are published.

^b Includes additional activity reported as gross beta activity.

^c Peak activity from ingrowth within a 15-hr air dispersion time period to an exposure point within a 50-mile (80-km) distance.

^d Includes additional activity reported as gross gamma activity.

Table D.3. Agricultural Pathway Parameters for Hanford Site Dose Calculations

	Leafy Vegetables	Root Vegetables	Fruits	Cereals	Eggs	Poultry	Beef	Milk	Hay (Beef Cattle, Milk Cows)	Pasture (Milk Cows)	Grains (Beef Cattle, Poultry)
Holdup time; day (MEI)	1	5	5	180	1	1	15	1	100	0	180
Holdup time; day (population)	14	14	14	180	18	34	34	4	100	0	180
Growing period; day	90	90	90	90	NA	NA	NA	NA	45	30	90
Yield; kg/meters ²	1.5	4	2	0.8	NA	NA	NA	NA	2	1.5	0.8
Irrigation rate; cm/year	77	88	77	¹	NA	NA	NA	NA	103	103	¹
Irrigation period; month	6	6	6	¹	NA	NA	NA	NA	6	6	¹
Water intake; L/year	NA	NA	NA	NA	0.3	0.3	50	60	NA	NA	NA
Food intake; kg/day	NA	NA	NA	NA	0.12	0.12	68 / 68 ³	55 / 55 ⁴	NA	NA	NA
Contaminated fraction of diet ²	NA	NA	NA	NA	1.0	1.0	0.25 / 0.75 ³	0.25 / 0.75 ⁴	NA	NA	NA
Livestock soil intake; kg/day	NA	NA	NA	NA	0.0	0.0	0.0	0.375 ⁵	NA	NA	NA

¹ No irrigation is assumed to occur for cereal crops or grains.

² Pertains to animal feed. 100 percent of animal water is assumed contaminated surface water.

³ First value pertains to grains, and second value pertains to hay.

⁴ First value pertains to hay, and second value pertains to pasture grass.

⁵ Calculated as 0.5 kg soil / day (EPA 2005) while grazing × 0.75 diet fraction of pasture grass.

Holdup is the time between harvest and consumption.

MEI: maximally exposed individual

NA: not applicable

Table D.4. Consumption Parameters for Hanford Site Dose Calculations

Medium	Consumption Rate ¹			
	Maximally Exposed Individual		Average Individual (Collective Dose)	
Leafy vegetables	30 kg/year	(66 lb/year)	15 kg/year	(33 lb/year)
Root vegetables	220 kg/year	(485 lb/year)	140 kg/year	(310 lb/year)
Fruits	330 kg/year	(728 lb/year)	64 kg/year	(140 lb/year)
Cereals	80 kg/year	(180 lb/year)	72 kg/year	(160 lb/year)
Milk	270 L/year	(71 gal/year)	230 L/year	(61 gal/year)
Beef	80 kg/year	(180 lb/year)	70 kg/year	(150 lb/year)
Poultry	18 kg/year	(40 lb/year)	8.5 kg/year	(19 lb/year)
Eggs	30 kg/year	(66 lb/year)	20 kg/year	(44 lb/year)
Fish ²	40 kg/year	(88 lb/year)	— ³	— ³
Drinking water ⁴	730 L/year	(193 gal/year)	440 L/year	(116 gal/year)
Inadvertent soil ingestion	36.5 g/year	(1.17 oz/year)	18.3 g/year	(0.59 oz/year)

¹ A transit time of 11 hour from the release to receptor locations is assumed.

² A holdup time of 1 day is used for both MEI and population calculations.

³ Average individual consumption not identified; see text of Section D.1.2.

⁴ A holdup time of 1 day is used for the Riverview calculations for identification of the location of the MEI.

Table D.5. Residency Parameters for Hanford Site Dose Calculations

Pathway	Exposure (hour/year)	
	Maximally Exposed Individual	Average Individual (Collective Dose)
Air: Inhalation ^{1,2}	24 hour/day, 365 days/year	24 hours/day, 365 days/year
Air: external (submersion) ²	24 hour/day, 365 days/year	24 hours/day, 365 days/year
Soil: external (ground shine)	12 hour/day, 365 days/year	8 hours/day, 365 days/year

¹ Inhalation rate, adult 1.0 m³/hour (35 ft³/hour)

² Dispersion time of 15 hours is protectively assumed for ingrowth of short-lived progeny during transport [50-miles (80-kilometers)] population dose radius and 4.9 feet/s (1.5 m/s) wind speed.

Table D.6. Columbia River Recreational Parameters for Hanford Site Dose Calculations

Activity and Pathway	Exposure (hour/year) ¹	
	Maximally Exposed Individual	Average Individual (Collective Dose)
Shoreline: sediment; external	5.0 hours/day, 100 days/year ²	1.7 hours/day, 10 days/year ²
Boating: river water; external	2.0 hours/day, 50 days/year ³	0.1 hour/day, 50 days/year ³
Swimming: river water; inadvertent ingestion ⁴ , external	2.0 hours/day, 50 days/year	0.2 hour/day, 50 days/year

¹ A transit time of 11 hour from the release to receptor locations is assumed

² A shoreline width factor of 0.2 is used

³ No shielding by the boat is assumed

⁴ Ingestion rate of 0.02 L/hour (0.68 oz/hour).

D.1.2 Fifty-Miles (Eighty-Kilometers) Collective Population Dose

Regulatory limits have not been established for collective doses to a population. However, evaluation of the collective population doses to all residents within 50-miles (80-kilometers) radius of Hanford Site operations is required by [DOE O 458.1](#), Chg. 2. The radiological dose to the collective population within 50 miles (80 kilometers) of the site operations areas was calculated to confirm adherence to DOE environmental protection policies, and provide information to the public. The 50-miles (80-kilometers) collective dose is the sum of doses to all individual members of the public within 50-miles (80-kilometers) of the four Hanford Site operations areas (100 Area, 200 Area, 300 Area, and 400 Area).

The same exposure pathways evaluated for the maximally exposed individual (Section D.1.1) were used to calculate doses to the offsite population. The primary difference between the maximally exposed individual and collective dose calculations is in the values selected for certain exposure parameters. As shown in Tables D.4, D.5, and D.6, exposure parameter values for the collective dose calculations reflect an average individual rather than a maximally exposed individual.

In calculating, the collective dose related to water-mediated exposure pathways (drinking water, irrigated foods, Columbia River recreation, and fish consumption), estimates were made of the size of the offsite population expected to be affected by each pathway. The assumptions of population size and the calculation of collective dose for each of these four exposure pathways are described in the following paragraphs.

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 182,000 people reside in the Tri-Cities¹ and are assumed to obtain all of their drinking water directly from the Columbia River or from impacted wells adjacent to the river. Annual drinking water dose for an average individual is multiplied by the Tri-Cities population to calculate the collective drinking water dose.

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. Because these crops are widely distributed, any individual is likely to receive only negligible potential exposure. Annual irrigated foods dose for an average individual is multiplied by the estimate population of 2,000 individuals to calculate the collective irrigated foods dose.

Columbia River Recreation – As described in Section 4.2 and Section D.1.1, these recreational activities include fishing, swimming, boating, and shoreline recreation. It was protectively assumed that all 182,000 individuals in the Tri-Cities participated in these recreational activities. Annual recreational dose for an average individual is multiplied by the Tri-Cities population to calculate the collective recreational dose.

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 (33,000 pounds) per year. It was protectively assumed that 100% of the annual catch was consumed by individuals in the Tri-Cities area. Population dose related to fish consumption was calculated as:

$$\text{Population dose (person-rem)} = \text{MEI dose (mrem)} \times 0.001 \text{ rem/mrem} \times (\text{annual catch [kg/year]} / \text{IR}_{\text{fish}} [\text{kg/year/person}])$$

Where:

MEI dose = dose for the maximally exposed individual

Annual catch = 15,000 kg fish/year

IR_{fish} = individual fish ingestion rate used in the MEI calculation (40 kg/year/person)

¹ The cities of Pasco, Kennewick, and Richland—known as the Tri-Cities—are located in southeastern Washington State. Population estimates from <http://quickfacts.census.gov/qfd/index.html>.

Collective dose related to air-mediated exposure pathways was calculated based on the geographic distribution of the population residing within a 50-mile (80-kilometer) radius of the Hanford Site operating areas, as shown in [PNNL-20631](#), *Hanford Site Regional Population – 2010 Census*. These distributions are based on 2010 Bureau of the Census data ([PNNL-20631](#)). These data influence the population dose by providing estimates of the number of people exposed to radioactive air emissions and their proximity to the points of release.

The air pathways collective dose calculations are based on modeled radionuclide air concentrations and deposition rates downwind of the Hanford Site operating areas coupled with the geographic population distribution in these areas. Both the meteorological data and the population distribution data are organized according to 16 directional sectors based on the four cardinal, four ordinal, and eight cross-wind directions (N, NNE, NE, ENE, etc.). These sectors were transformed into grids using concentric circles with radii of 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles. These radii correspond to the downwind distances specified in the GENII Chronic Plume Air Module. Four population files were created based on the number of individuals located in each of the 160 grid segments, as tabulated in [PNNL-20631](#). These files were identified in the GENII Air Dose Report Module.

D.2 Calculation of Biota Doses

The RESRAD-BIOTA computer code was used to screen the 2012-radionuclide concentrations in water and sediment to see if they exceeded the established biota concentration guides. Biota concentration guides are 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. Table D.7 presents the Tier 1 biota concentration guides for the radionuclides evaluated. 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. 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 dose limit (sum of fractions more than 1.0), additional screening calculations are performed (Tier 2 or Tier 3) to evaluate more accurately exposure of the biota to the radionuclides. The process may culminate in a site-specific assessment requiring additional sampling and study of exposure.

In the initial screening assessment, researchers compare maximum measured concentrations to the biota concentration guides. The maximum detected concentrations in 100 Area sediment and seep water samples are presented in Table D.8. If the sum of fractions does not exceed one, no further analysis is required. However, if the sum of fractions does exceed one, a second analysis is performed using average concentrations. For the aquatic biota dose assessment, paired sediment, and water data are required and in the event, only one of these media was sampled, and then the other is calculated using the water to sediment partition coefficient. These coefficients are tabulated in Table D.7. For West Lake, Tier 2 and Tier 3 calculations were implemented using the mean media concentrations presented in Table D.9. Means were calculated based on the reported concentrations in biota, water, and sediment. For a given quarter, only a single sample was pulled of sediment and water. Some exceptions were cases where filtered and total samples were collected and analyzed. The biota sometimes represented multiple samples. For 2012, the average of the water concentrations for uranium calculated for these mean values were used in the Tier 2 and Tier 3 calculations. The screening process is further described in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* ([DOE-STD-1153-2002](#)).

The Tier 1 and Tier 2 West Lake biota dose assessments were driven by the potential for dose from uranium isotopes in water and the assumed potential for these isotopes to accumulate in biota. Therefore, the Tier 3 West Lake biota dose calculations utilized site-specific information on bioaccumulation. As defined in [DOE-STD-1153-2002](#), bioaccumulation is the ratio of the contaminant concentration in the organism relative to the contaminant concentration in an environmental medium resulting from the uptake of the contaminant from one or more routes of exposure. The more relevant biota data collected from West Lake are the brine flies sampled in 2000 and 2007 ([PNNL-13487](#), [DOE/RL-2007-50](#)). Birds (avocets) were also sampled in 2000 and had lower concentrations than the brine flies ([PNNL-13487](#)). Birds are not year-round residents and thus have lower exposure and less potential for bioaccumulation from West Lake ([DOE/RL-2007-50](#)).

Appendix K). The maximum concentration of any of the uranium isotopes in brine flies was 0.77 pCi/g in 2007. The maximum uranium-238 water concentration was 1400 pCi/L in 2007. The bioaccumulation factor is calculated by dividing the biota concentration (in pCi/g) by the water concentration (in pCi/L). Therefore, the maximum bioaccumulation factor for uranium would be less than one. As presented in Table D.9 the bioaccumulation factors for uranium isotopes based on the mean concentrations in flies and water are between 0.2 and 0.5. A bioaccumulation factor of one was used for the West Lake Tier 3 biota dose calculation as a somewhat protective measure of site-specific uranium uptake into the food chain. Table D.10 presents the Tier 3 BCGs for isotopic uranium for both aquatic and riparian animals.

Table D.7. Tier 1 Biota Concentration Guides and Water to Sediment Partition Coefficients

Radionuclide	Water (pCi/L) ¹	Limiting Organism	Sediment (pCi/g) ¹	Limiting Organism	Default Kd (mL/g)
H-3	2.65E+08	Riparian animal	3.74E+05	Riparian animal	0.001
C-14	6.09E+02	Riparian animal	5.90E+04	Riparian animal	0.001
Sr-90	2.78E+02	Riparian animal	5.82E+02	Riparian animal	30
Cs-137	4.26E+01	Riparian animal	3.12E+03	Riparian animal	500
Pu-239/240	1.87E+02	Aquatic animal	5.86E+03	Riparian animal	2000
U-234	2.02E+02	Aquatic animal	5.27E+03	Riparian animal	50
U-235	2.17E+02	Aquatic animal	3.73E+03	Riparian animal	50
U-238	2.23E+02	Aquatic animal	2.49E+03	Riparian animal	50

¹Biota concentration guides, (pCi/L or pCi/g)

Kd = Water to Sediment Partition Coefficients, (mL/g)

Table D.8. Maximum Concentrations of Sediment and Water Evaluated for Biota Dose Assessment

Radionuclide	Priest Rapids Dam ¹	100-B Area Seeps ²	100-K Area Seeps ²	100-N Area Seeps ²	100-D Spring Sediment ¹	100-D Area Seeps ²	100-H Area Seeps ²
	Carbon-14	—	—	57.3	—	—	—
Cesium-137	0.336	—	—	—	0.209	—	—
Hydrogen-3	—	1090	2890	1280	—	603	275
Plutonium-239/240	0.011	—	—	—	0.00282	—	—
Strontium-90	—	—	—	4.61	—	—	—
Uranium-234	1.36	—	—	—	0.516	0.238	—
Uranium-235	0.0581	—	—	—	0.0401	—	—
Uranium-238	1.15	—	—	—	0.49	0.229	—

Radionuclide	White Bluffs Slough ¹	100-F Slough ¹	Hanford Slough ¹	Hanford Spring ²	300 Area Springs Seeps ²	McNary Dam Sediment ¹	West Lake Sediment ¹	West Lake Water ²
	Hydrogen-3	—	—	—	32600	4300	—	—
Carbon-14	—	—	—	—	—	—	—	—
Cesium-137	0.322	0.169	0.247	—	—	0.234	1.56	—
Plutonium-239/240	0.00233	—	—	—	—	0.0209	—	—
Strontium-90	—	—	—	—	—	—	0.49	—
Uranium-234	0.951	0.461	0.925	—	24.2	1.33	4.37	3850
Uranium-235	0.0426	0.0541	0.0789	—	1.61	0.0822	0.205	147
Uranium-238	1.03	0.406	0.938	—	22.8	1.23	4.07	3650

¹ pCi/g
² pCi/L

— not detected or not measured

Table D.9. Mean Concentrations of Biota, Sediment, and Water Measured in West Lake

Media Groups	Year 2000-2012	Units	U-234 Mean	U-235 Mean	U-238 Mean
Avocet	2000-Q2	pCi/g	0.013	0.001	0.013
Brine flies	2000-Q2	pCi/g	0.43	0.021	0.40
Brine flies	2007-Q2	pCi/g	0.52	0.028	0.42
Brine fly bioaccumulation factor	2000-ALL	g/ml	0.27	0.30	0.26
Brine fly bioaccumulation factor	2007-ALL	g/ml	0.42	0.48	0.38
Lake	2000-Q1	pCi/L	810	30	754
Lake	2000-Q2	pCi/L	1036	39	964
Lake	2000-Q3	pCi/L	1990	86	1880
Lake	2000-Q4	pCi/L	2650	132	2500
Lake	2001-Q1	pCi/L	345	14	326
Lake	2001-Q2	pCi/L	461	18	425
Lake	2001-Q3	pCi/L	2460	89	2240
Lake	2006-Q2	pCi/L	2175	47	1423
Lake	2007-Q2	pCi/L	1235	59	1118
Lake	2011-Q2	pCi/L	370	17	353
Lake	2011-Q3	pCi/L	1200	60	1180
Lake	2011-Q4	pCi/L	8.8	0.54	7.9
Lake	2011-ALL	pCi/L	526	26	514
Lake	2012-Q1	pCi/L	263	12.3	237
Lake	2012-Q1	pCi/L	3850	147	3650
Lake	2011-ALL	pCi/L	2056.5	79.65	1943.5
Sediment	2000-Q2	pCi/g	1.2	0.063	1.2
Sediment	2001-Q4	pCi/g	2.5	0.095	2.4
Sediment	2002-Q1	pCi/g	0.289	0.01	0.29
Sediment	2002-Q2	pCi/g	0.625	0.02	0.61
Sediment	2002-Q3	pCi/g	4.8	0.18	4.3
Sediment	2002-Q4	pCi/g	2.3	0.08	2.1
Sediment	2003-Q1	pCi/g	0.55	0.02	0.50
Sediment	2003-Q2	pCi/g	1.1	0.04	1.0
Sediment	2003-Q3	pCi/g	9.1	0.34	8.5
Sediment	2003-Q4	pCi/g	3.2	0.11	3.0
Sediment	2004-Q1	pCi/g	0.38	0.01	0.34
Sediment	2004-Q2	pCi/g	0.70	0.02	0.66
Sediment	2004-Q3	pCi/g	3.9	0.12	3.7
Sediment	2004-Q4	pCi/g	4.8	0.17	4.4
Sediment	2005-Q1	pCi/g	0.91	0.035	0.87
Sediment	2005-Q2	pCi/g	0.65	0.019	0.59
Sediment	2005-Q3	pCi/g	7.7	0.32	7.2
Sediment	2005-Q4	pCi/g	2.8	0.093	2.6
Sediment	2006-Q1	pCi/g	0.28	0.008	0.28
Sediment	2006-Q2	pCi/g	1.3	0.044	1.1
Sediment	2006-Q3	pCi/g	4.9	0.18	4.5
Sediment	2006-Q4	pCi/g	1.2	0.085	1.9
Sediment	2007-Q1	pCi/g	1.1	0.038	0.94
Sediment	2007-Q4	pCi/g	1.8	0.047	1.7
Sediment	2008-Q1	pCi/g	0.68	0.057	0.68
Sediment	2008-Q3	pCi/g	1.7	0.15	2.6
Sediment	2009-Q1	pCi/g	1.9	0.10	1.8
Sediment	2009-Q4	pCi/g	6.4	0.36	6.1
Sediment	2010-Q1	pCi/g	1.4	0.072	1.3
Sediment	2011-Q2	pCi/g	2.1	0.13	2.0
Sediment	2012-Q1	pCi/g	4.37	0.205	4.07
Seep	2000-Q2	pCi/L	29	0.95	28
Seep	2007-Q2	pCi/L	92	5.3	81

Table D.10. Tier 3 Biota Concentration Guides (BCG)

Radionuclide	Water BCG (pCi/L)		Sediment BCG (pCi/g)	
	Aquatic Animal	Riparian Animal	Aquatic Animal	Riparian Animal
U-234	202000	20200	3030000	5270
U-235	217000	21700	110000	3790
U-238	222000	22200	42900	2490

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